NAVAIR 01-1A-505–1
TO 1–1A–14
TM 1–1500–323–24–1
15 September 2009

TECHNICAL MANUAL

INSTALLATION AND REPAIR PRACTICES

VOLUME 1
AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

This manual is one of a series of four volumes.

For U.S. Navy Users Only– This manual supersedes NAVAIR 01–1A–505–1 dated 1 September 2004 with Change 3 dated 15 May 2007.

For U.S. Air Force Users Only– This manual supersedes TO 1–1A–14 dated 1 September 2004 with Change 3 dated 15 May 2007.

For U.S. Army Users Only– This manual supersedes TM 1–1500–323–24–1 dated 1 September 2004 with Change 3 dated 15 May 2007.

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NUMERICAL INDEX OF EFFECTIVE WORK PACKAGES/PAGES

List of Current Changes

Original . . . . 15 September 2009

Only those work packages/pages assigned to the manual are listed in this index. Dispose of superseded and deleted work packages/pages. Superseded and deleted classified work packages/pages shall be destroyed in accordance with applicable regulations. If changed pages are issued to a work package, insert the changed pages in the applicable work package. The portion of text affected in a changed or revised work package is indicated by change bars or the change symbol “R” in the outer margin of each column of text. Changes to illustrations are indicated by pointing hands or change bars, as applicable. Changes to wiring diagrams and schematics are indicated by shading.

NUMERICAL INDEX OF EFFECTIVE WORK PACKAGES/PAGES (Cont)

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001 00	
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004 01	
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1 – 9	0
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012 01	
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012 02	
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013 00	
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014 02	
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014 03	
1 – 3	0
4 Blank	0
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LIST OF TECHNICAL PUBLICATIONS DEFICIENCY REPORTS INCORPORATED

INSTALLATION PRACTICES
AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Identification No./ QA Sequence No.	Service
01053090001	Navy-USMC
01053090002	Navy-USMC
01053090003	Navy-USMC
01053090004	Navy-USMC
09047090008	Navy
44329090308	Navy
65886060001	Navy
65886060002	Navy
6592307RC01	Navy
6592307RC02	Navy
6592307RC03	Navy
6592307RC04	Navy
6592307RC05	Navy
65923080001	Navy
6592308P024	Navy
6592308P025	Navy
6592308P026	Navy
6592308P027	Navy
6592309P384	Navy
6592309P487	Navy
68626090001	Navy
68626090002	Navy
68626090004	Navy
68626090005	Navy
68626090006	Navy
68626090007	Navy
68626090008	Navy
68626090010	Navy
68626090011	Navy

Identification No./ QA Sequence No.	Service
68626090012	Navy
68626090013	Navy
68626090015	Navy
68626090016	Navy
51MWRLEETX5782	Air Force
20J0097AMW7123R	Air Force
20MOHQAFRC5002	Air Force
21L00317AG8005R	Air Force
21M0402MXW8001	Air Force
21M0412TWG7110R	Air Force
21M0412TWG7022R	Air Force
21M0402MXW80001	Air Force
24Z0116ACW8065	Air Force
24Z0119WG7036	Air Force
24Z0119WG7037	Air Force
24Z0119WG7038	Air Force
24Z0123MXQ8003	Air Force
24Z0162FW08008R	Air Force
51MWRLEETX5782	Air Force
51MWRLTSAA5001	Air Force
20J0056FWG8008R	Air Force
20V0001MXG8064	Air Force
21C0095LGQ8008	Air Force
24Z00119WG7036	Air Force
20D0086MXG0005	Air Force
24Z00119WG7038	Air Force
24Z0123MXQ8003	Air Force
24Z0162FW08008R	Air Force
07P02438	Army
08P01068	Army

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WARNINGS APPLICABLE TO HAZARDOUS MATERIALS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

1. INTRODUCTION.

2. Warnings for hazardous materials listed in this manual are designed to warn personnel of hazards associated with such items when they come in contact with them by actual use. Additional information related to hazardous materials is provided in OPNAVINST 5100.23, Navy Occupational Safety and Health (NAVOSH) Program Manual, NAVSUPINST 5100.27, Navy Hazardous Material Control Program, and the DOD 6050.5, Hazardous Materials Information System (HMIS) series publications. For each hazardous material used within the Navy, a material safety data sheet (MSDS) is required to be provided and available for review by users. Consult your local safety and health staff concerning any questions on hazardous chemicals, MSDS's, personal protective equipment requirements, and appropriate handling and emergency procedures and disposal guidance.

3. Complete warnings for hazardous materials referenced in this manual are identified by use of an icon, nomenclature and specification or part number of the material, and a numeric identifier. The numeric identifiers have been assigned to the hazardous materials in the order of their appearance in the manual. Each hazardous material is assigned only one numeric identifier. Repeated use of a specific hazardous material references the numeric identifier assigned at its initial appearance. The approved icons and their applications are shown below in Explanation of Hazardous Symbols.

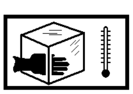
4. In the text of the manual, the caption **WARNING** will not be used for hazardous materials. Such warnings will be identified by an icon and numeric identifier. The material nomenclature will also be provided. The user is directed to refer to the corresponding numeric identifier listed in this WP under the heading HAZARDOUS MATERIALS WARNINGS for the complete warning applicable to the hazardous material.

5. Items in italics in the Specification Number or Part Number column of the Work Package materials Required list indicates the item is a class 1 ozone depleting substance (ODS1).

6. EXPLANATION OF HAZARD SYMBOLS

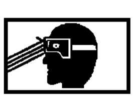
Breathing Hazard. The symbol of a human figure in a cloud shows that breathing this material can present a health hazard.

Corrosive (Caustic or Acidic). The symbol of drops of a liquid burning a hand shows a material that causes burns to human skin or tissue.



Cryogenic. The symbol of a hand in a block of ice shows a material is so cold it will burn your skin on contact.

Explosive. The rapidly expanding symbol shows that the material may explode if subjected to high temperature, sources of ignition, or high pressure.



Eye Protection. The symbol of a person wearing goggles shows a material that can injure your eyes.

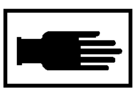
Fire. The symbol of a fire shows that a material can ignite and burn you.

Highly Toxic. The symbol of a skull and crossbones shows a material that is highly toxic and can be a danger to life and health.

Ingestion Hazard. The symbol of a liquid entering the mouth shows that eating or drinking this material can cause a health hazard.

Oxidizer. The symbol of an “O” with a flame shows a material that will promote fire and cannot be stored near flammable or organic materials.

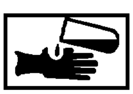
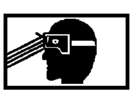
Radiation. The symbol of three circular wedges shows that the material emits radioactive energy and can injure human tissue or organs.



Skin Hazard. The hand symbol shows a material that can irritate the skin or enter the body through the skin and cause a health hazard.

HAZARDOUS MATERIALS WARNINGS

Index	Material	Warning
1	**Isopropyl Alcohol, TT-I-735 Grade A**	**Isopropyl Alcohol, TT-I-735 Grade A.** Isopropyl alcohol, TT–I–735, is toxic and flammable. Avoid contact with skin and eyes. Use in a well ventilated area and avoid breathing vapors. May be fatal if swallowed. Keep away from heat, sparks, and flame. Store in a clean, cool, well ventilated area away from ignition sources and oxidizing agents. Keep containers tightly closed when not in use. Protection: butyl gloves and chemical goggles; face shield and protective clothing required when splashing is possible or expected; half–mask respirator with organic vapor cartridge required in poorly ventilated areas


ALPHABETICAL INDEX

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

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INTRODUCTION

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

1. **PURPOSE AND SCOPE.**

2. This manual was prepared for the following reasons:

a. To gather under one cover the recommended practices and techniques to be used for installing, repairing, and maintaining aircraft electrical wiring.

b. To standardize these techniques and methods so that electrical installations will be done in a uniform manner.

c. To indoctrinate all personnel with the importance of good workmanship.

d. To point out the failures which may result from poor workmanship.

e. To promote safety by pointing out and prohibiting unsafe practices.

3. This manual covers all general purpose wiring and wiring devices used for the interconnection of equipment in aircraft. It also includes thermocouple systems and coaxial cabling installed in aircraft.

4. **ARRANGEMENT AND USE.**

5. This manual is divided into work packages (WPs) which are self-contained procedures that may be used to support specific tasks.

6. Each WP is maintained separately. The WPs are identified by five-digit numbers in the upper right corner of each page. This number aids in rapid assembly of a complete manual and is used for referencing within a manual.

7. This manual was prepared using Navy series manual numbers throughout the text as references to reduce the amount of text required. When other services are using this joint service manual refer to Table 1 for an explanation of their corresponding manual number (i.e. 01–1A–505–1 Navy is 1–1A–14 Air Force or 1–1500–323–24–1 Army). When a conflict exists between this series of manuals and other manuals the precedence is as follows:

a. OEM drawings

b. Platform Specific Manuals

c. SAE AS50881

d. NAVAIR 01–1A–505 (series)

8. **REQUISITIONING AND AUTOMATIC DISTRIBUTION.**

9. Procedures to be used by Naval activities and other Department of Defense activities requiring NAVAIR technical manuals are defined in NAVAIR 00-25-100.

Table 1 . Joint Services Manual Cross Reference

	Service		
Manual Topic	Navy	Air Force	Army
General Wiring	01–1A–505–1	1–1A–14	1–1500–323–24–1
Circular Connectors	01–1A–505–2	00–25–255–1	1–1500–323–24–2
Rectangular Connectors	01–1A–505–3	00–25–255–2	1–1500–323–24–3

10. QUALITY ASSURANCE.

11. Maintenance procedure steps, essential to equipment performance or to the safety of personnel, are highlighted by the addition of the abbreviation (QA) following the procedure. Quality Assurance action shall be taken on all steps designated (QA) prior to proceeding to the next step.

12. SUPPORT EQUIPMENT REQUIRED.

13. Table 2 provides a cumulative list of the support equipment required to maintain the components covered in this manual. The equipment required for each maintenance task is listed in the corresponding WP. When alternate repair procedures exist, different tools may be required. Where possible, the alternate tools are identified.

14. CONSUMABLE MATERIALS REQUIRED.

15. Table 3 provides a cumulative list of materials required to maintain the components covered in this manual. The materials required for each maintenance task are listed in the corresponding WP. When alternate repair procedures exist, different materials may be required. Where possible, the alternate materials are identified.

16. REFERENCE MATERIAL.

17. Table 4 provides a list-of the reference material required to install aircraft wiring and wiring devices.

18. TECHNICAL DIRECTIVES.

19. A record of applicable technical directives will also appear in each WP in this manual, but will list only technical directives that affect the text and illustrations of that particular WP.

20. WARNINGS, CAUTIONS, AND NOTES.

21. Warnings, Cautions, and Notes are used throughout this manual. They are defined as follows:

WARNING

An operating or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in injury to or death of personnel.

CAUTION

An operating or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in damage to, or destruction of, equipment or loss of mission effectiveness.

NOTE

An essential operating or maintenance procedure, condition, or statement, which must be highlighted.

22. GENERAL SAFETY PRECAUTIONS. The following general safety precautions shall apply:

a. Observe and follow all written safety precautions while performing procedures given in the methods of this and other work packages contained within this manual.

b. Observe and adhere to all Warning/Caution/Advisory signs on equipment and materials.

c. Observe and adhere to all Warning/Caution/Advisories/Notes in the applicable Type/Model/Series aircraft manuals for repair of, and operational verification of wiring and interconnect systems.

d. The following are general safety precautions which are not related to any specific procedure and therefore do not appear elsewhere in this publication. These are recommended precautions that personnel shall understand and apply during many phases of operation and maintenance.

23. **KEEP AWAY FROM LIVE CIRCUITS.** Operating personnel shall observe all safety regulations at all times. Do not replace components inside the equipment when potentially lethal voltages are present. Turn off system power before making/breaking electrical connections. Regard any exposed connector, terminal board, or circuit boards as a possible shock hazard. Components that retain a charge shall be discharged only when such grounding does not result in equipment damage. If a test connection to energized equipment is required, make the test equipment ground connection before probing the voltage or signal to be tested. Adhere to all lock out/tag out requirements.

24. **DO NOT SERVICE OR ADJUST ALONE.** Personnel shall not under any circumstance reach into or enter any enclosure for the purpose of servicing, or adjusting the equipment alone, without immediate presence, or assistance of another person capable of rendering aid.

25. **RESUSCITATION.** Personnel working with, or near high voltages or hazardous materials shall be familiar with modern methods of resuscitation. More information may be obtained by consulting with: the Office of Bioenvironmental Health (Air Force), Navy Safety Center, Activity HAZMAT Officer (Navy), or the local Red Cross organization.

26. **DO NOT WEAR JEWELRY.** Remove rings, watches, and other metallic objects which may cause electric shock, or burn hazard.

Table 2 . Support Equipment Required

Nomenclature	Part No./Type Designation
Fixture, Holding	AD-1319
Crimping Tool	AD-1377
Clamp Assembly Tool	ADEL560
Crimping Tool	AMP 49935
Connector, Thermocouple	AN 5537
Ohmmeter	AN/USM-21A
Adapter, Fixture	AT-1319-11
Adapter, Fixture	AT-1319-14
Adapter, Fixture	AT-1319-17
Adapter, Fixture	AT-1319-18
Adapter, Fixture	AT-1319-19
Pliers, Padded Conduit	AT508K
Wrench, Strap	BT–BS–609 or BT–BS–610
Tool, Thermogun Heating	CV-5000
Heat Gun, Mini	CV-5300
Tool, Mini-Gun Hot Air	CV-5302
Heat Gun	CV-5700
Coaxial Cable Splice Kit	D-150-02
Coaxial Cable Splice Kit	D-150-12
Coaxial Cable Splice Kit	D-150-15
Coaxial Cable Splice Kit	D-150-16
Coaxial Cable Splice Kit	D-150-28
Coaxial Cable Splice Kit	D-150-29
Tool, Banding	DBS-1100
Loop, Strap Fastener	GE21E1
Wire Twister Plier with Side Cutter	GGG-W-3408
Heat Gun	HT-900B

Table 2 . Support Equipment Required (Cont.)

Nomenclature	Part No./Type Designation
Heat Gun	HT-920B
Infrared Heating Tool	IR-500
Infrared Heating Tool	IR-550
Two-Station Solder Tacts Heater	IR-1044
Infrared Heating Tool	IR-1079
Die, Crimp	MS23002
Crimp Tool, Hydraulic	MS25441
Die, Crimp	MS90485
Crimp Tool Frame	M22520/1-01
Turret	M22520/1-12
Turret	M22520/1-13
Turret	M22520/1-14
Positioner	M22520/1-15
Inspection Gage	M22520/3-12
Inspection Gage	M22520/3-13
Inspection Gage	M22520/3-14
Crimp Tool	M22520/5
Crimp Tool	M22520/5-01
Crimp Tool Frame	M22520/5-03
Die	M22520/5-05
Die	M22520/5-07
Die	M22520/5-09
Die	M22520/5-11
Die	M22520/5-13
Die	M22520/5-19
Die	M22520/5-25
Die	M22520/5-33
Die	M22520/5-35
Die	M22520/5-41
Die	M22520/5-55
Die	M22520/5-57
Die	M22520/5-59
Die	M22520/5-61
Die Set	M22520/5-100
Die Set	M22520/5-102
Die Set	M22520/5-103
Crimping Tool	M22520/10-01
Die Set	M22520/10-103
Die Set	M22520/10-104
Crimp Tool	M22520/24
Crimp Tool Frame	M22520/36-01
Positioner	M22520/36-02
Positioner	M22520/36-03
Locator	M22520/36-04

Table 2 . Support Equipment Required (Cont.)

Nomenclature	Part No./Type Designation
Locator	M22520/36-05
Locator	M22520/36-15
Positioner	M22520/36-16
Positioner	M22520/36-17
Locator	M22520/36-18
Crimping Tool	M22520/37-01
Inspection Gage	M22520/39-01
TJS Block Removal Tool	M81714/39-01
TJS Block Removal Tool	M81714/69-02
Reflector	MG-2
Pliers, Connector	Model 11-6147-1
Knife, Thermal	Model 2A
Hand Tool, Strap Installation	MS90387
Crimping Tool	OMNI SPECTRA T-200
Reflector	TG-12
Reflector	TG-13
Reflector	TG-13A
Reflector	TG-21
Reflector	TG-22
Reflector	TG-23
Reflector	TG-24
Metallic Time Delay Reflectometer, Tektronix 1502c	070-7168-04
Contact Gauge Pin Set	16U42563-1
Cable Stripper	45-162
Cable Stripper	45-163
Cable Stripper	45-164
Cable Stripper	45-165
Wire Strippers	45-1610
Ideal 45-123 Cutters, Wire	45-1611
Wire Strippers	45-4987
Syringe 33cc, 23 Gauge Needle	5585
Insulation Tester (Megger), MEGGER	6625-00-376-5105
Multimeter	77/BN
Wiring Diagnostic Tester, Advanced System Tester	900AST
Crimping Tool	901-2500
Stripper No-Nik (.010)	980-0005-548
Stripper No-Nik (.016)	980-0005-549
Diamond Scribe	980-0006-755
Jewel Tweezers	980-0006-757
Kevlar Shears	980-9500-000
Wiring Diagnostic Tester, ESP+ Reflectometer	980-ESP-00256
Tip, Boot and Tubing Gun, Sealing	979648
Brush, Bristle	—
Crimping Tool, Modified	—

Table 2 . Support Equipment Required (Cont.)

Nomenclature	Part No./Type Designation
Diagonal Cutters	—
Flashlight and Inspection Mirror	—
Knife	—
Knife, Exacto	—
Micrometer Metric	—
Nitrogen Bottle	—
Paddle, Wooden	—
Pliers, Diagonal	—
Pliers, Padded Conduit	—
Pliers, Resistance Heating	—
Pliers, Slip Joint	—
Pliers, Wire Twister with Side Cutter	—
Ruler, 12 In.	—
Safety Glasses	—
Scissors	—
Scissors, Small Line Splicing	—
Shears, Full Bypass	MFE–100
Screwdriver, Flat	—
Screwdriver, Torque Limiting	—
Scribe	—
Sealing Gun	—
Shield, Notched Copper Sheet	—
Socket, 3/8 Inch	—
Soft Bristled Brush	—
Solder Pot	—
Soldering Iron, 140 Watt	—
Soldering Iron, 200-250 Watt	—
Spacer, 3/8 Dowel	—
Spatula	—
Strap Wrench	—
T-Handle, 1/4 inch Drive	—
Torque Wrench, 0-100 in. lbs.	—
Wrench, Torque 0-150 in. lbs.	—
Wrench, Torque 150-250 in. lbs.	—
Wrench, Torque Limiting Socket	—
4 LED Headlamp	04–0245
LED Headlamp (Navigation. capability)	05–0140

Table 3 . Materials Required

Nomenclature	Specification No./Part No.
Abrasive Mat	A–A–58054
Adhesive	RTV-108
Adhesive	S-1009
Adhesive	S-1030
Adhesive	S-1125
Alcohol, Denatured	O–M–232
Alcohol, Isopropyl 150	TT-I-735
Alcohol, Isopropyl (Isopropanol)	TT-I-735
Alcohol, Isopropyl, Grade A, Technical	TT–I–735 Grade A
Bag, Plastic	—
Bands, 3 In.	4-1380
Bolt	AN-3
Bonding Paste	—
Boot, Bulbous	202A100 Series
Boot, Bulbous	202D100 Series
Boot, Low Profile	200D200 Series
Borax	—
Braid, Metallic	A–A–59569
Brush	A–A–3077
Brush, Acid Swabbing	—
Brushing Compound, Zinc Chromate	—
Cable, Safety, Self-Looping	AS3621 Series
Cap, End	MS25274-1
Cap, End	MS25274-2
Cap, End	MS25274-3
Cap, End	MS25274-4
Carbon Dioxide, Solid	—
Casting Compound, Epoxy (Stycast 2651 B Emerson and Cuming)	MIL-I-16923
Chemical Conversion Material	MIL-C-5541, Class 3
Clamp, Bonding	AN735
Clamp, Cushioned Metal	AS21919
Clamp, Plastic	AS25281
Cleaning Cloth	CCC-C-46, Class 4
Cleaning Compound	MIL-PRF-29608, Type I, Class C
Cloth	MIL-C-85043
Cloth, Abrasive Coated	ANSI B74.18
Component Rack Assembly	M81714/67
Component Rack Assembly	M81714/67
Component Rack Assembly	M81714/67
Component Rack Assembly	M81714/67
Compound, Molding	—

Table 3 . Materials Required (Cont)

Nomenclature	Specification No./Part No.
Compound, Sealing	MIL-PRF-8516
Compound, Thread Coating	MIL-S-46163 Type 2, Grade: N/ASTM D 5363-AN0321
Conductor, Copper	ASTM-B172
Contact	M39029/73–396
Contact	M39029/73–397
Contact	M39029/73–398
Contact	M39029/74–399
Contact	M39029/74–399
Contact	M39029/74–400
Contact	M39029/74–401
Contact	D-602-16
Contact	D-602-17
Contact	D-602-44
Contact	D-602-45
Contact	D-602-46
Contact	D-602-47
Contact	D-602-54
Contact	D-602-55
Contact	D-602-56
Contact	D-602-57
Contact	D-602-72
Contact	D-602-73
Contact	D-602-94
Contact	D-602-95
Contact	D-602-104
Contact	D-602-105
Contact	D-602-106
Contact	D-602-107
Cord, Lacing	—
Corrosion Preventive Compound	MIL-C-81309, Type II and Type III
Crimp Splice, Red	M81824/1-1
Crimp Splice, Yellow	M81824/1-3
Dichloromethane (Methylene Chloride)	ASTM D4701 or other approved solvent
Emery Cloth #320	—
End caps, Heat shrinkable (also known as SSC end caps)	SAE AS81765/1
Environmental Test Methods for Aerospace and Ground Equipment	MIL–Std–810
Ferrule, Elongated	AS3619 Series
Fluorocarbon Etchant (WL Gore, etc.) (or Equivalent Such as Bondaid or S16943)	Tetra Etch
Flux, Brazing, Silver Alloy, Low Melting Point	O–F–499

Table 3 . Materials Required (Cont)

Nomenclature	Specification No./Part No.
Flux, Lactic Acid	—
Flux, Liquid	J–STD–004, J–STD–005 and J–STD–006
Flux, or Equivalent	A–A–51145
Flux, Silver Brazing	AMS3411–S
Glue, Epoxy	—
Grommet, Caterpillar	NASM22529/2 /3
Grommet, Donut	MS35489
Gross Shield	—
Insulator	MS3373
Kim Wipes	—
Kit, Safety Cable	AS3617 Series
Locknut	MS21042
Locknut	MS21043
Lockwasher	AN-935
Lockwasher	AN-936B
Lockwasher	MS35338
Lockwasher	MS35340
Lockwasher	MS-35388
Lockwire, Aluminum Alloy, Anodized, Blue, 0.020 Diameter	MS20995-AB20
Lockwire, Aluminum Alloy, Anodized, Blue, 0.032 Diameter	MS20995-AB32
Lockwire, Nickel-Chromium-Iron Alloy, 0.032 Diameter	MS20995-N32
Lockwire, Nickel-Chromium-Iron Alloy, 0.020 Diameter	MS20995-N20
Lockwire, Nickel-Copper Alloy, 0.020 Diameter	MS20995-NC20
Lockwire, Nickel-Copper Alloy, 0.032 Diameter	MS20995-NC32
Loop, Strap Fastener	GE21E1
Magnesium Alloy, Pretreatment	SAE AMS–M–3171 TYPE VI
Marker, Harness I.D.	HT-TMS-WM9
Methanol	O-M-232
Mold Release	—
Nut	AN-345
Nut	MS-25682
Nut, Plain	AN-340
Nut, Self locking	MS-21042
Nut, Self locking	MS-21044
Nut, Steel	MS-35649
Nut, Steel	MS-35650
Permanent Marker (black, fine tip)	03–0109
Petrolatum,-Zinc Dust Compound	—
Pin Contact	MIL-C-39029
Pipe Cleaner	840507

Table 3 . Materials Required (Cont)

Nomenclature	Specification No./Part No.
Polyethlene Sheeting	—
Polyethylene Bags	—
Polyethylene Wax	—
Polyurethane Coating	PR-1532
Primer, Coating, Alkyd Base, One Component	TT−P−1787
Primer, Coating, Epoxy	MIL−PRF−23377
Primer for Specific Sealing Compound	Primer
Primer for Silicone Substrates	MIL−P−47215
Protective Sleeve	RNF-100
Push-On End Caps	—
Q-Tips	—
Remover, Paint, Epoxy	TT−R−2918
Rosin	A−A−59142
Sandpaper	—
Screw	MS51957
Screw	NAS1801
Screw	NAS1802
Sealing Compound, Polysulfide	AMS 3276 Class B−1/4
Sealing Compound, Polysulfide	MIL-PRF-8516
Sealing Compound, Polyurethane	MIL-M-24041
Sealing Compound, Silicone	MIL-PRF-23586
Sealing Compound, Silicone (DC3140, DC3145 Dow Corning)	MIL-A-46146
Sealing Compound, Silicone, Oil Resistant (Dow Corning)	RTV 735
Shearwire, Copper, Cadmium Plated, Yellow, 0.020 Diameter	MS20995-CU20
Sheet, Teflon	P5100C04 (9330−01−110−8972)
Shield Terminations	SAE AS83519 Series
Shielding Jumper Wire	M22795/11-22-5
Shielding Termination Ferrule	1 3280XX
Shielding Termination Ferrule	1 5M608-XX
Shipping Cap, Plastic	MS90376
Sleeve, Filling	CTA-0006
Sleeve, Filling	CTA-0042
Sleeve, Protective	RNF-100
Sleeving, Heat Shrink	CRN-T
Sleeving, Heat Shrink	SAE AMS−DTL−23053
Sleeving, Heat-Shrinkable	—
Sleeving, Insulation	1 M23053/12-XX-0
Sleeving, Insulation, Heat Shrinkable	SAE AMS−DTL−23053/5, Class I
Solder	Sn60WRMAP3

Table 3 . Materials Required (Cont)

Nomenclature	Specification No./Part No.
Solder Sleeve Shield Termination	SAE AS83519
Solder, Hard	QQ–B–654, 46S657
Solder, Soft	—
Solder, Soft	J–STD–004, J–STD–005, AND J–STD–006
Splice Set, Quick Disconnect	M6852-3
Spot Tie	—
Standard Application Wrap Around Heat Shrink	1 ZT98–04–016–#1 through ZT98–04–016–#14
Standard Application Wrap Around Environmentally Sealed Heat Shrink	1 ZT03–04–010–01/03/05/07/09/11 and ZT03–04–010–13/15/17/19/21/23/25/27
Tape	—
Tape, Adhesive Copper Foil	1245, NSN 7510–01–171–2852
Tape, Black Non-Adhesive Self-Bonding	A–A–59163 Type II, NSN 5970-00-955-9976
Tape, Cellophane	CHR, M-60
Tape Electrical Insulation, Self–Adhering	MIL–I–22444C, Part No: RL6000SA
Tape, Finish C, Glass Tying, Size 2	AA52083–C–2 (0.099–0.121 width)
Tape, Finish C, Glass Tying, Size 3	AA52083–C–3 (0.077–0.094 width)
Tape, Finish C, Polyester Tying, Size 2	AA52081–C–2 (0.099–0.121 width)
Tape, Finish C, Polyester Tying, Size 3	AA52081–C–3 (0.077–0.094 width)
Tape, Identification	B632 (7510–01–167–2606)
Tape, Lacing and Tying	A–A–52080 thru A–A–52084
Tape, Non-Adhesive Silicone	—
Tape, Non-Adhesive, Self-Bonding, Black	A–A–59163 TYPE II, NSN 5970-00-955-9976
Tape, Non-Adhesive, Self-Bonding, Red	A–A–59163 TYPE II, NSN 5970-00-949-4846
Tape, Non–Adhesive Silicone	–
Tape, Pressure Sensitive	—
Tape, Red Non-Adhesive Self-Bonding	A–A–59163 TYPE II, NSN 5970-00-949-4846
Tape, Self-Adhesive, Color	—
Tape, Self–Bonding Silicone	A–A–59163, TYPE II
Tape, Self–Bonding Silicone Rubber	A–A–59474
Tape, Silicone	—
Tape, Teflon	A–A–59474 Type I, Class 4, NSN 5970–01–012–4280
Tape, Teflon	299-947-110, Type III, Class I
Terminal Board	MS27212
Terminal Board Cover	MS18029
Terminal Lug, Aluminum	SAE AS70991
Terminal Lug, Aluminum	MS25435
Terminal Lug, Copper	SAE AS7928
Terminal Lug, Copper	MS20659
Terminal Lug, Copper	MS36036
Terminal Lug, Crimp Copper Insulated	MS25036 (Series)
Terminal Lug, Crimp Copper Uninsulated	MS20659 (Series)

Table 3 . Materials Required (Cont)

Nomenclature	Specification No./Part No.
Texmet Polishing Cloth	980-0005-546
Thinner, Dope and Lacquer	TT−R−2918
Tubing	RP-4800
Tubing	VPB-RT
Tubing or Vinyl Sheet	—
Tubing, Heat Shrink	SAE AMS−DTL−23053
Tubing, Plastic	—
Tubing, Plastic Spiral Wrap	T12T (9330−01−201−0658)
Tubing, Plastic Spiral Wrap	T25T (9330−01−169−5995)
Tubing, Plastic Spiral Wrap	T50T (9330−01−179−0242)
Tubing, Wire Braid	2194
Uni-Boot	202C600 Series
Washer	NAS1149
Washer, Flat Plated	MS25440
Washer, Plain	AN-960
Water-Displacing Corrosion Preventive Compound	MIL-DTL-85054, Type 1A
Wire	M22759/41, /42
Wire	MIL-W-22759
Wire, 30 AWG Bare	—
Wire, Filterline	M85485/9, /10
Wire, Heavy Wall	MIL-W-22759
Wire Mesh, Nickel Plated Copper	2010−1000−0152 (or SM−B−450436−3, Rev B) − NSN:5999−00−005−3272

NOTES: 1 Size required to be determined by technician.

Table 4 . Reference Material

Nomenclature	Publication
Tape, Lacing and Tying Polyester	A−A−52081
Tape, Lacing and Tying Glass	A−A−52083
Tape, High−Temperature Pressure−Sensitive	A−A−59474
Clamp, Cushioned Metal	AS21919
Clamps, Plastic	AS25281
Circuit Breaker, Aircraft, Trip Free, Push−Pull, 1/2−20 Amp, Type 1, −55 to +121 Deg. C	AS33201
Straps, Self−Clinch Cable Straps	AS33681
Terminal Junction System	AS81714
Connectors, Coaxial, Radio Frequency, Series LT	MIL-C-26637
Electrical Contacts	MIL−C-39029
Cable, Electric, Filter Line, Radio Frequency Absorptive	MIL−C-85485
Wire, Electrical, Insulated	MIL−DTL−16878
Cables, Radio Frequency, Flexible and Semi-Rigid	MIL-DTL-17

Table 4 . Reference Material (Cont)

Nomenclature	Publication
Connectors, Plug and Receptacle, Electrical, Rectangular, Polarized Shell, Miniature Type General Specification for	MIL–DTL–21617
Crimping Tools, Hand or Power Actuated, Wire Termination and Tool Kits, General Specification for	MIL-DTL–22520
Cables, Radio Frequency, Semi–Rigid Coaxial Semi–Air–Dielectric	MIL–DTL–22931
Cables, Radio Frequency, Coaxial, Semi-Rigid, Foam Dielectric	MIL-DTL-23806
Connectors, Electric, Rectangular, Non–environmental, Miniature, Polarized Shell, Rack and Panel, General Specification for	MIL–DTL–24308
Wire, Electric, High Temperature, and Fire Resistant	MIL–DTL–25038
Connectors, Electrical, Miniature, Coaxial, Environment Resistant, General Specification for	MIL–DTL–25516
Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs	MIL–DTL–26482
Connectors, General Purpose, Electrical, Miniature, Circular, Environment Resisting	MIL-DTL-26500
Connectors, Electrical, Miniature, Rack and Panel, Environment Resisting, 200¿C Ambient Temperature	MIL–DTL–26518
Connectors, Electrical, Rectangular, Removable Contact, Formed Blade, Fork Type (for Rack and Panel and Other Applications)	MIL–DTL–28731
Connectors, Electrical, Rectangular, Rack and Panel, Solder Type and Crimp Type Contacts	MIL–DTL–28748
Connectors, Plug and Receptacle, Electric, Rectangular, High Density, Polarization Center Jackscrew, General Specification for	MIL–DTL–28804
Connectors, Coaxial, Radio Frequency, Series Pulse, General Specification for	MIL–DTL–3607
Connectors, Coaxial, Radio Frequency, Series LC	MIL–DTL–3650
Connectors, Plug and Receptacle, Electrical, Triaxial, Radio Frequency, General Specifications for	MIL–DTL–3655
Line, Radio Frequency, Transmission	MIL-DTL-3890
Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for	MIL–DTL–38999
Connectors, Coaxial, Radio Frequency, General Specification for	MIL-DTL-39012
Cables, Power, Electrical (Flexible, Flat, Unshielded), (Round Conductor) General Specification for	MIL–DTL–49055
Connectors, Electrical, Circular Threaded, AN Type, General Specification for	MIL–DTL–5015
Wire, Electric, Polyimide Insulated Copper or Copper Alloy	MIL-DTL-81381
Connectors, Electrical Circular, High Density, Quick Disconnect, Environment Resistant and Accessories	MIL–DTL–81511
Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys	MIL–DTL–81706
Connectors and Assemblies, Electrical, Aircraft Grounding, General Specification for	MIL–DTL–83413
Connectors, Electrical, Rectangular, Microminiature, Polarized Shell, General Specification for	MIL–DTL–83513
Connectors, Electrical, Circular, (Environment Resisting), Receptacles and Plugs	MIL-DTL-83723
Connectors, Electrical Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200ºdegree symbol ºC Total Continuous Operating Temperature	MIL-DTL-83733
Connector Accessories, Electrical, General Specification for	MIL-DTL-85049

Table 4 . Reference Material (Cont)

Nomenclature	Publication
Corrosion Preventative Compound, Clear (Amlguard)	MIL−DTL−85054
Fuses; Instrument, Power and Telephone	MIL−F−15160
Fuse, Current Limiter Type, Aircraft	MIL−F−5372
Fuseholders, Block Type, Aircraft	MIL−F−5373
Standard General Requirements for Electronic Equipment	MIL-HDBK-454
Insulation Sleeving, Electrical, Heat Shrinkable	MIL-I-23053
Insulation Tape, Electrical, Plastic, Pressure–Sensitive	MIL–I–24391
Fuses, Instrument, Power, and Telephone (Nonindicating)	MIL−PRF−15160
Corrosion Preventative Compound, Solvent Cutback, Cold−Application	MIL−PRF−16173
Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating	MIL−F−19207
Primer Coatings: Epoxy, High−Solids	MIL−PRF−23377
Fuse, Instrument Type	MIL−F−23419
Sealing Compound, (with accelerator), Silicone Rubber, Electrical	MIL−PRF−23586
Cleaning and Cleaning−Lubricating Compounds, Electrical Contact, Low Ozone Depletion Potential (ODP)	MIL−PRF−29608
Connectors, Coaxial, Radio Frequency, General Specification for	MIL-PRF-39012
Connectors, Plugs and Receptacles, Electrical, Triaxial, Radio Frequency, General Specification for	MIL-PRF-49142
Switches, Rotary, Selector Power, General Specification for	MIL−PRF−680
Corrosion Preventative Compounds, Water Displacing, Ultra−Thin Film	MIL−PRF−81309
Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured	MIL-PRF-8516
Primer Coatings: Epoxy, Waterborne	MIL−PRF−85582
Electromagnetic Environmental Effects Requirements for Systems	MIL-STD-464
Transmission Lines, Transverse Electromagnetic Mode	MIL-T-81490
Composite Termination System Socket Connectors	MIL-T-81714
Wire, Electric, Fluoropolymer, Insulated Copper or Copper Alloy	MIL−W−22759
Wire, Electric, Polyvinyl Chloride Insulated	MIL-W-5086
Wire, Electrical, Iron and Constantan Thermocouple	MIL-W-5845
Wire, Electrical, Chromel and Alumel Thermocouple	MIL-W-5846
Wire, Electrical, Copper and Constantan Thermocouple	MIL-W-5908
Wire, Electric, 600 Volt Aluminum Aircraft	MIL-W-7072
Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkaneimide Polymer, or Polyarylene Insulated Copper or Copper Alloy	MIL−W−81044
Terminal Board Assembly, Molded-In Stud, Electric	MS27212
Sealing Plugs	MS27488
Grommets, Synthetic and Silicone Rubber, Hot–Oil and Coolant Resistant	MS35489
Straps, Adjustable Hand Tools for Installing Self−Clinching Plastic Tiedown	MS90387
Grommet, Cushion, Composition, Edging	NASM22529/2
Grommet, Cushion, Composition, Edging	NASM22529/3
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair	NAVAIR 01−1A−23

Table 4 . Reference Material (Cont)

Nomenclature	Publication
Aircraft Fuel Cells and Tanks, Organizational, Intermediate and Depot Instructions	NAVAIR 01-1A-35
Installation Practices, Aircraft Electric and Electronic Wiring	NAVAIR 01-1A-505–1
Installation Practices, Aircraft Electric and Electronic Wiring, MIL-PRF-39012 RF Connector	NAVAIR 01-1A-505-2
Installation and Repair Practices, Volume III, Aircraft Rectangular Electrical Connectors and Accessories	NAVAIR 01–1A–505–3
Aircraft Fiber Optic Cabling	NAVAIR 01–1A–505–4
Corrosion Program and Corrosion Theory	NAVAIR 01–1A–509–1
Avionic Cleaning and Corrosion Prevention/Control	NAVAIR 01–1A-509–3
Toxicity, Flash Point, and Flammability of Chemicals	NAVAIR 07-1-505
Consolidated Hazardous Item List	NAVSUP Publication 4500
Cable, Electric, Shielded and Unshielded Aerospace	NEMA WC 27500
Brazing Alloys, Silver	QQ-B-654
Surface Clearing and Preparing	SAE AIR 4069
Design and Handling Guide Radio Frequency Absorptive Type Wire and Cables (Filter Line, MIL–C–85485)	SAE AIR 4465
Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for	SAE AMS–DTL–23053
Safety Cable Kit Procurement Specification and Requirements for Use	SAE AS4536
Wiring Aerospace Vehicle	SAE–AS50881 (previously MIL-W-5088K or MIL–W–5088L)
Terminals: Lug and Splice, Crimp Style, Aluminum for Aluminum Aircraft Wire, General Specification for,	SAE AS70991
End caps, Heat shrinkable (also known as SSC end caps)	SAE AS81765/1
Splices, Electric, Permanent, Crimp Style, Copper Insulated Heat Shrinkable, Environment Resistant, General Specification for	SAE AS81824 or MIL-S-81824
Wiring Aerospace Vehicle	SAE–AS50881
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair	T.O. 00–25–259
Instruction with PL –– Time Domain Reflectometer, PN 1502 (TEKTRONIX	T.O. 33A1–4–73–1
Operators Guide for Reflectometer Models ESP, ESP+; Version 1.07E (Part Number 980–ESP–00256)	T.O. 33DA39–89–11
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair	TM 5895–45/ID

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DEFINITIONS AND SYMBOLS
INSTALLATION AND REPAIR PRACTICES FOR
AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

None

Alphabetical Index

1. INTRODUCTION.

2 This work package (WP) lists definitions of terms used in aircraft wiring. The electrical and electronic symbols and their meanings are in accordance with ANSI–Y32.2–1975.

3. SYMBOLS.

4 Refer to Table 1 for listing of common symbols utilized in the electrical/electronic field.

NOTE

Only those symbols associated with aircraft electronic/electrical wiring are listed here. These symbols have been categorized in general. Refer to ANSI–Y32.2–1975 for specific details on each symbol.

5. DEFINITIONS.

6 Table 2 defines terminology utilized in the electrical / electronic field.

Table 1. Electronic/Electrical Symbols

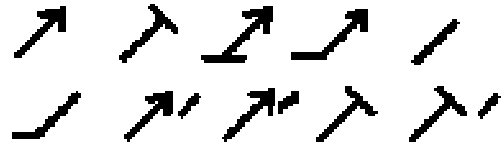
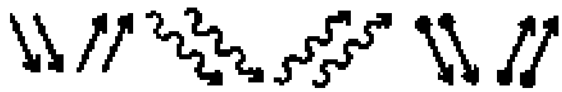
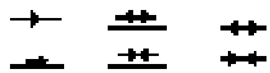
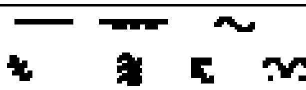
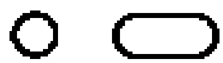
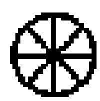
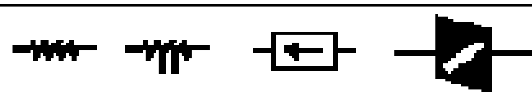
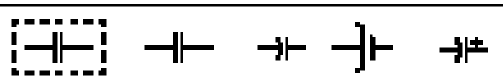
Meaning	Symbol
Adjustability Variability	
Radiation Indicators	
Physical State Recognition	
Test-Point Recognition	
Polarity Markings	
Direction of Flow of Power, Signal, or Information	
Kind of Current	
Envelope Enclosure	
Shield Shielding	
Special Connector or Cable Indicator	
Resistor	
Potentiometer	
Variable Resistor	
Capacitor	

Table 1. Electronic/Electrical Symbols (Cont.)

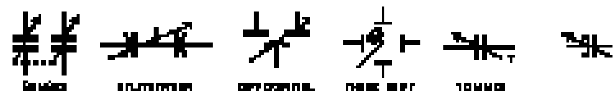
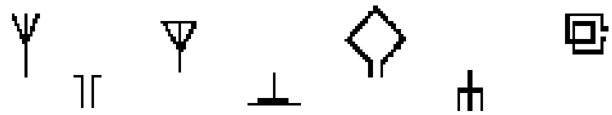
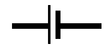
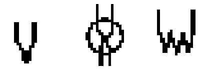
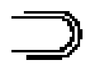
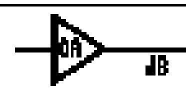
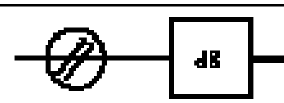
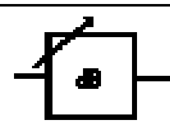
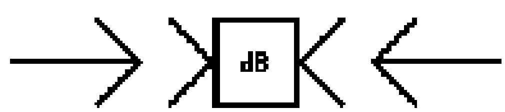
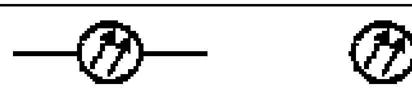
Meaning	Symbol
Variable Capacitor	
Antenna	
Battery	
Thermal Element, Thermomechanical Transducer	
Thermocouple	
Spark Gap/Igniter Gap	
Continuous Loop Fire Detector (temperature sensor)	
Ignitor Plug	
Amplifier, optical NOTE: Indicates the specific change in dB.	
Attenuator, optical NOTE: Indicates the specific change in dB.	
Attenuator, variable, optical NOTE: Indicates the specific change in dB.	
Attenuator, within a connector assembly, optical NOTE: Indicates the specific change in dB.	
Optical Fiber /Optical Component	

Table 1. Electronic/Electrical Symbols (Cont.)

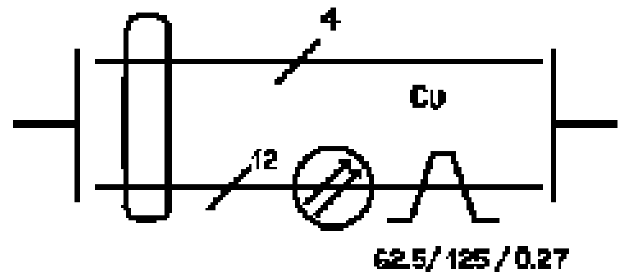
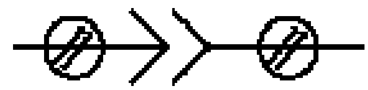
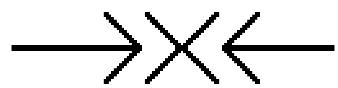
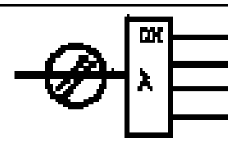
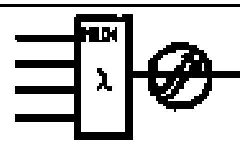
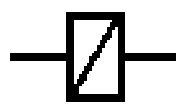
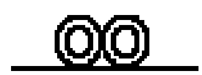
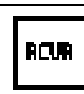
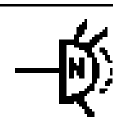
Meaning	Symbol
Cable, composite NOTE: Composite cable shown contains following supplementary information: 4 copper conductors 12 optical fibers with core diameter = 62.5 microns clad diameter = 125 microns NA = 0.27 (optional)	
Connector, plug–to–receptacle type, optical	
Connector, male–to–male with mating adapter type, optical NOTE:”NC” or ”PC” can be added. NC = non–contact. PC = physical contact.	
Demultiplexer, wavelength (WDM) NOTE: Four channel configuration shown.	
Multiplexer, wavelength NOTE: Four channel configuration shown.	
Polarizer	
Polarization controller	
Receiver	
Splice	
Splitter, optical	

Table 1. Electronic/Electrical Symbols (Cont.)

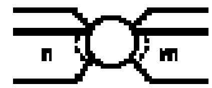
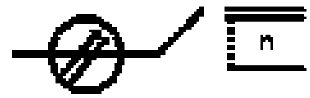
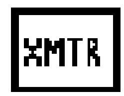
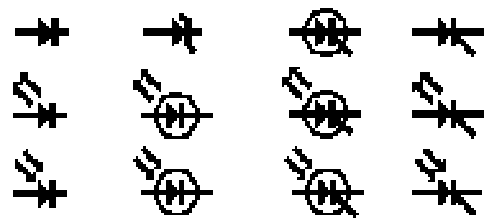
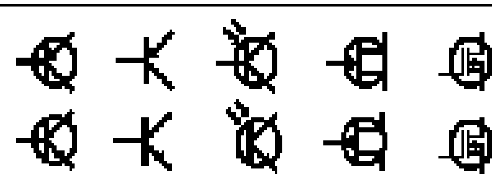
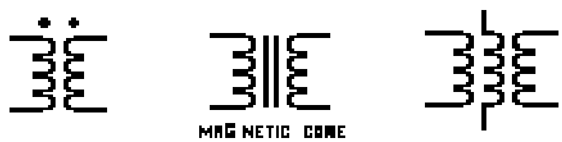
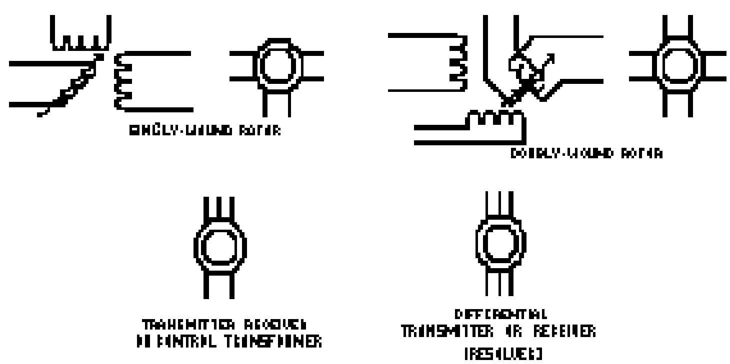
Meaning	Symbol
Star coupler NOTE: n by m star coupler shown. Change in dB may be placed in circle.	
Switch, optical NOTE: 1 by n switch shown.	
Transmitter	
Diodes, SCRs	
Transistors	
Transformers	
Inductive Paths	
Synchros	

Table 1. Electronic/Electrical Symbols (Cont.)

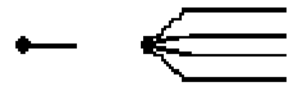
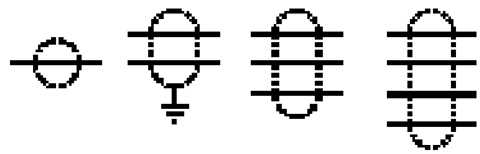
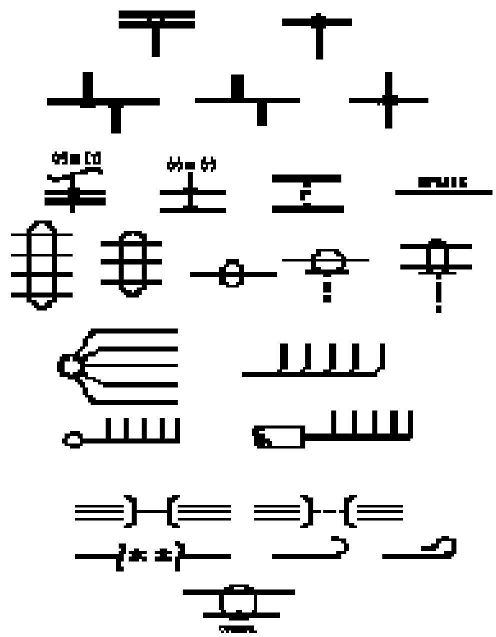
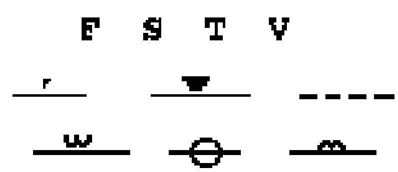
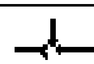
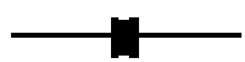
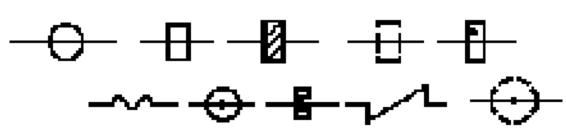
Meaning	Symbol
Terminations	
Shielded Transmission Path Conductor Cable Wiring	
Transmission Path Conductor Cable Wiring	
Distribution Lines/Transmission Lines	
Alternative or Conditioned Wiring	
Intentional Isolation of Direct-Current Path in Coaxial or Waveguide Applications	
Waveguide	

Table 1. Electronic/Electrical Symbols (Cont.)

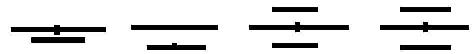
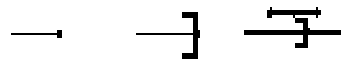
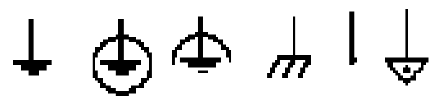
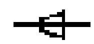
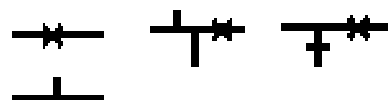
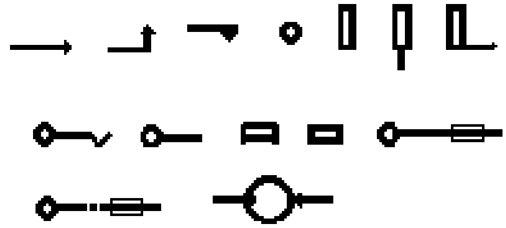
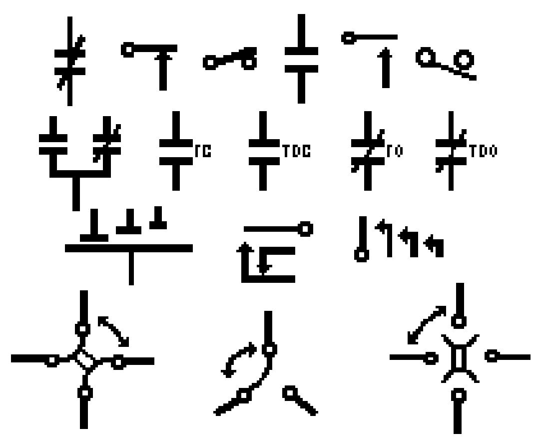
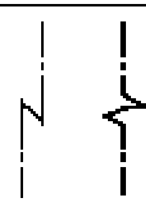
Meaning	Symbol
Strip-Type Transmission Line/Stripline	
Termination	
Circuit Return/Ground	
Pressure-Tight Bulkhead Cable Gland Cable Sealing End	
Switching Function	
Electrical Contact	
Basic Contact Assemblies	
Magnetic Blowout Coil	

Table 1. Electronic/Electrical Symbols (Cont.)

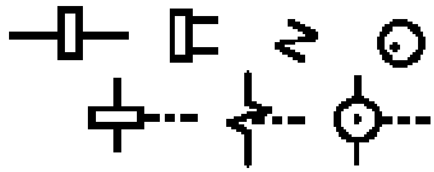
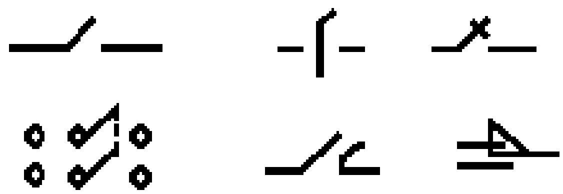
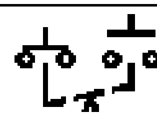
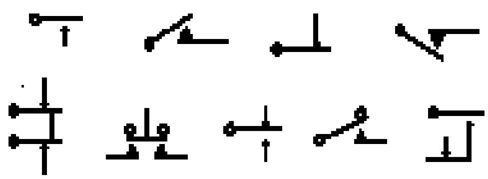
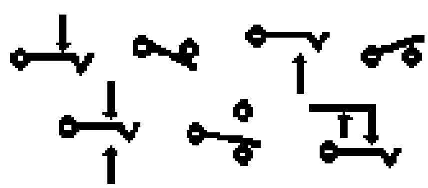
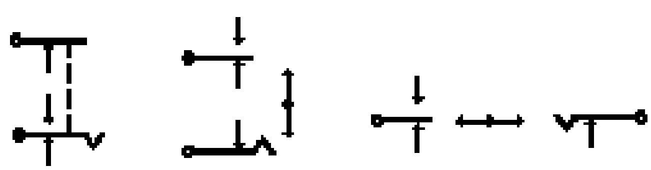
Meaning	Symbol
Operating Coil Relay Coil	
Switch	
Pushbutton, Momentary or Spring-Return	
Two-Circuit, Maintained or Not Spring-Return	
Nonlocking Switching, Momentary or Spring-Return	
Locking Switch	
Combination Locking and Nonlocking Switch	
Key-Type Switch/Lever Switch	

Table 1. Electronic/Electrical Symbols (Cont.)

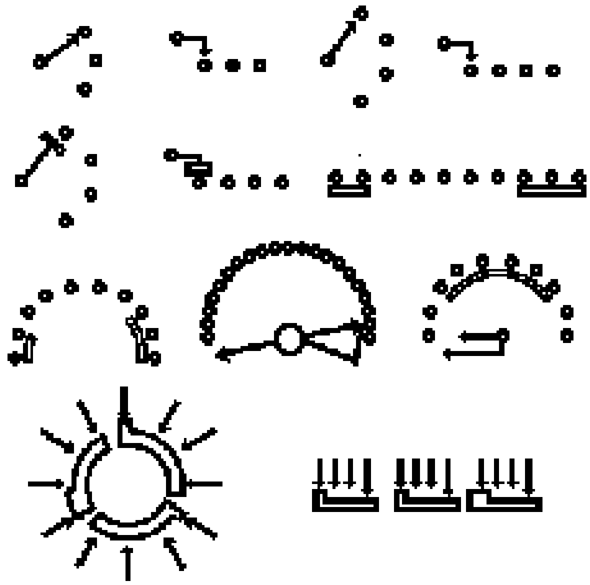
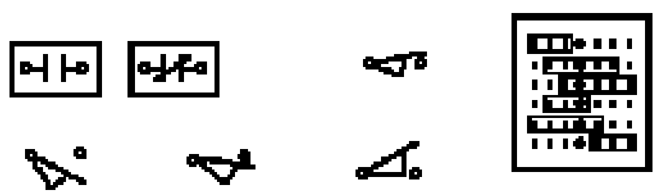
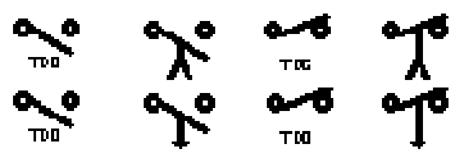
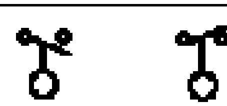
Meaning	Symbol
Selector or Multiposition Switch	
Safety Interlock	
Limit Switch/Sensitive Switch	
Switches with Time-Delay Feature	
Flow-Actuated Switch	
Liquid-Level Actuated Switch	

Table 1. Electronic/Electrical Symbols (Cont.)

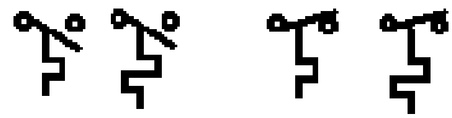
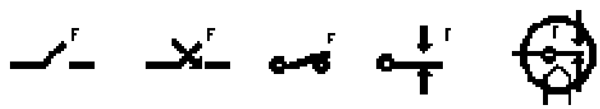
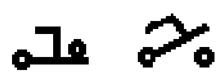
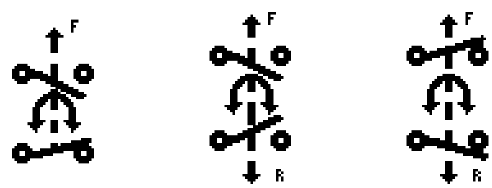
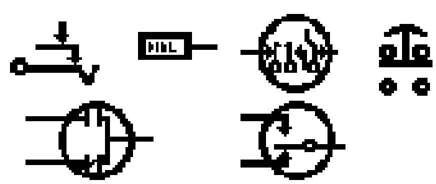
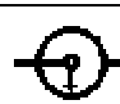
Meaning	Symbol
Pressure- or Vacuum-Actuated Switch	
Temperature-Actuated Switch	
Thermostat	
Flasher Self-interrupting Switch	
Foot-Operated Switch Foot Switch	
Switch Operated by Shaft Rotation and Responsive to Speed or Direction	
Switches with Specific Features	
Governor Speed Regulator	

Table 1. Electronic/Electrical Symbols (Cont.)

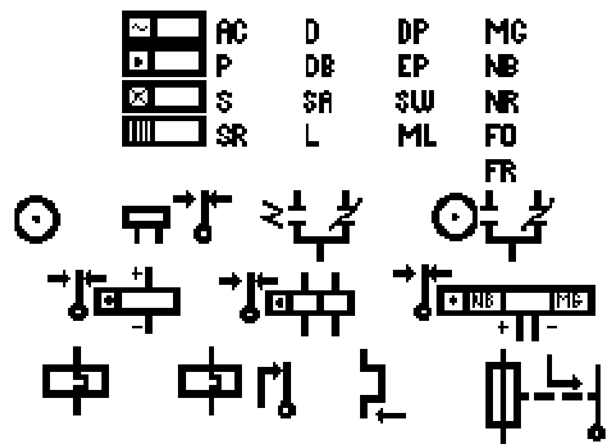
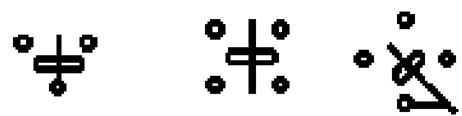
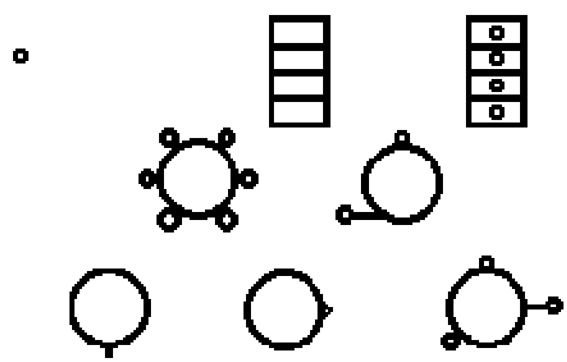
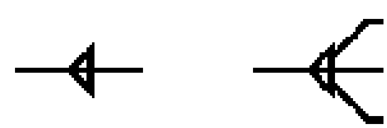
Meaning	Symbol
Relay	
Inertia Switch	
Mercury Switch	
Terminals	
Cable Termination	

Table 1. Electronic/Electrical Symbols (Cont.)

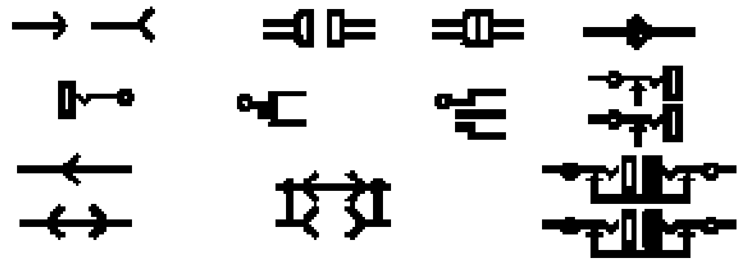
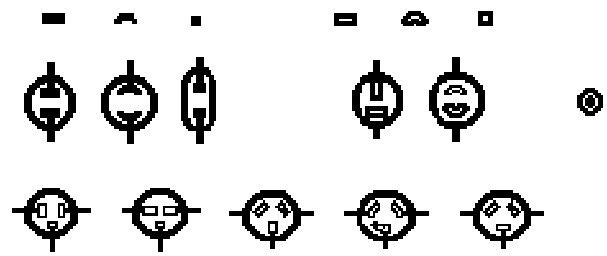
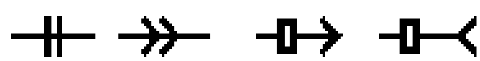
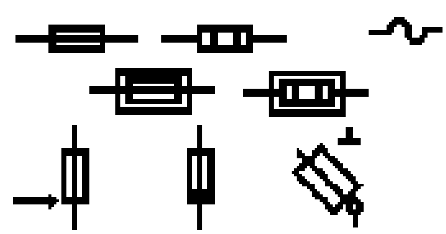
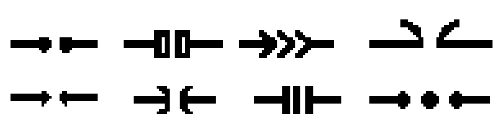
Meaning	Symbol
Connection / Disconnection Device	
Connectors of the Type Commonly Used for Power-Supply Purposes	
Test Blocks	
Coaxial Connector	
Waveguide Flanges Waveguide Junction	
Fuse	
Lightning Arrester Arrester Gap	

Table 1. Electronic/Electrical Symbols (Cont.)

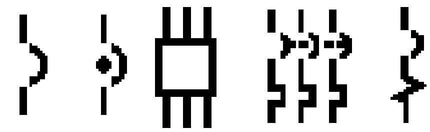
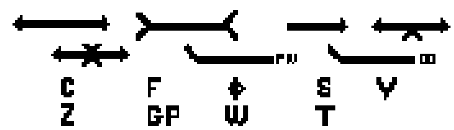
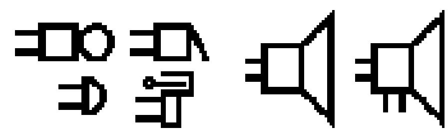
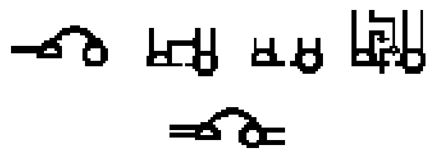
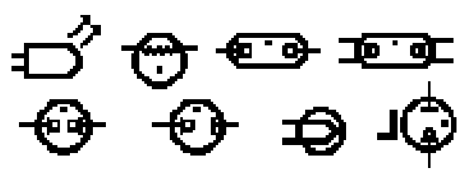
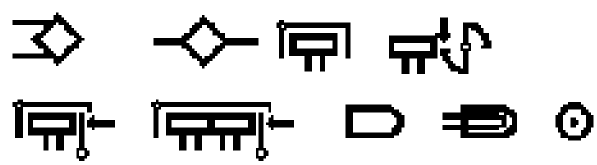
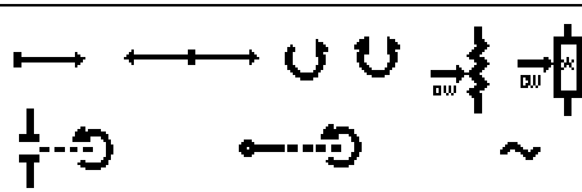
Meaning	Symbol
Circuit Breaker	
Protective Relay	
Audible-Signaling Device	
Microphone	
Handset/Operator's Set	
Lamp /Indicator	
Visual-Signaling Device	
Mechanical Connection Mechanical Interlock	
Mechanical Motion	

Table 1. Electronic/Electrical Symbols (Cont.)

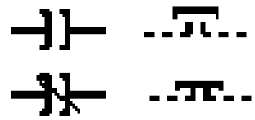
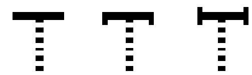
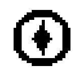
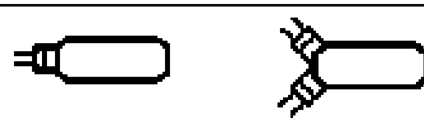
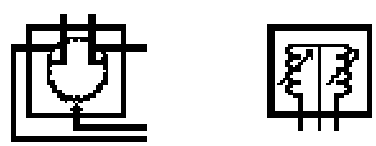
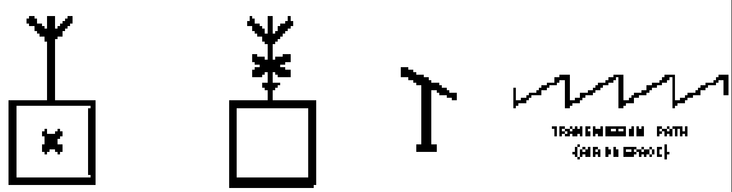
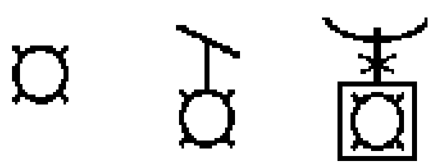
Meaning	Symbol
Clutch Brake	
Manual Control	
Gyro/Gyroscope/Gyrocompass	
Position Indicator	
Fire Extinguisher Actuator Head	
Position Transmitter	
Radio Station – Air / Space Transmission Path	
Space Station	

Table 2. Terms And Definitions

Term	Definition
A	(1) Designation for asbestos insulated, no braid type of wire. Dry locations only. Only for leads within apparatus or within raceways connected to apparatus. Limited to 300 V, 392°F (200°C). (2) (See Ampere).
AA	(1) Designation for asbestos insulated type of wire, asbestos or glass braid. Dry locations only. Only for leads within apparatus or within raceways connected to apparatus or as open wiring. Limited to 300 V, 392°F (200°C). (2) Abbreation for the Aluminum Association.
AAAC	All Aluminum Alloy Conductor, usually used to refer to 6201 aluminum alloy.
AAC	All Aluminum Conductor.
AASC	Aluminum Alloy Stranded Conductors.
AB	Designation for high voltage butyl cable.
ABP	Designation for butyl-polyethylene high voltage cable, 167°F (75°C).
Abrasion machine	Laboratory device for determining the abrasive resistance of wire or cable. Testing devices include the squirrel cage with square steel bars and the abrasive grit types.
Abrasion resistance	Ability of a wire, cable, or material to resist surface wear.
ABS	(See Acrylonitrile-Butadiene-Styrene).
Absolute zero	Theoretical temperature at which all thermal motion of heat action ceases, approximately -459.69°F (-273.16°C, 0°K).
Absorption	Amount of material, such as water, that a given substance will assimilate and retain. It is an important property consideration in the selection of insulating materials.
AC	(1) Designation for branch circuit and feeder cables with flexible metal tape armor. (2) (See Alternating Current).
ACAR	Aluminum Conductor Alloy Reinforced.
Accelerated aging	Test in which certain parameters, such as voltage and temperature, are increased above normal operating values to obtain observable deterioration in a relatively short period of time. The plotted results give expected service life under normal conditions. Also called accelerated life test.
Accelerator	Chemical used to speed up a reaction or the curing of a plastic. Often used with a catalyst, hardener, or curing agent. Sometimes used to describe the curing agent.

Table 2. Terms And Definitions (Continued)

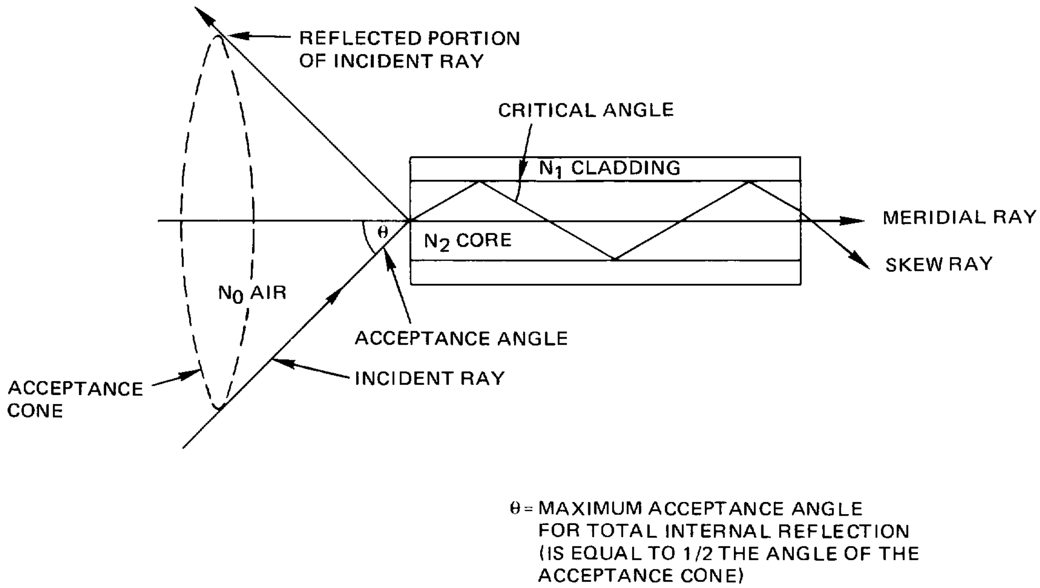
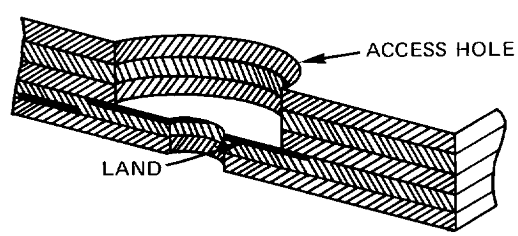
Term	Definition
Acceptance angle (fiber optic)	Angle, measured from the core centerline, above which light will not enter the fiber. It is equal to one half the angle of the acceptance cone. 
Acceptance pattern (fiber optic)	Curve of total transmitted power plotted against the launch angle (fiber bundle or fiber).
Acceptance test	Test that determines conformance of a product to design specifications as a basis for acceptance.
Access holes	Series of holes in successive layers, each set having a common center or axis. These holes of a multilayer printed board provide access to the surface of the land in one of the layers of the board. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Accessories	Mechanical devices, such as cable clamps, added to connector shells and other such hardware which are attachable to connectors to make up the total connector configuration.

Typical Accessory Applications

Application of Function	Cable Type	Cable Clamp or Grommet Nut	Sealing Glands	Transition	Ground Rings	Backshell
Strain Relief Directly to Connector	Wire Bundle	X				
Strain Relief to Accessory	Wire Bundle	X				X
Strain Relief Cable Sealing to Accessory (Note 1)	Jacketed Wire Bundle	X	X			X
Strain Relief Shield Grounding to Accessory	Shielded Wire Bundle		X		X	X
Strain Relief Cable Sealing, Shield Grounding to Accessory (Note 2)	Jacketed, Shielded Wire Bundle	X	X	X	X	X

NOTES

1. Sealing glands not required for MS3057-B or MS3057-C cable clamps.

2. Sealing glands and transition are not required for MS3057-B or MS3057-C cable clamps.

Table 2. Terms And Definitions (Cont.)

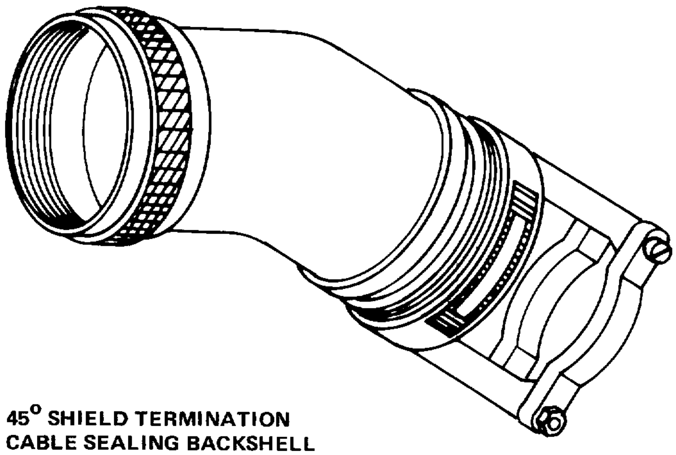
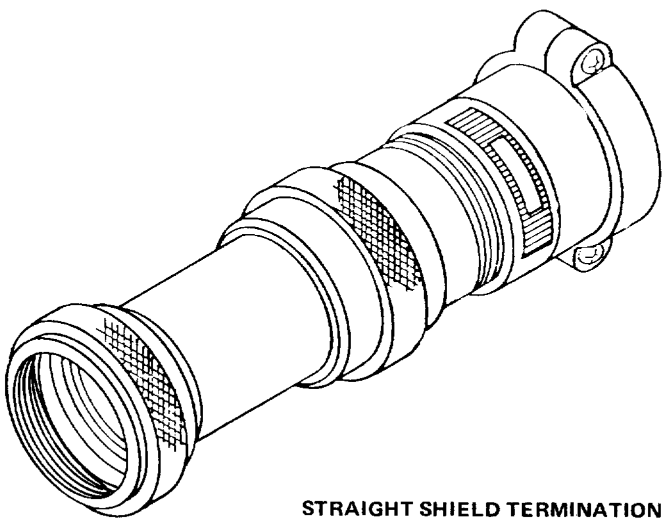
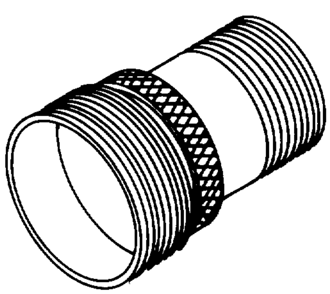
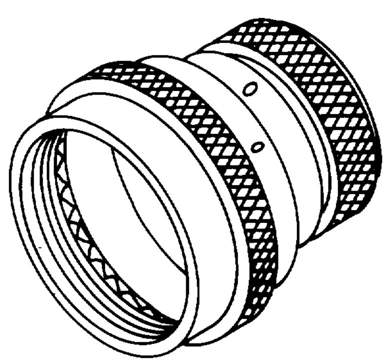
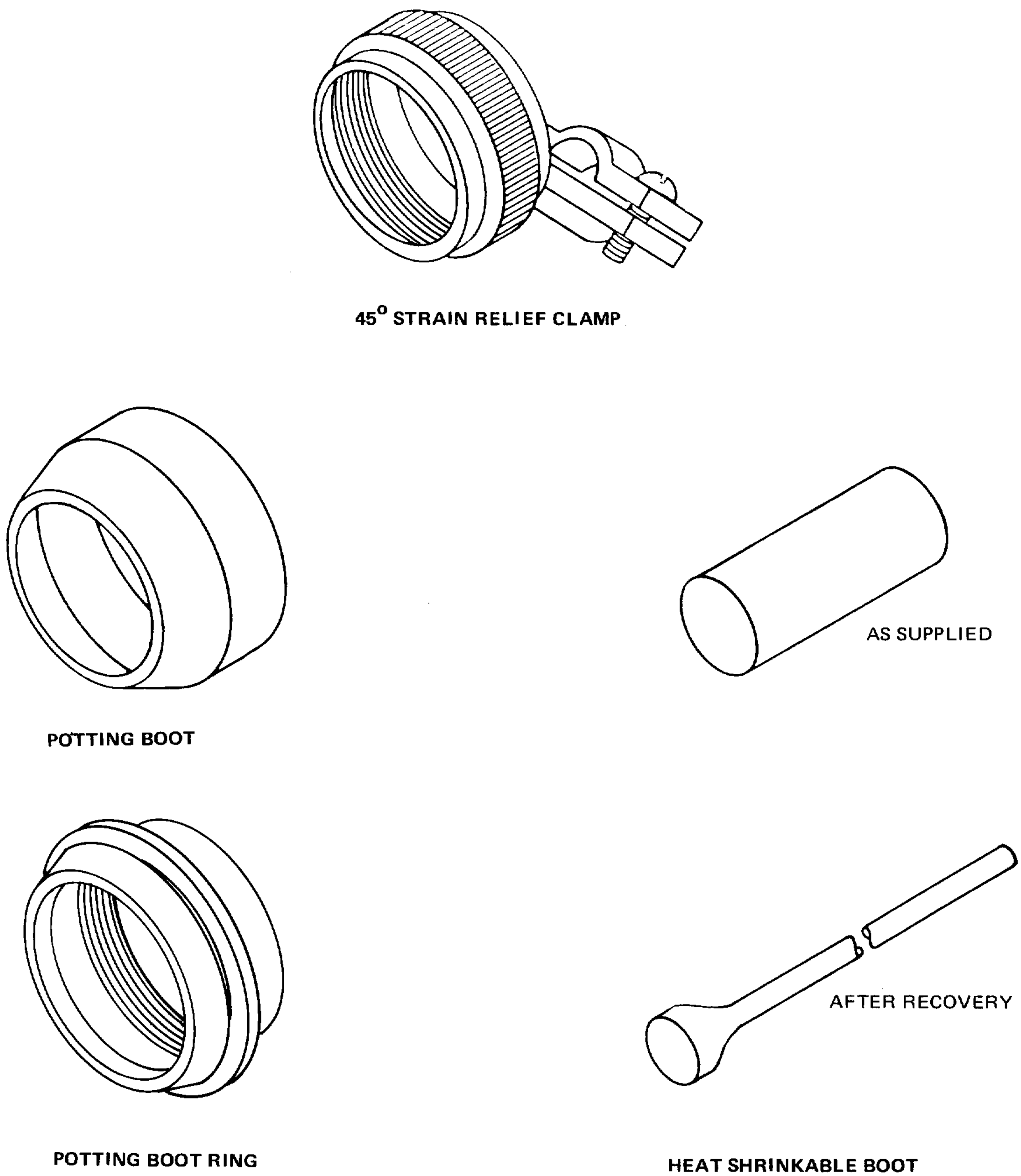
Term	Definition
Acccessories (Cont.)	 45° SHIELD TERMINATION CABLE SEALING BACKSHELL  STRAIGHT SHIELD TERMINATION CABLE SEALING BACKSHELL  THREADED ADAPTER  SHRINK BOOT ADAPTER **TYPICAL CONNECTOR ACCESSORIES**

Table 2. Terms And Definitions (Cont.)

Term	Definition



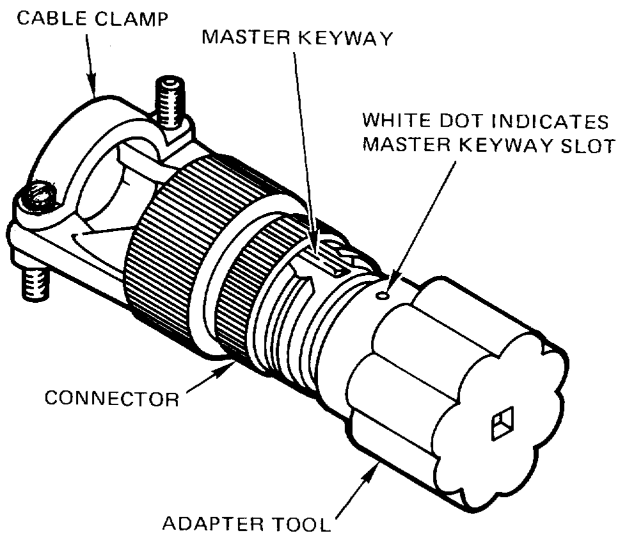
TYPICAL CONNECTOR ACCESSORIES

Table 2. Terms And Definitions (Cont.)

Term	Definition
Accordion	(1) Retractable cable with a series of equally-spaced tranverse folds. (2) Type of connector contact where a flat spring is given a Z shape to permit high deflection without overstress.
Acetal resins	Rigid thermoplastics with properties similar to zinc, aluminum, and other metals. The molecular structure of the polymer is that of a linear acetal, consisting of unbranched polyoxymethylene chains. Can be molded or extruded to provide high tensile and flex strengths, resilence, and solvent resistance. Good electrical properties that survive humid conditions. Used commonly in tape and yarn.
Acetate fibers	Acetate fibers are cellulose based fibers in filament form characterized by high dielectric strength and a dielectric constant of about 5.0 at 60 Hz and 50% RH. The primary electrical application appears to be in the form of woven cloth for pressure sensitive electrical tapes because of noncorrosiveness. (See tape-acetate cloth).
Acid	Hydrogen-containing substance which breaks down in water to produce hydrogen ions which are released in solution. The higher the concentration of hydrogen, the stronger the acid. (See pH). The hydrogen ion carries one positive electrical charge.
Acid core solders	Wire solders with self-contained acid flux.
Acid gas generation	Amount of acid-forming gases liberated by a compound when exposed to elevated temperatures.
Acid number	Quantitative value that can be assigned to measure the degree of acidity of any acid. However, there is not necessarily a relationship between a high acid number and the corrosiveness of an acid; corrosive acid action is a function of free or ionic acidity.
ACR	Designation for cable with corona resisting insulation.
Acrylic	Synthetic resin made from acrylic acid or from an acrylic acid derivative. For enamel film coated magnet wire, the basic resin is copolymer of acrylonitrile plus acrylate and phenolic resin. The enamel film is applied for an aqueous dispersion. The film is resistant to refrigerants and many solvents. Suggested for use in hermetic motors.
Acrylic resins	Synthetic resins made from acrylic acid or from an acrylic acid derivative. Flame resistance and clarity offer applications in lighting fixtures.
Acrylonitrile	Monomer (CH_2 CHCN) useful in copolymers.
Acrylonitrile-Butadiene-Styrene (ABS)	Family of three-polymer engineering thermoplastics. Acrylonitrile, styrene liquids, and butadiene gas are polymerized together in a variety of ratios to produce required properties such as suitable electrical properties, chemical resistance, and dimensional stability.
ACSR	Designation for Aluminum Conductor Steel Reinforced. Aluminum wires stranded around a steel core. Used for high voltage transmission lines.
ACT	Designation for armored cable with plastic insulated conductors.
Activated	Condition of a compound or mixture of compounds having higher chemical activity than that normally found with the compound or mixture. An example is the addition of an activator to rosin to increase its fluxing activity.
Activation	Changing of the passive state of the surface of metal to a chemically active state. Contrast with passivation.
Activator	Chemical additive used to initiate the chemical reaction in a specific chemical mixture.
Active port diameter	On a light source or detector the diameter of the area in which light can be coupled to or from an optical fiber.
Active wire	(1) The wire in an armature winding which produces useful voltage. (2) That portion of the winding in which induction takes place.
ACU	Designation for armored cable with latex rubber insulated conductors.

Table 2. Terms And Definitions (Cont.)

Term	Definition
ACV	Designation for varnished cambric insulation and polyvinyl chloride, with overall interlocked armor, rated at 5000 V.
Adapter	Intermediate device to provide for attaching special accessories or to provide special mounting means.
Adapter tool	A device used to hold the connector while installing or removing adapters, cable clamps, etc. from the rear of the connector.



Term	Definition
Additive process	Process for obtaining conductive patterns by the selective deposition of conductive material on unclad base material.
Adhesion	Force of attraction between the molecules (or atoms) of two different phases, such as liquid brazing filler metal and solid copper or plated metal and basic metal. Contrast with cohesion.
Adhesive-bonded	Cables where bonding is accomplished by adding an adhesive coating to the surface of the cable components (wire insulation, cable jacket or spacer), and joining and curing the adhesive to form a cable. (See bonded cables).
Admittance	Measure of the ease with which an alternating current flows in a circuit. The reciprocal of impedance.
AD 123	Aluminum alloy used for making electric wire.
AF	Designation for asbestos insulated, single or stranded conductor fixture wire impregnated with moisture-resisting, flame retarding compound with or without braid, 300 V, 302°F (150°C).
AFC	Designation for two or three individually braided (cotton or rayon) AF conductors, twisted together without overall covering, 300 V, 302°F (150°C).
AFPD	Designation for two or three AF conductors twisted together with cotton or asbestos braid overall, 300 V, 302°F (150°C).
AFPO	Designation for two AF conductors without individual braid, laid parallel and braided overall, 300 V, 302°F (150°C).
AFS	Designation for two or three conductor heat resistant cord with impregnated asbestos insulation and rubber jacket. For use in damp locations, 300 V.

Table 2. Terms And Definitions (Cont.)

Term	Definition
AFSJ	Designation for cord same as AFS, but for lighter (junior) service, 300 V.
Aging	Change in properties of a material with time under specific conditions.
AGS	Designation for solid or stranded flexible nickel conductor with silicone impregnated, asbestos insulation and with glass braid overall. For appliance wiring, 300 V, 392°F (200°C).
AI	Designation for impregnated asbestos insulated appliance wire similar to type A, but moisture, heat, and flame resistant. Dry locations only. Without braid, 300 V, 257°F (125°C).
AIA	(1) Designation for felted asbestos fibers with outer asbestos or glass braid, impregnated with heat, flame, and moisture resistant compound. Dry locations only. 600 V, 257°F (125°C). (2) Aircraft Industries Association.
AIEE	Former American Institute of Electrical Engineers. Now known as Institute of Electrical and Electronics Engineers (IEEE).
Air core cable	Telephone cable in which the interstices in the cable core are not filled with a moisture barrier.
Aircraft ignition cable	High tension cable for ignition systems of internal combustion aircraft engines.
Aircraft wire	Wire for airborne equipment. It often must meet severe environmental conditions such as heat, cold, altitude, solvents, fuels, etc.
Air dielectric coaxial cable	Coaxial cable in which air is the dielectric material. A spiral filament or spacer may be used to center the conductor.
Air spaced coaxial cable	Coaxial cable in which air is the dielectric material. A spirally wound, synthetic filament, beads, or braided filaments may be used to center the conductor.
AL or ALS	Designation used as a suffix to denote a wire or cable having an aluminum sheath.
Alkali	Chemical that gives a base reaction.
Alkaline cleaner	Material blended from alkali hydroxides and such alkaline salts as borates, carbonates, phosphates, or silicates. The cleaning action may be enhanced by the addition of surface-active agents and special solvents.
Alkyd resin	Polyester resins made with a fatty acid modifier. Thermosetting, molding compounds are used in electrical motor control, automotive ignition, and electronic components.
Alkylated chlorodiphenyl oxide	Used primarily as an impregnant for large power capacitors, it has a maximum operating temperature range of -76°F (-60°C) to 257°F (125°C). It offers superior corona behavior and good stress handling. Impregnated capacitors reportedly have achieved an exceptionally low-failure field record.
Alligator clip	Mechanical device, similar to the jaws of an alligator, generally used as a temporary connection on the end of a test lead or interconnections wire.
Alloy	Combination of two or more metal elements. The combination may be in the form of a solid solution of one or more metals in another metal, or in distinct phases, or components, of the alloy. Generally, alloys will have different properties from those exhibited by their constituent elements. An example is 63% tin plus 37% lead, a solder alloy. This alloy melts at 361°F, (182.8°C), whereas pure tin melts at 449°F (231.7°C), and pure lead at 621°F (326.7°C).
All-rubber cable	Cable in which all interstices between conductors are filled with rubber compound. This provides greater resistance to impact, adds strength, reduces the tendency to kink, and reduces flexibility.

Table 2. Terms And Definitions (Cont.)

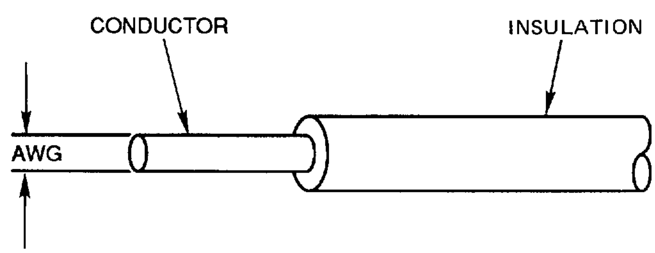
Term	Definition
Allyl plastics	Plastics based on resins made by additional polymerization of monomers containing allyl groups, such as diallyl phthalate. Often compression molded, offering good high temperature performance and chemical resistance.
Alpha-cellulose	Very pure form of cellulose.
Alphanumerical coding	Wire identification by letters and/or numbers. (See surface printing).
Alternating Current (AC)	Current in which the charge-flow periodically and regularly reverses in cyclic manner. A graph to a base of time shows the waveform, which comprises a succession of instantaneous values, the greatest of which is the amplitude or peak value. The time taken by one complete cyclic repetition is the period or Pulse Repetition Time (PRT), and the number of periods in one second is the frequency. (See frequency, formulas-electrical).
Alumina	Alumina ceramics have very good mechanical characteristics at room and elevated temperatures. They also have good dielectric loss properties which persist at low and high frequencies. High-alumina ceramic is one of the best all-around insulations available.
Aluminum and its alloys	Metal characterized by high resistance to corrosion, good electrical and thermal conductivity, and a density of one third or less than that of steel, copper, or nickel. It can be fabricated, joined, and treated by most methods used for other metals. Because of its relatively high conductivity in relation to its light weight and low cost, aluminum is used as a conductor in large AWG sizes. Since its conductivity is 61% that of copper, aluminum restricts miniaturization. Aluminum is used extensively in wire form for power lines. Other major applications include magnet strip or foil, and shielding for wire, cable, and other products. It is available in wire, extrusion, sheet foil, powder, and cast forms.
Aluminum-steel conductor	Composite conductor made up of a combination of aluminum and steel wires. In the usual construction, the aluminum wires surround the steel.
Amalgam	Alloy of mercury with one or more other metals.
Ambient temperature	Temperature of the environment, usually air, surrounding a connector, conductor, cable or other device.
American National Standards Institute (ANSI)	Federation of trade, technical, and professional organizations, government agencies, and consumer groups. Coordinates the development of, and publishes standards. Operates a voluntary certification program.
American Society for Testing and Materials (ASTM)	A non-profit, industry-wide organization which publishes standards, methods of tests, recommended practices, definitions, and other related material.
American Wire Gauge (AWG)	Standard system used for designating wire diameter. Also referred to as the Brown and Sharpe (B&S) Wire Gauge. 
Amorphous	Condition of a material whose atoms and molecules are not arranged in any definite pattern or form. The material is not crystalline. A characteristic of amorphous materials is the lack of certain well defined physical properties. For example, the material is homogeneous, but does not show a sharp melting or freezing point. Generally, amorphous materials are poor conductors of heat and electricity. Glass, carbon, and rosin are examples of amorphous materials.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Ampacity	Maximum current a conductor can carry without exceeding insulation and jacket temperature limitations.
Ampere (A)	Unit of current. One ampere equals the current (I) flowing through one ohm of resistance (R) at one volt (E) potential. I = E/R (See Current).
Ampere's rule	Current in a certain direction is the flow of an electrical current. One ampere is the current flowing through one ohm of resistance at one volt potential.
Ampere turn	Unit of magnetomotive force obtained by multiplying the current in amperes by the number of turns in a coil.
Amplifier	Device used to boost the strength (db level) of an electronic signal.
Amplitude	Distance between high or low points of a waveform or signal. Also referred to as wave "height".
Amplitude modulation	Method of adding information to an electronic signal where the height (amplitude) of the wave is changed to the added information.
Analog signal	Electrical signal that varies continuously over an infinite range of voltage or current signal, which varies discreetly between two values, usually one and zero.
Analytical chemistry	Branch of chemistry which deals with the detection or identification of the atoms, ions, or radicals (groups of atoms which react as a unit) of which a substance is composed, the compounds which they form, and the proportions of these compounds which are present in a given substance.
AND	Air Force-Navy Design.
Angle of incidence	Angle between an incident ray and the normal to a reflecting or refracting surface.
Angular misalignment loss	Optical power loss caused by angular deviation from the optimum alignment of source to optical fiber, fiber-to-fiber, or fiber-to-detector.
Anion	Negatively charged atom or radical.
Anneal	Relief of mechanical stress in brittle materials through heat and gradual cooling, to make it less brittle.
Annealed-in-process wire	Wire annealed at an intermediate stage between rod size and finished size in order to produce a softer wire of fairly uniform temper.
Annealed wire	Wire which has been softened by heating. Sometimes referred to as soft drawn wire.
Annular conductor	Round, stranded conductor whose strands are laid around a suitable core. The core is usually made wholly or mostly of non-conducting material. This construction has the advantage of lower total AC resistance for a given cross-sectional area of conducting material by eliminating the greater skin effect at the center.
Annular ring	Portion of conductive material completely surrounding a hole.
Anode	(1) Positive pole of a plating cell. It is the physical entity of the plating setup at which negatively charged ions leave the plating solution. The ions are converted back to the parent atom (or group of atoms) and are discharged as gas, redissolve in the solution, or precipitated as sludge in combination with other components of the solution. The electrical charge which had been carried by the ion then enters the external electrical circuit. In plating solder, as in many plating baths, the anode is consumed by giving up its metal content to the bath in the form of positive metal ions. These are then deposited on the cathode. (2) The P-type or more positively doped material of a diode, symbolized by the arrow section of the schematic symbol.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Anodic films	Anodic film insulation (aluminum oxide coating on aluminum conductor) can be used on magnetic wire but other wire applications have been suggested. The coating is thin, space-saving, inorganic, and resistant to extreme temperatures with a 3600°F (1982.2°C) melting point. Although anodic film insulated conductors can be bent and processed without rupturing the film, flexibility is limited relative to other insulations.
Anodizing	Electrolytic process for producing a protective or decorative film on certain metals, chiefly aluminum and magnesium.
ANSI	(See American National Standards Institute).
Antenna wire	Wire generally with high tensile strength used as an antenna. It may be insulated or uninsulated.
Anti-fray lacquer	Lacquer used to coat textile or glass braid to prevent ends from fraying when cutting.
Anti-oxidant	Substance which prevents or slows down oxidation of material exposed to air.
Apparatus wire and cable	Overall term used to describe a number of specific wire types including nonautomotive battery cables, defroster wire, electric furnace cables, and gas tube sign ignition cables. Also included under this heading in AWG sizes 14 and heavier are appliance wire, fixture wire, machine tool wire, motor and transformer lead wire, pump or well cable, and switchboard and control wire.
Aramid fiber	Excellent heat resistance, durability and good dimensional stability. Does not melt and is flame retardant. At 482°F (250°C), it retains 60% of its room temperature breaking strength.
Arc	Luminous discharge of electricity through a gas. Characterized by a change (approximately equal to ionization potential of the gas) in the space potential in the immediate vicinity of the negatively charged electrode.
Arc Fault Circuit Breaker	Circuit breaker with internal electronic circuitry, capable of detecting arcing events of much shorter duration than required for traditional thermal activated bi–metal circuit breakers.
Arc resistance	Time required for an arc to establish a conductive path in a material. Breakdown between two electrodes usually occurs as a conducting paths burned on the surface of the dielectric material.
Arc Tracing/Tracking	An event that occurs when electrical wire insulation material is carbonized as the result of an arcing incident. This carbonizing of the insulator material is capable of propagating the length of the wire and often results in wire and proximity damage due to fire.
Armature wire	Stranded annealed copper wire, straight lay, with soft, loose, white cotton braid. It is used for low voltage, high current, rotor winding motors and generators. Straight lay permits forming in armature slots and increases compressibility.
Armor	Braid or wrapping of metal, usually steel, used for mechanical protection of a wire or cable.
Arrhenius curve	Method whereby accelerated aging data is plotted graphically to produce curves that may be used to predict end of life conditions.
ASA	American Standards Association.
Asbestos	Silicate mineral that readily separates into flexible fibers suitable for use as an incombustible, non-conducting, chemical resistant material, but is physically weak. Fibrous asbestos insulation is used in the form of yarn servings, felts, lap, roving, braid, and paper.
ASC	Aluminum Stranded Conductors.
ASE	Designation for service entrance cable, above ground use. Some constructions are suitable for underground use. Covering is flame retardant, moisture resistant, and abuse resistant.
ASESA	Armed Services Electro Standards Agency.

Table 2. Terms And Definitions (Cont.)

Term	Definition
ASG	Aeronautical Standards Group.
ASME	American Society of Mechanical Engineers.
ASP	Filled direct burial telephone cable used in areas subject to rodent attack. Consists of a filled cable core, corrugated aluminum shield, corrugated steel tape, flooding compound, and polyethylene jacket.
Aspect ratio	Length divided by width or diameter.
Assembly	Article consisting of detailed parts and sub-assemblies performing functions necessary to the operation of the device.
ASTM	(See American Society for Testing and Materials).
Asynchronous	Method of transmitting data. Low-cost alternative to synchronous communications.
Atom	Smallest particle of an element which can enter into a chemical combination. All chemical molecules are composed of atoms. The differences between molecules result from the differences in type and number of atoms involved.
Atomic percentage	Number of atoms of an element in a total of 100 representative atoms of a substance; often written A/O.
Attenuation	Power loss in an electrical system. Applied to coaxial cables, the power drop or signal loss in a circuit. Expressed in decibels (dB). It is also the decrease in amplitude of a wave with distance of wave propagation when the amplitude at any given place is constant in time, or the decrease in amplitude with time at a given place.
Attenuation allowance	(See Flux budget).
Attenuation coefficient	Factor expressing optical power loss per unit of length, expressed in d b/km.
Attenuation-limited operation	Condition prevailing when the received signal amplitude (rather than distortion) limits performance.
Audio frequency	Range of frequencies audible to the human ear. Usually 20 Hz to 20 KHz.
Auto-ignition point	Temperature at which vapor from a material in air will spontaneously burst into flame. This is opposed to the flash point where the material vapors will ignite only under the influence of an external energy source such as a flame or spark.
AV or AVC	Designation for asbestos and varnished cambric insulated power and control cables.
AVA	Designation for impregnated asbestos and varnished cambric insulated wire with asbestos or glass braid, 600 V, 230°F (110°C).
Avalanche Photodiode (APD)	Photodiode that show gain in its output power that it receives through avalanche multiplication of photo current.
AVB	Same as AVA except with cotton braid, 194°F (90°C).
AVL	(1) Same as AVA except lead sheath in place of braid, 600 V, 230°F (110°C); 500 V, 212°F (100°C). (2) Approved Vendors List.
AVPD	Designation for asbestos and varnished cambric insulated cord with asbestos braid, two or three conductors. Heat and moisture resistant, and flame retardant. For damp locations, 600 V, 212°F (100°C). Round construction.
AVPO	Same as AVPD except two-conductor flat construction.
AWG	(See American Wire Gauge).
AWM	Designation for Appliance Wiring Material.
Axial lead	Wire coming out from the end along the axis of a component. (See radial lead).
Axial ray	Light ray that travels along the optical fiber's axis.

Table 2. Terms And Definitions (Cont.)

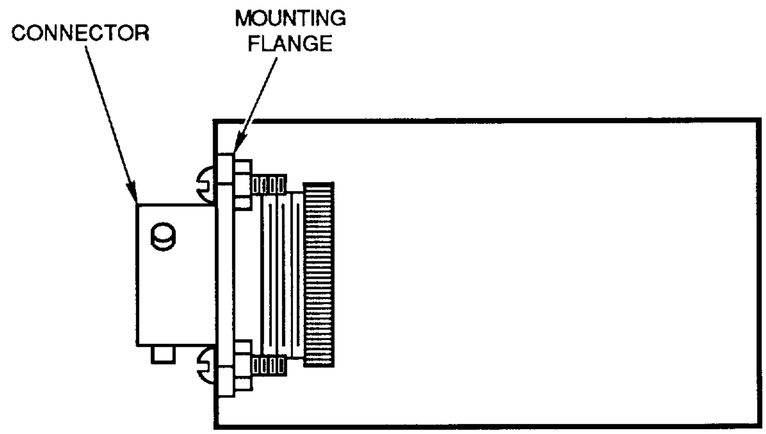
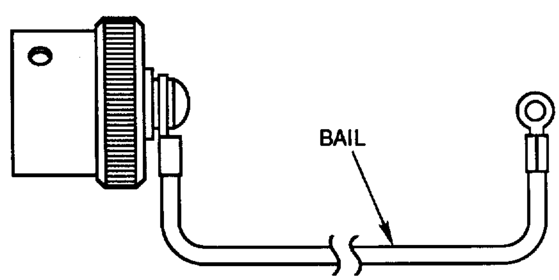
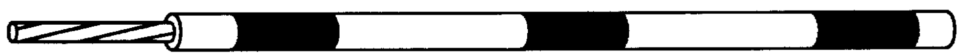
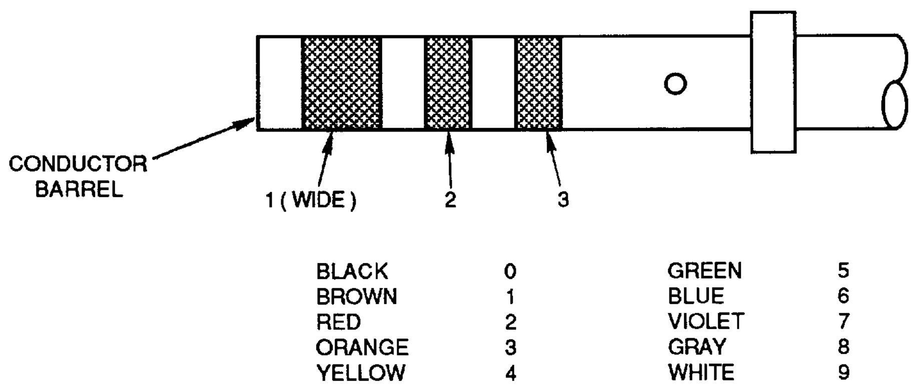
Term	Definition
Azeotropic system	System of two or more liquid compounds which has a constant boiling point at a particular composition.
B	(See Braid).
Back-mounted	When a connector is mounted from the inside of a panel or box with its mounting flange inside the equipment. 
Backplane panels	Interconnection panel into which Printed Circuit (PC) cards or other panels can be plugged. These panels come in a variety of designs ranging from a PC mother-board to individual connectors mounted in a metal frame. Panels lend themselves to automated wiring.
Backplane wiring	Connections between levels to each other and to other sub-circuits.
Backscattering	That portion of scattered light which returns in a direction generally reverse to the direction of propagation.
Backshell mold	Form used to mold a rubber or neoprene covering over the backshell of a connector or plug after it is connected to a cable. The compound is usually chemically cured. (See potting mold).
Bail	Loop of wire used to prevent permanent separation of two or more parts assembled together. One example is the bail holding the dust cap on cylindrical connectors. 
Balun	Device for matching an unbalanced coaxial transmission line to a balanced two-wire system. Normally, also gives impedance transformation, such as 300 ohm balanced to 75 ohm unbalanced.
Banded cable	Two or more cables banded together by stainless steel strapping.

Table 2. Terms And Definitions (Cont.)

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Band marking</td><td>Continuous circumferential band applied to a conductor at regular intervals for identification.



WIRE IDENTIFICATION



CONTACT IDENTIFICATION</td></tr>
<tr><td>Bandwidth (BW)</td><td>Frequency range of electrical signals transmitted. Coaxial cable has a broad bandwidth and will transmit signals from 0 to 5 MHz. (See formulas-electrical).</td></tr>
<tr><td>BAIZAL</td><td>Designation for Bare Aluminum conductor.</td></tr>
<tr><td>Baron nitride</td><td>Less brittle than most ceramics. It has high thermal shock resistance, high thermal conductivity, and is lightweight. It is relatively weak and affected by humidity.</td></tr>
<tr><td>Barrel</td><td>(1) Conductor barrel. Section of the terminal, splice, or contact that accommodates the stripped conductor.
(2) Insulation barrel. Section of the terminal, splice, or contact that accommodates the conductor insulation.

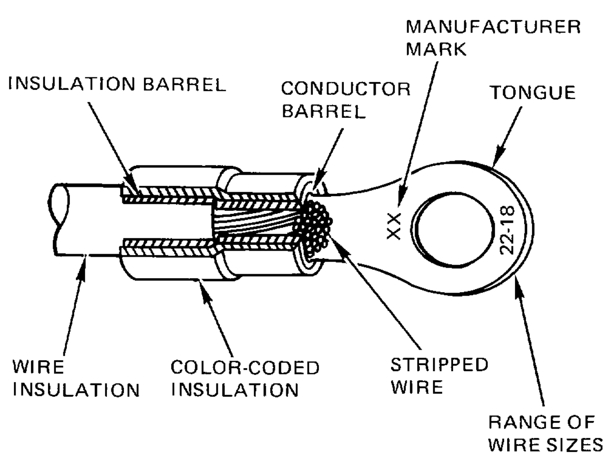

</td></tr>
<tr><td>Barrel chamfer</td><td>Bevel at the end of the conductor barrel for easier entry of the conductor.</td></tr>
</table>

Table 2. Terms And Definitions (Cont.)

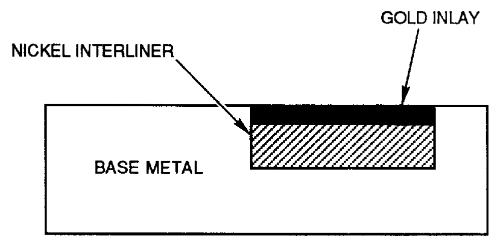
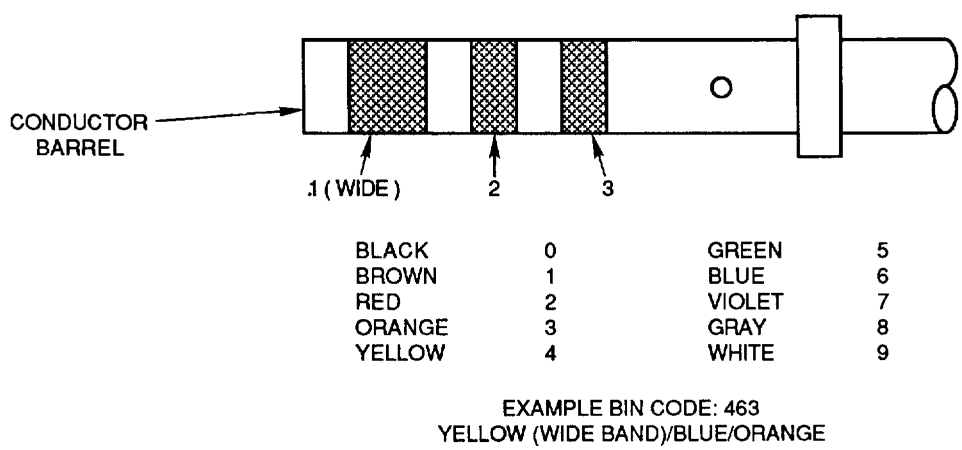
Term	Definition
Barrel-packed	Method of coiling into a fiber drum for shipment. It has wide application where large volumes of wire are used with automatic feed systems. Sometimes termed, drummed packing.
Base	(1) Material (such as paper, cotton, glass, fabric, fiber, felted asbestos, and nylon fabric) in the form of sheets which are impregnated with resin to form laminated plastics. (2) Substance which upon solution in water produces one or more hydroxyl ions. A hydroxyl ion is composed of one atom of oxygen and one atom of hydrogen. The hydroxyl ion carries one negative electrical charge. The strength of a base is determined by the number of hydroxyl ions that are released into solution. (See pH).
Base band	Signaling technique in which the signal is transmitted in its original form and not changed by modulation.
Base element	Easily oxidized element as opposed to a noble element.
Base film	Original form in which a film, such as polyester, exists prior to coating.
Base material	Insulating material upon which the conductive pattern may be formed. The base material may be rigid or flexible.
Base metal	Metal from which the connector, contact, or other metal accessory is made and on which one or more metals or coatings may be deposited. 
Basic Identification Number (BIN)	Contact numbering system which utilizes color coding for contact identification. 
Battery cable	Single conductor cable, insulated or uninsulated, used for carrying current from batteries to the point where power is needed. Also used for grounding.
Baud	Measurement of the signaling speed of a data transmission device.
Bayonet coupling	Quick coupling device for plug and receptacle connectors. Accomplished by rotation of a cam operating device designed to bring the connector halves together.

Table 2. Terms And Definitions (Cont.)

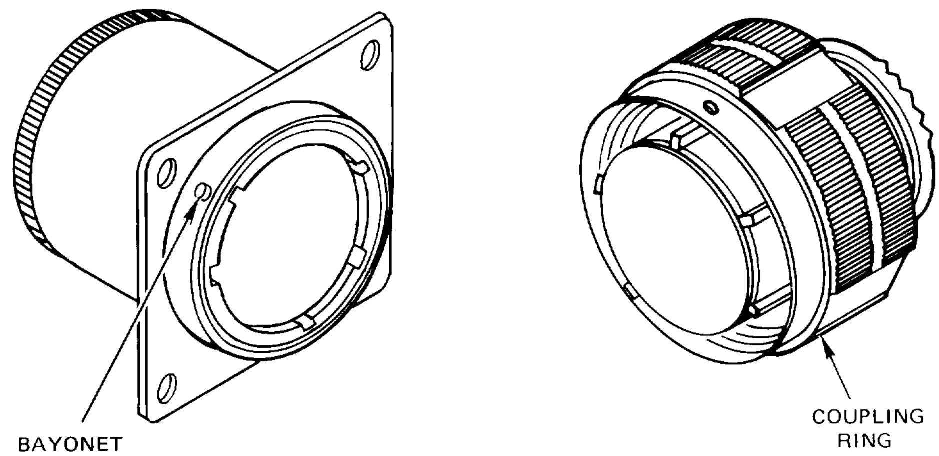
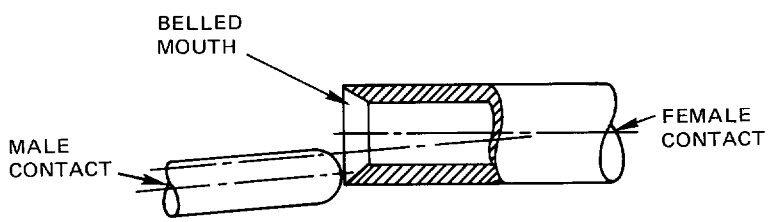
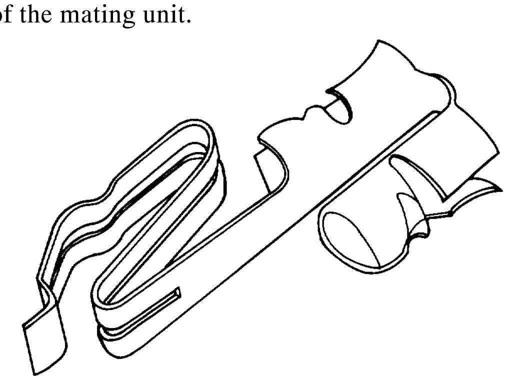
Term	Definition
	
BC	Bare Copper or Bell Cord.
BCF	(See Billion Conductor Feet).
BDC	Designation for Busdrop Cable, plastic.
Beaded coax	Coaxial cable with a dielectric consisting of beads made of various materials.
Beam diameter	Distance between two diametrically opposed points at which the irradiance is a specified fraction of the beam's peak irradiance.
Beam divergence	Increase in beam diameter with increase of distance from the source.
Beamsplitter	Device for dividing an optical beam into two or more separate beams.
Beamwidth	(See beam diameter).
Belled mouth (bellmouth)	Flared or wide entrance of a terminal, splice, or contact barrel to permit easier insertion of the conductor. 
Bellows contact	Contact in which a flat spring is folded to provide a more uniform spring rate over the full tolerance range of the mating unit. 
Belt	Number of layers of insulation on a conductor or number of layers of jacket on a cable.

Table 2. Terms And Definitions (Cont.)

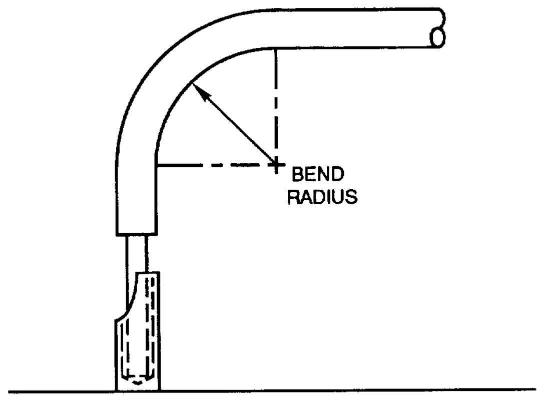
Term	Definition
Belted-type cable	Multiple conductor cable having a layer of insulation over the assembled insulated conductors.
Bend loss	Increased attenuation occurring when the fiber is curved around a restrictive radius.
Bend radius	Maximum amount a wire, cable, fiber, or fiber cable can be bent without causing damage. Usually called minimum safe bending radius. 
Beryllia	Beryllium oxide ceramics (BeO) are significant in that they have high thermal conductivity characteristics. Applications include heat sinks, circuit boards, diodes, ceramic to metal seals, and waveguide windows.
Beryllium	Metal lighter than aluminum, non-magnetic, and characterized by good electrical conductivity and high thermal conductivity. Available in sheet, foil, and wire forms. Strong conductor wire can be made from beryllium for use in applications where light weight is critical. The most important use for beryllium is in alloys, especially beryllium-copper alloys.
Bifilar	Winding made non-inductive by winding two wires carrying equal current in opposite directions together, side-by-side, as one wire.
Bifurcate	Describes lengthwise slotting of a flat spring contact, as used in a printed circuit connector, to provide additional independently operating points of contact. One application is the bifurcated contact.
Bifurcated contact	Contact (usually flat spring) which is slotted lengthwise to provide additional independently operating points of contact.

Table 2. Terms And Definitions (Cont.)

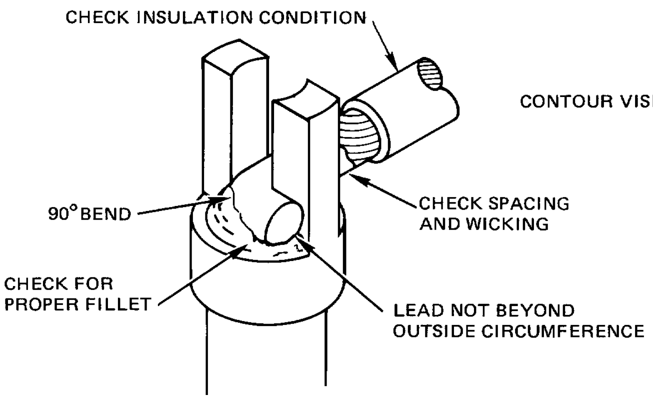
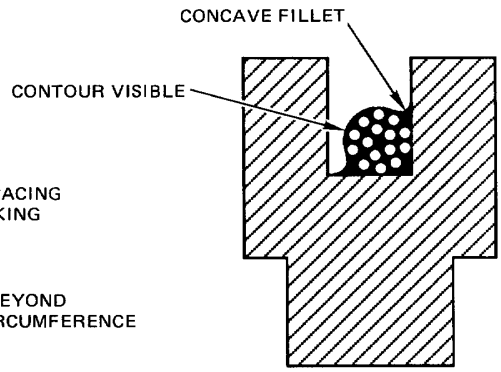
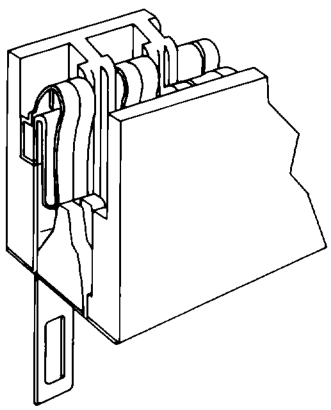
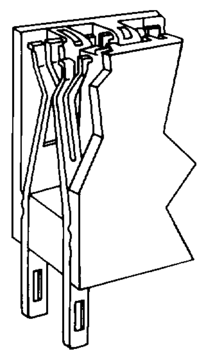
Term	Definition
	
Bifurcated terminal	Terminal containing a slot or split in which wires or leads are placed and soldered.  BIFURCATED BELLOWS CONTACT  BIFURCATED CANTILEVER CONTACT
Billion Conductor Feet (BCF)	Quantity derived by multiplying the number of conductors in a cable by the amount of cable. Usually used to indicate plant capacity or an annual requirement.
Bimetallic wire	Any wire formed of two different metals joined together (not alloyed). It can include wire with a steel core for high strength, clad wire, or plated or coated wire.
BIN	(See Basic Identification Number).
Binary alloy	Alloy containing two component elements.
Binder	(1) Spirally served tape or thread used for holding assembled cable components in place until additional manufacturing operations are performed. (2) Substances added to unfired substrates and thick film compounds to hold ingredients together or fill voids.
Bird cage	Defect in stranded wire where the strands in the stripped portion between the covering of an insulated wire and a soldered connection (or an end-tinned lead) have separated from the normal lay of the strands.
Birmingham Wire Gauge (BWG)	Birmingham Wire Gauge was used extensively in Great Britain and the United States for many years, but is now obsolete. Its uses have persisted, however, for certain purposes including sizing galvanized steel wire for cable armor.
Blade contact	Flat male contact designed to mate with a tuning fork or a flat-formed female contact.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Blind joint	Concealed or covered joint.
Blister	Localized swelling and separation between any of the layers of a laminated base material or between the base material and a conductive foil. (A form of delamination).
Blowhole	Small hole or cavity in the vicinity of the solder joint caused by gas entrapped during solidification.
Blown jacket	Term used for outer cable covering applied by the controlled inflation of the cured jacket tube and the pulling of the cable through it.
BMC	(See Bulk Molding Compound).
Board thickness	Thickness of the metal-clad base material including conductive layer or layers. (May include additional platings and coatings depending upon when the measurement is made).
Board to motherboard or backplane	Connection point between printed circuit boards or sub-circuit modules and the motherboard or a backplane board.
Bobbin	(1) Spool used for taking up drawn wire and subsequently used for pay out packages in cabling and stranding equipment. (2) Insulated spool which serves as a support for a coil.
Bobbin lugs	Mounted in plastic or paper bobbins, lugs serve to connect coil wires to external lead wires.
Body, connector	Main portion of a connector to which contacts and other components are attached. This term is not used with connectors incorporating non-integral shells in their construction.
Boiling point	Temperature of a liquid at which its vapor pressure is equal to the pressure of the atmosphere surrounding the fluid. For example, at 212°F (100°C), water has a vapor pressure equal to 14.7 psi, which is the pressure of the atmosphere at sea level.
Bond	Junction of joined parts. Where solder is used, it is the junction of the solder and the heat affected base metal.
Bond strength	Force per unit area required to separate two adjacent bonded surfaces by a force perpendicular to the surface. (See peel strength).
Bondable wire	Insulated wire whose surface has been treated to facilitate adherence to other materials such as potting compounds. The term also could be applied to magnet wires used in making coils where bonding the turns together is desirable.
Bonded	Joined by atomic attraction or by direct contact with a melted filler material (as a solder joint).
Bonded assembly	Connector assembly in which the components are bonded together using an electrically appropriate adhesive in a sandwich type structure. Provides sealing against moisture and other environmental conditions which weaken electrical insulating properties.
Bonded assembly, electrical	Assembly whose supporting frame and metallic non-circuit elements are connected so as to be electrically shorted together.
Bonded cables	Cables consisting of pre-insulated conductors or multiconductor components which are laid in parallel and bonded into a flat cable. (See solvent-bonded, adhesive-bonded, film-bonded, flat cable).
Bonded construction	Type of insulation construction in which the glass braid and nylon jacket are bonded together.
Bonding pad	Metallized area at the end of a thin metallic strip or on a semiconductor to which a connection is made.
Bonding wire	Fine gold or aluminum wire for making electrical connections in hybrid circuits between various bonding pads on the semiconductor device substrate and device terminals or substrate lands.

Table 2. Terms And Definitions (Cont.)

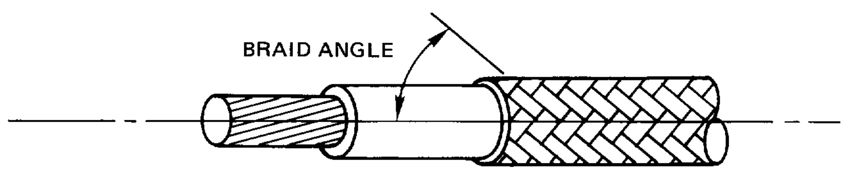
Term	Definition
Booster	Device inserted into a line (or cable) to increase the voltage. Boosting generators are also used to raise the level of a DC line. Transformers are usually employed to boost AC voltages. The term booster is also applied to antenna preamplifiers.
Boot	(1) Protective covering over any portion of a cable, wire, or connector in addition to the normal jacketing or insulation. (2) A form placed around the wire termination of a connector to contain the liquid potting compound before it hardens. (3) A protective housing usually made from a resilient material to prevent entry of moisture into a connector.
Bow	Deviation from flatness of a board characterized by a roughly cylindrical or spherical curvature such that, if the board is rectangular, its four corners are in the same plane. (See twist).
Braid angle	Angle between the axis of the cable and the axis of any one member or strand of the braid. It is the smaller of the two angles formed by the carrier and the longitudinal axis of the braid. 
Braid (B)	(1) Flexible conductor made of a woven or braided assembly of fine wires. (See shield). (2) Covering formed from textile yarn. Braids provide mechanical and thermal protection to plastic insulation, separate cable segments in multiconductor cables, and act as components in flame retardant cables.
Braid carrier	Spool or bobbin on a braiding machine which holds one group of strands or filaments consisting of a specific number of ends. The carrier revolves during the braiding operation.
Braid ends	Number of strands used to make up one carrier. The strands are wound side by side on the carrier spool and lie parallel in the finished braid.
Braider or braiding machines	Machines used to apply braids to wire and cable and to produce braided sleeving and braids for tying or lacing purposes. Braiding machines are identified by the number of carriers such as 16-carrier or 24-carrier. Strands from the individual supply packages are braided as the upper and lower carriers revolve in opposite directions.
Brake wire	Wires used in automotive and truck trailers to supply current to the electrical braking system.
Brazing	Group of joining processes wherein the filler metal is a non-ferrous metal or alloy whose melting point is typically higher than 1000°F (537.8°C), but lower than that of the metals or alloys to be joined. At one extreme, brazing is similar to soldering and is sometimes called hard soldering.
Breakdown (puncture)	Disruptive discharge through insulation.
Breakdown voltage	Voltage at which the insulation between two conductors fails.

Table 2. Terms And Definitions (Cont.)

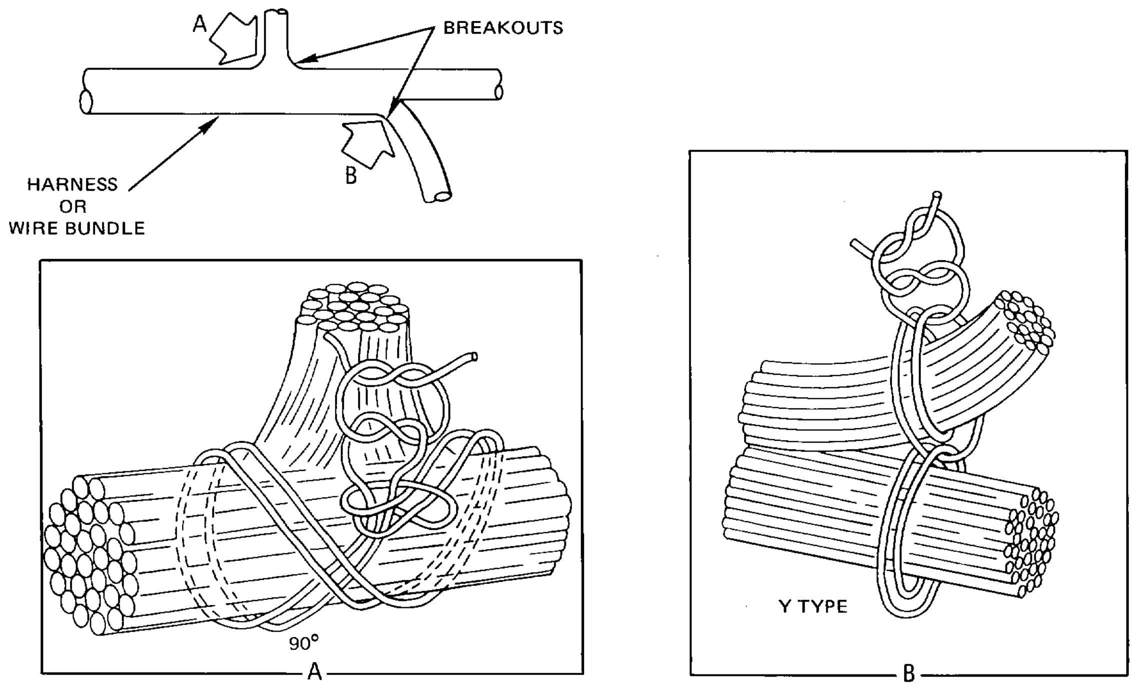
Term	Definition
Breakout	Point at which a conductor or group of conductors leaves a multiconductor cable or harness to complete circuits at various points along the cable. 
Break-out boxes	Device that you can connect different cables together and see what works with what.
Bright dip	Solution which produces, through chemical action, a bright surface on an immersed metal.
British standard wire gauge	Modification of the Birmingham Wire Gauge and the legal standard of Great Britain for all wires. Variously known as Standard Wire Gauge (SWG), New British Standard (NBS), English Legal Standard, and Imperial Wire Gauge.
Broadband	Signaling technique in which more than one signal can be carried simultaneously.
Brown and Sharp (B&S) wire gauge	Wire diameter standard that is the same as American Wire Gauge (AWG). (See American Wire Gauge).
B-stage material	(See prepreg, resin - B stage of).
Buffer	Substance or substances added to an acid or base solution. Its purpose is to reduce the rate at which acidity or alkalinity of the solution is changed during chemical reactions. An example is a buffered acid flux.

Table 2. Terms And Definitions (Cont.)

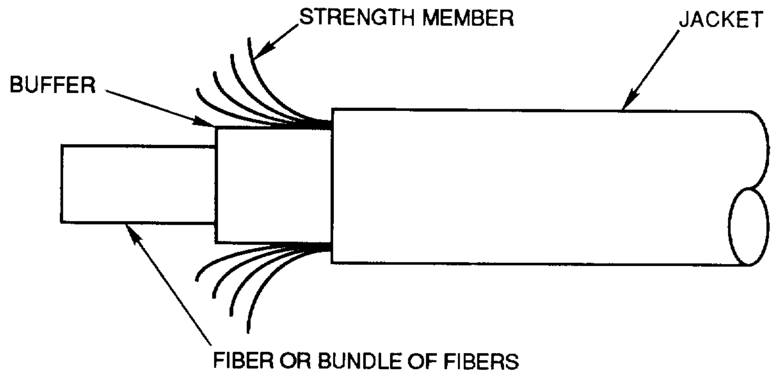
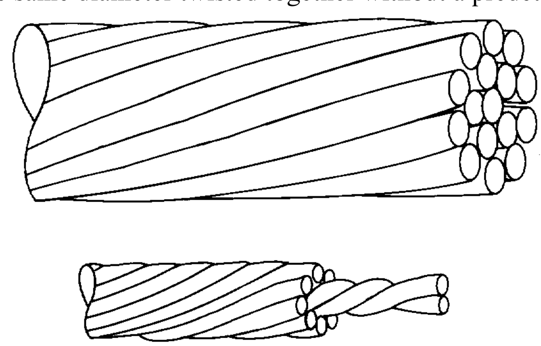
Term	Definition
Buffer (fiber optic)	Protective material which covers and protects a fiber, or fiber bundle, in a fiber cable. The buffer has no optical function. 
Buffing stripper	Motorized device for removing flat cable insulation by means of one or two buffing wheels that melt the insulation and brush it away from the conductors. Also called abrasion stripper.
Building wire	Wire used for light and power distribution in the building trades.
Bulk Molding Compound (BMC)	Thermosetting plastic resins mixed with standard reinforcement, a filters, and other additives into a viscous compound for compression or injection molding.
Buna rubber	(See nitrile-butadiene rubber, styrene-butadiene rubber).
Buncher	Machine that twists wires together in random arrangement.
Bunch stranding	Group of wires of the same diameter twisted together without a predetermined pattern. 
Bundle	Number of wires and/or cables, groups, or harnesses routed together.
Burnoff	Removal of electroless copper as a result of excessive current. Usually occurs at edges of holes and causes plating failure in the hole.
Burrs	Featherlike cross sections developed along the edge of a piece of metal that has been sawed, filed, or ground.
Bus	Used to connect two terminals inside of an electrical unit. A common point for electrical circuits to return. Can be bare, tinned, or insulated.
Busbar	Heavy copper (or other metal such as aluminum) strip or bar used to carry heavy currents.
Bused	Joining of two or more circuits.
Bushing	Mechanical device used as a lining for an opening to prevent abrasion to wire and cable. Also used as a low cost method of insulating, anchoring, cushioning, and positioning. Usually, a non-metallic material is preferred.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Bus network	Network in which all work stations are connected to a single cable.
Butadiene	Hydrocarbon synthetic rubber used in compounds such as butadiene-styrene and acrylonitrile-butadiene-styrene.
Butt	When two conductors come together end-to-end, with their axes in line, but do not overlap.
Butt contact	Mating contact configuration in which the mating surfaces engage end-to-end without overlap and with their axes in line. This engagement is usually under spring pressure with the ends designed to provide optimum surface contact.
Butting die	Crimping die so designed that the nest and indentor touch at the end of the crimping cycle. Also called bottoming die.
Butt joint	Joint between two members lying approximately in the same plane.
Button-hook contact	Contact with a curved, hooklike termination often located at the rear of hermetic headers to facilitate soldering or de-soldering of leads. (See hook terminal).
Butt splice	Splice wherein two wires from opposite ends butt against each other, or against a stop, in the center of a splice.
Butt wrap	Tape wrapped around an object or conductor in an edge-to-edge condition.
Butyl rubber	Synthetic rubber copolymer of isobutylene and isoprene. It has excellent moisture, ozone, and aging characteristics. It is usually used as an insulation on power and high voltage cables.
BW	(See Bandwidth).
BWG	(See Birmingham Wire Gauge).
BX	Designation for armored building wire, 600 V.
Bypass cabling or relays	Wired connections in a ring network that permits traffic to travel between two nodes that are not normally wired next to each other.
C	(1) Designation for lamp cord, two or more conductors twisted together. Rubber insulation, cotton braid. For pendant or portable use in dry places. No overall covering, 300 V or 600 V, 140°F (60°C). (2) (See Capacitance). (3) (See Coulomb).
Cable	Two or more insulated conductors, solid or stranded, contained in a common covering; two or more insulated conductors twisted or molded together without common covering; one insulated conductor with a metallic covering shield or outer conductor.
Cable and wire fault locating equipment and counters	Cable and wire fault locating equipment can be classified into two separate categories - that used in cable and wire manufacturing operations, and that for locating faults in cable after installation. The two categories have little in common. In the case of manufacturing operations, sparkers are used to continuously monitor the integrity of the insulation (as it is being applied to the wire) by a voltage between the wire and the sparker electrode. In the case of installed cable or wire, particularly long power or communication circuits, the problem is somewhat different. Here, a discrete single fault may have occurred during operation of the system. The problem is to locate it within a few feet, in a circuit that may be miles in length. Types of equipment may be: special bridges, a combination of some form of tone generator with a suitable detector, a pulse generator with an oscilloscope for observing the electrical reflection from the fault, a high voltage surge generator with a suitable detector, or an instrument for measuring capacitance.
Cable assembly	Completed cable and its associated hardware.

Table 2. Terms And Definitions (Cont.)

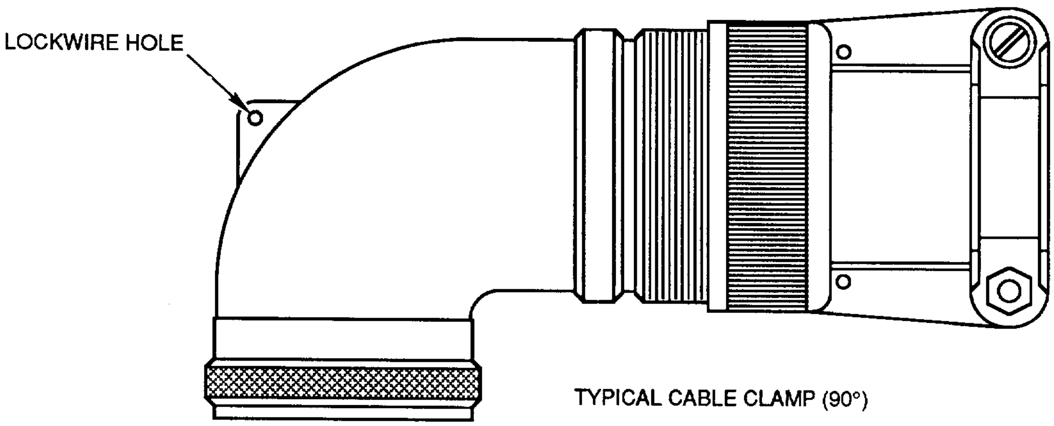
Term	Definition
Cable clamp	Mechanical clamp attached to the cable side of the connector to support the cable or wire bundle, provide strain relief, and absorb vibration and shock otherwise transmitted by the cable to the contact/wire connection.  TYPICAL CABLE CLAMP (90°)
Cable clamp adapter	Mechanical adapter that attaches to the rear of a plug or receptacle to allow the attachment of a cable clamp.
Cable clips	Harnessing system for mounting wire and cables. Some clips are adjustable for tension control.
Cable, coaxial	Cable in which one conductor is concentrically centered inside another. Used primarily for the transmission of radio frequency signals.
Cable core	The portion of an insulated cable lying under the protective covering or coverings.
Cable core binder	Wrapping of tapes or cords around the several conductors of a multiple-conductor cable used to hold them together. Cable core binder is usually supplemented by an outer covering of braid, jacket, or sheath.
Cable covers	“U” channel sections of fiberglass cloth reinforced epoxy tubing rated at 311°F (155°C), used to protect wire and cable.
Cable fiber optic	Jacketed Fiber in a form that can transmit optical signals.
Cable filler	Material used in multiconductor cables to occupy the interstices formed by the assembly of the insulated conductors, thus forming a cable core of the desired shape (usually circular).
Cable guards	Rectangular pieces of fiberglass laminated epoxy, 311°F (155°C), used to protect delicate cable harnesses and connectors.
Cable loss	Amount of RF signal attentuated by coaxial cable transmission.
Cable pullers	A tool for pulling cables through a conduit.
Cable sealing clamp	Device consisting of a gland nut and sealing member. Designed to seal around a single jacket cable.
Cable sheath	Protective covering applied to cables.
Cable, shielded	One or more insulated conductors covered with a metallic outer conductor.
Cable shielding clamp	Device designed to terminate the shield of an electrical cable.
Cable terminal	Device which seals the end of a cable and provides insulated egress for the conductors. In power work, also known as a pothead or end bell.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Cable ties	Belt-like plastic strip devices which loop around bundles of cables or insulated wires to hold them together or anchor them to an electronic cabinet, a wall, or another assembly.
Cable vulcanizers	Simple compression molding machines used to repair cable jacketing that has had a part removed for splicing, for adding connectors or other devices, or for replacing damaged sections. Both portable and stationary models are available.
Cabling	(1) Mechanically twisting together two or more insulated conductors to form a cable. (2) Bundling of wires together as in forming wire harnesses. (3) (Fiber optic) A method by which a group of fibers or bundle of fibers is mechanically assembled.
Cabling factor	Used in the formula for calculating the diameter of an unshielded, unjacketed cable. D = Kd, where D is the cable diameter, K is the factor, and d is the diameter of one insulated conductor.
CAC	Designation for flexible copper, synthetic tape, felted asbestos, and lacquered braid, 1000 V, 257°F (125°C).
Cadmium	White, ductile metallic element generally used in plating steel hardware for electronic equipment. It provides improved solderability, surface conductivity, and helps to prevent corrosion.
Cadmium-chromium-copper	Alloy with a small loss in conductivity to provide high strength. Used in high temperature applications. Flex life is good.
Cadmium-copper	High strength alloy. Easy to work with and relatively inexpensive, but it has a softening temperature of 347°F (175°C) to 392°F (200°C).
Caged armor	Armor wires within a polyethylene jacket. Often used in submarine cables.
Caliper	Overall flat cable thickness.
Cambric	Fine weave linen or cotton fabric used for insulation.
Canvas	Cotton fabric weighing more than four ounces per square yard.
Capacitance and dissipation factor, equipment	AC high voltage capacitance ridges are used for the measurement of capacitance and dissipation factors in the testing of insulators, cables, and dielectrics.
Capacitance (C)	That property of a system of conductors and dielectrics which permit the storage of electricity when potential difference exists between the conductors. The value is expressed as the ratio of a quantity of electricity to a potential difference. A capacitance value is always positive. (See formulas-electrical).
Capacitance coupling	Desirable or undesirable electrical interaction between two conductors which is caused by the capacitance between them. (See crosstalk).
Capacitor	Device consisting of two conducting surfaces separated by an insulating material such as air, paper, mica, ceramic, glass, metal, or plastic film. A capacitor stores electric energy, blocks the flow of direct current, and permits the flow of alternating current to a degree dependent on the frequency and capacitance of the device.
Capillary action	Interaction between a liquid and a small diameter channel, or opening in a solid. Because of the physics involved, if the liquid wets the sides of the solid channel, surface tension will draw the liquid up into the capillary channel. This travel is sometimes for a considerable distance. The term capillary, alone, refers to the channel itself. An example of this action in soldering is demonstrated by dipping a stranded wire into a liquid flux which wets the conductor. The small spacings between the individual strands of the wire act as capillary channels. The liquid flux will travel for a considerable distance up the stranded wire.
Capillary attraction	Combination of force, adhesion, and cohesion which causes liquids, including molten metals, to flow against gravity between very closely spaced solid surfaces.
Capillary force	Phenomenon of surface tension which causes a liquid to be drawn into the space created by two closely mated parallel surfaces.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Carrier	(1) Basic woven element of a braid consisting of one or more ends (strands) which create the interfaced effect. (2) A spindle, spool, tube, or bobbin (on a braiding machine) containing yarn or wire, employed as a braid. It is normal to have an 8-carrier, 12-carrier, 16-carrier, 24-carrier, 32-carrier, or 48-carrier machine. Larger cable diameters require a greater number of carriers to apply the braid. (3) Holders for electronic parts and devices which protect parts during transport, and facilitate handling during processing, production, imprinting, or testing operations. (4) The basic signal used for transmission prior to modulation.
Carrier signal	Continuous waveform whose properties are capable of being modulated or impressed with a second information-carrying signal.
Castor oil	Can be used in such applications as plasticizers for vinyl electrical resins, and as a dielectric for energy storage capacitors, since it exhibits corona resistance. A highly refined grade is recommended for DC applications where high voltages may be imposed.
Catalyst	Substance which initiates and/or accelerates a chemical reaction, but normally does not enter into the reaction.
Cathode	(1) Negative pole of a plating cell. It is the physical entity of the plating set up at which positively charged ions leave the plating solution. The cathode is normally the object of the plating; i.e., a metal is deposited on the cathode. In solder plating, for example, metal from the anode is plated on the cathode. The anode metal enters the bath as positive ions which are attracted to the negative cathode, where they give up their electrical charge to the external circuit. The ion is then converted to an atom which remains adhering to the cathode. (2) The N-type, or more negatively doped material of a diode. Represented by the straight line in the schematic symbol.
CCITT	Comite Consulatit International de Telegraphic et Telephonic.
Cellular insulation	Material in foamed or sponge form with cells closed or interconnected.
Cellular plastics	Materials with cell structure throughout their mass. Also called foamed plastics.
Celluloid	Thermoplastic material made by the direct blending of cellulose nitrate with camphor. Alcohol is normally employed as a volatile solvent to assist plasticization and is subsequently removed.
Cellulose	Carbohydrate found in plants, used to form thermoplastic materials.
Cellulose acetate	An acetic acid ester of cellulose that is a tough thermoplastic material. Cellulose acetate film offers low moisture absorption, good heat resistance to 220°F (104.4°C), and a glossy transparent finish.
Cellulose acetate butyrate	Acetic and butyric ester of cellulose and a thermoplastic material.
Cellulose ester	Cellulose in which the free hydroxyl groups have been replaced, wholly or in part, by acidic groups. Used in the manufacture of thermoplastic molding compositions.
Cellulose lacquer	Coating for magnet wire based on cellulose acetate.
Cellulose nitrate (nitrocellulose)	Nitric acid of cellulose.
Cellulose propionate	Ester of cellulose and propionic acid. Used as the basis of a thermoplastic molding material.
Cellulosic resins	Thermoplastic compounds used for good electrical properties. Suitable insulators against usual industrial and domestic currents.
Center-to-center distance	(See pitch).
Ceramic fiber	Inorganic, non-metallic substance used as insulation for extremely high temperature applications. Usually applied to as a braid or tape. Excellent radiation resistance, but poor mechanical and moisture characteristics. May operate at 1000°F (537°C) or more.

Table 2. Terms And Definitions (Cont.)

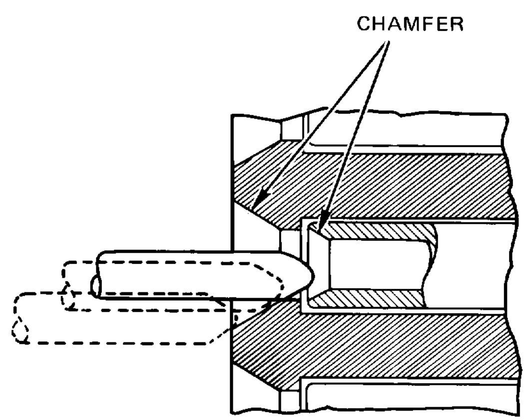
Term	Definition
Ceramics	Ceramics are basically a combination of three main materials: clay, feldspar, and sand. A wide variety of ceramics are shaped and used for numerous applications; including, spark plug insulation, sockets, fuse blocks, circuit substrates, etc. They are used primarily because of their low loss qualities, long life characteristics, and ability to withstand high operating temperatures and heat shock. Applications are being developed in the area of superconductors, conductors with very low resistance.
Cermet	Combination of ceramic and metal powders used for thin- and thick-film resistors.
Certification	Act of verifying that required training has been completed, and specified proficiency has been required.
CF	Designation for fixture wire, heat resistant with flame retardant, moisture resistant, impregnated cotton insulation with or without cotton braid, 300 V, 194°F (90°C).
CFC	Designation for two or three CF type wires twisted together without overall covering. Color coded, 300 V, 194°F (90°C).
CF Glass	Continuous Filament glass yarn which is used in braiding and in making glass fabric and thread.
CFPD	Designation for two or three CF type wires twisted together with overall braid. Color coded, 300 V, 194°F (90°C).
CFPO	Designation for two CF type wires laid parallel with overall braid. Color coded, 300 V, 194°F (90°C).
CFT	Abbreviation for 100 feet.
Chafing	Repeated relative motion between wiring system components, or between a wiring system component and the structure or equipment, which results in a rubbing action that causes harmful wear.
Chamfer	Funnel type angle, on the inside edge of the barrel entrance of a connecter insert and/or socket contact, which permits easier insertion of a pin contact into the barrel. (See belled mouth). 
Characteristic impedance	Characteristic impedance of a uniform line is the ratio of an applied potential difference to the resultant current, at the point where the potential difference is applied when the line is of infinite length. The term is applied only to a uniform line. Coaxial cable is such a uniform line. There are three main impedance groups in coaxial cable; 50, 70, and 93 ohms.
Charge	In electrostatics, the amount of electricity present on any substance which has accumulated electric energy.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Chemical analysis - wet	This method, quantitative or qualitative, is performed by manipulating the unknown through a series of predetermined chemical reactions. The term “wet” means that most of the chemical manipulations are carried out in a solution.
Chemical cleaning	Removal, by chemical means, of foreign material or oxide film which would interfere with soldering.
Chemical hole cleaning	Chemical process for cleaning conductive surfaces exposed within a hole. (See etchback).
Chemical stability	Characteristic of a compound which describes its ability to retain, without modification, its chemical properties over a long period of time. The term, “shelf life” is normally used to describe the extent of this characteristic of a compound.
Chemical stripping	Processing of removing enamel insulation from wire using compounds specifically formulated for dissolving and removing enamel coating.
Chemical Vapor Deposition (CVD) Chip	Process by which a heated gas produces an oxide deposit to fabricate a glass fiber preform. The deposited glass becomes the core. Single substrate on which all the active and passive circuit elements have been fabricated, by using one or all of the semiconductor techniques of diffusion, passivation, masking, photoresist, and epitaxial growth. The term is also applied to discrete capacitors and resistors, which are small enough to be bonded to substrates by hybrid techniques.
Chip capacitors	Discrete devices which introduce capacitance into an electronic circuit. Made in tiny wedge or rectangular shapes.
Chip carrier	Multiple contact device with connections from chips to external circuit. Leadless: surfaces to be connected are soldered to carrier surfaces. Leaded: surfaces to be connected are soldered to leads from carrier.
Chip component	Unpackaged circuit element (active or passive) for use in electronics. Besides integrated circuits, the term includes diodes, transistors, resistors, and capacitors.
Chlorinated hydrocarbon	Organic compound having hydrogen atoms and, more importantly, chlorine atoms in its chemical structure. Trichloroethylene, methyl chloroform, and methylene chloride are chlorinated hydrocarbons.
Chlorinated polyether	Crystalline thermoplastic polymer with excellent resistance to heat and various chemicals.
Chloropentafluoroethane	Gas used as a dielectric. (See gaseous dielectrics).
Chlorosulphonated Polyethylene (CSPE)	Synthetic rubber most often used as a jacket material. It has good resistance to ozone, heat, solvents, and moisture. Widely used as a substitute for neoprene because of its superior thermal characteristics.
Circuit	Interconnection of a number of devices, in one or more closed paths, needed to perform a desired electrical or electronic function.
Circuit density	Amount of circuitry on a given area of board. Usually expressed as a ratio of total surface area to circuitry and component coverage.
Circuit sizes	Popular term for building wire sizes 14 thru 10 AWG.
Circular Mil (CM)	Area of a circle one mil (0.001 in.) in diameter, 7.854×10^{-7} sq. in. Used in expressing wire cross-sectional area.
Circumferential crimp	Type of crimp where the crimping dies completely surround a barrel and result in symmetrical indentations in the barrel. (See crimp termination).
Cladding (fiber optic)	Sheathing or cover of a lower refractive index material directly in contact with the core of a higher refractive index material. Provides optical insulation and protection to the total reflection interface. (See fiber).
Clad metals	Composite of two or more metals to effectively combine the best qualities of each metal. Possible applications include contacts, thermostats, blades, springs, lead frames, connectors, etc.

Table 2. Terms And Definitions (Cont.)

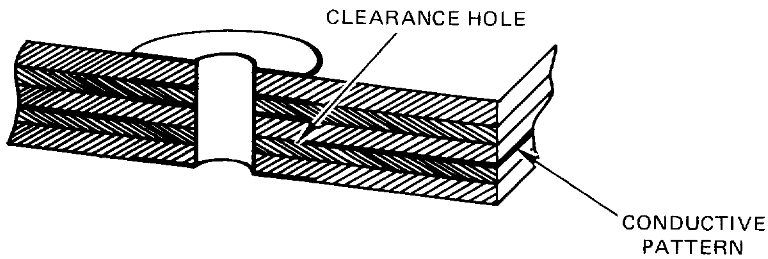
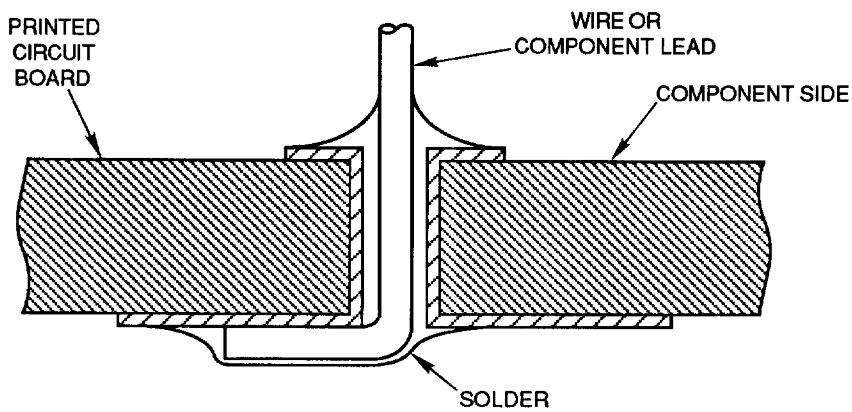
Term	Definition
Clad or cladding	(1) Relatively thin layer or sheet of metal foil bonded to a laminate core to form the base material for printed circuits. (2) Method of applying a layer of metal over another metal; whereby, the junction of the two metals is continuously welded.
Cladding mode	Mode that is confined by virtue of a lower index medium surrounding the cladding (See Mode).
Cladding mode stripper	Device that encourages the conversion of cladding modes to radiations modes.
Clearance	(1) Gap or space between two mating parts. (2) Space provided between the relief of a cutting tool and the surface cut.
Clearance hole	Hole in the conductive pattern larger than, but coaxial with, a hole in the printed board base material. 
Clinched-wire through connection	Connection made by a wire which is passed through a hole in a printed circuit board, then subsequently formed or clinched, in contact with the conductive pattern, and soldered. 
Closed entry	Contact or contact cavity design in the insert or body of the connector, which limits the size or position of the mating contact or printed circuit board to a predetermined dimension.
Closed entry contact	Socket contact designed to prevent the entry of a pin or probing device, having a cross-sectional dimension (diameter) greater than the mating pin.
CM	(See Circular Mil).
CMIP	Common Management Information Protocol.
Coatings	Usually applied in a liquid state for thin coatings. Printed circuit coatings are thin, very conformable coatings that follow the shape of the printed circuit board and its components. May be applied by spraying, dipping, or brushing. Coatings protect printed circuit boards from moisture, dirt, and other contaminants. (See Varnishes).

Table 2. Terms And Definitions (Cont.)

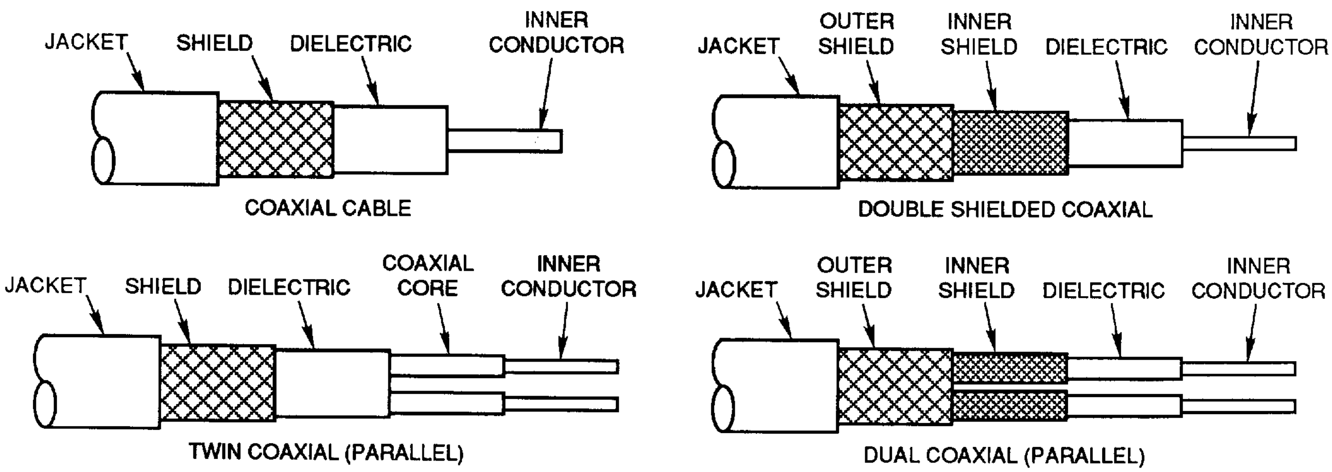
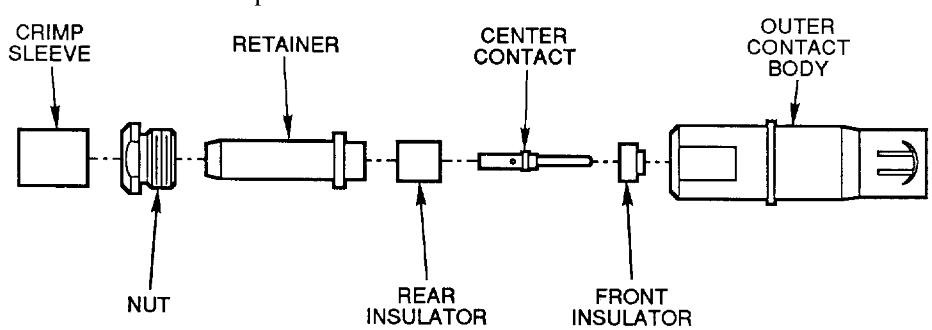
Term	Definition
Coaxial cable	Cable consisting of two cylindrical conductors with a common axis. The two conductors are separated by a dielectric. The outer conductor or shield, normally at ground potential, acts as a return path for current flowing through the center conductor and prevents energy radiation from the cable. The outer conductor is commonly used to prevent external radiation from affecting the current flowing in the inner conductor The outer conductor consists of woven strands of wire, or is a metal sheath. 
Coaxial connector	Connector that has a coaxial construction and is suitable for use with coaxial cable.
Coaxial contact	Contact having two conducting surfaces, a center contact, and a coaxially placed sleeve. Pin contacts have a pin outer contact with a socket center contact. Socket contacts have a socket outer contact with a pin center contact.  TYPICAL SOCKET COAXIAL CONTACT
Coefficient of expansion and contraction	Degree to which a material will expand or contract when heated or cooled.
Coherent light (fiber optic)	Light of essentially one wavelength, in phase, traveling in the same direction. Used as the means of transmitting information in a fiber optic system. (See fiber optics).
Cohesion	Force of attraction between the molecules (or atoms) within a single phase. Contrast with adhesion.
Coil form terminals	Used on small transformer coils to connect coil wires. Terminals are attached to the coil base or collar.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Coin silver	Alloy containing 90% silver, with copper being the usual alloying element.
Cold flow	Permanent deformation of a compound due to mechanical force or pressure; not heat induced.
Cold short	Metallurgical term to denote a brittle condition in a metal at temperatures below the recrystallization temperature.
Cold solder joints	This type of solder joint is characterized by non-wetting one or both of the surfaces being joined. Usual causes are: surfaces which are not clean, soldering iron with too low a tip temperature, or heating of the solder rather than the metals to be joined.
Cold weld	Joining together of two metals (without an intermediate material) by the application of pressure only, without an electrical current or elevated temperature.
Collimation	Process by which a divergent or convergent beam of radiation is converted into a beam with the minimum divergence possible for the System. (See Beam Divergence).
Color code	System for circuit, terminal, and related device identification through use of solid colors, tracers, stripes, and surface printing, etc.
Combustible liquids	Any liquid having a flash point at or above 140° F (60°C), and below 200°F (98.2°C).
Combustion	Rapid oxidation. The oxidation process of rusting iron is not combustion. It proceeds at a very slow rate. The burning of a candle is an oxidation process which proceeds at great speed and is an example of combustion.
Component	Article which is normally a part or combination of detailed parts, subassemblies, or assemblies, and is a self-contained element which performs a function necessary to the operation of the device. A component may be any of various electrical devices such as a resistor or capacitor. It may also be a mechanical device.
Component density	Quantity of components on a printed board per unit area.
Component hole	Hole used for the attachment and electrical connection of component terminations, including pins and wires, to the printed board.
Component lead	Solid or stranded wire which extends from and serves as a connection to a component.
Component side	Side of the printed board on which most of the components will be mounted.
Composite cable	(See hybrid cable).
Composite (clad) wire	Wire having a core of one metal, to which an outer shell of one or more different metals is fused.
Composite conductor	Two or more strands of different metals, such as aluminum and steel or copper and steel, assembled and operated in parallel.
Composite laminates	Laminated plastic joined to a non-plastic material such as a metal or rubber.
Compound	Insulating or jacketing material made by mixing two or more ingredients.
Compression cable	Pipe type cable in which the pressure medium (oil or gas) is separated from the insulation by a membrane or sheath.
Compression set	Amount of compression an elastomer retains. Expressed as a percentage of original dimensions.
Computer cable	Used for interconnecting computers, electronic equipment, and the conveyance of information.
Concentric	Central core surrounded by one or more layers of helically wound strands in a fixed, round, geometric arrangement. It is optional for the direction of lay for successive layers to be alternately reversed or in the same direction. The standard direction of lay of the outer layer is left hand.
Concentricity	In a wire or cable, the measurement of the location of the center of the conductor with respect to the geometric center of insulation.

Table 2. Terms And Definitions (Cont.)

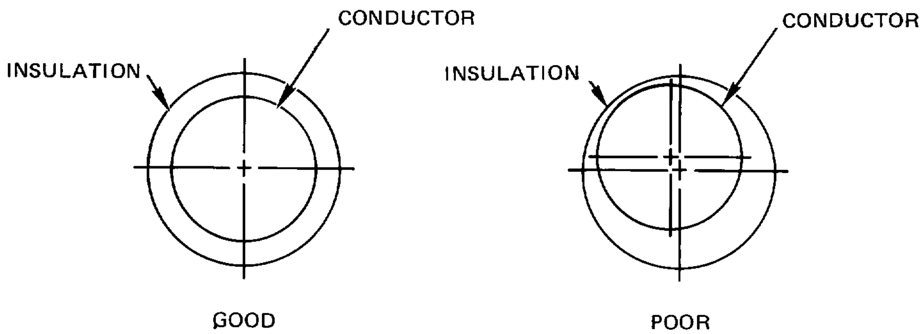
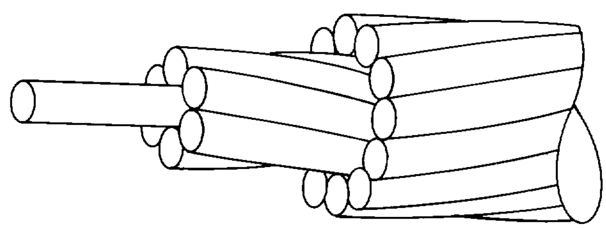
Term	Definition
	
Concentric-lay cable	Multiple-conductor cable composed of a central core surrounded by one or more layers of helically laid insulated conductors.
Concentric-lay conductor	Conductor composed of a central core surrounded by one or more layers of helically laid wires. In the most common concentric-lay conductor, all wires are the same size, and the central core is a single wire.
Concentric stranding	Central wire surrounded by one or more layers of helically wound strands in a fixed round geometric arrangement. Each layer after the first has six more strands than the preceding layer and is applied in a direction opposite to that of the layer under it. (See true concentric, unidirectional concentric). 
Condensation soldering	(See vapor phase soldering).
Conductance (G)	Reciprocal of resistance. The ratio of current passing through a material, to the potential difference at its ends.
Conducted susceptibility	Tendency of a piece of equipment to have the performance degraded in response to noise on the connecting wires.
Conductive compounds	Coatings, materials, inks, and paints used for: chip bonding, electrostatic shielding, corona shielding, making connections, repairing printed circuits, attaching leads, adhesive work, ignition cable sheath coating, making electrodes, contacts, terminations, surfaces receptive to plating, hybrid circuit paths, land areas, and solderable surfaces.
Conductive ink	In hybrid technology, the conductive paste used on thick-film materials to form the printed conductor pattern. Usually contains metals, metal oxide, glass frit, and solvent.
Conductive pattern	Configuration or design of the conductive material on the base material. Includes conductors, lands, and through connections, when these connections are an integral part of the manufacturing process.
Conductivity	Measure of the capability of a material to carry electrical current. Usually expressed as a percentage of copper conductivity (copper being 100%).
Conductor	Material suitable for carrying electrical current.
Conductor barrel	Section of the terminal, splice, or contact which accommodates the stripped conductor.

Table 2. Terms And Definitions (Cont.)

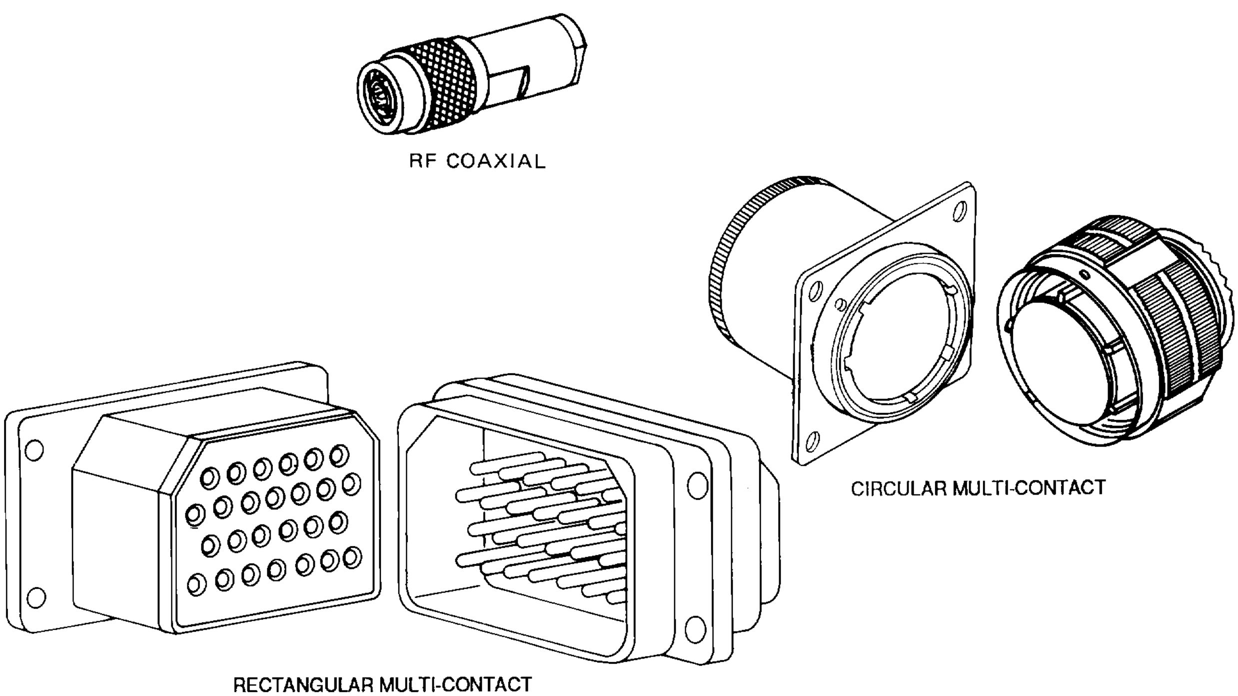
Term	Definition
Conductor spacer	Distance between adjacent edges (not centerline to centerline) of isolated conductive patterns in a conductor layer.
Conductor stop	Device on a terminal, splice, contact, or tool used to prevent excessive extension of the conductor beyond the conductor barrel.
Conductor thickness	Thickness of the conductor including all metallic coatings.
Conductor to hole spacing	Distance between the edge of a conductor and the edge of a supported or unsupported hole.
Conductor width	Observable width of the pertinent conductor at any randomly chosen point on the printed board, normally viewed from above, unless otherwise specified. (Imperfections, such as: nicks, pin-holes, or scratches allowable by the relevant specification, shall be ignored).
Conduit	Tube or trough in which insulated wires and cables are run.
Configuration control	Discipline providing for uniformity in a manufactured items material, processes, geometry, and performance.
Conformal coating	Insulating protective coating, which conforms to the configuration of the object coated, applied to the completed board assembly.
Connector	Describes all devices, either plug or receptacle, used to provide rapid connect/disconnect service for electrical cable and/or wire interconnections. A fixed connector is used for attachment to a rigid surface, while a free connector mates with the wire or cable. Connectors used in military applications generally fall into three broad categories; single contact coaxial connectors, circular multi-contact connectors, and rectangular multi-contact connectors. 
Connector area	That portion of printed wiring used to provide for external electrical connections.
Connector classes	Categories based on shape, function, and smallest size contact in the series. Shapes are: cylindrical, rectangular, and keystone, etc. Functions are: hermetic, rack-and-panel, pendant, bulkhead, firewall, and feed-thru, etc. Sizes include: standard (size 16 contacts), miniature (size 20 contacts), subminiature or high-density (size 22 contacts), and micro-miniature (size 24 contacts).

Table 2. Terms And Definitions (Cont.)

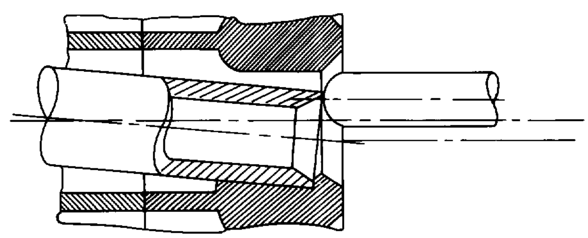
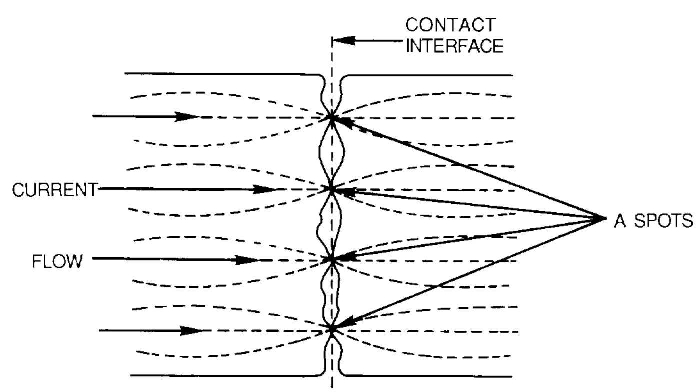
Term	Definition
Connector induced optical conductor loss (fiber optic)	Connector insertion loss, expressed in decibels, due to impurities or structural changes to the optical conductors caused by termination or handling within the connector. (See coupling loss).
Connector insertion loss	Power loss, expressed in decibels, due to insertion of a mated connector onto a cable.
Connector set, electrical	Two or more separate connectors, plug connector and receptacle connector, designed to be mated together. The set may include mixed connectors mated together, such as one connector plug and one dummy connector receptacle, or one connector receptacle and one dummy electrical plug.
Constantan	An alloy of 55% copper and 45% nickel used in thermocouples with copper in the temperature range of 336.2°F (169°C) to 730.4°F (388°C). Temperature coefficient of electrical resistivity, 0.0002°C. Usually the copper is the positive wire and the constantan is the negative wire.
Contact	Conducting members of a connecting device which are designed to provide a separable electrical connection. (See socket contact, pin contact, nude contact, dressed contact).
Contact alignment	Defines the overall side play which contacts have within the insert cavity to permit self alignment of contacts. Sometimes referred to as the amount of contact float. 
Contact area	When two contacts are joined, true areas of contact occur only at minute points of asperity spread over the two interface surfaces. These are shown as A spots. Their number and location depend on the shape and finish quality of the two contact members. 
Contact cavity	Defined hole in the connector insert into which the contacts must fit.
Contact engaging and separating force	Force needed to either engage or separate pin and socket contacts when they are in and out of connector inserts. Values are generally established for maximum and minimum forces. Performance acceptance levels vary by specification and/or customer requirements. Contact engaging and separating force is not only measured initially, but after a specified number of engagements and separations. (See contact pressure).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Contact, insertable/ removable	Contact that can be mechanically joined to, or removed from an insert. Usually special tools lock the contact in place or remove it for repair or replacement. (See front release contact, rear release contact).
Contact inspection hole	Hole in the cylindrical rear portion of a contact used to check the depth to which a conductor has been inserted. Crimp-type contacts usually have inspection holes, solder-types seldom do. Larger solder-type sizes have contact inspection holes in which the hole's function is to allow solder and air to bleed out during soldering.
Contact length	Length of travel made by one contact in contact with another during assembly or disassembly of a connector. (See contact wipe, wiping action).
Contact plating	Metal plated over basic contact metal to provide required contact resistance, wear resistance, and electrical conductivity. Contact platings may be classified as noble: gold, rhodium, palladium, and platinum; or non-noble: tin, tin-lead, silver, and nickel.
Contact pressure	Force which mating surfaces exert against one another.
Contact resistance	Maximum permitted electrical resistance of pin and socket contacts when assembled in a connector. Carrying a specific test current, electrical resistance of each pair of mated pin and socket connections is determined by measuring from the pin to the extreme terminal end of the socket (excluding both crimps). Overall contact resistance includes wire to wire measurement.
Contact retaining member	Device, on the contact or in the insert, to retain the contact in an insert or body.
Contact retention	Axial load, in either direction, which a contact can withstand without being dislodged from its normal position within an insert or body.

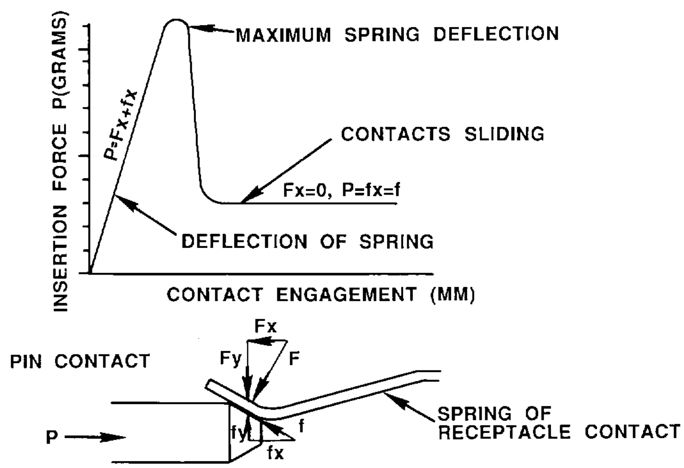


Table 2. Terms And Definitions (Cont.)

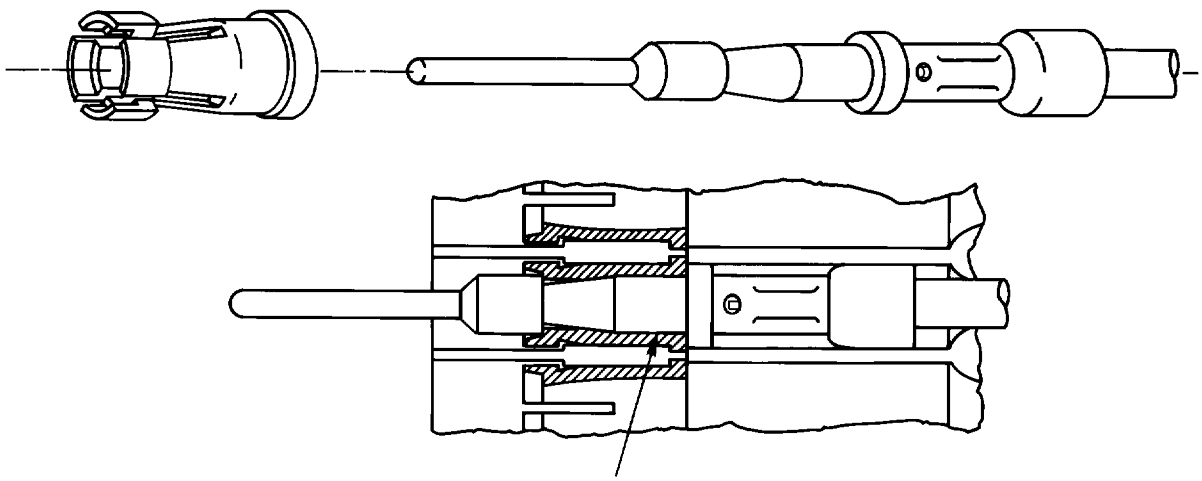
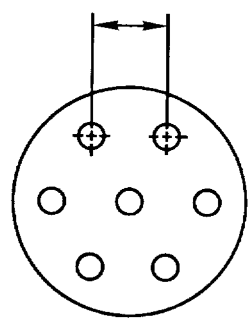
Term	Definition
Contact shoulder	Flanged portion of the contact which limits its travel into the insert.  CONTACT SHOULDER
Contact size	Defines the largest size wire which can be used with the specific contact. By specification dimensioning, it also defines the diameter of the engagement end of the contact. For example, size 16 AWG contacts will accept a wire up to 16 AWG.
Contact spacing	Distance between centers of contacts within an insert. 
Contact spring	Spring placed within the socket type contact to force the pin into a position of positive direct contact. Depending upon the application, various types are used including leaf, cantilever, napkin ring, squirrel cage, hyperbolic, and Chinese finger springs. All types perform the function of wiping and establish good contact. Several metal alloys are used. For example, beryllium copper is used where high conductivity and long life are required. Stainless steel, while its conductivity is only about 2%, is used in high temperature applications.
Contact wipe	Distance of travel (electrical engagement) made by one contact with another during its engagement or separation, or during mating or unmating of the connector halves. (See wiping action).
Contaminant	Impurity or foreign substance present in a material or on a surface which affects performance of the material or circuit.
Continuity	When a conductor path is complete from one point to another and will allow electrical current to flow between the two points.
Continuity check	Test performed on a length of finished wire or cable to determine if the electrical current flows continuously throughout the length. Separate conductors may also be checked against each other to ensure there are no shorts.

Table 2. Terms And Definitions (Cont.)

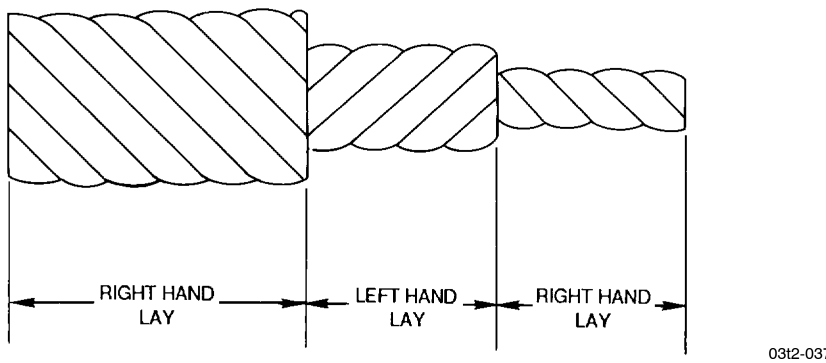
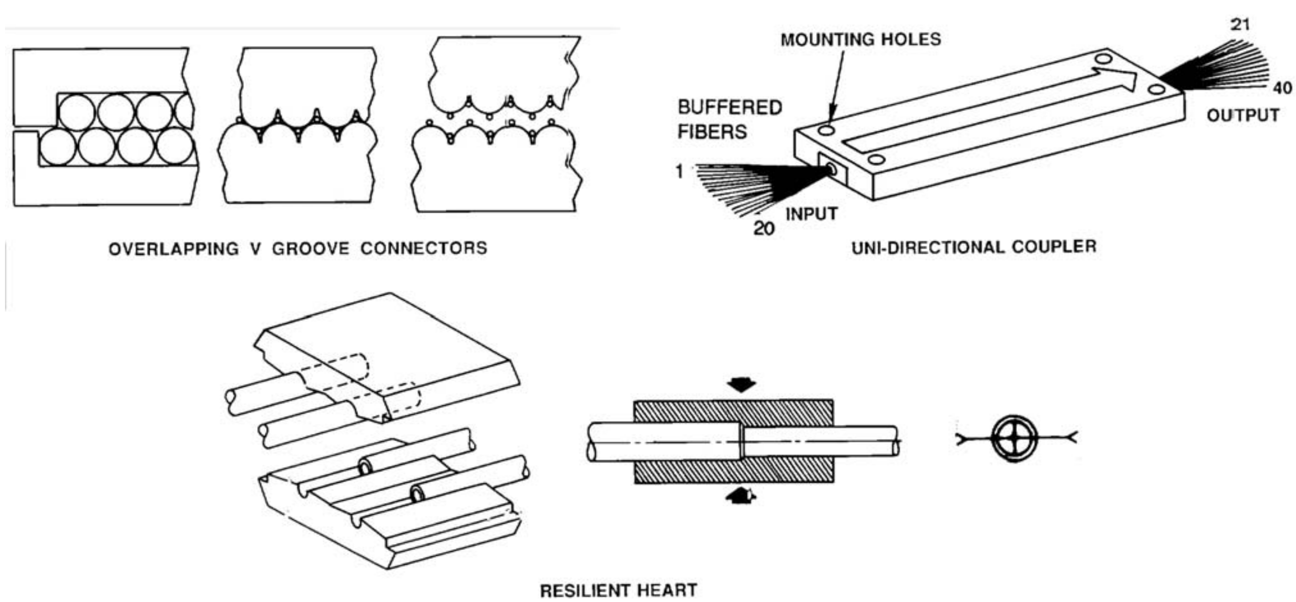
Term	Definition
Continuous duty	In some portable cords there are two standard number of strands of a given wire size. The one with the greater number (most flexible) is called continuous duty, and the other is called stationary duty.
Continuous Vulcanization (CV)	Simultaneous extrusion and vulcanization of rubber type materials usually by application of steam and pressure.
Contrahelical lay	Term meaning the application of two or more layers of spirally applied materials where each successive layer is wrapped in the opposite direction to the preceding layer. (See true concentric). 
Controlled impedance cable	Package of two or more insulated conductors where impedance measurements between respective conductors is kept essentially constant throughout the entire length.
Control wire and cable	Any wire which carries current to control a valve, to control a relay, or to cause any event without actually carrying the energy controlled in the event.
Copolymer	Compound formed from the chemical reaction of two different monomers with each other.
Copper and copper alloys	Available in rod, sheet, foil, tube, and wire forms. On a volume basis, copper has the best conductivity of the common (non-precious) metals. Copper and copper alloys offer excellent corrosion resistance, high thermal conductivity, and ease of fabricating, joining, and forming. However, copper and copper alloys are readily attacked by alkalies. The strength to weight ratio of copper is relatively low and it loses strength at elevated temperatures. Copper is the most widely used electrical conductor in wires and cables.
Copper clad invar	Strip material consisting of outer layers of copper metallurgically bonded to a core of invar, a nickel-iron alloy with low thermal expansion characteristics. The composite is used as a substrate, thermal plane, and/or heat sink for ceramic and/or silicon package interconnection.
Copper clad stainless steel	Strip material consisting of outer layers of copper metallurgically bonded to a core of stainless steel. Used in lead frame applications to achieve the optimum combination of thermal conductivity, mechanical strength, and fracture resistance.
Copper-covered steel wire	Wire having a steel core to which an outer shell of copper is fused.
Copperweld	Trade name for copper-clad steel conductors.
Cord	Small flexible insulated cable constructed to withstand mechanical abuse. There is no sharp dividing line in respect to size between a cord and a cable, but generally a cord is considered to be 10 AWG or smaller.
Cordierite	Cordierite ceramics exhibit a very low thermal coefficient of expansion. This aids in their ability to withstand extreme thermal shocks. They have poor mechanical strength and relatively poor dielectric properties at high frequencies.
Cordwood construction	Method of mounting components perpendicular between two printed wiring boards.

Table 2. Terms And Definitions (Cont.)

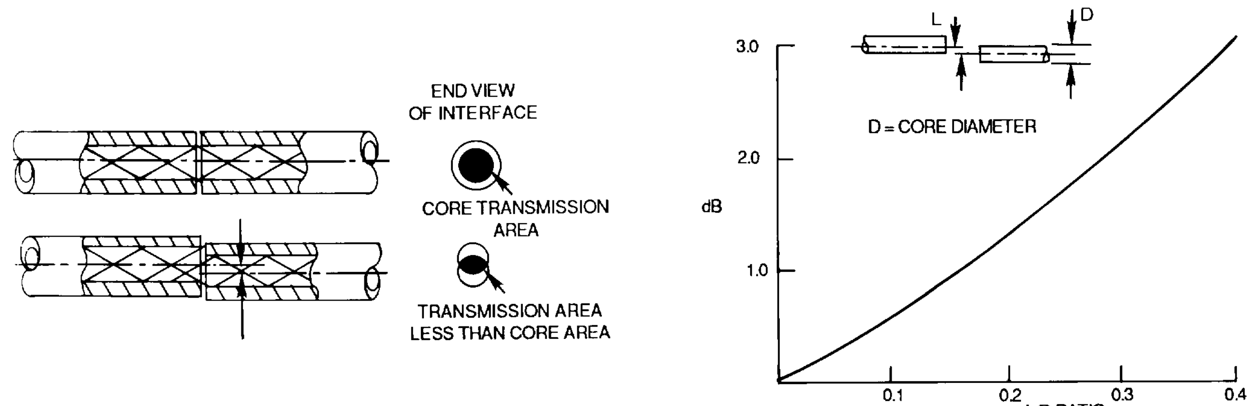
Term	Definition
Cord sets	Portable cords fitted with any type of wiring device at one or both ends.
Core	(1) In cables, a component or assembly of components over which additional components are applied, such as a shield, a sheath, or armor. (2) In fiber optic, high refractive index central material of an optical fiber through which light is propagated. (See fiber).
Core-to-cladding ratio (fiber optic)	Ratio of the cross-sectional area of the core to the total cross-sectional area of the fiber.
Corona	Luminous discharge due to ionization of the gas surrounding a conductor around which exists a voltage gradient exceeding a certain critical value.
Corona initiation point	Value in the application of an increasing electrical potential where corona is first noticed by a detection device.
Corona resistance	Time that the insulation will withstand a specified level of ionization that does not result in the immediate complete breakdown of the insulation.
Corrosion	The most common kind of corrosion is that of rusting. This is a special case of a general classification known as atmospheric corrosion, or oxidation, wherein the oxygen of the atmosphere reacts with the material in question. Most metals, with the exception of the noble metals such as gold, can be oxidized by atmospheric oxygen. Usually water vapor must be present before any appreciable oxidation takes place. Corrosion is considered to consist of the slow chemical and electrochemical reactions between a metal and its environment.
Cosmetic defect	Variation from the conventional appearance of a product, such as a slight change in color or surface finish not necessarily detrimental to service performance.
Cotton	Used for servings and braids. Flexibility and strength are good. Treatments are required to provide chemical and fungus resistance. Heat resistance is limited.
Coulomb (C)	Unit quantity of electricity; the quantity transferred by one ampere in one second.
Coupler (fiber optic)	Optical device used to interconnect three or more optical conductors.



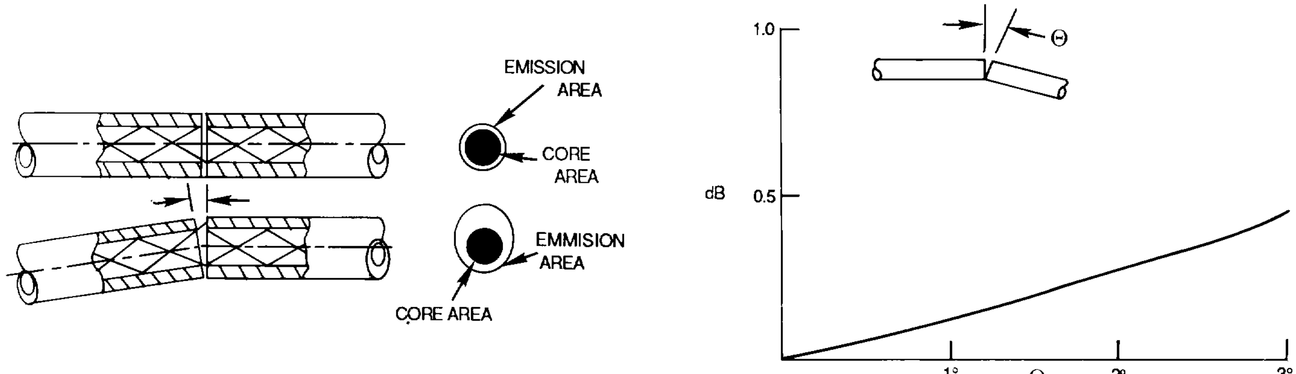
Coupling efficiency	Fraction of available output from a radiant source which is coupled and transmitted by an optical fiber.

Table 2. Terms And Definitions (Cont.)

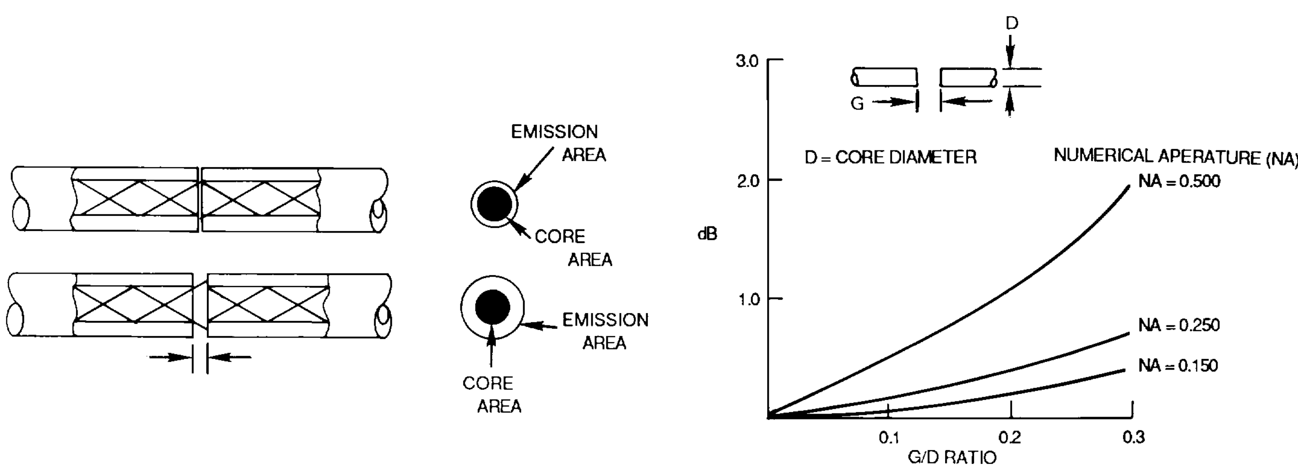
Term	Definition
Coupling loss (fiber optic)	Total optical power loss within a junction, expressed in decibels, due to small differences in numerical aperture, core diameter, core concentricity, and tolerances in splicing connectors when two fibers are aligned. Also known as splicing loss and transfer loss.



LATERAL MISALIGNMENT LOSS



ANGULAR LOSS



GAP LOSS

Table 2. Terms And Definitions (Cont.)

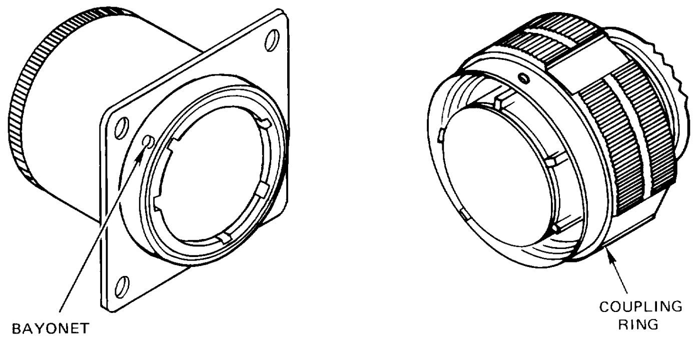
Term	Definition
Coupling ring	Device used on cylindrical connectors to lock plug and receptacle together. It may or may not give mechanical advantage to the operator during the mating operation. 
Coverage	Calculated percentage which defines the completeness in which a metal braid covers the underlying surface. The higher percentage of coverage, the greater the protection against external interference.
Cover, electrical connector	Item which is specifically designed to cover the mating end of a connector for mechanical and/or environmental protection.
Coverings	Textile braids or jackets of rubber, plastics, or other materials applied over wire and cables to provide mechanical protection and possible identification.
Crazing	Minute cracks on the surface of materials such as plastics.
CRCS	Continuous Rigid Cable Support, synonymous with tray.
Creep	Time-dependent strain occurring under stress. The creep strain occurring at a diminishing rate is called primary creep; that occurring at a minimum and almost constant rate is secondary creep; that occurring at an accelerating rate is tertiary creep.
Creepage	Conduction of electricity across the surface of a dielectric.
Creepage path	Path across the surface of a dielectric between two conductors. Lengthening the creepage path reduces the possibility of arc damage or tracking.
Creep distance	Shortest distance on the surface of an insulator separating two electrically conductive surfaces.
Creeping surface	Insulating surface which provides physical separation as a form of insulation between two electrical conductors of different potential.
Creep strength	Characteristic of a material which describes strength and resistance to elongation, i.e. stretching, at low loads. This characteristic can be measured either as the load to fracture the sample at a given temperature, or the load that will produce a given percent of stretch, or elongation, at a given temperature.
CRES	Designation for Corrosion Resistant Steel.
Crimp	Physical compression (deformation) of a contact barrel around a conductor in order to make an electrical connection.
Crimp contact	Contact whose conductor barrel is a hollow cylinder accepting the conductor. After a bared conductor is inserted, a crimping tool is applied to swage or form the contact metal firmly against the conductor. Excellent mechanical and electrical contact results. Often referred to as a solderless contact.

Table 2. Terms And Definitions (Cont.)

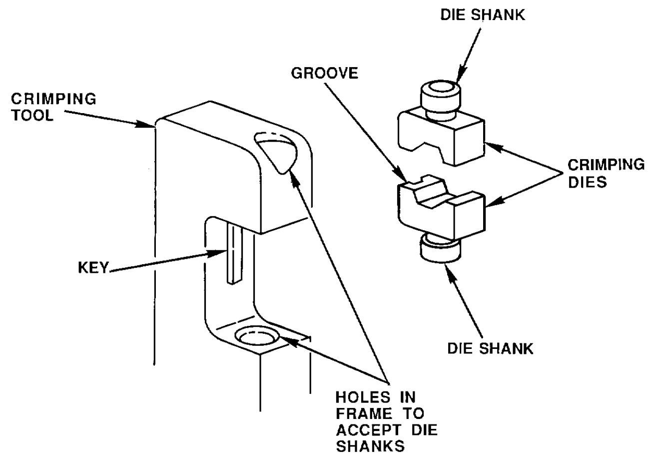
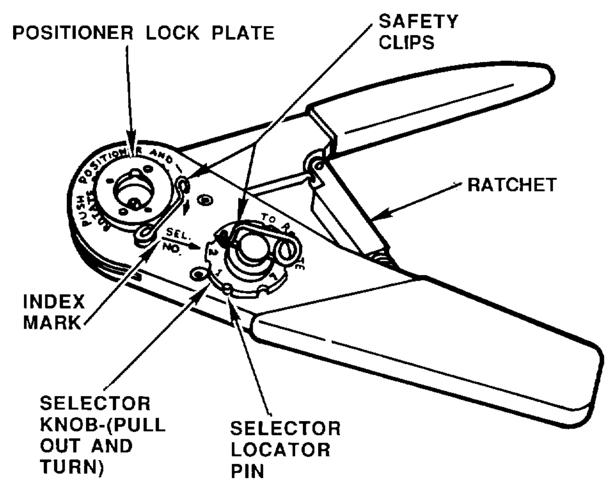
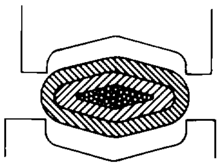
Term	Definition
Crimping die	Portion of the crimping tool that shapes the crimp. 
Crimping tool	Mechanism used for crimping. (See crimp termination).  M22520/2-01 CRIMP TOOL FRAME

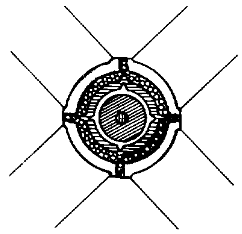
Table 2. Terms And Definitions (Cont.)

Term	Definition
Crimp termination	Connection in which a metal sleeve is secured to a conductor by mechanically crimping the sleeve with pliers, presses, or automated crimping machines. Splices, terminals, and multicontact connectors are typical terminating devices attached by crimping.



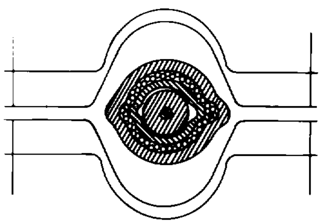
SYMMETRICAL

USED ON INSULATED CRIMP BARRELS



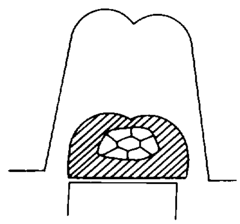
FOUR INDENT

AS USED ON FERRULES FOR SHIELDED WIRE



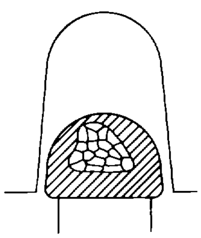
CIRCUMFERENTIAL

USED ON INNER/OUTER FERRULES FOR SHIELDED WIRE



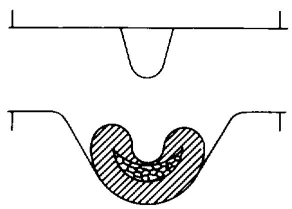
B CRIMP

FOR OPEN-SADDLE FORMED CONTACTS



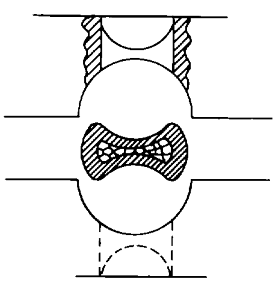
D CRIMP

FOR OPEN-SADDLE FORMED CONTACTS (ALSO USED ON SOLID WIRE)



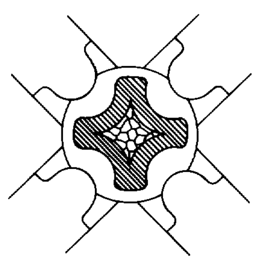
NEST AND INDENT

USED FOR LUGS AND OTHER SOFT BARREL TERMINALS. WILL COVER A BROAD RANGE OF WIRE SIZES



TWO INDENT

HOLDS BARREL FROM EXPANDING. GOOD FOR HARDER MATERIALS



FOUR INDENT

PROVIDES MINIMUM DISTORTION WITH BROAD RANGE OF WIRE SIZES. GOOD FOR HARDER MATERIALS

Table 2. Terms And Definitions (Cont.)

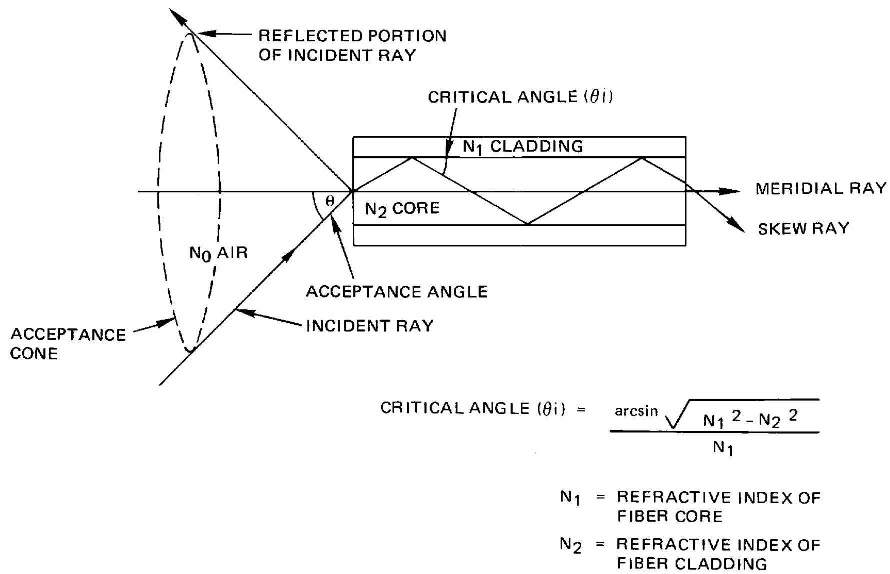
Term	Definition
Critical angle (fiber optic)	Maximum angle at which light can be propagated within a fiber. 
Crossed wire	Technique of measuring contact resistance that eliminates all resistances but the resistance of the contact point.
Cross-linked	Intermolecular bonds produced between long chain molecules in a material to increase molecular size by chemical or electron bombardment, resulting in an improved change in physical properties in the material.
Cross-Linked Polyethylene (XLPE)	Polyethylene material that has been modified by chemical or irradiation processing to change it from a thermoplastic to a thermoset material. It has good resistance to cut-through, solvents, and abrasion. Most often used in 600 to 2000 V control cable applications. Normally rated 194°F (90°C).
Cross-sectional area of a conductor	Sum of the cross-sectional areas of its component wires. Each wire is measured perpendicular to its individual axis.
Crosstalk	(1) Undesired electrical currents in conductors caused by electromagnetic or electrostatic coupling from other conductors or from external sources. Also called spurious signal. (See inductive coupling, capacitive coupling). (2) In fiber optic, leakage of optical power from one optical conductor to another.
Cryogenics	Study of the behavior of matter at super-cold temperatures.
Crystal	Solid composed of atoms, ions, or molecules arranged in a pattern which is repetitive in three dimensions.
Crystalline	Describes material which has atoms or molecules arranged in geometric repeating patterns. Salts and metals are the most common examples of crystalline materials. With a crystalline material, the dividing line between atoms and molecules is usually obliterated. The number of repeating patterns of atoms that form the crystal are generally not fixed, but are dependent upon the conditions under which the crystal was formed. No definite number of atoms go into an individual crystal. Since these atoms are not grouped in any way other than the regular geometry of the crystal, there is no real meaning to the subdivision of the material called a molecule. Crystalline materials have definite and sharp melting points, which in most metals, are relatively good conductors of heat and electricity.

Table 2. Terms And Definitions (Cont.)

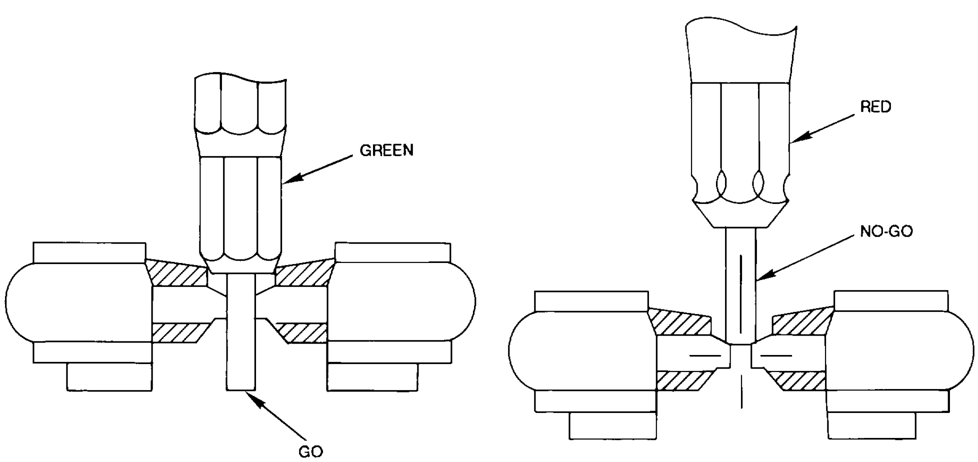
Term	Definition
Crystallization	Separation, usually from a liquid cooling phase, of a solid crystalline phase.
CSA	Canadian Standards Association, a non-profit, independent organization which operates a listing service for electrical and electronic materials and equipment. The Canadian counterpart of the Underwriters' Laboratories.
CSPE	(See Cholorosulphonated Polyethylene).
Cure	Change in the physical properties of a material by chemical reaction, by the action of heat and catalysts, alone or in combination, with or without pressure.
Cure time	Time at which ultimate physical properties of the curing thermoset plastic composition are reached. For many materials, this time may be a week or more.
Curing	Chemical energy (heat) being liberated by the reaction of an epoxy resin and a hardening agent. This heat raises the temperature of the hardening resin and increases the rate of cure.
Curing agents	Agents added to accelerate the reaction or curing of thermosetting plastics. They act as catalysts; i.e. they do not react directly with the polymer in the polymerization. Crosslinking agents are distinguished from catalysts because they react with molecules and are coupled directly into the cured system as a structural member of the polymer.
Curing cycle	Time, temperature, and pressure required for cure.
Curl	Degree to which a wire tends to form a circle after removal from a spool. An indication of the ability of the wire to be wrapped around posts in long runs.
Current-carrying capacity	Current a conductor of given size and length is capable of carrying safely without exceeding its temperature limitations.
Current density	Plating term referring to the amount of electrical current (amperes) passing through an anode (or cathode) divided by the surface area (square feet) of the anode. For example, if an anode 1 foot by 2 feet by 1 foot thick was totally immersed in the plating solution, its surface area would be 10 square feet. If 16 amperes of current are passing through the anode, then the current density of that anode would be 1.6 amperes per square foot.
Current (I)	Rate of transfer of electricity, measured in amps, which represents the transfer on one coulomb per second. (See ampere, formulas-electrical).
Current rating	Maximum continuous electrical flow of current recommended for a given wire in a given situation. Expressed in amperes.
Cut-through resistance	Ability of a material to withstand mechanical pressure, usually from a sharp edge or small radius, without penetration.
Cutout, connector	Hole, usually round or rectangular, cut in a panel for mounting a connector. May include holes for mounting screws or bolts.
CV	(See Continuous Vulcanization).
CVD	(See Chemical Vapor Disposition).
Cyanoethyl sucrose	A liquid used as a dielectric. (See liquid dielectrics).
Cycle	Complete sequence, including reversal, of the flow of an alternating electric current. (See wavelength).
D	Used as a suffix to indicate a twin wire with two insulated conductors laid parallel under an outer nonmetallic covering.
Daisy chain	Cable assembly with three or more connectors. The term is also used as a verb.
DAP	(See Diallyl Phthalate).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Dark current	External current that, under specified biasing conditions, flows in a photodetector when there is no incident radiation.
Data link service	Service which guarantees transmission between two stations sharing the same physical medium.
Data set	Device containing the electrical circuitry necessary to connect data processing equipment to a communication channel, usually through modulation and demodulation of the signal.
Datum reference	Defined point, line, or plane used to locate the pattern or layer for manufacturing, inspection, or both.
dB	(See decibel).
dBm	Decibels above or below one milliwatt.
dBmV	Abbreviation for decibel millivolt.
DBWP	Double Braided Weatherproof cable.
DC	(See Direct Current).
D cable	Two-conductor cable, each conductor having the shape of the capital letter D, with insulation between the conductors and between conductors and sheath.
DCC wire	Double Cotton Covered magnet wire.
DCR	(See Direct Current Resistance).
Dead face	Term which describes the various methods used to protect contacts when not engaged. The most common method uses a cover on the mating ends of connectors which automatically cover the contacts when the connectors are separated. Typical is a spring powered cover which automatically flips over the faces of the plug and/or receptacle when the two are separated.
Dead front	Mating surface of a connector designed so that the contacts are recessed below the surface of the connector insulator body to prevent accidental short-circuiting of the contacts.
Decibel (dB)	Unit to express differences of power level. Used to express power gain in amplifiers, or power loss in passive circuits or cables. Ten times the logarithm (to the base 10) of the ratio of two intensities.
Decomposition	Process whereby a chemical compound is broken down into simpler constituents. An example is the breaking down of activators in rosin fluxes when soldering temperatures are reached.
Defect	Condition that impairs the usefulness of an object or a part of that object.
Definition	Sharpness of circuit patterns as reproduced in the master film, in the resist film, or in the circuit after etching.
Degree of cure	Arbitrary term approximating the percentage of ultimate performance properties; such as, flexural strength, deflection temperature, and volume resistivity, reached by a curing thermoset plastic composition at any given time.
Degree rise	Amount of increase in temperature caused by the introduction of electricity into a unit.
Deionized and demineralized water	Water which has been treated to remove the small quantity of minerals normally dissolved in hard water. In addition, any ions present are also removed in the process. Pure water is required for certain applications in the electronic and semiconductor industries where extreme precautions must be taken to remove or reduce contamination on parts rinsed in the water.
Delamination	Separation between any of the layers of a base material, or between the laminate and the conductive foil, or both.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Delay line	Cable made to provide a very low velocity of propagation with long electrical delay for transmitted signals.
Demodulation	Process of separating a data (digital) signal from an analog carrier signal.
Denier	Term that describes the weight of a yarn (not cotton or spun rayon) which in turn determines its physical size.
Density	Ratio of the weight or mass of a substance to its volume. For example, the density of water is 62.4 lbs./cu.ft. Units of measurement can also be grams per cubic centimeter, in place of pounds and cubic feet.
Depth of crimp	Thickness of the crimped portion of a connection measured between two opposite points on the crimped surface. (See T dimension).
Derating factor	Factor used to reduce the ampacity of a wire when in environments other than that for which the value was established.
Detector (fiber optic)	Device which converts optical energy to electrical energy, such as a PIN photodiode. The optical receiver in a fiber optic system. (See fiber optics).
Detent	Bump or raised section projecting from the surface of a spring or other part.
Dewetting	Condition which results when molten solder has coated a surface and then receded, leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film. Base metal is not exposed.
D-glass	Fibers of glass with high boron content used in laminates for controlling dielectric constant.
Diallyl Phthalate (DAP)	Thermosetting molding materials used in electrical/electronic applications where high arc resistance and dielectric strength, low dielectric loss, and good mechanical properties must be maintained under high humidity and temperature conditions. They can be produced to withstand 350°F (176.7°C).
Dichlorofluoromethane	Gas used as a dielectric. (See gaseous dielectrics).
Die	(1) Device used in the drawing of wire which reduces it to achieve a predetermined diameter. (2) That part of a plastic extrusion machine that forms the plastic compound around the wire or cable.
Die closure	Gap between indenter dies at full handle closure. Usually defined by Go/No-Go dimensions.



TYPICAL DIE CLOSURE CHECK

Table 2. Terms And Definitions (Cont.)

Term	Definition
Dielectric	(1) Any insulating medium which intervenes between two conductors and permits electrostatic attraction and repulsion to take place across it. (2) Material having the property that energy required to establish an electric field is recoverable in whole or in part, as electric energy.
Dielectric absorption	Property of an imperfect dielectric where there is an accumulation of electric charges within the body of the material when placed in an electric field.
Dielectric breakdown	Voltage required to cause an electrical failure or breakthrough of the insulation.
Dielectric constant (K)	Property of a dielectric which determines the electrostatic energy stored per unit volume for unit potential gradient. The ratio of the capacitance between two electrodes separated by the dielectric, as compared to the same electrodes separated by a vacuum. Also called permittivity and specific inductive capacity.
Dielectric loss	Time rate at which electric energy is transformed into heat in a dielectric when subjected to a changing electric field.
Dielectric loss angle	Difference between ninety degrees and the dielectric phase angle. Also called dielectric phase difference.
Dielectric loss factor	Product of dielectric constant and the tangent of the dielectric loss angle. Also called dielectric loss index.
Dielectric phase angle	Angular difference in phase between the sinusoidal alternating potential difference applied to a dielectric, and the component of the resulting alternating current having the same period as the potential difference.
Dielectric power factor	Cosine of the dielectric phase angle, or sine of the dielectric loss angle.
Dielectric strength	Maximum voltage that a dielectric material can withstand, under specified conditions, without rupturing. Usually expressed as a voltage gradient (volts/unit thickness). Also called electric strength and disruptive gradient.
Dielectric strength and breakdown test equipment	High potential test equipment is produced in both alternating current and direct current types. Equipment for measuring dielectric breakdown of electrical insulation: a 60 Hz step-up transformer, a variable primary voltage, a circuit breaker, and a means of indicating the voltage applied.
Dielectric test	Test in which a voltage, higher than the rated voltage, is applied for a specified time to determine the adequacy of the insulation under normal conditions.
Diffusion	Physical process whereby one material passes, i.e., diffuses, through another. The diffusion of gases through solid materials, or the diffusion of one metal with another are examples. In soldering, the gold of a gold-plated object migrates or diffuses into solder.
Digital signal	Signal that is either zero (off) or one (on), rather than as a continuum of voltages.
Diode	Semiconductor device with two electrodes, cathode and anode, having a much greater resistance in one direction. In the forward biased condition, anode voltage more positive than cathode, current flows through the device with little resistance. In the reversed biased condition, cathode voltage more positive than anode, current flow is effectively blocked. Zener diodes are designed to operate in the reverse biased condition until a certain breakdown or avalanche voltage is reached. This quality is useful in voltage regulation.
DIP	(See Dual In-line Package).
Dip brazing	Brazing by immersion in a molten salt or metal bath. Where a metal bath is employed, it may provide the filler metal.
Dip coating	Method of coating an article by dipping it into tank or resin, and chilling the coating which adheres to the surface.

Table 2. Terms And Definitions (Cont.)

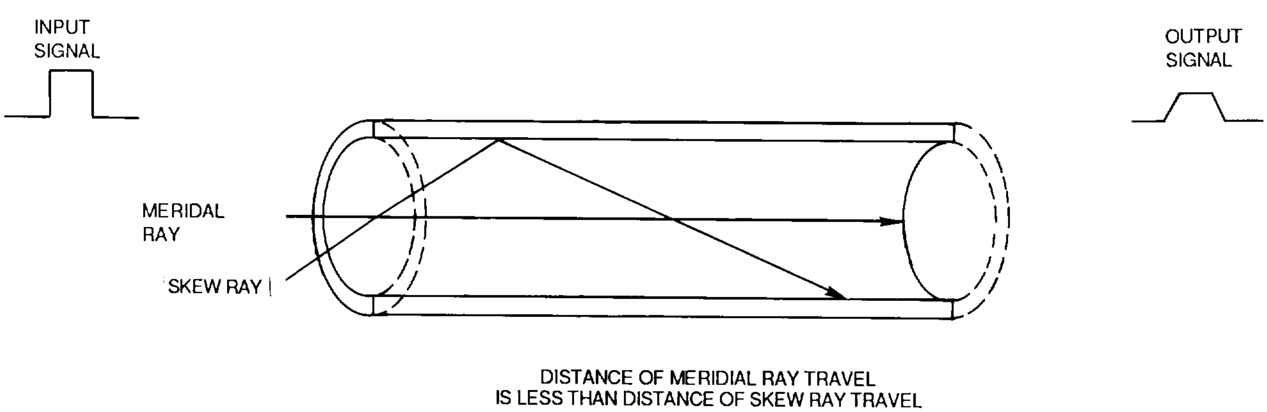
Term	Definition
Dip soldering	Process whereby printed boards are brought in contact with the surface of a static pool of molten solder for the purpose of soldering the entire exposed conductive pattern in one operation.
Dip solder terminal	Terminals on a connector which are inserted into holes in the printed circuit board and then soldered in place.
Direct capacitance	Capacitance measured directly from conductor to conductor through a single insulating layer.
Direct Current (DC)	Electric current which flows in only one direction.
Direct Current Resistance (DCR)	Resistance offered by any circuit to the low of direct current.
Directional coupler	Passive device used in a cable system to divide or combine unidirectional RF power sources.
Discrete component	Circuit component having an individual identity, such as a transistor, capacitor, or resistor.
Discrete wiring	Wire or wires having distinct identity and individuality of purpose.
Dispersion (fiber optic)	(1) Spread out or broadening of a light pulse as it propagates through the optical conductor. Dispersion increases with length of conductor and is caused by the difference in ray path lengths within the fiber core. (2) Variation of the refractive index of a material with wave-length. This variation causes light of different wave-lengths to travel at different velocities in the material. They are also bent differently as they pass from one material to another. This creates the familiar spectrum when white light passes through a prism. 
Displacement current	Current which exists in addition to ordinary conduction current in AC circuits. Proportional to the rate of change of the electric field.
Disruptive discharge	Sudden and large increase in current through an insulation medium, due to the complete failure of the medium under electrostatic stress.
Disruptive gradient	(See dielectric strength).
Dissipation factor	Measure of the AC loss. Dissipation factor is proportional to the power loss per cycle (f) per potential gradient (E squared) per unit volume as follows: $\text{Diss Fac} = \dfrac{\text{power loss}}{E^2 \times f \times \text{volume} \times \text{constant}}$

Table 2. Terms And Definitions (Cont.)

Term	Definition
Distillation	Boiling or evaporation process generally used to separate one liquid component from a mixture of other liquids. In soldering, for example, the cleaning solution used to remove flux residues after soldering can be distilled. By maintaining the proper temperature, the basic solvent is boiled off, leaving behind a residue of soil that has been removed from the work. The solvent vapors are then collected and condensed back into the liquid form and reused.
Distortion	Any deviation from the desired shape or contour.
Distortion-limited operation	Condition prevailing when distortion of a received signal, rather than its amplitude (or power), limits performance.
Disturbed conductor	Conductor that receives energy generated by the field of another conductor or an external source such as a transformer.
Disturbing conductor	Conductor carrying energy that creates spurious signals in another conductor.
Dopant	Material, usually germanium or boron oxide, added to silica to change its index of refraction.
Double-faced tape	Tape finished on both sides with a rubber or synthetic compound.
Double shield	Two shields, one over the other. Maximum coverage 98%. (See shield).
Double-sided board	Printed board with a conductive pattern on both sides.
Drag in	Water or solution carried into another solution by the work and the associated handling equipment.
Drag-out	Solution carried out of a bath by the work and the associated handling equipment.
Drain wire	In a cable, an uninsulated wire laid over the component or components and used as a ground connection and method of termination for a shield.
Draw feed stock	Rod or wire that is subsequently drawn to a smaller size.
Drawing	In wire manufacture, pulling the metal through a die or series of dies to reduce the diameter to a specified size.
Dressed contact	Contact with a permanently attached contact retaining member.
Dross	Metal oxides and other entrapped impurities which float in or on the surface of a molten metal bath. In the case of solder, it would include the oxides of lead and tin. In addition to non-metallic impurities such as flux residues that were dragged into the solder bath and oxides of any metal impurities found in the solder.
Drummed packing	(See barrel-packed).
Dual coaxial cable	Two individually insulated conductors laid parallel or twisted, and placed within an overall shield and sheath.

Table 2. Terms And Definitions (Cont.)

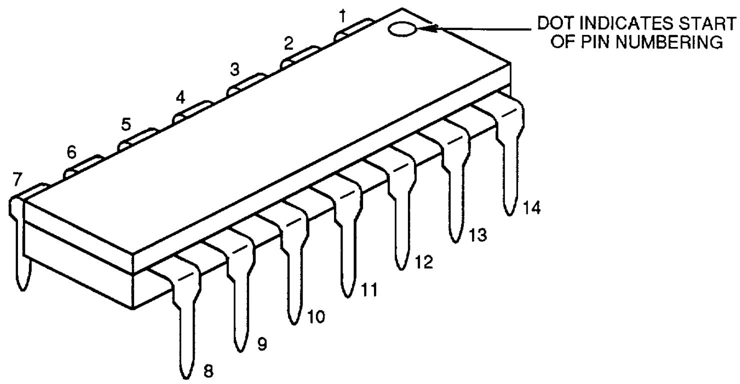
Term	Definition
Dual In-Line Package (DIP)	Carrier in which a semiconductor integrated circuit is assembled and sealed. Package consists of a plastic or ceramic body with two rows of vertical leads which are inserted into a circuit board and secured by soldering. 
Duct	Underground or overhead tube for carrying electrical conductors or cable.
Ductility	Ability of a material to deform plastically without fracturing. Measured by elongation or reduction of area in a tensile test, by height of cupping in an Erichsen test, or by other means.
Dummy connector	Connector which does not have provisions for attaching conductors. Generally used for storage of a cable assembly connector.
Dumping period	Length of time a material, such as a liquid flux or the solder in a solder pot, can be used before it is necessary to replace with new material.
Duplex	Characteristic of data transmission either full or half duplex.
Duplex cable	Cable composed of two insulated single conductor cables twisted together. The assembled conductors may or may not have a common covering of binding or protecting material. (See parallel pair).
Durometer	Measurement device used to determine the hardness of a substance.
Dust cover	(See cover, electrical connector).
Dyne	The unit of force in the centimeter-gram-second system equal to the force that would give a free mass of one gram an acceleration of one centimeter per second per second.
E	(1) (See voltage). (2) (See Enamel).
E-glass	Electrical glass; fibers of glass with low alkali borosilicate, used to reinforce plastics and provide high resistivity.
Eccentricity	Like concentricity, a measure of the center of a conductors location with respect to the circular cross section of the insulation. Expressed as a percentage of displacement of one circle within the other.
ECMA	European Computer Manufacturers Association.
ECTFE	(See Ethylene-Chlorotrifluoroethylene).
Eddy currents	Circulating currents induced in conducting materials by varying magnetic fields. Usually undesirable because they represent loss of energy and cause heating.

Table 2. Terms And Definitions (Cont.)

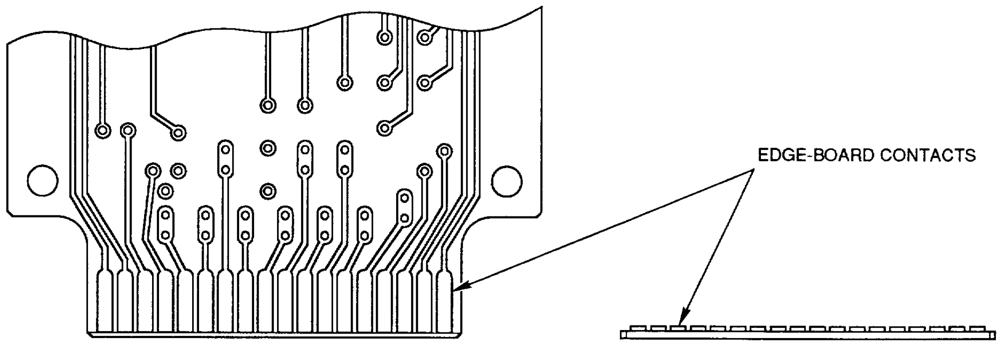
Term	Definition
Edge-board contacts	Series of contacts printed on or near any edge of a printed circuit board and intended for mating with an edge connector. 
Edge connectors, printed circuit boards	One-piece. Connector mates directly with Printed Circuit (PC) board by slipping over and gripping board edge. Connection is made between spring contacts in connector and edge-board contacts on PC board. The PC board acts as one-half of the connector.
Edge margin	(See margin).
EEI	Edison Electric Institute.
Egg crating	Insulation walls between each cavity within the contact wire entry face of the connector housing normally allows the rear portion of the contact to be fully protected by housing material, thereby preventing shorts between adjacent contacts, and minimizing the danger of shock. Sometimes used to improve crosstalk characteristics or to minimize the flexing of wires and/or contacts.
EIA	Electronic Industries Association.
EIA Interface	Standardized set of signal characteristics (time duration, voltage, and current) specified by the EIA.
Elastic deformation	Change of dimensions accompanying stress in the elastic range. Returning to original dimensions upon release of stress.
Elasticity	That property of a material which tends to recover its original size and shape after deformation.
Elastic limit	Maximum stress to which a material may be subjected without any permanent strain remaining upon the complete release of stress.
Elastic modulus	(See modulus of elasticity).
Elastomer	(See rubber).
Electric connector	Provides fiber optic transceiver access to AC power, then transmits this power source to the unit's power converter.
Electrical insulation	This property is the inverse of electrical conductivity and is proportional or related to electrical resistance. The insulating properties of a material describe its ability to restrict or block the flow of electricity. (See resistance).
Electrical Moisture Absorption (EMA)	Water tank test during which submerged cables are subjected to voltage and the water is maintained at rated temperature. The immersion time is long, with the object being to accelerate failure due to moisture in the insulations. Simulates buried cable.
Electric field strength	At a given point, the vector limit E of the quotient of the force that a small stationary charge will experience by virtue of its charge, to the charge as the charge approaches zero in a macroscopic sense.

Table 2. Terms And Definitions (Cont.)

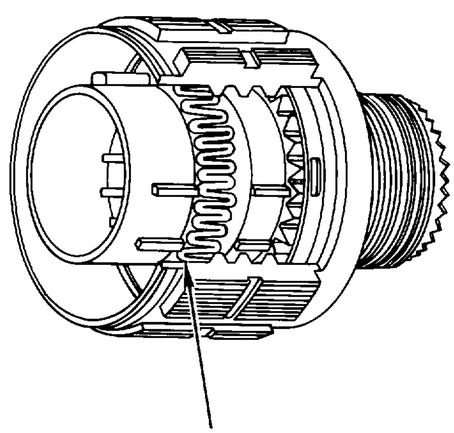
Term	Definition
Electric resistance soldering	Soldering by connecting work between a ground and an electrode, or between two movable electrodes, to complete an electrical circuit. Coalescence is produced by means of resistance of work or tips connecting the work to the electric current.
Electric strength	Maximum potential gradient that the material can withstand without rupture. Value obtained for the electric strength will depend on the thickness of the material, and on the method and conditions of test. Also called dielectric strength or disruptive gradient.
Electrode	Conductor, not necessarily metal, through which a current enters or leaves an electrolytic cell, arc, furnace, vacuum tube, gaseous discharge tube, or any conductor of the nonmetallic class.
Electrode potential	Potential of a half cell, as measured against a standard reference half cell.
Electrolyte	This term is commonly applied to substances which, either in the molten state or in solution, conduct electricity by transfer to ions. The more important electrolytes are solutions of salts, acids, or bases, in water.
Electrolytic corrosion (soldered joint)	Deterioration of a joint produced by contact of dissimilar metals in an electrolyte.
Electrolytic Tough Pitch Copper (ETPC)	Widely used for wire and bus bars. Has a minimum conductivity of 99.99%.
Electromagnet	Coil of wire, which produces a strong magnetic field when current is sent through the coil. The field is strengthened by the addition of an iron core.
Electromagnetic field	Rapidly moving electric field and its associated moving magnetic field. Located at right angles to the electric lines of force and to their direction of motion.
Electromagnetic induction	Production of a voltage in a coil, due to a change in the number of magnetic lines of force (flux linkages) passing through the coil.
Electromagnetic Interference (EMI)	Frequency spectrum of electromagnetic radiation extending from subsonic frequency to X-rays. This term should not be used in place of the term Radio Frequency Interference (RFI). (See radio frequency interference). Shielding materials for the entire EMI spectrum are not readily available. 
Electromotive Force (EMF)	Pressure or voltage. The force which causes current to flow in a circuit.
Electromotive series	List of elements arranged according to their standard electrode potentials. In corrosion studies, the more practical galvanic series of metals is generally used. The relative position of a given metal is not necessarily the same in the two series.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Electron	That portion of an atom which circles around the center, or nucleus, and flows as current in a circuit. An electron possesses a negative electric charge, and is the smallest charge of negative electricity known.
Electronic	Pertaining to the application of that branch of science which deals with the motion, emission, and behavior of currents of free electrons, especially in vacuum, gas or photo-tubes, and special conductors or semi-conductors. Contrasted with electric which pertains to the flow of large currents in wires or conventional conductors.
Electronic hook-up wires	Wires used to make the internal connections between the various electrical parts of electronic assemblies.
Electronic wire and cable	Length of conductive or semiconductive material, with or without insulation and other refinements, which is used in an electronic application. It could be a length of cord when used as a speaker extension cable, or a piece of braided wire cable used as a chassis ground strap.
Electroplate	Electrodeposition of an adherent metal coating on a conductive object for protection, decoration, or other purposes. The object to be plated is placed in an electrolyte and connected to one terminal of a DC voltage source. The metal to be deposited is similarly immersed and connected to the other terminal. Ions of the metal transfer to the object as they make up the current flow between the electrodes.
Electrostatic powder coating	Directing resin powders with high voltage charge onto metal, to be subsequently fused.
Electro-tinned	Electrolytic process of tinning wire using pure tin.
Electrotinning	Electroplating tin on an object.
Elongation	Fractional increase in length of a material stressed in tension.
EMA	(See Electrical Moisture Absorption).
Embossing	Marker identification by means of thermal indentation leaving raised lettering on the sheath material of cable.
Embrittlement	Reduction in the normal ductility of a metal due to physical or chemical change.
Emergency overloads	Loads which occur when larger than normal currents are carried through a cable or wire over a certain period of time.
EMF	(See Electromotive Force).
EMI	(See Electromagnetic Interference).
Emitter or source	Source of optical power. (See fiber optics).
EMP	Electromagnetic Pulse.
EMV	Electromagnetic Vulnerability.
Enamel	Varnish-like finish that is applied by repeated dipping and baking cycles, producing a very thin insulation. Enamel insulation is most often used on magnet wire for motors, coil windings, and thermocouple type wire, etc.
Enameled wire	Conductor with a baked-on enamel film insulation. In addition to magnet wire, enameled insulation is used on thermocouple type wires.
Encapsulate	To coat a component or assembly in a conformal or thixotropic coating by dipping, brushing, or spraying. Generally used to protect components from environmental and/or handling stresses. (See potting).

Table 2. Terms And Definitions (Cont.)

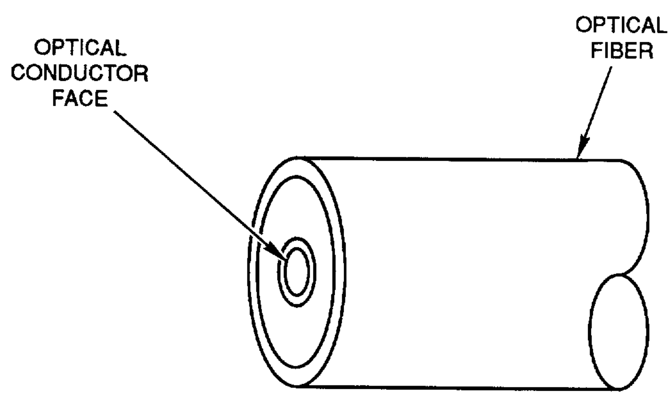
Term	Definition
Encapsulating shells and molds	Containers into which components and assemblies are inserted. After which, potting compounds are poured in the shells in order to completely surround and protect the components or assemblies. When the potting compound is cured, the unit is completely sealed. (See potting mold).
End bell	Accessory similar to a cable clamp which attaches to the back of a plug, receptacle, or junction. Serves as an adapter for the rear of termination assemblies. Some angular end bells have built-in cable clamps. Angular end bells are available up to 90°. (See accessories).
End cap	Short pieces of tubing having one end sealed. Cap is placed over the wire splice and heated to shrink and permanently seal.
End finish (fiber optic)	Surface condition at the optical conductor face. 
End separation loss	Optical power loss caused by distance between the end of a fiber and source, detector, or another fiber.
End-to-end check	Tests conducted on a completed wire and/or cable run to ensure electrical continuity.
Ends	In braiding, the number of essentially parallel wires or threads on a carrier.
Energize	To apply rated voltage to a circuit or device in order to activate it.
Energy of a charge	Given in ergs when the charge, Q, and the potential, V, are in electrostatic units, $E = 1/2QV$.
Energy of the electric field	Represented by $E = KH/8$, where H is the electric field intensity in electrostatic units, K the specific inductive capacity, and the energy of the field E is in ergs per cm.
Engaging and separating force	Amount of force needed to engage and/or separate contact elements in mating connectors. Force levels vary. Measurements are taken during initial insertion and removal, and/or after a specified number of insertion-removal cycles. (See contact engaging and separating force).
Engineering plastics	Plastics with properties suitable for high performance use.
English Legal Standard	(See British Standard Wire Gauge).
Environment	Surroundings into which wire or cable is to be placed.

Table 2. Terms And Definitions (Cont.)

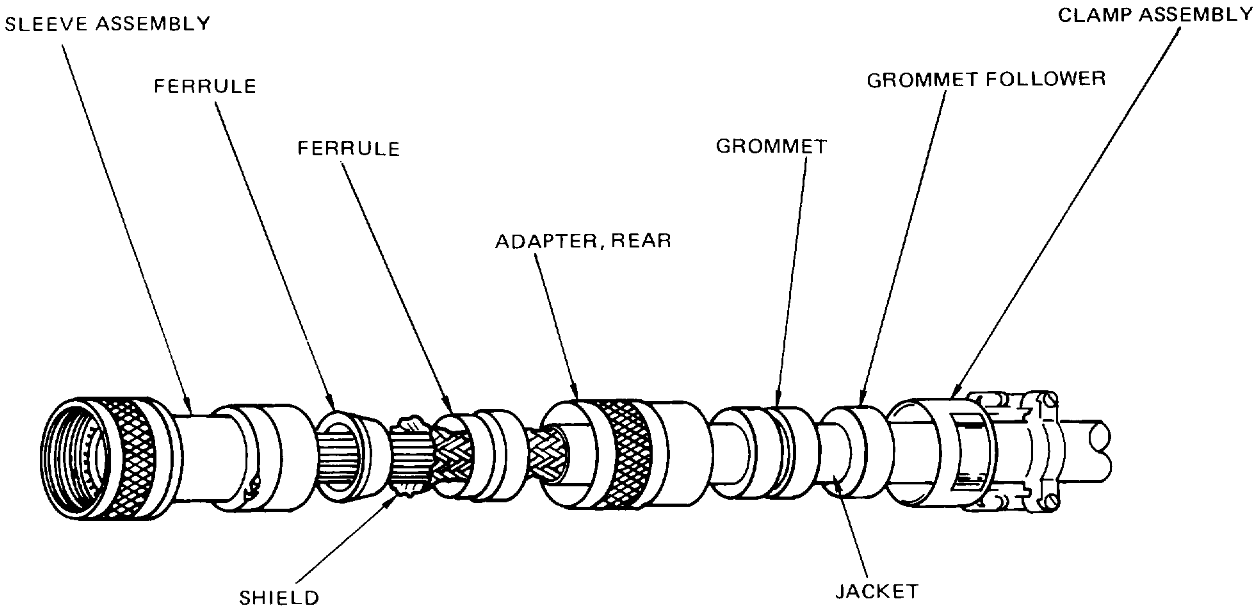
Term	Definition
Environmentally sealed	Device that is provided with gaskets, seals, grommets, potting, or other means to keep out moisture, dirt, air, or dust which might reduce performance. Does not include non-physical environments such as RF and radiation.  TYPICAL ENVIRONMENTAL SHIELDED BACKSHELL
Environment resistant	(See environmentally sealed).
EPDM	Ethylene-Propylenediene Monomer rubber.
Epoxy Potting Compound	Nonconductive, organic plastic used for encapsulation of components and wires.
Epoxy resins	Straight-chain resins based on ethylene oxide, its derivatives, or homo-logs. Used for bonding, potting connectors, and for splicing in some infield splicing kits. For magnet wire enamels, the basic resin is an epoxy of high epoxide equivalent with urea-formaldehyde modifying resins. Other resins may be present as modifiers in some enamels. (See potting compound-epoxy).
EPR	(See Ethylene Propylene Rubber).
EPT	Ethylene-Propyleneterpolymer rubber.
Equalization	Means of modifying the frequency response of an amplifier or network, thereby resulting in a flat overall response.
Equilay	More than one layer of helically laid wires with the direction of lay reversed for successive layers, but with the length of lay the same for each layer.
Equilibrium	Dynamic condition of balance between atomic movements, where the resultant is zero and the condition appears to be one of rest, rather than change.
Equilibrium diagram	Graphical representation of the temperature, pressure, and composition limits of phase fields in an alloy system as they exist under conditions of complete equilibrium. In metal systems, pressure is usually considered constant.

Table 2. Terms And Definitions (Cont.)

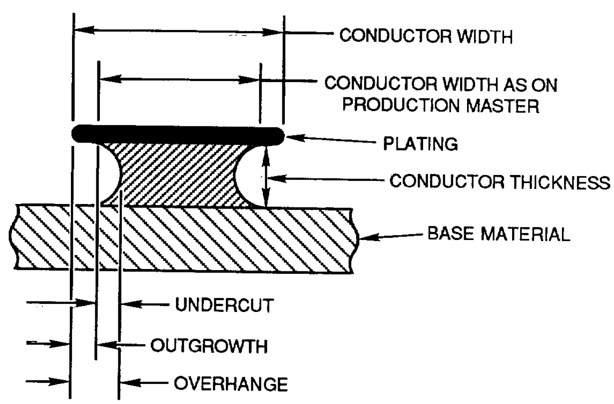
Term	Definition
Equilibrium length	For a specific excitation condition, the length of multimode optical wave-guide necessary to attain stable distribution of power among propagating modes.
Equilibrium Mode Distribution (EMD)	Condition in a multimode optical fiber in which the relative power distribution among the propagating modes is independent of length.
Erg	A centimeter-gram-second unit of work equal to the work done by a force of one dyne acting through a distance of one centimeter.
Error detection	Checking for errors in data transmission. A calculation is made on the data being sent and the results are sent along with it.
Error detection code	Code in which each data signal conforms to specific rules of constructions so that departures from the norm errors are automatically detected.
Ester	Reaction product of an alcohol and an acid.
Etchant	Solution used, by chemical reaction, to remove the unwanted portion of a conductive material bonded to a base.
Etchback	Controlled removal of all components of base material by a chemical process on the side wall of holes in order to expose additional internal conductor areas.
Etched wire	Process applied to fluoroplastic wire in which the wire is passed through a sodium bath to create a rough surface and allow epoxy resin to bond the fluoroplastic.
Etch factor	Ratio of the depth of etch (conductor thickness) to the amount of lateral etch (undercut). 
ETFE	(See Ethylene Trifluoreothylene).
Ethyl cellulose	Of the cellulosic resins, the one with the lowest density. Chemically an ether, it has toughness and dimensional stability. Can be extruded, injection molded, cast as film, or used in coating.
Ethylene-Chlorotrifluoroethylene (ECTFE)	Fluorocarbon copolymer, made from ethylene and chlorotrifluoroethylene, with outstanding strength and wear characteristics. Has outstanding resistance to solvents, cleaners, or chemicals, and is flame retardant. Disadvantages include, cost and stiffness. It is rated 302°F (150°C).
Ethylene glycol	Liquid used in antifreeze and as a liquid dielectric.(See liquid dielectrics).
Ethylene-Propylene Rubber (EPR)	Low cost synthetic rubber copolymer, made from ethylene and propylene, these materials offer excellent resistance to corona, ozone, and weathering. They also have excellent electrical properties and good to excellent heat resistance and high temperature properties, but poor mechanical and flame characteristics. Widely used as an insulation for 600 V and high voltage cables, and normally rated 194°F (90°C). Often combined with hypalon as a conductor jacket to overcome its deficiencies.

Table 2. Terms And Definitions (Cont.)

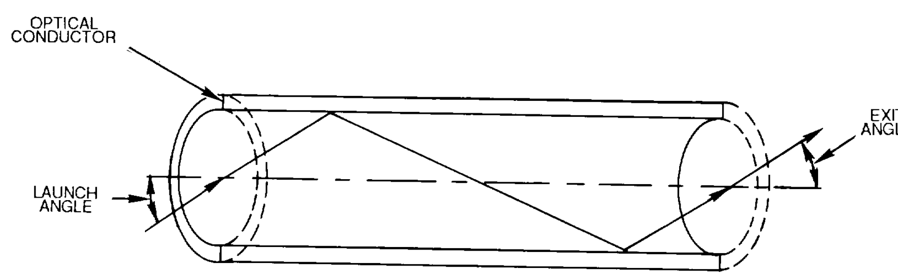
Term	Definition
Ethylene-Trifluoroethylene (EFTE)	Fluoropolymer that is thermoplastic with very good electrical, mechanical, and chemical resistance characteristics, 302°F (150°C).
ETPC	(See Electrolytic Tough Pitch Copper).
Eutectic	(1) Isothermal reversible reaction in which a liquid solution is converted into two or more directly mixed solids on cooling, the number of solids formed being the same as the number of components in the system. (2) Alloy having the composition indicated by the eutectic point on an equilibrium diagram. (3) Alloy structure of intermixed solid constituents formed by a eutectic reaction.
Evaporation	Physical process by which a liquid loses material to the atmosphere surrounding it. Evaporation is caused by the motion of the molecules of a liquid. These molecules are moving randomly in all directions. Molecules which head in the direction of the surface of liquid can escape completely if they have sufficient velocity. Vapor pressure is an indication of the rate of evaporation which a material will undergo. The evaporation process generally increases with increasing temperature.
Exane	Trade name of ITT Surprenant for its family of irradiated cross-linked polyolefin insulation. This material combines electrical, mechanical, and heat aging characteristics to give an excellent balance of properties. Most often used for control and power cables at 600 V to 2000 V. Rated 194°F (90°C) to 257°F (125°C).
Excess solder	This condition completely obscures the configuration of the joint, and may be characterized by globules of solder hanging from the joint. Because of the mass of solder present, the condition may disguise other defects which compound the unacceptability of the joint.
Exit angle (fiber optic)	Angle between the output radiation vector and the axis of the fiber or fiber bundle. 
Exotherm	Characteristic curve of a resin during its cure, which shows the heat of reaction (temperature) versus time. Peak exotherm is the maximum temperature on the curve.
Extender	Substance added to a plastic composition to reduce the amount of resin required per unit volume. Generally has adhesive action.

Table 2. Terms And Definitions (Cont.)

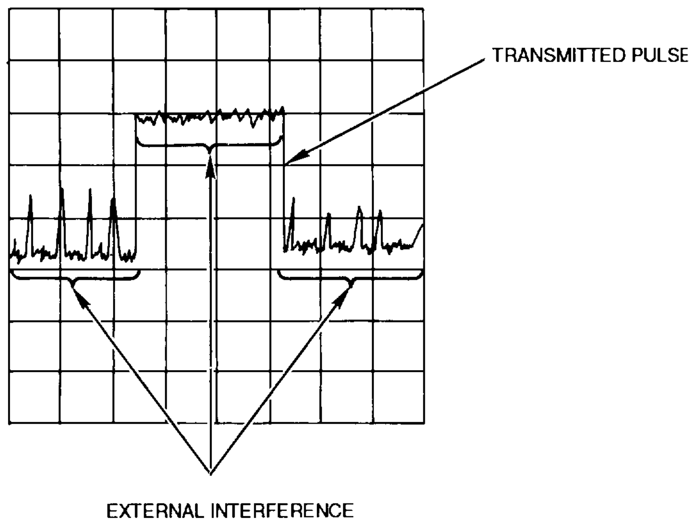
Term	Definition
External interference	Effects of electrical waves, fields, or physical external circuit conditions, which cause variations other than the desired signal. Static. (See crosstalk). 
External wiring	Category of electronic wiring which interconnects various subsystems within the weapons system. It is frequently subjected to severe environments. (See internal wiring).
Extruded cables	Cables with conductors which are insulated and formed in a uniform configuration by the application of a homogeneous insulation material in a continuous extrusion process.
Extrusion	Method of forcing plastic, rubber, or elastomer material through an orifice in continuous fashion to apply insulation or jacketing to a conductor or cable.
Eyelet	Metallic, donut-shaped device used to terminate conductors. Eyelet is attached to a conductor or to a Printed Circuit (PC) board with pliers or an eyelet setting machine. On PC boards, wire or component lead is inserted through eyelet and soldered in place.
f	(See Frequency).
F	(1) Designation for flat band metallic armor. (2) (See Farad).
Factor of assurance of wire or cable insulation	Ratio of the voltage at which completed lengths are tested to that at which they are used.
Farad (F)	Unit of capacitance. The capacitance of a capacitor which, when charged with one coulomb, gives a difference of potential of one volt. (See capacitance).
Faraday shield	Network of parallel wires heated to a common conductor at one end to provide electrostatic shielding without affecting electromagnetic waves. The common conductor is usually grounded.
Fatigue	Phenomenon leading to fracture under repeated or fluctuating stresses having a maximum value less than the tensile strength of the material. Fatigue fractures are progressive, beginning as minute cracks that grow under the action of the fluctuating stress.
Fatigue life	Number of cycles of stress that can be sustained prior to failure for a stated test condition.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Fatigue limit	Maximum stress below which a material can presumably endure an infinite number of stress cycles. If the stress is not completely reversed, the value of the mean stress, the minimum stress, or the stress ratio should be stated.
Fatigue resistance	Resistance to metal crystallization which leads to conductors or wires breaking from flexing.
Fatigue strength	Maximum stress that can be sustained for a specified number of cycles without failure, the stress being completely reversed within each cycle unless otherwise stated.
Fatigue strength reduction factor (Kf)	Ratio of the fatigue strength of a member or specimen with no stress concentration to the fatigue strength with stress concentration. Kf has no meaning unless the geometry, size, and material of the member or specimen, and its stress range, are stated.
FCC	(1) Designation for Flexible Control Cable. (2) Federal Communications Commission.
FDDI	An emerging standard for a 100 Mbit/sec local area network, based upon fiber optic media configured as dual control rotating token rings.
Feed-thru insulators	Fabricated from dielectric materials, feed-thru insulators are used to carry a metal conductor through the chassis while preventing the hot lead from shorting to the ground chassis.
Feed-thru or feed-through	Use of special connectors or junctions to pass conductors thru bulkheads or panels. Contacts can be pin on one side, socket on the other, or can be pin on either side, or socket on either side. Feed-thru connectors differ from rack and panel types in that connection can be made on both sides of the panel to which they are attached.
Feedback module	Module having one face containing contact cavities. It is used for general purpose interconnection and busing. (See terminal junction module).
Female contact	(See socket contact).
FEP	(See Fluorinated Ethylene Propylene).
FEPB	Designation for FEP insulated wire with glass or asbestos braid.
FEPCC	Designation for high temperature control cable.
Ferrites	Ferrites are powdered, compressed, and sintered magnetic materials having high resistivity and consisting chiefly of ferric oxide combined with one or more metals. These oxides have a crystal structure into which a divalent metal, i.e., iron, zinc, nickel, barium, and manganese can be fitted. Ferrites are lightweight, flexible, resistant to chemicals, and offer relatively good magnetic properties.
Ferrous metals	Alloys containing iron.
Ferrule	Short tube used to make connections to shielded or coaxial cables. Also used in connectors to reduce transmission of torque to grommet.
FF-1	Designation for fixture wire, flexible, rubber insulated, single conductor, 300 V, 140°F (60°C).
FF-2	Same as FF-1, but with 600 V rating.
FFC	Flexible Flat Cable. (See flat cable).
FFH-1	Same as FF-1, except heat resistant.
FFH-2	Same as FFH-1, but with 600 V rating.

Table 2. Terms And Definitions (Cont.)

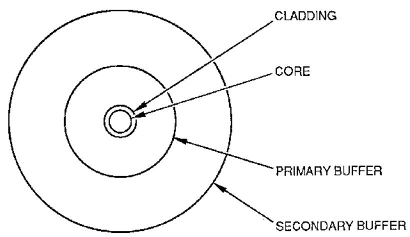
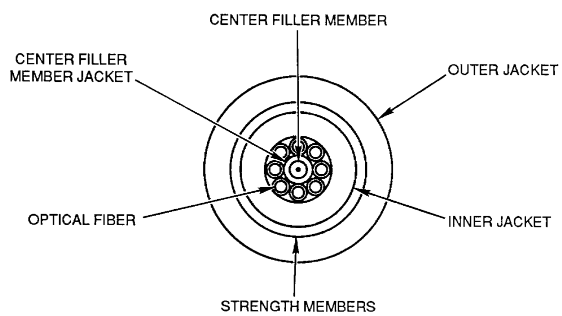
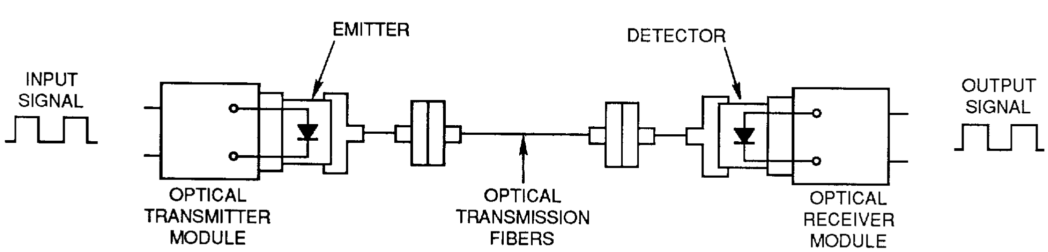
Term	Definition
Fiber	(1) (fiber optic) Single discrete element used to transmit optical (light wave) information. Analogous to a single wire used to transmit electrical information. Usually consists of a core that transmits the information and a cladding around the core. (2) Thread or threadlike structure such as cellulose, asbestos, or glass yarn. 
Fiber bandwidth	Range of frequencies over which light intensity exiting a waveguide can be varied before attenuation varies 3dB from the mean expressed in megahertz.
Fiber buffer	Materials used to protect an optical fiber or cable from physical damage, providing mechanical isolation or protection.
Fiber bundle (fiber optic)	Consolidated group of single fibers used to transmit a single optical signal. 
Fiber cable (fiber optic)	Cable composed of a fiber bundle or single fiber, strength members, and a cable jacket used to transmit optical signals.
Fiber glass	Yarn used for braiding when high heat and moisture resistance are necessary. While not as abrasion resistant as cotton, it is satisfactory for most applications and can, if necessary, be protected with an extruded nylon jacket.
Fiberguide (fiber optic)	Optical fiber. (See fiber).
Fiber Optics (FO)	General term describing a lightwave or optical communications system. In such a system, electrical information is converted to light energy, transmitted to another location through optical fibers, and is there converted back into electrical information. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Fiber optic link	Any optical transmission channel designed to connect two end terminals or to be connected in series with other channels.
Fiber Optic Medium Attachment Unit (FOMAU)	Fiber optic device that provides for the connection to all Ethernet and IEEE 802-3 compatible DTE's via baseband transceivers with full compliance to Ethernet and IEEE 802-3 standards.
Fiber optic transceiver	Device that converts electronic signals to optic signals then drives them on to the fiber optic.
Fiber tubing (fiber optic)	Loose crush-resistant cylinder applied over individual fibers to provide mechanical protection.
Field	Area of influence around a magnet or electric charge.
Field coil	Suitable insulated winding to be mounted on a field pole to magnetize it.
Field strength	Strength of an electromagnetic field. The measurement may be either the electric or the magnetic component of the field, and may be expressed as V/m or A/m. Either of these may be converted to solve for the others.
Figure 8 cable	Aerial cable configuration in which the conductors and the steel strand which supports the cable are integrally jacketed. A cross section of the finished cable approximates the figure eight.
Filament	Fiber characterized by extreme length.
Filled cable	Cable construction in which the cable core is filled with a material that will prevent moisture from entering or passing through the cable.
Filled-core annular conductor	Conductor composed of a plurality of conducting elements disposed around a non-conducting supporting material which substantially fills the space enclosed by the conducting elements.
Filled tape	Fabric tape which has been thoroughly filled with a rubber or synthetic compound, but not necessarily finished on either side with this compound.
Filler	(1) Material used in multiconductor cable to occupy interstices formed by the assembled conductors. (2) An inert substance added to a compound to improve properties or decrease cost.
Filler metal	Metal added in making a brazed, soldered, or welded joint.
Fillet	(1) Radius (curvature) imparted to inside meeting surfaces. (2) Concave cornerpiece used on foundry patterns.
Film	Sheeting having a nominal thickness not greater than 0.010 inch. Plastic films are used for pressure sensitive tapes, flexible circuit substrates, and a wide variety of insulating and protective applications in electrical/electronic products either alone or in combination with other materials.
Film bonded	Cables where bonding is accomplished by solvent-bonding or adhesive-bonding wire, cable, or spacer to a film to form a cable. (See bonded cables).
Film resistor	Device whose resistive material is a film on an insulator substrate; resistance value is adjusted by trimming.

Table 2. Terms And Definitions (Cont.)

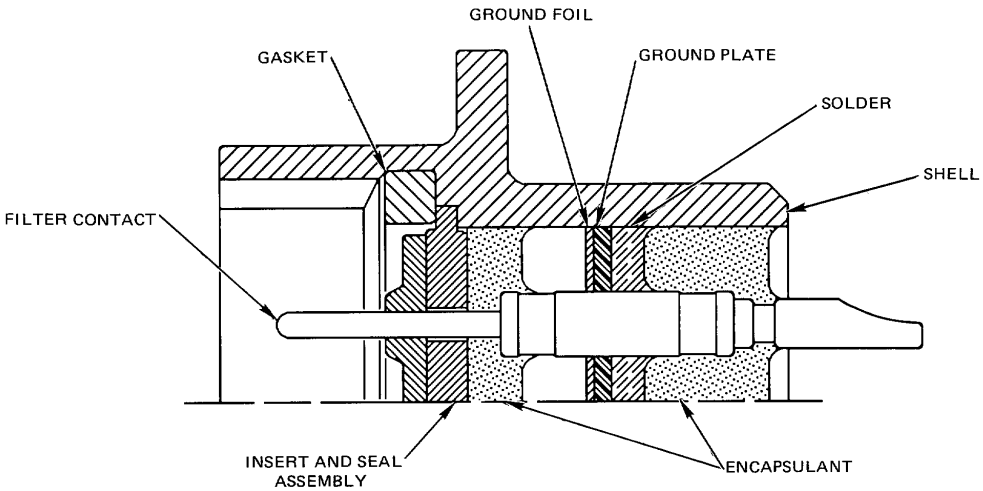
Term	Definition
Filter contact	Filters are assembled onto a common contact shaft and the active electrodes are soldered to the pin. In a connector, the ground electrode is connected to a ground plate which in turn is connected to the connector shell. Consequently the filter works between the pin and the connector shell. There is the conventional Pi, and unbalanced Pi, a cascaded Pi and a capacitor filter. All are designed to meet a specific EMI environment. 
Filter line cable	Filter line cable provides protection from conducted and radiated high frequency Electromagnetic Interference (EMI). It acts as a low-pass filter, which strongly attenuates conducted signals or noise above 100 MHz while lower frequency signals pass with little loss. Filter line cable configurations are typically defined in MIL-C-85485, or AS85485.
Fine silver	Silver (Ag) with a fineness of 999; equivalent to a minimum content of 99.9% Ag with the remaining content not restricted.
Fingers	(See edge-board contacts).
Firewall	Point of interconnection between two portions of a network, usually implemented by an intelligent router, where information propagating into one network from the other can be restricted for reasons of fault isolations and routing control.
Fixed contact	Contact permanently included in the insert material. It is mechanically locked, cemented, or embedded in the insert.
Fixture wire	Fixture wires, according to the National Electrical Code, are designed for installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use. They also are used for connecting lighting fixtures to the conductors of the circuit that supplies the fixtures. Fixture wires shall not be smaller than 18 AWG. Flexible stranding is used for most fixture wire, but solid conductors may be used in some applications.
Flag terminal	Type of terminal where the tongue projects out from the side of the terminal barrel rather than the end of the barrel.
Flame resistance	Relative ability of a material not to propagate flame.

Table 2. Terms And Definitions (Cont.)

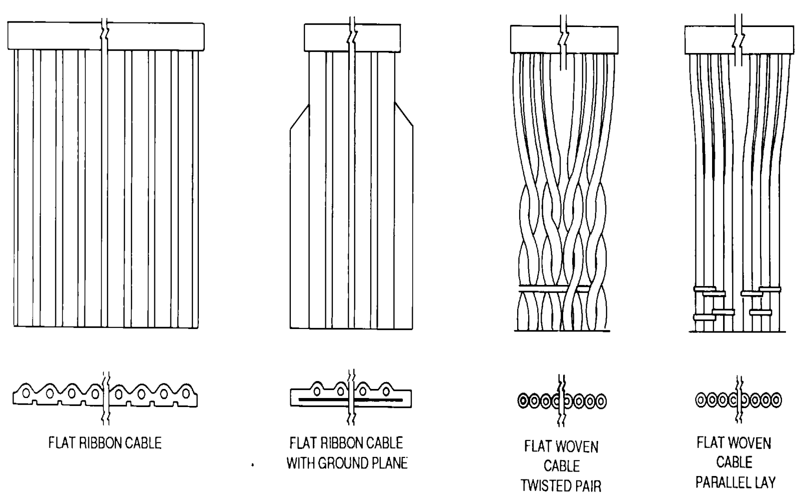
Term	Definition
Flame retardant	Either reactive compounds or additive compounds added to formulation to increase resistance to combustion. Reactive fire-retardant compounds become an integral part of the polymer structure, while additive fire-retardant chemicals are physically dispersed in the polymer.
Flammability	Measure of the material's ability to support combustion.
Flammable	Capable of bursting into flame when a spark or open flame is passed sufficiently near, as with fumes and vapors from hot oils or volatile combustible liquids, and with finely powdered, combustible solids.
Flammable liquids	Liquid having a flash point below 140°F (60°C) and having a vapor pressure not exceeding 40 pounds per sq in.(absolute) at 100°F (37.8°C).
Flange, connector	Projection extending around a connector with provisions to permit mounting the connector to a panel.
Flange spade terminal	Terminal whose tongue edges are turned at an angle to the plane of the tongue.
Flash	Thin film of material formed at the sides of a forging, casting or molded part where some of the material is forced between the faces of the forging dies or the mold halves. (2) The excess metal extruded between both halves of crimping dies when making certain circumferential or symmetrical crimps. (3) Thin deposit of plastic material usually at the base of molded-in pins.
Flashover	Disruptive discharge around or over the surface of a solid or liquid insulator.
Flash point	Temperature at which a volatile liquid mixes with air in such proportions as to produce a flammable gaseous mixture. This mixture will flash when exposed to a flame or spark but will not necessarily continue to support combustion.
Flash welding	Resistance butt welding process in which the weld is produced over the entire abutting surface by pressure and heat, the heat being produced by electric arcs between the members being welded.
Flat braid	Woven braid, composed of tinned copper strands, which is rolled flat at time of manufacture to a specific width depending upon construction. It is generally used as a high current conductor at low voltages.
Flat cable	Cable with two or more parallel, round, or flat conductors in the same plane encapsulated by an insulating material. Also called flexible flat cable. 
Flat conductor	Conductor with a width-to-thickness ratio of 5 to 1 or greater, having a rectangular shape rather than round, cross sections.

Table 2. Terms And Definitions (Cont.)

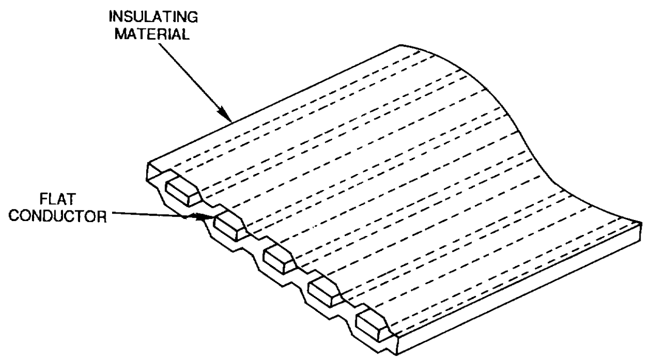
Term	Definition
Flat conductor cable	Flexible flat cable with a plurality of flat conductors that have rectangular, rather than round, cross sections. 
Flat jacketed	Parallel conductor configuration which is usually restricted to vinyl insulated wires and vinyl jackets. The outer jacket does not fuse with the primary insulation, a condition which would make impossible the stripping of the jacket without damage to the individual wire coverings. While opaque jackets are generally specified, transparent materials are available which allow the color-coded wires to be seen throughout the cable length.
Flatpack	Subassembly composed of two or more stages made up of integrated circuits and thin-film components mounted on a ceramic substrate. This semiconductor network is enclosed in a shallow rectangular or square package with the connecting leads projecting from the edges of the package. Normally designed for surface mounting.
Flat transmission cable	(See transmission cable).
Flexibility	Ease with which a cable may be bent.
Flexibilizer	Additive that makes a resin or rubber more flexible. More often called plasticizer.
Flexible	That quality of a cable or cable component which allows for bending under the influence of outside force, as opposed to limpness which is bending due to the cable's own weight.
Flexible Flat Cable (FFC)	(See flat cable).
Flexible printed wiring	Random arrangement of printed wiring utilizing flexible base material with/without flexible cover layers.
Flex life	(1) Time of heat aging that an insulating material can withstand before failure when bent around a specific radius (used to evaluate thermal endurance). (2) The ability of a conductor, wire, or cable to withstand repeated bending.
Flexural strength	Material's ability to flex without sustaining permanent distortion or fracture.
Floating	Referring to a circuit which has no connection to a ground.
Floating bushing	Design feature which aids in the alignment of plug and receptacle shells during engagement. The floating bushing generally is an eyelet-type bushing which is fitted into the plug mounting holes so that there is freedom of motion in all directions between the plug and receptacle.
Flow	Movement of molten solder in and around a joint.
Flow brazing	Pouring molten filler metal over a joint.
Flow point	Point at which an alloy is completely liquid.
Flow soldering	(See wave soldering).
Fluidity	Relative ease with which a liquid material will flow.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Fluorinated Ethylene Propylene (FEP)	Melt-extrudable fluorocarbon copolymer made from perfluorethylene and perfluoropropylene. It has outstanding chemical inertness and heat resistance. Most often used as an insulation in thin wall constructions. Disadvantages include cost, cold flow, and stiffness. Rated 392°F (200°C).
Fluorocarbon	Compound of fluorine and carbon. Large numbers of such compounds are known in many of their properties they resemble the hydrocarbons, differing in their greater stability. The chemical inertness of the fluorocarbons makes them useful as solvents.
Fluorocarbon resins	Resins which include fluorine in their molecular structure; the greater the fluorine content, the better are the polymers electrical, mechanical, thermal, and chemical properties. Polyvinylidene fluoride, polytetrafluoroethylene,fluorinated ethylene propylene, and perfluoroalkoxy are wire insulations from the fluorocarbon family.
Fluoroplastics	Polymers with monomers containing one or more atoms of fluorine or copolymers of such monomers. The family includes fluorocarbons, which are composed of carbon and fluorine. Typical examples of fluoroplastics are polytetrafluoroethylene,fluorinated ethylene propylene, polyvinylidene fluoride, polychlorotrifluoroethylene, ethylene chlorotrifluoroethylene, etc.
Fluorosilicones	Liquid used as a dielectric. (See liquid dielectrics).
Flush conductor	Conductor whose outer surface is in the same plane as the surface of the insulating material adjacent to the conductor.
Flux	(1) Lines of force which make up an electrostatic field. (2) Rate of flow of energy across or through a surface. (3) Substance used to promote or facilitate fusion, such as a material that removes oxides from surfaces to be joined by soldering or welding.
Flux budget	Optical power attenuation permitted between any two transceivers. Attenuation allowance plus Loss budget plus Optical Power budget equals the Flux budget.
Flux consistency	Degree to which the flux is liquid.
Flux residue	Residue left on the joint after soldering is completed.
FO	(See Fiber Optics).
Follower	Sleeve used to compress the grommet, thus tightening the seal around the conductors entering the connector.
Foamed plastics	Resins in flexible or rigid sponge form with the cells closed or interconnected. Foamed insulations provide low dielectric constants and weight savings.
Foaming agents	Chemicals added to plastics and rubbers that cause them to assume a cellular structure.
Foil	Thin, continuous sheet of metal, usually copper or aluminum. Foil is used for electrical coils as a replacement for copper magnet wire, static shielding, contacts, and many other electrical applications. Aluminum foil is available in a wide variety of thicknesses as thin as 0.00015 in. It is used to a large extent in many types of capacitors. Copper foil is best known for its use in printed-circuits. Copper is used because of its low resistance, high heat conductivity, high softening and melting temperatures, strength, ductility, workability, and ability to be coated or plated readily with other metals, or to be soldered or brazed. Steel foil in thicknesses as low as 0.001 in. and up to 42 in. wide is suggested for the resistive element in radiant heating panels, electromagnetic shielding in color TV, and other applications. Steel foil is adaptable to soldering, welding, adhesives, mechanical fastening, and laminating to a variety of materials.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Formulas, electrical	Mathematical formulas are used for determining values in electrical circuits. Normally, two or more circuit parameters (values) must be known. The following generalized listing can be used for the most common circuit parameters. To define letter designations not identified here, refer to the designation definition or the general heading it falls under. The subscript t denotes total or true (as in power) and the subscript a denotes applied (as in voltage) or apparent (as in power). The subscript n denotes up to and including the last item in a set. The designation N denotes the number of items in a set. When dealing with transformers, N denotes the number of turns in a coil, subscript p denotes the primary winding, and subscript s denotes the secondary winding. When performing trigonometric functions, θ is an angle of a right triangle which is not 90°, the Opposite (O) side is the length of the side opposite angle 0, the Adjacent (A) side is the length of the side adjacent to angle 0, and the Hypotenuse (H) is the length of the side opposite the 90° angle (right angle). The trigonometric function conversion table can be used to determine the trigonometric functions Sine (Sin), Tangent (Tan), Cotangent (Cot), and Cosine (Cos) when the angular measurement is known. When the value of a specific trignometric function is known, the table may also be used to determine the angular measurement. The value of a trigonometric function can be determined by locating the angular measurement and crossing it to the specific function heading and value. To determine the angular measurement when the value of a specific function is known, locate the value under its respective function and cross it to the angular measurement. The angular measurements from 0° to 45° are located on the left side of the chart and correspond to the headings at the top of the chart. The angular measurements from 45.1° to 90° are located on the right side of the chart and correspond to the headings at the bottom of the chart. (See Ohm's law, Kirchoff's law). Voltage (E) $E = IR$ $E = P/I$ $E = \sqrt{PR}$ Resistance (R) $R = E/I$ $R = E^2/P$ $R = P/I^2$ Current (I) $I = E/R$ $I = P/E$ $I = \sqrt{P/R}$ Series Circuits $E_t = E_1 + E_2 + E_3 + E_n$ $I_t = I_1 = I_2 = I_3 = I_n$ $R_t = R_1 + R_2 + R_3 + R_n$ $P_t = P_1 + P_2 + P_3 + P_n$ $L_t = L_1 + L_2 + L_3 + L_n$ $C_t = \frac{C_1 \times C_2}{C_1 + C_2}$ (2 capacitors) $C_t = \frac{1}{\frac{1}{C_1}\quad \frac{1}{C_2}\quad \frac{1}{C_3}\quad \frac{1}{C_n}}$ (2 or more capacitors) $C_t = \frac{C}{N}$ (2 or more capacitors of equal value)

Table 2. Terms And Definitions (Cont.)

Term	Definition
Formulas, electrical (Cont.)	
	Parallel Circuits
	$E_t = E_{branch1} = E_{branch2} = E_n$
	$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$ (2 capacitors)
	$R_t = \frac{1}{\frac{1}{R_1} \quad \frac{1}{R_2} \quad \frac{1}{R_3} \quad \frac{1}{R_n}}$ (2 or more resistors)
	$R_t = \frac{R}{N}$ (2 or more resistors of equal value)
	$I_t = I_1 + I_2 + I_3 + I_n$
	$P_t = P_1 + P_2 + P_3 + P_n$
	$L_t = \frac{L_1 \times L_2}{L_1 + L_2}$ (2 inductors)
	$L_t = \frac{1}{\frac{1}{L_1} \quad \frac{1}{L_2} \quad \frac{1}{L_3} \quad \frac{1}{L_n}}$ (2 or more inducts)
	$L_t = \frac{L}{N}$ (2 or more inductors of equal value)
	$C_t = C_1 = C_2 = C_3 = C_n$
	Transformers
	$\frac{E_p}{E_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$
	$P_p = P_s$
	$\% \text{ Efficiency} = \frac{P_{out}}{P_{in}} \times 100$
	Time Constant (TC)
	$TC = RC$
	$TC = \frac{L}{R}$
	Power (P)
	$P_t = I_t^2 R_t$
	$P_t = T_t E_a$
	$P_t = IE \text{ Cos } \angle\Theta$
	$Pt = E_a^2/R_t$
	$P_a = I_t E_t = I_t^2 Z_t$
	$P_X = I^2 X_L$
	$P_X = I^2 X_C$
	$PF = \frac{P_t}{P_a} = \text{Cos } \angle\Theta$

Table 2. Terms And Definitions (Cont.)

Term	Definition
Formulas, electrical (Cont.)	
	VSWR
	$\text{VSWR} = \dfrac{E_{max}}{E_{min}} = \dfrac{E_i + E_r}{E_i - E_r}$
	Impedence (Z)
	$Z_t = \sqrt{X_t^2 + R_t^2}$
	$Z_t = \dfrac{E_a}{I_t}$
	Reactance (X)
	$X_L = 2\pi fL$
	$X_C = \dfrac{1}{2\pi fC} = \dfrac{0.159}{fC}$
	$X_t = X_L - X_C$ (resultant is inductive)
	or
	$X_t = X_C - X_L$ (resultant is capacitive)
	(The smaller is always subtracted from the larger)
	Frequency (f)
	$f = \dfrac{1}{PRT}$
	$f_{co} = \dfrac{1}{2\pi RC} = \dfrac{0.159}{RC}$
	$f_{co} = \dfrac{R}{2\pi L}$
	$f_o = \dfrac{1}{2\pi\sqrt{LC}} = \dfrac{0.159}{\sqrt{LC}}$
	Inductor quality (Q)
	$Q = \dfrac{X_L}{R}$
	Bandwidth (BW)
	$BW = \dfrac{f_o}{Q}$
	$BW = f_2 - f_1$
	Alternating Current
	$E_{RMS} = E_{peak} \times 0.707$
	$E_{peak} = E_{RMS} \times 1.414$
	$WVDC = E_{RMS} \times 1.5$

Table 2. Terms And Definitions (Cont.)

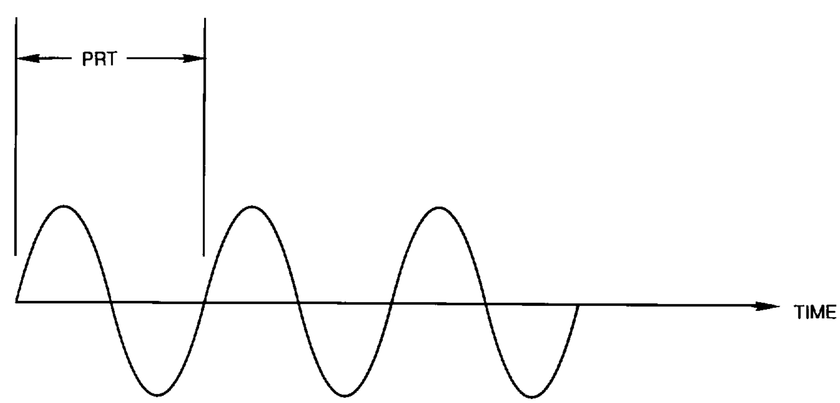
Term	Definition
Formulas, electrical (Cont.)	Trigonometric Functions Sine $\angle\Theta = \frac{O}{H}$ Cosine $\angle\Theta = \frac{A}{H}$ Tangent $\angle\Theta = \frac{O}{A}$
Form wound	Coil or winding prewound on a form of a predetermined shape.
Forsterite	Forsterite ceramics have the desired vacuum tightness, thermal expansion characteristics, and high operating temperature ability for ceramic-to-metal sealing in vacuum tubes. They also can be used in the high frequency range.
Fracture	Irregular surface produced when a metal is ruptured or broken.
Fractured joints	Fractured or disturbed joints are usually caused by movement, relative to each other, of one or both of the surfaces being joined before the solder has completely solidified. This defect may be characterized by strain marks on the surface, by small cracks in the solder, or by a rough, gritty appearance. A lack of electrical continuity may result from this defect, as well as decreased structural strength or loss of a hermetic seal in non-electrical applications.
Frame	In the case of a multiple contact connector having a removable body or insert, the frame is the surrounding portion (usually metal) which supports the insert and permits a method for mounting the connector to a panel or a mating connector half.
Free connector	Connector for attachment to the free end of a wire or cable.
Freezing point	Temperature at which a previously molten material solidifies, or becomes completely solid.
Frequency (f)	Number of times an alternating current repeats its cycle in one second. Expressed in Hertz (Hz). The designation f_{co} is the cut-off frequency, and designation f_o is the frequency of oscillation or resonant frequency. (See formulas-electrical). Frequency (f) = Number of cycles per second expressed as Hertz (Hz) f = 1/PRT Pulse Repetition Time (PRT) = Time to complete one cycle in seconds (1/f) 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Frequency division multiplex (FDM)	Method by which the available transmission frequency range is divided into narrower bands, each used for a separate channel.
Frequency division multiplexing	Splitting of a communication line into separate frequency bands each capable of carrying information signals.
Frequency modulation	Process of using a medium to carry information.
Frequency plan	Specification of how the various frequencies of a broadband cable system are allocated for use.
Frequency response	Change of gain with frequency.
Fresnel reflection	Reflection of a portion of the light incident on a plantar interface between two homogeneous media having a different refractive indices.
Fresnel reflection loss (fiber optic)	Loss that is incurred at the optical conductor interface due to refractive index differences.
Fretting	Condition where slight movement between mated surfaces occurs which continually exposes fresh metal. As the metal oxidizes it builds-up until electrical continuity is broken.
Frit	Finely ground glass used to join glass to metal or other glasses. Also called solder glass, it may or may not lose its transparency during temperature cycles.
FRMR	Flame Retarding Moisture Resisting finish.
Front mounted	Connector mounted on the outside of a panel or box with its mounting flange outside the equipment.

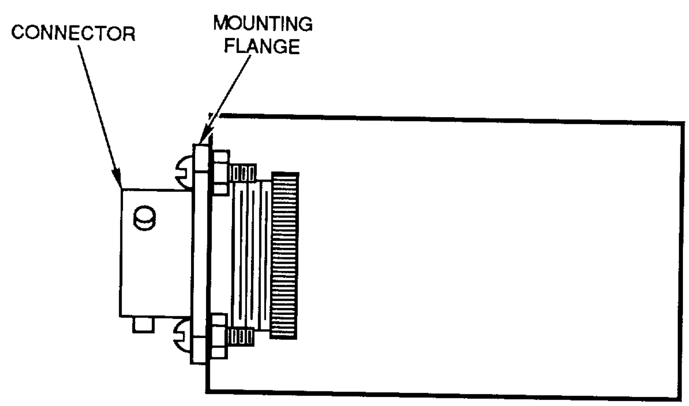


Table 2. Terms And Definitions (Cont.)

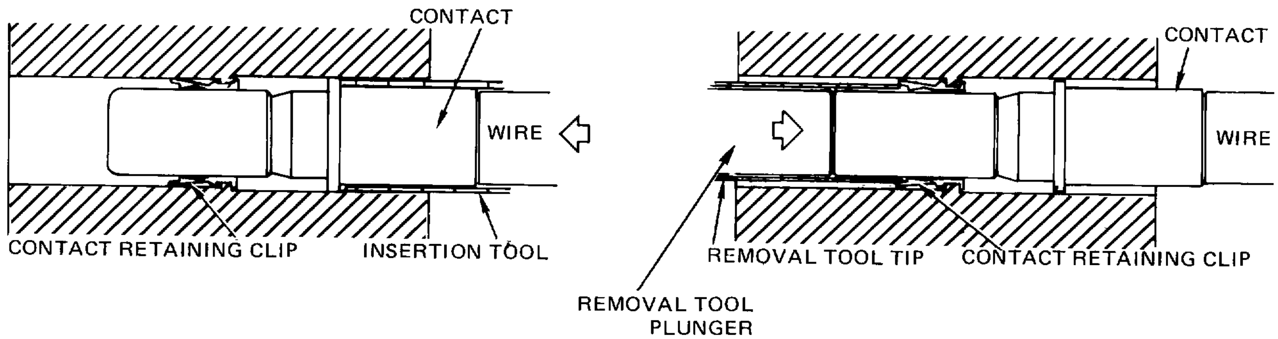
Term	Definition
Front release contact	Connector contact released from the front side of the connector and then removed from the back wire side of the connector. The removal tool engages the front portion of the contact and pushes it out the back where it is removed by hand.  INSERTION REMOVAL
FR-1	Flammability rating established by Underwriter’s Laboratories for wires and cables that pass a specially designed vertical flame test FR-1. Replaced by VW-1. (See VW-1).
Full cycling control	Controls placed on the crimping cycle of crimping tools forcing the tool to be closed to its fullest extent completing the crimping cycle before the tool can be opened.
Full duplex	Connection on the network that allows transmission in both directions at the same time.
Funnel entry	Flared or widened entrance to a terminal or connector wire barrel. Permits easier insertion of the conductor, and helps assure that all wire strands will be directed into the wire barrel. (See belled mouth).
Furnace soldering	Joining together by heating in a furnace.
Fused coating	Metallic coating (usually tin or solder alloy) which has been melted and solidified forming a metallurgical bond to the base material.
Fused conductors	Individual strands of heavy tinned copper wire stranded together and then bonded together by induction heating.
Fused spiral tape	Refers to a type of PTFE insulated hookup wire. The spiral wrapped conductor is passed through an oven where the overlaps are fused together.
Fuse wire	Wire made from an alloy that melts at a relatively low temperature.
Fusing	Fusing, or wire fusing, describes the termination of magnet wire to a terminal without prior removal of its film insulation. The insulation is then removed during the fusing process.
G	(1) Designation for rubber insulated, neoprene jacketed, power cable with two to five 8 AWG or larger conductors with ground wires, 203°F (95°C). (2) (See conductance). (3) (See Gauss). (4) (See Giga).
Gage	Term used to denote the physical size of a wire. Also called gauge. (See American Wire Gauge).
Gain	Increased signal power, usually the result of amplification.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Galvanic corrosion	Corrosion associated with the current of a galvanic cell consisting of two dissimilar conductors in an electrolyte or two similar conductors in dissimilar electrolytes. Where the two dissimilar metals are in contact, the resulting reaction is referred to as couple action.
Galvanic series	Series of metals and alloys arranged according to their relative electrode potentials in a specified environment. (See electromotive series).
Galvanizing	To coat a metal part with zinc by dipping or electroplating.
Galvanometer	Instrument for detecting or measuring a small electric current by movements of a magnetic needle or of a coil in a magnetic field.
Gang disconnect	Connector that permits the rapid and simultaneous disconnection of two or more electrical circuits.
Ganged Contact Release (GCR)	System whereby all contacts in an assembly are locked/unlocked simultaneously.
Gang strip	Simultaneously stripping all conductors in a flat or ribbon cable.
Gap loss (fiber optic)	Power loss, expressed in decibels, due to the deviation from optimum spacing between the ends of separable optical conductors. (See coupling loss).
Gaseous dielectrics	Gaseous dielectrics are used for insulating and cooling purposes in a variety of applications. Chemical and thermal stability, inertness, compatibility with other materials, price, nonflammability, toxicity, high heat transfer rates, low boiling and melting points, and resistance to decomposition under arcing conditions (with no toxic by-products) are the factors which must be considered when evaluating specific gases.
Gas filled cable	Self-contained pressure cable in which the pressure medium is an inert gas having access to the insulation.
Gas filled pipe cable	Pipe cable in which the pressure medium is an inert gas having access to the insulation.
Gas pressure compensated	Saturated paper insulated cable containing tubes for the transmission of gas pressure along a cable, and with external gas feed to the tubes.
Gas tight	Contact system that utilizes soft metals at low contact pressure or hard metals at high contact pressure so that upon mating, metal is upset and the resultant joint prevents contaminant gases from entering the contact area.
Gauge	Term used to denote the physical size of a wire. Also called gage. (See American Wire Gauge).
Gauss (G)	The centimeter-gram-second unit of magnetic induction equal to the magnetic flux density that will induce an electromotive force of one one-hundred millionth of a volt in each linear centimeter of a wire moving laterally with a speed of one centimeter per second at right angles to a magnetic flux.
Gb	(See Gilbert).
GCR	(See Ganged Contact Release).
Gel	Semi-solid system consisting of a solid held in liquid.
Gel time	Time required for a curing thermoset plastic composition to undergo the change in state from a fluid to a solid or semi-solid under the conditions of use (film, thin casting, laminate, thick casting, etc.).
General purpose	Expression used to describe a low-cost, heavy-duty connector.
GG	Ground to Ground.

Table 2. Terms And Definitions (Cont.)

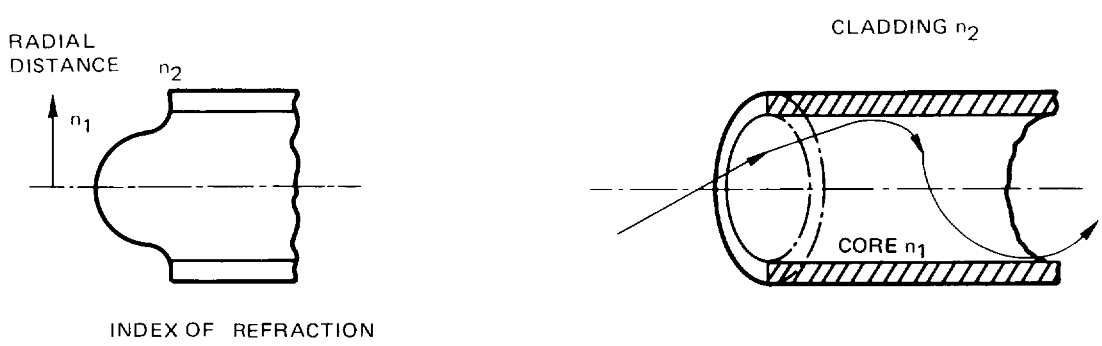
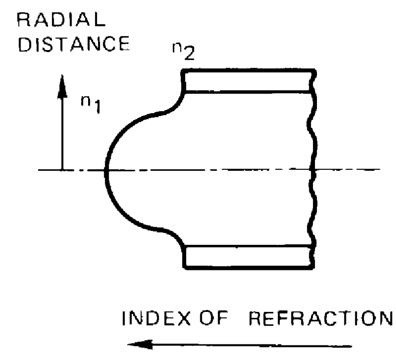
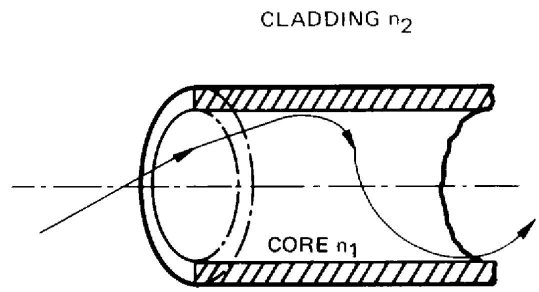
Term	Definition
Giga (G)	Numerical prefix denoting one billion (10^9).
Gigahertz (GHZ)	Unit of frequency equal to one billion hertz.
Gilbert (Gb)	The centimeter-gram-second electromagnetic unit of magnetomotive force, equal to 10/4 ampere-turns.
Gimmick	Short length of wire which is soldered onto a circuit component and used as a small adjustable capacitor. A gimmick is often two short insulated wires that are twisted together to form a capacitor.
Glass	Amorphous transparent or translucent brittle material usually made by fusion of silica, soda ash, lime, salt cake, or similar materials. Glass fibers are used in yarn servings and braids and as strength members. High tensile strength, nonflammability, flexibility, and resistance to moisture and high temperatures are characteristics of glass fibers. Glass is also used in fibers and fiber cables.
Glass bonded mica	By using a low-melting electrical grade of glass as a binder for mica, inorganic plastic insulating materials can be made that offer the combined properties of high dielectric strength, low loss at high frequencies, high heat resistance, arc resistance, mechanical strength, and no moisture absorption.
Glassivation	Deposited layer of glass on top of a metallized wafer or chip. Primarily a protective layer.
Glazed substrate	Glass coating on a ceramic substrate to effect a smooth and nonporous surface.
Gold	This metal is a very soft, yellow, and ductile material, which is noted for its resistance to corrosion. Next to silver, gold has the highest electrical conductivity and is specified for critical communication and electronic products. Electroless gold can be used to deposit coatings on small parts, such as eyelets, screws, and terminals. It is also used to improve contact resistance of selected areas that are not electrically joined, thus avoiding electroplating and the use of electrical contacts.
Gold dot	Interconnection system for flat cable. Gold buttons are plated directly onto the flat flexible circuitry; when compressed with proper force, the gold button flows producing a gas-tight joint.
GOR	Designation for Gasoline and Oil-Resistant wire.
Government Rubber Synthetic (GRS)	Government standard for Buna-S Rubber for jacketing and insulating compounds for military wires and cables.
GPU	Ground Power Unit.
Graded index fiber (fiber optic)	Fiber whose refractive index decreases with increasing radial distance from the center of the core. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Graded insulation	Combination insulations with the portions thereof arranged in such a manner as to improve the distribution of the electric field to which the insulation combination is subjected.





Grain	Individual crystal in a polycrystalline metal or alloy.
Grid	Orthogonal network of two sets of parallel equidistant lines used for locating points on a printed board. Connections should be located on the crosspoints of the gridlines. The position of conductors may be independent of the grid, i.e., not necessarily following the gridlines.
Grid spaced	When contacts in a multiple–contact connector or on the edge of a printed circuit board are spaced equally in a rectangular pattern.
Grommet	Rubber seals that are placed in the cable side of a connector with hole patterns that correspond to the insert configuration. The wires entering the rear of the connector go through the grommet and are affixed to the contacts. Inside the rubber grommet are one or more seals which hold themselves against the wire and prevent moisture and dirt from entering the contact cavity.
Groove	(1) Slot or cavity in a connector which bears directly on the cable.
	(2) The depression in a crimping die which holds the connector during crimping.
Grope free	(1) Connector coupling system which can be easily mated and locked, usually with one hand.
	(2) A coupling ring held in the proper position to start the mating cycle while uncoupled. (See scoop–proof).
Ground conductor	Conductor in a transmission cable or line that is grounded.
Grounded neutral	Neutral wire is metallically connected to ground.
Ground (GRD)	(1) Connection to the earth or other large conducting body to serve as an earth thus making a complete electrical circuit.
	(2) A point of common potential in an electric circuit used for common connections and reference voltage.
Grounding	The electrical connecting of conducting objects to primary structure for return of current.

Table 2. Terms And Definitions (Cont.)

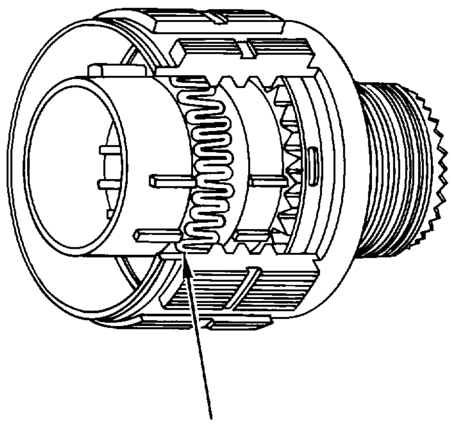
Term	Definition
Grounding fingers	Set of spring fingers provided in the connector to allow shell to shell grounding, before contacts mate and after they separate. 
Ground insulation	Major insulation used between a winding and the magnetic core or other structural parts usually at ground potential.
Ground loop	Generation of undesirable current flow within a ground conductor, from the circulation currents which originate from a second source of voltage (frequently as a result of connecting two separate grounds to a single circuit).
Ground plane	Conductor layer, or portion of a conductor layer, used as a common reference point for circuit returns, shielding, or heat sinking.
Ground power cable	Cable assembly fitted with appropriate terminations to supply power to an aircraft from ground power unit.
Ground support cable	Cable construction, usually rugged and heavy duty for use as interconnection for ground support control or power systems for missiles.
Ground wire	Conductor leading from radio equipment to an electrical connection with the ground.
Group	Number of wires and/or cables secured together and routed to a single item or set-up of equipment.
GR-S	(See styrene-butadiene rubber).
GRD	(See Ground)
GRS	(See Government Rubber Synthetic).
Guide pin	Pin or rod extending beyond the mating faces of a connector designed to guide the closing or mating of the connector to ensure proper engagement of contacts.
h	(See Henry).
H	Designation for shielded power cable. Multi-conductor cables have paper varnished cambric insulation applied directly over individual conductors, spiralled metallic shielding tape over insulation, with overall protective covering.
Halar	Allied Chemical trade name for their brand of ethylene chlorotrifluoroethylene.

Table 2. Terms And Definitions (Cont.)

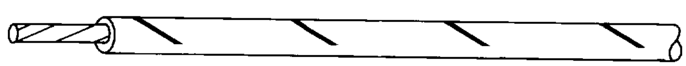
Term	Definition
Half duplex	Connection on the network that allows transmission in two directions, one direction at a time.
Halogenated hydrocarbon	Organic compound in which some, or all, of the hydrogen atoms linked to the carbon atoms are replaced by atoms of the halogen family. One of the largest uses for these compounds is as solvents.
Halogens	Group of elements similar in their properties and chemical activities. These elements, in order of decreasing activity, are fluorine, chlorine, bromine, and iodine.
Haloing	Mechanically-induced fracturing/delamination on or below the surface of the base material. Usually exhibited by a light area around holes, other machined areas, or both.
Handshaking	An exchange of predetermined signals for purposes of control when a connection is established between two data sets.
Hardboard	(See paper).
Hard drawn copper wire	Copper wire that has not been annealed after drawing.
Hardener	Chemical added to a thermosetting resin for the purpose of causing curing or hardening, and which becomes a part of the chemical reaction and chemical composition after curing.
Hardness	(1) Resistance of metal to plastic deformation, usually by indentation. However, the term may also refer to stiffness or temper, or to resistance to scratching, abrasion, or cutting. Indentation hardness may be measured by various hardness tests, such as Brinell, Rockwell, and Vickers. (2) For grinding wheels, the same as grade.
Hardware	Hardware usually refers to shells, guide pins, polarizing pins, strain relief clamps, mounting screws, etc.
Harness	Assembly of wires and/or cables arranged so it may be installed or removed as a unit.
Hash mark stripe	Non-continuous stripe applied to an insulated conductor for circuit identification. 
HC	Designation for two or more conductor Heater Cord, asbestos and rubber insulation with cotton braid over each conductor. Twisted, no overall covering.
HDPE	(See High Density Polyethylene).
Head assembly	(See positioner).
Header	Feedthrough device which introduces a conductive path through an insulating plate.
Head set cord	Very flexible cord used for communication equipment usually 24 to 22 AWG multi-conductor. Usually made with Buna insulation, rubber, or neoprene jacket; sometimes the outer jacket is a cotton braid. The conductor may be bare copper or cadmium bronze.
Heat-affected zone	That portion of the base metal which was not melted during brazing, cutting, or welding, but whose microstructure and physical properties were altered by the heat.
Heat aging	Exposing a cable or material to specific time and temperature conditions to determine degree of thermal stability.
Heat distortion	Deformation of a material caused by the application of heat. Heat distortion temperature is the maximum temperature that a material will withstand without deformation.

Table 2. Terms And Definitions (Cont.)

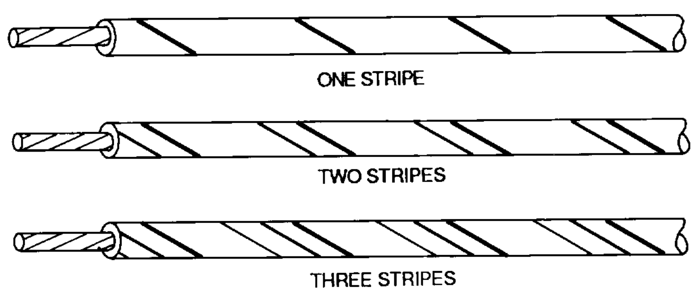
Term	Definition
Heat endurance	Time of heat aging that a material can withstand before failing a specific physical test.
Heat resistant	Copper or brass terminal, nickel plated to withstand 650°F (343.3°C).
Heat seal	Method for sealing a tape-wrap jacket by heat fusion.
Heat shock	Test to determine stability of a material by sudden exposure to high temperatures for a short period of time.
Heat shrinkable	Term describing tubes, sleeves, caps, boots, films, or other forms of plastic which shrink to encapsulate, protect, or insulate connections, splices, terminations, and other configurations with the application of heat. Heat shrinkable sleeves are typically defined in MIL-S-23053.
Heat sink	Device used to absorb or transfer heat away from heat sensitive parts.
Helical	Spiral
Helical stripe	Continuous, colored, spiral stripe applied to an insulated conductor for circuit identification. 
Helix	Spiral winding.
Henry (h)	Unit of inductance when the induced electromotive force of one volt is produced when the induced current changes at a rate of one ampere per second. (See inductance).
Hermaphroditic connector	Connector design which utilizes pin and socket contacts in a balanced arrangement such that both mating connectors are identical. The contacts may also be hermaphroditic.
Hermaphroditic contact	Contact design which is neither pin nor socket and mates with another contact of the same design. The contacts may be arranged as male and female contacts as for pins and sockets. Hermaphroditic contacts may also be used in a manner that one half of each contact mating surface protrudes beyond the connector interface and both mating connectors are identical.
Hermetic	Permanently sealed by fusion, soldering, or other means to prevent the transmission of air, moisture vapor, and all other gases.
Hermetic connector	Hermetically sealed connectors are usually multiple contact connectors where the contacts are bonded to the connector by glass or other materials and permit a maximum leakage rate of gas through the connector of 1.0 micron ft/hr at one atmosphere pressure (14.7 psig). For special applications, maximum leakage rates below 1.0 can be specified.
Hertz (Hz)	Unit of frequency equal to one cycle per second. (See frequency).
Heterogenous insulation	Cable insulating system composed of two or more layers of different insulating materials. (See homogeneous insulation).
Hexafluoroethane	A gas used as a dielectric. (See gaseous dielectrics).

Table 2. Terms And Definitions (Cont.)

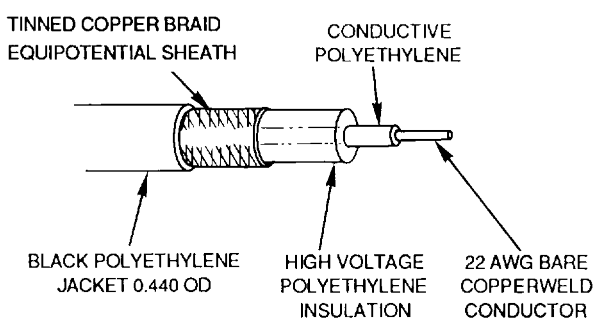
Term	Definition
Hi-pot	Test designed to determine the highest potential that can be applied to a conductor without breaking through the insulation.
High density harness	A harness designed to save weight and space which requires an outer covering for mechanical protection. High density harnesses have proven to have maintenance accessibility problems and a high rate of failure due to shorting caused by abrasion.
High Density Polyethylene (HDPE)	Those polyethylenes whose density ranges from 0.94 to 0.96 and above. They are linked to longer chains, forming a more rigid resin material.
High frequencies	Frequencies from 160 MHZ to 400 MHZ allocated for the forward direction in a mid-split system.
High-pressure laminates	Laminates molded and cured at pressures not lower than 1000 psi.
High-split	Broadband cable system in which the bandwidth utilized to send toward the head-end (reverse direction) is approximately 6 MHZ to 180 MHZ, and the bandwidth utilized to send away from the head end (forward direction) is approximately 220 MHZ to 400 MHZ. The guard band between the forward and reverse directions (180 MHZ to 220 MHZ) provides isolation interference.
High strength alloy conductor	Conductor which shows a maximum 20% increase in resistance and a minimum of a 70% increase in breaking strength over the equivalent construction in pure copper while exhibiting a minimum elongation of 5% in 10 inches. As required, the alloy should be capable of sustaining continuous exposure to temperatures as high as 572°F (300°C) without suffering an appreciable permanent change in properties.
High tension	(See high voltage cable).
High voltage cable	Generally considered to be a wire or cable with an operating voltage of over 600 V. Also called high tension.  TYPICAL HIGH VOLTAGE CABLE CONSTRUCTION
High voltage time test	Accelerated life test on a cable sample in which the voltage is the factor increased.
HMWPE	High Molecular Weight Polyethylene.
Holding strength	Ability of a connector to remain assembled to a cable when under tension.
Hollow copper conductors	An electrical conductor that integrally provides a means of heat exchange. A cooling fluid is passed through the interior of the conductor and carries away the heat generated by the flow of the electrical current.

Table 2. Terms And Definitions (Cont.)

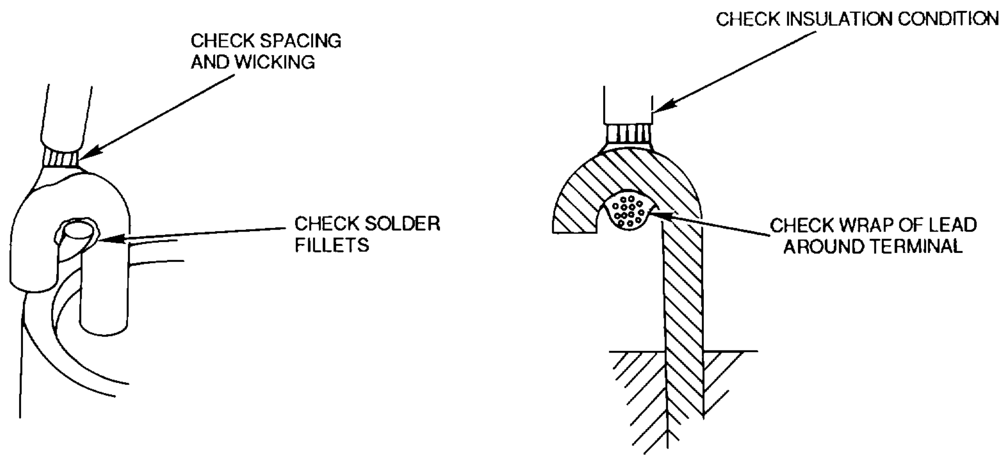
Term	Definition
Hollow-core annular conductor	(1) Conductor composed of a plurality of conducting elements disposed around a supporting member which does not fill the space enclosed by the elements. (2) Plurality of such conducting elements disposed around a center channel and interlocked one with the so shaped that they are self-supporting. Also called hollow-core conductor.
Homogeneous insulation	Complete cable insulation structure whose components cannot be identified as layers of different materials. (See heterogeneous insulation).
Hook terminal	Terminal with a hook-shaped tongue. 
Hook-up wire	Insulated wire used for low current, low voltage (under 1000 V) applications within enclosed electronic equipment.
Hot	Wire, terminal, or any ungrounded conductor connected to a voltage source and energized.
Hotcracking	Cracking of a metal or alloy upon freezing. In relation to solder, this can occur as a result of stress developed in the solder joint by uneven cooling. For example, if a very massive part is soldered to a very light part, the heat of a soldering will tend to flow more rapidly toward the massive part which acts as a heat sink. The stresses developed by this unequal cooling can crack or fracture the joint. This phenomenon may or may not be associated with hotshortness.
Hot dip	Term denoting the covering of a surface by means of dipping the surface into a molten bath of the coating material.
Hot melt	(See wax).
Hot plate soldering	Joining wires together using a hot plate as a heat source.
Hotshortness	Brittleness which develops at elevated temperatures in certain metals and alloys.
Hot stamping	Method of alphanumerical coding. Identification markings are made by pressing heated type and marking foil into softened insulation surfaces. Hot stamping inherently reduces insulation thickness, this can easily damage thin wall insulations typically used in aircraft applications. (See surface printing).
Hot tin dip	Process of passing bare wire through a bath of molten tin to provide a coating.
Housing, connector, electrical	Connector less insert, but with insert-retaining and positioning hardware required by standard construction.

Table 2. Terms And Definitions (Cont.)

Term	Definition
HPD	Designation for rubber and asbestos-insulated heater cord. No braid on individual conductors; but braid overall. Also made with neoprene insulation.
HPN	Designation for two-conductor, neoprene-insulated heater cord. Parallel construction. For damp locations.
HS	Designation for rubber and asbestos insulated heater cord. Cotton serving and rubber jacketed overall for damp locations has 14 AWG or 12 AWG conductors. Also made with neoprene insulated inners and asbestos.
HSJ	Same as type HS but with 18 AWG or 16 AWG conductors and differing jacket thickness.
HSJO	Same as HSJ but with neoprene jacket.
HSO	Neoprene jacketed heater cord.
Humidity test	Test involving exposure of specimens at controlled levels of humidity and temperature.
HW	Designation for radio hook-up wire with polyvinyl insulation, with or without nylon jacket, braid, or shield, 2500V.
Hybrid cable	Multiconductor cable containing two or more types of components.
Hybrid integrated	The physical realization of electronic circuits or subsystems from a number of extremely small circuit elements electrically and mechanically interconnected on a substrate.
Hydrin	(See epichlorohydrin).
Hydrocarbon	Organic compound having hydrogen atoms in its chemical structure. Most organic compounds are hydrocarbons. Aliphatic hydrocarbons are straight chained hydrocarbons, and aromatic are ringed structures based on the benzene ring. Methyl alcohol, trichloroethylene, etc. are aliphatic; benzene, xylene, toluene, etc. are aromatic.
Hydrogen	Gas used as a dielectric. (See gaseous dielectrics).
Hydrogen brazing	Brazing in a hydrogen atmosphere, usually in a furnace.
Hygroscopic	This characteristic of a material describes its ability to absorb water, usually from the air. Examples of hygroscopic materials are quite common in ordinary life. Most salts are hygroscopic. This is manifested by their clumping or lumping together when exposed to humid conditions. The salts absorb water and form solutions which then causes the particles to be bound together. The resin used in soldering fluxes is an example of a non-hygroscopic material. That is, after soldering and hardening, the resin residues do not absorb water from the atmosphere.
Hypalon	Dupont trade name for chlorosulfonated polyethylene, an ozone resistant synthetic rubber.
Hypereutectic alloy	Any binary alloy which has a composition that lies to the right of the eutectic on an equilibrium diagram, and which contains some eutectic structure.
Hz	(See Hertz).
I	(1) Designation for interlocked armor of aluminum, bronze, or steel. (2) (See current).
IACS	International Annealed Copper Standard.
ICEA	(See Insulated Cable Engineers Association).
Icicling	Formation of solder spikes resulting from poor drain-off of liquid solder following wave or dip-soldering of printed circuit boards and assemblies. Poor solderability of the surfaces to be soldered and contaminated solder are frequent causes of icicling.
ICR	(See Individual Contact Release).
IDC	(See Insulation Displacement Connector).
IEC	International Electrotechnical Commission.

Table 2. Terms And Definitions (Cont.)

Term	Definition
IEEE	Institute of Electrical and Electronic Engineers.
IEEE 802/802.3	Standards for the interconnection of local area network computer equipment.
IEEE 802.5	Standard for using token passing as an access method.
IEE 802.6	Standard (under development) for a Metropolitan Area Network spanning many kilometers using a distributed queuing access control method and a dual bus architecture.
IIR	(See Isobutylene - Isoprene Rubber).
Impact energy	The amount of energy required to fracture a material, usually measured (impact value) by means of an Izod of Charpy test. The type of specimen and the testing conditions affect the values and therefore should be specified.
Impact strength	A test for determining mechanical abuse a cable can withstand without breakdown by impacting with a given weight, dropped a given distance, in a controlled environment.
Impedance matching	Very generally, connecting cables and devices together which have the same impedance value in ohms.
Impedance (Z)	Total opposition that a circuit offers to the flow of alternating current or any other varying current at a particular frequency. It is a combination of resistance, R, and reactance X, measured in ohms, and designated by Z. (See formulas - electrical).
Imperial Wire Gauge	(See British Standard Wire Gauge).
Impregnation	Application of a resin to tightly built devices (for example, coil windings). The resin penetrates internal voids and a solid assembly results. Impregnation may be used together with embedment or encapsulation.
Impulse	Surge of unidirectional polarity.
Impulse ratio	Ratio of the flashover, sparkover, or breakdown voltage of an impulse to the crest value of the power frequency flashover, sparkover, or breakdown voltage.
Impulse strength	Voltage breakdown of insulation under voltage surges on the order of microseconds in duration.
Impulse test	Voltage test for finished wire in which the wire passes through an ionized air space created by a continuous voltage wave for a specific duration, rise time, frequency, and damping. Used to detect manufacturing flaws.
Impurities	Elements or compounds whose presence in a material is undesired.
IMSA	International Municipal Signal Association.
In-line	Term used to describe a termination that has no structural mounting provisions and joins conductors end to end. (See pendant).
Inclusions	Non-metallic materials, such as slag and dirt, entrapped during solidification of a molten metal.
Incoherent source	Light source which emits wide, diffuse beams of light of many wave (fiber optic) lengths. Light waves emitted from an incoherent source are out of phase. (See coherent light).

Table 2. Terms And Definitions (Cont.)

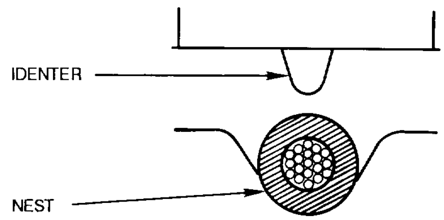
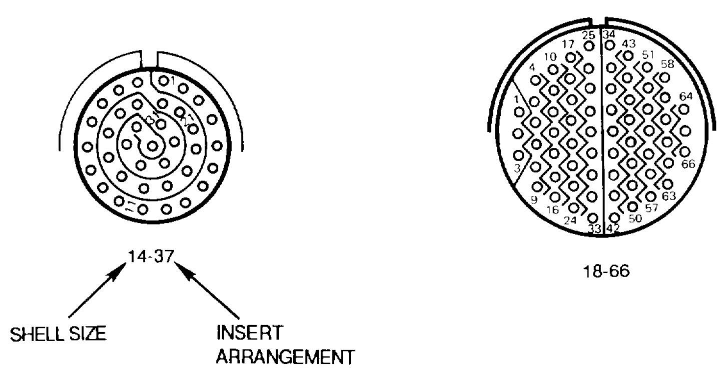
Term	Definition
Indenter	That part of a crimping die, usually the moving part, which indents or compresses the conductor barrel. 
Index edge	(See reference edge)
Index matching fluid (fiber optic)	Fluid with refractive index same as fiber core; used to fill air gap between fiber ends at connectors.
Index matching materials (fiber optic)	Materials used for intimate contact between the ends of optical conductors to reduce coupling losses by reducing Fresnel reflection loss. (See Fresnel reflection loss).
Index of refraction (fiber optic)	Ratio of the speed of light in a vacuum to the speed of light in a material. (See refractive index).
Index profile	In a graded-index optical fiber, the refractive index as a function of radius.
Indium	Indium is a semi-precious, non-ferrous metal. It is soft and ductile and exhibits high adhesion to other metals. In spite of its softness however, indium will harden copper, tin, or lead alloys to increase their strength. Approximately 1% in lead will double the hardness of lead. In solders it improves wetting and lowers the melting point.
Individual Contact Release (ICR)	System whereby each contact in an assembly can be individually locked or unlocked and removed without unlocking the other contacts.
Inductance (L)	Property of a circuit or circuit element that opposes a change in current flow. Inductance thus causes current changes to lag behind voltage changes. Inductance is measured in Henrys (H). (See formulas - electrical).
Induction	Influence exerted by a charged body or by a magnetic field on neighboring bodies without apparent communication. Electrifying, magnetizing, or inducing voltage by exposure to a field.
Induction coil	Device for changing direct current into high-voltage alternating current. Its primary coil contains relatively few turns of heavy wire, and its secondary coil, wound over the primary, contains many turns of fine wire. Interruption of the direct current in the primary by a vibrating contact arrangement induces a high voltage in the secondary.
Induction heating	Heating process which utilizes a phenomenon associated with metallic or crystalline materials. A high frequency electrical current is generated in a solid material by placing that material within an externally applied high frequency magnetic field. The external current is matched within the material by the material absorbing electrical energy from the field. Individual atoms or molecules of the material will then vibrate in step with the frequency, and small local currents are generated in groups of atoms or molecules. The heat is generated by the electrical resistance of the material to the small local currents. The term high frequency refers to any alternating current above approximately 1KHz. This method of heating is extremely efficient and usually very fast. Since the heating is accomplished by local currents which are generated in the body of the material (see eddy currents), the higher the resistivity of the material, the faster it will heat up under the influence of an induction heating unit.
Inductive coupling	Electrical interaction resulting from the action of the electromagnetic field of one conductor on the other. (See crosstalk).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Inductive Soldering	Joining produced by the heat obtained from resistance of the work to the flow of induced electric current.
Inductor Quality	(Q-factor) Ratio of coil reactance to effective coil resistance which is the measure of electrical loss in a coil. (See formulas - electrical).
Infrared radiation	Band of electromagnetic wavelengths extending from 770 nanometers (the extreme of the visible) to the shortest microwaves. The strong absorption of infrared by many substances renders it a useful means of applying heat energy.
Inhibitor	(1) Material which prevents or delays oxidation and galvanic action on a connector surface, or the interface of different conductors. (2) A chemical compound added to a mixture to restrain its chemical reaction until a desired condition exists.
Injection Laser Diode (ILD)	Semiconductor device consisting of at least one P-N junction capable of emitting coherent stimulated radiations under specified conditions.
Inorganic	Chemistry of those compounds found in nature or synthesized by man which do not depend essentially upon the chemistry of carbon for their properties (see organic). Examples of inorganic compounds are minerals, metals, and gases such as those found in the air.
Inorganic chemicals	Chemicals whose chemical structure is based on atoms other than the carbon atom.
Input/Output (I/O)	Connections for power and signals into and out of a system. Connections may be between subassemblies within the same enclosure or between individual units.
Insert	That part which holds the contacts in their proper arrangement and electrically insulates them from each other and from the shell.
Insert arrangement	Number, spacing, and arrangement of contacts in a connector. Also called insert configuration.



TYPICAL INSERT ARRANGEMENTS

Term	Definition
Insert, closed entry	One having openings that restrict the entry of devices larger than the specified contact.
Insertion loss	Loss in load power resulting from the insertion of a cable, component, or device. It is expressed in decibels as the ratio of power received at the load before insertion, to the power received at the load after insertion.

Table 2. Terms And Definitions (Cont.)

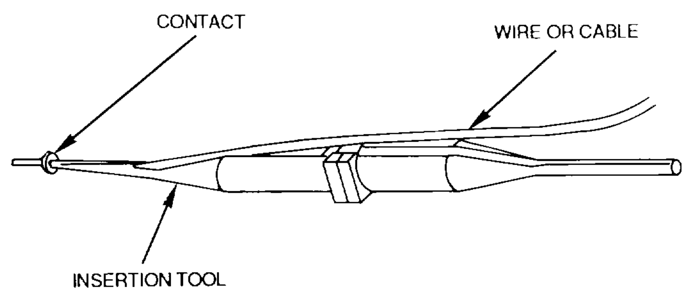
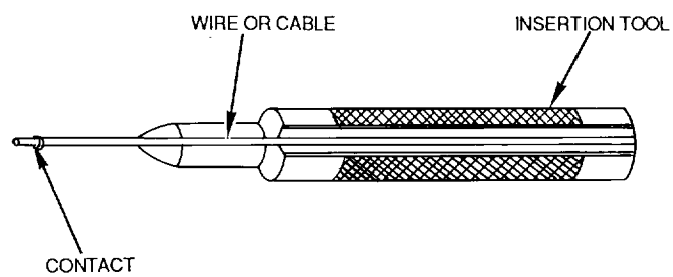
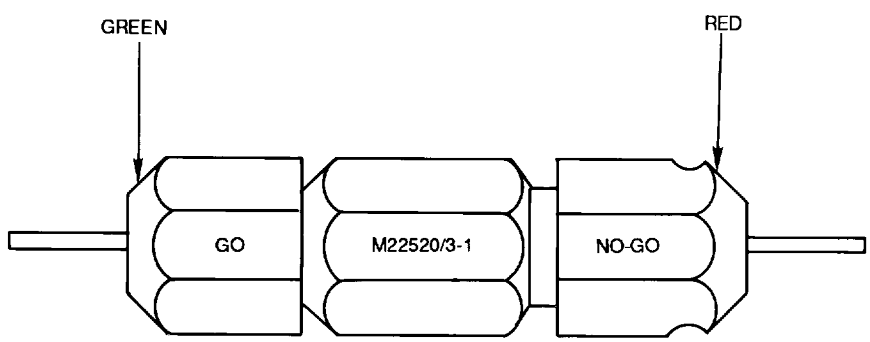
Term	Definition
Insertion tool	Hand tool used to insert contacts into the connector insert or retainer.
	 TYPICAL PLASTIC INSERTION TOOL
	 TYPICAL METAL INSERTION TOOL
Insert retention	Axial load in either direction which an insert must withstand without being dislocated from its normal position in the connector shell.
Inspection gage	A device which conforms to the gaging limits specified on the applicable tool specification sheet, used to ensure correct die closure.
	
Inspection hole	Hole placed at the bottom end of a contact conductor barrel to permit visual inspection in seeing that the conductor has been inserted to the proper depth in the barrel prior to crimping.
Insufficient solder	Defect readily identified by the lack of enough solder to properly wet and bond the surfaces being joined. The resulting joints are very weak and highly susceptible to vibration failures.

Table 2. Terms And Definitions (Cont.)

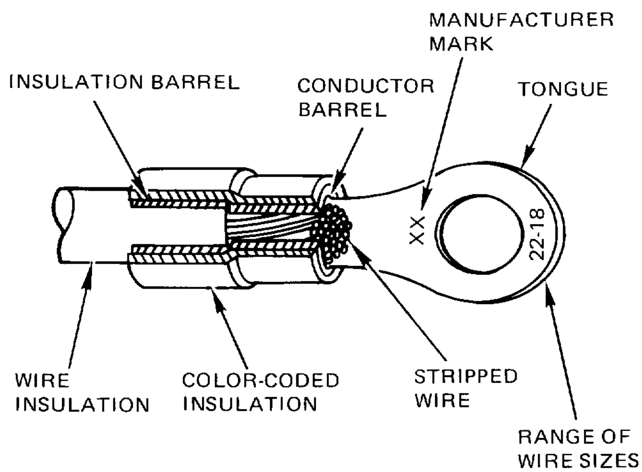
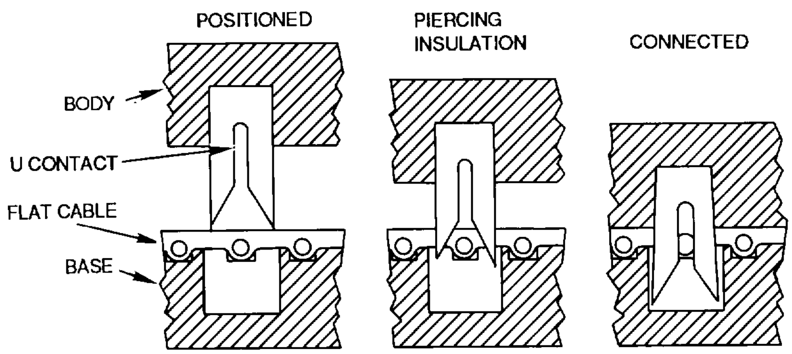
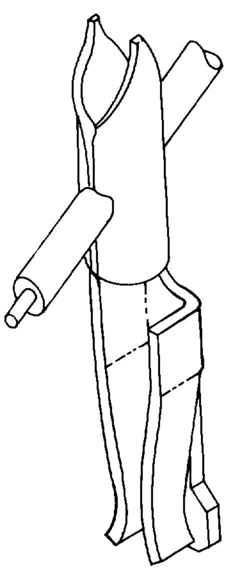
Term	Definition
Insulated Cable Engineers Association (ICEA)	Association of power cable engineers from many different companies. Their object is to establish standards in the insulated power cable industry.
Insulated terminal	Terminal having its barrel and insulation support or grip, if used, covered with a dielectric material.  TYPICAL INSULATED TERMINAL
Insulated wire	Conductor of electricity covered with a nonconducting material (insulation).
Insulating joint	Device which mechanically couples and electrically insulates the sheath and armor of continuous lengths of cable.
Insulation	Material which offers high electric resistance making it suitable for covering components, terminals, and wires to prevent the possible future contact of the adjacent conductors resulting in a short circuit.
Insulation adhesion	Degree of looseness or tightness of the insulation over the base conductor measured in terms of force required to remove a specified length of insulation from the wire.
Insulation barrel	Section of the terminal, splice or contact that accommodates the conductor insulation. (See barrel).
Insulation crimp	Area of a terminal, splice, or contact that has been formed around the insulation of the wire.

Table 2. Terms And Definitions (Cont.)

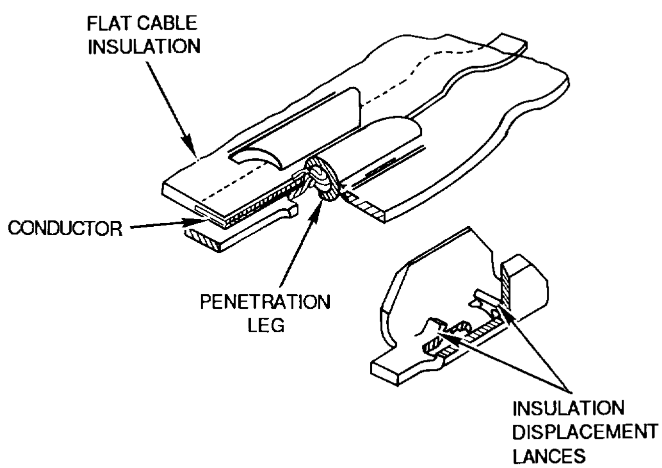
Term	Definition
Insulation Displacement Connector (IDC)	Assembly process wherein an insulation piercing edge of the contact is pushed through the insulation and into contact with the conductor. Most commonly used in mass termination applications.



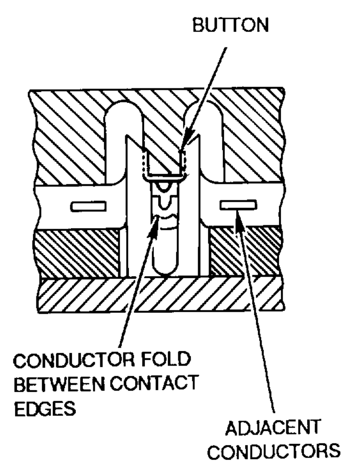
U-CONTACT



MODIFIED-U CONTACT



FLAT CONDUCTOR CRIMP



FLAT - CONDUCTOR ADAPTER

Term	Definition
Insulation grip	Certain crimp type contacts have extended cylinders at the rear designed to accept the bare wire and a small length of its insulation. When crimped, both the wire and insulation are held firmly in place. This prevents the wire from being exposed by the insulation receding.
Insulation level	Impulse voltage breakdown of cable and accessory equipment.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Insulation piercing	Method of crimping, whereby lances cut thru the insulation of the wires and into the strands making electrical contact thus eliminating stripping of the wire. (See insulation displacement connector).
Insulation resistance (IR)	Ratio of the applied voltage to the total leakage current between two electrodes in contact with a specific insulation.
Insulation stress	Molecule separation pressure caused by a potential difference across an insulator. The practical stress on insulation is expressed in volts per mil.
Insulation support	Portion of a barrel similar to an insulation grip except that it is not compressed around the conductor insulation.
Insulation system	All of the insulation materials used to insulate a particular electrical or electronic product.
Insulator	Material of such low electrical conductivity that the flow of current through it can usually be neglected.
Integral belt	In a cable, a layer of insulation or semiconductive material applied usually by extrusion over two or more insulated, twisted or parallel conductors, to form a round, smooth diameter.
Integrated circuit	Small, complete circuit built up by vacuum deposition and other techniques, usually on a silicon chip, and mounted in a suitable package. Makes possible extremely high circuit board densities.
Integrated detector/ preamplifier	Single chip which contains a detector and an amplifier which converts optical signals to usable electrical output.
Intercalated tapes	Two or more tapes, generally of different composition, applied simultaneously in such a manner that a portion of each tape overlies a portion the other tape.
Intercom wire	Wire used to connect communication instruments, telephones, telegraph, etc.
Interconnecting cable	Wiring between modules, units, or the larger portions of a system.
Interconnecting wire	Physical wiring between components (outside of a module), between modules, units, or larger portions of a system or systems.
Interconnection	Mechanically joining assemblies together to complete electrical circuits.
Interface	(1) Common boundary shared by individual components where they are joined electrically, e.g., conductor to contact, pin to socket, contact to bus. (2) Device, cable, or process used to electrically join together different assemblies.
Interfacial compression	Compression of the resilient material faces of mating inserts that provides positive sealing and insulation when plug and receptacle are locked together.
Interfacial gap	Any gap between the faces of mated inserts.
Interfacial junction	Junction that is formed by the faces of the two mating halves of a connector. This junction can be tightly compressed or loose, depending upon the requirements of the application of the connector.

Table 2. Terms And Definitions (Cont.)

Term	Definition

Stranding Lay Lengths

AWG	No. of Wires	Strand Diameter Each Strand (In.)	Stranded Diameter (In.)		Length of Lay (In.)	
			Min	Max	Min	Max
0000	2109	0.0100	0.580	0.605	*5.24	8.47
000	1665	0.0100	0.515	0.540	*4.32	7.56
00	1330	0.0100	0.455	0.480	*3.84	6.72
0	1045	0.0100	0.405	0.425	*3.40	5.95
1	817	0.0100	0.360	0.380	*3.04	5.32
2	665	0.0100	0.320	0.340	*2.72	4.76
4	133	0.0179	0.250	0.274	*2.19	3.84
6	133	0.0142	0.192	0.217	*1.74	3.04
8	133	0.0113	0.157	0.173	*1.38	2.42
10	37	0.0159	0.103	0.114	0.91	1.82
	49	0.0142	0.118	0.128	1.02	1.79
12	37	0.0142	0.090	0.100	0.80	1.60
	19	0.0179	0.083	0.092	0.74	1.47
	37	0.0126	0.082	0.090	0.72	1.44
14	19	0.0142	0.066	0.073	0.58	1.17
16	19	0.0113	0.052	0.058	0.46	0.93
18	19	0.0100	0.046	0.051	0.41	0.82
	16	0.0100	0.045	0.048	0.38	0.77
20	19	0.0080	0.037	0.041	0.33	0.66
	7	0.0126	0.037	0.039	0.31	0.62
22	19	0.0063	0.029	0.033	0.26	0.54
	7	0.0100	0.029	0.031	0.25	0.50
24	19	0.0050	0.023	0.026	0.21	0.42
	7	0.0080	0.023	0.025	0.20	0.40
26	19	0.0040	0.019	0.021	0.17	0.34
	7	0.0063	0.018	0.020	0.16	0.32
28	7	0.0050	0.0147	0.016	0.13	0.26
30	7	0.0040	0.0117	0.013	0.10	0.23

* Rope Strandings - Lay lengths area minimum of 8 times, and a maximum of 14 times, the maximum stranded diameter. All other stranding lay lengths are 8 times minimum and 16 times maximum stranded diameter.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Interfacial seal	Depending upon connector design there can be either one or two interfacial seals. These are pieces of rubber which have been bonded to the face of the insert and have hole patterns that correspond to the insert configuration. When the receptacle and plug are fully mated, the plug and receptacle interfacial seals are compressed together. This provides an environmental seal between the faces of the plug and receptacle and also increases the dielectric between contacts which can increase the service rating of the connector.
Interference	Any undesirable electromagnetic emission or any electrical or electromagnetic disturbance, phenomenon, signal or emission, man-made or natural which causes (or can cause) an undesired response, malfunctioning, or degree radiation of the electrical performance of electrical and electronic equipment.
Intergranular penetration	Process by which solder, by diffusion, penetrates into grain boundaries of parent metal.
Interlayer connection	Electrical connection between conductive patterns indifferent layers of a multilayer printed board. (See through connection).
Intermetallic compound	Intermediate phase in an alloy system, having a narrow range of uniform composition and relatively simple component quantity proportions, in which the nature of the atomic binding can vary from metallic to ionic.
Intermittent weld	Weld in which the continuity is broken by recurring unwelded spaces.
Internal layer	Conductive pattern which is contained entirely within a multilayer-printed board.
Internal wiring	Electronic wiring which interconnects components, usually within a sealed subsystem. (See external wiring).
Interstice	In cable construction, the space, valley, or void left between or around cabled components.
Intrinsic joint loss	Loss by fiber-parameter mismatches when two non-identical fibers are joined.
I/O	(See Input/Output).
Ion	Particle, usually in solution, composed of a single atom or groups of atoms, bearing an electrical charge. These atoms or groups of atoms breakdown from compounds when the compound is dissolved. An ion carrying a positive charge is called a cation, while an ion carrying a negative charge is called an anion. Ions formed outside of a solution usually are very short-lived unless they are in high vacuum. Corrosion is a process usually resulting from ionic reaction.
Ion-exchange column	Apparatus containing specially treated resin particles of two types, an-ionic and cationic resins, which attract and remove both positively and negatively charged ions from a solution. Also known as demineralizers and deionizers.
Ionizable	Characteristic of a material which has the capability of breaking down into ions when in a solution. (See ion).
Ionization	(1) Dissociation of an atom or molecule into positive or negative ions or electrons. (2) State of an insulator whereby it facilitates the passage of current due to the presence of charged particles usually induced artificially.
Ionization factor	Difference between percent power factors of a dielectric at two specified values of electrical stress. The lower of the two stresses is usually selected so that the effect of ionization on power factor at this stress is negligible.
Ionization voltage (corona level)	Minimum value of falling RMS voltage which sustains electrical discharge within the vacuous or gas-filled spaces in the cable construction or insulation.

Table 2. Terms And Definitions (Cont.)

Term	Definition
IPCEA	Insulated Power Cable Engineers Association. (See ICEA).
IPE	Designation for Irradiated Polyethylene tape.
IR	(See Insulation Resistance).
IRE	Former Institute of Radio Engineers.
Iron-constantan	Combination of metals used in thermocouples, thermocouple wires, and thermocouple lead wires. The iron wire is positive, the constantan negative.
Irradiation	In insulations, the exposure of the material to high energy emissions for the purpose of favorably altering the molecular structure.
ISDN	Integrated Service Data Network.
ISHM	International Society for Hybrid Microelectronics.
ISO	International Organization for Standardization.
Isobutylene-Isoprene Rubber (IIR)	Polymer of isobutylene with small amounts of isoprene. This insulation and jacketing material is characterized by excellent resistance to oxidation and aging, exceptional ozone resistance, and very good electrical properties. Resistance to moisture, physical abuse, and chemicals is also good. Applications include power cables, apparatus and equipment leads, control cables, and various other cables. It is alkali-sensitive and may revert under hot, wet conditions.
Isocyanate resins	This resin is generally reacted with polyols such as polyester, polyethers, etc. The reactants are joined through the formation of the urethane linkage.
ISO OSI	ISO's architecture for Open Systems Interconnection, a scheme for universal standard architecture and protocol suite.
ISO reference model for OSI	Standard approach to network design which introduce modularity by dividing the complex set of functions into more manageable, self contained, functional slives. These layers, from innermost layer, are as follows: (1) Physical, (2) Link, (3) Network, (4) Transport, (5) Session, (6) Presentation, and (7) Application Layers.
j	(See Joule).
J	Designation for asphalted Jute, nonmetallic armor.
Jack	Plug-in type terminal widely used in electronic apparatus for temporary connections. A connection is made to a jack simply by plugging a probe or plug attached to a flexible insulated wire or cable into the jack.
Jacket	(1) Rubber or synthetic covering applied over the primary insulation, braids, shields, cable components, or over the cable itself. (2) (fiber optic) A covering, frequently plastic, over a fiber, bundle of fibers, or cable which protects against the environment.
Jackscrew (screwlock)	Screw attached to one-half of a two piece multiple contact connector used to draw and hold both halves together and to separate them. (See mechanically engaged connector).
JAN specification	Joint Army-Navy specification.
Joint	Location where two or more members are to be or have been fastened together mechanically or by brazing, welding, or soldering.
Joint clearance	Dimensions between interfaces of the soldered joint.
Joule (j)	Unit of energy or work. The absolute joule is equal to 10 million ergs or 0.7375 foot pounds. The internal joule is equal to the work required to maintain a current of one ampere for one second in a resistance of one ohm.

Table 2. Terms And Definitions (Cont.)

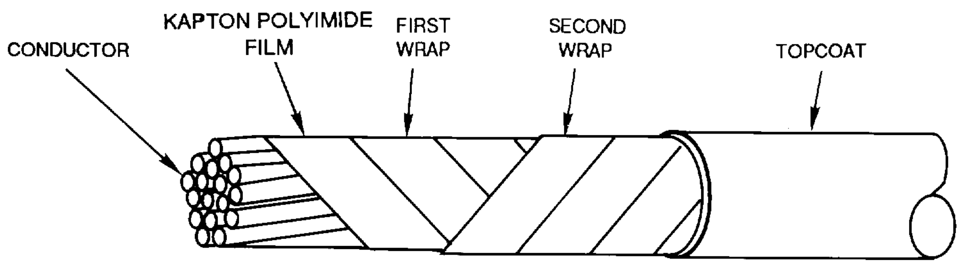
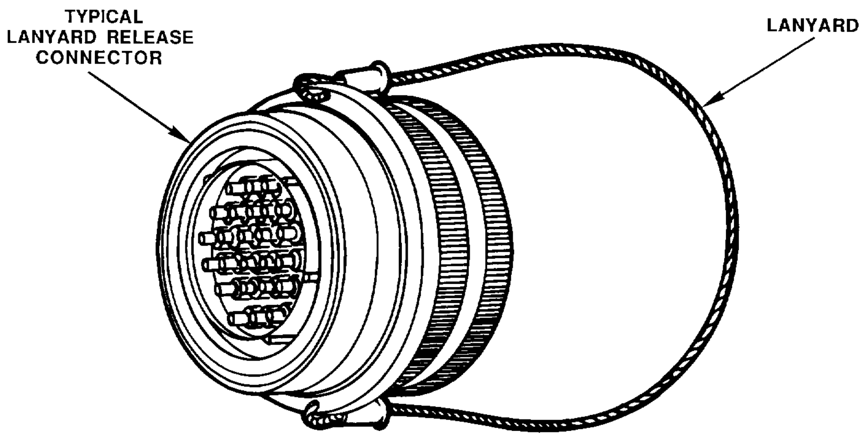
Term	Definition
Jumper	Electrical connection between two points on a printed board added after the intended conductive pattern is formed.
Junction	Joining of two different semiconductors or of semiconductor and a metal. Alloy, diffused, electrochemical, and grown are the four junction types.
Jute	Natural fiber of plant base formed into rope-like strands. Used in cables for filling the interstices to give a round cross-section.
K	(1) (See dielectric constant). (2) (See Kilo).
Kapton	A trademark of the DuPont Company for their polyimide resin film used as wire insulation. Kapton polyimide film is transparent and is amber in color. The film is wrapped in one direction on the wire or cable at an angle with approximately a 50% overlap, then wrapped in the opposite direction with a 50% overlap. After wrapping, the film is heated to seal the wrapped layers. An opaque top coat is applied to provide different colors of wire and a surface for wire printing. Kapton wire configurations are defined in MIL-DTL–81381B. Kapton wire has poor life characteristics and is no longer recommended for Navy aircraft.  TYPICAL KAPTON INSULATED WIRE
Kari butanol value	Measure of the strength of a solvent, such as its ability to dissolve soils. The higher the value, the more effective the solvent, and the greater the tendency to attack delicate plastic.
Key	A short pin or other projection which slides in a mating slot, hole, groove, or keyway to guide two parts being assembled and hold the parts in position. Generally used in shell-enclosed connectors to obtain polarization.
Keyway	Slot in which a key slides; to ensure the correct location in a mating connector.
Kf	(See fatigue strength reduction factor).
Kilo (K)	Numerical prefix denoting 1000 (10^3).
Kilovolt ampere (KVA)	1000 volts x amperes.
Kirchoffs laws	(1) The algebraic sum of the currents which meet at any point is zero. (2) In any closed circuit the algebraic sum of the products of the current and the resistance (voltage drops) in each conductor in the circuit is equal to the electromotive force (voltage applied) in the circuit.
Kraft paper	(See Paper).
KVA	(See Kilovolt Ampere).
Kynar	The trade name of Pennwalt Company for their brand of polyvinylidene fluoride.

Table 2. Terms And Definitions (Cont.)

Term	Definition
L	(1) Designation for Lead Sheath. (2) (See inductance).
Lacing and harnessing	Lacing, harnessing, or bundling is a method of grouping wires by securing them in bundles or designated patterns. (See breakout).
Lacing cord or twine	Used for lacing and tying cable forms, hook-up wires, cable ends, cable bundles, and wire harness assemblies. Available in various materials and impregnants.
Lacing tape	Flexible, flat fabric tape for tying harnesses and wire bundles, securing of sleeves and other items, and general lacing and tying applications. Available in various materials and impregnants.
Lacquer	Solution of natural or synthetic resins in readily evaporating solvents. Lacquers can be applied by dipping, spraying, die wiping, screening, or other suitable means. The film or coating is formed by the evaporation or the volatile components. The use of lacquer as an insulating material has found the greatest acceptance in the manufacture of insulated wire and printed circuits.
Lacquer finish	Finish applied over braided wire or cable for appearance and protection against fraying, wicking, moisture absorption, abrasion, etc.
Lambertian radiator (fiber optic)	Radiance distribution that is uniform in all directions of observation.
Laminate	Raw material for printed circuits. Consists of a sheet of plastic with copper foil adhered to one or both sides.
Laminated cable, heterogeneous	This class of cable is fabricated using a film of insulating material which has been pretreated by the addition of an adhesive coating that reacts to heat and/or pressure. When two films are pressed together, the adhesive flows around the conductors, which helps to provide good insulation between them.
Laminated cable homogeneous	This class of cable is fabricated using insulating materials which can be softened, melted, or cured by the use of heat and/or pressure. The insulating material is fusion bonded and does not use any other adhesive.
Laminated plastics	Class of standard structural shapes, plates, sheets, angles, channels, rods, tubes, and zees that are produced by combining layers of resin-impregnated materials in a press under heat and pressure. Base materials may be paper, asbestos paper and mat, cotton cloth and mat, glass cloth and mat, nylon cloth, silica cloth, and wood veneer. Resins include phenolics, melamines, epoxies, silicones, polyesters, polyimides, and others.
Laminated tape	Tape consisting of two or more layers of different materials bonded together.
Land	Portion of a conductive pattern usually, but not exclusively, used for the connection and/or attachment of components.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Lanyard	Device attached to certain connectors which permits uncoupling and separation of connector halves by a pull on a wire or cable.



Term	Definition
Lap joint	Two conductors joined by placing them side by side so that they overlap. (See parallel splice).
Lap winding	An armature winding in which opposite ends of each coil are connected to adjoining segments of the commutator. The windings thus overlap.
Lap wound	(See taped insulation).
Lap wrap	Tape wrapped around an object in an overlapping condition.
Large-Scale Integration (LSI)	Usually denotes arrays of integrated circuits on a single substrate that comprise 100 or more individual active circuit functions or gates.
Laser	Acronym for Light Amplification by Stimulated Emission of Radiation, a device which transmits an extremely narrow and coherent beam of electronmagnetic energy in the visible light spectrum.
Laser diode (fiber optic)	Semiconductor diode that when pulsed, emits coherent light, light of essentially one wavelength, in phase, traveling in the same direction.
Lasing threshold	Lowest excitation level at which a laser's ouput is dominated by stimulated emission rather than spontaneous emission.
Lateral loss (fiber optic)	Power loss, expressed in decibels, due to the deviation from optimum coaxial alignment of the ends of separable optical conductors. (See coupling loss).
Lateral misalignment loss (fiber optic)	That portion of the loss, expressed in decibels, due to the lateral or angular misalignment of the optical junction centerline. (See coupling loss).
Lateral offset loss	An optical power loss caused by transverse or lateral deviation from optimum alignment of source to optical fiber, fiber-to-fiber, or fiber-to-detector.
Latex	Rubber material used for insulation of wire.

Table 2. Terms And Definitions (Cont.)

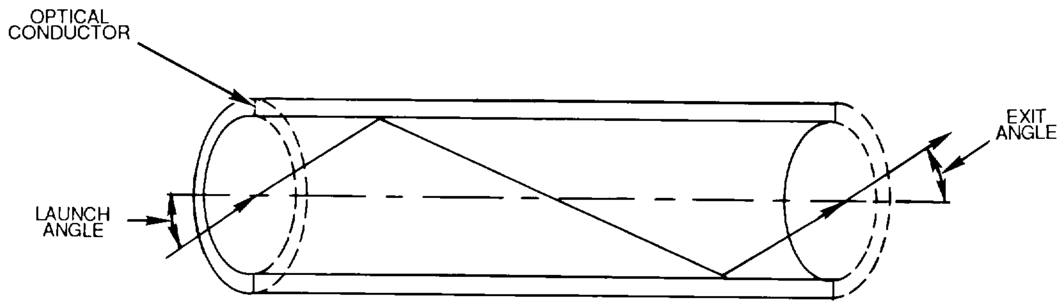
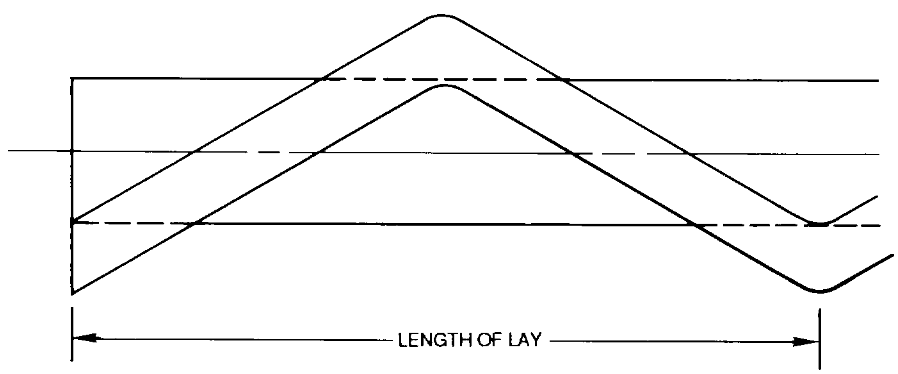
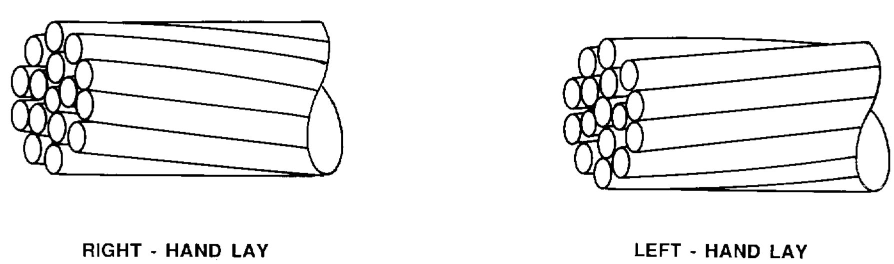
Term	Definition
Launch angle (fiber optic)	Angle between the input radiation vector and the axis of the fiber or fiber bundle.
	
Lay	Lay of any helical element of a cable is the axial length of a turn of the helix of that element. Among the helical elements of a cable may be each strand in a concentric-lay cable, or each insulated conductor in a multi-conductor cable. Lay is often referred to as pitch.
	
Lay, direction of	Direction in which the strands or a conductor or components in a cable pass over the top of the bundle as they recede from an observer looking along the axis of the conductor or cable. Termed right hand or left hand. (See lay).
	
Layer	Consecutive turns of a coil lying in a single plane.
Layer insulation (for transformers)	Dielectric used between the layers of magnet wire in a coil.
Layer-to-layer spacing	Thickness of dielectric material between adjacent layers of conductive circuitry in a multilayer printed board.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Layout	Original design of a circuit board. Includes not only circuitry but locating marks, pilot holes, identification marks, and number of units per board.
LC	Designation for Lead Covered.
LDPE	(See Low Density Polyethylene).
Leaching and non-leaching	In a leaching wire the plasticizer will migrate or leave the vinyl compound when exposed to the heat of baking. The wires treated become brittle and hard. A non-leaching wire will retain its plasticizer under extreme temperature conditions remain flexible after baking. A non-leaching wire is desirable for use as motor lead wire.
Lead	Wire, with or without terminals, that connects two points in a circuit.
Lead aluminosilicate	Lead aluminosilicate ceramics show low shrinkage and self-glazing properties. Dense ceramic bodies in the compositional range of lead oxide (47.5% to 83.9%), alumina (2.5% to 27.2%), and silica (10.8% to 35.0%), when fabricated from commercial raw materials and by conventional fabricating techniques, exhibit low fired shrinkage characteristics. When fabricated at optimum pressures, bodies of zero fired shrinkage are obtained.
Lead covered cable	Cable provided with a sheath of lead for the purpose of excluding moisture and affording mechanical protection. Also called lead sheathed cable.
Lead cured	Vulcanizing process whereby a lead sheath is used as a mold to contain a rubber compound during curing.
Lead dress	Placement or routing of wire and component leads in an electrical circuit.
Lead frames	Large scale integrated circuits are connected to lead frames to facilitate making connections to and from the various solid-state devices of the package. The leads are generally flat ribbons, down to mils wide and from 2 to 10 mils thick. Lead frames are made of kovar, nickel, copper, and other metals.
Lead-in	Conductor or conductors that connect the antenna to electronic equipment.
Leakage	Loss of insulation between conductors on a board. May be due to improper cleaning procedures that leave conductive residues.
Leakage current	Undesirable flow of current through or over the surface of an insulation.
Lecher wires	Two parallel wires with a movable shunt that are connected to the output of a radio frequency source and are used mainly to measure wave lengths shorter than about 10 meters.
LEL	Lower Explosive Limit
Lenz’s law	When an electromotive force is induced in a conductor by any change in the relation between the conductor and the magnetic field, the direction of the electromotive force is such as to produce a current whose magnetic field will oppose the change.
LESCW	Designation for Low Energy Safety Circuit Wire.
Levels of interconnection	Device to board or chassis. Connection point between components (tubes, transistors, integrated circuits, etc.) and the Printed Circuit (PC) board or chassis. Board to mother board or backplane. Connection point between PC boards or sub-circuit modules and the mother board or a back-plane board. Backplane wiring. Connections between levels to each other and to other subcircuits. Input/output. Connections for power and signals into and out of a system. Connections may be between subassemblies within the same enclosure or between individual units.
LID	Leadless Inverted Device.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Life cycle	A test performed on a material to determine the length of time before failure in a controlled and accelerated environment.
Light	In a strict sense, the visible spectrum nominally covering the wave-length range of 400nm to 750nm.
Light Emitting Diode(LED)	Semiconductor device which emits incoherent light from a P-N junction (when biased with an electrical current).
Light-intensity ratio	Ratio of input light intensity to the output light intensity.
Light source (fiber optic)	Any object capable of emitting coherent light. The light source is normally either a light emitting diode or a laser. (See fiber optics, coherent light).
Lightwave communications (fiber optic)	Communications using light, instead of an electric current, to carry the information. (See fiber optics).
Limpness	Ability of a cable to lay flat or conform to a surface.
Line balance	Degree to which the conductors of a cable are alike in their electrical characteristics with respect to each other, to other conductors, and to ground. Similar to balanced line.
Line cord	Cord, terminating in a plug at one end, used to connect equipment or appliances to a power outlet.
Line drop	Voltage loss occurring between any two points in a power or transmission line. Such loss, or drop, is due to the resistance, reactance, or leakage of the line.
Line equalizer	Reactance (inductance and/or capacitance) connected in series with a transmission line to alter the frequency-response characteristics of the line.
Line level	Level of a signal at a certain point on a transmission line. Usually expressed in decibels.
Line of force	Used in the description of an electric or magnetic field to represent the force starting from a positive charge and ending on a negative charge.
Line voltage	Voltage existing in a cable or circuit such as at a wall outlet or other terminals of a power line system. The line voltage is usually between 115 and 120 volts, with 117 as an average, but may vary at times as much as five volts above or below the 115 and 120 volt limits.
Liquation	Tendency of the more fusible components of an alloy to separate from the less fusible components during melting.
Liquid coatings	Liquid or semi-liquid resinous compounds which, when dried or cured, provide a protective barrier between the coated product and the environment. (See conformal coating, potting).
Liquid dielectrics	Liquids serve as dielectric filling agents or impregnants in transformers, capacitors, switch gear, high voltage cables, terminals, circuit breakers, and electronic devices. In addition to their dielectric function, they also may be used for coating and arc quenching functions.
Liquidus	In a constitution or equilibrium diagram, the locations of a set of points representing the temperatures at which the various compositions in the system begin to freeze on cooling or to finish melting on heating. (See solidus).
Lithium aluminosilicates	Lithium aluminosilicates have low or negative thermal expansion characteristics, allowing for excellent thermal shock resistant bodies. They have slightly below average strength properties.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Litz wire	Wire made from a number of fine, separately-insulated strands specially braided or woven together for reduced skin effect and hence, lower resistance to high frequency currents for lower radio frequency losses. The full name is Litzendraht wire.
Loaded line	Transmission line that has lumped elements (inductance or capacitance) added at uniformly spaced intervals. Loading is used to provide a given set of characteristics to a transmission line.
Locator	Device for positioning terminals, splices, or contacts into crimping dies, positioners, or turret heads. (See positioner).
Locking spring	(See contact retaining member).
Long-haul network	Network most frequently used to transfer data over distances of from several thousand feet to several thousand miles.
Longitudinal indent	Crimp indent shape where the longest dimension is in line with the connector barrel. (See crimp termination).
Longitudinal shield	Tape shield, flat or corrugated, applied longitudinally with the axis of the core being shielded. (See shield).
Longitudinal wrap	Tape applied longitudinally along the axis of the core being covered, as opposed to a spiral wrap.
Loopback	Diagnostic test in which the transmitted signal is returned to the sending device after passing through a data communications link or network.
Looping-in	Wiring method which avoids tee joints by carrying the conductor or cable to and from the point to be supplied.
Loop resistance	Total resistance of two conductors, measured round trip from one end (twisted pair, shield and conductor, etc.).
Loss	Energy dissipated without accomplishing useful work.
Loss budget	(See Flux budget).
Loss factor	For an insulating material, the product of dissipation and dielectric constant,
Loss Index	Product of the power factor and the dielectric constant.
Lossy line	Cable having large attenuation per unit of length.
Low Density Polyethylene (LDPE)	Polyethylene whose density ranges from about 0.915 to 0.925. Relatively soft but tough material.
Low frequencies	Frequencies from 5 MHZ to 116 MHZ allocated for the return direction in a mid-split system.
Low loss	Term applied to a dielectric material or cable that has a small amount of power loss over long lengths making it suitable for transmission of radio frequency energy.
Low noise cable	Cable specially constructed to eliminate spurious electrical disturbances caused by capacitance changes, or self-generated noise, induced by either physical abuse or adjacent circuitry.
Low pressure laminates	Laminates molded and cured in the range of pressures under 400 psi.
Low tension	Low voltage, as applied to ignition cable.
LSI	(See Large-Scale Integration).
Lug	Termination, usually crimped or soldered to the conductor, with provision for screwing on to terminal.

Table 2. Terms And Definitions (Cont.)

Term	Definition
LW	Designation for radio hook-up wire with polyvinyl insulation with or without nylon jacket, braid, or shielding braid, 300 V.
m	(See Milli).
M	(1) Suffix indicating two or more insulated, twisted conductors under an outer, nonmetallic covering. (2) (See Mega).
Machineable glass	Machineable glass ceramics are distinguishable from other ceramics and glasses by their micro-structure. This structure consists of a highly interlocked array of plate-like mica crystals dispersed throughout a glassy matrix. Some of these materials can be fabricated on conventional metalworking equipment, allowing parts to be made with the ease of machining.
Macrobending	In a a optical fiber, all macroscopic deviations of the axis from a straight line, distinguished from microbending.
Macrostructure	Structure of metals as revealed by examination of a polished specimen at a magnification not exceeding ten diameters.
Magnesium	Magnesium has a high melting point 5072°F (2800°C) and excellent thermal and dielectric properties. However, it is difficult to fabricate and sinter high purity bodies.
Magnetic	Generally speaking, magnetic metals contain iron, whereas non-magnetic metals do not contain iron. However, this varies in the case of certain types of stainless steel which contain iron but are non-magnetic, and monel which does not contain iron but is mildly magnetic. In view of this fact, should mild steel, stainless steel or monel pieces become mixed up, they can be readily identified by exposing them to a magnet.
Magnetic core	In an armature, magnet transformer, etc., the iron stampings or laminates which, when assembled, form a metallic path for the magnetic circuit.
Magnetic density	Number of lines of magnetic force passing through a magnet or magnetic field per unit area of cross section.
Magnetic field	Region surrounding a magnet, through which magnetic forces act. Composed of lines of force.
Magnetic flux	Rate of flow of magnetic energy across or through a surface (real or imaginary).
Magnet strip	Sheet or foil aluminum (either bare or insulated) used as the conductor in electric windings. Copper is also used. Usually in the form of a bare aluminum strip with shaped, rounded, or contoured edges. This is wound with paper, plastic film, mica paper, or other sheet insulation between layers. A coated strip (of both aluminum and copper) has also been developed.
Magnet wire	Insulated wire intended for use in windings on motor, transformer, and other coils for electromagnetic devices.
Magnetostriction	Characteristic of a material that is manifested by strain when it is subjected to a magnetic field; or the inverse. Some iron-nickel alloys expand; pure nickel contracts.
Male contact	(See pin contact).
Malleability	Ability of a material to accept deformation under pressure, i.e., coining.
Manufacturer’s identification	Colored threads under insulation or jacket, or surface printing or marking, intended to identify a wire or cable construction as the product of a particular manufacturer. Often required by Underwriter’s Laboratories or Government specifications.
Margin	Distance between reference edge of cable and nearest edge of first conductor.
Marker tape	Tape laid parallel to the conductors under the sheath in a cable, imprinted with the manufacturer’s name and the specification to which the cable is made.

Table 2. Terms And Definitions (Cont.)

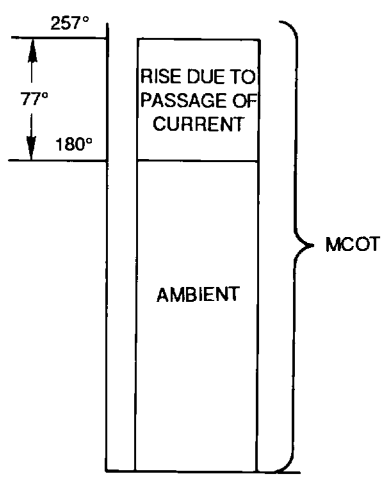
Term	Definition
Marker thread	Colored thread laid parallel and adjacent to the strand in an insulated conductor which usually identifies the manufacturer and specification of the wire.
Mask	Material applied to enable selective etching, plating, or the application of solder to a printed board.
Mass termination	Simultaneous termination of several or all conductors of a cable. This process generally uses terminals that pierce the insulation without stripping to cold flow mate with the conductors and form a gas-tight, metal-to-metal joint. (See insulation displacement connector).
Master drawing	Document that shows the dimensional limits or grid locations applicable to any or all parts of a printed board (rigid or flexible), including the arrangement of conductive and nonconductive patterns or elements; size, type, and location of holes; and any other external characteristics.
Mat	Randomly distributed felt of fibers used in reinforced plastics and flexible composites and coated materials.
Mate	To join two connector halves in a normal engaging mode.
Material dispersion	Light empulse broadening caused by various wavelengths of light traveling at differing velocities through a fiber.
Material scattering loss (fiber optic)	Loss due to fluctuations in the refractive index and to non-uniform material composition and temperature.
Matteucci effect	Voltage generating property of a twisted ferromagnetic wire upon change of magnetization.
Maximum Conductor Operating Temperature (MCOT)	Ambient temperature plus temperature rise due to passage of electric current. 
Maxwell (Mx)	The centimeter-gram-second electromagnetic unit of magnetic flux through a square centimeter normal to a magnetic induction of one gauss.
Maxwell's rule	Every part of an electric circuit is acted upon by a force tending to move it in such a direction as to enclose the maximum amount of magnetic flux.
MBit/Sec	Megabits per second, a measure of network bandwidth.
MC	Designation for cable with interlocking metal tape or corrugated tube enclosure.
MCM	One thousand circular mils. 200 MCM = 200,000 circular mils. (See circular mil).
MCOT	(See Maximum Conductor Operating Temperature).

Table 2. Terms And Definitions (Cont.)

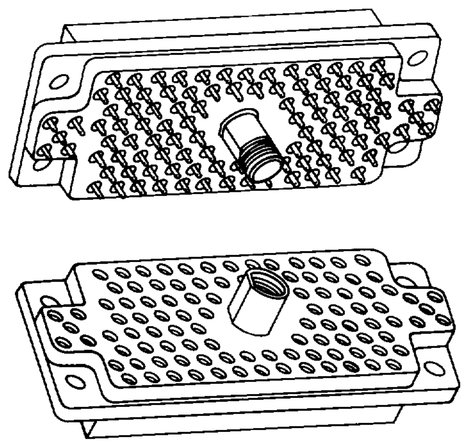
Term	Definition
Measling	Condition existing in the base material in the form of discrete white spots or crosses below the surface of the base material, reflecting a separation of fibers in the glass cloth at the wave intersection.
Mechanically engaged connector	A connector in which engagement is made mechanically, normally through the use of a bayonet coupling, a threaded coupling, or a jack-screw. 
Mechanical Properties	Properties of a material that reveal elastic and inelastic behavior where force is applied, thereby indicating suitability for mechanical applications; for example, modulus of elasticity, tensile strength, elongation, hardness, and fatigue limit.
Mechanical wrap	Securing of a wire or the lead of a component around a terminal prior to the soldering operation.
Medium	Copper wire or microwave transmission signal.
Medium-Scale Integration	Physical realization of a microelectronic circuit fabricated from a single semiconductor integrated circuit having circuitry equivalent to more than 10 individual gates or active circuit functions.
Megabyte	Basic unit of mass storage (1,048,576 bytes) and data-transfer rates.
Megahertz (MHZ)	Unit of frequency equal to one million hertz.
Meg or Mega (M)	Numerical prefix denoting 1,000,000 (10^6).
Megarad	Unit for measuring radiation dosage, lx (10^6) rads.
Megohmmeter	High range ohmmeter, often with hand cranked generator, used to measure insulation resistance. Readings are in megohms.
Melamine-formaldehyde resins	Family of amino resin thermosetting materials. Low molecular weigh types are used for laminating, impregnating paper, etc.
Melt index	Extrusion rate of a thermoplastic material through an orifice of specified diameter and length under specified conditions of time, temperature, and pressure.
Melting point	Temperature at which a pure metal, a compound, or a eutectic changes from solid to liquid; the temperature at which the liquid and the solid are in equilibrium.
Melting range	Difference in temperature between the melting point of an alloy and its flow point.

Table 2. Terms And Definitions (Cont.)

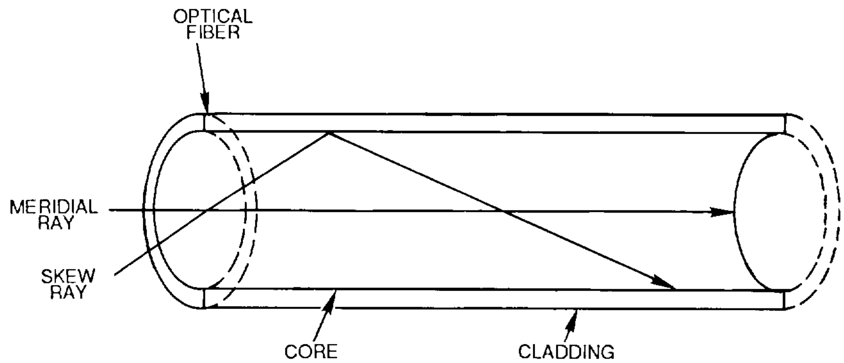
Term	Definition
Meridial rays (fiber optic)	Rays of light which propagate by passing through the axis of the fiber and travel in one plane. 
Mesh (powdered metal)	Screen number of the finest screen of a standard screen scale through-which almost all the particles of a powder sample will pass. Also called mesh size.
Metal	Most substances that are chemically classified as metals have certain characteristics and almost unique physical properties. Among these are high electrical and thermal conductivity, attributed to free electrons; non-transparent and high reflectivity of light, due to the same cause; malleability, a sort of plasticity by virtue of which a metal may be cold-worked and rolled into thin sheets; ductility, a combination of malleability and toughness which permits a metal to be drawn into wire. Metals in their normal state are crystalline.
Metal clad	Refers to construction in which the cable core is enclosed in a metal covering.
Metallizing (spray metallizing)	Forming a metallic coating by atomized spraying with molten metal or by vacuum deposition.
Metallography	Study of the structure and properties of metals and alloys, principally by microscopic and X-ray diffraction methods.
Metallurgy	Term comprises both the science and technology of metals. That area concerned with the extraction of metals for their ores and the refiring of these metals is known as process metallurgy. Physical metallurgy, on the other hand, is primarily concerned with the uses of metals and deals with their physical and mechanical properties as they are affected by heat treating, mechanical working, and alloying.
Metal Oxide Semiconductor (MOS)	A technology for producing transistors that incorporates metal over oxide over silicon layers. Used commonly with Field Effect Transistors (FET), designated MOSFET.
Metered solder cup	Term used when the cylindrical portion of the contact (in which the conductor is inserted) is partially filled with a specific amount of solder before assembly of the connector. Thus the conductor can be soldered into the contact by the simple addition of heat and without additional solder.
MHD	Medium Hard Drawn copper wire.
Mho	Unit of conductance. Reciprocal of an ohm. One ampere of current passing through a material under a potential difference of one volt provides one Mho of conductance. (See Mineral Insulated).
MI	(See Mineral Insulated).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Mica	Silicate which separates into layers and has high insulation resistance, dielectric strength, and heat resistance. It is used as an insulation wrap in wires and cables, to a limited degree, where radiation resistance requirements are severe, and for high temperature work demanding good heat resistance.
Micro (μ)	Numerical prefix denoting one-millionth (10^{-6}).
Microbending loss (fiber optic)	Loss due to small geometrical irregularities along the core/cladding interface of the fiber.
Microcircuit	Physical realization of a (hybrid or monolithic) interconnected array of very small active and passive electronic elements.
Microelectronics	Electronic circuits or systems from a number of extremely small circuit elements inseparably on or within a continuous body. Microelectronics had developed along two basic technologies - monolithic integrated circuits and hybrid integrated circuits.
Micrograph	Graphic reproduction of the surface of a prepared specimen, usually etched, at a magnification greater than 10 diameters. If produced by photographic means, it is called a photomicrograph.
Micron	Measure of length equal to (10^{-6}) meters. Used to describe wavelength, it is equal to 100 nanometers, the preferred term.
Microphone cable	Special shielded cable used to connect a microphone to an amplifier.
Microphonics	Noise in a system caused by mechanical vibration of components within the system. In a microphone cable, for example, microphonic noise can be generated by the shield rubbing against the dielectric as the cable is moved or flexed.
Microprocessor	Integrated circuit package incorporating logic, memory, control, and/or interface circuits, the whole of which is designed to handle certain central processing functions during computer operation.
Microstrip	Type of transmission line configuration which consists of a conductor over a parallel ground plane, and separated by a dielectric.
Microstructure	Structure of polished and etched metals as revealed by a microscope at a magnification greater than 10 diameters.
Microwave	Short electrical wave with a wavelength less than 30 cm and a frequency above 1000 MHz.
Mid-Split	Broadband cable system in which the cable bandwidth is divided between transmit and receive frequencies.
Migration	Movement of some metals, notably silver, from one location to another. It is felt that this results from a plating action in the presence of moisture and an electrical potential.
Migration of plasticizer	Loss of plasticizer from an elastomeric plastic compound with subsequent absorption by an adjacent medium of lower plasticizer concentration.
MIL	Abbreviation for Military as in Military Standard (MIL-STD).
Mil	A unit used in measuring diameter of wire and thickness of an insulation over a conductor, 0.001 in.
Milli (m)	Prefix denoting one thousandth.
Millivolt drop test	Test designed to determine the voltage loss due to resistance of a crimped joint.

Table 2. Terms And Definitions (Cont.)

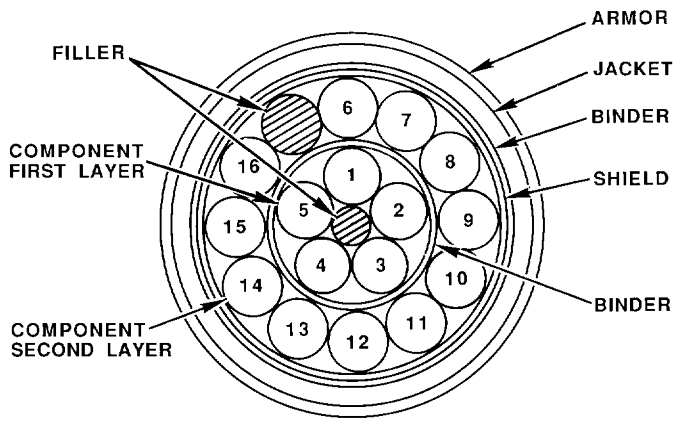
Term	Definition
Mineral Insulated (MI)	Designation for cable and thermocouple wire consisting of one or more conductors surrounded by magnesium oxide insulation and enclosed in a liquid and gas-tight metallic sheathing. Because the construction is completely inorganic, the cable is very heat resistant and inert to most conditions.
Mineral oil	Liquid used as a dielectric. (See liquid dielectrics).
Miniature wire	Insulated conductors of 24 AWG to 34 AWG.
Mismatch, connector impedance	Terminal or connector having a different impedance than that for which the circuit or cable is designed or mated to.
ML	Designation for two wire types. Type A is AVC mine locomotive cable, 600 V and Underwriter's Laboratories approved. AVC cables will not carry flame or support combustion. Type B is a motor lead type wire used as wire to electric motors with stranded copper conductor polyvinylchloride, rubber, or rubber and braid insulation.
Mode (fiber optic)	One of the components of a general configuration of a propagating wave front. Mode is characterized by a particular geometrical pattern and propagation constant.
Mode coupling	In an optical fiber, the exchange of power among modes.
Modular	Connector in which similar or identical sections can be assembled together to provide the best connector type or size for the application.
Modulation	(1) Manner in which a carrier radio frequency is coded with audio or other signals for transmission purposes. May be either Amplitude Modulation (AM) or Frequency Modulation (FM). (2) (Fiber optic) Manner in which in-is coded into light for transmission through a fiber. May be either pulse modulation (digital) or intensity modulation (analog).
Module (electronic)	Group of electronic parts joined by welding, soldering, or other methods to form a separable part of an assembly.
Modulus of elasticity	Measure of the rigidity of metal. Ratio of stress, within proportional limit, to corresponding strain. Specifically, the modulus obtained in tension or compression in Young's modulus, stretch modulus, or modulus of extensibility; the modulus obtained in torsion or shear is modulus of rigidity, shear modulus or modulus of torsion; the modulus covering the ratio of the mean normal stress to the change in volume per unit volume is the bulk modulus. The tangent modulus and secant modulus are not restricted within the proportional limit; the former is the slope of the stress-strain curve at a specified point; the latter is the slope of a line from the origin to a specified point on the stress-strain curve. Also called elastic modulus and coefficient of elasticity.
Moisture absorption	Amount of moisture in percentage that an insulation will absorb under specified conditions.
Moisture resistance	Ability of a material to resist absorbing moisture from the air or when immersed in water.
Molded plug	Connector molded on the end of a cord or cable.
Mold release	Material applied to the surfaces of a mold cavity to ease removal of the material(s).
Molecular weight	Weight of any molecule which is the sum of the weights of its constituent atoms.
Molecule	Smallest quantity of matter which can exist by itself and be recognizable as a particle of the original material. A molecule retains all the properties of the bulk substance from which it came.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Molybdenum	Metallic element like iron, copper, aluminum, and nickel that is found world-wide. An alloying ingredient for iron and nickel base alloys, it is also used in its pure form and as a lubricant base. It displays high temperature strength, good fabricability, and good electrical conductivity.
Monofilament	Single strand filament as opposed to a braided or twisted filament.
Monomer	Chemical (usually a liquid or gas) of low molecular weight used as a starting material for polymerization to produce solid or heavy liquid materials of larger molecular weight, called polymers.
Monotectic	Isothermal reversible reaction in a binary system, in which a liquid, on cooling, decomposes into a second liquid of a different composition and a solid. It differs from a eutectic in that only one of the two products of the reaction is below its freezing range.
MOS	(See Metal-Oxide-Semiconductor).
Mother-board	Printed board used for interconnecting arrays of plug-in electronic modules.
Motor lead wire	Wire which connects to the usually fragile and easily damaged magnet wire found in coils, transformers, and stator or field windings. General requirements are abrasion resistance, toughness, flexibility, dielectric strength, thermal resistance, and low percent of extratables (where applicable; such as in hermetic wires).
Mounting hole	Hole used for the mechanical mounting of a printed board or for the mechanical attachment of components to the printed board.
Mouth	Cable entrance of a connector barrel. (See belled mouth).
MRFR	Designation for Moisture Resistant Flame Retardant finish.
MS	Military Standard (sheet).
MSI	(See Medium-Scale Integration).
MT	Machine Tool wire used for internal wiring of appliances or tools. Solid or stranded conductor, thermoplastic insulation.
MTW	Designation for thermoplastic insulated Machine Tool Wire, 194°F (90°C) to 221°F (105°C), 600 V.
Mullite	Mullite has a good thermal shock resistance and high refractoriness. Mullite ceramic tubes are used to make thermocouple insulating beads and tubes.
Multi-channel cable	Optical cable having more than one fiber.

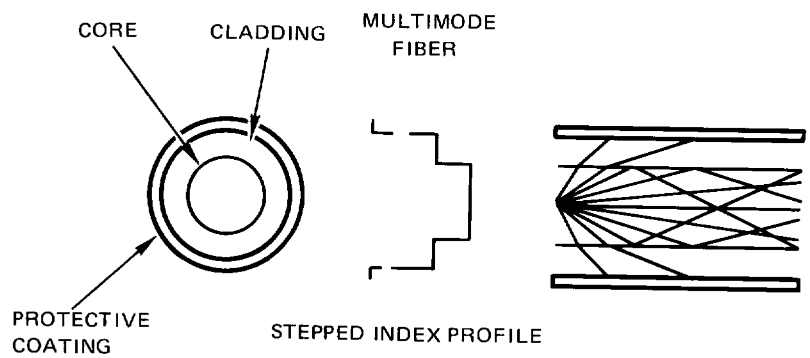
Table 2. Terms And Definitions (Cont.)

Term	Definition
Multiconductor cable	Combination of two or more conductors cabled together and insulated from one another and from sheath or armor where used. Special cables are referred to as 3-conductor cable, 7-conductor cable, 50-conductor cable, etc.



TYPICAL MULTICONDUCTOR CABLE

Term	Definition
Multiconductor concentric cable	Cable composed of an insulated central conductor with one or more tubular stranded conductors laid over it concentrically and insulated from one another.
Multilayer printed circuit board	Printed board consisting of alternate layers of conductive patterns and insulating materials bonded together, with conductive patterns in more than two layers, and with the conductive patterns interconnected as required.
Multimode fiber (fiber optic)	Fiber which transmits many modes.



Term	Definition
Multiplexing	Sending several signals over a single line and separating them at the other end.
Mutual capacitance	Capacitance between two conductors when all other conductors including ground are connected together and then regarded as an ignored ground.
MW	Designation for radio hook-up wire, with polyvinyl insulation and plain or nylon jacket, or braid or shield, 1,000 V.
Mx	(See Maxwell).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Mylar	Trade name of the DuPont Company. A polyester film used widely as a binder tape or separator in cables.
n	(1) (See Nano). (2) (fiber optic) (See refractive index).
NA (fiber optic)	(See Numerical Aperture).
Nano (n)	Numerical prefix denoting one-billionth (10^{-9}).
Nanometer	One billionth of a meter.
Nanosecond	One billionth of a second.
National Electrical Manufacturers Association (NEMA)	It is known in industry for its standardization of wire and cable specifications.
National Electric Code (NEC)	Consensus electrical construction standard published by the National Protection Association (NFPA), incorporated in OSHA regulations, and used nationally.
Natural Rubber (NR) (isoprene)	Rubber by itself is lacking in many properties required of wire and cable insulating and jacketing materials. However, by proper compounding and mixing with other products, it can be converted to a material with excellent physical properties, good electrical properties, and fair to moderate ozone resistance and chemical resistance. (See rubber).
NBC	(See NBR/PVC).
NBR	(See Nitrile-Butadiene Rubber).
NBR/PVC	Blend of Nitrile-Butadiene Rubber and Polyvinyl Chloride, recommended for oil and ozone resistant jacketing of flexible cord and fixture wires, cables, and ignition wires. NBR/PVC is said to offer toughness, smoothness, flame resistance, flexibility, and resistance to abrasion and heat deformation, and to give outstanding service when exposed to weather, light, fuel, oil, or ozone.
NBS	(1) National Bureau of Standards. (2) New British Standard (See British Standard Wire Gauge).
NEC	(See National Electric Code).
Negative lap wound	(See taped insulation).
Negative (noun)	Artwork, artwork master, or production master in which the intended conductive pattern is transparent to light, and the areas to be free from conductive material are opaque.
NEMA	(See National Electrical Manufacturers Association).
NM	Designation for Nonmetallic sheathed cable, braid or plastic covered. For dry use, 140°F (60°C).
NMC	(1) Designation for Nonmetallic Sheathed Cable, plastic or neoprene covered. Wet or dry use, 140°F (60°C). (2) Abbreviation for Naval Material Command.
Neoprene	Trade name of the DuPont Company. Chemically this synthetic rubber is known as polychloroprene. Although the electrical properties of neoprene are inferior to many other insulations, they are adequate for low voltage work. The physical properties of neoprene are similar in some respects to natural rubber but it is considerably better from the standpoint of resistance to oil, ozone, heat, weather, sunlight, and aging. It does not support combustion and resists abrasion and cutting. It is used for a wide variety of wire and cable jacketing applications. (See polychloropene).
Nest	Portion of a crimping die which supports the barrel during crimping.

Table 2. Terms And Definitions (Cont.)

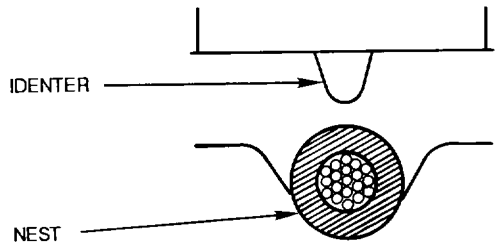
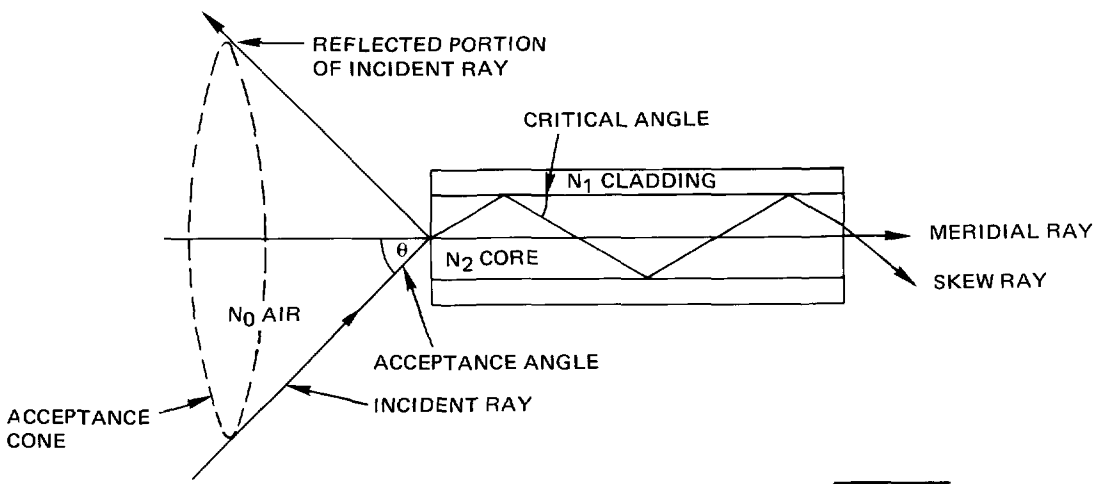
Term	Definition
	
Neutral Flame	Gas flame in which there is no excess of either fuel or oxygen.
New British Standard (NBS)	(See British Standard Wire Gauge).
Nickel	This metal offers combination of moderate corrosion resistance, formability, and tough physical properties. For these reasons, nickel is used for alloying purposes and in nickel clad copper wire.
Nickel clad copper wire	Wire with a layer of nickel on a copper core where the area of the nickel is approximately 30% of the conductor area. The nickel has been rolled and fused to the copper before drawing.
Nick (notch)	Cut or notch in conductor strands or insulation.
Nitrile-Butadiene Rubber (NBR)	Specific properties depend on the actual composition but generally, this rubber offers excellent resistance to oils and solvents. Low temperature flexibility is good. Nitrite rubber has a very low resistivity value. Tensile strength, hardness, toughness, oil and solvent resistance, and resilience vary with the acrylonitrile content (the rubber is the result of the copolymerization of acrylonitrile and butadiene). Also known as nitrite rubber.
Nitrite-Polyvinyl	A thermosetting jacket compound which combines the resistance of Chloride rubber to oils, greases, and solvents with the ozone and sunlight resistance of polyvinyl chloride.
Nitrogen	A gas used as a dielectric. (See gaseous dielectrics).
Noble metal	(1) Metal whose potential is highly positive relative to the hydrogen electrode. (2) Metal with marked resistance to chemical reaction particularly to oxidation and to solution by inorganic acids. The term as often used is synonymous with precious metals.
Noise	Refers to random spurts of electrical energy or interference. Random electrical signals, generated by circuit components or by natural disturbances, that make up transmitted data inaccurate by introducing errors.
Noise Equivalent Power (NEP)	Root-mean-square (rms) value of optical power which is required to produce an rms signal-to-noise ratio of 1.
Noise weighting	Method of assigning a specific value, in numerical readings, to the transmission impairment due to the noise encountered to an average user operating a particular class of subset.
Non-conductor	(See insulation).
Noncontaminating	(1) Material that will not migrate into and contaminate or degrade adjacent materials. (See migrate). (2) Type of PVC jacketing material whose plasticizer will not migrate into the dielectric of a coaxial cable and thus avoids contaminating and destroying the dielectric. (See migrate).
Non-ferrous metals	Alloys not containing iron.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Non-migrating	Synonymous with non-contaminating. (See migrate).
Non-polar compound	This type of compound has electrical charges symmetrically distributed over the surface of the molecule and, therefore, shows no electrical, effects in solution or otherwise. (See polar compound).
Notch sensitivity	Measure of the reduction in strength of a metal caused by the presence of stress concentration. Values can be obtained from static, impact, or fatigue tests.
Notch strength (notch tensile strength)	Ratio of maximum load to the original minimum cross-sectional area in notch tensile testing.
NP	Nickel Plate.
NR	(See Natural Rubber).
NRHW	Designation for moisture and heat resistant rubber insulation with neoprene jacket for use in ducts. Dry and wet locations, 600 V, 167°F (75°C).
Nude contact	Contact with a contact retaining member that remains in the insert at all times.
Numerical Aperture (NA) (fiber optic)	Characteristic of an optical conductor in terms of its acceptance of impinging light. Equal to the refractive index of the coupling medium multiplied by the sine of the acceptance angle, and equals the square root of the difference of the square of the refractive index of the fiber core minus the square of the refractive index of the fiber cladding.



NUMERICAL APERTURE (NA) = $N_0 \sin\theta = \sqrt{N_2^2 - N_1^2}$

θ = MAXIMUM ACCEPTANCE ANGLE FOR TOTAL INTERNAL REFLECTION

N_0 = REFRACTIVE INDEX OF AIR = 1.00

N_1 = REFRACTIVE INDEX OF FIBER CLADDING

N_2 = REFRACTIVE INDEX OF FIBER CORE

Nylon	Generic name for synthetic fiberforming polyamides. Available in three forms for wires and cables: as a yarn for wire serving and braid; as an extrusion material (primarily for jackets); and a coating. For conductors of any but a small size, the electrical and hygroscopic properties of nylon limit its use to jacketing rather than primary insulation. Nylon extrusions are characterized by toughness and excellent oil resistance. Nylon magnet wire has excellent windability due in part to the smooth coating that resists rubbing abrasion. It can be soldered through by using rosin alcohol flux and tin-lead solders.

Table 2. Terms And Definitions (Cont.)

Term	Definition
OD	(See Outside Diameter).
Oe	(See Oersted)
OEM	(See Orginal Equipment Manufacturer).
Oersted (Oe)	Centimeter-gram-second electromagnetic unit of magnetic intensity equal to the intensity of a magnetic field in a vacuum in which a unit magnetic pole experiences a mechanical force of one dyne in the direction of the field.
Off center	Conductor displaced within the cross-section of its insulation; not perfectly centered within the insulation. (See concentricity).
Offgassing	Percentage of a specified gas released during the combustion of insulation or jacketing material.
Offset terminal	Terminal whose tongue is forward of, and whose stud hole is offset from, the centerline of a terminal barrel.
OFHC	(See Oxygen-Free High Conductivity Copper)
Ohm (Ω)	Unit of electrical resistance. The resistance of a circuit in which a potential difference of one volt produces a current of one ampere.
Ohm's law	Current, I, electromotive force, E and resistance, R, expressed by the equations I = E/R, R=E/I, and E=IR. (SEE formulas-electrical).
Oil aging	Cable aged in an accelerated manner (to simulate field conditions) by placement in an oil bath, heated to a pre-set temperature, for a stated time. At the end of such an oil bath test, the cable is subjected to physical and electrical tests in order to evaluate any decline in properties.
Oil feeding reservoirs	Oil storage tanks situated at intervals along the route of an oil filled cable or at oil filled joints of solid cable for the purpose of keeping the cable constantly filled with oil under pressure.
Oil-filled cable	Cable, into which high grade mineral oil is forced underpressure, saturating the insulation to prevent moisture and gases from entering.
Oil-filled pipe cable	Pipe cable in which the pressure medium is oil having access to the insulation.
Oil-modified phenolic	(See phenolic varnish, oil modified).
Olefin	Types of unsaturated aliphatic hydrocarbons, having the formula CnHn, including ethylene, propylene, and butene. They are the bases for such plastics as polypropylene and polyethylene.
Oleoresin	(1) Mixture of resin with the oil of the resin's source plant. (2) Similar mixtures of drying oils and natural or synthetic resins.
Oleoresinous (plain enamel)	This magnet wire film is basically a cured varnish made with a natural resin and a drying oil. Plain enamel is still being used in applications where the winding hazards are not severe. In some applications, it is chosen due to its low cost, ease of winding, and performance ability.
Opaque (fiber optic)	Not permitting the passage of light.
Open butt	(See taped insulation).
Open cell	Foamed or cellular material with cells which are generally interconnected. Closed cells refer to cells which are not interconnected.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Open entry contact	Socket whose engaging end is split and vulnerable to distortion or damage from test probes or other wedging devices.
Operating temperature	Maximum internal temperature resistant capabilites of a connector in continuous service.
Optical cable assemblies	Cable complete with connectors.
Optical communication cable (fiber optic)	Fiber with a protective jacket around it. A cable may have one or more fibers within it. (See fiber cable).
Optical communication fiber (fiber optic)	Term analogous to a single strand of electrical fiber wire in that it wire in that it carries information from point to point. (See fiber).
Optical communications (fiber optic)	Communications using light, instead of an electric current, to carry information. Also called lightwave communications. (See fiber optics).
Optical conductors (fiber optic)	Materials which offer a low optical attenuation to transmission of light energy. Types of optical conductors include: (1) Single Fiber - a discrete optical conductor; (2) Bundle - a number of optical conductors in a random arrangement, grouped together and used as a single transmission medium (channel); (3) Single Channel, Single Bundle Cable - a bundle with a protective covering; (4) Multi-Channel, Single Fiber Cable - more than one single fiber cable jacketed; (5) Single Channel, Single Fiber Cable - a discrete optical conductor with a protective covering; (6) Multi - Channel, Bundle Cable - more than one single bundle cable jacketed; (7) Multi-Channel Cables - a combination of cables.
Optical connectors	Used to attach the transmit and receive optical fibers in the fiber optic cable to the fiber optic transceiver.
Optical filter	Device that selectively transmits certain optical wavelengths and blocks a range of wavelengths.
Optical power (LED)	Radiant power expressed in watts.
Optical power budget	(See Flux budget).
Optical receiver	Device that receives optical signals from an optical transmitter via the receiver fiber of the fiber optic cable.
Optical Time Domain Reflectometry (OTDR)	Method for characterizing a fiber wherein an optical pulse is transmitted through the fiber and the resulting backscatter and reflections are measured as a function of time.
Optical transmitter	Receives electrical signals from the Ethernet controller via the fiber optic transceiver's interface cable and converts electrical signals to optical signals.
Optical waveguide (fiber optic)	Fiber used for optical communications. Analogous to a waveguide used for microwave communications. (See fiber).
Organic	When used in reference to chemistry, relates to the chemistry of carbon compounds. Some carbon compounds, such as carbon dioxide gas, do not fall into this category but the vast bulk of carbon-containing compounds do fall into the organic chemistry class. The reason for the use of the word organic in describing these compounds is that until fairly recently, all of the carbon-containing compounds were found only in nature as part of growing organisms.
Organic ester	A liquid used as a dielectric. (See Liquid Dielectrics).
Organic halides	Organic compounds containing halogens. (See halogens, organic).
Orifice	Opening or hole.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Original Equipment Manufacturer (OEM)	Organization that assembles a complete functioning device, e.g., plane, missile, satellite, truck, automobile, etc.
Oscillator	(1) Device used to create waveforms. (2) Device used mainly in cabling telephone paired components. By oscillating the pairs, alternately rotating the cable forming plate left and right, a false cable lay is obtained.
Oscillatory surge	Surge which includes both positive and negative polarity values.
OSHA	Occupational Safety and Health Act. The Williams-Steiger law passed in 1970 covering all factors relating to safety in places of employment.
OSI	Open Systems Interconnection, a logical structure for network operations standardized with the ISO.
Outgassing	Dissipation of gas from a dielectric evidencing decomposition.
Outside Diameter (OD)	Distance between external surfaces measured perpendicular to the axis of a circular cross section.
Overall diameter	Finished outside diameter of wire or cable.
Overcoat	Stranded conductor made from individual strands of tin coated wire stranded together, and then given a coat of tin overall.
Overcurrent	Current which causes an excessive temperature rise in a conductor.
Overheating	Heating a metal or alloy to such a high temperature that its properties are impaired. When the original properties cannot be restored by further heat treating, by mechanical working, or by a combination of working and heat treating, the overheating is known as burning.
Overlap	Amount the trailing edge laps over the leading edge of a spiral tape wrap.
Oxidation	Simple addition of oxygen to a metal, the addition of atmospheric oxygen to iron to form rust, or any process where a metal loses electrons and is converted from the metal form, zero electrical charge, to a metallic ion with a positive charge. (See corrosion).
Oxide	Substance resulting from the combination of metal and oxygen, which though most prevalent on the surface of the metal, is also capable of penetrating the sub-surface of the metal. This substance forms at room temperature and its development is greatly accelerated at elevated temperatures.
Oxygen bomb test	Method of determining aging effect on wire under heat, tensile strength, and elongation conditions. Wire is placed in a bomb at 158°F (70°C), under 300 psi using pure oxygen gas for a period of 48 to 96 hours.
Oxygen-Free High Conductivity Copper (OFHC)	Copper with no residual deoxidant, 99.95% minimum copper content and an average annealed conductivity of 101%.
Oxygen index	Percentage of oxygen necessary for a compound to support combustion under a given test configuration.
Ozone test	Exposing materials to a high concentration of ozone to give an accelerated indication of degradation in normal environments and in proximity to ozone-producing apparatus.
p	(See Pico).

Table 2. Terms And Definitions (Cont.)

Term	Definition
P	(1) Designation for two or more rubber-insulated stranded conductors with cotton braid over each. Reinforced with overall covering of cotton braid over rubber filler. For pendant or portable use in damp locations 300 V to 600 V. (2) (See Power).
PAC	Preassembled Aerial cable.
Package	(1) Complete assembly of board and components; may be encapsulated. (2) The case used to contain semi-conductors or integrated circuits.
Packing fraction loss (fiber optic)	That part of the loss, expressed in decibels, due to packing fraction.
Packing fraction (PF) (fiber optic)	Ratio of active cross-sectional area of fiber core, or cores, to the total end surface area of the fiber or fiber bundle.
Pad	Area of copper surrounding a hole in a board to be used for insertion of lead of component or inter-connecting wire. Provides area for solder bonding. (See land).
Pair	Term used for two insulated conductors usually twisted together and considered as a unit. (See twisted pair).
Palladium	This metal is used in the fabrication of contact parts and strips. It is used as a contact material when low and consistent surface resistances are required. Various amounts of iridium, ruthenium, and other elements are added to palladium to create alloys with higher mechanical wear resistance.
Pan cured	Method of vulcanizing. Coils of unvulcanized insulated wire are coiled in pans and vulcanized under pressure with steam.
P & R	Pendant and Reel cable.
Panel	Side or front of a piece of equipment, usually metal, on which connectors are mounted.
PAP	Commonly used term for air core (unfilled) direct burial telephone cable with a corrugated aluminum shield.
Paper (and board)	Paper is a term applied to all kinds of matted or felted sheets of fiber formed on a fine wire screen from a water suspension. Paperboard is basically the same, but is generally thicker, more dense, and less flexible. Paper and paperboard are used as insulation for telephone cable, high voltage cable, magnet wire, and with a lead sheath for underground service conductors. They are relatively economical, efficient, and versatile. Their chief problem is in nonuniformity, variation in dielectric constant, dielectric loss factor, strength, and conductivity. Oil impregnated paper has improved electrical and moisture resistance properties. Paper is also used as a cable filler.
Paper, aramid	Aramid paper is non-matting and has a long useful life at temperatures to 428°F (220°C). It is tough with extremely stable electrical and chemical properties over wide ranges of temperatures and humidity.
Paper, cellulose fiber	Cellulose fiber papers exhibit excellent dielectric strength and low dielectric loss for DC and power frequency use. Its chief advantage lies in its economy compared to most solid insulating materials.
Paper, ceramic	An alumina-silica paper composed of approximately 51% alumina and 47% silica. It is resilient, uniform product that is not affected by thermal shock and can be used continuously at temperature to 2192°F (1200°C).

Table 2. Terms And Definitions (Cont.)

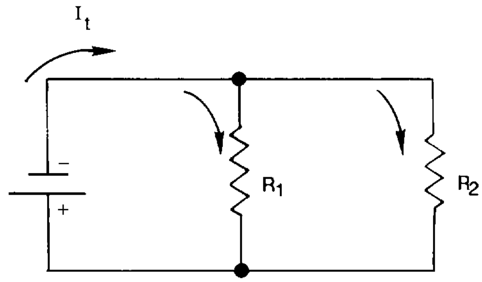
Term	Definition
Parallel circuit	Circuit which has more than one possible path for current to flow. The current flow in each parallel branch is independent of the other parallel branches of the circuit. The sum of the currents in all parallel branches is equal to the total current supplied to the circuit. (See formulas-electrical).  $I_t = I_{R_1} + I_{R_2}$
Parallel pair	Duplex construction where the two insulated conductors are laid parallel and then covered overall with a braid or jacket. Often referred to as duplex cable.
Parallel splice	A device for joining two or more conductors in which the conductors lie parallel and adjacent. (See lap joint).
Parallel stripe	Stripe applied longitudinally on a wire or cable parallel to the axis of the conductor.
Paraxylylene	Generic name of a polymer series that provides continuous conformal coatings as thin as 250 angstroms. These coatings are claimed to offer unequaled thin layer protectection for precision parts, including electronic components and assemblies. They are applied by a vacuum deposition system and reportedly provide an even coating on all surfaces, sharp edges, complex shapes, and in deep, narrow holes.
Parity	Method of ensuring each data byte transmitted or received.
PASP	Air core (unfilled) direct burial telephone cable used in areas subject to rodent attack. It consists of an unfilled cable core, corrugated aluminum shield, corrugated steel tape, flooding compound, and polyethylene jacket.
Passivation	Form of surface oxidation that acts as a barrier to further oxidation or corrosion.
Pasty range	Region between the solidus and liquidus temperatures.
Patch cable	Cable with plugs or terminals on each end of the conductor or conductors used to temporarily connect circuits of equipment together.
Patch cord	Usually braid covered with plugs or terminals on each end. Used to connect jacks or blocks in switchboards or programming systems.
Pattern	The configuration of conductive and non-conductive materials on a panel or printed board.
Pay-off	(1) Process of feeding a cable or wire from a bobbin, reel, or other packages. (2) A device used for paying out wire or cable into a piece of equipment or machinery.
PC board	(See Printed Circuit).
PCG	Commonly used term for air core (unfilled) direct burial cable with a corrugated copper shield.
PCS (fiber optic)	(See Plastic Clad Silica fiber).
PCTFE	Polychlorotrifluoroethylene.

Table 2. Terms And Definitions (Cont.)

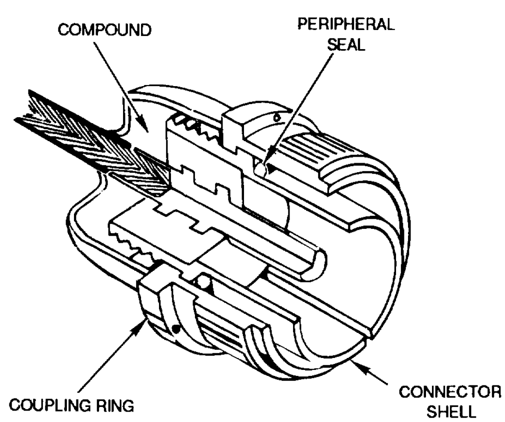
Term	Definition
PD	Designation for rubber insulated stranded conductors with cotton braid over each. Conductors twisted with braid overall. Light duty, dry locations, or appliances, 300 V.
PE	(See Polyethylene).
Peak exothermic temperature	Maximum temperature, in degrees C, reached by a curing thermoset plastic, measured during determination of the gel time.
Peak time	Time from the start of mixing the components of a thermoset plastic composition, until the peak exothermic temperature is reached.
Peak voltage	Maximum instantaneous voltage.
Peak wavelength	Wavelength at which the optical power of a source is at maximum.
Pendant	Type of plug and/or receptacle that is not mounted in a fixed position or attached to a panel or side of equipment. (See in-line).
Percent conductivity	Conductivity of a material expressed as a percentage of that of copper.
Percent plating	Quantity of plating on a conductor expressed as a percentage by weight; thus, for the same percentage, as the conductor diameter increases, so does the thickness of the plating.
Perfluoralkoxy (PFA)	Fluoropolymer similar to PTFE and FEP teflon. It may be extruded as an insulation using conventional high temperature extrusion equipment. It has superior mechanical properties over FEP at high temperatures and possesses excellent electrical characteristics.
Perfluorobutane	A gas used as a dielectric. (See gaseous dielectrics).
Perfluoropropane	A gas used as a dielectric. (See gaseous dielectrics).
Perforated or pierced terminal	Terminal containing a hole through which leads or wires are placed before soldering.
Periodicity	Uniformly spaced variations in the insulation diameter of a transmission cable that result in reflections of a signal, when its wavelength or a multiple there of is equal to the distance between two diameter variations.
Peripheral seal	Either a flat gasket, O-ring seal, or preformed packing used to keep moisture from entering the connector from the outside via the connector shell. Flat gaskets are commonly used on receptacles and O-rings on plugs. When the metal shells of the plug and receptacles come together or bottom out, the seal prevents any moisture from entering the connector shell. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Peritectic	An isothermal reversible reaction in which a liquid phase reacts with a solid phase to produce another solid phase on cooling.
Permittivity	Preferred term for dielectric constant. (See dielectric).
Petroleum oils	A liquid used as a dielectrics. (See liquid dielectrics).
PF	(1) (fiber optic) (See Packing Fraction). (2) (See Power Factor).
PFA	(See Perfluoralkoxy).
PG	Designation for portable mine cable having power and ground conductors, 600 V.
pH	Measure of the acidity or alkalinity of a solution. A pH of 7 is considered neutral (neither acid nor base). Solutions having pH below 7 are acid, and those greater than 7 are basic. The further the pH measurement of the solution is away from seven, the stronger the acid or base. (See acid, base).
Phase	Physically homogeneous and distinct portion of a material system.
Phase diagram	Graphical representation defining the phase fields of a multiphase system, such as an alloy, in a coordinate system using the temperature and the compositions of the phases as coordinates. The tin/lead phase diagram, for example, shows the solidus and liquidus temperatures for a variety of tin/lead solder compositions.
Phase modulation	Modulation is the process of using a medium to carry information.
Phenolic resin	A synthetic resin produced by the condensation of phenol with formaldehyde. Thermosetting material is compatible with many filters and modifiers to achieve high temperature and shock resistance, and other properties. Many electrical applications in molded parts, impregnation, coating, encapsulation, etc. (See varnish).
Phenoxy resins	Linear thermoplastics with high molecular weights, good processing properties, low mold shrinkage, and good creep resistance.
Phenylene oxide based resin	Engineering thermoplastic with very low specific gravity. It is a tough, rigid material which maintains its excellent mechanical properties, relatively unchanged, up to about 300°F 148.9°C. It also exhibits excellent dimensional stability with low creep and low moisture absorption. Dielectric strength is high and dissipation factor is low and constant up to 1 MHz.
Phosphor bronze	This strong and relatively hard material is used to fabricate metal parts and springs. It is formulated by reducing tin bronze with phosphorus and is available in several grades. Phosphor bronze is resistant to corrosion.
Photoconductivity	Conductivity increase exhibited by some nonmetallic materials, resulting from the free carriers generated when photon energy is absorbed in electronic transitions.
Photocurrent	Current that flows through a photosensitive device as the result of exposure to radiant power.
Photomask	Square, flat glass substrate, coated with a photographic emulsion of a very thin layer of metal on which appear several hundred circuit patterns (each containing thousands of images). The patterns are exposed onto semiconductor wafers.
Photon	Quantrum of electromagnetic energy.
Photovoltaic effect	Production of a voltage difference across a P-N junction resulting from the absorption of photon energy.
Physical properties	Properties, other than mechanical, that pertain to the physics of a material; for example, density, electrical conductivity, heat conductivity, and thermal expansion.

Table 2. Terms And Definitions (Cont.)

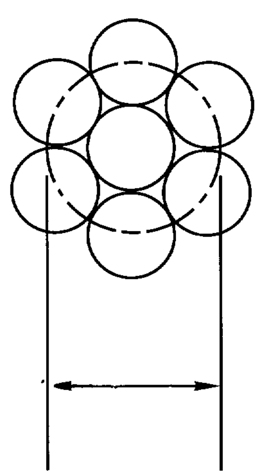
Term	Definition
PIC	General term for any type of Plastic Insulated Telephone cable.
Pick	Distance between two adjacent crossover points of braid filaments.
Pickling	Chemical treatment of parts to remove oxide, generally a combination of certain types of acid and water.
Picks per inch	Number of times the carriers in a braid cross over each other in the same direction along the longitudinal axis for each inch of length.
Pico (p)	Numerical prefix denoting one-millionth of one-millionth (10^{-12}).
Pigtail	A short piece of wire attached to a shield for terminating purposes, the conductor extending from a small component, or a short wire extending from an electric or electronic device to serve as a jumper or ground connection.
Pigtail wire	Fine stranded, extra flexible, rope lay lead wire.
PILC	Paper Insulated, Lead Covered.
Pilot hole	Hole used to position board for other operations so registration will be accurate.
Pin contact	Contact type designed to slip inside and be surrounded by, the mating socket contact. Normally connected to the dead side of the circuit.
Pin-diode	Device used to convert optical signals to electric signals in a receiver.
Pinholes	Small holes visible on the surface of soldered joints which generally indicate the presence of a larger void within the joint. Typically caused by the generation of gas during solidification due to presence of salts and water. Sometimes called blowholes.
Pin photodiode	Diode with a large intrinsic region sandwiched between P and N doped semiconducting regions.
Pipe cable	Pressure cable in which the container for the pressure medium is a loose fitting rigid metal pipe.
Pitch	Nominal distance from center-to-center of adjacent conductors. Where conductors are of equal size, and spacing is uniform, the pitch is usually measured from the reference edge of a conductor to the referenced edge of the adjacent conductor.
Pitch diameter	Diameter of a circle passing through the center of the conductors in any layer of a multiconductor cable. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
PL	Two rubber insulated, parallel laid, lamp cords with overall cotton or rayon braid. For light duty on small appliances in dry locations 300 V.
Plain conductor	Conductor consisting of one metal only.
Plain enamel	Magnet wire film coating. (See oleoresinous).
Plain weave	Weave used on woven cables. Threads between the wire act as binders and give the cable a lateral stiffness while maintaining a linear flexibility. Plain weave is used when the cable is to be programmed with leads exposed at fixed lengths. Also called standard weave and square weave.
Planck's constant	Number h that relates the energy E of a photon with the frequency g of the associated wave through the relation E = hg; h = 6.626 x 10^{-34} joule second.
Planetary cabler	Versatile cabler capable of laying down any number of shielded, over-braided, or jacketed singles, pairs, called groups, or any combination of them in a prearranged sequence. These cablers can be operated in tandem.
Planetary twister	Twisting machine whose payoff spools are mounted in rotating cradles that hold the axis of the spool in a fixed direction as the spools are revolved about one another so the wire will not kink as it is twisted.
Plastic	(1) High polymeric substances, including both natural and synthetic products that are capable of flowing under heat and pressure at one time or another. Does not include rubbers. (2) Used in soldering, that condition of a material which allows it to deform and/or flow continuously without rupturing. The term applies only to solids. The creep properties (see creep strength) of a material are due to its plastic properties. At elevated temperatures, under relatively low loads, tin/lead solders will deform to extreme lengths without rupture. This is a plastic characteristic of the solder.
Plastic clad silica (PCS) fiber	Fiber composed of a silica glass core with a transparent plastic cladding.
Plastic deformation	Change in dimensions under load that is not recovered when the load is removed.
Plasticizer	Chemical agent added to plastics to make them more pliable.
Plastic range	Refers to a range of temperature in which a metal or alloy can be mechanically worked without danger of cracking the material. The term is sometimes used in reference to the range of temperatures between the liquidus and solidus, where the material is a combination of liquid and solid.
Plastic silver brazing	Alloy that develops a plastic or mushy condition at some point within its melt range.
Plated soldering iron tip	Solid copper tip that has been plated or coated or clad with iron, nickel, chromium, or similar metal that will extend the service life of the tip.
Plated-through hole	Hole in which electrical connection is made between internal or external conductive patterns, or both, by the deposition of metal on the wall of the hole.
Plating	Overlaying of a thin coating of metal on metallic components to improve conductivity, provide for easy soldering, or prevent rusting or corrosion.
Platinum	Platinum is a contact material which provides low and consistent surface resistances. It is used in the moving contacts of ultrasensitive relays, thermostats, and potentiometers. Other elements are added to this previous metal to create alloys with higher mechanical wear resistance. Platinum sometimes can be used to replace gold in the plating of metal parts. It is resistant to corrosion and film formation.
PLSJ	All rubber, parallel jacketed, two conductor, light duty cord for pendant or portable use in damp locations, 300 V.

Table 2. Terms And Definitions (Cont.)

Term	Definition
PLT	Same as PLSJ except thermoplastic insulation.
Plug	Part of the two mating halves of a connector which is free to move when not fastened to the other mating half. The plug is usually thought of as the male portion of the connector. This is not always the case. The plug may have female contacts if it is the free to move member.
Plug, end seal	(See sealing plug).
Ply	Number of individual strands or filaments twisted together to form a single thread. In two-ply yarns, two strands are thus twisted; in three-ply, three strands, etc.
PNA, PNR, PNW	Designations for polyethylene-insulated control cables with nylon sheath on individual conductors. Cabled tape and polyvinylchloride jacket. Dry or wet locations, 600 V,167°F (75°C).
PO	Designation for two stranded copper conductors with separator and rubber insulation and cotton braid over each. Laid parallel with cotton or rayon braid overall. For use in dry locations on small appliances, 300 V to 600 V.
Point-to-point wiring	Interconnecting technique wherein the connections between components are made by wires routed between connecting points.
Poise	Unit of coefficient of viscosity, equal to 1 dyne sec cm.
Polar compound	Compound in which the electrical charges are not distributed symmetrically over the surface of the molecule. Ionizable compounds, such as flux activators, are usually polar compounds. (See non-polar compound).
Polarity	(1)Electrical condition determining the direction in which current tends to flow. (2) The quality of having two opposite charges.
Polarization	Mechanical arrangement of inserts and/or shell configuration (referred to as clocking in some instances) which prohibits the mating of improper plugs and receptacles. This is to allow connectors of the same size to be lined up, side by side with no danger of making the wrong connection. Coded arrangements of contacts, keys, keyways, and insert positions are used. In rectangular connectors, the shells are so designed that mating usually is possible only in one way.
Polarizing pin, key or keyway	Pin or key located on one half of a two-piece connector in such a position that by mating with an appropriate hole or keyway on the other half during assembly of the connector it will ensure that only related connector halves can be assembled.
Polishing (fiber optic)	Act of smoothing ends of fibers to an optically smooth finish, generally using abrasives. Optically smooth surfaces allow maximum transmission of light between fibers at connections and minimum coupling loss.
Polyamide	A nylon-like polymer in which the structural units are linked by amide or thioamide groupings. Generally thermo plastic with high mechanical strength.
Polyamide-imide	High temperature plastic with an aromatic structure which cures with heat to a linear amide-imide homopolymer. Because of its outstanding thermal stability and very good electrical properties, it was introduced initially in magnet wire enamels and insulating varnishes. Sheet, bar-stock, and other shapes are available. (See varnish polyamide-imide).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Polyamide-imide enamel	Magnet wire insulating film based on an aromatic polyamide-imide resin. It is based on trimellitic anhydride (TMA). The film is tough, smooth, and abrasion resistant. It has high dielectric strength which is maintained under humid conditions and after long-time aging. It resists deformation under heat and pressure. It can be used in applications as high as 428°F (220°C). This enamel has found its greatest use as an overcoating for other enamels.
Polyarylate	Family of engineering polymers exhibiting good electrical properties, flex recovery, resistance to deformation, ultraviolet stability, and heat resistance.
Polyarylsulfone	Thermoplastic resin composed mainly of phenyl and biphenyl groups linked by thermally stable ether and sulfone groups. Wide temperature range and good resistance to chemicals, impacts, and solvents leads to use in electrical insulation.
Polybutadiene	Family of thermosetting molding compounds formulated from essentially all-hydrocarbon polymeric resins containing high loadings of filler (such as ground silica) reportedly offer good physical properties, excellent electrical properties, and outstanding resistance to water and aqueous liquids. Heat aging results show the moldings to possess excellent high temperature stability at temperatures as high as 500°F (260°C) for as long as 1000 hours.
Polybutenes	A liquid used as a dielectric (See liquid dielectrics).
Polycarbonate resins	Polymers derived from the direct reaction between aromatic and aliphatic dihydroxy compounds with phosgene or by the ester exchange reaction with appropriate phosgene derived precursors. Strength, dimensional stability, flexibility, and predictable injection molding results are reasons why polycarbonates are suggested for structural parts in electrical products. Has outstanding heat stability, impact strength, and dimensional stability over a wide range of temperature and humidity environments, and stable electrical properties. Transparency, creep resistance, a high gloss surface, and low, predictable mold shrinkage are also important attributes.
Polychloroprene	Synthetic rubber polymer most often used as a jacket material. Although available in a variety of types and grades, it has generally good mechanical strength, abrasion, and cut through characteristics, and resistance to solvents and oils. It is thermoset, has good aging properties, and is quite flexible. Generally rated 167°F (75°C) to 194°F (90°C).
Polycrystalline	Polycrystalline ceramics have high dielectric strength, high melting point, 3704°F (2040°C), and are essentially gas-tight.
Polyester	Synthetic polymer most often used as a film or tape separator in wire or cables. Polyesters are generally good dielectric materials, are transparent, have high strength, and good resistance to heat and chemicals. Polyester tape wraps are often applied to isolate braided shields and to protect insulated conductors from damage. Rated 221°F (105°C) to 257°F (125°C).
Polyester magnet wire enamels	These films are composed of synthetic resin based on polyesters of terephthalic acid and polyhydric alcohols with or without a superimposed polyester film. The polyesters may be modified with other resins. The enamels can be used alone or two may be employed where one serves as an overcoat for the other. In addition, they may be overcoated with other polymers including nylon, amide-imide, epoxy, etc. There also are polyester-amide-imide and polyester-imide enamels. The many different types available provide a variety of desirable properties.
Polyesters, saturated	Family of polyesters whose molecular backbones are vinyl-saturated and unreactive. Some are low molecular weight liquids used as plasticizers or as reactants to form urethane polymers. Some are high molecular weight linear thermoplastics.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Polyesters, unsaturated	Family of polyesters characterized by vinyl unsaturation in the polyester backbone. These can cure and harden by copolymerizing with some reactive monomers. They are thermosetting and are used for potting electrical components and in reinforced plastics.
Polyethersulfone	A high temperature thermoplastic composed of repeating phenyl groups linked by thermally stable ether and sulfone groups. Good flame and tear resistance, transparency, and dimensional stability. Extruded and injection molded.
Polyethylene (PE)	Thermoplastic material composed of polymers of ethylene. A variety of types of polyethylene are used in wires and cables in very large amounts. Polyethylene has excellent electrical properties for wire and cable insulation plus superior abrasion and solvent resistance, moisture resistance, light weight, low brittle point, and durability. Polyethylene is used as an insulation or jacketing material for hook-up wire, coaxial cable, communication cable, line wire, lead wire, high voltage cable, etc. Flame retardant types of polyethylene are available. Chlorinated Polyethylenes (CPE) can be produced in a wide range of elastomeric to rigid polymers. They impart flame retardance and flexibility to blends with polyethylene. Other features reported for chlorinated polyethylene include resistance to low temperature cracking as well as ozone and oil resistance. CPE/PE blends have excellent heat and abrasion resistance.
Polyhalocarbon	General name for polymers containing halogen atoms. The halogens are fluorine, chlorine, bromine, and iodine.
Polyimide	High temperature thermoplastic resins available as molded parts, injection molding compounds, glass reinforced compression molding compounds, potting and encapsulating compounds, and plastic film and coatings for fabrics and wire. Have a wide range of physical and mechanical properties including high resistance to oxidative degradation, weathering, radiation, and all chemicals except strong bases; excellent resistance to abrasive and frictional wear; and excellent mechanical and electrical properties which can be retained during continuous use at 480°F (248.9°C) in air. (See tape - polyimide film).
Polyisobutylene	Polymerization product of isobutylene. (See butyl rubber).
Polymer	Compound formed by polymerization which results in the chemical union of monomers or the continued reaction between lower molecular weight polymers.
Polymerize	A process whereby compounds link together to form long chains. The compounds involved may be the same or may be a mixture of several compounds, in which case the result is a copolymer, terpolymer, etc. When polymerization of the same compound results in long chains, the end result is called a polymer. Plastics are the most common example of this. The properties of the polymer are usually radically different from that of the compounds which make it up. Polymerization usually results in the formation of a resin from simpler compounds. The hardening of resin residues after soldering is an example of polymerization.
Polyolefin	Family of plastics including cross linked polyethylene and various ethylene copolymers. Polyolefins are used as high speed laminated flat cable insulation. (See rubber - polyolefin based).
Polyparbonic acid	(See tape - polyparbonic acid film).
Polyphenylene sulfide	Crystalline aromatic polymer which features a service temperature of 450°F (232.1°C), excellent chemical resistance, and is non-burning. Has a melting temperature of 550°F (287.8°C) and can be used as an injection and compression molding compound and as a coating resin. Molded parts are rigid and tough. Available also in glass-reinforced compounds, with excellent electrical properties.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Polypropylene	Plastic made by the polymerization of high-purity propylene gas in the presence of an organometallic catalyst at relatively low pressures and temperatures. It is similar to polyethylene but is lighter and offers even better heat resistance, tensile strength, abrasion resistance, and lower dielectric constant. For high frequency work, a specially purified grade is required. The material is used in solid extruded and foam forms. In addition, polypropylene film is being used, either alone or in combination with other material, as a cable or core wrap to act as a thermal (during extrusion) or moisture barrier in cable constructions.
Polystyrene	Thermoplastic produced by the polymerization of styrene (vinyl benzene). The homopolymer is clear in color, has good electrical properties and good dimensional stability. Often copolymerized to overcome brittleness or increase chemical resistance. Used when stable dielectric loss is required.
Polysulfones	Strong heat-resistant thermoplastic, available, in both clear and opaque forms. The material is flame resistant and stable over a temperature range of -150°F (-118.9°C) to over 300°F (148.9°C) for extended periods of time. It can be electroplated. Chemically, the polymer is composed of phenylene units, linked by three different chemical groups - isopropylidene, ether, and sulfone. The presence of a diphenylene sulfone group in the linkage is responsible for the polymer's thermal stability, resistance to oxidation, and rigidity at elevated temperatures.
Polytetrafluoroethylene (PTFE)	This is the most thermally stable and chemically resistant of all carbonaceous insulating compounds. It is unaffected by sunlight, moisture, and practically all chemicals. Temperature range is -130°F (-90°C) to 482°F (250°C) and electrical properties are very constant over the temperature range and a wide range of frequencies. Insulation may be applied by extrusion, taping, dipcoating, and in cases where another material is used, by dispersion coating. Both conventional and ribbon type wires are made as well as magnet wire. PTFE is used for both primary insulation and extruded jackets. Also as TFE.
Polytrifluorochlor-ethylene	This material approaches PTFE in many properties but is characterized by somewhat lower heat resistance.
Polyurethane	This material is primarily of interest as a magnet wire enamel for wires which can be soldered without prior removal of the film. The mechanical, chemical, and electrical characteristics of the wires are such as to render them suitable for withstanding winding hazards. Extruded polyurethane is being used for jacketing coaxial and hook-up cables. In tape form, it is suggested as a cable jacketing wrap. Polyurethane resins Family of resins used to form thermosetting materials by reacting with water, glycols, or other urethanes, under the action of heat or catalysts.
Polyvinyl Chloride (PVC)	Thermoplastic material composed of polymers of vinyl chloride. PVC is widely used for primary wire insulation or jacketing on communication wires, control cables, bell wire, building wire, hook-up wire, fixture wire, appliance cords, power cables, lighting cables, motor leads, and other low voltage work (to 600 V). Many different formulations are available including grades for high temperatures, low temperatures, flame resistance, deformation resistance, etc. Dielectric strength is excellent and flexibility is very good. Some formulations may have limitations when considering toughness, moisture resistance, and resistance to chemicals. PVC is probably the most versatile of the lower cost, conventional temperature wire insulations in round and ribbon forms. A conductive vinyl can be used to obtain shielding and mechanical protection at the same time.
Polyvinyl formal	This magnet wire film is formed in place from a solution of two principal resins. In some cases one or more other resins may be added. The resin present in the larger proportion is polyvinyl formal. The resin present in smaller proportion is an alkyl phenol-formaldehyde condensation reaction product. This wire has been used in very large quantities. The characteristics are such that it is suitable for use in most electrical apparatus designed for operation as class A devices. It has excellent windability. It is compatible with most insulations, varnishes, and compounds.

Table 2. Terms And Definitions (Cont.)

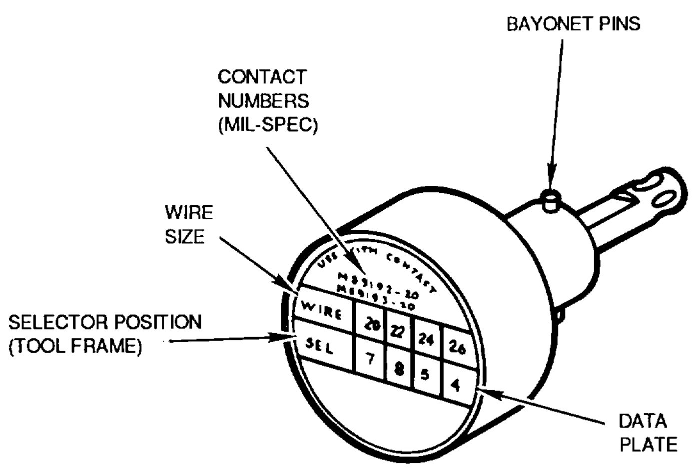
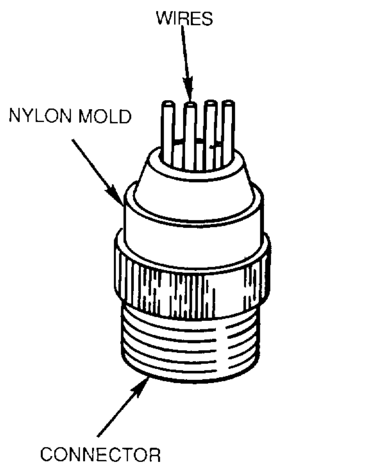
Term	Definition
Polyvinylidene fluoride	This thermoplastic resin, a fluorocarbon, is characterized by good (PVF) mechanical, electrical, and chemical properties. In primary insulation and in jackets for multi-conductor cables, it has performed successfully at temperatures from -80°F (-62.2°C) to 300°F (148.8°C). This material can be extruded, or applied as a film, or solution or dispersion coating. PVF offers excellent resistance to abrasion and cut-through. Radiation cross-linking provides improved heat resistance. Applications include hook-up, control, aircraft, lead, and computer wires and cables.
Porcelain	Porcelain exhibits satisfactory electrical properties for low frequency insulation, but poor performance for high frequency insulation.
Porcelainize	To coat and fire a metal with glass material, as in forming a hybrid circuit substrate.
Porosity	Fine holes or pores within a substance.
Portable power cable	Flexible, all rubber insulated for hard usage. Some cables have shielded conductors (metallic or nonmetallic and can have neoprene sheath overall).
Positioner	Device that is attached to a crimping tool and locates the contact in the correct location. 
Positive lap wound	(See taped insulation).
Positive lock	(1) Type of latch or locking mechanism used to hold a die set in an installation tool, or an insert in a connector shell, in such a way that the parts cannot be unlocked accidentally. (2) Describes retention of certain wire terminating contacts (tabs) used with edge or printed circuit connectors.
Positive (noun)	Artwork, artwork master, or production master in which the intended conductive pattern is opaque to light, and the areas intended to be free from conductive material are transparent.
Post insulate	To insulate a connection after assembly.
Post-type terminals	Fixed posts around which wire is wrapped and secured with a threaded nut, or over which a terminal, such as blade, tongue, etc., is placed and secured.
POT	Designation for thermoplastic, parallel, light duty ripcord, 300 V, 140°F (60°C).
Pot	(1) Vessel for holding molten metal. (2) To embed a component or assembly in a liquid resin using a case, shell, or other container which remains as an integral part of the product after the resin is cured.
Potential voltage	Work per unit charge required to bring any charge to the point at which the potential exists.

Table 2. Terms And Definitions (Cont.)

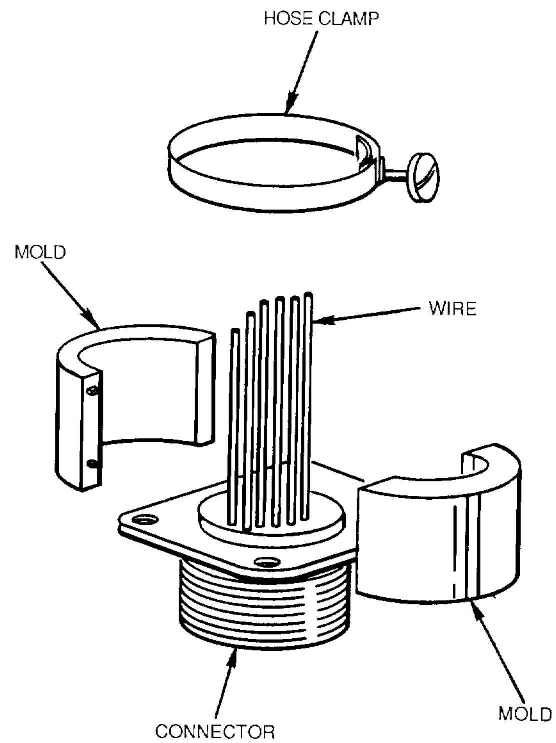
Term	Definition
Pot Life (working life)	Time required for a curing thermoset plastic composition to become unusable in the mass ordinarily mixed at one time (usually either 100 g or 415 ml).
Potting	Process of completely enclosing an article in an envelope of liquid dielectric material which then changes to a solid. Potting is performed to improve and protect the electrical functions of the unit. The compound acts as a dielectric and provides strain relief and protection to the unit from the environment.
Potting compound, addition cure silicone rubber	Addition cure silicone rubbers are distinguished by their reversion resistance to combustion, even without additives (which enables their use in hazardous locations). Dissipation factor dielectric strength, and volume resistivity values are equal to those of the best RTV silicone rubbers, dielectric constants are generally lower.
Potting compound, chemically cured polyurethane, polyether based	Compound used in potting connectors when resistance to oil and fuel is required at temperatures not exceeding 275°F (125°C). Conforms to MIL-M-24041. (See potting).
Potting compound, depolymerized rubber	A room temperature curing polymer which will not stress delicate components during cure nor during temperature cycling. They exhibit good resistance to vapor transmission, ozone, corona, and fungus. (See potting).
Potting compound, epoxy	Epoxy compounds have become the most widely used materials for potting and encapsulation and have established the performance standards against which other materials often are evaluated. They are especially desirable since they provide excellent adhesion, absence of weight gain and low shrinkage when cured, good electrical properties, resistance to moisture and chemicals, and good compatibility and adaption with other materials. (See potting).
Potting compound, ethyl cellulose base	A thermoplastic potting compound which is a blend of waxes and plasticizers in an ethyl cellulose base. It can be melted at about 350°F (176.7°C) for sealing and insulating connectors, rectifiers, capacitors, etc. It sets into a hard, tough material. (See potting).
Potting compound, plastasols	Dispersions of polyvinyl chloride paste resin in a plasticizer. They are supplied as liquids, but with a temperature of 325°F, (162.8°C) to 375°F (190.6°C), they convert irreversibly into a solid. They possess excellent electrical properties.
Potting compound, RTV	(See Room Temperature Vulcanizing silicone rubber).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Potting mold	Item, solid or split, designed to be used as a hollow form into which potting compound is injected and allowed to cure or set to seal the back of an electrical termination. The potting may eliminate the need for a back shell on the connector. The form may or may not be removable after potting. (See potting).



TYPICAL ONE-PIECE PLASTIC MOLD

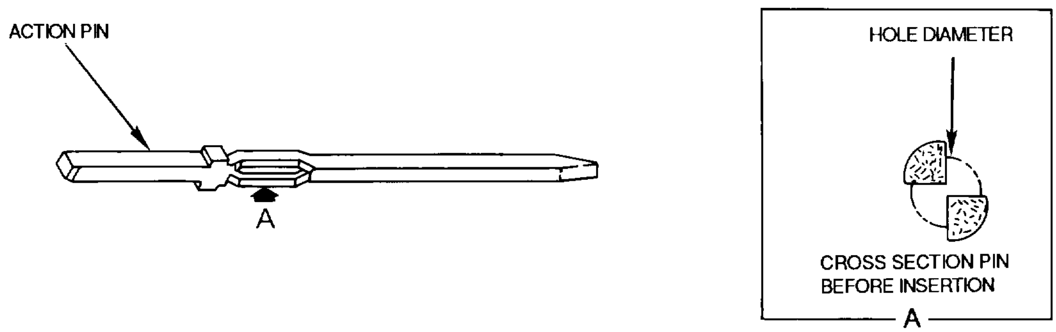


TYPICAL SPLIT TYPE CIRCULAR MOLD

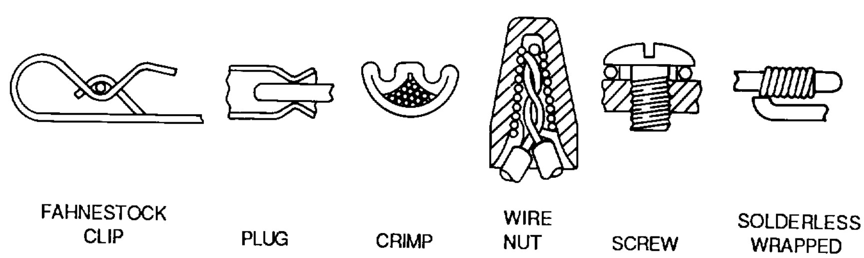
Term	Definition
Pour point	Lowest temperature at which a viscous substance will pour.
Power (P)	Rate of doing work, equivalent to the work divided by time, or, in a DC circuit, the product of voltage and current. Expressed in watts (W). (See formulas-electrical).
Power cable	Various cable sizes and constructions that are used to supply electrical power to many types of equipment.
Power contact	Type of contact used in multi-contact connectors to support the flow of rated current.
Power converter	An “AC-to-DC” converter which converts the +12 to +15 VDC power received from the controller/host to the voltages required by the fiber optic transceiver optoelectronic circuitry.
Power efficiency	Ratio of emitted optical power from a source to the electrical input power.
Power Factor (PF)	Ratio of resistance to impedance. The ratio of the actual power of an alternating current to apparent power. Mathematically, the cosine of the angle between the voltage applied and current resulting. (See formulas - electrical).
Pre-bond	Term used for stranded wire which has been fused, topcoat tinned, or overcoat tinned.
Precious metal	One of the relatively scarce and valuable metals; gold, silver, and the platinum-group metals. (See noble metals).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Pre-insulate	Insulation of a connector prior to assembly of the contact or terminal on the conductor.
Prepreg	Sheet material, notably glass cloth, available with semicured resins. These consist of the base material impregnated with a synthetic resin such as epoxy or polyimide partially cured to the B-stage. These materials are molded under heat and pressure for multilayer printed circuitry, and used for bonding together the individual circuit layers of multilayer printed circuit boards. As a general rule, for dielectric purposes, the thickness of the prepreg should be twice that of the copper foil. The bonding sheets or prepregs are available in both general purpose and flame-resistant types.
Press-fit contact	An electrical contact which can be pressed into a hole in an insulator, printed board (with/without plated-through holes), or a metal plate.



Term	Definition
Pressure cable	An oil-impregnated, paper-insulated cable in which positive gauge pressure is maintained on the insulation under all operating conditions.
Pressure connection	An electrical connection which is maintained by a mechanical force holding conductors together.



TYPICAL PRESSURE CONNECTIONS

Term	Definition
Pressure differential	Difference in pressure between one side of a connector and the other as in a bulkhead mounting, or the pressure difference between the inside and outside of a sealed connector.
Pre-tinned	Solder applied to either or both the contact and conductor prior to soldering.
Pre-tinned solder cup	Solder cups whose inner surfaces have been precoated with a small amount of tin-lead solder.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Primary insulation	Nonconductive material, usually the first layer, over a current-carrying conductor. Main function is to act as an electrical barrier for the applied potential.
Primary support	Support provided for wiring which carries the weight of the wiring and secures it in the intended position.
Primary winding	Transformer winding which receives the energy from a supply circuit.
Printed Circuit (PC)	(1) A generic term to describe a certain technique. (2) Circuit obtained by printing and comprising printed and/or conventional components, printed wiring, or a combination thereof, all formed in a predetermined design in, or attached to a surface or surfaces of a common base.
Printed Circuit (PC) board	General term for completely processed printed circuit or wiring configurations. It includes single, double, and multilayer boards, both rigid and flexible.
Printed component part	A component part, such as an inductor, resistor, capacitor, or transmission line, which is in printed form.
Printed contact	Portion of a conductive pattern formed by printing, serving as one part of a contact system.
Printed wiring	Printed circuit, or a portion thereof, intended primarily to provide point-to-point electrical connections.
Printed wiring assembly drawing	Document that shows the printed board (rigid or flexible), the separately manufactured components which are to be added to the board, and any other information necessary to describe the joining of these parts to perform a specific function.
Printed wiring layout	Sketch that depicts the printed wiring substrate, the physical size and location of electronic and mechanical components, and the routing of conductors that electrically interconnect components, in sufficient detail to allow the preparation of documentation and artwork.
Programmed wiring	Method by which conductors are attached to a multicontact termination panel by a programmable machine. Applicable to highly dense wiring and high production quantities. Wire attachment is by automatically wrapping the wire around a solid, square, or rectangular terminal.
Programming	(1) Ability to select various circuit patterns by interconnecting or jumping appropriate contacts on one side of a connector plug or panel. (2) The setting up of a computer to perform a predetermined task.
Propagation delay	Time delay between input and output of signal usually measured in nanoseconds per foot of cable.
Propagation time	Time required for an electrical signal to travel between two points on a transmission line.
Proportional limit	Maximum stress at which strain remains directly proportional to stress.
Protocol converter	Device for translating the data transmission code and/or protocol of one network or device to the corresponding code or protocol of another network or device, enabling equipment with different conventions to communicate with one another.
Proximity effect	Phenomena or non-uniform current distribution over the cross-section of a conductor caused by the variation of the current in a neighboring conductor.
PRT	(See Pulse Repetition Time).
PS	Designation for thermostat cable with solid conductors, individual rubber insulation and cotton braid. Twisted, rubber jacket and cotton braid overall.

Table 2. Terms And Definitions (Cont.)

Term	Definition
PSH	Three conductor cable. Each conductor has type PS shielding over the insulation and contains ground wires. The insulation is extra heavy. Recommended for intermediate voltage where extra safety factor is needed.
PTFE	Also as TFE (See Polytetrafluoroethylene).
Pulling eye	Device fastened to a cable in order to pull the cable into or from a duct.
Pull-out force	Force necessary to separate a conductor from a contact or terminal, or a contact from a connector, by exerting a tensile pull.
Pull strength	Amount of force (in pounds/kilograms) necessary to break a piece of material when loaded or pulled in a straight line at a constant rate. Rate of pull is in inches per minute.
Pulse	Energy which changes abruptly from one intensity to another. May be light energy or electrical energy.
Pulse cable	Type of coaxial cable constructed to efficiently transmit repeated high voltage pulses.
Pulse dispersion	Widening of a pulse as it travels the length of a fiber.
Pulse Repetition Time (PRT)	Time to complete one complete cycle of a waveform in seconds or fractions of a second. (See frequency).
Pulse spreading	Dispersion of incoming optical signals along the length of an optical fiber.
Purple plague	One of several gold-aluminum compounds formed when bonding gold to aluminum and activated by reexposure to moisture and high temperature 93.2°F (34°C). Purple plague is purplish in color and is very brittle, potentially leading to time-based failure of the bonds. Its growth is highly enhanced by the pressure of silicon to form ternary compounds.
Put-up	Packaging length for finished wire or cable.
PVC	(See Polyvinyl Chloride).
PVF	(See Polyvinylidene Fluoride).
PW	Designation for moisture proof, reinforced, portable cord with two or more rubber insulated conductors with individual cotton braid. Moisture resistant cotton braid finish over rubber jacket, 300V to 600 V. Sometimes referred to as PWP.
Q-factor	(See inductor quality).
QPL	Qualified Products List issued by the U.S. Government.
Quad	(1) Series of four separately insulated conductors, generally twisted together in pairs. (2) Series-parallel combination of transistors with increased reliability because failure of one transistor will not disable the entire circuit.
Quadders	Three-bay machines which can twist four wires together. They can cable braided and shielded wires with varying lay lengths.
Quad-indent	Indentor configuration of a crimp tool producing four closely grouped indents on the connector barrel. Also called four indent. (See crimp termination).
Qualitative analysis	Analysis of an unknown that determines what elements or compounds are present in an unknown. This type analysis does not indicate the amounts of the components present.
Quantitative analysis	Analysis that determines what elements and/or compounds are present in an unknown and the quantity of each.
Quartz	Quartz has low loss properties, therefore, its presence with a low loss fluxing or gloss phase results in low loss ceramic insulation.

Table 2. Terms And Definitions (Cont.)

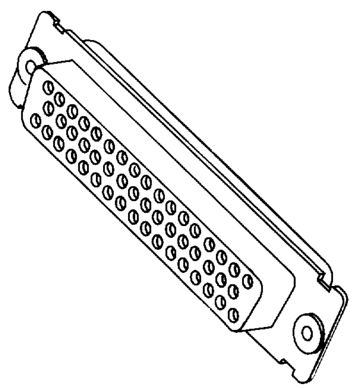
Term	Definition
Quench	Process of shock cooling a thermoplastic from a molten state. Often accomplished by immersion in water just after material is removed from mold.
Quick disconnect	Type of connector or splice which permits relatively rapid locking and unlocking of mating parts.
R	(1) Designation for rubber insulated building wire, 600 V, 140°F (60°C). (2) (See Resistance).
Rack	Type of structure used to house electronic components which permits convenient removal of portions of the equipment.
Rack and panel connector	Connects the inside back end of the cabinet (rack) with the drawer containing the equipment when it is fully inserted. The drawer permits convenient removal of portions of the equipment for repair or examination. Special design and rugged construction of the connector allows for variations in rack to panel alignment.  TYPICAL RACK AND PANEL CONNECTOR
Rad	The unit of measure of radiation dose.
Radial lead	Lead extending out the side of a component rather than from the end. (See axial lead).
Radiance (fiber optic)	Radiant flux per unit solid angle and per unit surface area normal to the direction considered. The surface may be that of a source, detector, or any other surface intersecting the flux.
Radiant power	Time rate of flow of radiant energy, expressed in watts.
Radiation pattern (fiber optic)	For a fiber or bundle, a curve of the output radiation intensity plotted against the exit angle.
Radio Frequency Interference (RFI)	Electromagnetic radiation in the radio frequency spectrum from 15 KHz to 100 GHz. The best shielding materials against RFI are copper and aluminum alloys. The term Electromagnetic Interference (EMI) should not be used in place of RFI since shielding materials for the entire electromagentic frequency spectrum are not available.
Radio Frequency (RF)	Frequency spectrum from 15 KHz to 100 GHz.

Table 2. Terms And Definitions (Cont.)

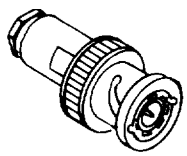
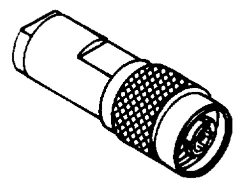
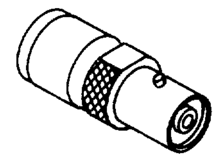
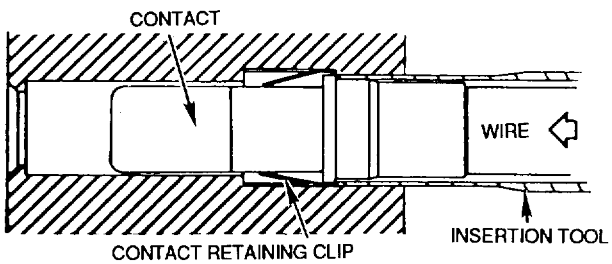
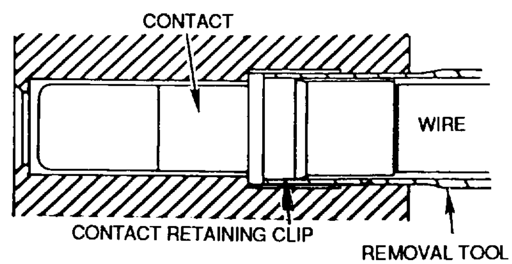
Term	Definition
Radio Frequency (RF) connector	Connector which terminates or connects coaxial cable.
	 BNC SERIES PLUG  N SERIES PLUG  C SERIES STRAIGHT RECEPTACLE
Radio Frequency (RF) contact	Impedence matched shielded contact.
Rail (track or frame)	Device to contain and retain a number of modules.
Rainbow cable	Two or more insulated conductors of different colors bonded into two flat parallel configurations.
RAM	(See Random Access Memory).
Ram	The moving portion in the head of a crimping tool.
Ram extruder	Type of wire-making machinery for extruding PTFE teflon insulation over a conductor.
Ramp	Portion of a terminal connector located between the tongue and the barrel. Also called stuff.
Random Access Memory (RAM)	Type of memory which offers access to storage locations within it.
Random winding	Winding in rotating equipment wherein the wires do not lie in an even pattern.
Range	Number of sizes of connectors or cables of a particular type.
Range, wire	(1) Sizes of conductors accommodated by a particular barrel. (2) The diameters of wires accommodated by a sealing grommet.
Ratchet control	Device to ensure the full crimping cycle of a crimping tool.
Rated temperature	Temperature at which one material is deemed to be operable without undue degradation or safety hazard.
Rated voltage	Maximum voltage at which an electric component can operate for extended periods without undue degradation or safety hazard.
Ray angle (fiber optic)	The angle between a light ray and a reference line or plane, usually the optical conductor face.
Ray (fiber optic)	Straight line, representing light, perpendicular to the light wave front and traveling in the same direction. At a boundary surface, or interface such as the surface between a fiber core and cladding, the ray may change direction suddenly, but it remains a straight line.
Rayleigh scattering	Scattering of refractive index fluctuations that are small with respect to wavelength.
Rayon	Synthetic used for yarn serving and braid applications generally in the same applications where cotton can be used.
RD	Designation for rubber insulated twin conductors, fibrous covered.
RDL	Designation for rubber insulated twin conductors, lead covered.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Reactance (X)	Opposition offered to the flow of alternating current by inductance (X) or capacitance (X) of a component or circuit. (See formulas - electrical).
Read Only Memory (ROM)	A random access storage in which the data pattern is unchangeable after manufacture.
Read out	Term used with printed circuit boards and printed circuit connectors, meaning the ability to make contact with certain circuits. Example: a double readout printed circuit connector will permit two wires to be connected to any one circuit on the printed circuit board.
Rear release contact	Connector contact released and removed from the rear (wire side) of the connector. The removal tool engages the contact from the rear and pulls the contact out of the connector contact retainer, and out the rear of the connector.



INSERTION



REMOVAL

Term	Definition
Rear seal	Design feature which provides an environmental seal at the rear of the plug or receptacle. It generally consists of rubber grommets which fit between the wire and sidewall of the insert cavities, or consists of a flat sheet of rubber which fits between the back-up of plate and insert of the plug and receptacle. This flat sheet of rubber is sometimes called family or group seal since it contains the same number of holes as the insert has cavities. It is through these holes that wires are threaded to the connector contacts.
Receiver, optical (fiber optic)	Electro-optical module which converts an optical input signal to an electrical output signal. (See fiber optics).
Receiving element (fiber optic)	The accepting terminus in an optical junction. (See terminus).
Receptacle	Electrical connector assembly with contacts constructed to be electrically connected to a cable, coaxial line, cord, or conductor to join with another electrical connector, and designed to be mounted on a bulkhead, wall, chassis, or panel.
Rectangular terminal	Terminal whose tongue is rectangular in shape.
Red	Unit of radiation dose which is absorbed, equal to 0.01 joule/kilogram.
Red plague	A powdery brown-red growth sometimes found on silver coated copper conductors and shield braids. It is fungus-like in appearance and will appear in random spots along the length of a conductor or shield. It most often occurs at the point of crossover in a shield or in the interstices of a standard conductor. Proper design and material selection has largely eliminated this problem.
Redraw	Consecutive drawing of wire through a series of dies to reach a desired wire size.
Reducing joint	Joint between two lengths of cable where the conductors are not the same size.

Table 2. Terms And Definitions (Cont.)

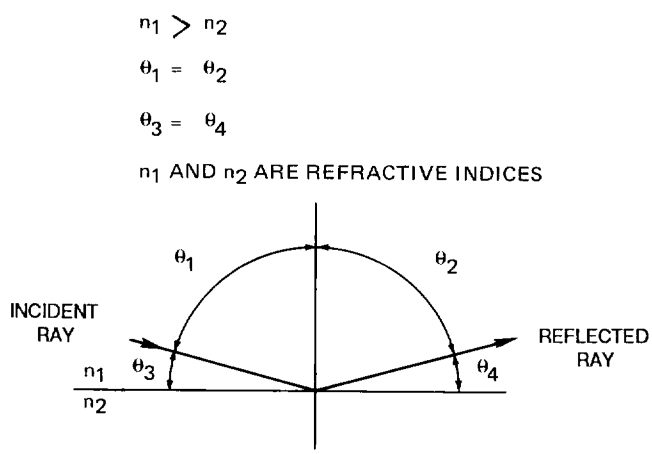
Term	Definition
Reduction	Chemical process opposite to oxidation, In the narrow sense, reduction is the removal of oxygen from a compound, such as the reduction of lead oxide to metallic lead. In the general chemical sense, reduction is a decrease in the positive charge on an element or ion. The process of plating, for example, converts metal ions in solutions to the metallic form of the element by gain of an electron. This reduces the positive charge of the ion thus, a reduction process.
Reel	Revolvable flanged device made of wood and/or metal which is used for winding flexible metal wire or cable.
Reference designation	Unique combination of letters and numbers assigned to each electrical part or item within the aircraft. The reference designations are labeled on identification markers close to or on electrical parts or items, and are divided into three major categories: electrical components, aircraft splices, and ground points.
Reference edge	Edge of cable or conductor from which measurements are made. Sometimes indicated by a thread, identification stripe, or printing. Conductors are usually identified by their sequential position from the reference edge, with number one conductor closest to this edge. Sometimes called index edge.
Reference surface	Surface of an optical fiber which is used to contact transverse alignment elements of a connector or other component.
Reflectance	Ratio of reflected power to incident power.
Reflection (fiber optic)	Change in direction of a light wave, or light ray when it strikes a surface. 
Reflection loss	Part of a signal which is lost due to reflection of power at a discontinuity, or a non-uniformity in the shield or conductor.
Reflow	(See fusing).
Reflowing	Melting of an electrodeposit followed by solidification. The surface has the appearance and physical characteristics of being hot-dipped (especially tin or tin alloy plates).
Reflow soldering	Method in which a solder joint is made by melting the solder coatings on the mating surfaces.
Refraction (fiber optic)	Bending of lightwaves or rays as they go from one material to another due to the difference in velocity in the materials.

Table 2. Terms And Definitions (Cont.)

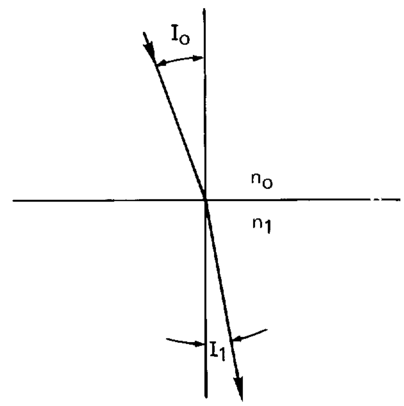
Term	Definition
Refractive index (n) (fiber optic)	Ratio of the velocity of light in a vacuum to its velocity in a material such as a fiber. Also, the ratio of the sine of the angle of incidence of light on the material to the angle of refraction of the light. The refractive index of any material varies with the wavelength of the light. Also called index of refraction. In a fiber, core refractive index must be greater than that of the cladding. n_o SIN I_o = n_1 SIN I_1 n_o AND n_1 ARE REFRACTIVE INDICES $n_o < n_1$ I_o = ANGLE OF INCIDENCE I_o = ANGLE OF REFRACTION 
Refractive index profile	Description of refractive index as a function of radius in a fiber.
Refractory	Difficult to fuse material such as a ceramic which requires extremely high fusion temperatures.
Registration	Degree of conformity of the position of a pattern, or a portion thereof, with its intended position or with that of any other conductor layer of a board.
Reinforced sheath	Outmost covering of a cable that has cable sheath constructed in layers with the addition of a reinforcing material, usually a braided fiber, molded in place between layers.
Reinforcement	Material used to reinforce strengthen, or give dimensional stability to another material such as the braid portion of a sheath contructed in layers.
Relay	Electrically controlled device that opens and closes electrical contacts to effect the operation of other devices in the same or another electrical circuit.
Reluctance	Property of a magnetic circuit which determines the total magnetic flux in the circuit when a given magnetomotive force is applied.
Remanence	Magnetic induction that remains in a magnetic circuit after the removal of an applied magnetomotive force.
Removable contact	A contact that can be mechanically joined to, or removed from an insert. Usually, special tools are required to lock the contact in place, or remove it for repair or replacement.

Table 2. Terms And Definitions (Cont.)

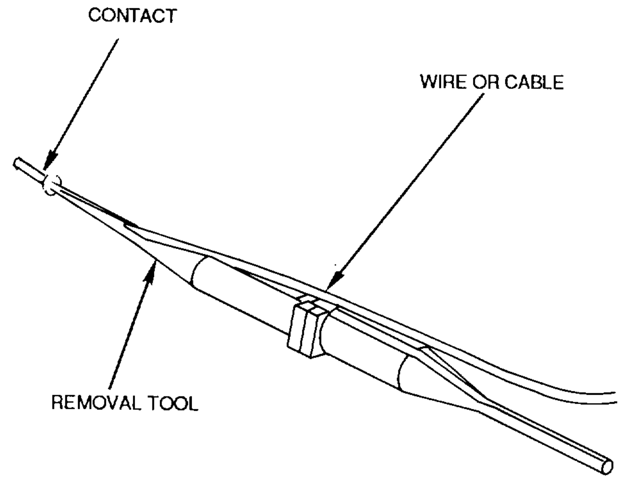
Term	Definition
Removal tool	Hand tool used to remove a contact from a connector, insert, or retainer.  TYPICAL PLASTIC REMOVAL TOOL
Repair	Approved operations performed on a nonconforming article to place the article in a usable condition.
Repeater (fiber optic)	Device which converts a received optical signal to its electrical equivalent, reconstructs the source signal format, and amplifies and reconverts it to an optical output signal; used to overcome previous attenuation.
Residual elements	Elements present in an alloy in small quantities, but not added intentionally.
Resin	Solid or semi-solid organic compound lacking a crystalline structure. Resins are characterized by not having definite and sharp melting points, are usually not conductors of electricity and many are transparent or translucent. Natural resins usually originate in plants, such as pine sap, and are not water-soluble. The rosin used in soldering fluxes is an example of a resin. Synthetic resins may have many of all of the properties of natural resins.
Resin, A stage of	Condition of low molecular weight of a resin polymer during which the resin is readily soluble and fusible.
Resin, B stage of	Condition of a resin polymer when it is more viscous, with higher molecular weight. It is insoluble, but plastic and fusible.
Resin, C stage of	Condition of a resin polymer when it is in the solid state, with high molecular weight, being insoluble and infusible.
Resin-rich	Significant thickness of non-reinforced, surface-layer resin of the same composition as that within the base material. Also called butter-coat.
Resist	Coating material used to mask or protect selected areas of a pattern from the action of an etchant, solder, or plating.

Table 2. Terms And Definitions (Cont.)

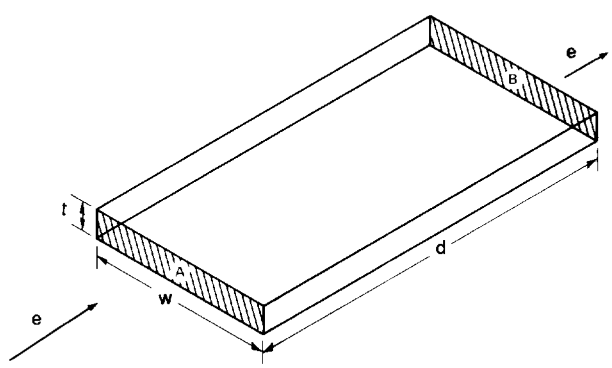
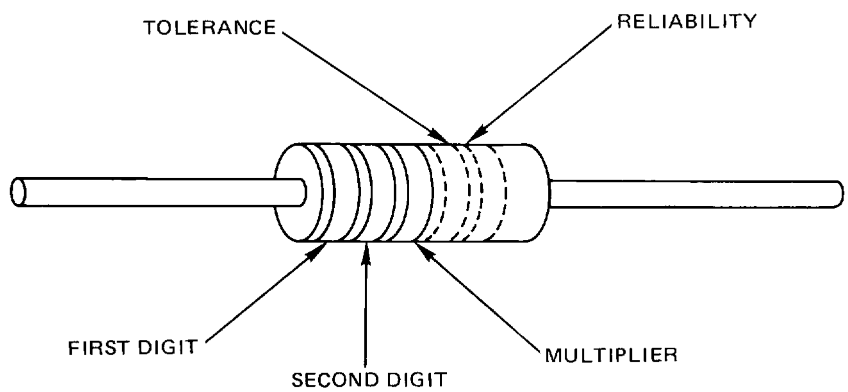
Term	Definition
Resistance alloys	Electrical resistance alloys are used to control or regulate either alternating or direct current. The electrical properties of interest are resistivity, temperature coefficient of resistance, and thermoelectric potential. The first is a measure of the resistance to the flow of current in a metal or alloy, while the second is a measure of the consistency of the resistance over a range of temperatures. The last defines the electromotive force generated when two dissimilar metals are joined and exposed to a variation in temperature.
Resistance brazing	Brazing by resistance heating, the joint being part of the electrical circuit
Resistance heating	Resistance heating is based on the resistance of an air gap, which causes arc and rapid heating until gap is filled by metal.
Resistance (R)	Property of an electrical component or assembly that describes its resistance to the flow of electricity. The unit of measurement of resistance is called an ohm, symbolized by the Greek letter Omega (Ω). The intrinsic property of a material that describes its resistance is called resistivity. The terms resistance and resistivity should not be confused, in as much as an assembly containing a material with a high resistivity may, because of its size, have a lower resistance than one containing a low resitivity material. An analogy to this would be two pipes of differing sizes. Under a given hydraulic pressure, the larger pipe will carry more water, or conversely it has a lower resistance to fluid flow. Solders usually-range from 10 to 20 times the resistivity of copper, which is the normal standard. Despite this, there is usually no problem with the resistance of a solder joint because of its large cross-section as compared to the copper conducting wires. (See formulas-electrical). Resistance soldering Method of soldering in which a current is passed through and heats the soldering area by contact with two electrodes.
Resistance soldering	Method of soldering in which a current is passed through and heats the soldering area by contact with two electrodes.
Resistance welding	Welding in which the metals to be joined are heated to melting temperatures at their points of contact by a localized electric current while pressure is applied.
Resistive conductor	Conductor used primarily because it possesses the property of high electric resistance.
Resistivity	Ability of a material to resist passage of electrical current either through its bulk, or on a surface. The unit of volume resistivity is the ohm. The resistivity does not change from 1 in. to 1 ft. According to the laws of electron flow, at a given t (thickness of coating), the resistivity between the faces (A and B) varies directly with d, doubling as d doubles. Resistivity also varies inversely with w, halving as w doubles. Thus, as long as d equals w, and t remains the same, for all practical purposes, the resistance remains the same in ohms per square. Varying the thickness of the coating (t), is the primary method of varying the resistivity. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Resistor	A device designed to intentionally limit the flow of current, or to provide a voltage drop.



Color of Band	First and Second Digits	Multiplier
Black	0	1
Brown	1	10
Red	2	10^2
Orange	3	10^3
Yellow	4	10^4
Green	5	10^5
Blue	6	10^6
Violet	7	10^7
Gray	8	10^8
White	9	10^9
Gold	—	0.01
Silver	—	0.01

Tolerance	
Gold	± 5%
Silver	± 10%
None	± 20%

Reliability (NOTE)	
Brown	1%
Red	0.1%
Orange	0.01%
Yellow	0.001%

NOTE

% Failures Per 1000 Hours

Table 2. Terms And Definitions (Cont.)

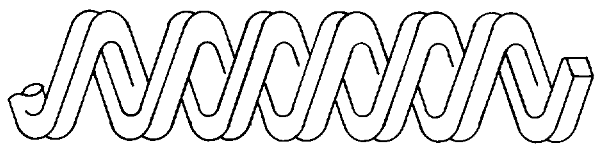
Term	Definition
Resolution	A measure of the thinness of a line a photoresist can successfully reproduce in a circuit.
Responsivity	Ratio of an optical detector's electrical output to its optical input, the precise definition depending on the detector type.
Respool	To rerun material from one package spool to another for various purposes, such as to verify lengths, inspect the defect, etc.
Retractile cable	Cable that returns, by its own stored energy, from an extended condition to its original contracted form. 
Retractile cord	Cord having specially treated insulation or jacket so that it will retract like a spring. Retractibility may be added to all or part of a cord's length.
Return wire	Common wire, a ground wire, or the negative wire in a direct-current circuit.
Rework	Reprocessing of articles or material that will make the articles or material conform to the drawings, specification, or contract.
RF	(1) Designation for fixture wire, code or latex rubber insulation and braid over solid or stranded conductor, 140°F (60°C). (2) (See Radio Frequency).
RFH	Same as RF, with rubber or latex rubber insulation, heat resistant, 167°F (75°C).
RFI	(See Radio Frequency Interference).
RG	Military designation for coaxial cable.
RG/U	Radio Guide. Universal. RG is the military designation for coaxial cable.
RH	Designation for rubber insulated, heat resistant, building wire, 167°F (75°C).
RHD	Designation for rubber insulated, twin conductor, heat resistant, fibrous covered wire.
RHDL	Same as RHD, except lead instead of fibrous covered.
RHH	Designation for rubber insulated, heat resistant, building wire, 194°F (90°C).
RHL	Same as RHH, but with lead sheath overall.
RHM	Designation for rubber insulated, multiple conductors, heat resistant and overall fibrous covered.
RHML	Same as RHM, but with lead cover overall.
Rhodium	Rare metal which is found in platinum ores. It is the hardest of the platinum-group metals, and is one of the most infusible. The plated metal has a high corrosion resistance and a light reflectivity of 80%. Rhodium is valued for use in electrical contacts.
RH/RW	Designation for rubber insulated, heat and moisture resistant, building wire, 167°F (75C) dry; 140°F (60°C) wet.
RHW	Designation for rubber insulated building wire, heat and moisture resistant, 167°F (75°C) dry or wet.

Table 2. Terms And Definitions (Cont.)

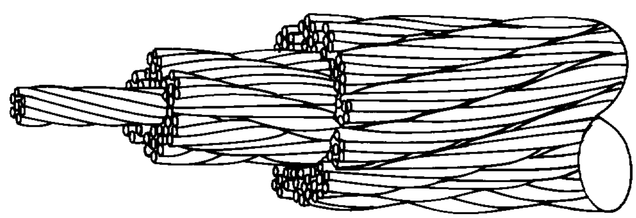
Term	Definition
Ribbon cable	Flat cable with conductors that have been individually insulated together. Structure is usually characterized by individual colors of insulation for each conductor, although a single color may be used for all conductors. (See flat cable).
Ridge marker	One or more ridges running laterally along the outer surface of plastic wire for purposes of identification. Readily perceptible to sight and touch, they are formed by minute notching of the extrusion die.
ROM	(See Read Only Memory).
Room Temperature Vulcanizing (RTV) silicone rubber	RTV silicone rubbers cure at room temperature to produce durable resilient and flexible silicone rubbers. They exhibit good physical and electrical properties, high and low temperature flexibility, solvent and ozone resistance, easy release, and excellent bonding ability.
Root Mean Square	Applied to alternating voltage and current, the effective value, that is, it (RMS) produces the same heating effect as a direct current or voltage of the same magnitude. Means of expressing AC voltage in terms of DC. The RMS is equal to 70.79 of the AC peak voltage.
Rope concentric	Group of standard conductors assembled in a concentric manner. The direction of lay of the outer rope members is left hand.
Rope-lay conductor or cable	Cable composed of a central core surrounded by one or more layers of helically laid groups of wires. This kind of cable differs from a concentric-lay conductor, in that the main strands are themselves stranded. In the most common type of rope-lay conductor or cable, all wires are of the same size, and the central core is a concentric-lay conductor.
Rope strand	Conductor or cable composed of a central core surrounded by one or more layers of helically laid groups of wires. 
Rope unilay	Group of stranded conductors assembled in a unilay manner. The direction of lay of the unilay rope is left hand.
Rosin	Naturally occurring resin usually associated as a component of pine sap. It is a mixture of several organic acids, of which abietic acid is the chief component. Rosin, alone, is a mild flux for soldering operations.
Rosin base flux	Flux made from rosin dissolved in an organic solvent.
Rosin core solder	Wire solder containing a rosin flux.
Rosin joints	Flux trapped in the solder joint identifies this defect. The entrapment is usually due to insufficient heat or insufficient time at soldering temperature, or both. The flux, under the conditions noted, cannot boil off the surfaces it is protecting and rise to the surface of the solder. The results of this defect are usually insufficient bonding and high electrical resistance.
Round conductor flat cable	Cable made with parallel, round conductors in the same plane. (See flat cable).

Table 2. Terms And Definitions (Cont.)

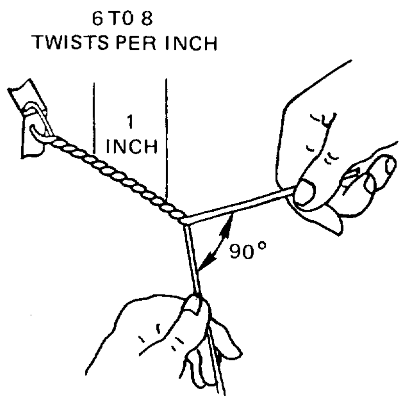
Term	Definition
Round wire shields	Shields constructed from bare, tinned, or silverplated copper wire. Three types of round wire shields include braided, spiral, and reverse spiral.
Router	An electronic device interconnecting two or more networks that operate at a Network Layer of the OSI model.
Routing	Path followed by a cable or conductor.
Roving	A collection of carded fibers rubbed into a single soft and bulky strand without twist, or a sliver which has been drawn out and slightly twisted. In the case of glass, roving is a collection of continuous filament, untwisted strands into a single bulky strand.
RP	Designation for performance grade rubber insulation, 140°F (60°C).
RR	Designation for rubber insulation, neoprene jacket.
RS	Designation for integral Rubber insulation and jacket on Single conductor cables.
RS-232-C	Technical specification published by the EIA that specifies the mechanical and electronic characteristics of the interface for connecting DTE and DCE.
RS-422	Standard operating in conjunction with RS-449 that specifies electrical characteristics for balanced circuits.
RS-423	Standard operating in conjunction with RS-449 that specifies electrical characteristics for unbalanced circuits.
RS-449	Applies to binary, serial, synchronous, or asynchronous communications.
RTL	Rubber Test Lead.
RTS	Reverse Twist Secondary.
RTV	(See Room Temperature Vulcanizing, silicone rubber).
RU	Designation for rubber insulated, latex building wire, 140°F (60°C).
Rub coating	Process in which a metal is precoated with molten solder by abrading the surface.
Rubber and elastomer	Rubber is a material which is capable of recovering from large deformations, quickly and forcibly, and can be, or already is, modified to a state in which it is essentially insoluble in boiling solvents. Elastomers have been defined as natural or synthetic materials that can be, or have been, vulcanized to a state in which they have the ability to accept, and recover from extreme deformation (in the order of hundreds of per cent). The term elastomer is used to include natural rubber, and a variety of synthetic materials exhibiting rubber-like properties.
Rubber, epichlorohydrin	Epichlorohydrin exhibits most of the better qualities of nitrile and neoprene. Commonly called hydrin, this elastomer is attacked by ketones, esters, aldehydes, and chlorinated and nitro hydrocarbons, but resists water and ozone weathering. It provides good tear and abrasion resitance. Compression set and resilience are also good.
Rubber, fluoro elastomers	Fluoro elastomers provide heat resistance up to 600°F (315.6°C), and excellent oil and solvent resistance. However, they are not recommended for ketones, low molecular weight esters, and nitro containing compounds. Fluoro elastomers adhere well to metals. They are abrasion and tear resistant, with good compression set and fair resilience. They offer excellent weather aging characteristics.

Table 2. Terms And Definitions (Cont.)

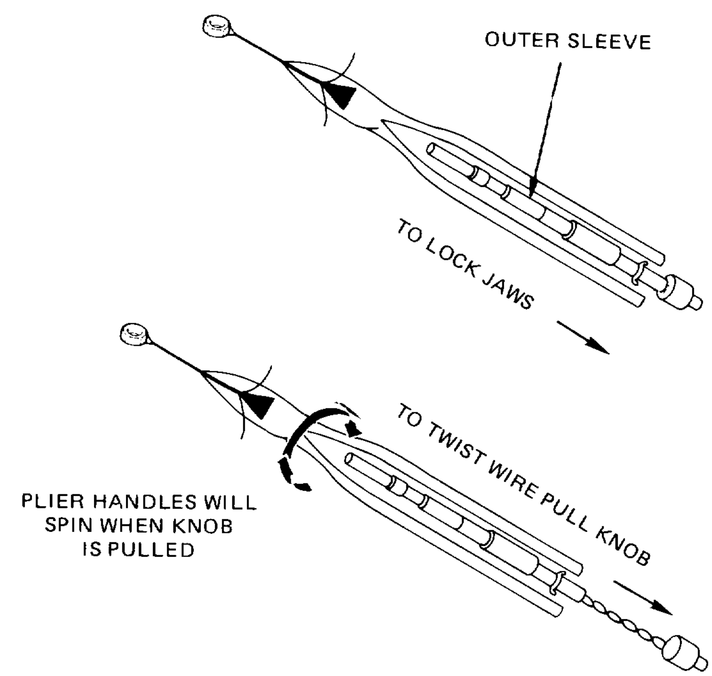
Term	Definition
Rubber, polyisoprene	Synthetic elastomer possessing physical properties which approximate those of natural rubber. It can be used in many of the same applications, and can be handled in existing equipment. However, the raw polymer is softer and can be plasticized at a more rapid rate. No electrical properties are reported, but it can be assumed that they are comparable to natural rubber.
Rubber, polyolefin based	Tough material suitable for primary insulation and jacketing for wire and cable. These applications range from high voltage to low frequency signals. Electrical properties are equal to those of cross-linked polyethylene. It resists the effects of prolonged sunlight and ozone, and it is not attacked by alkalis and acids common to soil burial.
Rubber, polysulfide	Polysulfides exhibit very good resistance to solvents and oils, good aging characteristics, exceptional resistance to ozone, and good electrical resistivity. However, they have an unpleasant odor and some deficiency in mechanical properties. The polysulfide rubbers are used for cable coverings where resistance to solvents and oil is required. MIL-S-8516 define typical sealing and potting compounds.
RUH	Same as RU, but heat resistant, 167 5°F (75°C).
Rulan	Trade name of DuPont Company. Material is a polyethylene composition with additives to reduce the rate of burning. Used for insulation.
Rupture	In breaking strength or tensile strength tests, the point at which a material physically comes apart, as opposed to yield strength, elongation, etc.
RUW	Same as RU, but moisture resistant, 140°F (60°C).
S	Designation for heavy duty, rubber insulated, portable cord. Stranded copper conductors with separator and individual rubber insulation. Two or more color coded conductors, cabled with filler, wrapped with separator, and rubber jacketed overall, 600 V.
SA	Designation for silicone rubber insulation, asbestos or glass braid, for use in dry locations. Maximum operating temperature for special applications, 257°F (125°C).
Safetying	Feature of connector design which permits safety wiring of plug and/or receptacle, to prevent the loosening or vibrating free of plug from receptacle.
Safety Cable	Securing cable used to prevent the loosening or vibrating free, of the attached part.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Safety wire	Securing wire used to prevent the loosening or vibrating free, of the attached part



WIRE TWISTING BY HAND



TWISTING WITH WIRE TWISTER PLIERS

Sag (conductor)	The vertical distance between a suspended conductor and an imaginary straight line connecting the points of suspension. Sag may be measured at the midpoint between the suspensions, the lowest point of the conductor, or at any specified point.
Salt	Sodium chloride compound formed by reaction between an acid and a base. The hydrogen ion of the acid is replaced by the metal associated with the base, and the hydroxyl ion of the base is replaced by the negative ion associated with the acid. The hydrogen and hydroxyl ions combine to form water. For example, a mixture of hydrochloric acid (hydrogen and chlorine) dissociates in solution into a hydrogen ion with a positive charge and a chlorine ion with a negative charge. When combined with sodium hydroxide (a base consisting of sodium, oxygen, and hydrogen which breaks down in a solution into a positive sodium ion and a negative hydroxyl ion), this combination results in common salt, i.e., sodium chloride. Separation of the salt from the solution can be accomplished by evaporating the water.
SAP	(See Sintered Aluminum Powder).
Sapphire	Sapphire provides a uniform dielectric constant, controlled orientation, thermal conductivity, and the single crystal surface desired for hybrid integrated circuit, and other microcircuit systems.
Saturated solution	Solution in which the solvent can accept no more solute (see solvent, solute). The result of adding additional solute to the solution is the formation of the solute as a distinct phase, e.g., solid particles suspended or precipitated to the bottom of the container in which the solution is held.

Table 2. Terms And Definitions (Cont.)

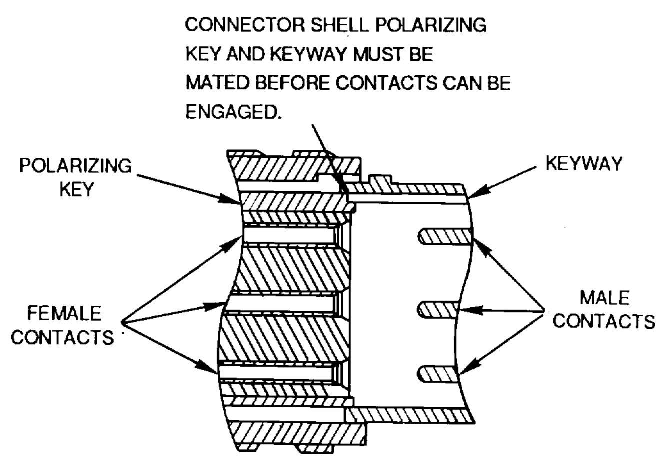
Term	Definition
Saturation	When received optical signal is too strong for the maximum power allowed by the receiver, optical saturation prevents regeneration of the input signal, thus resulting in distortion in the received signal.
SB	Designation for slow burning wire. Three cotton braids, impregnated, 194°F (90°C).
SBR	(See Styrene-Butadiene Rubber).
Scattering (fiber optic)	Change in direction of light ray due to heterogeneity (imperfections) in material. When a ray hits an imperfection, it is reradiated in a direction different from that of the original ray.
Schematic diagram	Drawing which shows, by means of graphic symbols, the electrical connections, components, and functions of a specific circuit arrangement.
Scoop-proof	Because of the connector's long shell design and the polarizing keys and keyways, it is impossible for the mating plug connector to inadvertently be cocked into the mating receptacle and damage or electrically short the contacts. 
Screen	Semiconductor or high resistance material used to reduce stress concentrations at the surface of stranded conductors or edges of outer shielding tapes. May be extruded plastic, rubber-filled tapes, carbon black paper, or thin aluminum foil laminated to paper (metallized paper). In the U.S., a screen at the conductor is frequently called a strand shield, although a shielded cable frequently has no strand shield.
Screwlock	(See jackscrew).
Screw-machine contact	Contact made by screw-machine operations.
Scrim	Light, non-woven fabric with relatively large openings between the yarns. Used as reinforcement for paper, and other products.
SD	Designation for service drop cable. Two coded, rubber insulated conductors, taped, laid parallel, with neutral conductor concentric thereover. Tape and braid overall. Also, round construction.
SDC	Self Damping Conductors.
SDN	Designation for small diameter, multiconductor control cable with neoprene jacket and nylon sheath over polyethylene insulation.

Table 2. Terms And Definitions (Cont.)

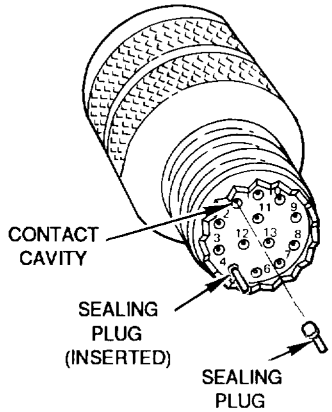
Term	Definition
SE	Designation for above ground service entrance cable, not protected against mechanical abuse. Flame retardant, moisture resistant covering. Overall neoprene sheath,140°F (60°C) to 167°F (75°C).
SEA	Designation for service entrance cable, steel armored under outer braid, one or two rubber insulated conductors with neutral conductor served concentrically, moisture resistant tape, weatherproof braid finish, 300 V, 167°F (75°C).
Sealing metals and alloys	Various metals and alloys used for sealing purposes, including sealing to glass and ceramics. These include iron-nickel-cobalt sealing alloy, iron-nickel sealing alloy, chromium-iron sealing alloy, dumet (copper coated 42% nickel-iron) wire for sealing to soft glass, and other products. These alloys are selected to match the thermal expansion of different types of glasses and ceramics, and are normally sold on the basis of expansion characteristics.
Sealing plug	Plug which is inserted to fill a contact cavity in a connector insert. Its function is to seal all unoccupied apertures in the insert, especially in environmental connectors. 
Seamless terminal or splice	Terminal or splice conductor barrel made without an open seam.
Secondary insulation	Non-conductive material whose prime functions are to protect the conductor against abrasion, and provide a second electrical barrier. Placed over the primary insulation.
Secondary metal	Metal recovered from scrap by remelting and refining.
Secondary winding	Transformer winding that receives energy by electromagnetic induction from the primary winding.
Sector cable	Multiple-conductor cable in which the cross section of each conductor is approximately the sector of a circle. Sector conductors are used in order to obtain, with a given conductor cross sectional area, a cable of decreased overall diameter; or to obtain, in a cable of given overall diameter, conductors of a larger cross sectional area.
Sector stand	Group of wires laid in triangular shape with rounded corners, for use as one conductor of a three conductor cable; with 120°angle between faces, and with 90°angle for a four conductor cable.
Segmental conductor	Stranded conductor consisting of three or more stranded conducting elements; each element having approximately the shape of the sector of a circle, assembled to give a circular cross section. The sectors are usually lightly insulated for each other and, in service, are connected in parallel.
Segregation	Non-uniform distribution of alloying elements, impurities, or microphases.

Table 2. Terms And Definitions (Cont.)

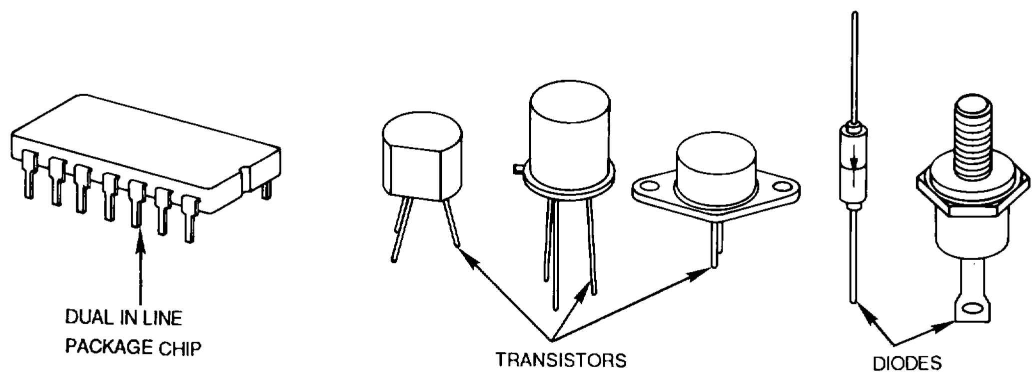
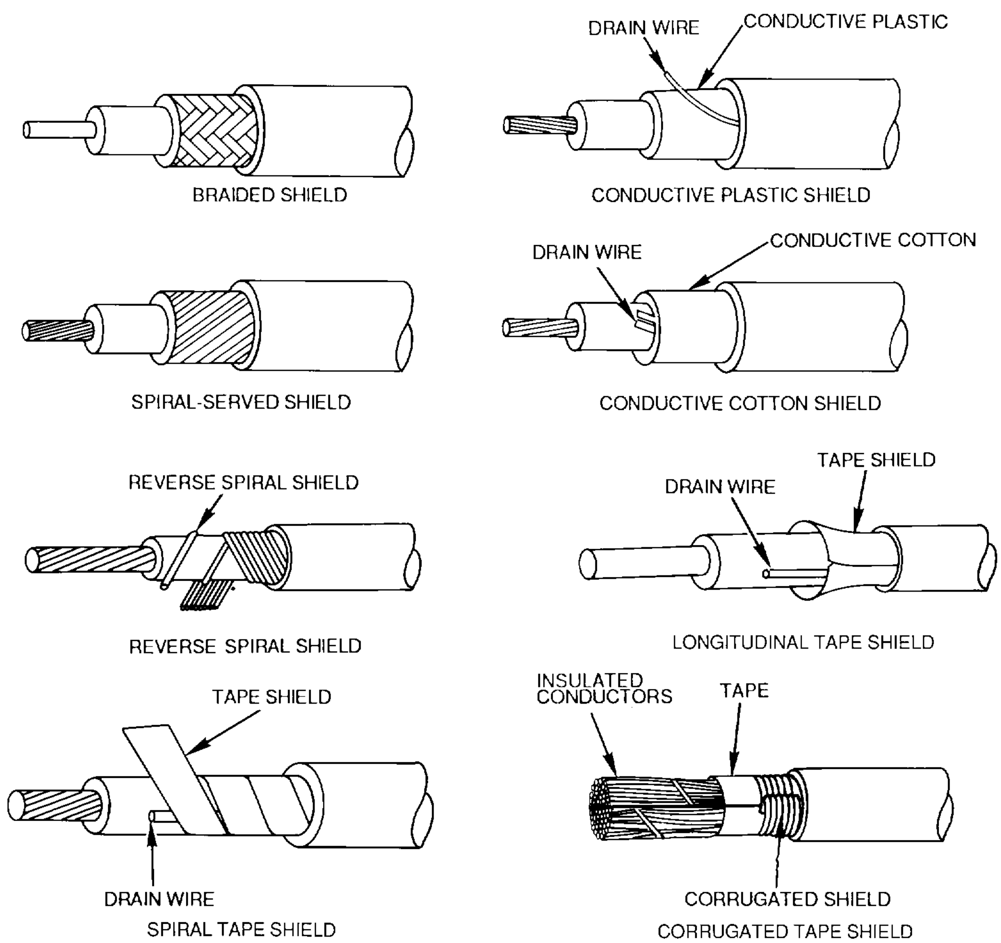
Term	Definition
Selective plating	Application of plating material to a limited portion of a connector contact, especially those areas susceptible to wear.
Selenium cure	Process used in curing neoprene and rubber jacketed wires and cables. The process makes a dense, tough, durable jacket.
Self-align	Design of two mating parts so that they will engage in the proper relative position. (See polarization).
Self-contained pressure cable	Pressure cable in which the container for the pressure medium is an impervious, flexible metal sheath, reinforced if necessary, which is factory assembled with the cable core.
Self extinguishing	Characteristic of a material whose flame is extinguished after the igniting flame is removed.
Semi-conducting jacket	Jacket having a sufficiently low resistance so that its outer surface can be kept at ground potential by a grounded conductor in contact with it at frequent intervals.
Semiconductor	Material whose conductive ability lies between that of a conductor, e.g., copper, and an insulator, e.g., glass. The most common semiconductor materials used in such solid state devices as transistors, rectifiers and diodes are silicon and germanium.
Semiconductor device	Any device based on either preferred conduction through a solid in one direction, as in rectifiers; or on a variation in conduction characteristics through a partially conductive material, as in a transistor.  TYPICAL SEMICONDUCTOR DEVICES
Semi-rigid	Cable containing a flexible inner core and a relatively inflexible sheathing material, such as a metallic tube; but which can be bent for coiling, spooling, or placing in a duct or cable run.
Semi-solid	Insulation cross section having a partially open space between the conductor and the insulation perimeter.
Separator	Pertaining to wire and cable; a layer of insulating material such as textile, paper, etc., which is placed between a conductor and its dielectric, between a cable jacket and the components it covers, or between various components of a multiconductor cable. It can be utilized to improve stripping qualities, and/or flexibility, or can offer additional mechanical or electrical protection to the components it separates.
Session	Logical network connection between two workstations typically a user station and a server - for the exchange of data.
SEU	Same as SEA, but not armored.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Severe Wind And Moisture Problem (SWAMP) areas	Areas such as wheelwells, wing folds, areas near wing flaps, and areas directly exposed to extended weather conditions are considered SWAMP areas on aerospace vehicles.
SF	Designation for silicone rubber insulated fixture wire, solid or seven strand conductor, 392°F (200°C).
SFF	Same as SF, except flexible stranding, 302°F (150°C).
SH-A	Designation for portable mine power cable, three or four individually shielded conductors, 932°F (500°C).
Shank	Cylindrical or rod-like portion of a connector or contact.
SH-B	Same as SH-A, except shield is overall.
SH-C	Same as SH-B, but with grounding conductors.
SH-D	Same as SH-A, but with grounding conductors.
Shear area or depth of shear	Distance that two parallel surfaces are overlapped.
Shear strength	Stress required to produce fracture in the plane of cross section. The conditions of loading being such that the directions of force and resistance are parallel and opposite, although their paths are offset a specified minimum amount.
Sheath	Outer covering or jacket over the insulated conductors to provide mechanical protection for the conductors. Also known as the external conducting surface of a shielded transmission line.
Sheet	Any material (conducting, insulating, or magnetic) manufactured in sheet form and cut to suit in processing.
Sheet metal contacts	Contacts made by stamping and bending sheet metal, rather than by the machining of metal stock. Available in a wide variety of configurations, and usually less expensive than machined contacts.
Sheet Molding Compound (SMC)	Thermosetting plastic resin, mixed with stranded fiberglass reinforcement, filters, and other additives, into a highly viscous compound which is rolled into sheet form for compression molding.
Shelf life	Length of time, under specified conditions, that a stored material in original, unopened containers retains its usability.
Shell, electrical	Outside case of a connector, into which the dielectric material and contacts are assembled.
SHF	Super High Frequency.
SHFS	Designation for polyvinyl insulated with felted asbestos, flame proof cotton or rayon braid, Navy switchboard wire, 600 V.

Table 2. Terms And Definitions (Cont.)

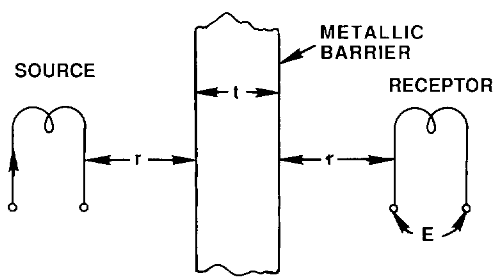
Term	Definition
Shield	Conducting envelope composed of metal strands that encloses a wire, group of wires, or cable. Constructed so that nearly every point on the surface of the underlying insulation is at ground potential, or at some predetermined potential with respect to ground. Shields level out surge impedance along the length of the cable, screen a signal from external excitation, or confine a signal to an intended electrical path. In coaxial cables, they may act as return wires. In telephone cables, they may protect against shorts due to ground surges, provide a barrier against termites and rodents, or filter out low frequency interference from nearby power lines.



Term	Definition
Shield coverage percent	Percentage of the surface area of cable core insulation covered by the shield. Also called shield percentage.
Shielded cable	Cable surrounded by a separate conductor (the shield), intended to minimize the effects of internal or external electrical circuits.
Shielded contact	(See coaxial contact).
Shielded line	Transmission line whose elements confine propagated radio waves to an essentially finite space inside a tabular conducting surface called the sheath, thus preventing the line from radiating radio waves.

Table 2. Terms And Definitions (Cont.)

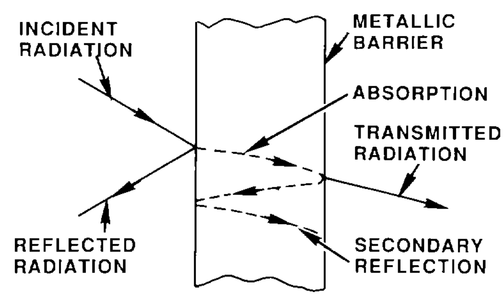
Term	Definition
Shield, electrical connector	Item especially designed to be placed around that portion of a connector which contains the facilities for attaching wires or cables. Used for shielding against electrical interference or mechanical injury, and usually has provisions for passage of the wire or cable.
Shielded-type cable	Cable in which each insulated conductor is enclosed in a conducting envelope constructed so that nearly every point on the surface of the insulation is at ground potential, or at some predetermined potential with respect to ground, under normal operating conditions. (See shield).
Shielding	Metal sleeving surrounding one or more of the conductors in a circuit to prevent interference, interaction, radio frequency or current leakage. Usually grounded, the shielding is carried through the connector shell or through a special internal shell in the case of individual coaxial contacts. (See shield, coaxial contact).
Shielding effectiveness	Relative ability of a shield to screen out undesirable signals.



SHIELDING EFFECTIVENESS (SE) (dB)=20 $\log_{10} \frac{E1}{E_2}$

WHERE E_1=VOLTAGE INDUCED IN RECEPTOR WITH BARRIER ABSENT

E_2=VOLTAGE INDUCED IN RECEPTOR WITH BARRIER PRESENT



SE (dB)=A + R + B

WHERE A=ABSORPTION LOSS

R=REFLECTION LOSS

B=CORRECTION FACTOR FOR INTERNAL REFLECTION

Term	Definition
Shore hardness	Instrument measure of the surface hardness of an insulating or jacket material.
Short circuit	Electrical loads which occur during fault conditions, and are usually high current flow.
Shroud, insulation	(See insulation support).
Shunt wire	Conductor joining two parts of an electric circuit to divert part of the current.
SIC	(See Specific Inductive Capacity).
Side-entry	Printed circuit board that slides into a connector which makes contact with three sides of board.
Signal	Current used to convey information; either digital, analog, audio, or video.
Signal cable	Cable designed to carry current of less than 1 ampere per conductor.
Signal conditioning	Amplification and/or modification of electrical signals to make them more appropriate for transmission over a certain medium.
Signal conductor	Individual conductor used to transmit an impressed signal.
Signal level	Root-mean square (rms) voltage measured during the peak of the RF signal.
Signal Quality Error Test (SQE/Heartbeat)	At the end of each transmission by a transceiver, it must send a short burst of 10 MHZ waveform on the collision lead to permit the controller to check proper operation of the collision signal path.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Signal-to-Noise (S/N) ratio	Usable information in a signal (optical or electrical), compared to the noise that tends to interfere with the transmission of the information.
Silica fibers	Silica (and quartz) fibers can withstand 1799.6°F (982°C) continuous service without change in physical properties. These fibers also withstand nuclear radiation without damage and without accumulating large residual amounts of radiation. Fused quartz fibers, however, become brittle at temperatures of 1400°F (760°C) to 1600°F (871°C) within hours. Both fiber forms have melting points of about 3099.2°F (1704°C). The extreme heat resistance of silica fibers recommends them for critical applications.
Silicate ester	Liquid used as a dielectric. (See liquid dielectrics).
Silicon	Brittle, gray, crystalline chemical element which, in its pure state, serves as a semiconductor substrate in microelectronics. Naturally found in compounds such as silicon dioxide.
Silicon dioxide	Structural material important in controlling the fabrication process of integrated circuits. Electrically, it serves to protect the silicon surface from contamination. It also serves as an insulating substrate for metallization, and as a dielectric in certain types of capacitors.
Silicone	Polymeric materials in which the recurring chemical group contains silicon and oxygen atoms as links in the main chain. Silicone rubber extrusions offer retention of good electrical properties, resilience, and flexibility after longtime heat aging. Excellent ozone resistance, low temperature flexibility, long life, low moisture absorption, weather resistance, radiation resistance, and corona resistance are other characteristics. Relatively poor resistance to some oils, solvents, and strong acids.
Silicone rubber	Thermosetting elastomer with excellent low temperature flexibility, ozone and corona resistance. Used in 200°F (93°C) to 450°F (232°C) potting applications, when designed to MIL–PRF–23586. (See potting).
Silicone treating	Silicone liquid treatment applied to insulated conductors to be jacketed to allow for easy jacket strippability.
Silky fracture	Metal fracture in which the broken metal surface has a fine texture usually dull in appearance. Characteristics of tough and strong metals.
Silver and its alloys	White, precious metal which is very malleable and ductile. Has the highest conductivity of all metals, and is a good material for many contact applications. Silver base alloys containing copper, nickel, palladium, and gold offer better mechanical, electrical, and corrosion resistance than pure or fine silver, with some sacrifice in surface and bulk resistance. Mixtures of silver and tungsten are also used as contact materials. When combined properly, silver-tungsten contacts offer the current carrying capability of silver, and the wear characteristics of tungsten.
Silver brazing	Brazing with silver-base alloys as the filler metal.
Silver chromate paper test	Simple qualitative test to determine presence of ionic halides. Usually used to check that a mildly activated flux, such as Type RMA, contains no ionic halides. The Silver Nitrate Test, also serves the same purpose.
Silver migration	Ionic displacement of metallic silver through an insulating medium. Usually caused by a combination of conditions of extended time, high humidity, temperature variations, and DC potential.
Simplex	Transmission in any one direction.
Single cable	One-cable system in broadband in which a portion of the bandwidth is allocated for send signals, and a portion for receive signals, with a guard band in between to provide isolation from interference.

Table 2. Terms And Definitions (Cont.)

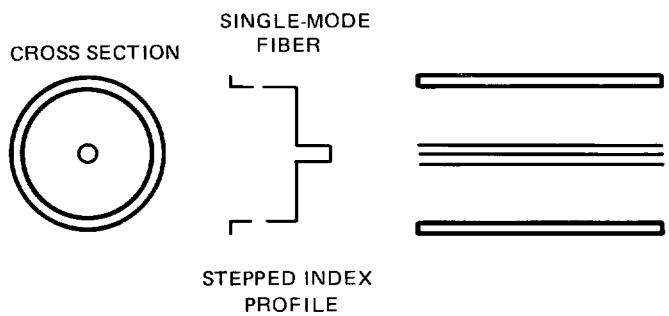
Term	Definition
Single-ended	Unbalanced, such as grounding one side of a circuit or transmission-line.
Single-faced tape	Fabric tape finished on one side with a rubber or synthetic compound.
Single mode fiber (fiber optic)	(1) Fiber that will propagate light only in a single wave form. (2) Fiber having a small core diameter (approximately 3 micrometers),with a cladding having a refractive index very close to that of the core. Will transmit light rays that enter at a narrow angle, and will transmit over very wide bandwidth. 
Single-sided board	Printed board with a conductive pattern on one side only.
Sinter	To thermally treat a powdered material, to cause the particles to fuse together.
Sintered Aluminum Powder (SAP)	Material composed of aluminum or an aluminum alloy in which is dispersed aluminum oxide. The material is used to improve the temperature stability of aluminum products.
Sizing	(1) Applying a material to a surface to fill pores. (2) Surface treatment applied to glass fibers.
SJ	Designation for junior hard service, rubber insulated pendant or portable cord. Same construction as type S, but 300 V.
SJO	Same as SJ, but neoprene, oil resistant compound outer jacket, 300 V, 140°F (60°C).
SJT	Designation for junior hard service thermoplastic or rubber insulated conductors with overall thermoplastic jacket, 300 V, 140°F (60°C).
SJTO	Same as SJT, but oil resistant thermoplastic outer jacket.
Skeining	Technique in which the coil wire ends are reinforced by folding a number of strands together, twisting them into a braid, and then securing them to the coil.
Skeleton braid	Widely separated braid of fiber, copper, or steel. Used to hold core together, for reinforcing jacket, or for shielding.

Table 2. Terms And Definitions (Cont.)

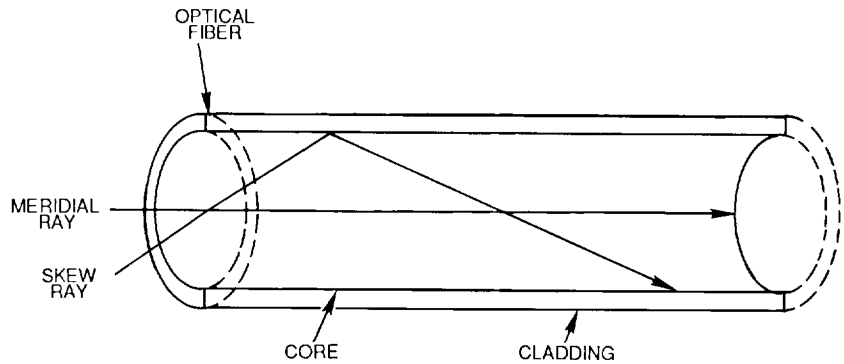
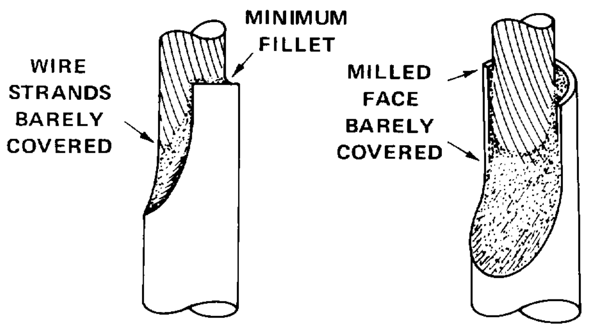
Term	Definition
Skew rays (fiber optic)	Rays of light which do not propagate through the axis of the fiber. 
Skim tape	Filled tape, coated on one or both sides with a thin film of uncured rubber or synthetic compound, to produce a coating suitable for vulcanization.
Skin effect	Phenomenon in which the depth of penetration of electric currents into a conductor decreases as the frequency increases.
Skived tape	Tape shaved in a thin layer from a cylindrical block of material such as skived PTFE tape.
SL	Designation for single conductor paper lead cables twisted together, without overall covering.
Sleeve	Braided, knitted, or woven tube used over wires or components as insulation tubing. Also called sleeving.
Slivers	Icicles, nubs, and spikes which are undesirable protusions from a soldered connection.
Slotted tongue terminal	Terminal with a slotted tongue for sliding onto the screw or stud so that neither screw nor unit needs removing. Also called spade tongue terminal.
Small Outline (SO) package	Similar to miniature, dual in-line package. Typical lead spacing: 0.050 in.
Small-scale integration	Circuit of under 10 gates, generally involving one metallization level, implementing one circuit function in monolithic silicon.
SMC	(See Sheet Molding Compound).
Snap-on	Used to describe the easy removal or assembly of one part to another. Certain connectors are provided with snap-on plastic covers to permit quick and convenient installation.
Snippers	Instrument for cutting wire.
SNM	Cable designed for use in hazardous locations. Consists of insulated conductors in an extruded non-metallic jacket, which is then covered with an overlapping spiral metal tape and wire shield, and jacketed with an extruded moisture, flame, oil, corrosion, fungus, and sunlight resistant non-metallic material.
S/N ratio	(See Signal-to-noise ratio).
SO	(1) Designation for a 600 V senior service, oil resistant neoprene jacket cord. Same construction as type S, except for neoprene jacket. (2) (See Small Outline package).

Table 2. Terms And Definitions (Cont.)

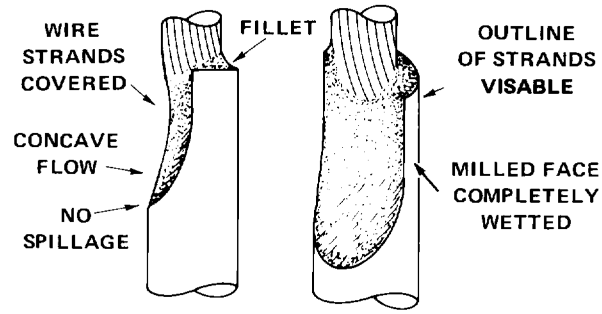
Term	Definition
Socket connector	Connector containing socket contacts into which a connector, having male contacts, is inserted.
Socket contact	Contact type (usually completely surrounded by insert material), designed to surround the mating pin contact. Normally connected to the live side of the circuit.
Socket contact sleeve	Sleeve that holds the contact spring in the correct position within the socket contact, and provides a smooth exterior surface.
Soft drawn	(1) Relative measure of the tensile strength of a conductor. (2) Wire which has been annealed to remove the effects of cold working.
Soils	In solder processing, foreign matter that might exist on a surface to be soldered. The soils may be organic or inorganic. An example would be the residue left by a finger print on a clean copper surface. This would be a combination of both organic and inorganic soils, which may interfere with soldering.
Solder	Metal or metal alloy, usually having a low melting point, used to join other metals having higher melting points than the solder. The action of the solder is of an adhesive type, that is, wetting of the surfaces and forming the joint by molecular attraction between the solder and the base metals; or involving some diffusion of the solder into the base metals, or vice versa. Solders are generally classified as soft solders and hard solders. Soft solders have melting points up to approximately 700°F (371°C), whereas the melting points of the hard solders are above 700°F (371°C). The most common soft solders are the tin/lead alloys (example; 63% tin/37% eutectic lead).
Solderability	Property of a metal to be wetted by solder.
Solder contact	Contact having a cup, hollow cylinder, eyelet, or hook to accept a wire for a conventional soldered termination.
Solder cream	Homogeneous combinations of solder, flux solvent, and a gelling or suspension agent for automated production of solder joints. Available with rosin or water soluble flux bases.

Table 2. Terms And Definitions (Cont.)

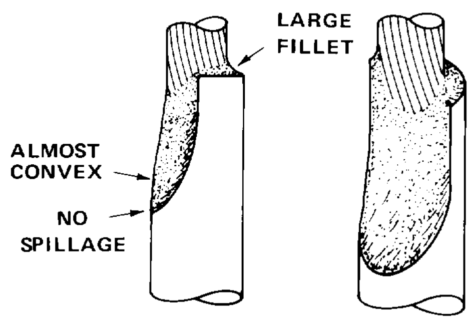
Term	Definition
Solder cup	Hollow cylinder at the tubular end of a terminal or solder contact, in which a conductor is inserted and soldered in place.



INSUFFICIENT SOLDER QUANTITY



MINIMUM ACCEPTABLE SOLDER QUANTITY



MAXIMUM ACCEPTABLE SOLDER QUANTITY

Term	Definition
Solder embrittlement	Reduction, in mechanical properties of a metal, as a result of local penetration of solder along grain boundaries.
Solder eye	Solder type contact provided with a hole at its end, through which a wire can be inserted, prior to being soldered.
Soldering	Similar to brazing, with the filler metal having a melting temperature range below an arbitrary value, generally 800°F (426.7°C). (See solder).
Solder joints	Connection of similar or dissimilar metals by applying molten solder, with no fusion of the basic metals.
Solderless connection	Joining of two metals by pressure means, without the use of solder, braze or any method requiring heat. (See pressure connection, solderless wrap).
Solderless wrap	Method of connecting a solid wire to a square, rectangular, or V-shaped terminal, by tightly wrapping the wire around the terminal with a special tool. (See wire wrap, wire wrap tool).
Solder lug	Device to which wire is secured by soldering.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Solder mask	(See solder resist).
Solder paste	(See solder cream).
Solder preforms	Manufactured solder configurations containing a predetermined quantity of alloy, with, or without a flux core or coating. Available as stamped discs and washers, spheres, and formed wire.
Solder resist	(Permanent or temporary) Coatings which mask and surface insulate those areas of a circuit where soldering is not desired or required. Also make possible the minimization of solder bridging between closely spaced conductors or runners.
Solder splatter	Unwanted fragments of solder.
Solder tapes	Solder alloys, in the form of thin tapes, in widths generally from 1/4 in. to 3 in. Also called solder foils or strips.
Solid conductor	Conductor consisting of a single wire (not stranded).
Solidification shrinkage	Decrease in volume of a metal during solidification.
Solids	When referring to rosin fluxes, solids or solids content, the percentage by weight of rosin in that formulation.
Solid state	Technology utilizing semiconductors in place of vacuum tubes.
Solidus	Temperature at which a metal alloy begins to melt. Some components of the alloy melt or begin to melt, whereas the balance of the material is still solid. This mushy characteristic is taken advantage of, especially in solders, for forming wiped joints. For example, the solder composition 30% tin/70% lead has a solidus of 361°F (182.8°C). Its liquidus is approximately 520°F (271°C). In the plastic range between them, the material can be mechanically worked and forced into joints. This wide plastic range is thus an advantage in plumbing and cable work for forming large solder joints. (See liquidus).
Solubility	Amount of solute present in a given amount of solvent or solution.
Solute	Component of a solution which is dissolved in solvent. Generally the solute is a solid, but can also be a liquid or gas.
Solution	Homogeneous mixture formed by processing, in which a substance that is solid, liquid, or gas, is mixed with a liquid (or by extension with a solid or gas) called a solvent. The term is usually associated with liquids, but may include solids, as in alloys or gaseous mixtures. Generally, a solution will be clear or transparent. A liquid mixture which is cloudy, is not considered a solution. (See suspension).
Solvent	One of the components of a solution. It is that component in which the other components, i.e., the solutes, are dissolved. In the case of a solution composed of several liquids, the liquid present in the greater quantity is usually referred to as the solvent. (See solution).
Solvent-bonded	Cables where bonding is accomplished by tackifying the surfaces of wire insulation, cable jacket, or spacer; then joining and driving off the solvents to form a cable. (See bonded cables).
Solventless polyester	(See varnish-solventless polyester).
Source (fiber optic)	Source of radiant energy, such as a Light Emitting Diode (LED). (See fiber optics).
Source coupling loss (fiber optic)	Loss of light intensity, as light from source passes into fiber. Depends on numerical aperture of fiber, and is less, for larger numerical apertures. Also, depends on end finish conditions and geometry of alignment.
SP	Silver Plate.

Table 2. Terms And Definitions (Cont.)

Term	Definition
SP-1	Designation for all rubber, parallel jacketed, two-conductor, light duty cord for pendant or portable use in damp locations, 300 V.
SP-2	Same as SP-1, but heavier construction, with, or without third conductor for grounding purposes, 300 V.
SP-3	Same as SP-2, but heavier construction for refrigerators or room air conditioners, 300 V.
Spacer	Metal piece placed between two conductors in a connector. Example: most aluminum to copper connectors use a spacer located between the dissimilar cable to reduce galvanic corrosion.
Spacing	Distance between closest edges of two adjacent conductors.
Spade contact	Contact with fork-shaped female members designed to dovetail with spade-shaped male members. Alignment in this type of connection is very critical if good conductivity is to be achieved.
Spade tongue terminal	Slotted tongue terminal designed to slip around a screw or stud without removing the nut.
Span	(1) Pertaining to flat conductors, distance from reference edge of the first conductor to the reference edge of the last conductor. (2) Pertaining to round conductors, distance between centers of the first and last conductors.
Sparking	Term used for continuous high voltage testing of insulated wire. (See spark test)
Spark test	Test designed to locate pin-holes in the insulation of a wire or cable by application of a voltage for a very short period of time while the wire is being drawn through the electrode field.
SPC	Silver Plated Copper.
Specialty wire not insulated	Constructions including those with unusual wire drawing (such as extremely fine diameters), annealing, elongation, tensile strength, stranding, and bunching requirements. This applies to copper, copper alloy, silver or tin- plated, and clad wires. Specific gravity Ratio of the density of a material to the density of water. For example, a cubic foot of water weighs 62.4 lbs. If a cubic foot of another material weighed 124.8 lbs., the specific gravity of the second material would be 2. In the metric system, where the units of weight and measurement are grams and cubic centimeters, specific gravity and density would be identical. The reason for this is that water weighs 1 gram per cubic centimeter. Therefore, if a material has a density of 4 grams per cubic centimeter, its specific gravity would be 4.
Specific Inductive Capacity (SIC)	Dielectric constant of insulating material. (See dielectric constant).
Spectral response (fiber optic)	Response of a detector (or a system) over different wavelengths.
Spectral width	Measure of the wavelength range of a sources output spectrum.
Spectrographic analysis	Analysis to determine elements present in an unknown. May be quantitative or qualitative. This type of analysis is based on the fact that when an element or group of elements is placed in an electrical arc or spark, each element will radiate wavelengths of light, i.e., colors, peculiar to itself. The light from the arc is then passed through a prism or diffraction grating to break it into its component colors or wavelengths. By noting those wavelengths, the elements that were present in the unknown can then be determined. By suitable standardizing (see standards, spectrographic) of the apparatus, one can determine quantitatively how much of the element is present by noting the intensity of the various colors of light given off by the arc.

Table 2. Terms And Definitions (Cont.)

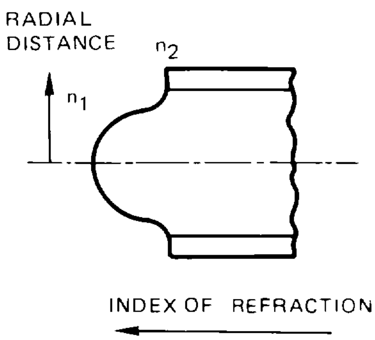
Term	Definition
Spike	Pulse having great magnitude.
Spinel	Spinel ceramic bodies, having the spinel crystalline phase (MgO:A1 O), are strong and have low loss qualities. Spinel has been used for substrates in microcircuit technology because silicon can be grown on it epitaxially.
Spiral shield	Metallic shield of fine stranded wires applied spirally rather than braided. (See shield).
Spiral stripe	Color coding stripe applied helically to the surface of an insulated wire or cable. (See helical stripe).
Spiral wrap	Term given to describe the helical wrap of a tape or thread over a core.
Spirit varnish	(See varnish-spirit).
Splice	Connection of two or more conductors or cables to provide good mechanical strength as well as good conductivity.
Splicing loss (fiber optic)	(See coupling loss).
Split conductor cable	Cable in which each conductor is composed of two or more insulated conductors normally connected in parallel.
Splitter	Passive device used in a cable system to divide the power of a single input into two or more outputs of lesser power.
Spodumene	Spodumene does not exhibit shrinking of 8% to 30% like most dense ceramic bodies. During sintering, alpha-spodumene inverts to betaspodumene accompanied by an expansion of 33%. These bodies are formed at optimum pressures, then sintered to obtain zero fired shrinkage characteristics on a dense body. A typical body has 60% spodumene and 40% lead bisilicate.
Spontaneous emission	Radiation emitted when the internal energy of a quantrum mechanical system drops from an excited level to a lower level without regard to the simultaneous presence of similar radiation.
Spot ties	Ties other than secondary support ties used to separate a number of wires, cables, groups, or harnesses within a bundle.
Spring-finger action	Design of a contact, as used in a printed circuit connector or a socket contact, permitting easy, stress-free spring action to provide contact pressure and/or retention.
SPT-1	Same as SP-1, except all thermoplastic, 300 V. With or without third conductor for grounding.
SPT-2	Same as SP-2, except all thermoplastic, 300 V. With or without third conductor for grounding.
SPT-3	Same as SP-3, except all thermoplastic, 300 V. With or without third conductor for grounding.
SR	Designation for silicone rubber control cable, 600 V, 257°F (125°C).
SR-AW	Designation for flexible, nickel plated copper conductor, silicone rubber insulation, glass braid, 600 V, 392°F (200°C).
SR-C	Designation for solid copper conductor, silicone rubber insulation, glass braid, 600 V, 257°F (125°C).
SR-H	Designation for silicone rubber insulated, asbestos braid, 500 V, 257°F (125°C).
SRL	(See Structural Return Loss).
ST	Hard service cord, jacketed, same as type S except all plastic construction, 600 V,140°F (60°C) to 221°F (105°C).

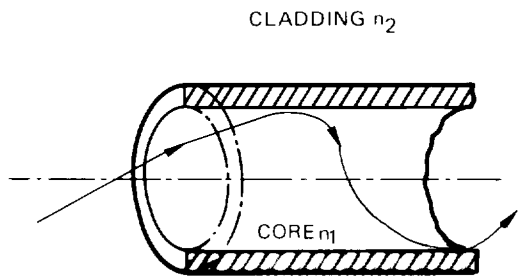
Table 2. Terms And Definitions (Cont.)

Term	Definition
Stabilizer	Ingredient used in some plastics to maintain physical and chemical properties throughout processing and service life.
Standard source (fiber optic)	Reference optical power source to which emitting and detecting devices are compared for calibration purposes.
Standards, spectrographic	Sample of material whose precise chemical composition is known. A standard is used to calibrate the equipment used in quantitative spectrographic analysis.
Standard Wire Gauge (SWG)	(See British Standard Wire Gauge).
Standing wave ratio	In a transmission line, waveguide, or analogous system, a figure of merit used to express the efficiency of the system in transmitting power, taking into account the mismatch between source, line, and load.
Stand-off	Terminal insulated from and usually mounted on the chassis for the purpose of bringing two or more wires of similar electrical characteristics to a common point.
Staple fibers	Fibers of spinnable length manufactured directly or by cutting continuous filaments to short lengths.
Stay cord	Component of a cable, usually a high tensile textile, used to anchor the cable ends at their points of termination and to keep any pull of the cable from being transferred to the electrical connections.
ST connector	Type of connector used on fiber optic cable utilizing a spring loaded twist and lock coupling similar to the BNC connectors used with coaxial cabling.
Steatite	Steatite can easily be fabricated to close tolerances because its composition contains a large portion of talc. It has good mechanical properties, low loss qualities at MHz, and poor thermal shock characteristics.
Steels, electrical	Steels that are made in an electric furnace. Electrical steels are available in several grades and are used when energy conservation is a major consideration. They are specialty alloys which are classified as non-oriented, oriented, or super-oriented. Non-oriented electrical steels are steels in which the magnetic properties are practically the same in any direction of magnetization in the plane of the material. Oriented electrical steels are steels that possess magnetic properties that are strongly oriented with respect to the direction of rolling. Super-oriented electrical steels provide an outstanding degree of grain orientation.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Stepped index fiber (fiber optic)	Multimode fiber consisting of a core of uniform refractive index, surrounded by cladding of slightly lower refractive index. Accepts light rays over wider angle, but has smaller bandwidth than single mode fiber. (See graded index fiber, single mode fiber).





Term	Definition
Step soldering	Technique of making a series of soldered joints in sequence. The first joint is made with a solder operation at the highest temperature. Each succeeding joint is made with a solder at such lower temperature as will not impair the first joint.
Steradian	Unit of solid angular measure, being the subtended surface area of a sphere divided by the square of the sphere's radius.
Sterling silver	Silver alloy containing at least 92.5% silver, the remainder being unspecified but usually copper.
Stimulated emission	Radiation emitted when the internal energy of a quantum mechanical system drops from an excited level to a lower level when induced by the presence of radiant energy at the same frequency.
STO	Same as ST, but with oil resistant thermoplastic outer jacket, 600 V.
Stopping off	(1) Applying a resist. (2) Depositing a metal such as copper in localized areas to prevent carburization, decarburization, or nitriding in those areas during heat treatment. (3) Filling in a portion of a mold cavity to keep out molten metal.
Stop plate	Device attached to a crimping tool to properly locate a terminal, splice, or contact in the tool prior to crimping. (See positioner).
Strain relief clamp	(See cable clamp).
Strain relief or stress loop	Forming of component leads in a designated pattern to provide relief from stress between terminations.
Strand	One of the wires, or groups of wires, of any stranded conductor.
Stranded conductor	Conductor composed of a group of wires, or of any combination of groups of wires. The wires in a stranded conductor are usually twisted or braided together.
Strand lay	Distance of advance of one strand of a spirally stranded conductor, in one turn, measured axially. (See lay).
Strand shield	Layer of semiconducting material or tape applied directly over the stranded conductor of cables rated 2000 V and higher. This reduces the possibility of high stress points occuring between the conductor and insulation.
Strap	Square or rectangular section bare conductor manufactured and used in coil form.

Table 2. Terms And Definitions (Cont.)

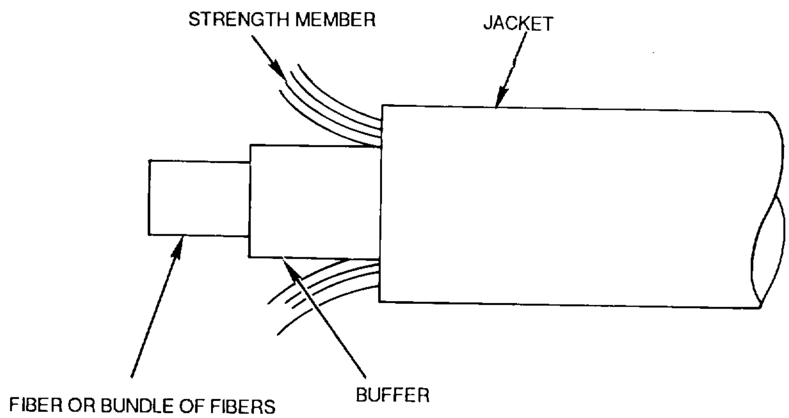
Term	Definition
Streamlined	Design of high-voltage connectors to eliminate sharp points or corners and to recess all hardware to reduce corona discharge.
Strength member (fiber optic)	Member included in a fiber cable to add tensile strength. Does not carry information. Also called tension member. 
Stress loop	Forming of a slight curve in the leads of components to avoid stress between terminations.
Stress raisers	Changes in contour or discontinuities in structure that cause local increases in stress.
Stress relief	Predetermined amount of slack to relieve tension in components to avoid stress between terminations.
Stress-rupture test	Tension test performed at constant load and constant temperature, the load being held at such level as to cause rupture. Also known as creep rupture test.
Stringular cable	Wire rope used to support electrical or fiber optic cable.
Strip	(1) To remove insulation from a cable. (2) Strip contacts: a continuous length of formed contacts for use in an automatic installation machine.
Strip force	Force required to remove a small section of insulation material from the conductor it covers. Usually measured in pounds.
Stripline	Type of transmission line configuration which consists of a single narrow conductor parallel and equidistant to two parallel ground planes.

Table 2. Terms And Definitions (Cont.)

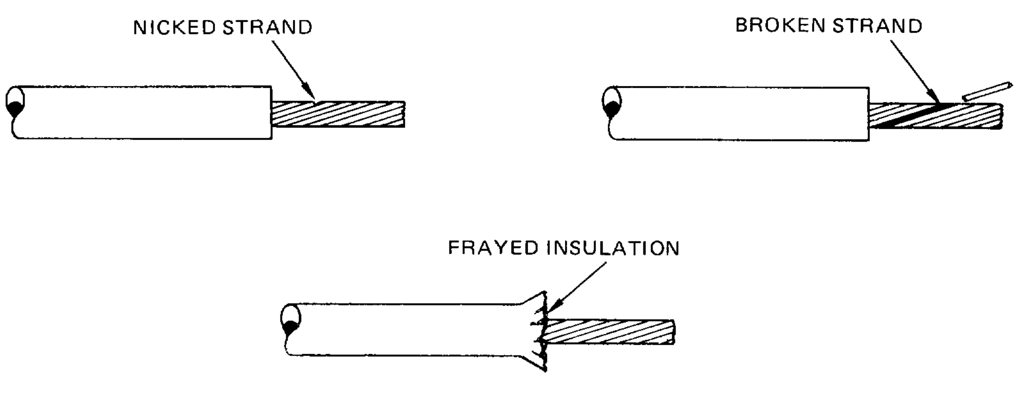
Term	Definition
Stripping tools and equipment	For wire stripping, a variety of hand-operated, hand-held electrically operated, and bench-mounted electrically or air powered units are available. Stripping actions include cutting (blades and knives), thermal abrasion, lasers, etc. When used for the proper application, all give quick, clean cutting of insulation and are safe-guarded to prevent cutting into the wire. The powered units use various types of strippers to handle various types of insulation. Thermal units will score through thermoplastic insulation up to 1/4 in. thick easily. These units need no adjustments to handle different size wires or cables. Fiberglass and wire brush stripping wheels are used to strip film and bonded insulation. Two wheel stripper heads or one wheel heads in conjunction with a carbide-edged blade are available for handling both round and rectangular conductors. Rotary strippers consist of a tiny, precision-hinged adjustable stripping blade which is actuated entirely by the movement of the wire being stripped. It is suitable for PTFE, nylon, vinyl, and similar insulations. Centrifugal force strippers include one with three counterbalanced knives that close around the wire and strip off the insulation by centrifugal force. Speed is varied according to wire size. Another uses a spinning, gimbal-mounted thermal element which is applied to the wire by its own centrifugal force. Application of the element is delicate yet positive. Automatic wire cutting and stripping machines will cut lengths of insulated wire or cable and strip both ends to the same or different lengths. Production rates vary with type of insulation, size of wire, and lengths cut. For stripping flat cables, high temperature 10,832°F (6000°C)] flame or infrared tools are available. The insulation is vaporized almost instantly. Since infrared light is radiant energy, it heats only those materials which absorb it - this means that transparent or translucent insulations must be painted where they are to be vaporized. Insulation on wire as fine as one mil in diameter can be removed with a high energy electric arc tool. With the tool, wire is fed through a narrow gap between two electrodes. The tool oscillates by means of a cam so that the arc generated by the electrodes sweeps across all the insulation to be removed. The insulation vaporizes almost instantly. Insulation can be removed from a specific segment of wire, or when the wire is fed automatically, on a continuous basis. A shielding stripper for the stripping of braided metal shielding on coaxial and other wires cuts the braid and leaves the strands of the braid fuse-welded together so that they cannot unravel and are easy to insert into connectors.
Stripping wire	Removal of a predetermined portion of insulation without affecting the mechanical or electrical characteristics of the conductor or the remaining insulation.  STRIPPED WIRE UNACCEPTABLE CONDITION
Strip process insulation	Insulation consisting of one or more strips of unvulcanized thermosetting material folded around a conductor and vulcanized after application.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Structural Return Loss (SRL)	Not all signals fed into the input end of a cable arrive at the output (load) end. Some of this signal energy is lost in the form of heat due to resistance of the cable, and some of this energy is reflected backward due to irregular dimensions in the cable structure. These backward reflected energies from uneven parts of the cable structure are termed structural return loss.
Stud	Post for connecting wire, similar to a binding post.
Stud hole	Hole or opening in the tongue of a terminal to accommodate a screw or stud.
Stuff	(See ramp).
Styrene-Butadiene Rubber (SBR)	Copolymers of styrene and butadiene, styrene-butadiene rubbers are not resistant to oils, solvents, and chemicals, being particularly susceptible to strong oxidizing agents, ozone, petroleum, and chlorinated and cyclic hydrocarbons. Resistance to water is one of the chief assets. SBR has good electrical insulating properties and is used in wire and cable insulation for general-purpose applications. Also GR-S or Buna-S.
Sublimation	Physical process in which a solid evaporates directly into a vapor, without passing through a liquid phase. The evaporation of dry ice is an example of this process.
Submarine cable	Cable used underwater from one point to another for power or communication. Lead sheath and/or rubber jacket.
Subsplit	Method of frequency division that allows two-way traffic on a single cable.
Substituted coromatic hydrocarbon	Liquid used as a dielectric. (See liquid dielectrics).
Substrate	(1) Physical material upon which an electronic circuit is fabricated. Used primarily for mechanical support but may serve a useful thermal or electrical function. (2) Material on whose surface an adhesive substance is spread for bonding or coating, or any material which provides a supporting surface for other materials.
Subtractive process	Process for obtaining conductive patterns by the selective removal of unwanted portions of a conductive foil.
Sudden jerk	Elongation rate of approximately 12 feet to 16 feet (3.6 meters to 4.8 meters) per second. Also called rapid elongation.
Sulphur hexafluoride	Gas used as a dielectric. (See gaseous dielectrics).
Superconductors	Materials in which the resistance drops to almost zero at a temperature near absolute zero. Superconductivity is exhibited by many of the metallic elements, their alloys, intermetallic compounds, and, most recently, ceramic compounds.
Supported hole	Hole in a printed board that has its inside surface plated or otherwise reinforced.
Surface conditioners	Specially formulated liquid cleaners to restore the solderability of the most commonly used metals and alloys in the soldering process.
Surface conductance	Conductance of electrons along the outer surface of a conductor.
Surface leakage	Passage of current over the boundary surfaces of an insulator as distinguished from passage through its volume.
Surface mounting	Electrical connection of components to the surface of a conductive pattern without utilizing component holes.
Surface printing	Method of wire identification in which engraved wheels turn in a bath of marking ink. Legends are imprinted on the moving insulation material.
Surface resistivity	Resistance of a material between two opposite sides of a unit square of its surface. Usually expressed in ohms. (See resistivity).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Surface tension	Property of liquids, due to molecular forces existing in the surface film of all liquids, which tends to contract the volume into a form with the least surface area. That is, the molecules on the surface of a liquid are not acted upon by the same forces as those molecules in the interior of the liquid. For example, a given molecule in the body of a liquid will be acted upon by forces of identical molecules completely surrounding it. At the surface, however, in one direction the surface molecules will be acted upon by air or whatever the atmosphere is above the liquid. The particles on the surface film are inwardly attracted, thus resulting in a tension force at the surface of the liquid. This surface tension or force can be broken down by the addition of certain chemical agents to the liquid. The breakdown of the surface tension film results in a flowing out, or wetting action, by the liquid (see wetting). One of the actions which must be accomplished by a soldering flux is a breaking down of the surface tension of the liquid solder. This results in a wetting or complete flowing of the solder over the surface to be coated. An example of a non-wetting situation: raindrops hitting a highly waxed automobile hood. The liquid drops do not wet the wax finish, with the result that the water droplets ball off into spheres. This action is entirely due to the surface tension of the water.
Surface transfer	If a current is caused to flow on the outside of a cable shield, then an impedance induced longitudinal voltage will result along the inside of that shield. The ratio of that induced voltage to the driving current is an impedance, or surface transfer impedance.
Surge	Transient variation in the current and/or potential at a point in the circuit.
Surlyn	Dupont’s trade name for their thermoplastic resin with ionic crosslinks.
Surveillance inspection	Random, unannounced daily inspections monitoring the processes.
Suspension	Mixture of liquid or solid in a liquid. Not considered a true solution because discrete particles or droplets are visible and the mixture is not clear. (See solution).
SWAMP areas	(See Severe Wind And Moisture Problem areas).
Swedging	Term for crimping.
Sweep test	Method to determine the frequency response of a cable by generating a radio frequency voltage whose frequency is varied at a rapid constant rate over a given range. Structural return loss values are obtained by this test method.
SWG	Standard Wire Gauge. (See British Standard Wire Gauge).
Switchboard cable	Cable used within and between the central office main frames and the switchboard
Switchboard wire	Chemically cross-linked polyethylene or asbestos insulated wire used in switchboards and control apparatus. Heat, flame, and corrosive vapor resistant.
Switches	Devices that make or break connections in an electrical or electronic circuit. Switches are usually manually operated, but can also work by mechanical, thermal, electromechanical, barometric, hydraulic, or gravitational means.
TAA	Designation for flexible nickel or nickelclad copper, PTFE tape, felted asbestos, asbestos braid, 392°F (200°C).
Tab	(See printed contact).
Take-up	Device to spool wire and cable in a manufacturing operation.
Tandem extrusion	Extruding two materials, the second being applied over the first, with the two extruders being just a short distance apart in the process. (See extrusion).
Tank test	Term used to describe a voltage dielectric test where the specimen to be tested is submerged in a liquid (usually water) and a voltage potential is applied between the conductor and the liquid as ground.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Tantalum	Gray, hard, lustrous metal resembling platinum which is used primarily in capacitors. Forms include powder, bar, rod, wire, foil, sheet, and tubing. Electrical stability, high temperature strength, and corrosion resistance are features.
Tap	Special lead brought out from an intermediate point of a coil or winding.
Tape	Relatively narrow, woven or cutstrip of fabric, paper, or film material.
Tape, acetate cloth	Combines the strength and impregnability of the acetate cloth backing with excellent electrical properties. It is also printable.
Tape, acetate cloth/acetate film	Addition of the acetate film gives improved electric strength properties without impairing the noncorrosive features and with only a slight added overall thickness.
Tape, acetate film	Combines thinness with good electrical properties. Their cost, compared to other film tapes, is low.
Tape, acetate film/rayon filament reinforced	Tape of exceptional tensile strength and tear resistance, it is practically always found in use where heavy conductors must be firmly anchored and where any other backing would not provide the necessary strength. The acetate film carrier produces high electrical strength properties.
Tape, acetate film/glass filment reinforced	Tape is similar to rayon filament reinforced, but is available in a thinner gauge which gives it good conformability. It is a strong tape for tough holding and insulating uses.
Tape cable	Form of multiconductor cable consisting of parallel metal strips imbedded in insulating material. Also called flat flexible cable. (See flat cable).
Tape, composite (combination)	Pressure sensitive tape made by combining two different types of backing by a laminating process and coating a pressure sensitive adhesive onto one side of the laminate. Generally, combinations are used which produce characteristics and properties not available in either of the individual backings by themselves.
Tape, epoxy bonded mica paper/glass cloth	Designed for use as a high-voltage lead pad in coils and as a form wound coil wrapper for high-voltage rotating equipment.
Tape, fluorohalocarbon film	Film has an electrical grade acrylic adhesive and is designed for use at class F operating temperatures.
Tape, friction (cotton cloth)	Product is never recommended for use internally in an electrical unit. It is commonly used where its function is strictly mechanical and low cost is mandatory.
Tape, friction (cotton cloth/rubber)	Designed specifically to save taping time in making electrical splices. Not recommended for use within an electrical unit.
Tape, glass cloth	Glass cloth backing used can be combined with either a rubber adhesive, an acrylic adhesive, or a high temperature silicone adhesive. These tapes are usable at different temperature ranges.
Tape, glass cloth, epoxy resin treated	Tape is readily conformable with good handling properties. The continuous epoxy film provides electrical properties and the glass cloth provides physical strength.
Tape, glass cloth, polytetrafluoroethylene treated	Polytetrafluoroethylene treatment imparts added electric strength properties to the glass cloth and also antifriction properties.
Tape, glass cloth, silicone rubber coated	Silicone rubber coating gives the glass cloth improved electric strength properties depending upon the total thickness of the rubber coating.
Tape, glass cloth, silicone varnished	The silicone varnish provides greater electric strength than available in the untreated glass cloth and when made with a silicone adhesive, is usable in the 356°F (180°C) temperature range.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Tape, impregnated creped kraft	Use of a creped kraft backing provides elongation features which allow the tape to be used in applications where conformance to an irregular surface is important.
Tape, impregnated flatback rope	This product is widely used. Individually, its properties do not compare to properties found in other pressure sensitive electrical tapes, but its low cost makes it most attractive for use in applications where requirements are not too demanding.
Tape, paper pressure sensitive	Most economical of the pressure sensitive electrical tapes. Used where the physical and electrical requirements are not excessive and/or the cost factor is of major importance. The papers used as the backings must be processed to negate as much as possible the corrosive properties of salts present in the base paper and to eliminate the hygroscopic properties.
Tape, plastic film or rubber pressure sensitive	Has diverse properties when used as backings for electrical tapes. The one common feature, and one of the features that makes tapes produced with these backings so valuable, is thinness.
Tape, polyester film	Tapes feature excellent physical properties (as compared to physical properties of other film backed tapes).
Tape, polyester film, bondable surfaced	A shortcoming in normal polyester film electrical tape is the possible poor bondability between the film backing and the varnishes or potting compounds frequently used in electrical/electronic equipment.
Tape, polyester film, heat shrinkable	Designed for use where a closely conforming, dielectric covering is required on metal can capacitors, solenoid coils, transformer laminations, and other electrical or electronic parts.
Tape, polyester film/rope paper	Laminating an electrical grade rope paper to a polyester film produces physical strength not found in the film itself and the film supplements the electric strength of the rope paper.
Tape, polyester film/ polyester mat	This combination produces excellent electric strength and noncorrosive properties, as well as exceptional physical strength features.
Tape, polyester mat, porous	This tape backing with a thermosetting pressure sensitive adhesive represents a completely permeable holding and insulating tape.
Tape, polyethylene film	Limited high temperature resistance has prevented this tape from being used to any extent internally in electrical units. However, the very satisfactory electrical insulating properties and the high degree of conformability make it potentially usable as a means for splicing conductors where elevated temperatures are not involved.
Tape, polyimide film	Aromatic polyimide polymer is one of the most thermally stable organic polymers yet developed. The film has the thermal capacity to allow higher operating temperatures in electrical components to improve their performance and to reduce size and overall weight of units.
Tape, polyparabonic acid film	Demonstrates good physical, chemical, dielectric, and insulating properties over a broad temperature range. Less expensive than higher temperature films, yet designed for high performance applications.
Tape, polytetrafluoroethylene film	These tapes, coated with a silicone based adhesive, are used in 356°F (180°C) applications. This, combined with the relative thinness, makes these tapes most usable and increasingly popular.
Tape, polytetrafluoroethylene film, printed surface	While the anti-friction or anti-stick property of polytetrafluoroethylene film is desirable in many instances, this property is a disadvantage if it is necessary or desirable for another material to adhere to it.

Table 2. Terms And Definitions (Cont.)

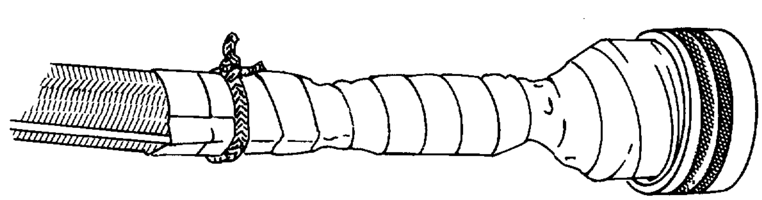
Term	Definition
Tape, pressure sensitive	Pressure sensitive tapes contain an adhesive coating applied to the backing material which allows the backing to be positioned with application of pressure only. The use of an activator such as heat, solvent, or water is not required. The two primary functions of electrical pressure sensitive tapes are holding and insulating. These tapes are commonly adhered to conductors or other insulating devices, and serve the purpose of holding or anchoring them in a desired manner. Secondary functions of electrical tapes include: (1) protection against abrasion; (2) use as a barrier to the entrance of moisture; (3)identification; (4) spacing factor; (5) reinforcing; (6) bundling. Cloth and mat pressure sensitive tapes are generally used for their physical strength factors. Widely different electrical properties are available depending on the specific chemical construction of the backing used.
Tape shields	Shields constructed from copper and aluminum (either alone or laminated with a dielectric), bimetallic tape (copper/stainless steel/copper), and bronze. Tape shields are supplied in two forms, flat and corrugated. (See shield).
Tape, silicone rubber	High temperature splicing tape with excellent conformability for wrapping splices or terminations. Excellent arc tracking resistance, electric strength, ozone resistance, and weathering resistance are also claimed.
Tape, vinyl film	These tapes are seldom used internally in an electrical unit, but are commonly used in the insulation of external splices, wrapping leads, and cable harnessing.
Taped insulation	Insulation of helically wound tapes applied over a conductor or over an assembled group of insulated conductors. When successive convolutions of a type overlie each other for a fraction of the tape width, the taped insulation is lap wound. This is also called positive lap wound. When a tape is applied so that there is an open space between successive convolutions, this construction is known as open butt or negative lap wound. When a tape is applied so that the space between successive convolutions is too small to measure with the unaided eye, it is a closed butt taping. Where there are multiple layers of tape, indexing refers to the fact that they are started a certain distance from each other along the axis of the cable to assure full coverage. (See tape wrap).
Taper pin	Pin-type terminal having a tapered end designed to be impacted into a tapered hole to form a connection.
Taper tab	Flat terminal having tapered side designed to receive a mating tapered female terminal.
Tape wrap	Term denoting a spirally or longitudinally applied tape material wrapped around the wire, either insulated or uninsulated, and used as an insulation or mechanical barrier. 
Taping	Process of insulating continuous length, large diameter wires with tape of non-extrudable materials. In most taping operations, two spiral wraps are applied in an opposite direction (cross-wrapped) directly over the conductor. Each tape is overlapped to form a multilayered, void-free covering, and heat sealed to produce an integral and continuous wall.
Tarnish	Surface discoloration of a metal caused by formation of a thin film of corrosion product.
TAS	Thermoplastic appliance shielded wire.

Table 2. Terms And Definitions (Cont.)

Term	Definition
TBS	Designation for switchboard wire, thermoplastic insulation, flame proof cotton braid, 600 V,194°F (90°C).
TBWP	Designation for switchboard wire, weatherproof saturated. No voltage rating.
TC	(1) Tinned Copper. (2) (See Tray Cable).
T dimension	Dimension of the crimped portion of a connector measured between two opposite points on the crimped surface. (See depth of crimp).
Tear strength	Force required to tear a material under specified conditions.
Teflon	Trademark of the DuPont Company for fluorocarbons FEP and PTFE.
Tefzel	Trade name of the DuPont Company for ethylene-trifluoroethylene (ETFE) compound.
Telemetry cable	Cable used for the transmission of information from instruments to the peripheral recording equipment.
Telephone wire	General term referring to many different types of communication wire. Refers to a class of wires and cables, rather than a specific type.
Tellurium cure	Curing process similar to selenium cure, except a different element is used.
Temper	(1) Hardness and strength produced by mechanical or thermal treatment or both, and characterized by a certain structure, mechanical properties, or reduction in area during cold working. (2) A measurement of the degree of hardness or lack of ductility in a metal.
Temperature coefficient of resistivity	Change in resistance (electrical) per degree change in temperature. Usually signified by the symbol alpha.
Temperature rating	Maximum temperature at which an insulating material may be used in continuous operation without undue degradation or safety hazard.
Tensile strength	Characteristic of a material which describes its resisance to fracture when the material is being stretched, i.e., under a tensile load. For example, if a wire is attached to a rigid frame at one end and a succession of increasing weights are hung from the other end of the wire, it would be under a tensile load. The point or load at which the wire breaks describes the tensile strength of the wire and the material of its construction.
Tensile test	Controlled pull test on the crimp joint to determine its mechanical strength.
Tension member (fiber optic)	Member included in a fiber cable to add tensile strength. Does not carry information. Also called strength member. (See strength member).
Tension meter	Meter used to measure and test the tension in all types of wire, yarn, tape, and film during production processing and winding.
Tension set	Condition when a plastic material shows permanent deformation caused by a tension stress, after the stress is removed.
Terminal	Metal wire termination devices designed to handle one or more conductors, and to be attached to a board, bus, or block with mechanical fasteners, or clipped on. Types are ring, tongue, spade, flag, hook, blade, quick-connect, off-set, flanged, etc. Special types include taper pin, taper tab, and others, either insulated or non-insulated.

Table 2. Terms And Definitions (Cont.)

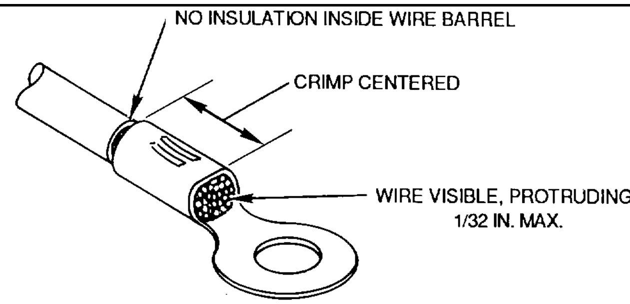
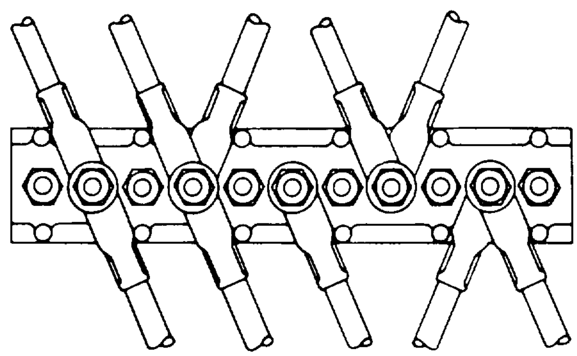
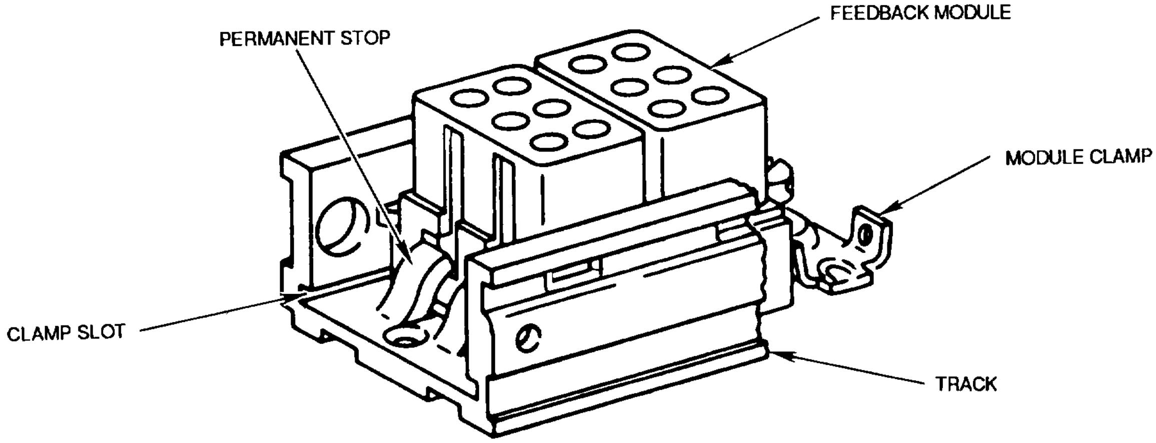
Term	Definition
	
Terminal area	(See land).
Terminal board	Insulating base equipped with one or more terminal connectors for the purpose of making electrical connections, typical terminal board designs are provided in SAE–AS27212.
	 NOTE: ALL TERMINALS SHOULD BE PLACED SO THAT MOVEMENT WILL TIGHTEN NUT
Terminal junction module	Termination assembly having multiple contacts interconnected in parallel to form a circuit. May contain one or more circuits. (See terminal junction system).
Terminal junction system	System conforming to MIL-T-81714 consisting of modules, tracks, and splices used for interconnecting electrical components and equipment requiring infrequent disconnection.
	 TERMINAL JUNCTION SYSTEM (TYPICAL)

Table 2. Terms And Definitions (Cont.)

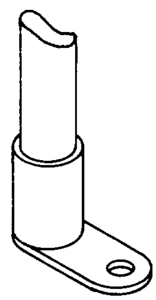
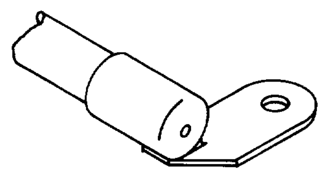
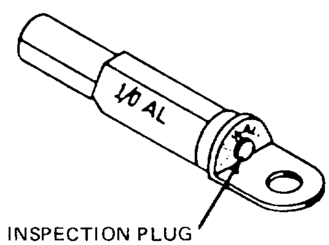
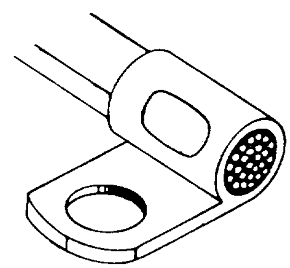
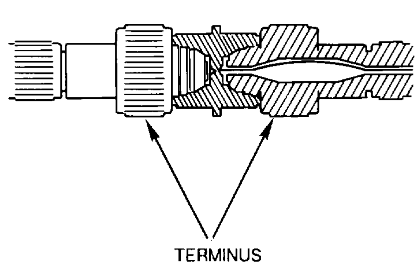
Term	Definition
Terminal lug	Device designed to be affixed, usually at one end, to a post, stud, chassis, or similar device, and with provison for attachment of an electrical conductor(s) in order to establish an electrical connection.  90º UPRIGHT TYPE ALUMINUM TERMINAL LUG  LEFT ANGLE TYPE ALUMINUM TERMINAL LUG  STRAIGHT TYPE ALUMINUM TERMINAL LUG  FLAG TYPE COPPER TERMINAL LUG
Terminal nipples	Used to provide overall insulation and protection on terminal lugs and studs. Conforms to A–A–59178.
Terminal style	Tongue design of the terminal (flag, flanged spade, off-set, rectangular, ring, slotted, spade, etc.).
Terminator	A 75-ohm resistive connector used to terminate the end of a cable or an unused tap.
Termini	A fiber optic connectioncomponent that is inserted into one of the insert cavity of a multiple terminit connector and terminated onto the end of a simplex, fiber optic cable. Plural form for the word terminus.
Terminus (fiber optic)	Device used to terminate an optical conductor that provides a means to allocate and contain an optical conductor within a connector. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Ternary alloy	Alloy that contains three principal elements.
Tertiary winding	Winding added to a transformer in addition to the conventional primary and secondary windings, such as for suppressing third harmonics or connecting to a power-factor correcting device.
Test lead	Flexible, insulated lead wire which usually has a test prod on one end. Ordinarily used for making tests, temporarily connecting instruments to a circuit, or making temporary electrical connections.
Textile braid	Any braid made from threads of cotton, silk, or synthetic fibers.
TF	Designated for solid or seven-strand copper conductor, thermoplastic insulated fixture wire, 140°F (60°C).
TFE	Also as PTFE. (See Polytetrafluoroethylene).
TFF	Same as TF, but flexible stranding, 140°F (60°C).
TG	Designation for flexible nickel or nickelclad copper conductor, PTFE tape, overall glass braid, 392°F (200°C).
TGS	Designation for solid or flexible copper, nickelclad iron or copper, or nickel conductor, PTFE tape, silicone glass braid, 600 V, 482°F (250°C).
Thermal aging	Exposure to a given thermal condition or a programmed series of conditions for prescribed periods of time.
Thermal conductivity	Property of a material or assembly which describes its ability to conduct heat. Metals, in general, are better thermal conductors than nonmetals. Silver and copper are the best conductors of heat. In general, thermal conductivity of a material parallels its electrical conductivity.
Thermal Electromotive Force (EMF)	Measure of a phenomenon which takes place when two dissimilar metals are bonded together. If the temperature of the bonded area is raised, a voltage is generated. An example of this is a thermocouple. Two dissimilar metals are bonded together, and the point of bonding is placed in the medium to be measured. The wires leading from the point of bond are then connected to an instrument that reads the voltage generated at the bond point. For the voltage to appear and be read, the point of measurement and the bonding point must be at two different temperatures. When this temperature difference and the dissimilar metals are present, the thermal electromotive force is generated.
Thermal endurance	Time at a selected temperature for an insulating material or system of materials to deteriorate to some predetermined level of electrical, mechanical, or chemical performance under prescribed conditions of test.
Thermal expansion	Process in which a constant mass of a substance undergoes an increase in volume when heat is applied.
Thermal expansion, coefficient of	Fractional change in length (or volume) of a material for a unit change in temperature.
Thermal insulation	Inverse of thermal conductivity. The ability of a material to thermally insulate, block or resist the flow of heat.
Thermal rating	Temperature at which a given material will perform relative to other materials.
Thermal resistance of a cable	Resistance offered by the insulation and other coverings to the flow of heat from the conductor or conductors to the outer surface. The thermal resistance of the cable is equal to the difference of temperature between the conductor or conductors and the outside surface of the cable divided by rate of flow of heat produced thereby.

Table 2. Terms And Definitions (Cont.)

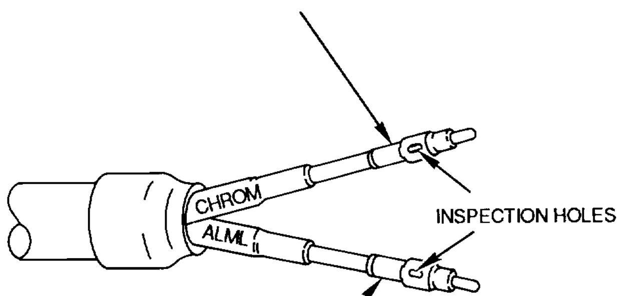
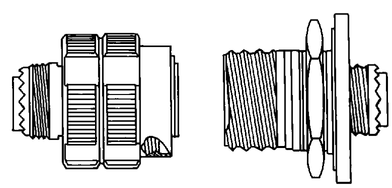
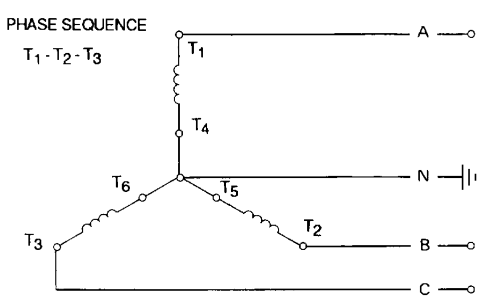
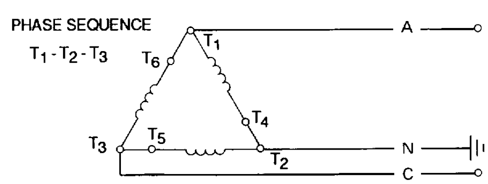
Term	Definition
Thermal shock	Resulting characteristics when a material is subjected to rapid and wide range changes in temperature in an effort to discover its ability to withstand heat and cold. In connectors, the effect can cause inserts and other insulation materials to pull away from metal parts.
Thermal shunt	Device capable of dissipating heat used to protect heat sensitive components.
Thermal stresses	Stresses in metal, resulting from non-uniform temperature distribution.
Thermal wipe	Slight movement of mated contacts caused by thermal expansion or contraction of parts that can cause poor performance.
Thermocompression bonding	Joining together of two materials without an intermediate material by the application of pressure and heat in the absence of electrical current.
Thermocouple	Device for measuring temperature. Two electrical conductors of dissimilar metals are joined at the point of heat application and a resulting voltage difference, directly proportional to the temperature, is developed across the free ends and is measured potentiometrically.
Thermocouple contact	Contacts of special materials used in connectors employed in thermocouple applications. Materials often used are iron, constantan, copper, chromel, alumel, and others.  TYPICAL THERMOCOUPLE CONTACTS
Thermocouple wire	A two conductor cable, each conductor employing a dissimilar metal, made up specifically for temperature measurements.
Thermoplastic	Term used to describe those plastics which can be repeatedly made to flow under the application of heat to fill a mold, coat non-plastic materials, extrude shapes, etc. Hardening is achieved by a decrease in temperature. The change with temperature is substantially physical rather than chemical.
Thermoplastic Elastomer (TPE)	Jacket material which has many of the characteristics of rubber, as well as excellent electrical, mechanical, and chemical properties. It is less expensive than neoprene or chlorosulfonated polyethylene.
Thermoset	Material which hardens or sets when heat is applied, and which, once set, cannot be resoftened by heating. The application of heat is called curing.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Thermosetting	Term used to describe plastic materials that are capable of being changed into substantially infusible or insoluble products when cured by application of heat or by chemical means. Once cured, the plastic cannot be made to flow. Not all thermosetting materials are cured by heat; some can be cured at room or lower ambient temperatures.
Thermostat metal	Clad metal consisting of at least two materials bonded together: one a high thermal expansion rate alloy, the other a low thermal expansion rate alloy. When heated or cooled, the difference in thermal expansion rate between the materials causes the metal to curve, thereby allowing its usage as a temperature responsive sensor or actuator. Also known as bimetals.
Thermostat wire	Single or multiconductor wire, bare, soft, solid copper conductor, usually PVC insulated. May be twisted and/or jacketed. May have enameled or nylon covered conductors and may have a metal armor covering. May also have asbestos insulation. Used to transmit electrical signals between the thermostat and the heating or cooling unit.
THHN	Nylon jacketed building wire for dry locations, 600 V, 194°F (90°C).
Thickening agents	Chemical additives to fluid solutions (such as coatings) to increase the viscosity or impart thixotropic character. They prevent flow and sag as the fluid sets.
Thick film	Conductive, resistive, and/or capacitive passive network deposited on a substrate using a metallic or resistive film which is more than 5 microns in thickness.
Thixotropic	Characteristic of a liquid or gel that is viscous when static, yet fluid when physically worked.
Thoria	Thoria is a very good refractory ceramic with a melting point of 5432°F (3000°C). Thoria cathodes are used in magnetrons to provide a stable emission and long life under environmental conditions.
Threaded coupling	Way to couple mating connectors by engaging threads in a coupling ring with threads on a receptacle shell. 
Three-phase current	Current delivered through three wires, with each wire serving as a return for the other two and with three current components differing in phase successively by one third cycle or 120 electrical degrees.



THREE - PHASE Y SYSTEM



THREE - PHASE DELTA SYSTEM

Table 2. Terms And Definitions (Cont.)

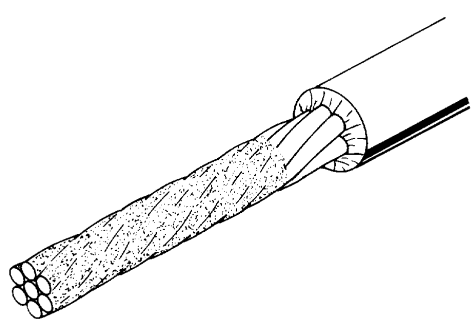
Term	Definition
Three-phase three-wire system	Alternating current supply system comprising three conductors over which three-phase power is sent. A four-wire system, which includes a ground, is sometimes used in local installations.
Three-wire system	A dc or single-phase ac system comprising three conductors, one of which (the neutral wire) is maintained at a potential, midway between the potential of the other two.
Through connection	Electrical connection between conductive patterns on opposite sides of an insulating base, e.g., plated-through hole or clinched lead.
THW	Designation for thermoplastic vinyl insulated building wire. Flame retardant and moisture and heat resistant, 167°F (75°C). Dry and wet locations.
THWN	Same as THW but nylon jacket overall, 167°F (75°C).
Time Division Multiplexing (TDM)	Method of utilizing channel capacity efficiently in which each mode is allotted a small time interval, in turns, during which it may transmit a message or a portion of a message.
Tin and tin alloys	Tin, or Stannum (Sn), is used primarily as a coating for other metals. It is resistant to corrosion and tarnish, non-toxic, ductile, and solderable. It is frequently alloyed with other metals to improve mechanical and physical properties. Tin can be plated from both an acid and an alkaline electrolytic although tin fluoborate is most common. Tin coating is slightly more expensive than bare copper wire, but labor savings offset the additional cost, especially when manual twisting and solder dipping of the stripped lead are required. The tin-nickel alloy deposit (65% tin and 35% nickel) can be soldered, has high hardness (650 Vickers), good conductivity, and a low coefficient of friction. These properties are of special interest in printed circuit and allied electronic applications. Tin and tin alloys also are widely used in soldering applications with tin lead being most frequently used in the electrical/electronic industry.
Tin-lead alloys	Tin-lead alloys, or solders, have a low melting temperature range. This makes them ideal for joining most metals, by convenient heating methods, with little or no damage to heat sensitive parts. Tin-lead alloys are also used for plating applications where two different metals are deposited simultaneously to form an alloy on the surface to be plated.
Tinned	Having a thin coating of pure tin or tin alloys.
Tinning	Coating of a terminal, wire, or conductive pattern with tin or solder alloy to improve or maintain solderability or to aid in the soldering operation. 
Tin Overcoat (TOC)	Tinned copper wire, stranded, coated with pure tin.
Tin pest	Polymorphic modification of tin which results in crumbling of the tin into a powder known as gray tin. The reaction can occur below 32°F (0°C) but does not proceed rapidly unless the metal is much colder. Maximum rate is at -54°F (-47.8°C).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Tinsel wire	Very flexible conductor made by serving one or more very small flat conductors over a fibrous core such as a high stength rayon, nylon, or cotton.
TOC	(See Tin Overcoat).
Topcoat	Bare (untinned) copper wire, stranded then coated with pure tin.
Topology	Description of the physical connections of a network.
Torch soldering	Bonding produced by heat from a torch.
Torsion	Strain created in a material by a twisting action. Correspondingly, the stress within the material resisting the twisting.
Total internal reflection	Total reflection that occurs when light strikes an interface at angles of incidence greater than the critical angle.
Toughness	Ability of a metal to absorb energy and deform plastically before fracturing. Usually measured by the energy absorbed in a notch impact test, but the area under the stress-strain curve in tensile testing is also a measure of toughness.
Toxicity	Relates to all forms of human exposure to substances that can cause distress: inhalation, skin contact, and ingestion. The term TLV is a measure of the inhalation toxicity of a substance, and establishes the maximum average concentration of vapors in air that a typical worker can continuously be exposed to without harm in an 8 hour day.
TP	(1) Tin Plate. (2) Designation for parallel tinsel cord. All rubber insulation and jacket over two extremely flexible conductors. Light duty, attached to appliances of 50 W or less. For use in damp places in lengths of eight feet or less.
TPE	(See Thermoplastic Elastomer).
TPO	Same construction as type PO, but with extra flexible tinsel conductors, 125 V.
TPT	Same as TP, but all thermoplastic insulation and jacket, 125 V.
Tracer stripe	When more than one color coding stripe is required, the first, or widest, stripe is the base stripe; the other, usually narrower stripes, are termed tracer stripes.
Track	(See rail).
Tracking	The formation of contaminants on the surface of insulating material due to arcing. Tracking can leave either a conductive or nonconductive path after the arcing stops.
Transceiver	Combined transmitter and receiver.
Transformer	Electrical device which changes voltage in direct proportion to currents and inverse proportion to the ratio of the number of turns of its primary and secondary windings. (See formulas-electrical).
Transient	Temporary voltage or current existing in a circuit during adjustment to a charged load, different source voltage, or line impulse.
Transistor	A semiconductor device with three or more electrodes commonly used to amplify or switch electric current. (See semiconductor device).
Transmission	Transfer of electric or optical energy from one location to another through conductors or by radiation or induction fields. The transfer is always accompanied by energy, which is inversely proportional to the efficiency of the medium through which transmission occurs.

Table 2. Terms And Definitions (Cont.)

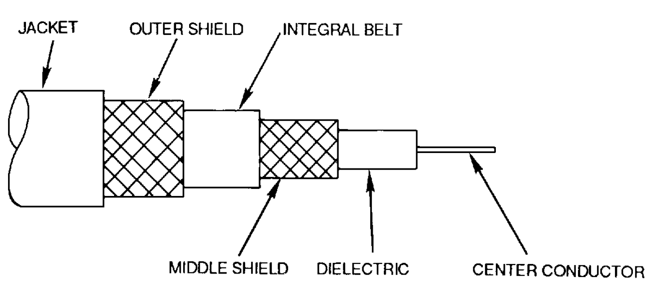
Term	Definition
Transmission cable	Two or more transmission lines. If the structure is flat, it is called flat transmission cable to differentiate it from a round structure, such as a jacketed group of coaxial cables. (See transmission line).
Transmission line	Signal-carrying circuit composed of conductors and dielectric material with controlled electrical characteristics used for the transmission of high-frequency or narrow-pulse type signals.
Transmission loss	Term used to denote a decrease or loss in power during the transmission of energy from one point to another. Usually expressed in decibels.
Transmission media	Anything such as wire, coaxial cable, fiber optics, air, or vacuum that is being used to carry an electrical signal which has information.
Transmitter, optical (fiber optic)	Electro-optical module which converts an electrical input signal to an optical output signal. (See fiber optics).
Transmitting element (fiber optic)	Radiating terminus in an optical junction. (See terminus).
Transparent (fiber optic)	Transmitting rays of light such that objects can be seen through the material.
Transposition	Interchanging the relative positions of wires to neutralize the effects of induction to or from other circuits or, in two-wire parallel lead-ins for an antenna, to minimize interference pickup by the lead-in during reception.
Transverse conductance	Measure of the flow of electrical current from strand to strand in a multistrand conductor.
Trap wire	Low voltage wire used at hinge points, where severe flexing occurs, usually in burglar alarm systems. Made with tinsel conductor.
Tray	Unit or assembly of sections and associated fittings forming a rigid structural system to support cables.
Tray Cable (TC)	Factory-assembled multiconductor control, signal, and power cable specifically approved by the National Electrical Code for installation in trays.
Triad	Group of three insulated conductors twisted together. Also called a triplex or triplet.
Triaxial cable	A three-conductor cable with one conductor in the center, a second circular conductor shield concentric with the first, and the third circular conductor shield insulated from and concentric with the first and second. Usually with insulation, and a braid or impervious sheath overall. 
Triboelectric noise	Noise generated in a shielded cable due to variations in capacitance between shielding and conductor as the cable is flexed.
Trigonometric functions	(See Formulas - electrical).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Triple cable	Cable composed of three insulated single conductors and often one bare conductor, all twisted together. The assembled conductors may or may not have a common covering of binding or protecting material. Also called a triad.
Triplex cable	Cable composed of either three insulated single conductor cables twisted together or two insulated single conductor cables twisted together with a bare conductor for ground.
TRPA	Same as TPA except stranded nickel-clad conductor, 650°F (343.2°C).
True concentric	A true concentric stranding or twisted cable is when each successive layer has a reversed direction of lay from the preceding layer.
TS	Designation for two or three conductor rubber insulated and jacketed tinsel cord. Light duty, attached to an appliance of 50 W or less. For use in damp places in lengths of eight feet or less.
TSO	Same as TS, but with neoprene jacket, 125 V.
TST	Same as TS, but all thermoplastic insulation and jacket.
TT	Designation for polyvinyl chloride insulation and sheath, aerial and duct.
Tubing, flexible	Flexible tubings can be made from materials normally available in sheet form. This type of tubing may be used for specific reasons such as low cost, high dielectric strength in thin thicknesses, high temperature resistance, thin wall, cut-through resistance, or solvent resistance.
Tubing, rigid insulating	These tubes can be made from nearly any type of material by most fabrication methods. The shapes are generally round or rectangular, and they are used for a variety of purposes, i.e., fabricated coil forms, shaft insulators, supports, separators, etc.
Tubing, shrinkable (non-heat)	Encapsulating parts without exposure to heat is accomplished with shrinkable tubing and tape that is automatically activated by chemical evaporation upon exposure to air.
Tubular adapter	Accessory attached to the rear of a connector, usually metallic, used to extend the shell far enough to support a sealing gland or to give mechanical support for a cable or wire harness.
Tungsten	Hard metallic element which is used for low voltage electrical contacts because of its resistance to wear and spark erosion, along with its relatively good electrical conductivity.
Turn	Conductor making one complete loop around a magnetic circuit.
Turret head	Device that contains more than one locator which can be indexed by rotating a circular barrel, and when attached to a crimping tool, positions the contact.

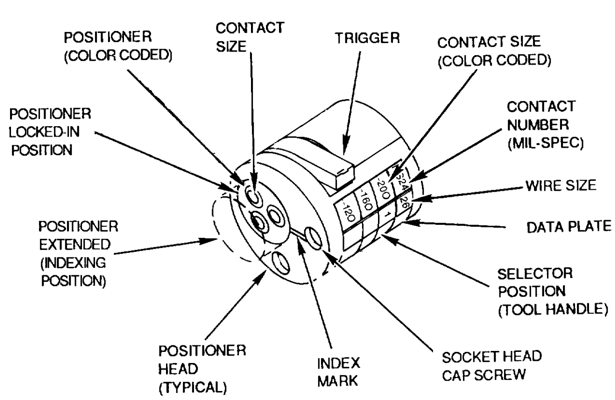


Table 2. Terms And Definitions (Cont.)

Term	Definition
Turret terminal	Round post-type grooved stud around which wires or leads are snugly hooked before soldering.
TW	Designation for thermoplastic vinyl jacketed building wire. Moisture resistant, 140°F (60°C).
Twill weave	A weave, used on woven cables, which does not require threads between the conductors and is used where high flexibility and quick lead exposure are essential.
Twin cable	Pair of insulated conductors twisted and/or sheathed or held together mechanically and not identifiable from each other in a common covering.
Twin coaxial	Configuration containing two separate, complete coaxial cables laid parallel or twisted around each other in one complex.
Twin line	Type of transmission line which has a solid insulating material, in which the two conductors are placed in parallel to each other and whose impedance is determined by the diameter and spacing of the conductors and the insulating material. Also known as twin lead.
Twinner	Device for twisting together two conductors, an operation called twinning or pairing. Tapes, binders, and flat shields can be applied simultaneously during the twisting process.
Twist	Deformation of a rectangular sheet such that one of the corners is not in the plane containing the other three corners. (See bow).
Twisted pair	Cable composed of two small insulated conductors, twisted together without a common covering. The two conductors of a twisted pair are usually substantially insulated, so that the combination is a special case of a cord.
Two-piece contact	Contact made of two or more separate parts joined by swedging, brazing, or other means of fastening to form a single contact. This type provides the mechanical advantages of two metals but also has the inherent electrical disadvantage of differences in conductivity.
Two-piece edge connector	Connector plug half is soldered to printed circuit board tabs and becomes a permanent part of the board. The plug/board unit is joined to a receptacle half to make connection.
Two-sided board	(See double-sided board).
U-bend test	Determines corona discharge and ozone resistance. The time to failure is measured.
UG	Universal Government, the two letter designation that precedes the number on connectors for coaxial cable.
UHF	Ultra High Frequency, 300 MHz to 3000 MHz.
UL	(See Underwriters' Laboratories).
U/L Approved	Mark of approval issued by Underwriters' Laboratories. (See Underwriters' Laboratories).
Ultimate strength	The maximum conventional tensile, compressive, or shear-stress that a material can withstand.
Ultrasonic	Sound waves that vibrate at frequencies beyond the hearing power of human beings (above 16 KHz). Commercial and military applications include ultrasonic cleaning, gauging, cutting, detection instruments, and welding.

Table 2. Terms And Definitions (Cont.)

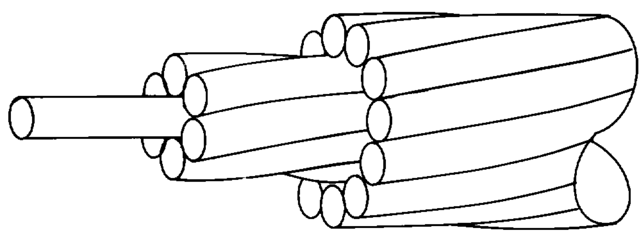
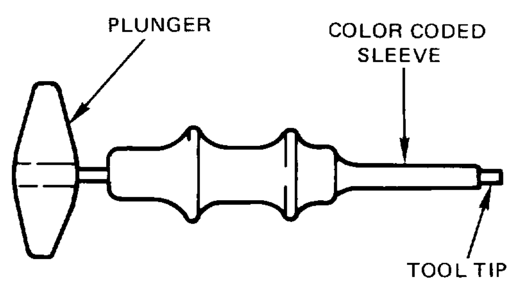
Term	Definition
Ultrasonic bond	Bond made by a process in which the wire is pressed against a bonding pad, and the pressing mechanism ultra-sonically vibrated at a frequency above 10 KHz. High-frequency vibrations break down and disperse the oxide films present on the conductor surfaces. As these surface films are removed, diffusion of the conductor materials occurs at the interface. The joints formed are metallurgically sound diffusion bonds.
Ultrasonic cleaning	Immersion cleaning aided by ultrasonic waves which cause microagitation.
Ultrasonic soldering	Fluxless soldering, wherein molten solder is vibrated at ultrasonic frequencies while making the joint.
Umbilical connector	Connector used to connect cables to a rocket or missile prior to launching and which is unmated from the missile at the time of launching.
Unbalanced line	Transmission line in which voltages on the two conductors are unequal with respect to ground; a coaxial cable.
Undercut	The narrowing of a circuit line during etching by the horizontal attack by the etching solution. (See etch factor).
Underwriters' Laboratories (UL)	A non-profit independent organization which operates a listing service for electrical and electronic materials and equipment.
Unidirectional concentric stranding	Stranding in which each succesive layer has a different lay length, thereby retaining a circular form without migration of strands from one layer to another. 
Unidirectional stranding	Term denoting that in a stranded conductor, all layers have the same direction of lay.
Unilay strand	Conductor constructed with a central core surrounded by more than one layer of helically-laid wires, with all layers having a common length and direction of lay.
Unsupported hole	Hole containing no conductive material nor any other type of reinforcement.
Unwired contact removal tool	Hand tool used to remove an unwired contact from a connector insert or retainer. Not to be used for contacts with broken wires (tool tip must slide into the conductor barrel).  TYPICAL UNWIRED CONTACT REMOVAL TOOL
URC	Designation for weatherproof wire.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Urethane	Family of thermosetting plastics produced by reacting isocyanate compounds with polyois (compounds having hydroxyl groups). These polyois are usually glycols, polyesters, and polyethers. Applications include insulation, wire coatings, dipping and impregnating materials for electrical and electronic components, and foam encapsulants. Through choice of materials, varying flexibilities can be achieved. As a class, urethane coatings can be considered to possess toughness, hardness, smooth and glossy film surfaces and resistance to abrasion, moisture, and chemicals.
V	(1) Designation for varnished cambric insulation with fibrous covering. (2) (See Volt).
Vacuum encapsulation, potting, and impregnating	Process of enclosing or impregnating electrical components by subjecting the parts to a high vacuum, introducing the impregnant or encapsulant, and then releasing the vacuum. The resin-mix and parts are held under vacuum (in separate chambers) for a period of time to remove moisture, gases, and other contaminants. Then the resin is admitted into the parts chamber and cured at proper temperature.
Vapor Pressure	Pressure exerted by a vapor in equilibrium with a solution, or the material from which the vapor emanated. For example, a quantity of water placed in a closed container will evaporate a certain amount of water vapor. The pressure exerted by this vapor at a given temperature is the vapor pressure of water at that temperature. Vapor pressure, naturally, is dependent upon temperature, i.e., the higher the temperature, the higher the vapor pressure. Vapor pressure is a good indication of the volatility of a material, i.e., the higher the vapor pressure of a material at a given temperature, the higher its evaporation rate will be. This is quite applicable to fluxes or cleaning solvents used in soldering processes. Since these materials are generally mixtures of materials, the components with the highest vapor pressure will evaporate faster than the other components. The result, eventually, is imbalance of the flux or solvent.
Vapor Degreasing	Degreasing work in vapor over boiling liquid solvent, the vapor to be considerably heavier than air. At least one constituent of the soil must be soluble in the solvent.
Vapor density	Relative density of a vapor or gas (with no air present) as compared with air.
Vapor phase soldering	Vapor phase (condensation) soldering uses the high-temperture vapor of a boiling fluorocarbon as the heat-transfer medium.
Varnish	Coatings consisting of natural or synthetic resins which protect coils or windings from dirt, moisture, and other contaminants. They may be water or solvent based.
Varnish, Acrylic	Aqueous dispersions which are non-flammable and eliminate the hazard of fire during application. When cured, they produce tough, flexible films essentially unaffected by most common solvents and oils.
Varnish, Phenolic	Used for outstanding properties of fast cure and excellent chemical resistance. Classed as 221°F (105°C) materials, and perform well with polyvinyl acetal, formetic, nylon, and nylon polyvinyl acetal wire enamels.
Varnish, Phenolic, oil modified	Vary in hardness, speed of cure, and flexibility depending on the amount and kind of oil modification. Most of these varnishes have excellent dielectric properties and good chemical and moisture resistance.
Varnish, alkyd	Made of glycerolphthalate resins combined with drying oils such as linseed, tung, soya, or castor. Noted for heat stability, excellent dielectric properties, and resistance to oils. Usually recommended for 221°F (105°C) operation.
Varnish, alkyd phenolic	Good dielectric properties and good resistance to moisture, hot oil, and weak acids. Slightly better heat resistance than the oil-modified phenolics, and can be used with all magnet wire coatings.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Varnish, alkyd-silicone	Good dielectric properties and better oil resistance than pure silicones, but less moisture resistance. Tend to cure well internally, but some may soften under heat thereby losing their bonding properties at high temperatures.
Varnish, phenolic, polyester modified	Tough oil- and water-proof coatings with good coverage and adhesion. Develops heavy coatings in one application and air dries in two hours. Offers a good dielectric strength, and provides excellent water and oil resistance.
Varnish, polyamideimide	For high temperature applications. Has an aromatic structure which cures with heat to a linear amide-imide homopolymer. The cured polymer is said to have outstanding thermal stability and excellent electrical insulation and mechanical properties.
Varnish, polybutadiene	Exhibit excellent electrical properties, very low drift over a wide range of temperature, moisture, and frequency conditions; good adhesions; good moisture resistance.
Varnish, polyester	High temperature insulating varnishes designed for 266°F (130°C) and 311°F (155°C) operation. Excellent durability and chemical and moisture resistance, and maintain dielectric properties for long periods at temperatures of 356°F (180°C) and above.
Varnish, polyimide	High temperature varnishes for use in conjunction with polyimide enameled wire and coated glass fabrics. Exhibit excellent electrical properties from -392.4°F (-250°C) to 482°F (250°C), thermal stability, radiation, and flame, solvent, and oil resistance. Precautions are necessary to avoid toxic effects.
Varnish, silicone	Silicone varnishes at low temperature curing are designed for use where curing ovens are limited to 275°F (135°C). Used primarily for coating coils of both armatures and stators in electrical motors and generators, and in impregnating coils of transformers intended for high temperature and/or heavy duty service. Also used for the impregnation of assemblies and equipment by dipping or vacuum impregnation.
Varnish, solventless polyester	Semi-rigid varnishes with high thermal stability, good bond strength, excellent electrical properties, moisture resistance, and enough flexibility to withstand thermal shock. Can be applied by dipping or vacuum pressure impregnation, but maximum benefits are realized with the automated treating machines.
Varnish, spirit	Made by dissolving natural or synthetic resins in alcohol. Dry rapidly to a hard glossy surface and are used as a finishing coat. Exhibit good dielectric properties and a fairly good oil and chemical resistance. Have poor through-cure and bonding properties which limit them to protective coating and touch-up rework.
Varnish, urethane	Urethane varnishes have excellent through-curing properties and remain strong and tough at either low or high temperatures.
Varnish, water soluble, electrical insulating	Can be thinned with water or water and solvent combinations to retain their stability in the impregnating tank. Pollution-free, have excellent electrical properties, can be formulated for excellent bond strength, and are rated at 356°F (180°C).
Varnished cloth	Tape wraps of varnished cambric for insulation of wires and cable offer properties that lie between those of rubber and impregnated paper. This appiles to dieletric strength, flexibility, resistance to moisture and eat, and handling cable connections and terminations. It provides a greater measure of moisture resistance than paper. In dry locations, it may be used without a lead sheath. It can be used for low and moderate voltage cables.
VCB	Designation for varnished cambric insulation, cotton braid, flame retarding, moisture resisting finish.
VCL	Designation for varnished cambric insulation, lead covered cable. Ends must be hermetically sealed.
VD	Designation for twin wire having two type V conductors laid parallel under an outer fibrous covering.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Velocity of propagation	Applied to coaxial cables, the ratio of the dielectric constant of air to the square root of the dielectric constant of the insulator. Indicates the transmission speed of an electrical signal down a length of cable compared to speed in free space.
VG	Designation for varnished glass over a flexible copper conductor. Varnished glass or nylon braid, 600 V or 3000 V, 266°F (130°C).
VHF	Very High Frequency, 30 MHz to 300 MHz.
Via hole	Plated-through hole used as a through connetion, but in which there is no intention to insert a component lead or other reinforcing material.
Video pair cable	Transmission cable containing low-loss pairs with an impedance of 125 ohms. Used for TV pick-ups, closed circuit TV, telephone carrier circuits, etc.
Vinyl	Synthetic resin formed by the polymerization of compounds. As a jacket material, it affords normal mechanical protection, and is usually specified for indoor use and general purpose applications.
Vinyl resins	Synthetic resins formed by the polymerization of compounds. They are strong and tough, having good abrasion resistance. As a class, their electrical properties are excellent. The family includes polyvinyl chloride, polyvinyl acetate, polyvinyl fluoride, polyvinyl butyral, polyvinylidene fluoride, and other polymers.
Virgin metal	Pure metal obtained directly from ore.
Viscosity	Measure of resistance of a fluid to flow either through a specific orifice or in a rotational viscometer. The absolute unit of viscosity measurement is the poise (or centipoise).
Visible light	Electromagnetic wavelengths which can be seen by the human eye ranging from 380 nanometers to 770 nanometers.
Visual examination	Qualitative observation of physical characteristics, utilizing the unaided eye or with stipulated levels of magnification.
VM	Designation for cable having two or more type V conductors twisted together under an outer fibrous covering.
Void	Absence of substance in a localized area.
Voids and inclusions	Bare spaces on the joint surfaces or pockets in the alloy deposit, resulting from failure of the alloy to completely wet the joint surfaces or from flux, gas, or other foreign material becoming entrapped in the alloy deposit.
Volatile	Used to describe materials which have a relatively high evaporation rate or a tendency to evaporate. (See evaporation).
Volatilization	Evaporation and diffusion of substances at ordinary temperatures.
Volt (V)	Unit of measurement of electromotive force. The difference of potential required to make a current of one ampere flow through a resistance of one ohm.
Voltage (E)	Term most often used in place of electromotive force, potential, potential difference, or voltage drop, to designate electric pressure that exists between two points and is capable of producing a flow of current when a closed circuit is connected between the two points. (See formulas-electrical).
Voltage Standing Wave Ratio (VSWR)	Ratio of the maximum effective voltage to the minimum effective voltage measured along the length of a mismatched radio frequency transmission line.
Voltage breakdown	Test to determine maximum voltage capability of insulated wire before electrical current leakage occurs through insulation.
Voltage drop	Term expressing the amount of voltage loss from original input in a conductor of given size and length.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Voltage rating	Highest voltage that may be continuously applied to an electric component without undue degradation or safety hazard.
Voltage stress	Stress found within a material when subjected to an electrical charge.
Volume resistivity (specific insulation resistance)	Electrical resistance between opposite faces of a 1 cm cube of insulating material, commonly expressed in ohms/centimeter.
V-ring	Special shaped insulating structure with one or more V-shaped sections used in the construction of commutators.
VSWR	(See Voltage Standing Wave Ratio).
Vulcanization	Chemical reaction in which the physical properties of an elastomer are changed by reacting it with sulfur or other cross-linking agents.
Vulcanized fiber	Partially regenerated cellulose plastic material, made from rag-base paper or woodpulp. One of the strongest known materials per unit weight. Can be fabricated in complicated shapes and is an excellent electrical insulating material for many applications.
VW-1	A flammability rating established by Underwriters' Laboratories for wires and cables that pass a specific vertical flame test. Formally FR-1.
W	(1) Designation for heavy duty portable power cable, one to six conductor, 600 V,140°F (60°C). (2) (See Watt).
Wall thickness	Term used that expresses the thickness of a layer of applied insulation or jacket.
Warp	(See bow).
Water absorption	Ratio of the weight of water absorbed by a material to the weight of the dry material.
Water based	Description of a liquid system, where the primary solvent is water.
Waterblocked cable	Cable specially constructed with no internal voids in order to allow no longitudinal water passage under a given pressure when not subjected to differential pressure.
Water displacement	Characteristic of certain materials, such as lacquers and protective coatings, which replace water.
Water extract resistivity	Value in ohms per centimeter, principally for liquid rosin fluxes, obtained by carrying out a standard test that mmeasures the amount of ionizable material present. The higher the value, the higher the resistivity, hence the less ionizables present.
Water soluble	Description of a liquid system, where the prime solvent is not necessarily water. However, the system is soluble in water, i.e., can be dissolved in or by water.
Watt (W)	Unit of power or work done at a rate of one joule per second or rate of work represented by current of one ampere under a pressure of one volt (volt-ampere). (See power).
Waveguide	Guide capable of conducting electromagnetic radiation at single or multiple modes.

Table 2. Terms And Definitions (Cont.)

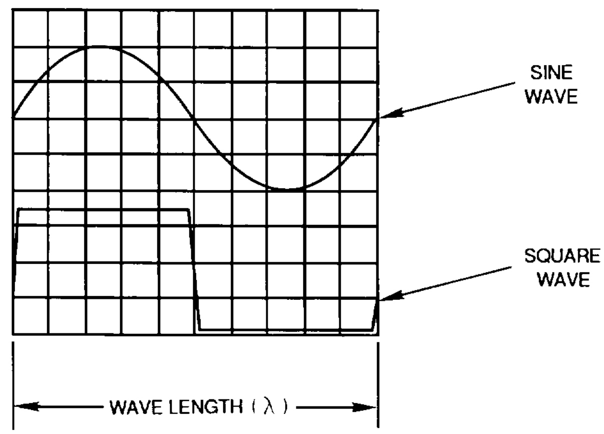
Term	Definition
Wavelength	Distance, measured in the direction of propagation, of a repetitive electrical pulse or waveform between two successive points that are characterized by the same phase of vibration. 
Wave soldering	(1) Removal of a predetermined portion of insulation without affecting the mechanical or electrical characteristics of the conductor or the remaining insulation. (2) Process wherein printed boards are brought in contact with the surface of continuously flowing and circulating solder.
Wave winding	Variation of the layer winding technique in which the pitch angle is much greater than one wire diameter resulting in a honeycombed coil with good cooling properties.
Waxes (hot melt)	Used for electrical components such as coils, transformers, capacitors, etc., as a sealing medium in potting, end sealing, and overdipping. Waxes offer ease of application, excellent moisture protection, low cost, and good electrical properties.
Weave exposure	Surface condition of base material in which the unbroken fibers of woven glass cloth are not completely covered by resin.
Webbing	As appled to soldering, refers to a condition wherein the plastic basic material of the printed circuit board is softened as it passes over the solder wave, with a resultant pick-up of fine particles of solder onto the tacky surface of the plastic. This condition generally is a result of inadequate curing of the plastic materials going into the printed circuit board and can create difficulties on boards where conductor paths are closely spaced or a high voltage is present on the board. Also called spidering.
Wet process	One in which a fluid is used, e.g., adhesives, inks, solder, potting materials, etc. Strict process controls are required, making it difficult to perform wet process when installing or maintaining electrical assemblies.

Table 2. Terms And Definitions (Cont.)

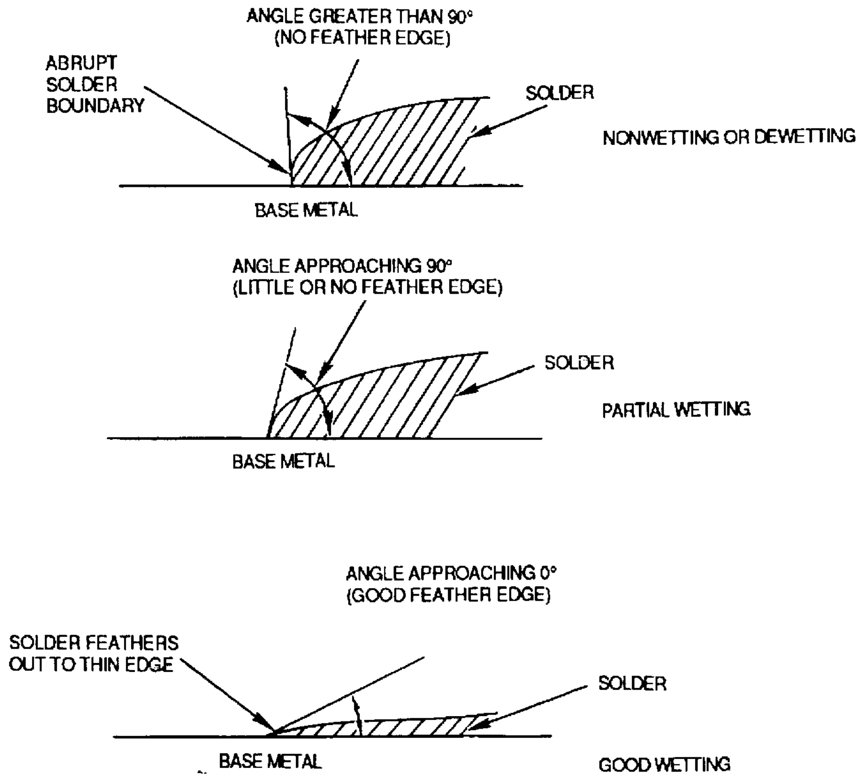
Term	Definition
Wetting	Physical phenomenon of liquids, usually in contact with solids, wherein the surface tension of the liquid has been reduced so that the liquid flows and makes intimate contact in a very thin layer over the entire substrate surface. An example of this is the wetting of a metal surface by a solder. Flux reduces the surface tension of the metal surface and the solder, with the result that the droplets of solder collapse into a very thin film, spreading and making intimate contact over the entire substrate surface. 
Wetting action	The forming of a new alloy by intermolecular attraction between the solder and the base metal and plating.
Wetting agent	Chemical material added to a liquid solution to reduce surface tension. The effect of this reduction of surface tension is to increase the power of the liquid mixture or solution to wet an object on which it is placed. (See wetting).
W/G	With Ground.
Whisker	Slender acicular (needle-shaped) metallic growth on a printed board.
White metal	General term covering a group of white-colored metals of relatively low melting points (lead, antimony, bismuth, tin, cadmium, and zinc) and of the alloys based on these metals.
Wicking	Capillary absorption of liquid (including water) along the fibers of the base material. The flow of solder along the strands and under the insulation of stranded lead wire.
Wideband	Communications channel offering a transmission bandwidth greater than a voice-grade channel.
Width	Pertaining to flat cable, distance between edges of the cable.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Winding	(1) One or more turns of wire forming a continuous coil. (2) The coil itself, as in transformer primary and secondary windings.
Wipe soldering	Forming a joint by applying semi-fluid solder and shaping the joint by rubbing with a greased cloth pad.
Wiping action	Action of two electrical contacts which come in contact by sliding against each other. (See contact wipe).
Wire	Technically, a slender rod or filament of drawn metal. Common usage: A solid or stranded group of solid cylindrical conductors, together with any associated insulation. NOTE: For the purpose of these definitions the term wire is used according to its technical definition. For the purposes of discussion in the text of this manual, the term wire is used according to its common usage.
Wire and cable identification	Identification marking of wire and cable can be accomplished in many ways, such as silk screen letters and/or numerals, helical stripes, colored insulation, laser, printed adhesive tape, sleeving, or heat shrinkable tubing, clip-on or crimp-on bands (metallic or non-metallic), ink jet printing, and wrap-arounds.
Wire and cable tying, clamping, and harnessing devices	In addition to tying tapes, lacing cords, and flexible sleevings which are used for wire and cable bundling, harnessing, and holding, a number of other products are also available for this purpose. Most of these devices are in the form of plastic ties or clamps which offer both time savings and weight savings. Spiral-cut plastic tubing, plastic U-shaped trays or ducts in long lengths with removable covers, and other products also are used for harnessing and cabling purposes.
Wire and lead cutters	These tools and machines can vary from plier type cutters to semiautomatic or fully automatic machines integrated with other wire processing operations such as stripping, forming, terminating, etc.
Wire damage curves	Electric current plotted against time required at each current to cause the conductor to be damaged. Such curves are used to establish the circuit protection device: fuse, circuit breaker, limiter, etc., that will prevent conductor damage.
Wire dress	Arrangement of wires and laced harnesses in an orderly manner.
Wire gauge	A system of numerical designation of wire sizes. (See American Wire Gauge).
Wire guides and parts	Guides and parts involved in wire processing and usage. Frequently must be made of materials which not only are very wear resistant but also which will withstand heat and chemicals. Ceramics are one of the materials used for these reasons. These parts include eyelet guides, bushings, rollers, pulleys, extruder tips, counter inserts, closing dies, and wire depressors.
Wire lead machines	Devices for processing wire leads vary from simple hand or benchstyle tools for bending and forming of leads to high speed equipment which can perform a number of operations. Machines are available which will measure, cut, form, bend, strip, and straighten wire leads.
Wire nut	Form of closed end splice, that is screwed on instead of being crimped. (See pressure connectioins).
Wire segment	Wire segment is a conductor between two terminals or connections.
Wire solder	Commercially available form of solder, produced in the shape of a wire.
Wire splice, removable	Splice with a main body accommodating a removable contact at each end.
Wire stop	Stop at the end of a terminal wire barrel to prevent wire from passing completely through the barrel in such a way as to interfere with the function of contact.

Table 2. Terms And Definitions (Cont.)

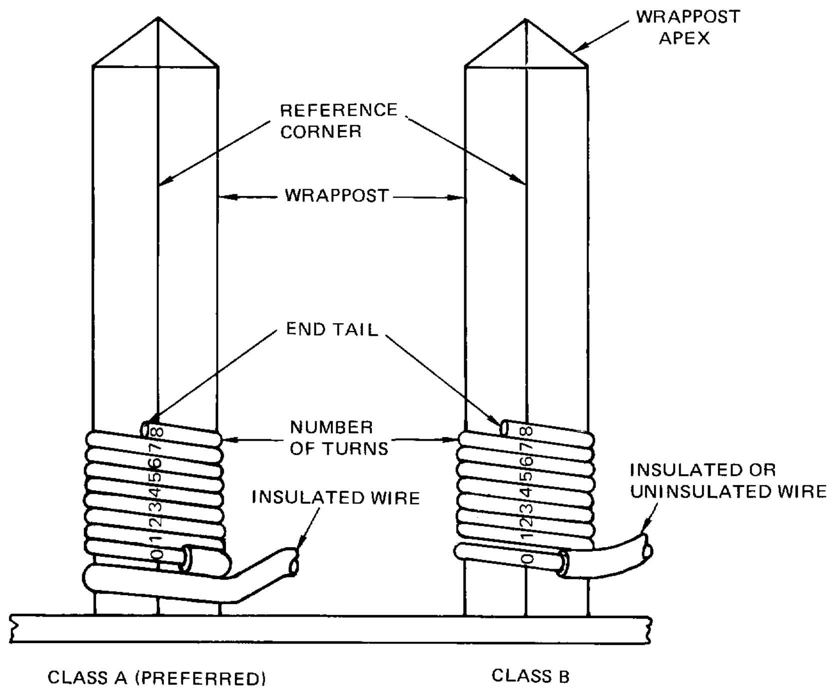
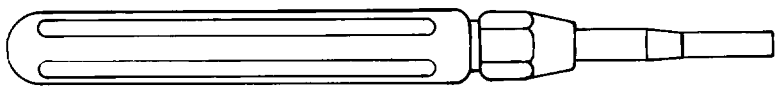
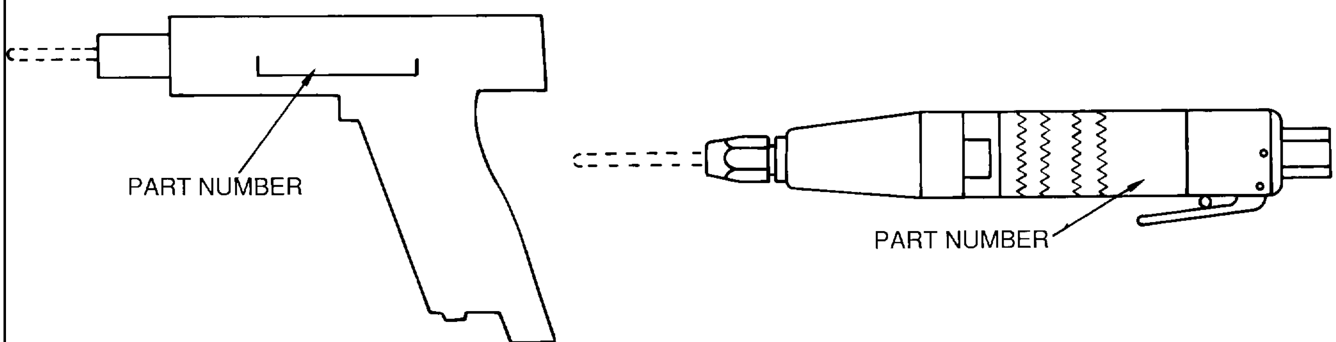
Term	Definition
Wire wrapped connection	Solderless connection made by wrapped bare wire around a square or rectangular terminal with a power or hand tool. Also called solderless wrapped connection, wrapped connection, or wrap post connection. 

Table 2. Terms And Definitions (Cont.)

Term	Definition
Wire wrap tool	Device which mechanically turns a wire around a termination of a contact, forming a gas tight electrical connection equal to a solder termination or a crimp termination.

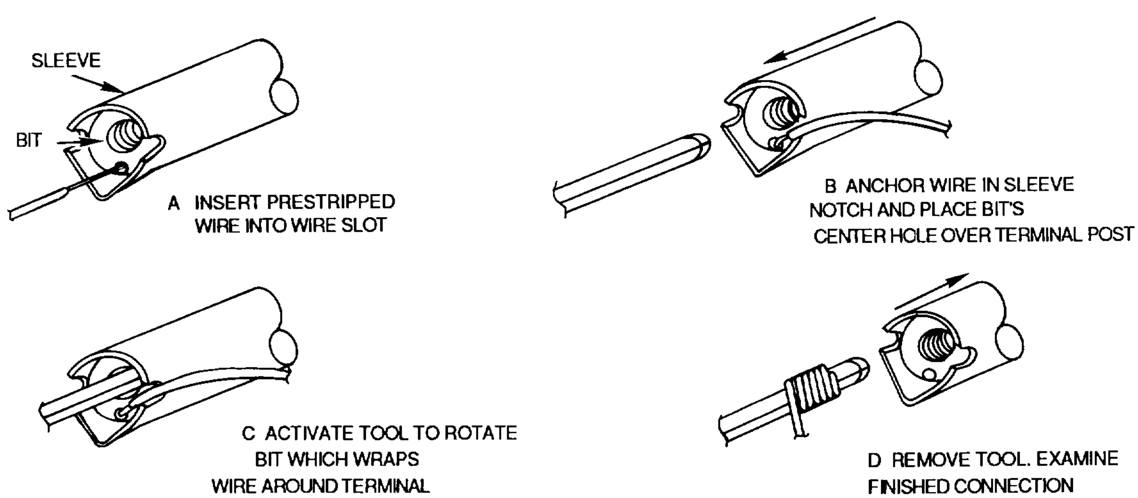


HAND OPERATED



POWER OPERATED

TYPICAL WIRE WRAP TOOLS



TYPICAL WIRE WRAP TOOL SEQUENCE OF OPERATION

Table 2. Terms And Definitions (Cont.)

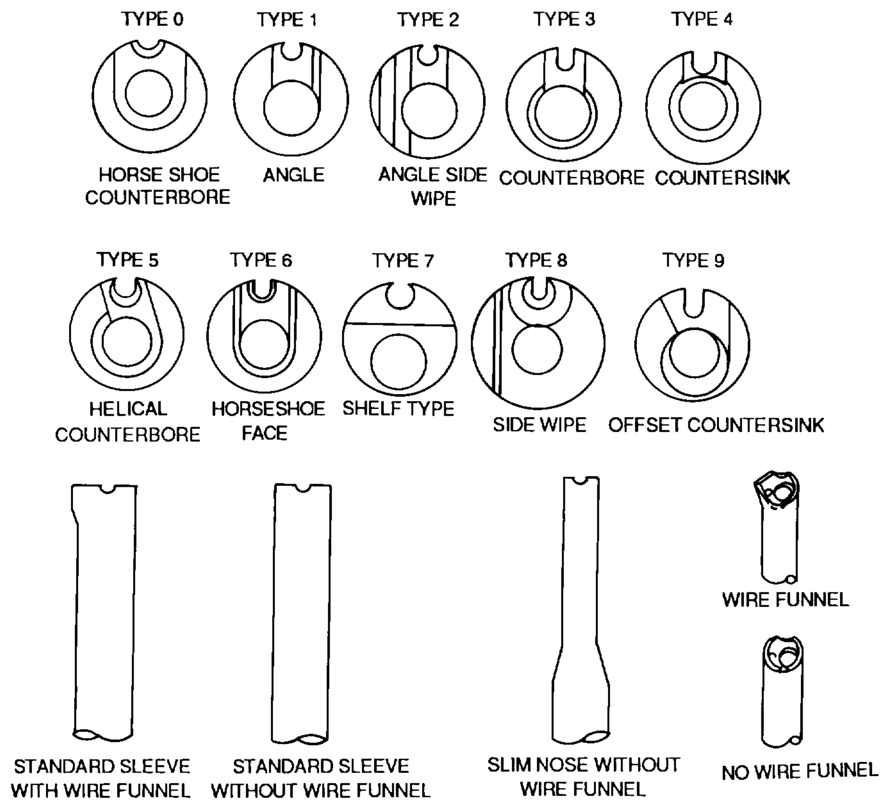
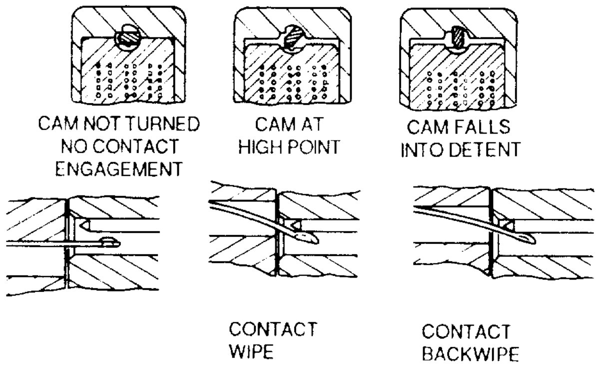
Term	Definition
Wire wrap tool tip	Removable portion of wire wrap tool used for making different types and sizes of wire wrapped connections. 
Wiring	Wires, cables, groups, harnesses and bundles, and their terminations, associated hardware, and support, installed in the vehicle. When used as a verb it is the act of fabricating and installing these items in the vehicle.
Wiring devices	Accessory parts and materials used in the installation of wiring, such as terminals, connectors, junction boxes, conduit, clamps, insulation, and supports.
Wiring ducts	Hollow conduit or raceway through which wires are passed. A duct is used as a protective shield for the wires it contains. Unlike a cable or harness assembly, it permits the addition or removal of individual wires.
Wiring kit	Packet of tools that cut and strip wire and crimp terminals to wire. Wiring kits also contain an assortment of solderless terminals.
Wiring testers	Continuity test instruments for checking wired assemblies. These instruments detect opens, shorts, and miswires in a given assembly. Some are designed to check a small number of wires while others can accommodiate thousands of wires. Speed of testing usually is a direct function of the total number of wires to be tested.
W/O/G	Without Ground
Wollastonite	Wollastonite compares to the best steatite bodies with regard to low loss properties. Some wollastonite-talc combinations offer a compromise on loss quality and die wear characteristics.

Table 2. Terms And Definitions (Cont.)

Term	Definition
Work curve	Graph which plots the pull out force, indent force and relative conductivity of a crimp joint as a function of various depths of crimping.
Working voltage	Maximum voltage at which a connector is rated to operate. (See service rating).
Workmanship samples	Samples of workmanship that will be delivered during the term of the contract.
Workmanship standards	Photographs, models, actual hardware, or other similar items to demonstrate acceptable characteristics to inspectors and operators during fabrication and assembly.
Woven cables	Cables with conductors that are held together in a flat, ribbon cable by thread as a result of a weaving process. (See twill weave, plain weave, flat cable).
WP	Designation for Weatherproof construction, two or three impregnated cotton braids, 176°F (80°C).
Wrapping	Method of insulating wire by serving insulating tapes around a conductor.
X	(1) Designation for two FX wires twisted together, color coded, 125 V, 140°F (60°C). (2) (See reactance).
XHHW	Cross-linked polyethylene insulated, 194°F (90°C), dry location; 167°F (75°C), wet location.
XLPE	(See Cross-Linked Polyethylene).
Xmit	Transmit.
XT	Designation for two FXT wires twisted together, color coded, 125 V, 140°F (60°C).
XON/XOFF	Abbreviation for transmitter on/transmitter off.
Yarns, fibers, and/or threads	There are two forms of fibers: staple fibers which are the short fibers such as those of cotton, and filament fibers which are long strands such as those of many man-made fibers and silk. Yarn construction can be varied according to actual fiber or fibers used, whether the fiber is staple or filament, staple length, size, weight, amount of twist, number of plies, etc. Spun yarns are produced by cleaning, paralleling, attenuating, and twisting staple fibers into yarn by spinning.
Yield point	First stress in a material, usually less than the maximum attainable stress, at which an increase in strain occurs without an increase in stress. Only certain metals exhibit a yield point. If there is a decrease in stress after yielding, a distinction may be made between upper and lower yield points.
Yield strength	Minimum stress at which a material will start to physically deform without further increase in load.
Z	(See impedance).

Table 2. Terms And Definitions (Cont.)

Term	Definition
Zero Insertion Force Connector	Connector in which the contact surfaces do not mechanically touch until it is completely mated thus requiring no insertion force. After mating the contacts are actuated in some fashion to make intimate electrical contact. 
Zinc oxide	Zinc oxide has been grown hydrothermally as single crystals and is used for transducers.
Zircon	Zircon porcelains have improved properties over the feldspathic porcelains in that the properties of strength, electrical characteristics, and thermal shock resistance are all improved.
Zirconia	Zirconia has high chemical inertness and low vapor pressure at high temperature. Therefore, it is useful in high vacuum. Often used as an insulator in swaged thermocouples.
Zytel	Trade name of the DuPont Company for nylon resins.

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WIRE CHARACTERISTICS, REPLACEMENT AND INSPECTION TECHNIQUES

EQUIPMENT AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Alphabetical Index (Cont.)

Alphabetical Index (Cont.)

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This Work Package (WP) describes the characteristics of wires typically used in aircraft wiring. The information is for edification and insufficient to determine specific selections for wire applications. However there is sufficient information to determine wire substitutions. Part number cross–references for wire substitutions for replacement are provided. The selection and installation of wires should be in accordance with SAE AS50881.

3. The term wire when used throughout this WP shall be interpreted as a single metallic conductor of solid, stranded, or tinsel construction, designed to carry current in an electrical circuit. It shall not have a metal covering, sheath, or shield. For the purpose of this WP, wire refers to insulated electric wire.

4. The term wiring when used throughout this WP shall be interpreted as wires, cables, groups, harnesses and bundles, associated hardware, terminations, and support installed. When used as a verb it is the act of fabricating, and installing these items.

5. ELECTRICAL WIRING INTERCONNECT SYSTEM (EWIS).

6. The Electrical Wiring Interconnect System (EWIS), also known as aircraft wiring, is defined as any wire, fiber optic link, wiring or fiber device, or a combination of these items (including terminations) installed in any area of the aircraft for the purpose of transmitting electrical energy, signals or data between two or more electrical end points.

7. APPLICATION AND IMPACT.

8. All aircraft are filled with miles of wiring and hundreds of wiring devices that connect and transfer power and signals to and from electrical components. Virtually all aircraft systems rely heavily on some type of wiring for safe operation. Much like the structural components of an aircraft the health and integrity of the EWIS can be significantly compromised due to premature aging, damage and the failure of wiring insulation. It is integral to the overall maintenance and sustainment of all aircraft that the EWIS be treated as a system and afforded the same level of importance as the aircraft structure and other critical flight control systems.

9. The majority of aircraft wiring in military service is of a thin–walled construction and, by its very nature, is susceptible to mechanical damage. However, there are several factors which may contribute to premature aging, damage, and failure of wiring insulation, including but not limited to:

a. Wire/Bundle Location (SWAMP Areas)

b. Temperature Cycling

c. Contamination

d. Improper Installation

e. Mishandling

f. Poor Maintenance Practices

g. Lack of effective Inspection and Maintenance Training

h. Battle Damage

10. EWIS MANAGEMENT.

11. EWIS Management is an essential and continuing process requiring the implementation of scheduled and unscheduled working practices by all personnel. The EWIS requires basic awareness to wiring problem areas, training related to system operation, maintenance, and troubleshooting requirements. The EWIS requires a scheduled maintenance cycle to ensure the system meets entire aircraft life cycle requirements. The interval should be based on a zonal approach as needed per type aircraft and operating environment. This process should be planned and estimated so as to effectively correct deficient wiring conditions during scheduled rework periods. The EWIS is an integral part of the aircraft, which if not properly managed has the potential to severely impact aircraft safety and mission capability. The continued airworthiness of the EWIS depends directly upon an effective, proactive, preventative approach to meet the aircraft's life cycle and mission requirements.

12. This manual covers general requirements for support and maintenance of the EWIS in all military aircraft. For engineering information or guidance on a specific platform or system, or if any deviation is needed, the user must contact the applicable Cognizant Engineering Authority for the affected aircraft. For additional support, users may contact the Joint Services Wiring Action Group (JSWAG) at www.navair.navy.mil/jswag.

13. INCOMING/RECEIVING WIRE INSPECTION. Upon receipt from supply, visually inspect the label on the spool against the wire (reading the wire marking) to verify the same type and gauge.

14. Visually inspect exposed wire while wrapped on the spool for physical damage, nicks, cuts burrs, abrasion, etc. Unwind the first 3-4 feet and check for general condition, insulation smoothness, kinks, insulation discontinuity, discoloration, or bleaching.

15. Inspect both ends of wire by stripping insulation off of the last one inch of wire, untwist strands and closely inspect conductor for any signs of corrosion Any sign of corrosion is cause for rejection. Refer to NA 01–1A–505–1, WP 004 01, Table 1 for corrosion types and appearance.

16. Gain access to both ends of the spool and ohm out / check wire for continuity. Continuity value should match the value on the label of the spool. If no label, or missing value, refer to values in Table 1.

17. If these conditions were not met, submit Report Of Discrepancy (If supply related) / Quality Deficiency Report (if manufacturing related). If these conditions are met, the wire is serviceable, provided that the user performs a thorough visual inspection each time a measure of wire length is used.

18. Terminate the exposed wire ends using a termination cap (WP007 00) or environmental splice shrink sleeve, part number M81824 (WP 014 00) when not in use on the spool to prevent wicking of moisture and / or conductor corrosion.

Table 1. Copper Wire Data

Wire Size Awg	Stranding No. / AWG of Strands	Individual Strand Diameter (Inch)	Maximum Diameter (Inch)	Maximum Resistance (Ohms per 1000 Ft @ 20xC) Silver Coated	Nickel Coated	Tin Coated
32	1/32	0.0080 in	0.009 in	169	175	178
32	7/40	0.0031 in	0.011 in	173	185	189
30	1/30	0.0100 in	0.011 in	108	112	116
30	7/38	0.0040 in	0.013 in	100.7	110.7	114.1
28	1/28	0.0126 in	0.013 in	68.0	70.0	71.6
28	7/36	0.0050 in	0.016 in	63.8	43.8	45.3
26	1/26	0.0159 in	0.017 in	42.7	43.8	43.4
26	7/34	0.0063 in	0.020 in	40.5	43.1	43.4
26	19/38	0.0040 in	0.022 in	38.4	42.2	41.3
24	1/24	0.0201 in	0.022 in	26.8	27.4	27.8
24	7/32	0.0080 in	0.025 in	25.2	26.5	27.0
24	19/36	0.0050 in	0.027 in	24.3	25.9	26.2
22	1/22	0.0253 in	0.026 in	17.0	18.7	17.7
22	7/30	0.0100 in	0.031in	15.9	16.6	17.1
22	19/34	0.0063 in	0.033 in	15.1	16.0	16.2
20	1/20	0.0320 in	0.033 in	10.5	10.7	10.9
20	7/28	0.0126 in	0.039 in	10.0	10.4	10.7
20	10/30	0.0100 in	0.040 in	11.3	11.8	12.1
20	19/32	0.0080 in	0.041 in	9.19	9.77	9.88
18	1/18	0.0403 in	0.041 in	6.60	6.70	6.90
18	7/26	0.0159 in	0.050 in	6.28	6.50	6.70
18	16/30	0.0100 in	0.051 in	6.30	6.60	6.80
18	19/30	0.0100 in	0.052 in	5.79	6.10	6.23
16	1/16	0.0508 in	0.052 in	4.20	4.35	4.36
16	19/29	0.0113 in	0.059 in	4.52	4.76	4.80
16	26/30	0.0100 in	0.062 in	4.31	4.55	4.69
14	1/14	0.0641 in	0.065 in	2.58	2.67	2.68
14	191/27	0.0142 in	0.073 in	2.88	3.00	3.06
14	41/30	0.0100 in	0.081 in	2.74	2.85	2.94
12	1/12	0.0808 in	0.082 in	1.62	1.68	1.69
12	19/25	0.0179 in	0.093 in	1.81	1.88	1.92
12	37/28	0.0126 in	0.091 in	1.90	1.98	2.02
12	65/30	0.0100 in	0.099 in	1.73	1.80	1.85
10	1/10	0.1019 in	0.103 in	1.02	1.05	1.06
10	37/26	0.0159 in	0.115 in	1.1	1.24	1.26
10	105/30	0.0100 in	0.130 in	1.07	1.11	1.15
8	133/29	0.0113 in	0.173 in	0.658	0.694	0.701
6	133/27	0.0142 in	0.217 in	0.418	0.436	0.445
6	266/30	0100 in	0.217 in	0.422	0.439	0.453
4	133/25	0.0179 in	0.274 in	0.264	0.275	0.280
4	418/30	0.0100 in	0.274 in	0.267	0.281	0.287
2	133/23	0.0227 in	0.355 in	0.167	0.171	0.176
2	259/26	0.0159 in	0.350 in	0.174	0.180	0.186
2	665/30	0.0100 in	0.342 in	0.170	0.177	0.183

Table 1. Copper Wire Data (Continued)

Wire Size Awg	Stranding No. / AWG of Strands	Individual Strand Diameter (Inch)	Maximum Diameter (Inch)	Maximum Resistance (Ohms per 1000 Ft @ 20xC)		
				Silver Coated	Nickel Coated	Tin Coated
1	259/25	0.0179 in	0.398 in	0.123	0.129	0.144
1	817/30	0.0100 in	0.382 in	0.139	0.144	0.149
1/0	259/24	0.201 in	0.444 in	0.103	0.108	0.113
1/0	1045/30	0.0100 in	0.431 in	0.108	0.113	0.116
2/0	259/22	0.227 in	0.492 in	0.084	0.088	0.090
2/0	1330/30	0.0100 in	0.486 in	0.085	0.089	0.091
3/0	259/22	0.0253 in	0.560 in	0.069	0.072	0.072
3/0	1672/30	0.0100 in	0.545 in	0.068	0.071	0.071
4/0	259/21	0.0286 in	0.620 in	0.053	0.055	0.055
4/0	2109/30	0.0100 in	0.635 in	0.054	0.056	0.056

Table 2. Preferred Color Code for Single Wires

Base Color	First Stripe or Band	Second Stripe or Band	Third Stripe or Band	Identification No.
Black				0
Brown				1
Red				2
Orange				3
Yellow				4
Green				5
Blue				6
Violet				7
Gray				8
White				9
White	Black			90
White	Brown			91
White	Red			92
White	Orange			93
White	Yellow			94
White	Green			95
White	Blue			96
White	Violet			97
White	Gray			98
White	Black	Brown		901
White	Black	Red		902
White	Black	Orange		903
White	Black	Yellow		904
White	Black	Green		905
White	Black	Blue		906
White	Black	Violet		907
White	Black	Gray		908
White	Brown	Red		912
White	Brown	Orange		913
White	Brown	Yellow		914
White	Brown	Green		915
White	Brown	Blue		916
White	Brown	Violet		917
White	Brown	Gray		918
White	Red	Orange		923
White	Red	Yellow		924
White	Red	Green		925
White	Red	Blue		926
White	Red	Violet		927
White	Red	Gray		928
White	Orange	Yellow		934
White	Orange	Green		935
White	Orange	Blue		936
White	Orange	Violet		937
White	Orange	Gray		938
White	Yellow	Green		945
White	Yellow	Blue		946

Table 2. Preferred Color Code for Single Wires (Continued)

Base Color	First Stripe or Band	Second Stripe or Band	Third Stripe or Band	Identification No.
White	Yellow	Violet		947
White	Yellow	Gray		948
White	Yellow	Blue		956
White	Green	Violet		957
White	Green	Gray		958
White	Blue	Violet		967
White	Blue	Gray		968
White	Violet	Gray		978
White	Black	Brown	Red	9012
White	Black	Brown	Orange	9013
White	Black	Brown	Yellow	9014
White	Black	Brown	Green	9015
White	Black	Brown	Blue	9016
White	Black	Brown	Violet	9017
White	Black	Brown	Gray	9018
White	Black	Red	Orange	9023
White	Black	Red	Yellow	9024
White	Black	Red	Green	9025
White	Black	Red	Blue	9026
White	Black	Red	Violet	9027
White	Black	Red	Gray	9028
White	Black	Orange	Yellow	9034
White	Black	Orange	Green	9035
White	Black	Orange	Blue	9036
White	Black	Orange	Violet	9037
White	Black	Orange	Gray	9038
White	Black	Yellow	Green	9045
White	Black	Yellow	Blue	9046
White	Black	Yellow	Violet	9047
White	Black	Yellow	Gray	9048
White	Black	Green	Blue	9056
White	Black	Green	Violet	9057
White	Black	Green	Gray	9058
White	Black	Blue	Violet	9067
White	Black	Blue	Gray	9068
White	Black	Violet	Gray	9078
White	Brown	Red	Orange	9123
White	Brown	Red	Yellow	9124
White	Brown	Red	Green	9125
White	Brown	Red	Blue	9126
White	Brown	Red	Violet	9127
White	Brown	Red	Gray	9128
White	Brown	Orange	Yellow	9134
White	Brown	Orange	Green	9135
White	Brown	Orange	Blue	9136
White	Brown	Orange	Violet	9137
White	Brown	Orange	Gray	9138

Table 2. Preferred Color Code for Single Wires (Continued)

Base Color	First Stripe or Band	Second Stripe or Band	Third Stripe or Band	Identification No.
White	Brown	Yellow	Green	9145
White	Brown	Yellow	Blue	9146
White	Brown	Yellow	Violet	9147
White	Brown	Yellow	Gray	9148
White	Brown	Green	Blue	9156
White	Brown	Green	Violet	9157
White	Brown	Green	Gray	9158
White	Brown	Blue	Violet	9167
White	Brown	Blue	Gray	9168
White	Brown	Violet	Gray	9178
White	Red	Orange	Yellow	9234
White	Red	Orange	Green	9235
White	Red	Orange	Blue	9236
White	Red	Orange	Violet	9237
White	Red	Orange	Gray	9238
White	Red	Yellow	Green	9245
White	Red	Yellow	Blue	9246
White	Red	Yellow	Violet	9247
White	Red	Yellow	Gray	9248
White	Red	Green	Blue	9256
White	Red	Green	Violet	9257
White	Red	Green	Gray	9258
White	Red	Blue	Violet	9267
White	Red	Blue	Gray	9268
White	Red	Violet	Gray	9278
White	Orange	Yellow	Green	9345
White	Orange	Yellow	Blue	9346
White	Orange	Yellow	Violet	9347
White	Orange	Yellow	Gray	9348
White	Orange	Green	Blue	9356
White	Orange	Green	Violet	9357
White	Orange	Green	Gray	0358
White	Orange	Blue	Violet	9367
White	Orange	Blue	Gray	9368
White	Orange	Violet	Gray	9378
White	Yellow	Green	Blue	9456
White	Yellow	Green	Violet	9457
White	Yellow	Green	Gray	9458
White	Yellow	Blue	Violet	9467
White	Yellow	Blue	Gray	9468
White	Yellow	Violet	Gray	9478
White	Green	Blue	Violet	9567
White	Green	Blue	Gray	9568
White	Green	Violet	Gray	9578
White	Blue	Violet	Gray	9678

19. **ENVIRONMENT EFFECTS.** There are numerous environmental conditions which must be taken into account when a particular wire is selected for an application. some of the more significant factors used to determine the wire selections are discussed here–in.

20. **TEMPERATURE EFFECTS.** All wire types age (degrade) with time and temperature. The rate of degradation depends upon the temperature level and the time of exposure at that temperature. As the longevity of aircraft is extended, increased degradation of the wire and related maintenance should be expected. The prime concerns of temperature are ambient and elevated temperature rise. Both of these temperature characteristics affect not only the insulation properties but conductor properties as well.

27 . **Ambient Temperature.** The temperature in which wire operates as determined by the surroundings through which the wire passes is the ambient temperature.

28 . **Elevated Temperature or Temperature Rise.** The increase of temperature of the conductor due to operation and current flow is elevated temperature or temperature rise. The higher the ambient temperature, the less heat required to reach maximum temperature, which results in a lower current carrying capacity. Temperature degradation is a function of time so that maximum permissible temperature is higher for a short time than permissible for continuous service. Temperature affects the internal conductor and the current carrying capacity, but also the insulation and jacketing materials as to their function.

a. **Tin Plated Conductors.** Tin–copper intermetallics will form with time resulting in an increase in conductor resistance and embrittlement. This increase in resistance is inverse to size, being up to 4 percent for the smallest gage. Also the surface of the tin plating becomes oxidized with time which inhibits solder ability. These potential problems should be considered in the application of tin plated copper wire.

(1). **Silver Plated Conductors.** Degradation in the form of inter–strand bonding, silver migration, and oxidation of the copper strands can occur with continuous operation near rated temperature, resulting in loss of flexibility. Due to potential fire hazard, silver plated conductors shall not be used in areas where they are subject to contamination by ethylene glycol solutions. These potential problems should be considered in the application of silver plated copper wire.

(2). **Nickel Plated Conductors.** The crimp joint of nickel plated conductors may deteriorate with temperatures which will cause high voltage drops in low signal applications and hot spots in power applications.

(3). **Solderability.** Solderability of tin plated copper wire degrades significantly within 6 months to a year after production. When significant oxidation occurs, mildly activated rosin (RMA) flux is required for proper soldering and depending upon temperature exposure, as well as storage time, an activated rosin (RA) flux may be required. Soldering of tin plated copper conductors should be avoided; but when required, compensating steps such as retinning shall be included in maintenance procedures for retermination. Refer to WP 016 00.

(4). **Insulation.** Wire insulation is extremely susceptible to degradation as heat may cause the insulation to soften, melt, or vaporize, and this will cause loss of insulating properties necessary to operation. In cases where an external jacket is used insulation degradation may not be noticed until the total system fails, and troubleshooting is extremely difficult as the system failure may only be noticed at altitude and not detectable on the ground.

21. **CURRENT CARRYING CAPABILITIES.** (Ampacity). This is the amount of current a wire can carry before the temperature rise exceeds the permissible value. There are numerous factors by which ampacity is influenced.

CAUTION

The use of parallel wires for load sharing is not a desirable practice and should be avoided.

29 . **Conductor Materials.** These affect ampacity as some material is more conductive than others. Copper is widely used and the most common due to a combination of properties as high electrical and thermal conductivity and the ability to be coated or alloyed. Aluminum conductors are lighter in weight, but only about 60% the conductivity of copper.

30 . **Conductor Diameter.** It is an important characteristic in that the larger the wire, the lower the resistance per unit length. This means that the larger

the wire diameter the greater the current that can be carried without overheating.

31 . **Ambient Temperature.** The higher the ambient temperature, less heat is required to reach maximum temperature, which results in a lower current carrying capacity.

32 . **Insulation.** Insulation not only acts as an electrical insulator but also a thermal insulator.

33 . **Installation.** Bundling, stacking, ventilation, and environment. all affect heat dissipation which will cause conductor heating to change resulting in changes of ampacity.

34 . **Number of Conductors.** Single conductors have a higher ampacity than equivalent size multistrand conductors. Each conductor in multistrand is not exposed and heat dissipation is therefore limited resulting in changed ampacity.

35 . **Amperage.** Heat rise varies as the square of the applied current, therefore, the more current, the greater the generated heat resulting in changed ampacity.

22. **VOLTAGE DROP.** For power distribution circuits, the total impedance of the wire supply and return paths shall be such that the voltage at the load equipment terminals is within MIL–STD–704 limits.

a. **Environmental Exposure**. The selection of a wire type is significantly affected by the various environmental exposures, such as fluids, humidity, vibration, available protection, sunlight, lightening, etc. Applications in Severe Wind and Moisture Problem (SWAMP) areas such as wheel wells, wing folds, flaps and other weather exposed areas can rapidly age a wire unless properly protected or specifically chosen for the environment.

23. **CORONA PHENOMENON.** Corona is also referred to as ionization, or partial discharges between the outside of an unshielded wire covering and structural elements over which the wire passes, or between the insulation and a braided shield. Corona is a voltage breakdown due to failure of the dielectric under electric field stress and occurs more readily in a gas than a solid.

a. **Influence.** Corona affects the operation of electrical circuitry in that corona generates spurious high–frequency voltages causing false logic switching, and even semiconductor damage. Corona consumes power and is the prime cause of radio frequency interference.

b. **Result.** Corona discharges some gasses or by products which will destroy the insulation to the extent that a hard short and circuit failure will eventually occur, and may corrode adjacent metallic components.

c. **Occurrence.** Corona may occur under certain conditions, notably high ambient temperature and/or high altitude (low pressure) or whenever there is a dielectric failure.

d. **Extinction Level.** Once the inception voltage (starting voltage) is reached and ionization begins in many cases corona will not extinguish until the applied voltage is lowered. This may be as much as 20% below the inception voltage.

CAUTION

Observe minimum bend radius requirements for all wiring systems installations. Failure to install wiring with the correct bend radius may result in wiring and associated system degradation and failure.

24. **BEND RADIUS.** The maximum amount a wire can be bent without causing damage to the conductor or insulation is referred to as minimum bend radius (Figure 1). Bending the wire in excess of the allowable amount (minimum bend radius) will result in the outer insulation to stretch or break, and the inner insulation to compress and wrinkle. Proper routing and installation is pivotal to wiring system integrity and operation. Refer to WP 010 00, 005 00 and 006 00 for additional information.

a. **Wires Individually Routed and Supported.** The minimum bend radius shall be ten times the outside diameter of the wire. At the point an individual wire breaks out from a group, harness, or bundle the minimum bend radius shall be ten times the outside diameter of the wire provided the wire is suitably supported.

b. **Wires Used as Shield Terminators.** Wires used as shield terminators or jumpers when required to reverse direction, shall have a minimum bend radius three times the wire diameter at the reversal point provided the wire is suitably supported.

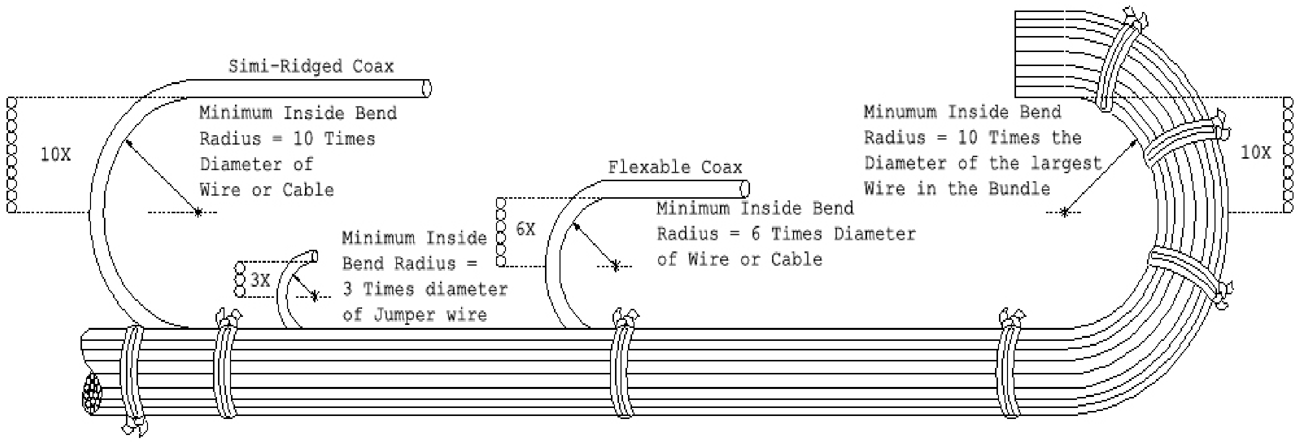

Figure 1. Bend Radius

25. **WIRE CONSTRUCTION.**

NOTE

This specification permits the general use of size 22 wire as the minimum wire size for airplanes, helicopters and lighter–than–air vehicles. Use of size 24 and smaller gage wire requires approval of procuring activity. Use of size 24 and smaller gage wires in harnesses shall be limited to wires which have break strength of 20 lbs. Size 24 and smaller gage wires shall not be installed as a single wire.

26. There is no simple or easy way to classify wires. Some are described by form, general application, specific application, conductor type, insulation type, property, and voltage. Therefore fundamental discussion of wires is difficult, and this section has been prepared to set forth only basic knowledge to aid in understanding how a wire is constructed. The detail characteristics of a wire are defined in the military specification used to procure the wire.

27. **WIRE SPECIFICATION / NON–GOVERNMENT STANDARDS.** Insulated wire for aircraft, missiles, and support equipment are of the many different types designed to meet the wide variety of uses and functions as set forth by military and non–government standards. Wire of this type must meet high performance standards, temperature extremes, resistance to radiation, nonflammability, physical toughness, permanence, and top electrical characteristics. The materials used are wide and varied and include nickel clad or plated copper, tin coated copper, silver plated copper stranded conductor, stranded aluminum conductor; coated with Ethylenetetrafluoroethylene copolymer (ETFE), Fluorinated Ethylene Propylene (FEP), Fluoropolymer Resin, Polytetrafluoroethylene (TFE), Polyvinylidene Fluoride (PVF_2) mica, and a combination of other insulating materials. Many of these insulating and jacketing materials are used in various combinations depending on the particular properties and protective characteristics required.

28. **CONDUCTOR MATERIALS.** Copper is widely used as an electrical conductor, but when greater strength is desired copper coated steel wire can be used. Copper conductors can also be coated with silver or tin; these coatings minimize oxidation and improve solderability. Silver coated copper wire is a very good high frequency conductor. The use of tin coated copper wire is limited to low frequencies as these conductors have a higher attenuation than bare copper wire, also they are limited to an ambient temperature of 302.F (150°C). Copper conductors coated with nickel plating has a poor solderability, therefore is used mostly in crimp applications. Nickel has an operating temperature of 260°C. The selection of a conductor is sometimes

dictated by the required current carrying capacity, as some conductor material is more conducive to current flow than others.

29. **CONDUCTOR CONSTRUCTION.** Conductors used are solid, stranded, and braided which is dictated by application.

a. **Solid Conductor.** Solid wires have a higher ampacity than equivalent size multi–strand conductors because heat dissipation is increased. In areas where little vibration and no flexing are required, solid conductors are used. Though the cost is lower when compared to stranded wire there remains disadvantages. The solid conductor when flexed or bent, stress and elongation, result at the outer portion of the bend, and the bend area becomes work hardened (brittle). Once the conductor begins to fail (develop cracks), continued flexing will cut through the conductor.

b. **Stranded Conductors.** Strands are utilized in most electronic wires to give them better limpness and longer flex life, thus service life is increased. Surface damage to stranded conductors, such as scratching or nicking during stripping will generally be less serious than damage to a solid conductor. A solid conductor if nicked or damaged will break after only a few bends, whereas the remaining undamaged strands would continue to provide reasonable service life. For a given size (gage) conductor, increasing the number of strands while reducing the size of the individual strands will increase conductor flexibility. Since type and thickness of insulation also affect flexibility all factors should be considered. Physical properties and flexibility are determined by the lay and stranding.

(1). Lay is the axial length of one complete turn of one strand in the conductor, either right hand or left hand twist (Figure 2).

(2). Bunch Stranding is composed of any number of wires of the same diameter twisted together in the same direction without regard to geometric arrangement of the individual strands. Used where low cost is an important factor (Figure 3).

(3). True Concentric Stranding is composed of a central wire surrounded by one or more layers of helically laid wires, with a reversed direction of lay, and an increased length of lay, for each successive layer (Figure 4).

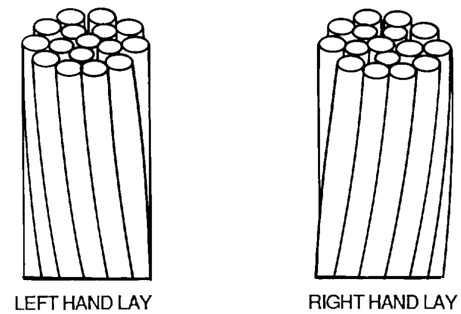

Figure 2. Lay

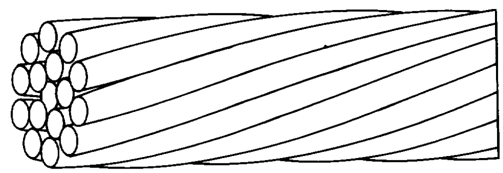

Figure 3. Bunch Stranding

(4). Equilay Stranding is composed of one or more helically laid wires, with a reversed direction of lay of the same length, for each successive layer.

(5). Unidirectional Concentric Stranding is composed of a central wire surrounded by one or more layers of helically laid wires, with the same direction, and an increased length of lay for each successive layer (Figure 5).

(6). Unilay Stranding is composed of more than one layer of helically laid wires, with the same direction of lay of the same length, for each successive layer.

(7). Rope Stranding is composed of groups of any of the above strandings combined in concentric configurations (Figure 6).

(8). Length of Lay. The shorter the lay the greater the flexibility since each single strand is approaching the shape of a coil spring. Shorter lays increase the cost since more conductor material is used in a given length and more time is required to strand the conductor. Physical properties are changed due to the twisting as well as the weight and resistance.

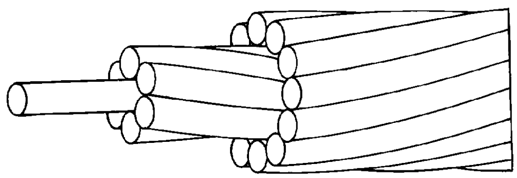

Figure 4. True Concentric and Equilay Stranding

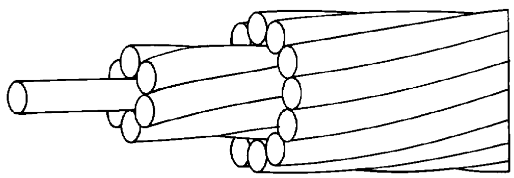

Figure 5. Unidirectional Concentric and Unilay Stranding

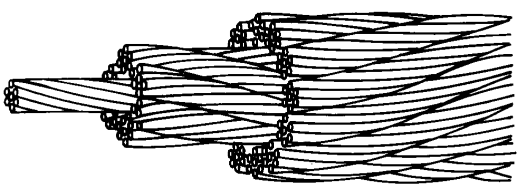

Figure 6. Rope Stranding

c. **Braided Conductors.** Flat or tubular braided conductors are occasionally used in certain applications for which they are better suited than round, solid or stranded wires. These are seldom insulated since the insulation would hinder the extra flexibility and the ability of the conductor to extend or retract slightly in length. Flat braids are usually used for grounding or bonding. Tubular braids are occasionally used for bonding but are more commonly desired as shields to slip over a wire or group of wires in an installation.

30. **INSULATION MATERIALS.** Numerous insulation and jacketing materials are used for wire applications. The properties considered are temperature, dielectric strength, dielectric constant, toughness, resistance to chemicals, resistance to moisture, processability and price. Wire and cable insulations may be classified in two very broad and basic categories, Thermosetting and Thermoplastic, the types, compounds, and mixtures within these groups are so varied as to make the available number of insulations almost unlimited. Most of the insulation materials used today are composed of compounds made from synthetic rubber polymers and synthetic plastics. These synthetic materials are compounded to provide specific physical and electrical properties.

31. **THERMOSETTING INSULATIONS.** These are characterized by their ability to be stretched, compressed or otherwise deformed, within reasonable limits, and then snap back to their original form and shape when the mechanical stress is removed. Thermosetting Insulations are not subject to heat softening and will not drip, flow, or deform appreciably during the application of external heat, or electrical overloads. In addition a wide range of physical and electrical properties can be compounded from the same basic polymers. Specific applications are covered by military specifications.

32. **THERMOPLASTIC INSULATION.** These materials are best known for their excellent electrical characteristics and relatively low cost. Thermoplastics are popular as insulation since much thinner insulation thicknesses may be used to obtain good electrical properties especially for higher voltage cables, as well as a much thinner cable of equivalent electrical size when thermosetting is used. By nature these materials are thermoforming in that they heat soften and flow under mechanical pressure and retain their deformed shape or form after cooling and/or removal of the mechanical strain. Specific applications are covered by military specifications.

33. **INSULATION COLOR–CODES.** Wire is available in numerous colors and stripes. The Navy prefers only white wire (–9) without stripes. In some older applications, which still exist, and in very unusual high density avionics wiring, color/stripes are still used to assist in the manufacturing. For the military wires discussed herein, the color/stripe is coded by the last three digits of the wire part number (M22759/34–20–9xxx). Table 2 lists the color codes used for wiring coding the insulation. See WP 005 00 for color coding cable primary wires.

34. ALUMINUM WIRE.

35. Aluminum conductors are typically used in size 8 and larger, because of their light weight. Aluminum conductors have less flexibility, and conductivity than other conductors. There are numerous application restrictions for aluminum conductors. Aluminum conductors are not interchangeable with copper conductors, nor in general, compatible with copper wire termination devices. Use of aluminum wires require procuring activity approval.

36. THERMOCOUPLE WIRE.

a. **USE.** Thermocouples are used as Thermoelectric Thermometers. The basic factors producing thermoelectric output can be controlled by alloying and heat treating. As a result the degree of this control Thermocouple wires have become one of the most reliable and widely used means of accurate temperature measurement (Figure 7).

b. **BASIC OPERATION.** Thermocouples essentially consist of a pair of dissimilar metallic conductors joined together to form an electrical circuit. When one junction is maintained at a higher temperature than the other an electromotive force (EMF) will be generated. This EMF is due to the temperature differential between the junctions, and as long as there remains temperature differential, current will continue to flow.

37. MILITARY WIRE SPECIFICATIONS.

38. The military wire specifications discussed herein are to provide a general description of the wire characteristics most commonly found in Navy aircraft. Many of the wire specifications have been canceled, made inactive for new design, superceded with other wire specifications or converted to non–government standards.

39. **MIL–W–5846 WIRE, ELECTRICAL, NICKEL–CHROMIUM (PREVIOUSLY KNOWN AS CHROMEL) AND NICKEL–ALUMINUM/SILICON (PREVIOUSLY KNOWN AS ALUMEL), THERMOCOUPLE.** This specification covers Nickel–Chromium (also known as Chromel) and Nickel–Aluminum/Silicon (also known as Alumel) Thermocouple wires.

40. **Classification.** Thermocouple wires are classified by type and class.

a. Type 1. These are solid and stranded conductors in five classes as follow:

(1). Class A, bare solid conductor.

(2). Class B, insulated solid conductor.

(3). Class C, insulated duplex solid conductor.

(4). Class D, insulated stranded conductor.

(5). Class E, insulated duplex stranded conductor.

41. **Part Number.** The MIL–W–5846 thermocouple cable part number example is shown as follows.

a. Example: M5846–1–A–1/14–A

b. M5684: Defines specification describing the wire performance requirements.

c. Type 2. Insulated duplex stranded conductor 7 ohms per 25 feet. Class A, standard insulation.

d. Type 3. Insulated duplex stranded conductor 7 ohms per 50 feet. Class A, standard insulation.

e. Type 4. Insulated duplex stranded conductor 7 ohms per 100 feet. Class A, standard insulation.

f. –1: Defines the type of wires.

g. –A: Defines the class of conductors.

h. –1: Defines the number of conductors.

i. /14: Defines the size of the conductors.

j. –A: Defines the conductor material.

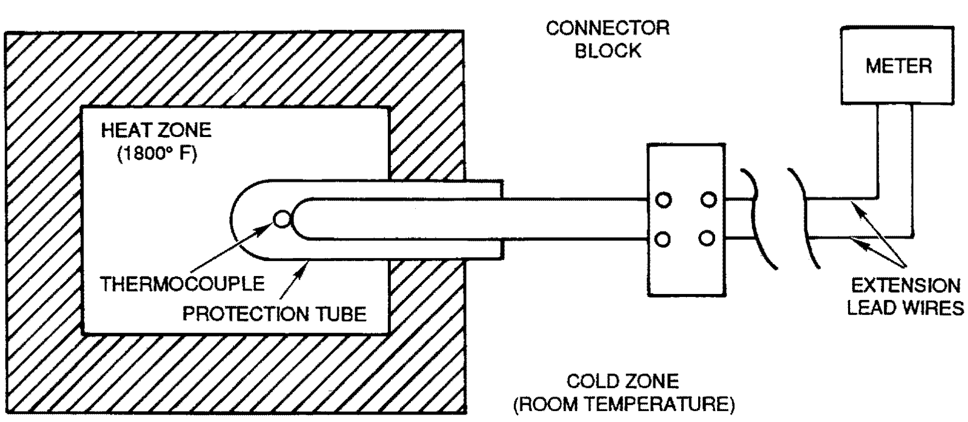

Figure 7. Typical Thermocouple Application

42. **Conductor Material.** The conductors consist Nickel–Chromium (also known as Chromel)/Nickel–Aluminum/Silicon (also known as Alumel).

43. **Stranding.** Stranding shall be bunched, concentric, or rope. The wire size of all strand are the same for any one conductor except for Types 2, 3, and 4 where strand size may vary to facilitate resistance adjustments.

44. **Insulation.** The wire insulation consists of a concentric layer or layers of suitable material as called for in the specification.

45. **Temperature.** The wire is intended for applications where temperatures of 597.2° F (315° C) are to be encountered.

46. **Repair.** Specific information on repair and installation of Thermocouples is found in WP 014 00.

47. **Intended Use.** Type 1, Class A, B, C, D, and E are intended for fabricating Thermocouples. Type 2, 3, and 4, Class A are intended for fabricating Thermocouple extension leads for aircraft use.

48. **MIL–W–5845 WIRE, ELECTRICAL, IRON AND CONSTANTAN THERMOCOUPLE.** This specification covers Iron and Constantan Thermocouple wires.

49. **Classification.** Thermocouple wire are classified by type and class as follow:

a. Type 1. These are solid and stranded conductor in ten classes:

(1). Class A, bare solid high accuracy.

(2). Class B, insulated solid high accuracy.

(3). Class C, insulated duplex solid high accuracy.

(4). Class D, insulated stranded high accuracy.

(5). Class E, insulated duplex stranded high accuracy.

(6). Class F, bare solid nominal accuracy.

(7). Class G, insulated solid nominal accuracy.

(8). Class H, insulated duplex solid nominal accuracy.

(9). Class I, insulated stranded nominal accuracy.

(10). Class J, insulated duplex stranded nominal accuracy.

(11). Type 2. These are stranded conductor 8 ohms per 100 feet.

(12). Class A, insulated duplex tinned iron wire 248°F (120°C) rating.

(13). Class B, insulated duplex tinned iron wire 446°F (230°C) rating.

(14). Class C, insulated duplex not tinned iron wire.

b. Type 3. These are stranded conductor 8 ohms per 200 feet.

(1). Class A, insulated duplex tinned iron wire 248°F (120°C) rating.

(2). Class B, insulated duplex tinned iron wire 446°F (230°C) rating.

(3). Class C, insulated duplex not tinned iron wire.

50. **Part Number.** The MIL–W–5845 thermocouple cable part number example is shown as follows.

a. Example: M5845–1–A–1/14–A

b. M5845: Basic specification defining performance characteristics.

c. –1: Defines the type of wires.

d. –A: Defines the class of conductors.

e. –1: Defines the number of conductors.

f. /14: Defines the size of the conductors.

g. –A: Defines the conductor materials.

51. **Conductor Material.** The conductor consists of Iron or Constantan.

52. **Stranding.** The stranding may be bunched, concentric, or rope lay. The wire size of all strands are the same for any one conductor, except for Types

2 and 3, Class A, B, and C where the strand size may vary to facilitate resistance adjustments.

53. **Insulation.** The insulation consists of a concentric layer or layers of suitable material as specified in the specification.

54. **Repair.** Specific information on repair and installation of thermocouples is found in WP 014 00.

55. **Intended Use.**

a. Type 1, Class A, B, C, D, and E are intended for fabricating Thermocouples where high accuracy is required.

b. Type 1, Class F, G, H, I, and J are intended for fabricating Thermocouples where nominal accuracy is required.

c. Types 2 and 3, Class A is intended for fabricating Thermocouple extension leads for applications where temperatures of 248°F (120°C) are encountered.

d. Types 2 and 3, Class B is intended for fabricating Thermocouple extension leads for applications where temperatures of 446°F (230°C) are encountered.

e. Types 2 and 3, Class C is intended for use where conditions do not require the iron wire be protected against corrosion.

56. **MIL–W–5908 WIRE, ELECTRICAL, COPPER AND CONSTANTAN THERMOCOUPLE.** This specification covers Copper and Constantan Thermocouple wire.

57. **Classification.** Thermocouple wire are classified by type and class as follow:

a. Type 1. Solid and stranded conductors in seven classes:

(1). Class A, bare solid conductor.

(2). Class B, insulated solid conductor.

(3). Class C, insulated duplex solid conductor.

(4). Class D, insulated stranded conductor.

(5). Class E, insulated duplex stranded conductor.

(6). Class F, insulated duplex stranded conductor 248°F (120°C) range.

(7). Class G, insulated stranded conductor 446°F (230°C) range.

b. Type 2. These are stranded conductor 7 ohms per 200 feet:

(1). Class A, insulated duplex 248°F (120°C) range.

(2). Class B, insulated duplex 446°F (230°C) range.

c. Type 3. These are stranded conductor, 20 gage copper, 18 gage constantan:

(1). Class A, insulated duplex 248°F (120°C) range.

(2). Class B, insulated duplex 446°F (230°C) range.

d. Type 4. These are stranded conductor, 20 gage copper, 16 gage constantan:

(1). Class A, insulated duplex 248°F (120°C) range.

(2). Class B, insulated duplex 446°F (230°C) range.

e. Type 5. These are stranded conductor, 18 gage copper, 14 gage constantan:

(1). Class A, insulated duplex 248°F (120°C) range.

(2). Class B, insulated duplex 446°F (230°C) range.

58. **Part Number.** The MIL–W–5908 thermocouple cable part number example is as follows:

a. Example: M5908–1–A–1/14–A.

b. M5908: Basic specification defining performance characteristics.

c. –1: Defines the type of wires.

d. –A: Defines the class of conductors.

e. –1: Defines the number of conductors.

f. /14: Defines the size of the conductors.

g. –A: Defines the conductor material.

59. **Conductor Materials.** The conductor consists of copper or constantan.

60. **Stranding.** Stranding may be bunched, concentric, or rope. The wire size of all strands shall be the same for any one conductor except for Type 2, Class A and B where the strand size may vary to facilitate resistance adjustments.

61. **Insulation.** The insulation consists of a concentric layer or layers of suitable material.

62. **Repair.** Specific information on repair and installation of thermocouples is found in WP 014 00.

63. **Intended Use.**

a. Type 1, Class A, B, C, D, and E are intended for use in fabricating Thermocouples.

b. Type 1, Class F and G are intended for fabricating Thermocouple extension leads. Class F is for applications where 248°F (120°C) are encountered. Class G is for applications where 446°F (230°C) are encountered.

c. Types 2, 3, 4, and 5, Class A are intended for fabricating Thermocouple extension leads for applications where 248°F (120°C) are encountered.

d. Types 2, 3, 4, and 5, Class B are intended for fabricating Thermocouple extension leads for applications where 446°F (230°C) are encountered.

64. **MIL−DTL−81381 WIRE, ELECTRIC, POLYIMIDE−INSULATED COPPER OR COPPER ALLOY (ALSO KNOWN AS KAPTON).** This type of wire is insulated with Aromatic Polyimide.

WARNING

Extensive testing on this type shows that it exhibits properties that are not acceptable for continued use in military aircraft.

65. **Part Number.** The MIL−DTL−81381 wire part numbers is as follows:

a. Example: M81381/11−22−93.

b. The specification for the wire is MIL−DTL−81381 and the part num,ber is M81381 with the applicable performance characteristics (i.e. part number M81381/11−22): Basic specification describing the performance characteristics.

c. /11: Detail specification defining the configuration, materials, and unique characteristics.

d. −22: Defines wire size.

e. −93: Three digit code defining the color. The first digit defines the background color and the last two digits define the stripe color when required. The last two digits are only present when required.

66. **Conductor Materials.** All conductors are stranded tin, silver, or nickel−coated soft annealed copper, or silver or nickel−coated high strength copper alloy.

67. **Stranding.** Conductors, sizes 10 through 22 are concentric lay with the outer layer being left−hand lay. Conductors, sizes 8 through 4/0, are rope lay with the outer layer either left or right−hand lay.

68. **Insulation.** The insulation is a fluorocarbon poly−imide tape wrap with a modified aromatic polyimide resin topcoat. For size 8 or larger the outer layer is a polyimide braid.

69. **Repair or Replacement.** Wherever maintenance instructions, diagrams, drawings, etc. specify MIL-DTL−81381 wire to be used for direct repair or replacement, the wire shall be repaired or replaced with the MIL−W−22759 wire designated in Table 3. Repair or replacement shall be in accordance with WP 014 00. Slight flaking of the topcoat does not require repair or replacement. Any flaking, or other damage (cuts, chafing, etc.) of the Kapton polyimide film requires repair or replacement in accordance with WP 014 00 and WP 004 01. If harness or cable is removed from aircraft for repair, all wire should be replaced when time and funding permits, regardless of the condition of the wire. If the MIL−DTL−81381 wire being replaced with a MIL−W−22759 wire that has a slightly larger diameter, and causes installation interference, contact the Cognizant Field Activity for guidance.

70. **MIL−W−7072 WIRE, ELECTRIC, 600 VOLT, ALUMINUM AIRCRAFT.** This specification covers single aluminum conductor electric wires capable of continued operation at a maximum conductor temperature of 221°F (105°C), and is suitable for use in aircraft. This specification has been cancelled without replacement. Contact Cognizant Engineering Authority for replacement guidance.

Table 3. MIL−DTL−81381 Wire Replacements

Present Designator	Replacement Designator	Present Designator	Replacement Designator
M81381/1	M22759/44 (Note 1)	M81381/12	M22759/41 (Note 4)
/2	/45 (Note 1)	/13	/35 (Notes 3 and 4)
/3	/43	/14	/42 (Notes 3 and 4)
/4	/41	/17	/44 (Note 4)
/5	/33	/18	/45 (Note 4)
/6	/46	/19	/33 (Note 4)
/7	/44 (Notes 1 and 4)	/20	/46 (Notes 2 and 4)
/8	/45 (Notes 1 and 4)	/21	/32 (Notes 1 and 4)
/9	/33 (Note 4)	/22	/34 (Note 4)
/11	/43 (Note 4)		

Notes:
1 No replacement for Wire Size 10
2 No Replacement for Wire Size 30
3 No Replacement for Wire Size 28
4 Replacement Wire Diameter is Slightly Larger

a. **Conductor Material.** All strand conductors are electrical conductor grade, hard drawn, aluminum wire.

b. **Stranding.** The direction of lay is unidirectional concentric with a left−hand lay or wire size 8. Wires, size 6 through 0000, are a rope lay. Individual members may be either concentric or bunch strand, then stranded unidirectional concentric with a left−hand lay.

c. **Insulation.** The primary insulation is extruded polyvinyl chloride, covered by finish treated glass braid, covered by braided nylon impregnated with nylon finishers. Polyvinyl Chloride (PVC) insulated wire shall not be used on any aerospace vehicle for new installation and repair.

WARNING

Do not terminate aluminum wire with SAE AS7928 copper terminals. Use only SAE AS70991 aluminum terminals. Do not splice to copper wire unless specific aircraft instructions are provided. Only point−to point repair (replacement) should be performed unless specific aircraft instructions provide otherwise.

d. **Repair or Replacement.** Aluminum wire has no alternative wire replacement.

e. **Intended Use.** The electric wire covered by this specification is intended for installation in aircraft electrical systems where the potential does not exceed 600 VOLTS RMS. This wire was primarily intended for use where a significant weight savings was realized.

71. **MIL−DTL−25038 WIRE, ELECTRICAL, HIGH TEMPERATURE AND FIRE RESISTANT.** This specification covers single conductor wires, for use under short−term emergency conditions, involving exposure to flames. This wire is predominantly used in engine compartments in circuits where it is necessary to maintain electrical integrity for 5 minutes in a flame at 2000°F (1093°C), with the operating potential not exceeding 125 volts RMS.

72. **Part Number.** The MIL−DTL−25038 wire part number is as follows:

a. Example: M25038/1−22−93.

b. M25038: Basic specification describing the performance characteristics.

c. /1: Detail specification defining the configuration materials, and unique characteristics.

d. −22: Defines wire size.

e. −93: Three digit code which defines the color of wire. The first digit describes the background color and the second two are the stripe colors and is present only when required.

73. **Conductor Materials.** All conductors are stranded of nickel−coated soft or annealed copper.

74. **Stranding.** Conductors, sizes 12 through 22, are concentric lay with the outer layer being left−hand lay. Conductors, sizes 10 through 4/0, are rope lay with the outer layer either right or left−hand lay.

75. **Insulation.** The insulation typically contains a layer of inorganic material combined with layers of silicone or tetrafluoroethylene. A glass braid jacket may also be present.

76. **Repair or Replacement.** There are no alternative wires for repair or replacement.

77. **Intended Use.** This wire is predominantly used in engine compartments, in circuits where it is necessary to maintain electrical integrity for 5 minutes in a flame at 2000°F (1093°C) with the operating potential not exceeding 125 VOLTS RMS.

78. **MIL–W–22759 WIRE, ELECTRIC, FLUROPOLYMER INSULATED, COPPER OR COPPER ALLOY.** This specification covers single conductor wire used for the interconnection of electronic and electrical equipment.

79. **Part Number.** The MIL–W–22759 wire part number example is as follows:

a. Example: M22759/46–22–93.

b. M22759: Basic specification describing the performance characteristics.

c. /46: Detail specification defining the configuration, materials, and unique requirements.

d. –22: Defines the wire size.

e. –93: Three digit code which defines the color of the wire. The first digit define the background color and the last two digits define the color of the stripes and is only present when required.

80. **Conductor Materials.** All conductors are stranded tin, silver, or nickel–coated copper, or silver or nickel–coated high–strength copper alloy.

81. **Stranding.** Conductors, sizes 10 through 22, are concentric lay with the outer layer being left–hand lay. Conductors, sizes 8 through 4/0, are rope lay with the outer layer either right or left–hand lay.

82. **Insulation.** The insulation may be used alone or in combination with any of the following materials:

a. Polytetrafluoroethylene (PTFE)

b. Fluorinated Ethylene Propylene (FEP)

c. Ethylene–tetrafluoroethylene (ETFE) copolymer

d. Fluoropolymer Resin

e. Polyvinylidene Fluoride (PVF2)

CAUTION

Replacement of MIL–W–22759 wire types with other wire types is not mandatory. Repair and replacement shall be in accordance with WP 014 00.

83. **Repair or Replacement.** Whenever maintenance instructions, diagrams, drawings, etc. specify certain types of MIL–W–22759 wires to be used for repair or replacement, the wire may be replaced with the MIL–W–22759 wire types specified in Table 4.

84. **Intended Use.** The electric wires covered by this specification are intended for use in any application where their performance characteristics are required. The wires are suitable for installation on aerospace electrical systems within the limitations of applicable performance requirements.

85. **MIL–W–81044 WIRE, ELECTRIC, CROSSLINKED POLYALKENE, CROSSLINKED ALKANE–IMIDE POLYMER, OR POLYARLENE INSULATED COPPER OR COPPER ALLOY.** This specification covers single conductor electric wires used in the interconnection of electronic and electrical equipment.

86. **Part Number.** The MIL–W–81044 wire part numbers is as follows:

a. Example: M81044/6–22–93.

b. M81044: Basic specification describing the performance characteristics.

c. /6: Detail specification defining the configuration, materials, and unique characteristics.

d. –22: Defines wire size.

e. –93: Three digit code defining the color. The first digit defines the background color and the last two digits define the stripe color when required. The last two digits are only present when required.

87. **Conductor Materials.** All conductors are stranded tin, silver, or nickel–coated soft annealed copper, or silver or nickel–coated high strength copper alloy.

88. **Stranding.** Conductors, sizes 10 through 22 are concentric lay with the outer layer being left–hand lay. Conductors, sizes 8 through 4/0, are rope lay with the outer layer either left or right–hand lay.

Table 4. MIL–W–22759 Wire Replacements

Present Designator	Replacement Designator	Present Designator	Replacement Designator
M22759/5	M22759/43	M22759/25	M22759/35
/7	/43	/26	/32 (Note 2)
/11	/43 (Note 1)	/27	/33
/13	/34	/28	/43 (Note 1)
/14	/32	/29	/12
/15	/33	/30	/35
/16	/34	/31	/23 (Note 3)
/17	/35	/36	/32
/18	/32 (Note 2)	/37	/34
/19	/33	/38	/33
/22	/33	/39	/34 (Note 4)
/24	/34	/40	/35
NOTES: 1 No replacement for Wire Size 28 2 No Replacement for Wire Size 10 3 No Replacement for Wire Size 30 4 No Replacement for Wire Size 26			

89. **Insulation.** The insulation is a cross link polyalkene with a polyvinylidene fluoride jacket.

90. **Compatibility.** Wires with polyvinylidene fluoride jackets may be degraded by contact with hydraulic fluids of phosphate ester type at high temperatures, and are not to be used where they will come in contact with this type of fluid at temperatures above 122°F (50°C).

CAUTION

Replacement of MIL–W–81044 wire with MIL–W–22759 wire is not mandatory. Repair or replacement shall be in accordance with WP 014 00.

Although MIL–DTL–16878 replacement is not mandatory, the higher quality MIL–W–22759 substitutions are recommended to be used.

91. **Repair and Replacement.** Whenever maintenance instructions, diagrams, drawings, etc. specify MIL–W–81044 wire to be used for repair or replacement, the wire may be replaced with the MIL–W–22759 wire specified in Table 4.

92. **Intended Use.** The electric wires covered by this specification are intended for use in any application where their performance characteristics are required. The wires are suitable for installation on aerospace electrical systems within the limitations of applicable performance requirements.

93. **MIL–W–5086 WIRE, ELECTRIC, POLYVINYL CHLORIDE INSULATED.** MIL–W–5086 includes wires rated for 105°C, 600 volt applications.

94. **Part Number.** The MIL–W–5086 part number example is as follows:

a. Example: M5086/5–20–9

b. M5086: Basic Specification which describe the performance characteristics.

c. /5: Detail Specification which defines the configuration, materials, and unique characteristics.

d. –20: Define the Wire Size.

e. –9: Defines a 3 digit Wire Color Code. The first digit is the background color and the remaining two digits is color stripes and is present only when required.

95. **Conductor Material.** The conductors are tin coated soft annealed copper or silver coated high–strength alloy copper.

96. **Insulation.** The primary insulation is a polyvinyl chloride. The Primary is usually covered with a nylon jacket. Polyvinyl Chloride (PVC) insulated wire shall not be used on any aerospace vehicle for new installation and repair.

Table 5. MIL−W−81044 Wire Replacements

Present Designator	Replacement Designator	Present Designator	Replacement Designator
M81044/1	M22759/43	M81044/16	M22759/34
/2	/34	/17	/35
/3	/44	/18	/32
/4	/32	/19	/33
/5	/43	/20	/34 (Note 2)
/6	/34	/21	/43
/7	/35	/22	/35
/8	/43	/23	/12
/9	/34	/24	/23
/10	/35	/25	/32
/11	/44 (Note 1)	/26	/44 (Note 1)
/12	/32	/27	/33
/13	/33	/28	/12 (Notes 1 and 3)
/14	/34	/29	/23 (Notes 1 and 3)
/15	/35		

NOTES:
1 No replacement for Wire Size 30
2 No Replacement for Wire Size 26
3 Replacement Wire Diameter is Slightly Larger

97. **Repair and Replacement.** Whenever maintenance instructions, diagrams, drawings etc. specify MIL−W−5086 to be used for repair or replacement, the wire shall be replaced with the MIL−W−22759 wire specified in Table 6.

98. **MIL−W−22759 WIRE REPLACEMENTS.** The various military wires mentioned herein may be replaced with the MIL−W−22759 wire types shown in Tables 6 through Table 7. Conductor size and color shall remain unchanged. For example a M81381/22−20−9 designation represents a size 20 wire colored white (−9) and may be replaced with a wire having a M22759/34−20−9 designation. In some cases the wire replacement outside diameter is slightly larger than the wire being replaced. If the increase in size causes physical interference during installation, contact the Cognizant Field Activity for guidance.

99. **Original Equipment Manufacturer Replacements.** In earlier aircraft versions the aircraft manufacturer controlled component part numbers by in−house control drawings. In many cases these components were mere duplicates of the existing military specification components. These components shall be substituted with MIL W−22759 wire.

100. **Wire Reference Information.** This information will assist users with some physical and electrical parameters of wire and cable assemblies. The information is given in Tables 1 and 8.

101. **Electrical Wire.** Table 1 provides information for coated copper wire. The stranding column has two numbers separated by a slash. The first number is the quantity of strands. The number following the slash is the American Wire Gage (AWG) of each individual strand. EXAMPLE: 7/44 means 7 strands of 44 AWG wire. The strand diameter and quantity of strands can be used to determine the AWG of an unmarked piece of wire. Measure an individual strand and count the number of strands. Match these numbers with those in Table 1. EXAMPLE: Seven (7) strands of 0.0031 in diameter (40 AWG) wire bundled together form a 32 AWG stranded wire. The Maximum DC Resistance values can be used to find the approximate length of wires. The resistance can also be used as a point of reference when troubleshooting cable assemblies for continuity.

102. **Pin Dimensions.** Table 8 is a connector contact engagement size cross reference from AWG to inches.

Table 6. MIL−W−5086 Wire Replacements

Present Designator	Replacement Designator	Present Designator	Replacement Designator
M5086/1	M22759/34	M5086/5	M22759/34
/2	/34	/6	/35 (Note 2)
/3	/34 (Note 1)	/7	/34
/4	None	/8	/32 (Note 3)

NOTES:
1 No replacement for Wire Sizes 03 and 04
2 No Replacement for Wire Size 28
3 No Replacement for Wire Size 32

Table 7. MIL−DTL−16878 Wire Replacements

Present Designator	Replacement Designator	Present Designator	Replacement Designator
M16878/4BCB	M22759/11−28	M16878/5BCB	M22759/9−28
/4DCB	/22−28	/5DCB	/20−28
/4BDB	/43−26	/5BDB	/9−26
/4BDE	/43−26	/5BDE	/9−26
/4DDB	/33−26	/5DDB	/20−26
/4DDE	/33−26	/5DDE	/20−26
/4BEB	/43−24	/5BEB	/9−24
/4BEE	/43−24	/5BEE	/9−24
/4DEB	/33−24	/5DEB	/20−24
/4DEE	/33−24	/5DEE	/20−24
/4BFB	/43−22	/5BFB	/9−22
/4BFE	/43−22	/5BFE	/9−22
/4DFB	/33−22	/5DFB	/20−22
/4DFE	/33−22	/5DFE	/20−22
/4BGB	/43−20	/5BGB	/9−20
/4BGE	/43−20	/5BGE	/9−20
/4DGB	/33−20	/5DGB	/20−20
/4DGE	/33−20	/5DGE	/20−20
/4BHB	/43−18	/5BHB	/9−18
M16878/4BKE	M22759/43−14	M16878/5BKE	M22759/9−14
/4BLE	/43−12	/5BLE	/9−12
/4BLG	/43−12	/5BLG	/9−12
/4BMG	/43−10	/5BMG	/9−10

103. **MIL–C–85485 CABLE, ELECTRIC, FILTER LINE, RADIO FREQUENCY ABSORPTIVE.** This specification covers the requirements for radio frequency absorptive component wires and finished cables, which function electrically as low–pass filters. The complexity of this type cable is explained to a greater detail in SAE AS 4465, Design and Handling Guide Radio Frequency Absorptive Type Wire and Cables (Filter Line, MIL–C–85485).

104. **Filter Line.** Filter line is a wire that can replace standard aircraft interconnection wiring to provide protection from conducted and radiated high frequency Electromagnetic Interference (EMI). Filter line, when correctly installed, acts as a low–pass filter, which strongly attenuates conducted signals or noise at frequencies above 100 MHZ while passing lower frequency signals with little loss. Filter line has been designed to replace older less reliable filter methods.

105. **Filtering.** In aircraft, most control and monitor systems operate at frequencies well below 50 MHZ whereas most interference operate in the high VHF, UHF, and SHF bands. By effectively attenuating these interference frequencies, filter lines serve the dual role of filtering and interconnection without the added weight of other filtering devices.

106. **Part Number.** The MIL–C–85485 cable part number is as follows:

a. M85485/5–22–7/L.

b. M85485: Basic specification describing the performance characteristics.

c. /5: Detail specification which define configuration, material, and unique requirements.

d. –22: Define the wire size.

e. –7/L: Define the color which is always light violet.

36 . **Conductor Material.** All conductors are stranded tin coated copper.

37 . **Insulation.** The insulation consists of an inner and outer layer of cross linked ethylene–tetrofluoroeythylene. The middle layer or filter layer is constructed of ferrite loaded, high temperature polymer, which provides the high frequency absorption. The filter layer is designed to absorb and dissipate high frequency energy.

CAUTION

Filter line cable may require special handling. See aircraft maintenance manual.

38 . **Color Code.** Filter line single conductor, unshielded cable is viewed as a wire and is always colored light violet to note special handling. See the aircraft repair manual for specific repair instructions. In shielded cable application the outer jacket is black and may be semi–conductive (see WP 005 00).

39 . **Repair and Replacement.** There is no alternative replacement wire. Filter line wire can be repaired in accordance with WP 015 00, if the specific aircraft maintenance manual has no detailed, or more specific procedures.

40 . **Intended Use.** This wire is used in aircraft where most control and monitor systems operate at frequencies well below 50 MHZ whereas most interferences operate in the high VHF, UHF, and SHF bands. This wire effectively attenuates these interference frequencies. This wire serves the dual role of filtering and interconnection without the added weight of other filtering devices.

Table 8. Contact Engagement Dimensions

Engagement End Size AWG	Engagement End Diameter
4/0	0.500 ± 0.001 in
2/0	0.406 ± 0.001 in
1/0	0.357 ± 0.001 in
2	0.283 ± 0.001 in
4	0.225 ± 0.001 in
6	0.178 ± 0.001 in
8	0.142 ± 0.001 in
10	0.125 ± 0.001 in
12	0.094 ± 0.001 in
14	0.078 ± 0.001 in
16	0.0625 ± 0.001 in
20	0.040 ± 0.001 in
22	0.030 ± 0.005 in
23	0.027 ± 0.005 in
24	0.025 ± 0.005 in
26	0.020 ± 0.005 in
28	0.015 ± 0.005 in

NOTE

The socket, inside diameter will be from 0.002 to 0.005 inch larger than the pin outside diameter. The larger the contact, the larger the difference.

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AIRCRAFT WIRING SYSTEM INSPECTION

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Military Specification, Wiring, Aerospace Vehicle (previously MIL–W–5088) . . . . SAE AS50881
Wire, Electric, Polyimide Insulated Copper or Copper Alloy MIL–W–81381

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part. No.	Nomenclature	Part. No.
Flashlight and Inspection Mirror	–	LED Light Bulb (50 Lumen) for Flashlight	TLE–1F
4 LED Headlamp	04–0245	LED Light Bulb (140 Lumen) for Flashlight	TLE–6EXB
LED Headlamp w. NVG capability	05–0140		

Materials Required

None

1. **INTRODUCTION.**

2. This work package (WP) is to provide general examination criteria and define wiring discrepancies in aircraft undergoing all levels of maintenance.

3. **BACKGROUND.** In today's military aircraft electrical wiring systems can no longer be considered a subsystem of another major component. normal operational environments, maintenance, modifications, and conversions can and do contribute to wiring systems stress, deterioration and deficiencies. these wiring systems which are comprised of individual wires, cables, groups, bundles, and harnesses located through out the entire airframe, have necessitated the establishment of this inspection criteria.

4. Documented fleet problems and inspections, collaborated with testing conducted by the Naval Research Laboratory, Washington DC, have determined MIL–W–81381 (polyimide insulated wire) and/or original equipment manufacturer's equivalents which use polyimide insulation, have exhibited characteristics undesirable for continued use. These characteristics which include but are not limited to, wet and/or dry arc tracking, topcoat cracking, flaking and peeling, have been specifically addressed in this specification.

5. **APPLICATION.** All military aircraft undergoing any level of maintenance.

6. **DEFINITIONS.**

a. **Bundle.** Any number of harnesses or branches routed and supported together along some distance within the aircraft.

b. **Cable.** Two or more insulated conductors, solid or stranded, contained in a common covering, or two or more insulated conductors twisted or molded together without common covering, or one insulated conductor with a metallic covering shield or outer conductor.

c. **Chafing.** Abrasion due to repeated relative motion between wiring system components, or between a wiring system component and structure or equipment, which results in a rubbing action that causes visually detectable wear.

d. **Cracks.** Voids or splits that appear in wire insulation as a result of long term exposure to environmental extremes, aging and installation practices.

e. **Dry Areas.** Include locations that are NON–SWAMP areas for the aircraft.

f. **Group.** A number of wires and/or cables and their terminations secured together within the structure of a bundle or harness. Groups normally contain wire and/or cable pertaining to a single circuit or routed to a single item of equipment.

g. **Harness.** An assembly of any number of wires, cables and/or groups and their terminations which is designed and fabricated so as to allow for installation and removal as a unit. A harness may be an open harness or a protected harness.

h. **High Temperature Areas.** They include all locations on the engine, the engine auxiliary power unit (APU), in the engine APU bay, nacelle or in the wake of the engine and APU exhaust. Also includes ECS bays, heat exchanger and exhaust areas.

i. **Severe Wind and Moisture Problem (SWAMP) Areas.** Areas such as wheel wells, wing folds and areas near any flight control surfaces and actuator panels, and areas directly exposed to extended weather conditions are considered SWAMP areas on aerospace vehicles.

j. **Top Coat MIL–W–81381 and/or OEM Equivalent (polyimide insulated) Wire/Cable Only.** A thin coating (1 mil or less, 0.5 mil nominal), applied to the outer surface of polyimide insulated wire. It provides a smoother outer surface, a better marking medium, a means for coloring the wire insulation surface, and eliminates the tendency for manufacturing and maintenance personnel to mistake the copper colored polyimide tape for exposed conductor.

k. **Top Coat Flaking. MIL–W–81381 and OEM Equivalent (polyimide insulated) Wire/Cable only.** Peeling, flaking, falling off of the top coat material.

l. **Wire.** A single metallic conductor of solid, stranded, or tinsel construction, designed to carry current in an electric circuit, but not having a metallic covering sheath or shield. For purpose of this manual “wire” refers to “insulated electrical wire”.

m. **Wiring.** Wires, cables, groups, harnesses and bundles, and their terminations, associated hardware, and support, individually or collectively in any combination installed in the aircraft. When used as a verb, wiring is the act of fabricating and/or installing these items in an aircraft.

7. **INSTRUCTIONS.** Wiring inspection shall be performed using a bright light and mirror, focusing on all the accessible wire system components (EWIS) in the applicable zone/area. For best results, findings are to be identified, documented and corrected immediately while access to the area is opened. Deficiencies not corrected shall retain appropriate documentation outstanding in applicable aircraft/end item records/forms and worked at next major maintenance opportunity. Until discrepancies are corrected (which should be no longer than is operationally required) they must be reinspected at each available opportunity to ensure minor deficiencies have not progressed to the state of endangering the aircrew or aircraft. Examine aircraft wiring in accordance with the following guidelines.

NOTE

In case of conflict between contractor installation drawings, reference (a) or this manual, the precedence is:

a. Contractor Installation Drawings

b. Platform–Specific Manual

c. SAE AS50881

d. NAVAIR 01–1A–505 Series

8. **EXAMINATION.**

WARNING

Ensure wire and cable is properly clamped and routed to prevent chafing of any wire, cable, or bundle. Installation practices of wiring using polyimide fluorocarbon insulating materials per MIL–W–81381 (or OEM equivalent) require greater attention to detail due to its undesirable characteristics. Ensure lacing or tied bundles are secure, but not so tightly tied that the cord cuts into the insulation.

9. **Wiring Support.** Examine wiring for proper support and security to prevent chafing IAW NA 01–1A–505–1 WP 010 00 or SAE AS50881. Examine plastic tie wraps for brittleness or improper cut–off and replace with approved lacing tape. Wiring not properly supported or secured is a discrepancy.

10. **Wiring Clearances.**

a. Examine wiring for a minimum 1/2 inch clearance from structure, surfaces, and equipment. Where a minimum of 1/2 inch clearance cannot be maintained, a minimum 3/8–inch clearance is acceptable where anti–chafing material is used. Refer to WP 010 00, Chafing paragraph for installation instructions.

b. A minimum of 2 inches clearance between wiring and fluid carrying lines, tubes and equipment shall be maintained. When there is less than 2 inches clearance between wiring and fluid carrying lines, there must be a positive means (clamp) to maintain a minimum of 1/2 inch clearance. Improper clearance between wiring, fluid carrying lines, tubes and equipment or lack of or improperly installed anti–chafing material is a discrepancy. This separation is not required when a conduit, bulkhead or other continuous structure separates wiring from fluid lines.

c. Examine for proper wiring clearance from linkages, throttle controls, boxes, covers, structures, control cables and component mounting hardware. Improper wiring clearance from any of these areas is considered a discrepancy.

d. Examine for proper clearance of terminal lugs between other lugs, adjacent components and nearby structures at contactors, circuit breakers, relays power control relays and terminal boards. Examine for loose/frayed wire strands bridging clearance gaps between contacts or structure. Lack of proper clearance between terminal lugs and nearby components or evidence of loose/frayed wire strands is a discrepancy.

e. Examine wiring for proper support independent of and with the maximum practicable separation from all fluid–carrying lines, tubes and equipment. Wiring shall not be attached to fluid carrying lines, tubes and equipment unless they require electrical connections. (Unless specifically authorized)

11. **Wire Chafing**. Examine for wire chafing where wiring is routed near structural members, crosses over/ under other wiring, passes through lightening holes. Examine wire in areas where it moves/flexes when door(s) are opened/closed, passes over or near hinged areas, turns or bends near components and at connector backshells flexed during the removal and installation of components. Examine around generator power wiring routing areas. Any chafing found is a discrepancy. Using a bright light and mirror, follow all wire runs and examine the backside that is hidden from view. Look for wire chafing structure, components, or hard lines and plumbing, and correct. Partially close all hinged access doors. With doors open as little as possible, examine with a flashlight to detect and wiring that may be coming in contact with the door hinges, latches, structures, or other mechanical components. Also look for possible door chafing with door open.

12. **Wire Bend Radius.** Examine wire(s), wire bundles and cables for proper bend radius IAW WP (004 00). Improper bend radius of any wire, wire bundle or cable is a discrepancy.

13. **Drip Loop.** Examine wiring for proper drip loop installation. Wiring dressed down to a connector should have a drip loop/trap to prevent fluids or condensation from running down the wiring into the connector. Where a drip loop has tape or tubing installed there should be a drainage hole in the tape or tubing at the lowest point , ensure hole is open and no fluids are present. Potted or fiber optic connectors do not require a drip loop. Refer to WP 010 00 for additional information on drip loops.

14. **INSULATION EXAMINATION.**

a. Cracking or peeling of the insulation of any wire or cable (excluding polyimide topcoat, see paragraph 16) is a discrepancy.

b. Circular cracking (circumferential to axis of wire or cable) is a discrepancy. Some insulation may be more susceptible to cracking within ½ inch of clamps.

c. Heat damage: Melting, scorching, charring and blistering is a discrepancy.

d. Fluid/moisture effects: Swelling, blistering or cracking is a discrepancy.

e. Mechanical damage that is caused by the installation or removal of equipment, crew movements, shifting cargo etc. is a discrepancy.

f. Wiring that bears evidence of having been crushed is a discrepancy.

15. **Polyimide Insulated Wiring In/Through Swamp Areas.** Missing, flaking or peeling top coat from insulated wire or cable is a discrepancy. In addition, inspect wire harnesses for oil, fuel and hydraulic fluid saturation, and if present determine the source and correct.

16. **Polyimide Insulated Wiring In/Through Dry Areas.** Missing, flaking or peeling top coat with no evidence of damaged or deteriorated insulation is acceptable.

17. **Examination of Cushion Clamps.** Cushion clamps must have “W” to be wedge type, non–wedge are not authorized. Examine area located at base or wedge of clamp cushion material to ensure wires are not pinched in metal band of clamp. Examine clamp size for being too small or too large for wire bundle. Refer to WP 010 00 for proper clamp installation procedures as necessary. Ensure that Plastic clamps are not located in zones where ambient temperature may exceed 185°F. Examine for loose, broken or deteriorated cushion clamps, lacing tape ties, strap ties, loose or damaged bundle clamp standoffs and distorted bundle clamp support brackets. Particular attention is required where wire bundles normally flex or move when doors or panels are opened and closed. Inspect for improper usage of clamps and clamp cushions with types not compatible with the installation environment. Any evidence of loose, broken or deteriorated cushion clamps, loose or damaged bundle clamp standoffs or distorted bundle clamp support brackets or improper usage of clamps or clamp cushions is a discrepancy.

CAUTION

Cushion compounds are manufactured to meet specific environmental requirements and deteriorate with age. Missing or deteriorating cushion material in clamps may result in chafing between the clamp band and wire bundle.

18. Look for deformed clamps and ensure no cracks are evident in the metal portion, particularly at the bolt location. If found cracked, replace clamp.

19. **Clamp, Hardware and Bracket Security.** Follow all wire/harness runs and lightly shake at all clamp or support devices. Inspect clamps for proper torque by attempting to rotate clamp around bolt/screw axis. If screw/bolt is not tight, improper length may be installed, and bolt may be bottomed out. Install proper length bolt to ensure clamp does not rotate. Check for proper thread protrusion on backside, 3–5 threads optimum. Flush, or less than 1 1/2 threads is unacceptable. While shaking all clamp locations, ensure airframe clips and brackets do not have loose rivets or fasteners. If found, repair in accordance with the applicable technical publication.

20. **Wire Routing.** Routing of wires with dissimilar insulation, within the same bundle, is not recommended, particularly when relative motion and abrasion between wires having dissimilar insulation can occur. Any poly–imide insulated wiring that crosses over or under dissimilar wire insulation should be string tied to prevent chafing. Insure that wire bundles routed near junctions do not contact saddle clamp screws at connectors. Examine wire bundle routing for proper support hardware and security of installation and droop support. Generally, wiring should be routed above fluid carrying lines. However, when routing beneath fluid carrying lines is unavoidable, routing should be at an angle rather than parallel to the lines. Use of improper support hardware, lack of security and droop support or misrouted wires adjacent to fluid carrying lines is a discrepancy.

21. **Wire Fraying.** Examine for loose or frayed wiring, cable shields and braided metal jackets. Evidence of loose or frayed wiring, cable shields or braided metal jackets is a discrepancy.

22. **General Wire System Inspection.** Whenever aircraft panels are removed or remote areas are accessed, the exposed areas should be examined for debris such as dust, lint, metal shavings, or any foreign materials or liquids that could impact the performance of the aircraft wiring system or create safety problems such as increased risk of fire, electrical short circuits or arcing possibilities.

23. **Connector Examination.**

a. Examine connectors and terminal junctions for bent or recessed contacts and corrosion. Examine electrical connections for security, and proper hardware installation. Evidence of bent, recessed, or corroded contacts, loose connections or improperly installed hardware is a discrepancy.

b. Examine potting of connectors or feed through bushings for proper sealing, cracking or deterioration. Look for contamination tracks, burn marks across potting material to metals. Pay close attention to vertically oriented connector parts for evidence of moisture. Evidence of improper sealing, cracking, deterioration, moisture or burn marks of potting is a discrepancy.

c. Examine all wiring for secure and legible connector identifications in accordance with NA–01–1A–505–1 WP 008 00 or SAE AS50881. Illegible or missing identification is a discrepancy.

d. Examine for paint overspray on wires or connectors (unless specifically authorized) check for paint over the coupling ring, paint on threaded surfaces or insert of plug or receptacle and clean as necessary.

e. Examine all receptacles with mounting holes; all mounting holes shall be installed with mounting screws installed.

f. Examine connector accessories, accessories shall not be used to terminate ground wires or shields unless the accessory was designed to terminate ground wires or shields. Ground wires shall not be terminated to saddle clamp screws.

NOTE

All unused cavities in circular and rectangular connectors shall be filled with unwired contacts and appropriate MS27488 sealing plugs (See WP 020 00, para 33, Sealing plug selection). The unwired contacts and sealing plugs are required to preserve the environmental sealing characteristics of the connectors.

g. Examine connectors and terminal junction blocks for sealing plugs. All unwired cavities shall have sealing plugs installed.

h. Examine connectors and terminal junction blocks to verify the strain relief clamp or the wire routing has not opened the rear grommet seals.

i. Connector plugs and receptacles should be examined for gold flaking on their interfaces. This condition indicates excessive wear between the pin and socket contacts and can cause short circuits or open circuit conditions. The connectors should also be examined for damaged threads (mating or accessory threads), bayonet pins, and keyways. The plating and base material in these areas are more susceptible to wear and can lead to catastrophic corrosion conditions and mechanical malfunctions.

j. On coaxial–type contacts inspect the dielectric insert for cracking, deterioration and security to connector inner shell. Any movement noted between the contact insert and connector shell is reason for connector replacement.

k. Inspect for bent or misaligned pins. If needed, correct using the following steps:

NOTE

A minor or slightly bent pin may be straightened and aligned using the following procedure (Figure 1).

CAUTION

Connector pin shall not show any signs of cracking or surface plating damage. Failure to observe this caution may result in equipment damage and loss of one or more aircraft systems.

Pliers or hemostats shall not be used unless a protective plastic sheath is fitted over pin to be straightened.

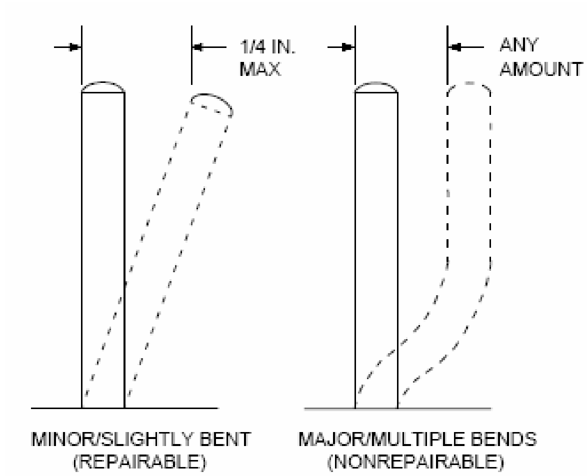

Figure 1. Bent Connector Pin Repair

24. **RECOGNIZING CORROSION.** Recognizing corrosion in metals is an important part of corrosion cleaning and prevention program (refer to NAVAIR 01–1A–509–3). modern avionics systems make use of many metals not normally considered for airframe structures. In addition to recognizing corrosion in metals, the inspection process must include the recognition of corrosion caused by solder fluxes and the deterioration of metals and non–metals caused by microbial, insects, and animal attack.

25. **Common Types of Corrosion.** There are many forms of corrosion that may occur depending upon the types of metal, configuration of the metal, and environment in which the components are placed. The

following types of corrosion are common to avionics equipment on military aircraft:

a. Uniform Surface Attack

b. Galvanic (dissimilar metals)

c. Pitting

d. Crevice (concentration cell)

e. Inter–granular

f. Stress

g. Erosion

26. Left untreated, corrosion on electrical connectors will continue to spread to adjacent surfaces and to mating connectors.

27. External corrosion on cable connectors will, if left untreated, continue to corrode into the electrical contacts causing system degradation and eventual failure.

28. The characteristics of corrosion on metals used in avionics systems are summarized in Table 1**.**

29. **Wire Grounding.** No more than four ground wires shall be connected to a common ground stud as per SAE AS50881. Examine grounds for corrosion, proper securing hardware, coating and installation. Insure that no more than four ground wires are terminated in a single lug and that no more than four lugs are attached to one stud. Evidence of corroded, improperly secured or improperly coated grounds is a discrepancy.

30. **Previous Wiring Repairs.** Examine wiring repairs previously performed for proper repair/installation practices for compliance with WP 013 00 and WP 014 00.

31. **TERMINAL LUGS AND SPLICES.**

a. Examine terminals crimped condition for any defective connections. Ensure lug barrel is not cracked, and ensure lug insulation is not cracked. Ensure all wire strands are in terminal barrel and no bare wire extends past the terminal barrel. Inspect lug for correct barrel size, ensure color is appropriate for wire gauges.

b. Examine terminal mounting for no more than four terminal lugs or three terminal lugs and a bus bar connected to any one stud (total number of terminal lugs per stud includes a common bus bar joining adjacent studs. Four terminal lugs plus a common bus bar thus are not permitted on one stud).

c. Ensure that when the terminal lugs attached to a stud vary in diameter, the greatest diameter shall be placed on the bottom and smallest diameter on top. Terminal connections shall not deform the terminal lugs or the studs when tightened.

d. Examine splice–crimped connection to ensure indent is centered on splice barrel. Ensure barrel is not cracked, and ensure wire cannot be pulled from splice. Ensure environmental shrink sealing sleeve has been installed correctly. Ensure all wire strands are in splice barrel and no bare wire extends past the splice barrel.

e. Examine terminal lugs/splices for disconnected wires, burn marks, or physical damage.

32. **CIRCUIT BREAKER INSPECTION.** Inspect the circuit breakers, buss bars, hardware, terminations, and all associated wiring for: looseness, misapplication, deformation, cracking, or corrosion. Perform the following visual inspections to check a circuit breaker for serviceability:

NOTE

Replace all affected circuit breakers, buss bars, and hardware with approved type replacements when found unserviceable.

a. Verify amperage indicator on end of actuator is legible and correct for circuit used in.

b. Verify orientation of amperage indicator is correct relative to panel of installation.

Table 1. Corrosion Of Metals – Nature And Appearance Of Corrosion Products

Alloy	Type of Attack to Which Alloy Is Susceptible	Appearance of Corrosion Product
Magnesium alloy	Extended or repeated contact with chlorinated solvents may result in embrittlement. Cadmium plated tools can cause embrittlement of titanium. Highly susceptible to pitting.	White powder snow–like mounds, and white spots on surface.
Carbon and low alloy steel (1000–800 series)	Surface oxidation and pitting, surface and intergranular.	Reddish–brown oxide (rust).
Stainless steel (300–400 series)	Intergranular corrosion. Some tendency to pitting in marine environment (300 series more corrosion resistant than 400 series).	Corrosion evidenced by rough surface; sometimes by red, brown or black stain.
Nickel–Base alloy (Inconel)	Generally has good corrosion–resistant qualities. Sometimes susceptible to pitting.	Green powdery deposit.
Copper–Base alloy (Inconel)	Surface and intergranular corrosion.	Blue or blue–green powder deposit.
Cadmium (used as a protective plating for steel)	Good corrosion resistance. Will cause embrittlement if not properly applied.	White to brown to black mottling of the surface.
Chromium (used as a wear–resistant plating for steels)	Subject to pitting in chloride environments.	Chromium being cathodic to steel, does not corrode itself, but promotes rusting of steel where pits occur in the coating.
Silver	Will tarnish in presence of sulfur.	Brown to black film.
Gold	Highly corrosion resistant.	Deposits cause darkening of reflective surfaces.
Tin	Subject to whisker growth.	Whisker–like deposits.

c. Check that mounting nut is present and/or secure to panel

d. Inspect for corrosion of mounting hardware.

e. Inspect for corrosion on white trip indicator of push–button.

WARNING

Ensure aircraft external electrical power and battery, or batteries, are disconnected before proceeding with any of the following instructions or routine maintenance. Failure to do so can result in severe injury, or death to personnel, and/or damage to equipment.

f. Inspect push–button for cracks or deterioration.

g. Inspect case for cracks, deterioration, discoloration and burn marks.

h. Check for foreign objects that could cause physical damage or electrical shorts.

i. Check leads of disconnected wires for burn marks and physical damage.

j. Check that terminal screws are present and tight.

k. Check for burn marks on the insulating barrier material of three phase circuit breakers.

l. Check for corrosion, discoloration and hot spots on all metal parts, including buss bars.

m. Check for broken wire strands at the wire terminations. If the number of broken strands exceed that allowable by WP 009 00, cut and re–strip the wire.

n. Check the boot for splits or deterioration. The boot should not be removed except for inspection.

o. Inspect for cross threaded screws/attaching hardware and for threads stripped on circuit breaker terminals. Hardware should be correct in length and type, and ensure all miscellaneous required hardware (i.e. lockwashers) is properly installed. Refer to the applicable aircraft Illustrated Parts Breakdown manual for hardware and order of assembly.

p. Clean all accumulated dust, lint, and foreign materials to a level that the area can be properly inspected.

q. Arch Fault Breakers, verify circuit breaker is not tripped for either thermal or arc.

33. Perform the following mechanical inspections to check circuit breakers for serviceability:

a. Pull the button out and push it in.

(1). Check for abnormally high pullout forces.

(2). Check for abnormally high reset forces.

b. All force measurements should be judged based on a normal feel of the circuit breaker when its pulled and reset (paragraph 61, WP 028 00).

34. Periodic Cycling. During the yearly cycling (or annual flight hour equivalent) inspection maintenance interval, all circuit breakers should be mechanically cycled a total of three pull/push cycles. Pull the button out and push it in three times with no electrical power applied. This helps clean possible corrosion from the contacts. Opening circuit breakers a few times a year does not lower their service life; however, the manual operation of the circuit breaker should be limited to two or three times yearly in order to avoid excessive dynamic wear of the trip mechanism. Refer to WP 028 00.

35. Trip History. Circuit breaker should not be allowed to develop a history of tripping. A tripped breaker may be faulty, may be in a faulty circuit, or may be improperly applied. A tripped circuit merits post flight analysis. The subject breakers should be sent to a higher maintenance level for failure analysis.

36. Replacement. If any circuit breaker does not meet the inspection criteria, the circuit breaker should be replaced.

37. **CATASTROPHIC WIRE HARNESS DAMAGE.** This type of damage includes either direct or representative damage from: burning, smoking, arcing, chafing, or severing of one or more wiring harnesses. When identified, catastrophic damage must be reported within 24 hours, via the Joint Deficiency Reporting System (JDRS) at: http://www.jdrs.mil. Fasteners, plugs, and connectors that sustain this type of damage will have a deficiency report submitted against the harness to which it is attached. In addition, the responsible activity shall ensure prompt reporting of these identified failures thru unit/service applicable safety resources and platform/weapon system specific requirements as well.

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LOW FREQUENCY, MULTICONDUCTOR ROUND CABLE DESCRIPTION AND REPLACEMENTS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directive

None

Support Equipment Required

None

Materials Required

None

1 . **INTRODUCTION.**

2 . This work package (WP) describes the types of cables authorized for use in aircraft wiring. This Work Package describes the characteristics of multiconductor Round Cables typically used in aircraft wiring. The information is only for edification and is insufficient to determine specific cable applications. However, there is sufficient information to determine cable substitution. Part numbers cross-reference for cable substitution or replacement are provided. The selection and installation of cables should be in accordance with AS50881.

3 . The term cable whenever used throughout this WP shall be interpreted as two or more insulated conductors, solid or stranded, contained in a common covering, or two or more insulated conductors twisted or molded together without a common covering, or one insulated conductor with a metallic covering, shield, or outer conductor.

4 . The term wiring whenever used throughout this WP shall be interpreted as wires, cables, groups, harnesses and bundles, associated hardware, terminations, and

installed support. When used as a verb it is the act of fabricating, and installing these items.

5. Multi-Conductor Round Cables vary widely in design configuration, many of which will be discussed in this WP. But all cables serve one or more of the following three principle functions:

a. To provide for a group of wires to be bundled for ease of routing an electrical/optical service to one central location.

b. To provide mechanical protection typically by an insulated jacket.

c. To prevent an electromagnetic signal from interfering with the conductor's electrical signal. This is typically provided by a metal braid, although cross talk effects can be reduced by wire positioning without braids (see WP 011 02).

6. **ENVIRONMENT EFFECTS.**

7. There are numerous environmental conditions, which must be considered when a particular cable is used in an application. These factors are discussed in WP 004 00.

8. **ELECTROMAGNETIC INTERFERENCE (EMI) AND ELECTROMAGNETIC VULNERABILITY (EMV) EFFECTS.** In addition to the typical environmental effects discussed above, stray magnetic fields and electrostatic fields can critically affect signal transmission in electronic and electrical circuits by inducing, radiating, or transmitting voltages (EMI), and by induced, radiated, or transmitted voltages (EMV) that alter transmission signals.

9. **EMI AND EMV PROTECTION.** By using or by employing a shield EMI and EMV can be controlled. A shield is a conducting envelope enclosing a wire, a group of wires, or cable so constructed that substantially every point on the surface of the underlying insulation is at ground potential or some predetermined potential with respect to ground. Shields may be multifunctional in that they may level out surge impedance along the length of the cable, screen a signal from external excitation, confine a signal to its intended path, or in some circuits act as a return as in a coaxial cable. The type of shielding required depends upon the identity of the potential fields in which the circuit will operate either magnetic or electrostatic.

10. **Magnetic Shielding.** Magnetic shielding is employed under three conditions:

a. D.C. and Low Frequency Magnetic fields. The shield will tend to short-circuit the flux lines as these fields attempt to extend through the shield. Shield effectiveness is directly proportional to its thickness.

b. Radio Frequency Magnetic fields. The shield is low resistance and the shield produces eddy currents which tend to oppose the magnetic field.

c. 1 KHz to 1 MHz Magnetic field. Though not as critical as the previous, still need to be cancelled and employ copper and steel tapes, copper braid 50% to 95% coverage or aluminum tape or paper.

11. **Electrostatic Shielding.** Does not present as severe a problem as magnetic shielding since neither the shield thickness nor degree of conductivity is critical. The most important factor is that shield effectiveness is proportional to percent coverage with 100% being desirable.

CAUTION

Observe minimum bend radius requirements for all wiring systems installations. Failure to install wiring with the correct bend radius may result in wiring and associated system degradation and failure.

12. **BEND RADIUS.** The maximum amount a cable can be bent without causing damage to the conductor or insulation is referred to as minimum bend radius (Figure 1). Bending the wire in excess of it's allowable amount (minimum bend radius) will result in the outer insulation to stretch or break, and the inner insulation to compress and wrinkle. For coaxial cables, the insulating dielectric within the cable may be damaged and the signal degraded, or lost. Proper routing and installation is pivotal to wiring system integrity and operation. Refer to WP 010 00, 004 00 and 006 00 for additional information.

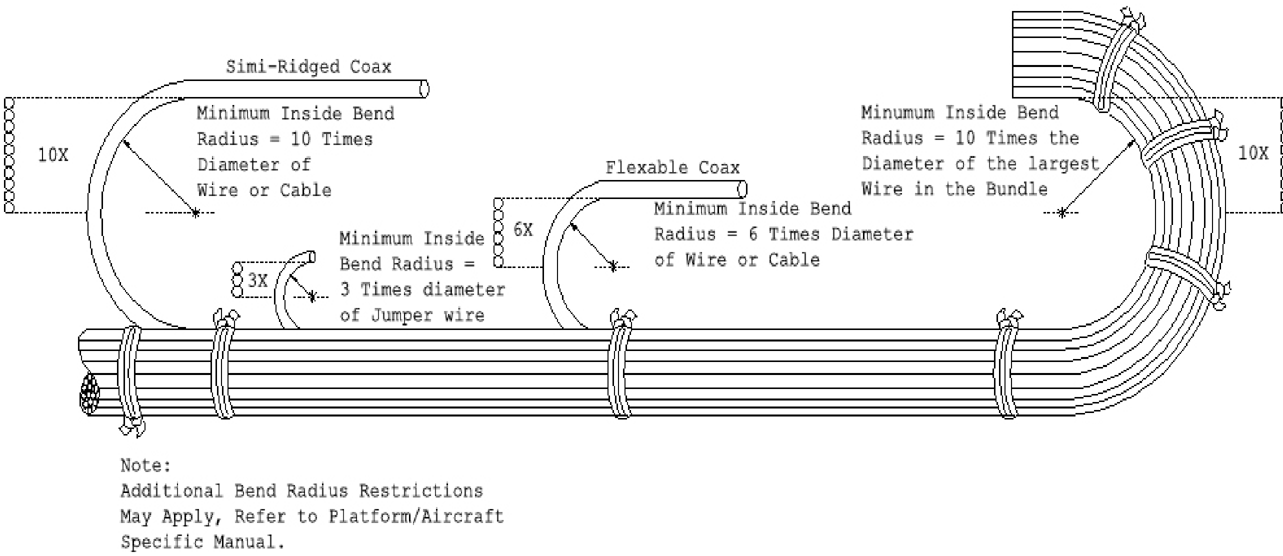

Figure 1. Bend Radius

13 . **Cables.** The minimum bend radius shall be ten times the outside diameter of the cable when individually routed and supported. At the point where an individual cable breaks out from a group, harness, or bundle the minimum bend radius shall be ten times the outside diameter provided the cable is suitably supported.

14 . **Coaxial Cable.** The minimum bend radius shall not adversely affect the characteristics of the cable.

a. When using flexible type coaxial cables, the radius of bend shall not be less than six times the outside diameter.

b. When using semi-rigid type cables, the radius shall not be less than ten times the outside diameter.

15 . **CABLE CONSTRUCTION**.

16 . There is no simple or easy way to classify cables. Some are described by form, general application, specific application, conductor type, insulation type, property, and voltage. A fundamental discussion of cables is difficult because of the variety of cable types. The cables discussed herein are those most commonly found on military aircraft.

17 . **UNSHIELDED CABLES.** Unshielded cables are typically twisted multi-conductors, insulated wires with or without an insulated jacket. Single conductor wires in large diameter (greater than size 4) are also called cables. A twisted unjacketed cable is often used to perform a point-to-point electrical function. The twisted unjacketed wires will have insulations thick enough to provide mechanical protection. When thinner wire insulations are used the cable must be jacketed. A jacket may also be used to provide a better form cable for tight installations. The various types of cable choices are almost unlimited. For applications the cable applications the cable types are restricted by AS50881.

18 . **SHIELDED CABLES.** Shielded cables are typically twisted, multi-conductor, insulated wires with a braided metal shield. The shield will typically be the same material and plating as the conductors in the cable. For aircraft application all shields are supposed to be jacketed. The jacket material will typically be the same as the wire insulation material. In some applications a single conductor insulated wire, shielded and jacketed will also be used. The various combinations of insulation, wire types, number of wires, shield types and jacket types is limited only by the available materials to perform the intended application. For Aircraft the cables type are limited by AS50881.

19 . **SHIELD CHARACTERISTICS.**

20 . **FUNCTION**. A shield is a conducting envelope enclosing a wire, group of wires or cable, so constructed that substantially every point on the surface of the underlying insulation is at ground potential or at some predetermined potential with respect to ground. Shields

perform many and varied functions, both electrical and mechanical. In electronic or electrical systems shields may:

a. Level out surge impedance along the length of the cable.

b. Screen the signal from external excitation.

c. Confine a signal to its intended path.

d. Act as a return.

e. Act as a safety measure in high voltage circuits.

f. Mechanically aid in protection of conductors and insulation.

21 . **SHIELD EFFECTIVENESS.** Stray magnetic and electrostatic fields can critically affect signal transmissions, in electric and electronic circuits, by inducing voltages that alter transmitted signals. Shield effectiveness is the measure of the success of a shield in reducing induced voltages and signal radiations.

22 . **SHIELD CONSTRUCTION.** Braided shields are formed in the same manner as textile braid with copper being substituted for yarn. Braid shield is widely used as it retains its structural integrity (Figure 2).

23 . **SHIELD COVERAGE.** The effectiveness of a braided shield is generally proportional to the amount of coverage espressed as a percentage with 100% being optimum. From an electrical stand point this percentage is unattainable as areas where leakage can occur, however minute, will always exist at points where the shield strands cross. For the majority of audio frequency applications 75% to 85% coverage will prove effective, at higher frequencies 85% to 95% coverage will be necessary for proper effectiveness

24 . **PERCENTAGE COVERAGE.** The percentage of coverage can be calculated and is influenced by four factors:

25 . **Number of Ends Per Carrier.** Generally four to seven are used per carrier. The number of ends effect attenuation and push back characteristics (Figure 3, Item N).

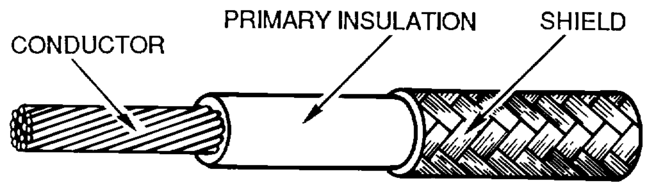

Figure 2. Braided Shield

26 . **Picks Per Inch.** These alter the braid angle (a) and are defined as the smaller of two angles formed by the shield strands and the axis of the cable (Figure 3, Item P).

27 . **Braid Angle.** This angle will always be between 0° and 90° when the number of picks is small and 90° when the number of picks is large. A high braid angle increases attenuation and also increases flexibility and flex life. Therefore shield design will be a compromise. Braid angle is shown (Figure 4).

28 . **Diameter of Individual Shield Strands.** This can be located in individual specifications. Generally size 36 or 34 AWG is used but can be as small as 40 AWG or as large as 28 AWG depending upon intended use (Figure 3, Item D).

29 . **Number of Carriers.** There are usually 16 to 24 carriers used but others may be added or deleted as necessary depending upon intended use (Figure 3, Item C).

a. Carrier refers to the individual braider.

b. 16 to 24 refers to the number of braiders used.

30 . **SHIELD TERMINATION.** There are several methods for terminating braided shields and individual repair and replacement specifications shall be followed in accordance with WP 015 00.

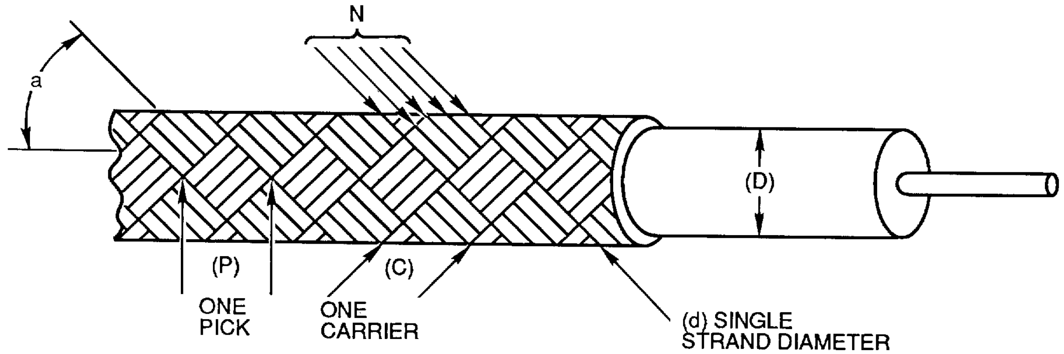

Figure 3. Shield-Constructional Details

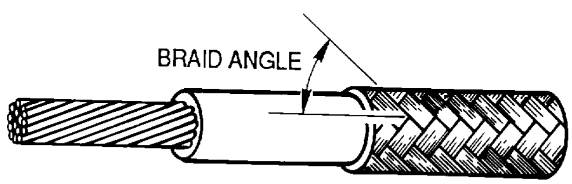

Figure 4. Braid Angle

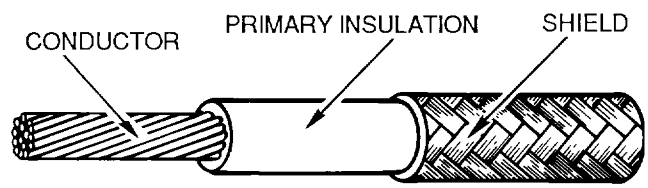

Figure 5. Single Conductor Cable Construction

31 . **SINGLE CONDUCTOR CABLE.**

32 . **DEFINITION.** These cables have one single insulated conductor with a metallic covering, shield, outer conductor, and a jacket or outer covering. These single conductor cables have varied uses and applications. Applicable specifications must be adhered to during repair and replacement, for individual applications and repair (WP 015 00). Each WP will refer to applicable military specifications. The basic construction of a single conductor cable is shown (Figure 5).

33 . **ELEMENTS.** There are three basic elements in the single conductor cable that when combined together during manufacture constitute a single conductor cable (Figure 5).

34 . **Basic Wire.** This basic wire constitutes the single conductor, and shall conform to the military specification for wire (WP 004 00).

35 . **Shield.** A shield or outer conductor will be present and is discussed in detail within this WP.

36 . **Jacket.** The single conductor shield cable will typically have a jacket similar to that shown in Figure 5. The jacket will be an insulating material, probably the same as the primary insulation shown in Figure 5.

37 . **MULTICONDUCTOR CABLES.**

38 . **DEFINITION.** A multiconductor cable may be described as two or more conductors along with those other components as used in single conductor cable. These may be in any combination of conductors and shield. Multiconductor Cables usually have a large number of identical components and when cabled together must be as round, lightweight, and small as possible in overall diameter, without an abundance of large air spaces or voids. These conditions plus, flexing, physical abuse, and electrical parameters must be taken into consideration in the design and manufacture. The basic construction of a multiconductor cable is shown (Figure 6).

39 . **ELEMENTS.** There maybe as few as four elements or as many as are conducive to good design and construction. All the elements listed are not required in cable construction but may be found. A basic multiconductor cable design is shown (Figure 7).

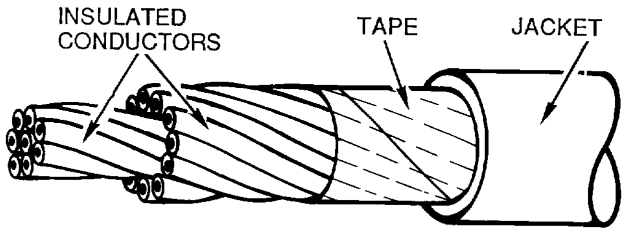

Figure 6. Multiconductor Cable-Twisted Components

40 . **Insulated Conductor Components.** A component is not necessarily one insulated conductor. A component could be a group of insulated conductors. These insulated conductors are termed basic wires and shall conform to the basic wire specifications (WP 004 00).

41 . **Shielding.** A shield may be present in the construction and is discussed in detail within this work package (paragraph 23).

42 . **Fillers.** These are non-conductive materials used to evenly space the insulated conductors, thus avoiding large air spaces and voids.

43 . **Binders.** These are non-conductive materials used to join individual components in concentric patterns.

44 . **Jacket.** The multiconductor cable jacket will be an electrical insulating material, which may or may not be the same as the conductor material compounds. The choice of jacket insulation will depend upon the application environment.

45 . **Armor.** This may be used to protect the cable.

46 . **MILITARY SPECIFICATION CABLES.**

47 . **NEMA–WC27500 CABLE, ELECTRICAL SHIELDED AND UNSHIELDED, AEROSPACE.** In aircraft applications unjacketed shielded cables are seldom used. The more typical types of cables are shown herein.

48 . **Description.** MIL-C-27500 cables typically found in aircraft are unjacketed, jacketed, or shielded and jacketed.

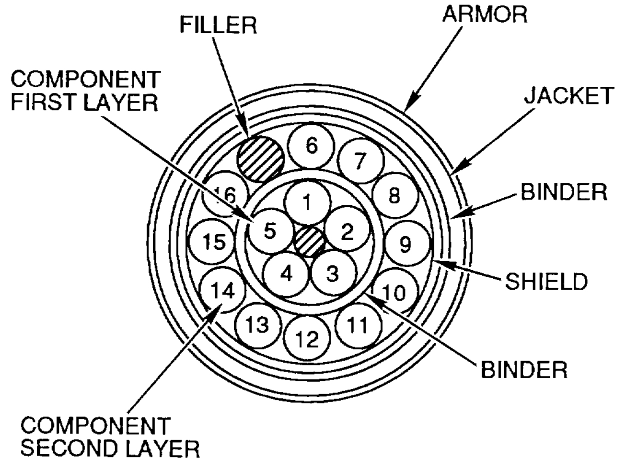

Figure 7. Typical Multiconductor Cable Design

CAUTION

Shielded/unjacketed cable shall not be used on aircraft.

a. Unjacketed cables are twisted (Spirally Laid) wires with no jacket for mechanical protection. The wires will have insulation thick enough to provide the mechanical protection. These types of cables are used to improve the time required to build and install a harness or help to define a point-to-point group of electrical signals. An example of an unjacketed, twisted pair is shown in Figure 8.

b. Jacketed cables are twisted wires with a jacket to provide additional mechanical protection or to help form the cable for ease of installation. Typically, the wires will have thinner insulations than the unjacketed cable. The cable may also be used to define a point-to-point group of electrical signals. An example of a jacketed, twisted form conductor cable is shown in Figure 9.

c. Shielded and jacketed cables are twisted wires with a shield braided over the outside then jacketed. The jacket provides mechanical protection to the shield and wires. The shield provides electromagnetic interference protection for wires. The wires provide a point-to-point group of electrical signals. An example of a shielded/jacketed twisted four conductor cable is shown in Figure 10.

Figure 8. Unshielded/Unjacketed/Twisted

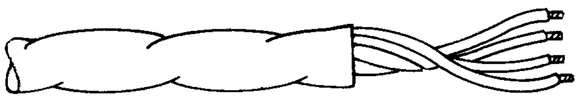

Figure 9. Jacketed/Twisted

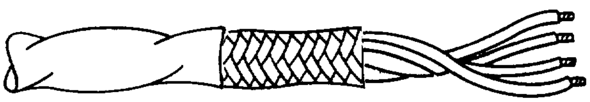

Figure 10. Shielded/Jacketed/Twisted

49 . **Part Number.** The NEMA–WC27500 cable part number is as follows:

a. Example: NEMA–WC27500 A22 CB 3T10

(1) NEMA–WC27500: Defines the military specification, which specifies the cable requirements.

(2) A: Defines the identification method required to clearly distinguish each wire in the cable from all other wires in the cable. The methods may be color code stripe or band code, or print code or a combination of both color and print codes.

(3) 22: Defines the conductor size of each wire in the cable. There are no mixed conductor sizes.

(4) CB: Defines the basic wire types specified by the wire specification. The codes may be one or two digits characters (or letters). For example "CB" refers to a MIL-W-22759/14 wire type. There are no mixed wire types in a cable.

(5) 3: Defines the number of wires in the cable. The code may be one or two digits.

(6) T: Defines the present or absence of a shield, type of shield, and number of shields (one or two).

(7) 10: Defines the jacket type and the number of jackets (one or two). The code is always two digits. The codes 01 through 24 are single jacket insulations and codes 51 through 74 are double jacket insulations. The code 00 means an unjacketed cable.

50 . **Cable Replacement and Repair.** In some cases cable types are nearly functionally interchangeable. Replaceable cables are provided here-in. Repair procedures of low frequency, multi-conductor round cables are provided in WP 015 02.

51 . **Optional Cable Replacements.** Whenever maintenance instructions, diagrams. drawings, etc., specifies a NEMA–WC27500 cable with the basic wire codes shown in Table 1, the cable may be replaced with a different cable as indicated.

CAUTION

Replacement is not mandatory.

Unless otherwise noted in Table 1, only the basic wire code and the jacket code changes for each cable replacement. Single jacket codes 01 through 24 are replaced with 23 and double jacket codes 51 through 74 are replaced with 73. A cable without a jacket is always code 00. Examples are as follows:

a. M27500A20NL2T12. Replaced by M27500A20SD2T23.

b. M27500A20NL2T. Replaced by M27500A20SD2T73.

c. M27500A20NL2T00. Replaced by M27500A20SD2T00.

CAUTION

In rare cases installation maybe difficult due to slight cable diameter increases. Guidance should be requested from the aircraft CFA.

52 . **Recommended Cable Replacements.** Unless otherwise specified by the CFA; whenever maintenance instructions, diagrams, drawings, etc. specify a NEMA−WC27500 cable with MIL-W-81381 basic wires, the cable is recommended to be totally replaced, if removed from the aircraft when funding and time permits. If a cable section is only being replaced, it is also recommended that the full cable be substituted. The replacement cables for the MIL-W-81381 basic wire codes are provided in Table 2.

CAUTION

In rare cases, installation may be difficult due to slight cable diameter increases. See CFA for guidance.

53 . **Aircraft Manufacturer Cable Replacements.** In some older aircraft the manufacturers used cable drawing control numbers rather than military part numbers to define the cable types. CFA guidance is recommended before performing any substitution of these cables.

54 . **SPECIALTY TYPE WIRES.** Specialty type wires include Filter Line Wire (SAE−AS−85485), Firewire (IEEE−1394), Ethernet (ARINC 664) and Universal Serial Bus (USB). These wire types are covered in WP 022 00 thru 022 04.

55 . **CATASTROPHIC WIRE HARNESS DAMAGE.** This type of damage includes either direct or representative damage from: burning, smoking, arcing, chafing, or severing of one or more wiring harnesses. When identified, catastrophic damage must be reported within 24 hours, via the Joint Deficiency Reporting System (JDRS) at: http://www.jdrs.mil. Fasteners, plugs, and connectors that sustain this type of damage will have a deficiency report submitted against the harness to which it is attached. In addition, the responsible activity shall ensure prompt reporting of these identified failures thru unit/service applicable safety resources and platform/weapon system specific requirements as well.

Table 1. NEMA−WC27500 Optional Replacements

Present Wire Code	Replacement Wire Code	Present Wire Code	Replacement Wire Code
A	SD	MD	SP
B	SD	ME	SD
C	SD (Note 1)	MF	SE
M	SP	MG	SP
Y	SR (Note 2)	MH	SD
AA	SD	MJ	SE
AB	SE	MK	SR (Note 4)
AD	SD	ML	SB
BA	SD	MM	SC
BB	SE	MN	SD
BC	SB	MP	SE
BE	SC	RC	SP (Note 3)
BF	SD (Note 3)	SA	SP
BG	SP	SF	SB
BH	SE (Note 4)	SG	SD
BJ	RE (Note 6)	SJ	SC
BK	TN (Notes 4 and 6)	SK	SD (Note 5)
BL	SB	SL	SE
BM	SR (Note 4)	TE	SD
BN	SC	TF	SE
BP	RE (Notes 4 and 6)	TG	SB (Note 2)
BR	TN (Notes 4 and 6)	TH	SC
CA	SD	TM	SC
CB	SB	TP	SE
CC	SC	TR	SB (Note 2)
JB	SP (Note 3)	TS	SC
JC	RE (Note 6)	TT	SD
JD	SE (Note 3)	VA	SP
JE	TN (Note 4 and 6)	YA	SS (Note 2)
MA	SD	YB	SP
MB	SR	YC	SM
MC	SB		

NOTES:
1 Not replaceable for basic wire sizes 03 or 04 (see WP 004 00).
2 Not replaceable for basic wire size 10 (see WP 004 00).
3 Not replaceable for basic wire size 28 (see WP 004 00).
4 Not replaceable for basic wire size 30 (see WP 004 00).
5 Not replaceable for basic wire size 26 (see WP 004 00).
6 Use single jacket code 06 for codes 01 through 24 and double jacket code 56 for codes 51 through 74.

Table 2. NEMA–WC27500 Recommended Replacements

M81381 Wire code	Replacement Wire Code	M81381 Wire Code	Replacement Wire Code
MR	SR (Note 1)	NB	SN (Note 3)
MS	SS (Note 1)	NE	SR
MT	SC	NF	SS
MV	ST (Note 2)	NG	SC
MW	SP	NH	ST (Note 2)
MY	SM	NK	SB (Note 1)
NA	SE (Note 3)	NL	SD

NOTES:
1 Not replaceable for basic wire size 10. See Cognizant EngineeringAuthority for support.
2 Not replaceable for basic wire size 30, See Cognizant EngineeringAuthority for support.
3 Not replaceable for basic wire size 28. See Cognizant EngineeringAuthority for support.

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RADIO FREQUENCY (RF) CABLE CHARACTERISTICS AND REPLACEMENTS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. **INTRODUCTION.**

2. The term RF cable usually implies that the cable is used to transmit radio frequency energy of 500 KHz upwards. Coaxial cables are often used in frequencies below 500 KHz and have many applications in the audio frequency range. All RF cables are commonly called coaxial cables, although they may include multiple conductors separated by multiple insulators. Coaxial cables used at lower frequency are commonly called audio cables. By definition (WP 003 00) audio cables are coaxial cables, because the shield is used as a second conductor. A single conductor shielded and jacketed cable (WP 005 00) looks like a coaxial cable, but the shield is used for EMI/RFI protection, not as a conductor. A coaxial cable is a Radio Frequency (RF) transmission line used for the propagation of Electro-magnetic energy in the transverse mode (TEM). Coaxial cables are commonly known as high frequency cables. The purpose of the Work package is to provide some of the more common characteristics of coaxial cables and replacement information when available.

3. **RF CABLE DESCRIPTIONS.** The cables described herein are the typical types. There are numerous variations depending on the electronic system requirements (Figure 1). When standard cables are not available, designers use MIL-T-81490 Transmission Lines, Transverse electromagnetic mode for guidance. Refer to the specific aircraft manual for repair and installation of these type of cables.

a. **COAXIAL.** A coaxial cable may be defined as two concentric wires, cylindrical in shape, separated by a dielectric of some type. One wire is the center conductor and the other wire is the outer conductor. These conductors are covered by a protective jacket, and this jacket may, in cases, be covered by a protective armor (Figure 2).

b. **TWIN COAXIAL.** A twin coaxial cable consists of two individually insulated conductors within a common shield. These insulated conductors are either laid parallel or twisted and placed concentrically within an additional dielectric cable core. The shield is placed over the cable core protected by a jacket and may be covered by an armor jacket (Figure 3).

c. **DUAL COAXIAL.** A dual coaxial cable is two individual coaxial cables, either laid parallel or twisted around one another and placed concentrically within a common jacket or a common shield and jacket (Figure 4).

d. **DOUBLE SHIELDED.** A double shield is often used when improvements over single shielding are required. This cable has a second shield braided over the first with no insulating barrier between them (Figure 5).

e. **TRIAXIAL.** A triaxial cable is very similar to a coaxial cable and is used when further shielding is required. This cable is cylindrical in shape having a center conductor located concentrically within a dielectric core, but having two shields separated by a dielectric material (Figure 6).

4. **AIR–SPACED CABLES.** Air–spaced cables are semi-solid air–spaced coaxial cables, which incorporate a variety of dielectric designs and outer conductor materials. The exact construction is specified on the cable specification and is selected on the basis of electrical performance and the required physical properties.

a. **Air–spaced–Cable Characteristics.** Air–spaced cable is used where one of the following characteristics is desired:

(1). When low capacitance or low attenuation is desired.

(2). When an overall smaller diameter than other dielectric electrically equivalent cables is desired.

(3). When lesser weight is desired than other dielectrically equivalent cables, but with some sacrifice in dielectric strength.

5. **INNER CONDUCTORS.** The inner conductor, or center conductor, is either solid, stranded, braided or helical, and the conductor may be either bare or coated. Copper is widely used, because it has high electrical and thermal conductivity, malleability, reasonable strength and the ability to be coated with other metals. In cables where increased strength and flexibility are required, copper clad steel conductors are used.

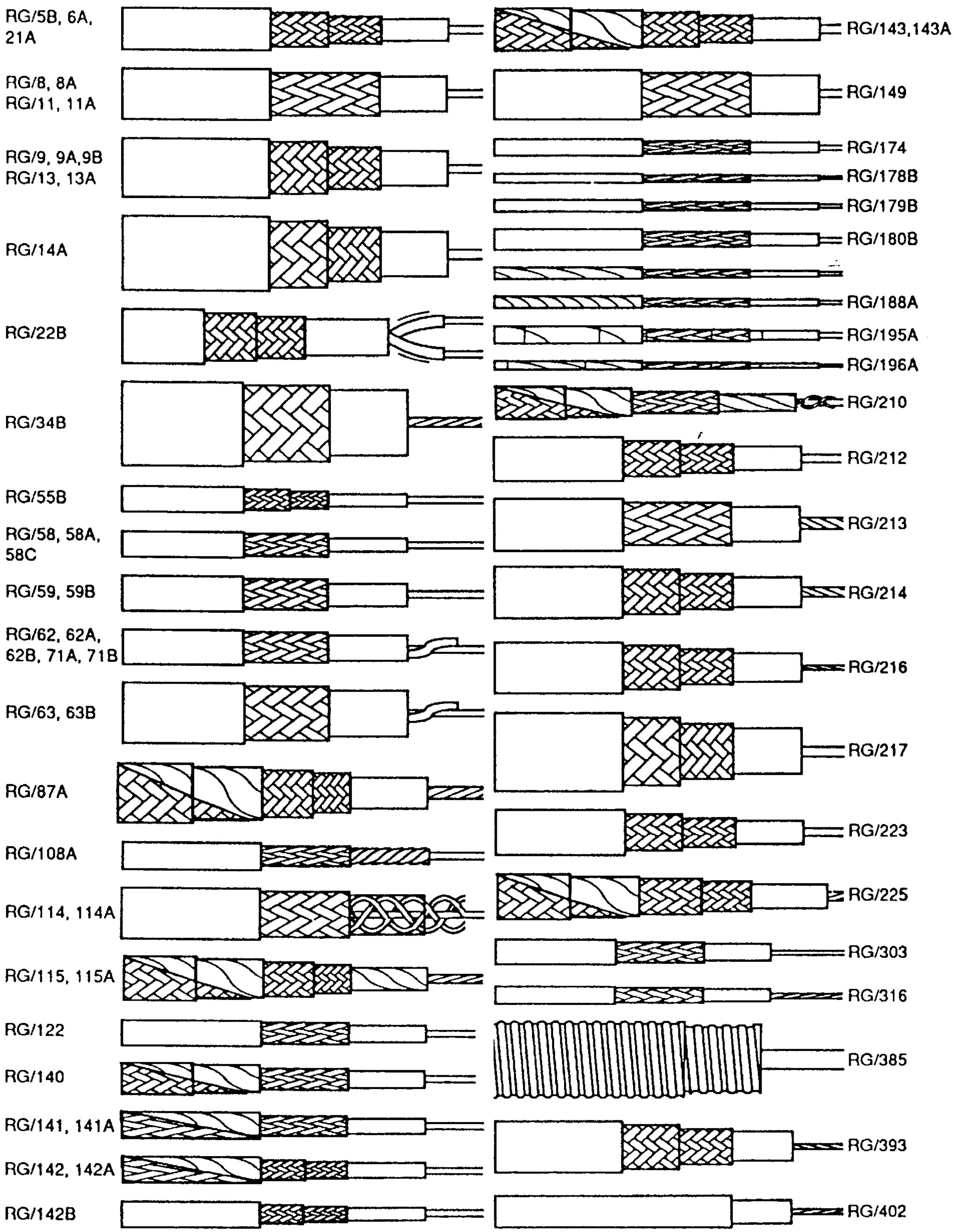


Figure 1. Typical MIL-C-17 Cables

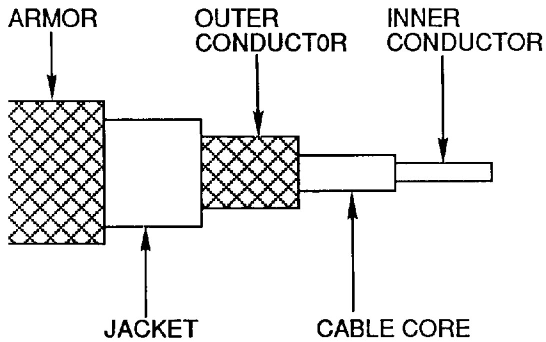


Figure 2. Coaxial Cable

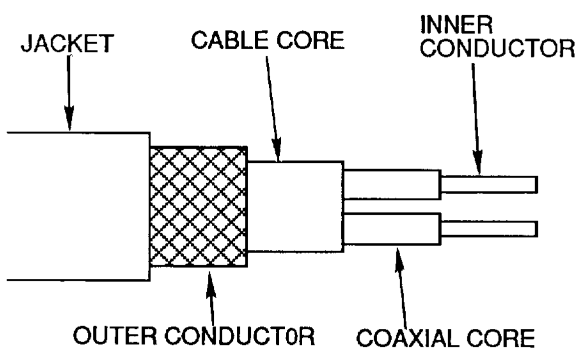


Figure 3. Twin Coaxial (Parallel)

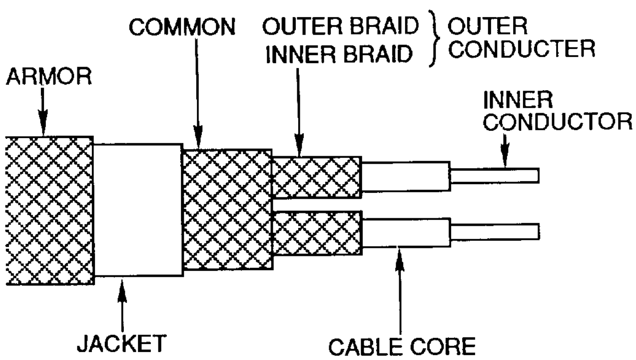


Figure 4. Dual Coaxial (Parallel)

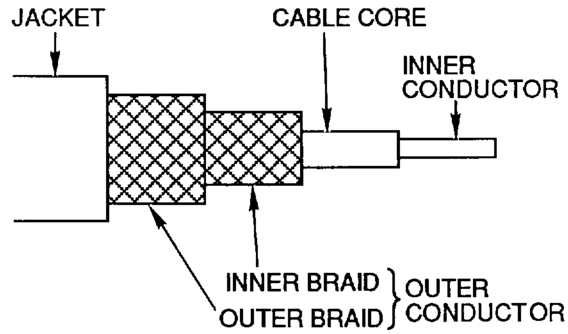


Figure 5. Double Shielded Coaxial

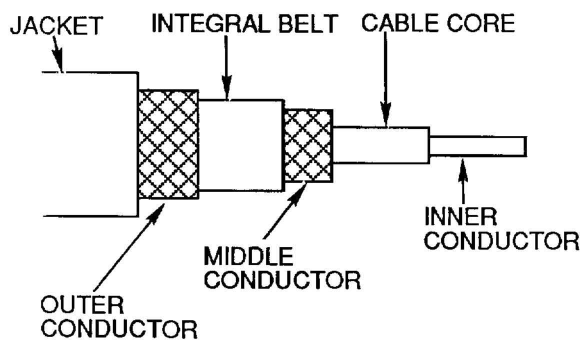


Figure 6. Triaxial Cable

a. **Inner Solid Conductors.** Solid conductors are constructed of multiple conducting metals and different coatings depending on the electrical and physical characteristics required. Examples are as follows:

(1). Bare Copper Wire.

(2). Tin Coated Copper Wire.

(3). Silver Coated Copper Wire.

(4). Copper Clad Steel Wire.

(5). Annealed Copper Clad Steel Wire

(6). Silver Coated Copper Clad Steel Wire.

(7). Annealed Copper Clad Aluminum Wire.

(8). Copper Beryllium Alloy Wire.

(9). Annealed Copper Beryllium Wire.

(10). Silver Coated Wire.

b. **Inner Stranded Conductors.** Stranded conductors are concentrically stranded and are constructed of the same conducting metals as solid conductors. The stranded conductors are coated prior to stranding and are not overcoated.

c. **Conductor Coatings.** Coating the conductor is performed to increase conductivity, prevent oxidation, and increase solderability. Copper by nature, though a good conductor, oxidizes rapidly when heat is applied. This oxidation will appear as a black coating that must be removed, and preferably prevented, before use. Tin and silver are used in varying degrees to achieve the desired electrical and physical characteristics.

(1). Tin Coating. Tin coated conductors act as an aid to soldering. Tin coated conductors will degrade when exposed to elevated temperatures, in that the formation of tin and copper intermetallics causes increased resistance and attenuation.

(2). Silver Coating. Silver coating is employed for cables operating above 302°F (150°C) to about 392°F (200°C), and in higher frequencies where higher conductivity is desired. When exposed to elevated temperatures, interstrand bonding will occur, resulting in a loss of flexibility. Silver migration will also occur, resulting in increased oxidation.

6. **DIELECTRIC CORE CHARACTERISTICS.** A dielectric is by definition any insulating material which intervenes between two conductors and permits electrostatic attraction and repulsion to take place across it. The dielectric core is also a material having the property that energy required to establish the electric field is recoverable in whole or in part as electrical energy when discharged. The material used in dielectric cores is uniform in thickness throughout the cable and consistent to ensure the electrical, environmental, physical, mechanical, and dimensional requirements. The dielectric constant and dissipation factors are constant throughout the cable, but each varies significantly depending on the core material. Changes in core material make for a wide variety of cable designs.

a. **Solid Dielectric Cores.** The dielectric core is either extruded over the conductor or a dielectric tape is wrapped over the conductor then sealed or heat cured.

b. **Air Spaced Dielectric Cores.** Semi-solid air spaced dielectric cores are constructed in such a manner that the air spaces become a basic element of construction. In air spaced cores the conductor is either suspended in foam, or a braid or filament is spiraled around the conductor and placed within spiraled fins of solid dielectric, or placed between tubes of dielectric.

7. **OUTER CONDUCTOR.**

a. **Braided Conductors or Shields.** When braids are used as outer conductors or shields, they are applied with the maximum amount of tension possible to prevent loosening or creeping, but not to cause broken ends. The individual wires used in construction are typically the same conductor metals, and meet the same requirements of the conductor material. Galvanized steel wire may also be used. Tin plate may be used as an alternate to galvanize.

b. **Solid Outer Conductors.** Typically, when solid outer conductors are used they are constructed of seamless, metallic tubing of either copper or aluminum and are 99% pure.

8. **JACKET.** Jackets are designed to be flexible, tough and are applied to the cable tightly and evenly. The jacket may be extruded, single or multiple barrier

tape wrap materials. There could be a barrier tape then an extruded jacket. The jacket provides physical, electrical, and environmental protection for the underlying cable. The jacket color is typically black, but may be other colors depending on material used or applications.

9. **ARMOR.** Armor is typically an aluminum alloy constructed to be rugged, tough, and flexible.

10. **ELECTRICAL CHARACTERISTICS OF RF CABLES.**

11. **THEORETICAL ELECTRICAL CHARACTERISTICS.** Theoretically, a transmission line has four basic parameters which consist of shunt capacitance (C), shunt conductance (G) series resistance (R), and series inductance (L) (Figure 7). Shunt capacitance and conductance are measured between the conductors and series resistance and inductance are measured along the cable length. Any transmission line regardless of length has these basic parameters uniformly and evenly distributed along its entire length. A transmission line may be considered as an infinite number of infinitesimally small sections connected end to end the entire cable length. These parameters are always present and are dependent upon the materials and their physical configurations which regulate the electrical performance of the cable.

a. **Shunt Capacitance.** Capacitance by definition is that property of a system of conductors and dielectrics which permit the storage of electricity when potential difference exists between the conductors. Shunt capacitance is directly proportional to a property of the dielectric called dielectric constant.

b. **Series Resistance.** The series resistance is the loop resistance of the center conductor and the outer conductor and is inversely proportional to the area through which the current flows.

c. **Series Inductance.** The series inductance is inductance due to the magnetic flux linkage which is set up by current flow in the conductors. Inductance is the property that opposes change in current flow which causes current changes to lag behind voltage changes.

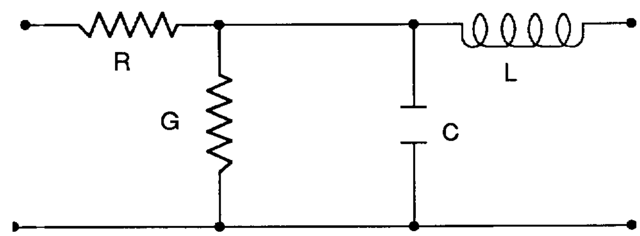


Figure 7. Basic Parameters of a Transmission Line

d. **Shunt Conductance.** The shunt conductance is the amount of conductance between the center conductor and the outer conductor.

12. **ELECTRICAL INFLUENCES.** There are various other electrical properties which influence the operation of coaxial cables and must be realized as their effect will regulate transmission line usage.

a. **Velocity of Propagation.** The velocity of propagation indicates the speed an electrical signal travels down the length of a cable as compared to the speed of that signal in free space. The velocity may be measured or calculated.

b. **Characteristic Impedance.** The characteristic impedance is when the termination to a transmission line yields the same value of the input impedance. When a cable is terminated in its characteristic impedance all energy transmitted down the line is absorbed in the termination. Any other termination will cause energy to be reflected. A line terminated in its characteristic impedance is then said to be matched.

c. **Attenuation.** All transmission lines and coaxial cables experience losses. These losses termed attenuation decrease the efficiency of the line which in turn limit the power capabilities. This power loss, power drop, or signal loss is expressed in decibels (db).

d. **Voltage Standing Wave Ratio (VSWR).** Whenever a transmission line is terminated in its own characteristic impedance, all energy sent down the line will be absorbed. If the line is terminated in any other impedance energy will be reflected. VSWR is the ratio of the transmitted energy and the reflected energy.

e. **Power Rating.** The maximum RF power a coaxial cable may safely transmit is the power rating, and is influenced by the voltage introduced to the peak power or the thermal heating due to average power.

f. **Power Handling.** The average power handling capacity is determined by the attenuation of the line and the minimum temperature the dielectric and conductor can withstand continuously. Excessive temperatures can result in conductor migration into the dielectric and mechanical damage due to different expansion rates.

13. **ELECTRICAL REFLECTION.** Reflection is energy that does not reach its intended load which causes increased attenuation, and it is desirable to minimize reflection for several reasons:

a. The reflection can cause echoes that will transmit false information.

b. A high VSWR can exceed the voltage rating of the cable.

c. Conductor maximum temperature can be exceeded.

14. **REFLECTION CAUSES.** Even though a cable is terminated in its own characteristic impedance, reflection can occur for various reasons.

a. The cable itself can be less than perfect and be nonconforming due to variations in the diameter of the cable core, poor concentricity of the conductor, or variation in the braid.

b. Improper installation can cause reflection as the cable could be damaged by exceeding the bend radius, improper connector assembly, or even improper connection.

15. **CORONA.** Corona is the ionization of the air that may exist within a coaxial cable and is a continuing problem of transmission lines. The Corona effect increases with altitude, but can be a factor at sea level, if the cable voltage is significantly high. Corona is produced by self-sustained electrical discharges within the cable's limited air spaces. These limited spaces are normally caused by improper manufacturing techniques and will cause corona to initiate at a much lower voltage than in a properly manufactured cable. Corona simply stated is caused by a difference of potential between the conductors.

a. **Corona Effect.** Corona has three effects on the performance of a coaxial cable in that it will cause premature electrical failure of the dielectric, cause interference with electrical, communication, and measurement systems, and reduce efficiency due to energy loss while power consumption is increased.

b. **Corona Initiation.** Corona initiation is the voltage level necessary to start corona which is a slightly higher voltage than the voltage necessary to sustain corona.

c. **Corona Extinction.** The extinction is the voltage level necessary to stop corona and may be as much as 20% below the initiation voltage. The extinction voltage determines the maximum voltage at which a coaxial cable may operate.

16. **ENVIRONMENTAL EFFECTS.** There are numerous environmental conditions that affect the performance of a RF cable. The typical ones are discussed herein only for information. Determining which cables to use from this information is not recommended (see AS50881).

NOTE

Cold temperature environments may cause RG–58 and RG–214 coaxial cables with polyethylene dielectric to back the pin out of coaxial connectors. The polyethylene shrinks more than the shield and outer insulation resulting in a poor if non existent connection at the coaxial cable/connector junction.

The problem is hidden within the connector and corrects itself in warmer temperatures. Arcing occurs at the contact point when this problem occurs. The arcing causes the destruction of the junction (high power) or a significant increase in connector loss when operating in cold temperatures.

High altitude contributes to the problem due to the decrease of the gap required for arcing. In many aircraft installations, the temperature may decrease lower than the expected −55 degrees Celsius.

Right angle coaxial connectors do not have the pin penetration, into the connector receptacle, that exists in the straight connectors and have a higher probability of this problem occurring.

For the reasons given above, it is not recommended, unless absolutely necessary, to use coaxial cables with polyethylene dielectric and right angle connectors

RG−400 or equivalent can be used in lieu of RG−58 cable and RG−393 or equivalent can be used in lieu of RG−214 cable.

a. **Temperature.** The effects of temperature, as with any wire or cable, fall into two basic and broad categories; performance degradation and physical deterioration. The degrading effects of temperature can occur at high temperatures as well as low temperatures. The most noticeable change will be in attenuation as this will increase and decrease proportionally with conductor temperature. The permanence and dissipation factor of the dielectric material are comparatively constant over its useful temperature range, and the electrical parameters are virtually independent, other than attenuation, over short periods of temperature fluctuations. Most degrading is attributable to the effects of repeated flexure over wide temperature extremes due to the wide difference in the expansion rates of metal and dielectric material. This can lead to kinking of the cable which causes conductor and dielectric material damage.

(1). Maximum temperature is the ambient temperature plus rise due to power transmission or conductivity. The maximum temperature determines the rate of aging and thermal endurance. Temperature degradation is a function of time in that maximum permissible temperature is higher for a short period of time than that permissible for continuous service.

(2). When cables are operated at high temperatures, then reduced, mechanical fittings can loosen, the corona limit will be reversed, and changes in impedance may be noticed. Cables operated above the upper temperature limits may cause plastic flow and softening which could dislodge mechanical connectors.

(3). Low temperatures, aside from changes in electrical characteristics, tend to make the insulations and dielectrics brittle. When moved, cracks will develop. These cracks, however minute, will continue to degrade even in the normal operating range of temperatures.

b. **Pressure and Humidity.** Variations in pressure and humidity will affect voltage and power ratings of transmission lines and must be considered. To overcome these differentiations and to minimize corrosion some nominal pressurization is employed in almost all rigid and semi rigid air spaced coaxial cables. Without this pressurization corona is more likely to occur as the cables try to obtain pressure equalization. The density of the air also affects the ability of the line to dissipate heat. At sea level virtually all heat is dissipated by convection. This convection is decreased at altitude in rarified atmosphere which will severely change the electrical characteristics. Humidity is of little concern for the cable, as the cable is normally sealed and non−hydroscopic. The connectors however, may collect water and other contaminants. At certain combinations of temperature, humidity, and pressure, condensation will form in and around these connectors causing possible arc-over. In all cases these connectors should be designed to be located to properly drain off water or be protectively sealed.

CAUTION

Observe minimum bend radius requirements for all wiring systems installations. Failure to install wiring with the correct bend radius may result in wiring and associated system degradation and failure.

17. **RADIUS OF BENDS.** The bend radius should be kept as large as possible during storage, handling, and installation so as not to damage the cable. The minimum bend radius shall be such as not to adversely affect the characteristics of the cable. Refer to Figure 8, and WP 004 00, 005 00 and 010 00 for additional information.

a. **Flexible Cable.** The bend radius for flexible type cable shall not be less than six times the outside diameter of the cable.

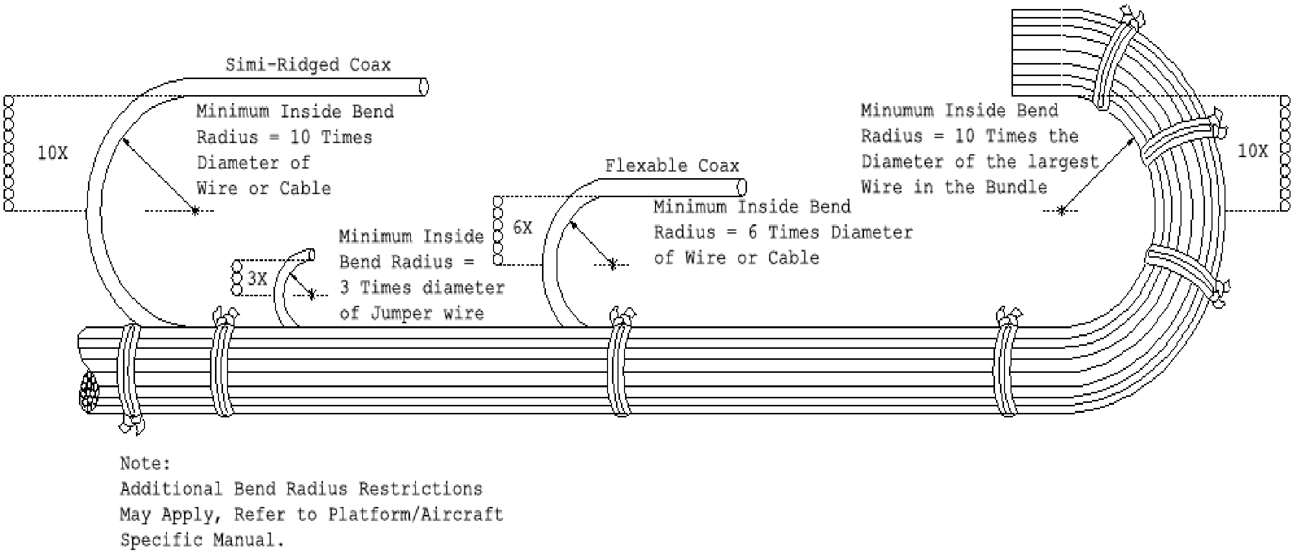


Figure 8. Bend Radius

b. **Semi-Rigid Cables.** The bend radius for semi-rigid cables shall not be less than ten times the outside diameter of the cable.

c. **Right Angle Fitting.** Wherever and whenever possible, right angle fittings shall be used to eliminate stress caused by sharp bends.

d. **Bend Effects.** The bend radius when exceeded will cause stress to the cable. These stresses not only affect the electrical characteristics but physical properties also. When the cable is stressed, fractures to the dielectric and jacket will occur, and the braid shield may break or loosen which will cause a reduction in the corona level as well as causing erratic attenuation at higher frequencies. The center conductor may also migrate through the dielectric to the outer conductor and eventually short the system. These fractures may not be noticed when the stress occurs but is accelerated greatly by ultraviolet rays of sunlight, and by atmospheric ozone which is increased in the presence of corona.

18. **MILITARY SPECIFICATIONS.**

19. **MIL-C-17 CABLES, RADIO FREQUENCY, FLEXIBLE AND SEMI-RIGID.** This specification covers flexible and semi-rigid cables with solid and semi-solid dielectric cores, with single, dual and twin inner conductors. Cables covered by this specification are primarily intended for use as transmission lines to conduct energy in a simple power transfer continuously or intermittently. In general these cables are designed for low loss stable operation from the relatively low frequencies through the higher frequencies in the microwave and radar regions of the frequency spectrum. Cables may also be used as circuit elements, delay lines, or impedance matching devices.

a. **Part Number.** The MIL-C-17 cable specifications cover numerous types of radio frequency cables each designed with unique characteristics (Figures 1 thru 6). Because of the wide variety, each cable type is defined in individual detailed specification sheets. The part number is as follows:

(1). Example M17/001-00001.

(2). M17: Basic specification describing performance requirements.

(3). /001: Detail specification describing specific configuration and electrical properties of the cable type.

(4). -00001: Dash number, which depicts slight difference in the cable type. There are usually only a few dash numbers, if more than one.

b. **Repair And Replacements.** The RF cable shall be repaired in accordance with WP 015 00. Coaxial cables cannot be partially replaced. Older cables can be replaced with new cables when replaced point to point. See the aircraft Cognizant Engineering Authority for guidance. See MIL-C-17 for old RG part number substitutions.

Table 1. MIL-L-3890 Replacement Cables

RG Cable	M3890/Cable	RG Cable	M3890/1 Cable
RG-151/u	/1-10	RG-154/u	/1-04
-152/u	/1-02	-155/u	/1-08
-153/u	/1-06	-382/u	/1-05

20. **MIL-L-3890 LINES, RADIO FREQUENCY TRANSMISSION (COAXIAL AIR DIELECTRIC).** This specification covers the requirements for radio frequency coaxial or air dielectric lines using copper or aluminum conductors. These transmission lines are used to transmit RF energy in the microwave region of the frequency spectrum.

a. **Part Number.** The MIL-L-3890 part number is as follows:

(1). Example: M3890/2-01010

(2). M3890: Basic specification describing the performance characteristics.

(3). /2: Detail specification defines specific cable details.

(4). -01: First two digits define a specific configuration.

(5). 010: Last three digits define a specific length in inches.

b. **Installation and Repair Sensitivity.** These cables are very sensitive to repair and installation. The electrical performance of the cable changes significantly with slight changes in cable configuration. The most notable effects are as follows:

(1). Bow. The natural bow or flex must not be greater than 1/2 inch between any two points 10 feet apart or electrical degradation will occur.

(2). Concentricity. The outer and the inner diameters of the conductors at any cross section must not differ more than 1% from the specified diameter or electrical degradation will occur.

c. Classification. These transmission lines are classed by the applicable military specifications and cables selected shall meet the requirements of these specifications as follows:

(1). MIL–L–3890/1 Lines RF Transmission (Coaxial, Air Dielectric) 50 ohms.

(2). MIL–L–3890/2 Lines RF Transmission (Coaxial, Air Dielectric) 75 ohms.

CAUTION

Handle cable with care during repair and installation.

d. **Repair and Replacement.** The cables should be repaired in accordance with WP 015 05. Cables identified with the RG numbers noted in Table 1 may be replaced with the indicated MIL-L-3890 cables.

21. **MIL–DTL–22931 CABLES, RADIO FREQUENCY, SEMI-RIGID, COAXIAL, SEMI-AIR-DIELECTRIC.** This specification covers semi-air-dielectric, coaxial, semi-rigid radio frequency cables with smooth, corrugated, or braided outer conductors. The diameter range is 1/2 to 3 1/4 inches with an impedance of 50 or 75 ohms operating within -67°F to +176°F (-55°C to +80°C) or -67°F to 392°F (-55°C to +200°C). These cables are intended for use in communications equipment.

a. **Part Number**. The MIL–DTL–22931 part number is as follows:

(1). Example: M22931/11-001

(2). M22931: Basic specification describing the performance characteristics.

(3). /11: Detail specification defining the specific cable details.

(4). -001: Defines cable configuration.

Table 2. MIL–DTL–22931 Replacement Cable

RG Cable	M22931/Cable	RG Cable	M22931/1 Cable
RG–197/u	/11–001	RG –255/u	/11–004
–232/u	/11–002	–257/u	/13–003
–233/u	/13–001	–258/u	/13–004
–236/u	/9–001	–269A/u	/11–005
–237/u	/9–002	–270/u	/13–005
–240/u	/13–002	–285/u	/17–001
–252/u	/8–003	–318/u	/11–006
–253/u	/8–004	–319A/u	/13–006
–254/u	/11–003	–378/u	/l3–007

NOTE

The cable shall be repaired in accordance with WP 015 00. Cables identified with the RG numbers noted in Table 2 may be replaced with the indicated MIL–DTL–22931 cables.

22. **MIL-C-23806 CABLES, RADIO FREQUENCY, COAXIAL, SEMI-RIGID, FOAM DIELECTRIC.** MIL-C-23806 cables are foam dielectric coaxial cables with a smooth outer conductor. The cables may be jacketed or unjacketed with a nominal diameter size of 1/2 or 7/8 inches. The cable impedance is 50 or 75 ohms. Foam dielectric cables are noted for their low loss characteristics. Attenuation loss in a foam dielectric cable normally is not quite as low as that in an air dielectric cable especially at higher frequencies (see MIL–DTL–22931 and MIL-L-3890), but is approximately 15 percent lower than the attenuation in a solid polyethylene dielectric cable of a corresponding size (see MIL-C-17). The average power rating of foam cable (as limited by temperature rise) is between solid polyethylene (which has a lower power rating) and air dielectric (which has a higher power rating) for corresponding cable sizes. Even though foam cables have a greater attenuation loss than corresponding air dielectric cable, the foam cable has one major advantage in that it does not have to be pressurized with dry air or nitrogen.

a. Example: RG-231/u

(1). RG: Basic cable description which when combined with the remaining parts of the part number (-231/u) determines which detail MIL-C-23806 specification is applicable. For example RG-231/u refers to MIL-C-23806/1. The detail specifications tie the particular RG cable to the basic specification MIL-C-23806.

(2). -231: Basic Cable Design. Digits are three numerical number with or with out a fourth alphabetical character; (A, B, C, etc.) which indicates a modification of the basic design.

(3). /u: Basic cable classification indicator. The designation "/u" indicates a general utility cable for airborne, shipboard, and ground applications.

b. __Part Number.__ The MIL-C-23806G part number is as follows:

c. __Repair and Replacement.__ The cable shall be repaired in accordance with WP 014 00. There are no cables that can replace MIL-C-23608 cables.

d. __RG Part Substitutions.__ The old RG cables are being replaced by military specification part numbers as needed. The RG cables listed in Table 1 and 2 may not be the only RG cables that may be substituted. When an RG cable is specified, review the appropriate military cable specification for substitution or contact the aircraft Cognizant Engineering Authority for support.

23. __CATASTROPHIC WIRE HARNESS DAMAGE.__

24. This type of damage includes either direct or representative damage from: burning, smoking, arcing, chafing, or severing of one or more wiring harnesses. When identified, catastrophic damage must be reported within 24 hours, via the Joint Deficiency Reporting System (JDRS) at: http://www.jdrs.mil. Fasteners, plugs, and connectors that sustain this type of damage will have a deficiency report submitted against the harness to which it is attached. In addition, the responsible activity shall ensure prompt reporting of these identified failures through unit/service applicable safety resources and platform/weapon system specific requirements as well.

CONNECTORS, WIRING AND HARNESS STOWAGE
FOR OPERATIONAL AND NON−OPERATIONAL AIRCRAFT

Reference Material

Cap, Electrical (Wire End, Crimp Style, Type II, Class 1) . . . . . SAE AS25274
Cleaning And Corrosion Control Volume III, Avionics And Electronics (Joint Service Manual) . . . . . NAVAIR 01−1A−509−3
Preservation of Naval Aircraft . . . . . NAVAIR 15−01−500
Tape, Lacing and Tying Glass A–A–52083
Tape, Lacing and Tying Aramid A–A–52084
Tape, Pressure Sensitive MIL–I–46852

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation	Nomenclature
M22520/5–01	Crimp Tool	M22520/10–101	Die, Crimp Tool
M22520/10–01	Crimp Tool	HT−900B	Heat Gun (or equlivent)
M22520/5–100	Die, Crimp Tool	M22520/3–9	Inspection Gauge
M22520/10–100	Die, Crimp Tool	M22520/3–10	Inspection Gauge

Materials Required

Specification/ Part Number	Nomenclature
101A052	Connector End Cap
101A062	Connector End Cap
101A073	Connector End Cap
101A083	Connector End Cap
101A094	Connector End Cap
SAE AMS DTL–23053	Heat Shrinkable Tubing
D–436–0184	Sealing End Cap
D–436–0185	Sealing End Cap
D–436–0186	Sealing End Cap
A-A-59163–1/ MIL–I–46852	Tape, Pressure Sensitive
A–A–52084	Tape, Lacing and Tying Aramid
A–A–52083	Tape, Lacing and Tying Glass
AD89503–01–18	Tape, Stretch Seal
AD89503–01–24	Tape, Stretch Seal
AD89503–01–36	Tape, Stretch Seal

1. **INTRODUCTION.**

2. This Work Package (WP) covers stowage of connectors and harnesses as well as capping and stowage of terminated wires, associated tools, assembly, and procurement information.

3. **ELECTRICAL CONNECTOR AND WAVEGUIDE PROTECTION AND STOWAGE.**

NOTE

The following guidance on how to protect and stow electrical connectors and waveguide connections applies only if there are no specifically designated procedures available in the platform specific manual or technical order.

4. Protection and stowage of connectors and wave guides is dependant upon the operational environment they are in. It is defined as follows:

a. Operational: while the aircraft is in ready for flight status.

b. Non–operational: Aircraft is not in ready for flight status, (major maintenance either scheduled or unscheduled).

c. Long term: Planned stowage of system connectors or waveguides available for use during specific mission configurations, but not regularly used on a daily basis or when in preservation for longer than 28 days. DEPOT level maintenance may use plastic caps provided they do not present an ESD danger to the system involved and all plastic caps are removed prior to aircraft return to operation.

d. Short term: Components removed for system maintenance (28 days or less) or when turned in for repair.

CAUTION

Plastic caps shall not be used for aircraft at any time on ready for flight aircraft, as they are a FOD hazard. Only military standard metal covers, heat shrinkable caps or pressure sensitive tape are authorized.

NOTE

For Depot Maintenance Only. The use of plastic caps only prevents contamination of equipment from airborne particles present in repair shops/supply spaces, but are not suited for on–aircraft use without additional moisture control (connector CPC is acceptable provided they are inspected at regular intervals and CPC is reapplied as required).

5. **Operational–Long Term.** Military standard metal covers shall be used in lieu of plastic covers or ESD bags in these cases. If military standard metal covers are not available refer to connector stowage for swamp area (paragraph 10a) or operational–short term. Connectors must be preserved, and at regular intervals (Navy, see NA 15–01–500) cleaned and re–preserved, refer to WP 026 00 for detailed cleaning and preservation procedures.

6. **Operational–Short Term.** During organizational/unit level maintenance, many electrical connectors may be exposed. Military standard metal covers are preferred. Connectors must be preserved and at regular intervals (Navy, see NA 15–01–500).

cleaned and re–preserved, refer to WP 026 00 for detailed cleaning and preservation procedures. If military standard metal covers are not available, proceed as follows:

CAUTION

No tape other than pressure sensitive tape, AA59163–1, MIL–I–46852 (NSN: 5970–00–955–9976) is authorized for use on wave guides or electrical connectors. Air Force only, refer to T.O. 00–25–234 for taping of wave guide connectors.

Do not use aluminum foil as a protective cover on electrical connectors. The use of aluminum foil as a cover could cause an electrical short circuit.

Failure to apply CPC prior to connector stowage and reapplication at required intervals will result in corrosion damage to the connector. CPCs are not to be used on connectors containing fiber optics, refer to NA 01–1A-505–4.

7. If military standard metal covers are not available, ensure connectors are cleaned of contaminants (WP 026 00) and cap off / protect electrical connectors or waveguides with pressure sensitive tape, AA59163–1, MIL–I–46852 (NSN: 5970–00–955–9976), refer to NA 01–1A–509–4 or 5 (Volume IV or V, Chapter 2) (See Figure 1) or capped per paragraph 10a for SWAMP areas. Secure connector per paragraph 10 (a) 6 a thru d, below. In no case will any other tape be used to seal or cap off electrical connectors. Connectors must be preserved before capping and at regular intervals (Navy, see NA 15–01–500) cleaned and re–preserved, refer to WP 026 00 for cleaning and preservation procedures.

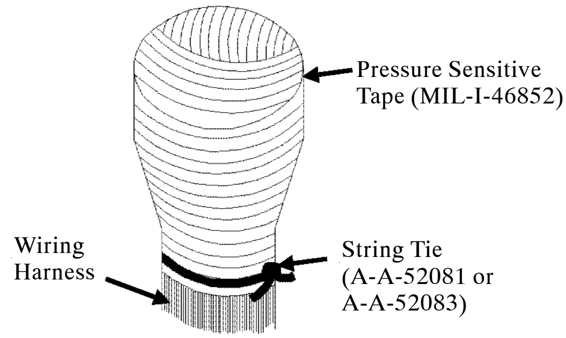


Figure 1. Tape Wrapped Connector

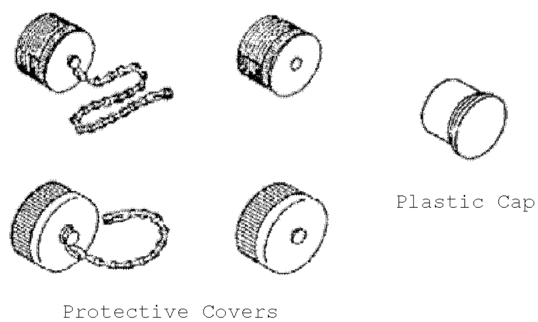


Figure 2. Typical Protective Covers

8. **Non–Operational–Long or Short Term.** Same requirement as for operational – short term (refer to steps above).

9. Standard protective covers for connectors are listed in the applicable connector specification, and NA 01–1A–505–2, or –3. Protective covers are available with or without an attaching chain (Figure 2).

10.. **ELECTRICAL CONNECTOR AND WAVEGUIDE PROTECTION AND STOWAGE IN SWAMP AREAS.**

CAUTION

Ensure that minimum bend radius of 10 times the largest wire diameter to be stowed while coiling the wire.

Failure to apply CPC prior to connector stowage and re–application at required intervals will result in corrosion damage to the connector.

NOTE

The following connector capping method is for Severe Wind and Moisture Prone (SWAMP) applications with temperature up to 150° C. It may be used for all areas if standard metal covers are not available.

a. Connector Stowage for SWAMP areas (circular multipin and RF connectors).

(1) Clean and preserve connector to be capped WP 026 00.

(2) Measure the connector diameter. Select the heat shrinkable cap with the smallest expanded diameter to fit over the connector (Table 1).

(3) Select the correct material for the application.

(4) To build part number, select part number for right size (Table 1), add dash number for the material type (Table 2) and add –0 for color black (standard). For example, the part number of a 1" ID, 2.4" long connector boot made of Flexible Polyolefin, color black is: 101A062–4–0 (see Figure 3).

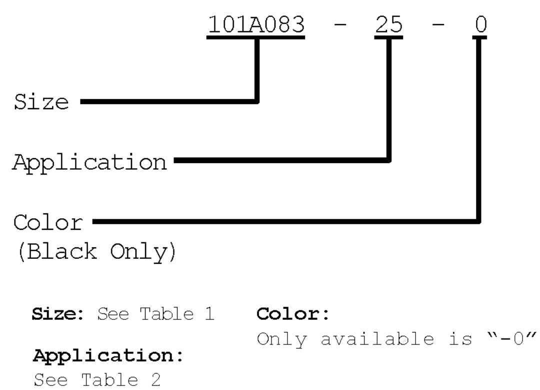


Figure 3. Heat Shrinkable Connector Caps Part Number

Table 1. Size of Heat Shrinkable Connector Caps

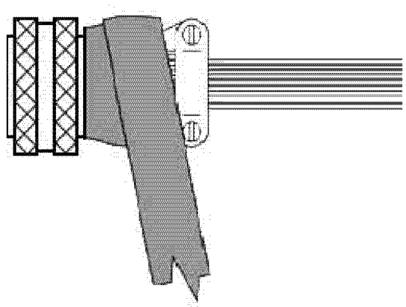
	Inner Diameter (inches)		Length, As Supplied After Shrinking (in)	Color	CAGE
Part Number	As Supplied	Shrunk			
101A052	.81	.37	2.4	Black	06090
101A062	1	.45	2.7	Black	06090
101A073	1.55	.71	3.6	Black	06090
101A083	2	.90	4	Black	06090
101A094	3.3	1.5	4.5	Black	06090

Table 2. Application of Heat Shrinkable Connector Caps

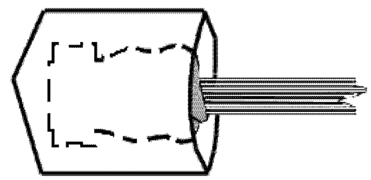
Material Dash Nr.	Material Type	Application
–3	Polyolefin, Semi–Rigid	Maximum sustained temperature of 135 °C/275°F
–4	Polyolefin, Flexible	Maximum sustained temperature of 135 °C/275°F
–25	Elastomer	Maximum sustained temperature of 150 °C/305°F
–100	Polyolefin, Semi–Flexible, Halogen–Free	Maximum sustained temperature 135 °C/275°F, for pressurized/inhabited compartments

Table 3. Stretch Seal Tape

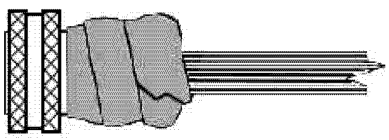
Connector Sealing	AD89503–01–18	1″ x 18″ Stretch Seal Tape	1560–01–531–8365
Connector Sealing	AD89503–01–24	1″ x 24″ Stretch Seal Tape	8030–01–520–8054
Connector Sealing	AD89503–01–36	1″ x 36″ Stretch Seal Tape	8030–01–531–6541



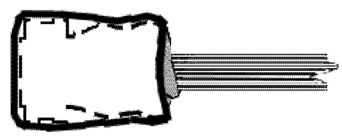
Starting AD89503–01–## Tape Wrap



Heat Shrinkable Cap Over Tape (As Supplied)



AD89503–01–## Tape Wrap Complete



Heat Shrinkable Cap Over Tape (Fully Recovered)

Figure 4. Swamp Area Long Term Connector Stowage

(5) Apply Stretch Seal Tape AD89503–01–## (Table 3) by beginning wrapping the Stretch Seal tape around the connector to be protected, behind the coupling ring (nut). Stretch the tape 25 to 50% to ensure good compression around the connector body and rear accessories. Continue to apply the Stretch Seal tape with a 50% overlap. Refer to Figure 4.

(6) Slide shrinkable end cap (Figure 4) over the connector and shrink/recover using approved heat gun in WP 012 00.

(a) Secure connector in vertical position using AS21919 cushioned clamp (Figure 5) such that the identification tag is exposed and can be readily seen. If hardware attachment hole in adjacent structure is not available, do not drill into structure without specific direction and approval from cognizant engineering authority.

(b) If clamping to structure cannot be used, secure to adjacent wire bundle (if available to place the connector in a vertical direction with the connector up) (Figure 6)

(c) If clamping to structure and wire bundle cannot be used, secure to adjacent structure using lacing and tying tape A–A–52084 (Figure 7).

(d) If no vertical adjacent mounting available, attach connector using one of the pervious three methods, route harness to include a drip loop to prevent moisture accumulation in the connector (Figure 8).

b. For Typical, Non–SWAMP Applications. Secure the protected connector in accordance with paragraph 10a(6), and Figure 5 thru 8.

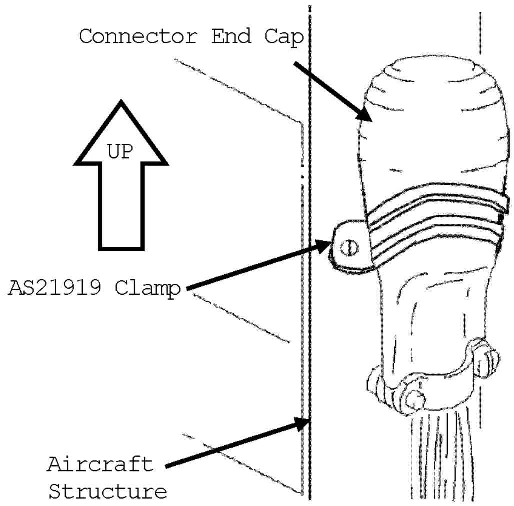


Figure 5. Connector Secured to Structure
Using AS21919 Clamp Connector End Cap

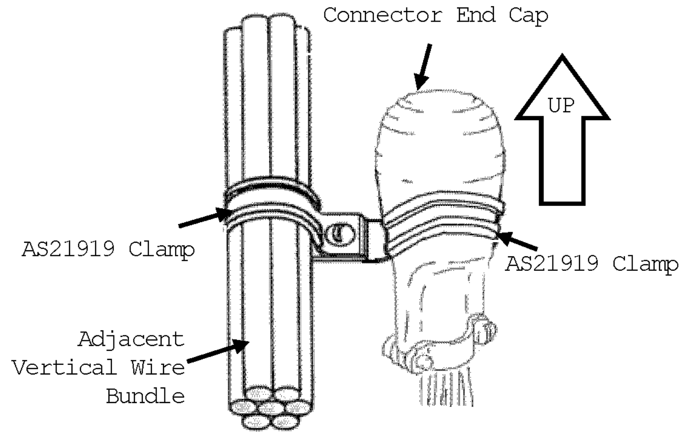


Figure 6. Connector Secured to
Adjacent Vertical Wire Bundle

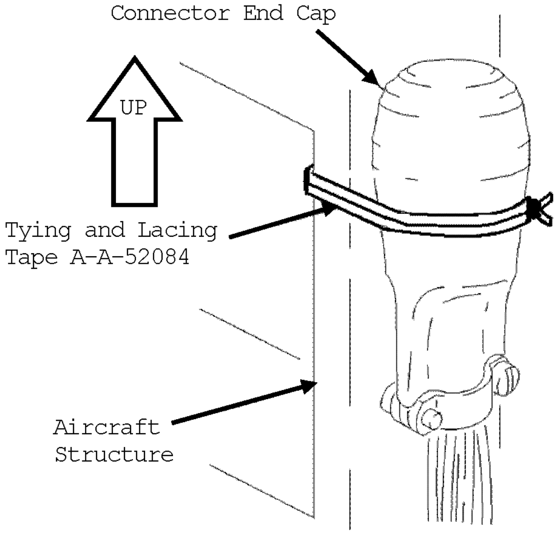


Figure 7. Connector Secured to Structure
Using Tying and Lacing Tape

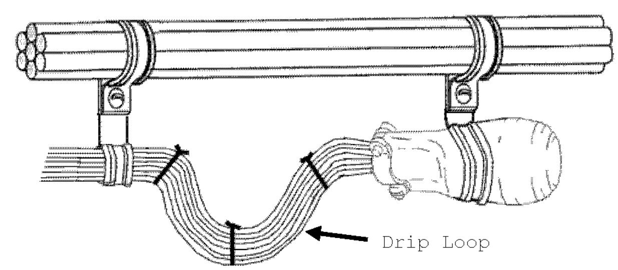


Figure 8. Drip Loop for Horizontal
Mounted Capped Connector

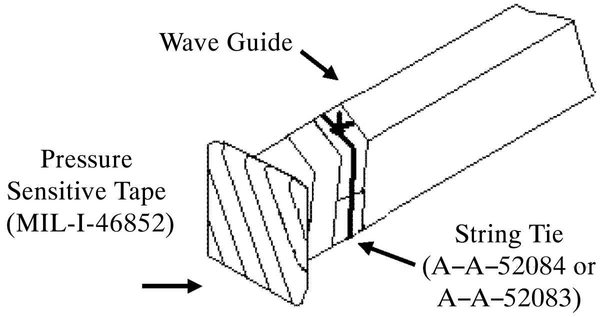


Figure 9. Tape Wrapped Wave Guide

11.. **WAVE GUIDES.** Wave guides must be kept extremely clean and dry, even the slightest amount of moisture or smallest speck of dirt can reduce the effectiveness of the device to transmit proper wave forms. Wave guides should be provided with attached covers but if not only pressure sensitive tape, A-A-59163–1, MIL–I–46852 (NSN: 5970–00–955–9976), is authorized for use on wave guides or electrical connectors.

CAUTION

No tape other than pressure sensitive tape, A-A-59163–1, MIL–I–46852 (NSN: 5970–00–955–9976), is authorized for use on wave guides or electrical connectors. Air Force only refer to T.O. 00–25–234 for taping of wave guide connectors.

12. Ensure wave guide is clean and free from moisture. Tape using a 50 percent overlap and ensuring all openings are covered. Secure tape with lacing and tying tape A–A–52084 for medium temperature, medium vibration applications, for high temp & vibe, use A–A–52083 (Figure 9).

13.. **HARNESS STOWAGE.** Harnesses removed from the aircraft shall have connectors preserved (See NA 01–1A–509–3 and NA 15–01–500) and connectors covered to prevent FOD. Plastic caps may be used on harnesses removed from aircraft, or they may be taped per paragraph 7. Installed harnesses shall have connectors covered per paragraph 7.

CAUTION

No tape other than pressure sensitive tape, A-A-59163–1, MIL–I–46852 (NSN: 5970–00–955–9976), is authorized for use on wave guides or electrical connectors. Air Force only refer to T.O. 00–25–234 for taping of wave guide connectors.

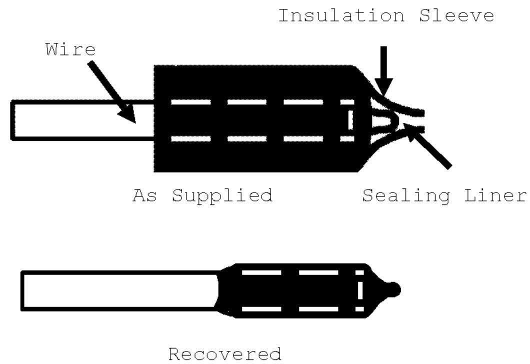


Figure 10. Typical Heat Shrinkable End Caps

14.. **WIRE CAPPING AND STOWING.** There are two methods of capping individual wires; heat shrinkable and crimp type end caps. The heat shrinkable is the preferred method. Crimp type end caps shall be used as a last resort.

15. **Heat Shrinkable Sealing End Caps.** Select correct sealing cap Table 4. Cut wire square and place end cap on wire so it bottoms in sealing liner. There is no need to strip wire insulation. Shrink using approved heat gun (Figure 10) using approved heat gun (WP 012 00).

16. **Crimp Type End Caps.** End caps or stub splices are used to terminate a wire in itself or for dead ending a wire. There are numerous ways to provide an end cap or stub splice. A stub splice is also known as a parallel connector. End caps should be selected from Table 5. There are four sizes of electrical end caps. Selecting the correct crimp tool is essential in the crimping process to ensure proper electrical contact. Table 6 is provided for proper selection of each crimping tool.

Table 4. Sealing End Caps by Wire Size

Wire AWG	Part No.	NSN
26 – 20	D–436–0184	5940–01–349–3799
18 – 12	D–436–0185	5940–01–349–3800
20 – 16	D–436–0186	5940–01–358–4938

Table 5. End Caps by Wire Size

Wire AWG	Part No.	Color
26 – 24	MS25274–1	Yellow
22 – 18	MS25274–2	Red
16 – 14	MS25274–3	Blue
12 – 10	MS25274–4	Yellow

Table 6. MS25247 Electrical End Cap and Crimp Tool

Part No.	Wire Size Range	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
MS25274–1 MS25274–2 MS25274–3	26 – 24 22 – 18 16 – 14	26 – 14	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
MS25274–4	12 – 10	12 – 10	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–100	M22520/3–9

17. **Crimp Type End Cap Crimping Procedure**. The following crimp procedures are recommended.

a. Select end cap for applicable wire diameter (Tables 5).

b. Select crimp tool, die and inspection gage. Check tool with proper gage (Table 5).

c. Insert end cap into wire side of tool crimping jaws, until barrel butts to tool stop on the locator.

d. Squeeze tool handles slowly until tool jaws hold barrel firmly in place, but without denting it.

e. Insert stripped wire into barrel until it bottoms out at back of cap.

f. Squeeze tool handles until ratchet releases.

g. Examine the crimped condition carefully for the following:

(1) Indent centered on barrel.

(2) Barrel not cracked.

(3) Insulation not cracked.

18. **Covering Crimp Type End Cap (Stub Splice)**. The military end cap must be covered for environmental protection. The caps may be covered with heat shrinkable insulation (SAE AMS–DTL–23053 heat shrinkable tubing WP 014 00) which is the preferred method, or with self–bonding tape.

19. **Cap and Stow Contacts**.

NOTE

The following procedure applies to connector contacts requiring stowing. This method applies to areas with maximum temperatures of 150 °C/305°F

a. Clean wires if required to ensure a good seal (WP 026 00).

b. Apply SAE AMS–DTL–23053 heat shrinkable tubing to snugly fit over individual contacts. Trim to minimum of 0.25” on either side of contact and shrink/recover using the approved heat gun (WP 012 00). (See Figure 11).

c. Group together and secure to adjacent wire bundle or structure using tying and lacing tape A–A–52083, or A–A–52084.

20. **Cap and Stow Terminals**.

NOTE

The following procedure applies to terminals requiring stowing. This method applies to areas with maximum temperatures of 150°C / 305°F.

a. Clean wires if required to ensure a good seal (WP 026 00).

b. Apply SAE AMS–DTL–23053 heat shrinkable tubing to snugly fit over individual terminals. Trim to minimum of 0.5” on either side of terminal and shrink/recover using the approved heat gun (WP 012 00).

c. Fold heat shrink tubing while still hot, so that the protruding pigtail is no longer than 0.25”.

CAUTION

Ensure that minimum bend radius of 10 times the largest wire diameter to be stowed while coiling the wire.

d. Group together and secure to adjacent wire bundle or structure using tying and lacing tape A−A−52084, or A−A−52083. The preferred method of securing the terminals is parallel and directly on to existing wire bundles. Only if the length of the wires to be stowed is excessive, shall the wire be coiled (see Figure 12).

21. **Coiling and Stowing Wire**.

CAUTION

Ensure that minimum bend radius of 10 times the largest wire diameter to be stowed while coiling the wire.

a. Secure capped and stowed wire as shown in the options below based on the length and access of wire and bundle (Figure 13).

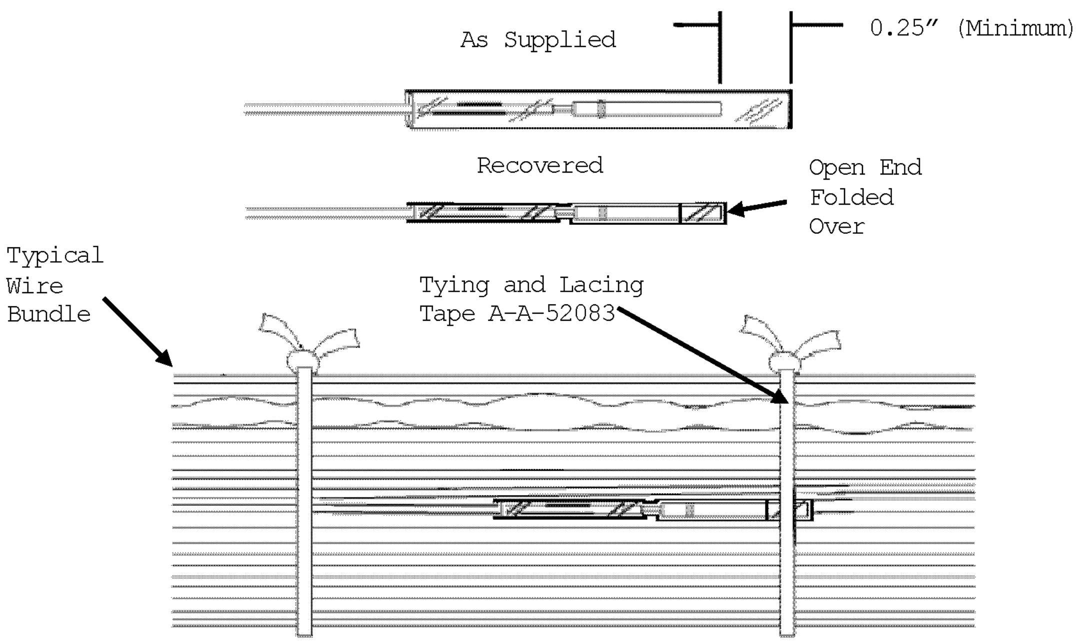


Figure 11. Capped and Stowed Contact

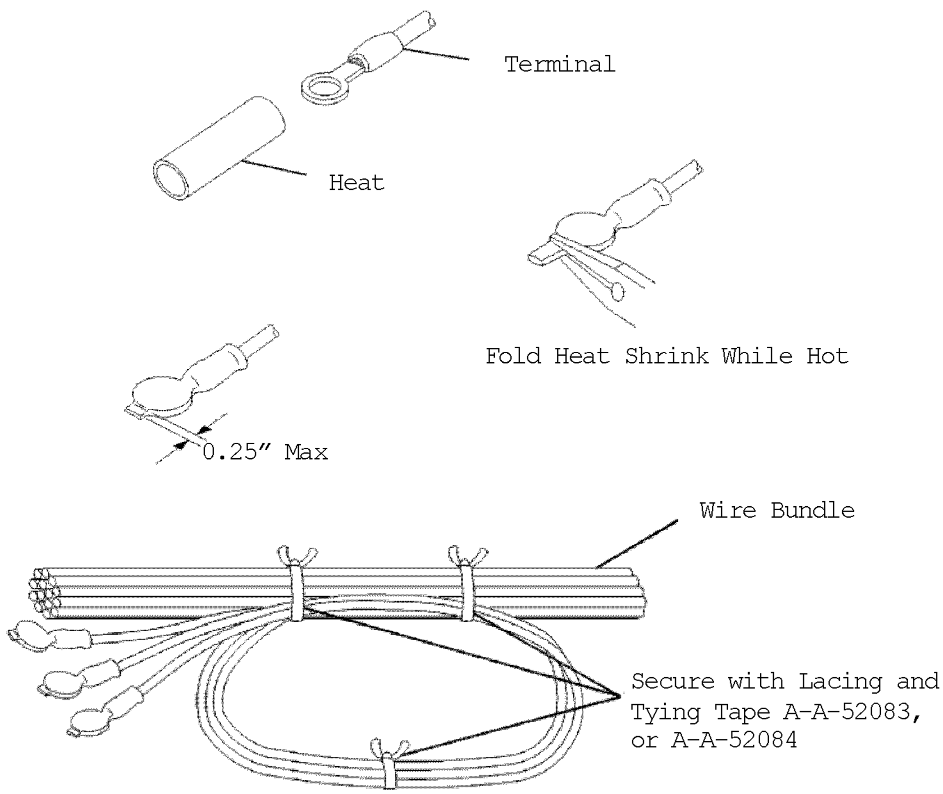


Figure 12. Terminal Stowing

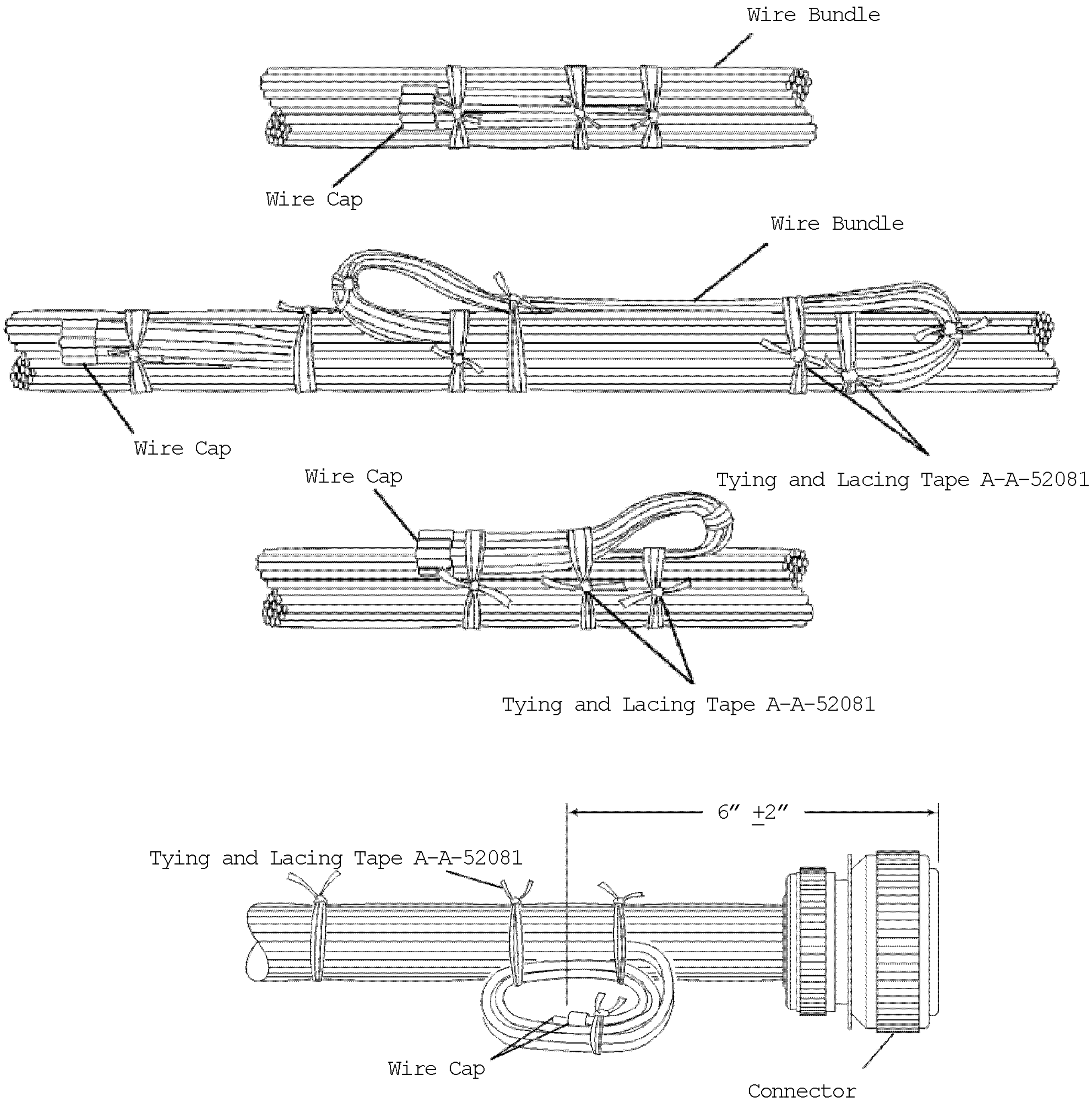


Figure 13. Coiling and Stowing Wire Options

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WIRE, CABLE, AND HARNESS MARKING

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Heating Tools 012 00
Wiring, Aerospace Vehicle (previously MIL–W–5088) . . . . . SAE AS50881
Ultraviolet (UV) Lasers for Aerospace Wire Marking . . . . . SAE AIR5468
Marking of Electrical Insulating Materials . . . . . SAE AS5942
Wire and Cable Marking Process, UV Laser . . . . . SAE AS5649

Alphabetical Index

Subject Page No.

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation	Nomenclature
BMXC–Plus	Brady Marker XC Plus Printer	––	Ultraviolet (UV) Lasers for Aerospace Wire Marking
LS2000	Brady Marker	TLS2200	Brady Marker (7025–01–499–4333)

Materials Required

Specification/ Part Number	Nomenclature	Specification/ Part Number	Nomenclature
PS–0231–094W	Portable Printing Sleeves	WML–1215–292–25	Label, Wire Marking
PS–0231–094Y	Portable Printing Sleeves	WML–1215–502	Label, Wire Marking
PS–0231–125W	Portable Printing Sleeves	WML–1223–292	Label, Wire Marking
PS–0231–125Y	Portable Printing Sleeves	WML–1231–292–22	Label, Wire Marking
PS–0331–187W	Portable Printing Sleeves	WML–1231–292–30	Label, Wire Marking
PS–0331–187Y	Portable Printing Sleeves	WML–1607–502	Label, Wire Marking
PS–0531–250W	Portable Printing Sleeves	WML–1615–502	Label, Wire Marking
PS–0531–250Y	Portable Printing Sleeves	WML–2007–502	Label, Wire Marking
PS–0831–375W	Portable Printing Sleeves	WML–2015–502	Label, Wire Marking
PS–0831–375Y	Portable Printing Sleeves	WML–205–292–1	Label, Wire Marking
PS–1031–500W	Portable Printing Sleeves	WML–205–292–75	Label, Wire Marking
PS–1031–500Y	Portable Printing Sleeves	WML–211–292–1	Label, Wire Marking
PS–2231–1000W	Portable Printing Sleeves	WML–211–292–75	Label, Wire Marking
PS–2231–1000Y	Portable Printing Sleeves	WML–2411–502	Label, Wire Marking
PSBXP–111–125	Portable Printing Sleeves	WML–2431–292–60	Label, Wire Marking
PSBXP–111–187	Portable Printing Sleeves	WML–2431–292–75	Label, Wire Marking
PSBXP–114–125	Portable Printing Sleeves	WML–305–502	Label, Wire Marking
PSBXP–114–187	Portable Printing Sleeves	WML–305–632	Label, Wire Marking
PSBXP–211–250	Portable Printing Sleeves	WML–311–292	Label, Wire Marking
PSBXP–214–250	Portable Printing Sleeves	WML–317–292	Label, Wire Marking
PSBXP–311–375	Portable Printing Sleeves	WML–350–292	Label, Wire Marking
PSBXP–314–375	Portable Printing Sleeves	WML–305–502	Label, Wire Marking
PSBXP–411–500	Portable Printing Sleeves	WML–505–632	Label, Wire Marking
PSBXP–414–500	Portable Printing Sleeves	WML–511–292	Label, Wire Marking
SBS–111–322	Sleeve, Marking	WML–511–502	Label, Wire Marking
SBS–117–322	Sleeve, Marking	WML–511–632	Label, Wire Marking
WML–0607–292–1	Label, Wire Marking	WML–517–502	Label, Wire Marking
WML–0607–292–75	Label, Wire Marking	WML–705–502	Label, Wire Marking
WML–0615–292–1	Label, Wire Marking	WML–705–632	Label, Wire Marking
WML–0807–292	Label, Wire Marking	WML–711–292	Label, Wire Marking
WML–0807–502	Label, Wire Marking	WML–711–292	Label, Wire Marking
WML–0811–292	Label, Wire Marking	WML–711–502	Label, Wire Marking
WML–0815–292	Label, Wire Marking	WML–711–632	Label, Wire Marking
WML–0823–292	Label, Wire Marking	WML–717–292	Label, Wire Marking
WML–1207–502	Label, Wire Marking	WML–905–502	Label, Wire Marking
WML–1207–502	Label, Wire Marking	WML–905–632	Label, Wire Marking
WML–1215–292	Label, Wire Marking	WML–911–502	Label, Wire Marking

Materials Required (cont.)

Specification/ Part Number	Nomenclature
WML–911–632	Label, Wire Marking
WML–917–502	Label, Wire Marking
WMS–111–322	Sleeve, Marking
WMS–117–322	Sleeve, Marking
WMS–211–322	Sleeve, Marking
WMS–217–322	Sleeve, Marking
WMS–411–322	Sleeve, Marking
WMS–417–322	Sleeve, Marking
WMS–611–322	Sleeve, Marking
WMS–617–322	Sleeve, Marking
7510–01–127–0648	Sleeve, Marking
7510–01–504–8938	Sleeve, Marking
03–0109	Marker, Permanent, Fine Tip
A–A–52081, Finish C, Size 2 or 3	Tape/String, Lacing
1244	Tape, Marking

1. **INTRODUCTION.**

2. This work package (WP) describes the repair and location of military aircraft circuit identification marking sleeves for cables, wires, and harnesses. Continuous printing of the circuit identification at about three inch intervals is typically required on all cables and wires for the original wiring installation, but marking sleeves are permitted for Organization and Intermediate level maintenance. Depot level wiring maintenance and modifications shall be identified in accordance with AS50881. The purpose of this work package is to describe when and how these sleeves may be used, even though continuous printing on the wiring may have been provided as part of the original wiring installation.

3. Each cable, wire, and harness must be marked with circuit identification codes. The circuit identification codes are defined in AS50881 (previously MIL-W-5088). There are two circuit identification code systems, significant and non-significant. Both the non-significant and significant code systems are described herein for only informational purposes. Circuit identification codes shall always be in accordance with the original aircraft requirements.

NOTE

Proper circuit identification is essential for future maintenance of the aircraft electrical system.

4. **SIGNIFICANT IDENTIFICATION CODES.**

5. Wire identification is significant when it indicates the Electromagnetic Environmental Effects (E^3) classification and circuit function. E^3 classification is indicated by a letter identification code that identifies the E3 category for each wire or cable. Electromagnetic classification codes may vary with aircraft type and may be located at the beginning or end of the circuit identification code. Typical Electromagnetic codes are provided in Table 1.

a. Circuit function is indicated with an equipment identification code (Figure 1).

b. Circuit function is also indicated by circuit function letter (Figure 2).

NOTE

Refer to 2 circuit function letters R, S, T and Y for examples of equipment identified by the equipment identification code.

6. **EQUIPMENT IDENTIFICATION CODE.** The equipment identification code is the portion of AN nomenclature following the /, but excluding the hyphen and suffix letters. For example, wires of an AN/APS-45 will be identified APS45, those of AN/ARC-52A will be ARC52 and those wires of MX94 will be MX94. These codes are used to identify the following equipment (Figure 1):

a. Radio (Navigational and Communication)

b. Radar (Pulse Technique)

c. Special Electronics

d. Armament Special Equipment

Table 1. E^3 Classification Category

E^3 Classification Letter	E^3 Category
X	Wires and cables which are used for special purposes such as pulsed circuits, low level signal circuits, RF-power circuits where interference may vitally effect operation.
E	Wires and cables which emit interference.
P	Wires and cables which carry electrical power.
S	Wires and cables which may be susceptible to interference.
Y	Wires and cables which are passive with respect to Electro Magnetic Compatibility (EMC), in that they do not emit and are not susceptible to interference.

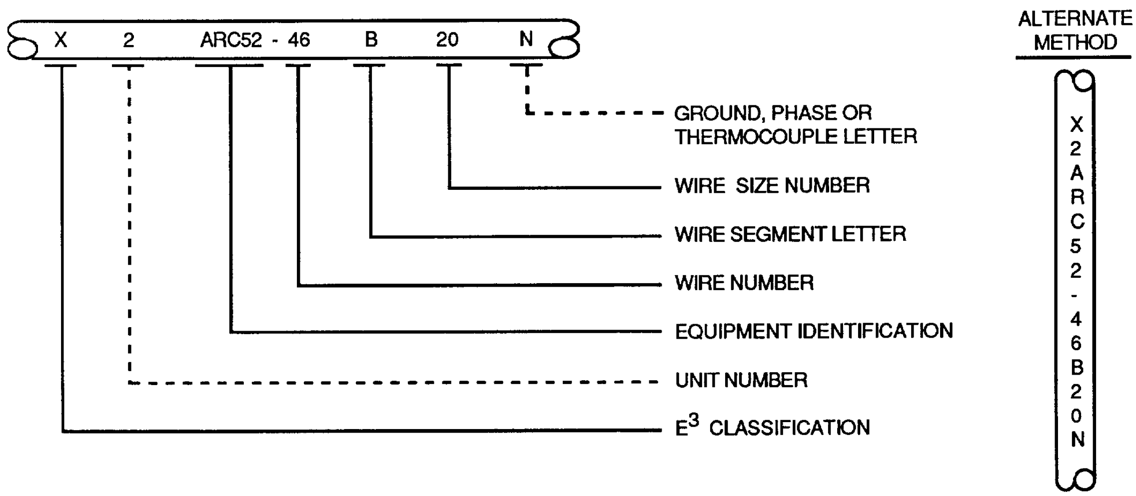


Figure 1. Wire Identification Coding (Circuit Function Letters R, S, T and Y)

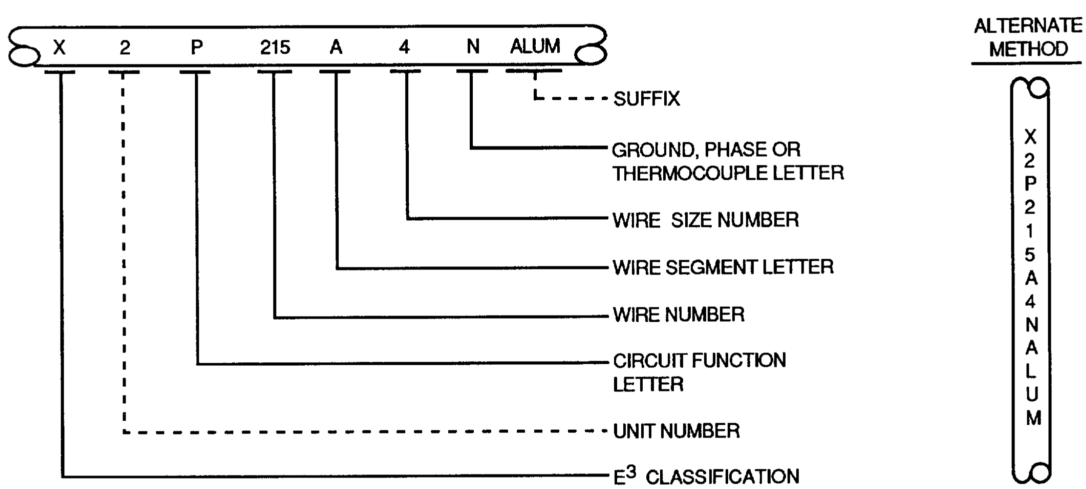


Figure 2. Wire Identification Coding (Except Circuit Function Letters R, S, T and Y)

7. **CIRCUIT FUNCTION LETTER.** Letters are used to identify the circuit function (except letters R, S, T and Y) specified in Table 2 (Figure 2).

a. A wire used for more than one circuit function will be identified with the functionally predominant circuit function letter. When functional predominance is questionable, the wire with the lowest wire number (Paragraph 9) will be used.

8. **UNIT NUMBER.** Unit numbers are used where two or more identical items of equipment are installed in the same vehicle. The unit numbers 1, 2, 3 etc. are used to differentiate between wires when it is desired that the equipment have the same basic identification (Figures l and 2).

a. Identical wiring located in left and right wings, nacelles, and major interchangeable structural assemblies may have identical identification and the unit number is not required.

9. **WIRE NUMBER.** The wire number is used to differentiate between wires in a circuit (Figures 1 and 2).

a. Wires with the same circuit function having a common terminal connection or junction shall have the same wire number, but different wire segment letters (paragraph 10). A different number shall be used for wires not having a common terminal or connection.

b. Each wire will be assigned one or more digits number. As far as practicable the numbers assigned will be in numerical sequence.

c. Numbers 2000 to 4999 inclusive shall be reserved. They are used to identify wires installed by service modifications.

10. **WIRE SEGMENT LETTER.** A wire segment is a conductor between two terminals or connections. The wire segment letter is used to differentiate between conductor segments in a particular circuit. A different letter shall be used for wire segments having a common terminal or connection. Two permanently spliced wires do not require separate segment letters if the splice is used for modification or repair (Figures 1 and 2).

a. Wire segments shall be lettered in alphabetical sequence and the letter A should identify the first segment of each circuit starting at the power source.

b. If a circuit contains only one wire segment, the wire segment shall be marked A. The letters I and O shall not be used as segment letters. Double letters AA, AB, AC, etc., will be used when more than 24 segments are required.

11. **WIRE SIZE NUMBER.** The wire size number identifies the size of the wire or cable. Coaxial cables do not have a wire size number. Thermocouple wires use a dash (-) in place of a wire size number (Figures 1 and 2).

12. **GROUND LETTER.** Any wire (unless otherwise specified) completing a circuit to the ground network of the aircraft electrical system without circuit malfunction will use the ground cable letter N as the wire identification code suffix. The N suffix will also identify all interconnecting ground leads in critical and sensitive electronic systems (Figures 1 and 2).

Table 2. Circuit Function Letters

Circuit Function Letter	Circuit	Examples
A	Armament	Stores Management System: Missiles/Rockets, Gun, Chemical
B	Photographic	Camera, Camera Doors, Camera Heating
C	Control Surface	Flight Control, Automatic Pilot, Hydraulic System, Wing Sweep, Trim Control, Airbrakes
D	Instrument (other than flight or engine instruments)	Position Indicator, Pressure Gage, Temperature Gage, Clock
E	Engine Instrument	Temperature Gage, Pressure Gage, Quantity meter, Flow Meter, Tachometer, Power Indicator, Nozzle Indicator
F	Flight Instrument	Gyroscopic Instrument, Attitude Indicator, Compass, Altitude, Heads Up Display

Table 2. Circuit Function Letters (Cont.)

Circuit Function Letter	Circuit	Examples
G	Landing Gear Wing folding	Extension and Retraction Braking, Locking, Steering, Anti-Skid, Arrestor Hook, Utility Hydraulics
H	Heating Ventilating and De-icing	Heating De-icing, Cabin conditioning, Galley, Equipment Bay Cooling
I	To avoid confusion with the numeral one, the letter I shall not be used for circuit or cable identification.	
J	Ignition	Engine Ignition, Jet assisted Take-off
K	Engine Control	Vent and Flap, Propeller Control, Engine Starting, Carburetor, Supercharging, Power Control, Nozzle Control, Thrust Reverser
L	Lighting (Illumination)	Internal, External
M	Miscellaneous (electrical)	Windshield wiper & spray, Door, Hoist and winch, Position (seat and pedal), Cigarette lighter, Auxiliary Power Unit, Emergency Power Unit
N	Unassigned	
O	In order to avoid confusion with the numeral zero, the letter O shall not be used for circuit or cable identification.	
P	DC Power	Generation, Distribution, Battery, Rectifier, External Power
Q	Fuel and Oil	Valves, Pumps, Refueling/Defueling, Transfer, Dump
R	Radio (Navigational and Communication)	Instrument landing: Homing, Liaison, Marker Beacon, VHF Radio, UHF Radio, HF Radio, Intercommunication, Direction Finding
S	Radar (Pulse Technique)	Radar Altimeter, Interception, Gun aiming, Mapping, Navigation, Bomb aiming, Search, Recognition (IFF), Terrain Following
T	Special Electronics	Active Electronic Countermeasures, Inertial Navigation, Television, Reconnaissance, Computer, Weapon Aiming, Chaff Dispensing, Infra-Red
U	Miscellaneous (electronic)	Electronic Wiring for which the R, S, or T identification is not applicable shall be assigned the circuit function letter U. An example would be common leads to electronic equipments and systems, inter-connection wiring, such as antenna or power circuits common to more than one equipment.
V	Both DC power cables and DC control cables for AC systems shall be identified by the circuit function letter V.	
W	Warning and Emergency (except those listed under other circuits functions)	Bail-out alarm: Oxygen indicator, Passenger sign, Central/Master warning
X	AC Power	Generation, Distribution, External Power
Y	Armament Special Equipment (except those listed under circuit function A)	
Z	Experimental Circuits	When flight test and experimental research wiring is installed, the appropriate Circuit Function Letter shall be used, preceded by the letter Z. When any such circuit has been adopted and becomes part of a standard installation, the letter Z shall be removed.

13. **PHASE LETTER.** Phase letters are used as a suffix to identify the phase of wires in the three phase power distribution wiring of AC systems (Figure 3 [b] and [c]). The letters A, B, and C will be used to indicate the phase sequence corresponding to T_1, T_2, and T_3 respectively. T_2 will be considered as the grounded phase for grounded delta systems and the wire will be identified with a letter N suffix (Figures 1 and 2).

a. The ungrounded wire on a single phase system will be identified with a letter V suffix (Figure 3 [a]).

14. **THERMOCOUPLE LETTER.** Thermocouple letters are used as a suffix to identify the thermocouple material. Two letter suffixes are used where space considerations dictate (Figures 1 and 2). The following thermocouple letter suffixes shall be used as applicable:

Preferred Suffix	Material	2 Letter Suffix (Where space considerations dictate)
a. CHROM	Nickel-Nickel Chromium	CR
b. ALML	Nickel-Aluminum/Silicon	AL
c. IRON	Iron	FE
d. CONST	Constantan	CN
e. COP	Copper	CU

15. **ALUMINUM WIRE IDENTIFIER.** The letters ALUMINUM or ALUM will be added to the wire identification code of aluminum wire (Figure 2).

16. **SPARE CONTACTS IDENTIFICATION.** Wires attached to spare contacts will be identified by the contact designation.

17. **HARNESS LETTER.** Each harness will be identified with the letter W and a distinct numerical suffix. Examples W-1, W-2, W-3, etc.

18. **NON-SIGNIFICANT IDENTIFICATION** (Figure 4).

19. Non-significant identification does not indicate circuit function and is unique. Each wire in a harness has a unique alpha-numeric identification. The alpha-numeric codes distinguish it from all other identification codes and consists of the following:

a. Wire harness class letter

b. Wire harness number identifier

c. Wire identifier

d. Wire gage number

e. Wire color code (where applicable)

f. Thermocouple wire code (where applicable)

g. Shield code (where applicable)

20. **WIRE HARNESS CLASS LETTER.** Each harness will be identified by the class letter W (Figure 4).

21. **WIRE HARNESS NUMBER IDENTIFIER.** The number identifier has no more than four digits. Always follows the wire harness class letter (Figure 4).

22. **WIRE IDENTIFIER.** The identifier distinguishes each wire from all others within a harness. Has no more than four digits (Figure 4).

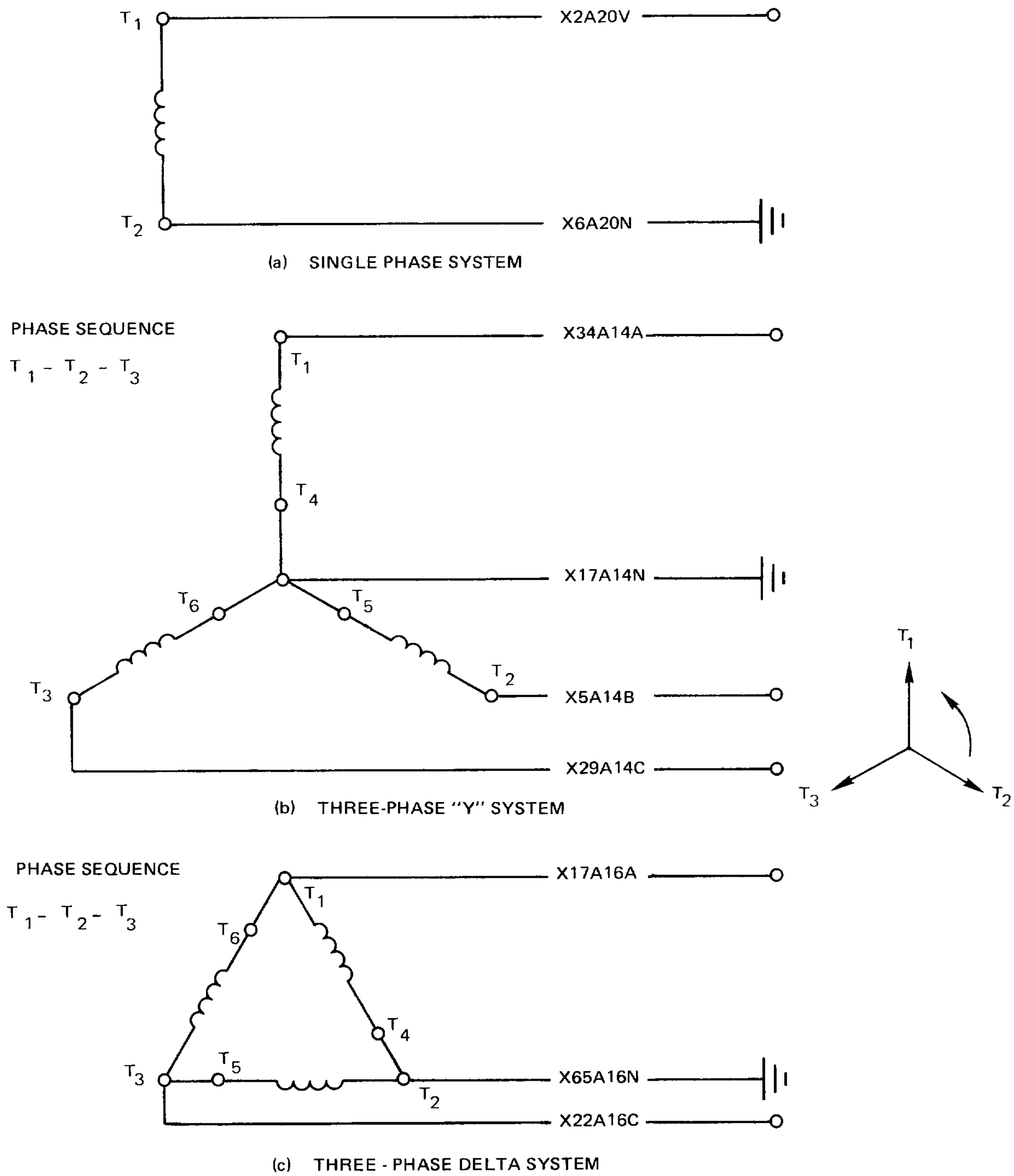
a. Wires joined by splices are required to have wire to wire continuity of the wire identifier. Harness to harness continuity of the wire identifier is not required, however it is desirable.

b. Wire identifiers 900 to 999 and 9000 to 9999 inclusive are reserved to identify wires installed by service modifications.

23. **WIRE GAGE NUMBER.** The wire gage number identifies the wire size. The wire gage number may be omitted from coaxial cable and thermocouple wire identification (Figure 4).

24. **THERMOCOUPLE WIRE CODES.** Use the following letter codes to identify thermocouple wire (Figure 4):

Material	Code
a. Nickel-Nickel Chromium	CR
b. Nickel-Aluminum/Silicon	AL
c. Iron	FE
d. Constantan	CN
e. Copper	CU



(FOR INVERTERS HAVING CONNECTORS WITH PHASE ROTATION C-B-A AT THE PINS, THE CORRESPONDING TERMINAL DESIGNATIONS ARE T1 - T2 - T3 AND THE WIRE IDENTIFICATION PHASE LETTERS SHOULD BE CONSISTENT WITH FIGURE (c) ABOVE.)

Figure 3. Wire Identification for AC Power Wiring

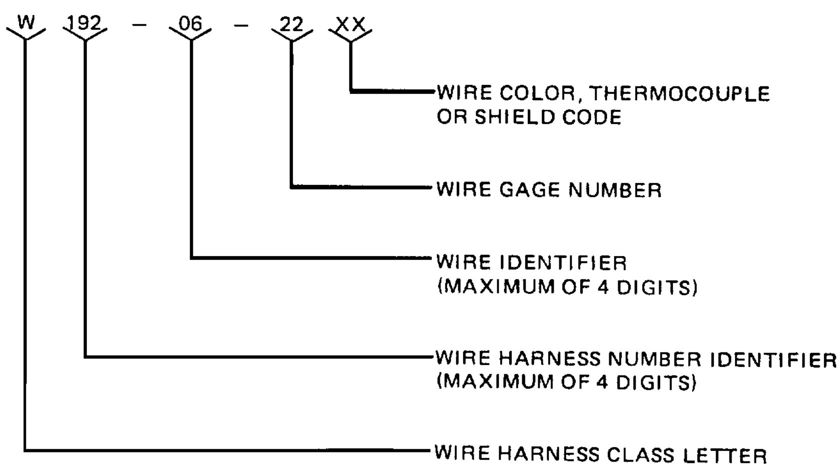


Figure 4. Identification Code Categories For Wire Number W192-06-22XX

25. **COLOR-CODED CABLE.** Jacketed, shielded or twisted cable consisting of two or more wires which are color coded by single stripes, bands, or solid colors shall be assigned the same wire identifier. The color shall be identified by using the following two letter code following the wire gage number (Figure 4).

Color	Code
Black	BK
Brown	BR
Red	RD
Orange	OR
Yellow	YE
Green	GN
Blue	BL
Violet	VT
Gray	GY
White	WH
Pink	PK

26. **SHIELD IDENTIFIERS.** Shielded cable having common wire identifiers will be assigned the same letters as the conductors in (paragraph 24). Shields over harnesses or over groups of wires having different wire identifiers assigned in accordance with paragraph 21 shall be assigned separate wire identifiers. The suffix SH will follow the wire-identifier (Figure 4).

27. **ALUMINUM WIRE IDENTIFIER.** The letters ALUMN (AM if use of ALUMN exceeds 15 characters) will be added to the wire identification code of aluminum wire.

28. **WIRE AND CABLE MARKING.**

29. Unless otherwise specified in the maintenance manual of the aircraft being serviced, the circuit identification codes shall be printed on sleeves or tags and installed during repair or replacement of the wire, cable, or harness as indicated herein.

30. **CRITICAL CLAMP INSTALLATION.** For required clearance when installing electrical cable assemblies. Critical routing points are indicated by colored markers (typically one inch wide, white or yellow) on the bundle which shall be located under cable clamp such that the colored marker is exposed on both sides of the clamp. For correct cable assembly routing and clamping of specific cables or harness, refer to the applicable aircraft electrical wiring installation drawings, or Illustrated Parts Breakdown. If none available, contact the Cognizant Engineering Authority for direction.

NOTE

The marking shall not be used as an electrical insulation device, and is not needed, if correct circuit identification is still present on the wire or cable.

31. **MARKING METHODS.** The two methods of marking wire and cables are as follows:

a. Direct Marking. Direct marking is accomplished by printing the wire or cables outer covering. Direct marking shall be identified at intervals not longer than 3 inches along the entire length or wire or cable.

b. Indirect Marking. Indirect marking is accomplished by printing a heat shrinkable sleeve and installing the printed sleeve on the wire or cables outer covering. Indirect marked wire or cable shall be identified with printed sleeves after the last clamp and within 12 inches of the cable termination and at intervals specified in paragraph 31.

32. **INDIRECT MARKER INDENTIFICATION LOCATION.** Wire, cable and harness marking locations shall be as follows:

a. Each individual wire not in a cable shall have a circuit identification code printed on a marker in the fashion specified herein. Each wire shall have a marker after the last clamp and within 12 inches of the termination point. Markers shall also be provided at intervals of three feet throughout the length of the wire. Wires less than 6 inches long need not be marked unless previously marked prior to repair. In some cases wire may be continuously marked with one circuit identification and the markers marked with another. For repair purposes, the marker information should always take presence.

b. Each cable circuit identification code (and individual wire color, where applicable) shall be printed on a marker in the fashion specified herein. Each marker shall be placed externally to the outer covering of the cable after the last clamp and within 12 inches of the cable termination. Markers shall also be provided at intervals not greater than three feet apart on the length of the cable.

c. Each harness code, when required, shall be printed on a marker in the fashion specified herein. The marker shall encompass all wires, cables, and harness jacket (if applicable). The marker shall be located at the ends of each major breakout and at intervals of three to four feet throughout the harness.

NOTE

Continuous printing methods such as Inkjet and Laser Marking require specific Quality Control requirements not included herein.

WARNING

Hotstamp marking directly on the wire or cable is not authorized for any application.

33. **MARKING METHOD.** The marking method described herein is not the only method available for circuit identification marking, but is the one most commonly used by the Navy and has been proven to meet military aircraft environmental requirements. The methods described herein is the BRADY marker System.

34. **BRADY WIRE MARKING SYSTEM.**

35. **DESCRIPTION OF PRINTER.** The Bradymarker XC Plus Printer (BMXC-Plus) is a portable, self-contained dot matrix label/sleeve printing system (Figure 5).

36. **PRINTER FEATURES.** The BMXC–Plus printer has important features designed to eliminate errors and save valuable time. These features are as follows:

a. The printer can automatically serialize markers.

b. The printer can store and reprint lists of commonly used markers.

c. The printer has an automatic alignment system that ensures that the printing is always on the mark.

d. The printer can operate on 120V AC power or a rechargeable power pack.

e. The printer has a 2–line LED screen to review data before printing.

f. The printer can display menus for the more advanced features of the printer.

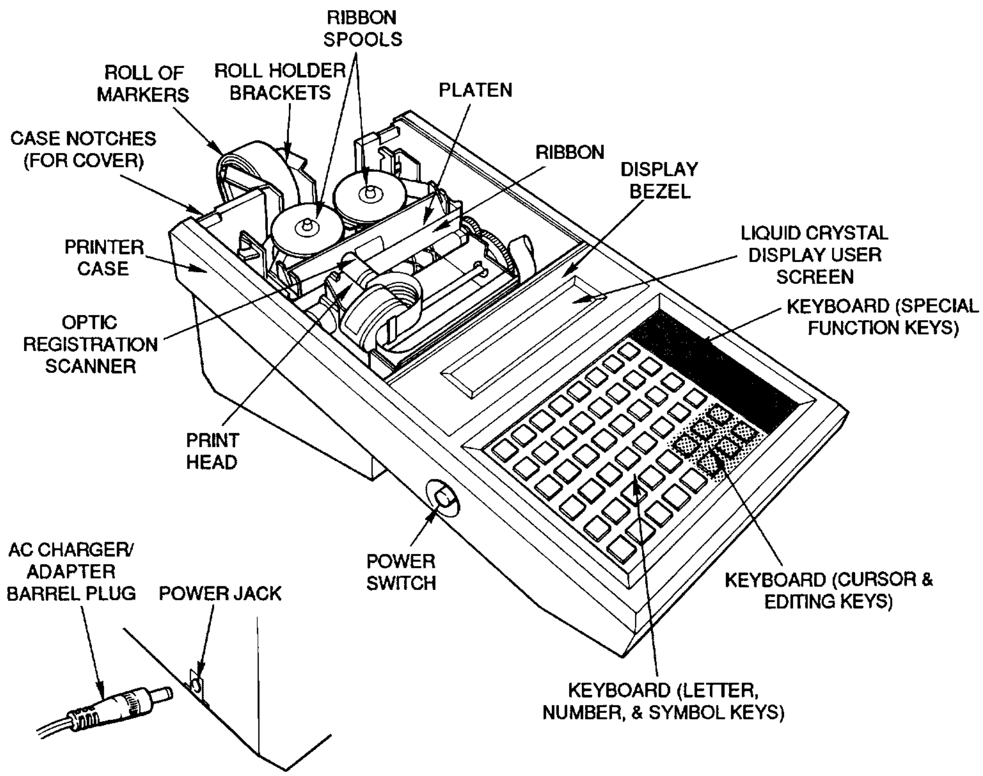


Figure 5. Bradymarker XC Plus Printer

NOTE

If the BMXC−Plus printer will be used to print sleeves markers for wires with an outside diameter less than .080 inch, the factory installed 1/16 inch drive option is required.

37. **DESCRIPTION OF SLEEVE.** The sleeving is a self−extinguishing, heat−shrinkable, flat profile polyolefin sleeve specially designed for use in the BMXC−Plus printer. The sleeving has a 2:1 shrink ratio, a shrink temperature of 300°F (150°C), and a service temperature rating of −40°F to 221°F (−40°C to 105°C) (Figure 6).

38. The BMXC−Plus uses a special permanent ink ribbon, part number R2100. The ink in this ribbon is absorbed into the special printable topcoat of the sleeve to provide a permanent, durable legend without any post printing process.

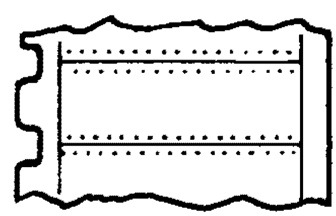


Figure 6. Bradysleeve Wire Marking Sleeve

40. **OPERATING PROCEDURES.** To operate the BMXC−Plus, proceed as follows:

a. Ribbon Installation.

(1) Ensure battery pack is fully charged, or printer is connected to 120V AC power source.

39. **MARKING SLEEVE SELECTION.** The outside diameter (OD) determines the sleeve to be used with this system (Table 3).

(2) Install R2100 ribbon (Figure 7).

(a) Place right−side ribbon spool onto spool shaft with spool drive pins pointing down.

(b) Push ribbon detecting lever away from spool shaft, press down on ribbon spool until it clicks in place, then release ribbon detecting lever.

(c) Install left−side ribbon spool in accordance with steps (a) and (b).

(d) Tighten ribbon by turning right−side spool counterclockwise.

b. Printer Setup. Set the printer for marker size, format, type size, and loading labels.

(1) Marker Size.

(a) If printer has never been used, enter marker size code shown on inside of marker roll core.

(b) If printer has been used, press MENU key, then S for Size, and enter marker size code shown on inside of marker roll core.

(2) Format. Printer will automatically bring up on screen to select marker format.

(a) Wire format repeats legend down length of marker.

(b) Component format vertically centers legend.

(3) Type Size. Printer will automatically bring up a screen to select type size.

(a) Select preferred type size.

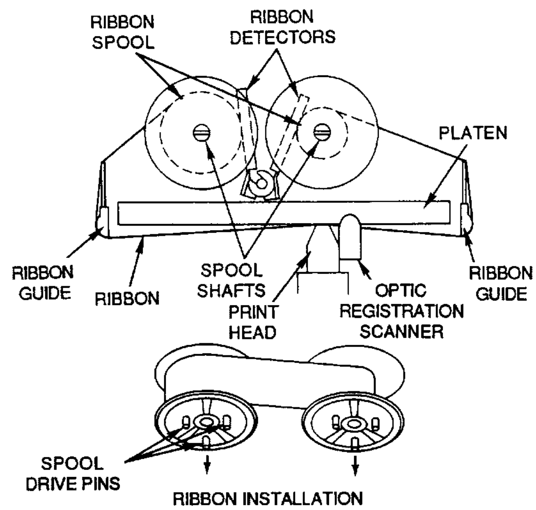


Figure 7. . Bradymarker XC Plus Printer

Table 3. WMS and SBS Sleeve Selection

Wire OD Range Min	Max	Part No 1 inch Length (Note 1)	1 1/2 inch Length (Note 2)
.040	.065	SBS−111−322 (Note 3)	SBS−117−322 (Note 3)
.065	.110	SBS−111−322	SBS−117−322
.080	.130	WMS−111−322	WMS−117−322
.120	.230	WMS−211−322	WMS−217−322
.230	.375	WMS−411−322	WMS−417−322
.375	.540	WMS−611−322	WMS−617−322

NOTES:
1. Can contain up to 11 normal sized characters with 12 characters per line and 7 large characters with 8 per line.
2. Can contain up to 17 normal sized characters with 12 characters per line and 11 large characters with 8 per line.
3. Cannot be shrunk tight on wires with OD less than .065 inch. Recommend these sleeves not be shrunk.

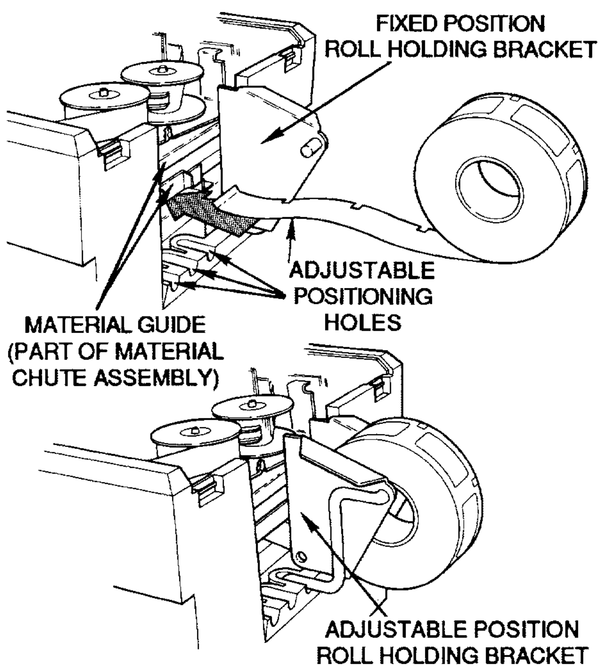


Figure 8. Loading Labels

(4) Loading Labels. The printer has a fixed position bracket on the left side and an adjustable position bracket that adjusts for 3/4, 1 1/4 or 1 3/4 inch side liners (Figure 8).

(a) Remove top cover and adjustable roll holding bracket and open material guide to farthest position.

(b) Turn power ON.

(c) Turn printer around so that back of printer is facing operator.

(d) Unwind 10 inches of markers from roll.

(e) While facing back of printer, insert markers with label or face of sleeve pointed downward and liner notch on right side of liner toward fixed position bracket.

(f) Fold slight upward bend (30°) into end of markers ensuring marker is cut straight and clean.

(g) Insert markers between material guides with notched side of marker tightly against roll holding bracket.

(h) Push markers forward until markers butt up against drive roller inside printer.

(i) While continuing to push markers forward, press and hold FEED key, driver roller should begin to pull markers into printer.

(j) After 1 inch of markers have been pulled through drive roller, release FEED key.

(k) Position roll on roll holding bracket and while holding roll, mount other roll holding bracket into appropriate slot in printer case.

(l) Ensure both roll holding brackets are pushed as far down as possible into case.

(m) Move material guide to proper position next to liner.

(n) Turn printer around so that keyboard is facing operator.

(o) Press and hold FEED key until leading edge of markers are visible above ribbon.

(p) Release FEED key. Printer should advance to top of first available marker.

(q) Replace top cover.

c. Entering Legends. The legend entry screen will only allow the number of lines and characters per line that will fit on the marker.

(1) Entering Text.

(a) Type in any combination of numbers, letters, symbols or spaces. Legend should automatically center on marker.

(b) To justify legend, press MENU key, then J,and then R or L.

(c) After first line is completed, press ENTER to move to second line, if required, or press PRINT to print marker.

(d) ENTER key does not require pressing after last line.

(2) Editing Text. To change text or insert additional characters, perform the following:

(a) Move cursor to desired position for inserting, replacing, or deleting a character.

(b) To change cursor style, press INSERT key.

(c) To insert a character, press INSERT key until a solid cursor line is present.

(d) To replace a character, press INSERT key until a flashing cursor line is present.

(e) Type in additional or replacement text or press DELETE key to eliminate a character.

(3) Serialized Markers. To print markers with consecutive alphanumeric serial numbers, perform the following:

(a) Position cursor at character(s) to be serialized.

(b) Press SERIAL key.

d. Printing Markers. The BMXC–Plus printer can print only a single marker each time the PRINT key is pressed or any quantity of markers may be selected.

(1) Single Marker Printing.

(a) To print markers from legend entry screen, press PRINT key.

(b) To print a single marker each time, PRINT key is pressed, press MENU, then S for single.

(2) Multiple Marker Printing.

(a) To select multiple quantity, press MENU, then Q for quantity, then M for multiple markers.

(b) Immediately after pressing print key, input quantity desired, then press ENTER key.

(c) If serialized, increment the serial number by inputting quantity, then press ENTER key.

e. Wire List Memory.

(1) Creating Wire List. To create a wire list, proceed as follows:

(a) Press MENU key.

(b) Press L to select list submenu.

(c) Press C to create a new list.

(d) Select any available list name (nonflashing alpha character), press ENTER.

NOTE

Each time SAVE key is pressed, the wire legend will be saved into the list name specified.

(2) Printing Wire List. To print markers from previously stored list, proceed as follows:

(a) Press MENU key.

(b) Press L to select list submenu.

(c) Press P to print on existing list.

(d) Select proper list name and press ENTER. Display screen will display marker size and type size.

(e) Verify correct markers are loaded and press Y.

(f) If multiple marker option is selected, immediately after pressing Y, input quantity desired and press ENTER key.

(g) If serialized legend in list, input number and press ENTER key.

41. **BRADY LS2000 LABELING SYSTEM.**

NOTE

Once the current Brady model LS2000 becomes unserviceable/obsolete, replace with new Brady TLS2200 printer (NSN: 7025–01–499–4333).

42. **DESCRIPTION**. The Brady LS2000 is a portable, self–contained, high resolution, shuttle head impact printer (Figure 9).

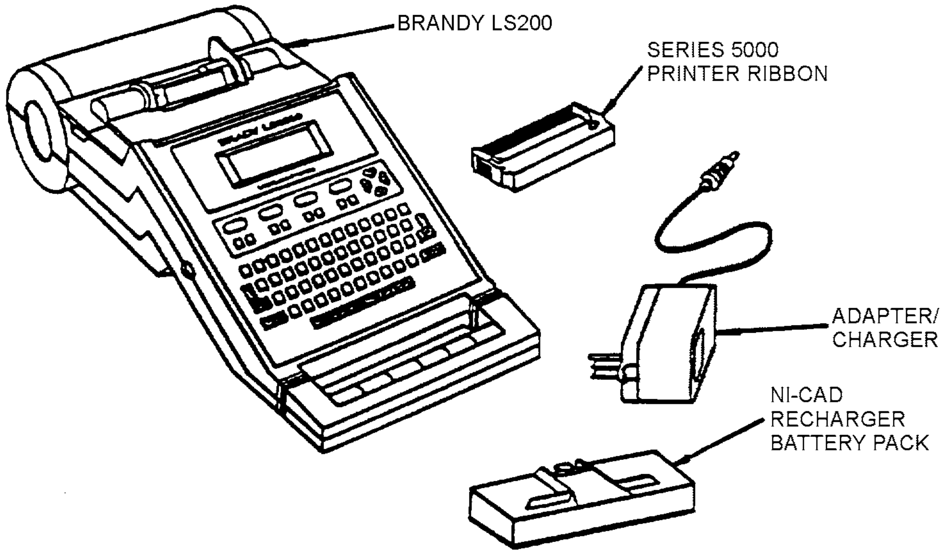


Figure 9. Brady LS2000 Labeling System

43. **FEATURES**. The LS2000 has important features designed to eliminate errors and save valuable time. These features are:

a. A 32K Random Access Memory (RAM) for storage and reprint of commonly used numbers.

b. An RS232 serial port for down loading from a personal computer (PC).

c. A 4–line by 20 character Supertwist LED screen to preview printing data.

d. The ability to operate on 120V AC or from a rechargeable power pack.

e. An optical registration system for precise print registration.

44. **KEYBOARD.** The keyboard of the LS2000 is divided into three groups and categorized by key functionality (Figure 10).

45. **Typewriter Keys.** Similar to standard typewriters, this section of keys consist of upper and lower–case letters, numbers, punctuation marks, and special symbols. To activate the symbols appearing in blue, press SHIFT plus the key containing the desired symbol.

46. **Cursor and Editing Keys.** This group of keys is used to control the movement of the cursor and enables text editing. The function of each key is contained in Table 4.

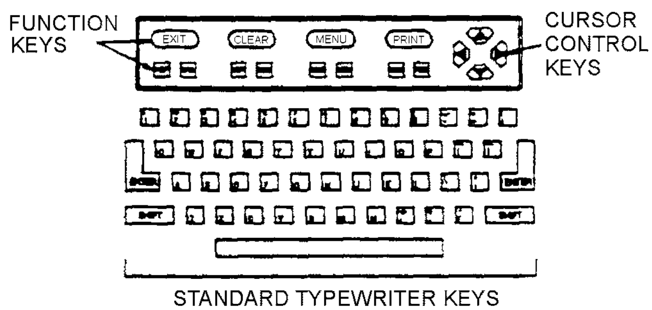


Figure 10. LS2000 Keyboard

47. **Function Keys**. The use of each function key while in the TEXT EDITOR is contained in Table 5.

48. **BATTERY**. Operating the LS2000 with the AC adapter/charger connected to the unit, simultaneously charges the rechargeable battery pack. Whether the power switch is ON or OFF, the battery pack will continue to charged by the adapter/charger (Figure 11).

49. It is recommended to charge the battery for a minimum of 16 hours before operating the printer solely on battery power. To maintain a full charge, and to extend battery life it is good practice to use the AC adapter/charger when possible.

50. If AC power fails, or the AC voltage is too low while using the printer, the printer automatically switches to battery power, without interruption. When AC power is restored it automatically switches back to AC power mode.

Table 4. Cursor and Editing Keys Functions

Key	Function
ENTER	Activates a screen selection or, when used while composing a legend, inserts a non visible end of line character and moves the cursor down to the next line. In general, pressing the ENTER key instructs the printer to accept a screen as displayed.
SHIFT + ENTER	Toggles between upper and lowercase characters. Upon pressing keys, unit beeps one time to indicate lowercase mode, and beeps twice to indicate in uppercase mode.
Cursor Control Keys	Moves the cursor one space to the left, right, up or down. Cursor moves in the direction of the arrow as indicated on the key.
SHIFT +	Moves cursor to beginning of current line.
SHIFT +	Moves cursor to end of current line.
SHIFT +	Moves cursor to beginning of first line.
SHIFT +	Deletes to character at the cursor position.
SHIFT + DELETE	Backspaces as it deletes characters.
INSERT	Toggles between the text entry modes of insert and overwrite. A flashing block cursor indicates that the printer is in the insert mode. A single line cursor line indicates that the printer is in the overwrite mode.
SPACE BAR	Moves the cursor 1 position to the right. Will erase the character at the current cursor position if in overwrite mode, or add a space if in the insert mode.

Table 5. Text Editor Function Keys

Key	Function
EXIT	Backs you out one level in the menu tree. Press this key to terminate or pause printing markers. Press this key to move from a submenu back to main menu or from the main menu to TEXT EDITOR screen. Press and hold this key when the message, Enter New Legend, is displayed in order to display the Editor Status (summary of defined parameters).
CLEAR	Clears all character from TEXT EDITOR screen.
MENU	Moves from the TEXT EDITOR screen to the main menu. While in the main menu, press and hold this key to display current setup status.
PRINT	Activates the printing function.
HELP	Press and hold the key down for help instructions appropriate to current activity.
SERIAL	Toggles the serialization status (on/off) of a character at the cursor.
SAVE	Stores current legend to a previously created list.
RECALL	Enables viewing of legends in a previously created list.
REPRINT	Prints a duplicate of the last marker printed.
FEED	Advances marker roll to next marker. (You must be in TEXT EDITOR).
SHIFT + FEED	Back feeds the marker roll through the printer (you must be in TEXT EDITOR).

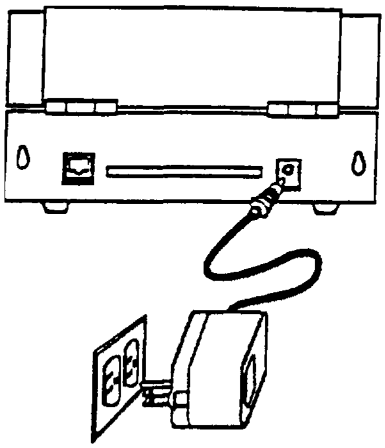


Figure 11. AC Connections

WARNING

The lithium cell contained within the LS2000 is considered hazardous, toxic waste, and must not be incinerated or thrown away in the shop trash; contact the Hazardous Waste Disposal Officer for proper disposal.

Do not expose lithium cells to extreme heat, battery may explode.

52. **INITIALIZATION.** Initialization of the printer simply means to electronically prepare the printer for any future use and it only needs to occur one time. It occurs in the background during the first power on session of the printer. What this means is that a few of the screens in this setup procedure appear automatically, and in the sequence that they do, only during the printer's initial setup. During any future use of the printer, you can freely maneuver among these menus to accommodate individual editing requirements.

53. **Preparation For Operation.** With the power OFF, follow the below procedures to set up the LS2000 for operation.

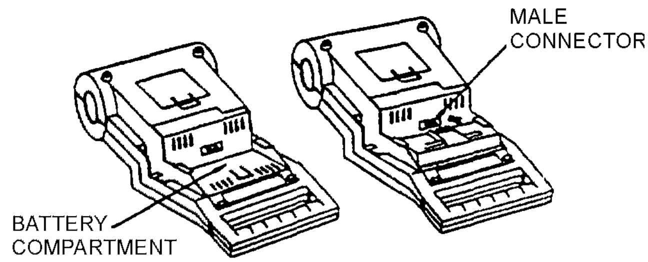


Figure 12. Battery Installation

54. **Battery Installation.**

WARNING

To prevent a hazard and destruction of the battery, the battery pack should be stored inside the battery compartment at all times. Avoid bridging the female connector on the battery pack with electrically conductive material.

There is a danger of explosion if the battery is incorrectly replaced.

a. Place the LS2000 upside down on a stable surface with the handle toward the operator to expose the battery compartment (Figure 12).

b. Place the NiCad battery pack at the top of the battery compartment with flat surface of battery facing down and female connector facing away.

c. Gently slide battery pack toward male connector located at rear of battery compartment.

d. The battery pack is secure once connectors are properly seated and a audible click is heard.

51. When the battery has reached a minimum level of power, the printer will emit short continuous beeps until the AC adapter/charger is connected. To extend life of the battery, restore the battery to full power (recharge for at least 16 hours) before operating the printer using battery power.

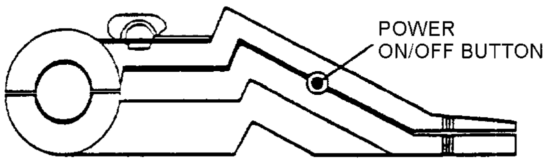


Figure 13. Power ON/OFF Button

55. AC Adapter/Charger Connection.

NOTE

Operating the printer with the AC adapter/ charge connected simultaneously charges the battery pack The battery pack should be charged for 16 hours before attempting to operate the printer exclusively on battery power.

a. Insert the adapter/charger's barrel plug connector into the port located at rear of printer (Figure 11).

b. Connect the adapter/charger box to an outlet.

56. Turning Power ON.

a. Locate power ON/OFF button found along left side of printer (Figure 13).

b. Gently push power button in until two clicks are heard. After a few seconds the screen will appear.

c. The screen will display a series of interactive screens pertaining to labels chosen to create.

57. Marker Selection.

a. Select a marker or sleeve from within the screen as either a 1) Standard Part, 2) Permasleeve, or 3) Terminal Block.

b. Press ENTER.

c. There are two methods used to select items within the display screen.

(1) Press the first letter of the selection. Pressing first leper of the selection will automatically activate the choice.

(2) Move the cursor by pressing control keys. The cursor will move in same direction as designated by cursor arrows (Figure 10).

d. Selections made will appear in uppercase lettering with flashing black cursor.

e. Press ENTER to activate selection.

58. Entering Marker Size Code.

a. Locate marker size code from Table 6 through Table 9 using Figure 14 as a guide for dimensions.

b. The marker size code can be found on both the package of markers and on the inside of the markers roll core.

c. To determine the size code from the stock number, locate first set of numbers contained in the stock number (Figure 14).

d. In the size code screen, enter the size code of selected marker.

e. Press ENTER.

59. Type Style, Font Scaling, and Format.

a. In the Type Style screen NORMAL is highlighted. For this set up procedure, press ENTER to select NORMAL type style.

b. In the Normal Scaling screen, the character height, line spacing, and character width are determined The number of lines that can be entered and number of characters per each line allowed for marker size is displayed on third line of this screen. For this procedure, press ENTER to select predetermined font scaling.

c. In the Format screen, COMPONENT LABEL is highlighted. For this procedure component label product should be used. Press ENTER to select the COMPONENT LABEL format.

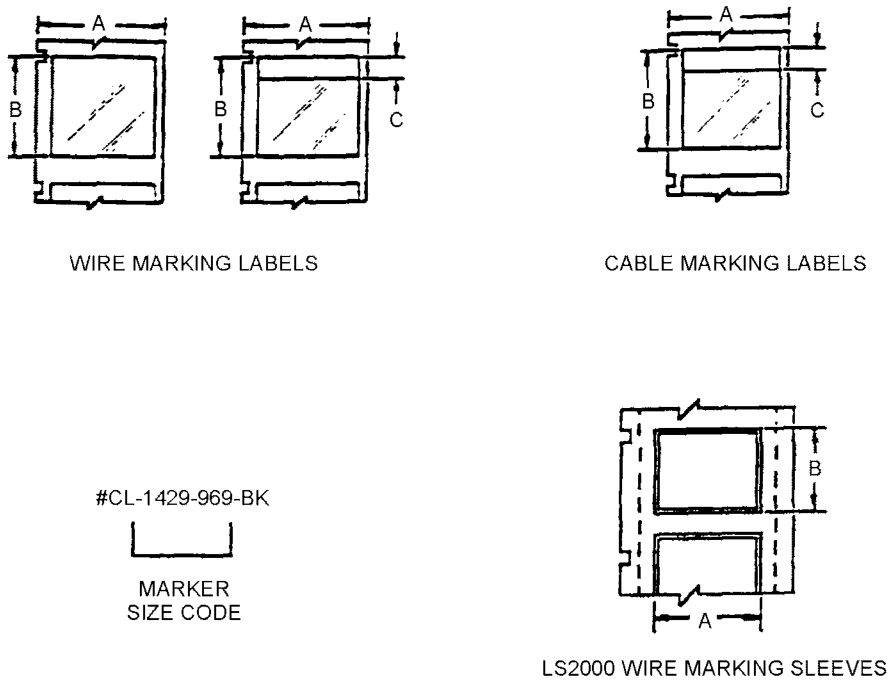


Figure 14. Label and Sleeve Dimensions with Marker Size Code

Table 6. Wire Marking Labels

Stock Number	Marker Size Code	Labels Per Roll	Labels Material	Label Dimensions Inch (mm)			Maximum Lines of Print		Maximum Characters Across			
				A	B	C	Nor.	Half	Lg.	Nor.	Sm.	Half
6 to 10 Gauge Wire (AWG Based on THHN Wire – Maximum Wire Diameter 0.026 in (6.60 mm)												
WML–905–502	905	250	General Purpose Vinyl Cloth	0.50 (12.70)	1.25 (31.75)	N/A	9	19	3	5	7	9
WML–905–632	905	250	Flame Retardant Low Profile Tedlar	0.50 (12.70)	1.25 (31.75)	N/A	9	19	3	5	7	9
WML–305–292	305	250	Self Laminating Vinyl	0.50 (12.70)	1.25 (31.75)	0.50 (12.70)	3	7	7	5	7	9
WML–911–502	911	250	General Purpose Vinyl Cloth	1.00 (25.40)	1.25 (31.75)	N/A	9	19	7	11	15	19
WML–911–632	911	250	Flame Retardant Low Profile Tedlar	1.00 (25.40)	1.25 (31.75)	N/A	9	19	7	11	15	19
WML–311–292	311	250	Self–Laminating Vinyl	1.00 (25.40)	1.25 (31.75)	0.50 (12.70)	3	7	7	11	15	19
WML–917–502	917	250	General Purpose Vinyl Cloth	1.50 (36.10)	1.25 (31.75)	N/A	9	19	11	17	23	29
WML–317–292	317	250	General Purpose Vinyl Cloth	1.50 (36.10)	1.25 (31.75)	0.50 (12.70)	3	7	11	17	23	29
WML–2007–502	2007	250	General Purpose Vinyl Cloth	0.50 (12.70)	1.25 (31.75)	N/A	10	20	3	5	7	9
WML–2015–502	2015	250	General Purpose Vinyl Cloth	1.00 (25.40)	1.25 (31.75)	N/A	10	20	7	11	15	19
WML–2411–502	2411	250	General Purpose Vinyl Cloth	0.80 (20.32)	1.50 (38.10)	N/A	12	24	5	8	11	14
WML–0811–292	0811	250	Self–Laminating Vinyl	0.80 (20.32)	1.50 (38.10)	0.50 (12.70)	4	8	5	8	11	14
WML–0807–292	0807	250	Self–Laminating Vinyl	0.80 (20.40)	1.25 (31.75)	0.50 (12.70)	4	8	3	5	7	9

Table 6. Wire Marking Labels (Cont.)

Stock Number	Mark-er Size Code	Labels Per Roll	Labels Material	Label Dimensions Inch (mm)			Maximum Lines of Print		Maximum Characters Across			
				A	B	C	Nor.	Half	Lg.	Nor.	Sm.	Half
6 to 10 Gauge Wire (AWG Based on THHN Wire − Maximum Wire Diameter 0.026 in (6.60 mm) (Cont.)												
WML−0815−292	0815	250	Self−Laminating Vinyl	1.00 (25.40)	1.25 (31.75)	0.50 (12.70)	4	8	7	11	15	19
WML−0823−292	0823	250	Self−Laminating Vinyl	1.50 (36.10)	1.25 (31.75)	0.50 (12.70)	4	8	11	17	23	29
10 to 12 Gauge Wire (AWG) Based on THHN Wire − Maximum Wire Diameter − 0.21 in (5.30 mm) (Cont.)												
WML−705−502	705	250	General Purpose Vinyl Cloth	050 (12.70)	1.00 (25.40)	N/A	7	15	3	5	7	9
WML−705−632	705	250	Flame Retardant Low Profile Tedlar	0.50 (12.70)	1.00 (25.40)	N/A	7	15	3	5	7	9
WML−205−292−1	205	250	Self−Laminating Vinyl	0.50 (12.70)	1.00 (25.40)	0.375 (9.53)	2	5	3	5	7	9
WML−711−502	711	250	General Purpose Vinyl Cloth	1.00 (25.40)	1.00 (25.40)	N/A	7	15	7	11	15	19
WML−711−632	711	250	Flame Retardant Low Profile Tedlar	1.00 (25.40)	1.00 (25.40)	N/A	7	15	7	11	15	19
WML−211−292−1	211	250	Self−Laminating Vinyl	1.00 (25.40)	1.00 (25.40)	0.375 (9.53)	2	5	7	11	15	19
WML−0607−292−1	0607	250	Self−Laminating Vinyl	0.50 (12.40)	1.00 (25.40)	0.375 (9.53)	3	6	3	5	7	9
WML−0615−292−1	0615	250	Self−Laminating Vinyl	1.00 (25.40)	1.00 (25.40)	0.375 (9.53)	3	6	7	11	15	19
WML−0615−502	1615	250	General Purpose Vinyl Cloth	1.00 (25.40)	1.00 (25.40)	N/A	8	16	7	11	15	19
WML−1607−502	1607	250	General Purpose Vinyl Cloth	0.50 (12.40)	1.00 (25.40)	N/A	8	16	3	5	7	9
10 to 12 Gauge Wire (AWG) Based on THHN Wire − Maximum Wire Diameter − 0.16 in (4.10 mm) (Cont.)												
WML−505−502	705	250	General Purpose Vinyl Cloth	0.50 (12.70)	0.75 (19.05)	N/A	5	11	3	5	7	9
WML−505−632	705	250	Flame Retardant Low Profile Tedlar	0.50 (12.70)	0.75 (19.05)	N/A	5	11	3	5	7	9
WML−205−292−75	205	250	Self−Laminating Vinyl	0.50 (12.70)	0.75 (19.05)	0.375 (9.53)	2	5	3	5	7	9
WML−511−502	711	250	General Purpose Vinyl Clofh	1.00 (25.40)	0.75 (19.05)	N/A	5	11	7	11	15	19
WML−511−632	711	250	Flame Retardant Low Profile Tedlar	1.00 (25.40)	0.75 (19.05)	N/A	5	11	7	11	16	19
WML−211−292−75	211	250	Self−Laminating Vinyl	1.00 (25.40)	0.75 (19.05)	0.375 (9.53)	2	5	7	11	15	19
WML−517−502	0607	250	General Purpose Vinyl Cloth	1.50 (38.10)	0.75 (19.05)	N/A	5	11	11	17	23	29
WML−1207−502	0615	250	General Purpose Vinyl Cloth	0.50 (12.40)	0.75 (12.05)	N/A	8	12	3	5	7	9
WML−1207−502	1615	250	Flame Retardant Low Profile Tedlar	0.50 (12.40)	0.75 (12.05)	N/A	8	12	3	5	7	9
WML−1215−502	1607	250	General Purpose Vinyl Cloth	1.00 (25.40)	0.75 (12.05)	N/A	8	12	7	11	15	19
WML−0607−292−75	0607	250	Self−Laminating Vinyl	0.50 (12.40)	0.75 (12.05)	0.375 (9.53)	3	6	7	5	7	9
WML−0615−292−75	0615	250	Self−Laminating Vinyl	1.00 (25.40)	0.75 (19.50)	0.375 (9.53)	3	6	7	11	15	19
16 to 22 Gauge Wire (AWG) Based on THHN Wire − Maximum Wire Diameter − 0.11 in (2.80 mm) (Cont.)												
WML−305−502	350	500	General Purpose Vinyl Cloth	0.50 (12.40)	0.50 (12.40)	N/A	3	7	3	5	7	9
WML−305−632	305	500	Flame Retardant Low Profile Tedlar	0.50 (12.40)	0.50 (12.40)	N/A	3	7	3	5	7	9
WML−0807−502	0807	500	General Purpose Vinyl Cloth	0.50 (12.40)	0.50 (12.40)	N/A	4	8	3	5	7	9

Table 7. Cable Marking Labels Self−Laminating White/Transparent Vinyl (B−292)

Stock Number	Marker Size Code	Labels Per Rolls	Label Dimensions Inch (mm)			Maximum Lines of Print		Maximum Characters Across			
			A	B	C	Nor.	Half	Lg.	Nor.	Sm.	Half
WML−511−292	511	100	1.50 (25.40)	2.50 (63.50)	0.75 (19.05)	5	11	7	11	15	19
WML−711−292	517	100	1.50 (38.10)	2.50 (63.50)	0.75 (19.05)	5	11	11	17	23	29
WML−711−292	711	100	1.00 (25.40)	4.00 (101.60)	1.00 (25.40)	7	15	7	11	15	19
WML−717−292	717	100	1.50 (38.10)	4.00 (101.60)	1.00 (25.40)	7	15	11	17	23	29
WML−1215−292	1215	250	1.00 (25.40)	2.25 (57.15)	0.75 (19.05)	6	12	7	11	15	19
WML−1215−292−25	1215	100	1.00 (25.40)	2.50 (63.50)	0.75 (19.05)	6	12	7	11	15	19
WML−1223−292	1223	100	1.50 (38.10)	2.50 (63.50)	0.75 (19.05)	6	12	11	17	23	29
WML−1231−292−22	1231	250	2.00 (50.80)	2.25 (57.15)	0.75 (19.05)	6	12	15	24	31	39
WML−1231−292−30	1231	100	2.00 (50.80)	8.00 (76.20)	0.75 (19.05)	6	12	15	24	31	39
WML−2431−292−60	2431	75	2.00 (50.80)	6.00 (152.40)	1.50 (38.10)	12	24	15	24	31	39
WML−2431−292−75	2431	75	2.00 (50.80)	7.50 (190.50)	1.50 (38.10)	12	24	15	24	31	39

Table 8. Portable Printing Sleeves Heat−Shrink White Polyolefin (B−341)

Stock Number	Marker Size Code	Sleeves Per Roll	Range of Wire Dia. In (Mm)		Approx. Wire Gage	Sleeve Dimensions Inch (mm)		Maximum Lines of Print		Maximum Characters Across			
			Min.	Max	(Note 1)	A	B	Nor.	Half	Lg.	Nor.	Sm.	Half
1.00 In. Marker Width													
PSBXP−111−125	111	500	0.062 (1.57)	0.110 (2.79)	18 – 16	1.00 (25.40)	0.235 (6.00)	1	3	7	11	15	19
PSBXP−111−187	111	500	0.094 (2.39)	0.150 (3.81)	16 – 12	1.00 (25.40)	0.335 (8.50)	1	3	7	11	15	19
PSBXP−211−250	211	500	0.125 (3.18)	0.215 (5.46)	12 – 10	1.00 (25.40)	0.439 (11.20)	2	5	7	11	15	19
PSBXP−311−375	311	250	0.188 (4.78)	0.320 (8.13)	8 – 6	1.00 (25.40)	0.645 (16.40)	3	7	7	11	15	19
PSBXP−411−500	411	250	0.250 (6.35)	0.450 (11.43)	4 – 1	1.00 (25.40)	0.851 (21.60)	4	9	7	11	15	19
1.25 In. Marker Width													
PSBXP−114−125	114	500	0.062 (1.57)	0.110 (2.79)	18 – 16	1.25 (31−75)	0.235 (6.00)	1	3	10	14	19	24
PSBXP−114−187	114	500	0.094 (2.38)	0.150 (3.81)	16 – 12	1.25 (31−75)	0.335 (8.50)	1	3	10	14	19	24
PSBXP−214−250	214	500	0.125 (3.18)	0.215 (5.46)	12 – 10	1.25 (31−75)	0.439 (11.20)	2	5	10	14	19	24
PSBXP−314−375	314	250	0.188 (4.78)	0.320 (8.13)	8 – 6	1.25 (31−75)	0.645 (16.40)	3	7	10	14	19	24
PSBXP−414−500	414	250	0.250 (6.35)	0.450 (11.43)	4 – 1	1.25 (31−75)	0.851 (21.60)	4	9	10	14	19	24
2.00 Marker Width													
PS−0231−094W	0231	500	0.047 (1.19)	0.080 (2.03)	22 – 18	2.00 (50.80)	0.182 (4.63)	1	2	15	24	31	39
PS−0231−125W	0231	500	0.062 (1.57)	0.110 (2.79)	18 – 16	2.00 (50.80)	0.235 (5.97)	1	2	15	24	31	39
PS−0331−187W	0231	500	0.094 (2.38)	0.150 (3.81)	16 – 12	2.00 (50.80)	0.335 (8.51)	1	3	15	24	31	39
PS−0531−250W	0531	500	0.125 (3.18)	0.215 (5.46)	12 – 10	2.00 (50.80)	0.439 (11.16)	2	5	15	24	31	39
PS−0831−375W	0831	250	0.188 (4.78)	0.320 (8.13)	8 – 6	2.00 (50.80)	0.645 (16.38)	4	8	15	24	31	39
PS−1031−500W	1031	250	0.250 (6.35)	0.450 (11.43)	4 – 1	2.00 (50.80)	0.851 (21.62)	5	10	15	24	31	39
PS−2231−1000W	2231	100	0.450 (11.43)	0.950 (24.13)	1 – 500	2.00 (50.80)	1.66 (42.16)	11	22	15	24	31	39

NOTES:
l. Based on National Electric Code insulation measurement of THHN wire.
2. Sleeves may be slit at factory for shorter marker lengths. Depending on overall length, sleeves may be slit in halves, thirds or fourths. Contact. your Brady Industrial Products distributor or Customer Service Representatives for ordering information.

Table 9. Portable Printing Sleeves Heat–Shrink Yellow Polyolefin (B–341)

Stock Number	Marker Size Code	Sleeves Per Roll	Range of Wire Dia. In (Mm)		Approx. Wire Gage	Sleeve Dimensions Inch (mm)		Maximum Lines of Print		Maximum Characters Across			
			Min.	Max	(Note 1)	A	B	Nor.	Half	Lg.	Nor.	Sm.	Half
2.00 Marker Width													
PS–0231–094Y	0231	500	0.047 (1.19)	0.080 (2.03)	22 – 18	2.00 (50.80)	0.182 (4.63)	1	2	15	24	31	39
PS–0231–125Y	0231	500	0.062 (1.57)	0.110 (2.79)	18 – 16	2.00 (50.80)	0.235 (5.97)	1	2	15	24	31	39
PS–0331–187Y	0231	500	0.094 (2.38)	0.150 (3.81)	16 – 12	2.00 (50.80)	0.335 (8.51)	1	3	15	24	31	39
PS–0531–250Y	0531	500	0.125 (3.18)	0.215 (5.46)	12 – 10	2.00 (50.80)	0.439 (11.16)	2	5	15	24	31	39
PS–0831–375Y	0831	250	0.188 (4.78)	0.320 (8.13)	8 – 6	2.00 (50.80)	0.645 (16.38)	4	8	15	24	31	39
PS–1031–500Y	1031	250	0.250 (6.35)	0.450 (11.43)	4 – 1	2.00 (50.80)	0.851 (21.62)	5	10	15	24	31	39
PS–2231–1000Y	2231	100	0.450 (11.43)	0.950 (24.13)	1 – 500	2.00 (50.80)	1.66 (42.16)	11	22	15	24	31	39

NOTES:
l. Based on National Electric Code insulation measurement of THHN wire.
2. Sleeves may be slit at factory for shorter marker lengths. Depending on overall length, sleeves may be slit in halves, thirds or fourths. Contact. your Brady Industrial Products distributor or Customer Service Representatives for ordering information.

NOTE

System defaults to uppercase; press SHIFT key in combination with any character to appear in lowercase. Press both SHIFT and ENTER keys to Lock–in lowercase type style.

Holding down any character in the standard keys will detain the help screen long enough for information provided to be read.

60. **Text Label.** The EDITOR screen is now displayed and the message “Enter New Legend” is displayed.

a. To activate any characters appearing in blue, press in combination with SHIFT key.

b. To delete any character, 1) press SHIFT + DELETE; characters to left of cursor will be deleted, or 2) place cursor under any character and press DELETE.

c. Press ENTER to advance to next line in legend.

d. Enter text desired for label.

e. Do not enter any more commands before installing markers and ribbon.

61. **Ribbon Installation.**

a. Release cover of printer by placing fingers in notch under cover on both sides of printer and pull–up. Lay cover back until it rests on hinges (Figure 15).

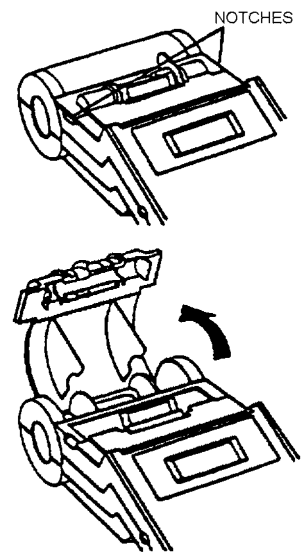


Figure 15. Printer Cover

b. Expose ribbon compartment by lifting cover on the house tear bar. Place a finger to either side of tear bar and tilt cover back toward front of printer (Figure 16).

c. Hold ribbon cartridge over ribbon compartment with exposed ribbon facing toward back of printer and small notch in ribbon cartridge facing down.

d. Tilt exposed portion of ribbon down and position ribbon along side of plastic shield closest to front of printer. Gently bring back of ribbon cartridge down and press it into ribbon compartment until a click is heard.

e. Tighten ribbon in cartridge by placing your thumb over ribbon advance knob and turn clockwise.

f. Locate platen gap adjustment (Figure 17).

g. Determine setting for marker from Table 10 (also under printer cover) and turn platen gap adjustment knob until value appears alongside alignment knob.

62. **Marker Tape Installation.**

a. Release cover of printer by placing fingers in notch under cover on both sides of printer and pull–up. Lay cover back until it rests on hinges (Figure 15).

b. Remove roll spindle from the printers crib and slide off blue adjustable spindle guide (Figure 18).

c. Holding roll of markers with notches to the left, slit roll of markers all the way to left side of roll spindle. With flat of adjustable spindle guide facing roll of markers, return guide onto spindle.

d. Position blue guide in one of slots on spindle close to roll of markers.

e. Place spindle in stage area of printer with blue adjustable spindle guide facing to right.

f. Locate the fixed and adjustable material guides found just beyond the spindle holder. Push adjustable material guide up in order to slide it from one slot to another along material guide detent shaft (Figure 19).

g. Slide the adjustable guide to a position along the shaft that fits the marker liner most comfortably. Assure that guide is positioned in one of grooves along shaft.

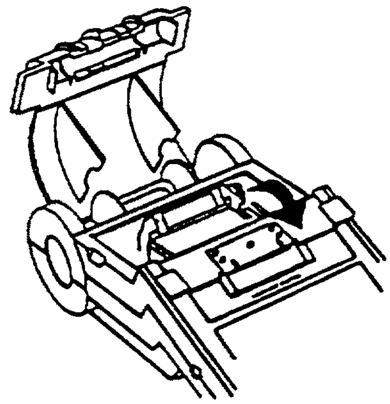


Figure 16. Ribbon Compartment

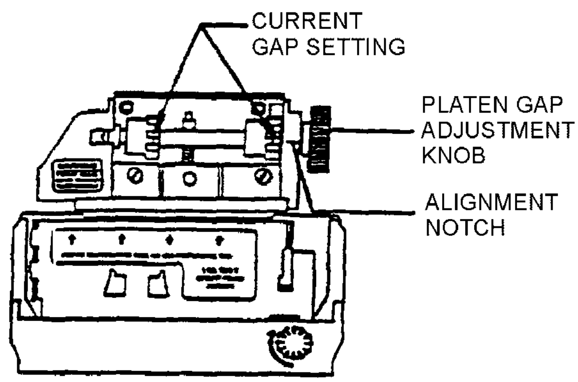


Figure 17. Platen Gap

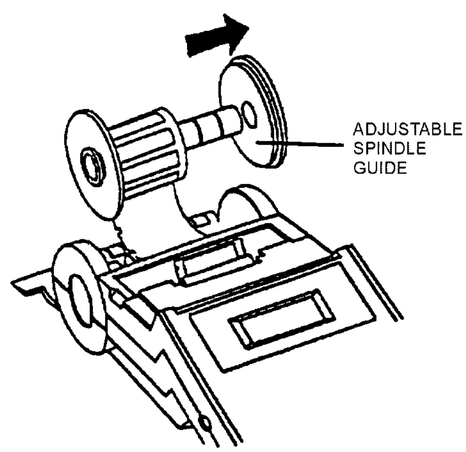


Figure 18. Adjustable Spindle

Table 10. Platen Gap Setting

Stock Code	Material	Gap Setting
B−122	Permanent Paper	1
B−292	Self−Laminating Vinyl	2 or 3
B−319	Non−Shrink Bradysleeve	3 or 4
B−321	Heat Shrink Bradysleeve	3 or 4
B−322	Self−Extinguishing Bradysleeve	3 or 4
B−341	Heat−shrink Permasleeve	5 or 6
B−502	Vinyl Cloth	2 or 3
B−607	Tamper Evident Vinyl	1
B−619	Polyester	2
B−621	Translucent Polyester	2
B−632	Tedlar	1
B−637	Tedlar Film	2
B−652	Polyimide Film	2 or 3
B−969	Metalized Polyester	2

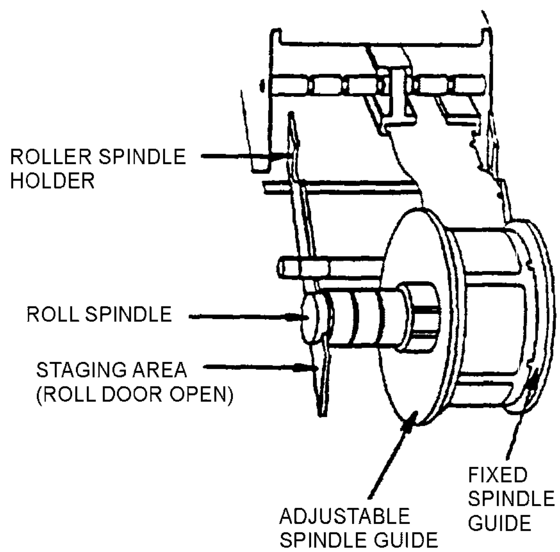


Figure 19. Spindle Guide

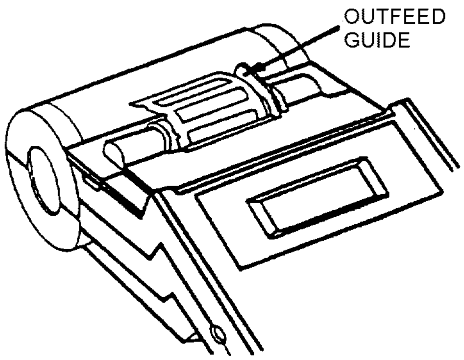


Figure 20. Outfeed Guide

h. Feed roll into slots of material guides until marker will not advance any further into printer.

i. Press FEED button located on function control panel of keyboard. Markers will advance to a position ready for, printing.

j. Move roll spindle from stage area to spindle holder.

k. Return ribbon compartment cover to its Original position, close printer cover.

l. Adjust blue outfeed guide to keep marker liner properly aligned as it advances out of printer. If necessary, readjust outfeed guide once the markers have advanced during a printing session (Figure 20).

m. After completing set up procedure the printer may be tuned OFF. When it is turned on again the TEXT EDITOR screen will appear, refer to Paragraph 60.

63. **SCREENS AND MENUS.**

64. **Text Editor.** After the printer has been initialized (Paragraph 60) the TEXT EDITOR screen will appear each time the screen is turned on. One of the following screens will appear.

a. ENTER NEW LEGEND. When this prompt is flashing, text for a new label can be entered, using previously defined parameters.

b. <CLEAR>TO ERASE. When this prompt is flashing, previously entered text can be edited or cleared.

c. LEGEND HAS BEEN TRUNCATED. This prompt indicates that characters/lines (data) of a current legend have exceeded the setup parameters designated in the EDITOR status.

65. **Amending Parameters.** To amend any parameters previously defined, complete the following procedure:

a. Press MENU button to call up MAIN MENU.

66. **LABEL PRINTING.**

NOTE

The text for labels should be displayed on the screen.

To terminate printing at any time press EXIT.

a. Press PRINT and Copy Quantity appears on the screen.

b. Enter the number of copies to be printed.

c. Press PRINT or ENTER, roll marker will begin to advance and printer will start to print labels.

d. Once printing has ended. a new legend can be entered by pressing CLEAR.

e. To duplicate a marker just printed, press REPRINT. (The reprint command will print a duplicate of a serialized marker without incrementing any serialized characters.)

f. Press the first letter of selection from any menu or submenu to make a selection or using cursor control keys highlight selection.

g. Press ENTER.

67. **CREATING A LEGEND USING MAIN MENU.**

68. **Setting Marker Size.** The LS2000 can print a wide variety of marker sizes. The parameters allowed by the legend are determined by the printable area on the marker selected (code size), so marker size must be identified. To set or change the marker size complete the following procedure:

a. Select MARKER option from main menu.

b. Select the type of marker being used (Standard Part, PermaSleeve or Terminal Block).

c. Key in new size in SIZE CODE display screen.

d. Press ENTER.

69. **Size Code.** Each roll of markers is identified by a stock number which includes the marker size code (Figure 14) The marker size code defines both the maximum number of print lines on each marker and the maximum number of characters on each line.

a. Maximum number of lines and characters assumes the character width, character height and line spacing are scaled at their baseline size of 1.

b. Maximum number of lines and characters assumes the character width, character height and line spacing are scaled at their baseline size of 1.

70. **Selecting Format.** The LS2000 can print markers in one of the following formats: Wiremarker Component Label, or Strip Wiremarker.

a. To select a format press PRINTER from main menu.

b. When PRINTER screen appears, select FORMAT.

NOTE

If wiremarker format is selected, the number of strips across that are to be printed will have to be indicated. The marker size code for strip markers refers to size of each strip, not total print area across all strips.

c. Choose one of print formats displayed on screen:

(1) Wiremarker Format. The wiremarker format is designed to automatically repeat the text of a legend down the length of a marker as many times as possible, considering the number of lines available in the marker. For example, maker size code 0531 allows a maximum of 5 lines per marker. When printing a 2–line legend, the legend will be repeated 2 times, for a total of 4 lines. The 5th line will be blank.

(2) Component Label Format. The component label format is designed to print all lines of a legend one time before advancing to the next marker.

(3) Strip Wiremarker Format. The strip wiremarker format is designed to be used with the strip, series of labels or PermaSleeve labels. The strip wiremarker is similar to the wiremarker format except that it is designed to print duplicate markers on a multiple across label (also referred to as butt cut set). The legend composed in this format will be duplicated in each strip of the butt cut set. It should be noted that the set is considered a single marker for serializing or printing.

71. **Selecting Printer Modes.** The LS2000 will print in 1 of 2 modes, single marker mode or multiple marker mode. To set the printing mode:

a. Select PRINTER from main menu followed by Q to select quantity.

b. Select SINGLE or MULTIPLE marker mode. The printer will remain in the mode selected until modified.

72. **Single Marker Mode.** This mode instructs the LS2000 to print 1 marker for each print command. It allows time to proof the marker for accuracy or edit the legend. Switch to the multiple marker mode to increase the quantity to print, per print command.

73. **Multiple Marker Mode.**

a. Instructs the LS2000 to print multiple markers without hesitation. Enter any number 1 – 999.

b. Notice that if the printer has been set in multiple marker mode, the screen will always prompt to enter the number of duplicate copies required per each print command.

c. After entering legend, simply press PRINT. Enter the number of identical markers to be printed and press ENTER to activate the command. (Press EXIT to terminate a print session in progress.)

74. **Type Size.** The LS 2000 will print in 5 different type sizes (Figure 21):

Small	16 characters per inch (CPI)
Normal	12 characters per inch
Large	8 characters per inch
Halfhigh	20 characters per inch
Rotated	16 characters per inch

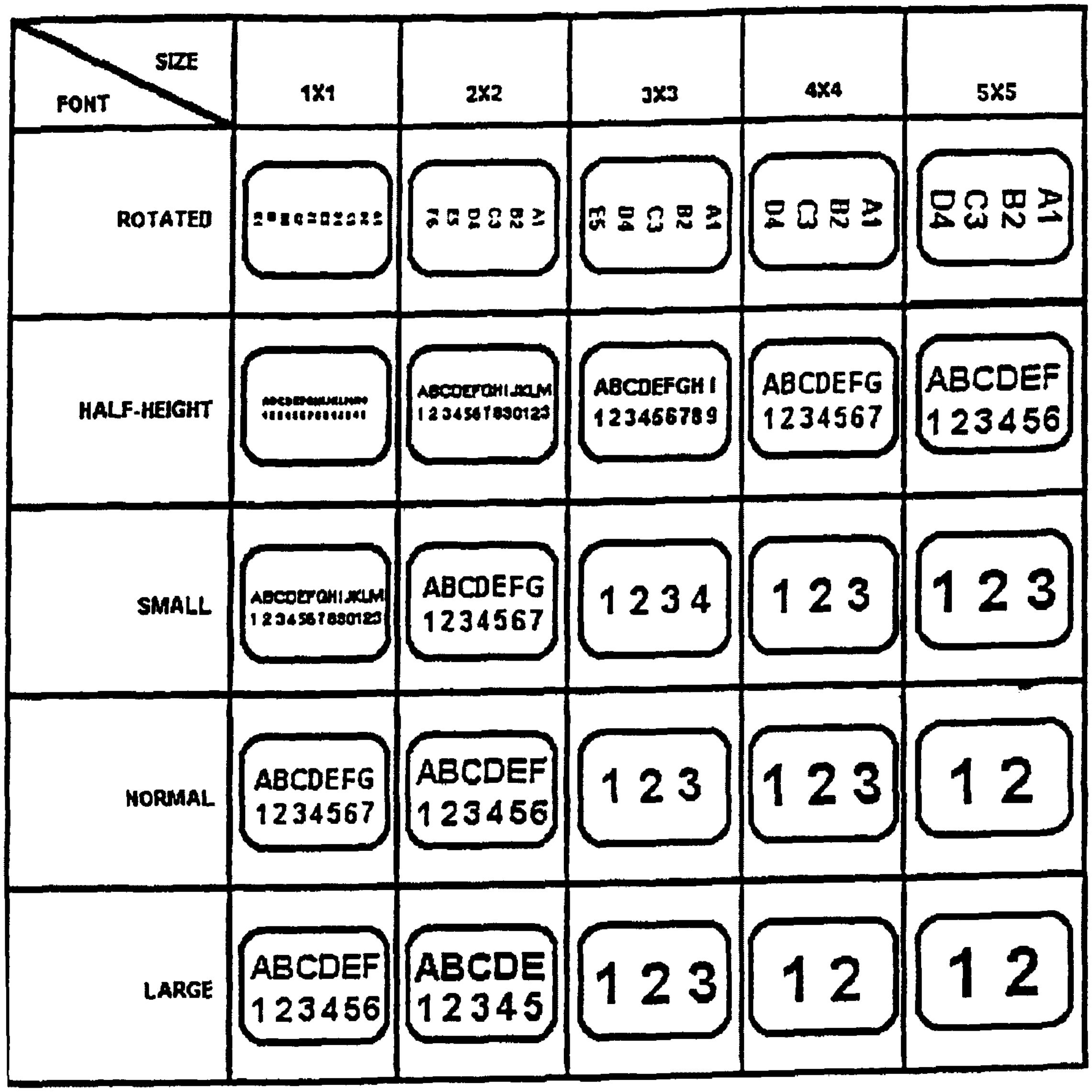


Figure 21. LS2000 Type Sizes

75. These sizes represent the initial baseline size of each type style. Each type style can be scaled up to 5 times its original size in both height and width dimensions. To set or change the type style and size complete the following steps.

a. Select TYPE– option from main menu.

b. Use cursor control keys to change style and size parameters.

c. Press left and right arrows or press first letter of selection to move between categories.

d. Press up and down arrows to increase or decrease the values within each category.

NOTE

The number of lines/characters will automatically change as a result of increasing or decreasing the scaling parameters. The type size combined with the marker size will determine the maximum number of characters that can be printed on each line of print.

76. For every increase of 1, the distance between lines of text increases by 1/2 of a print dot (0.00625 inch). This feature becomes very useful when printing characters containing ascenders and descenders.

77. **Width Spacing.** The third position on the scaling screen is for setting width scaling. This allows the scaling of the width of the character from its baseline size of 1, up to 5.

78. **PRINTING FROM THE EDITOR.** The easiest way to print markers is directly from within the TEXT EDITOR. To print a single marker of the legend currently displayed in the TEXT EDITOR, press PRINT.

a. If in the multiple marker mode, prompt will indicate to enter quantity desired to be printed.

b. If in the single marker mode, printer will immediately print just 1 marker.

79. **MENU TREE.** The general structure of the software is displayed in the menu tree (Figure 22). When you reach the options level of menu operations, the printer indicates that it accepts your input or selection with a brief 3–beep tone and will return to the TEXT EDITOR.

80. **PRINTING PERMASLEEVE MARKERS.** When creating a legend for Permasleeve marker, assure that you choose Permasleeve from the marker submenu. This is important because the Permasleeve has a larger lead margin than other markers and the printer will not print in the proper location on the sleeve if another type is chosen

a. Loosen two platen removal screws in platen assembly until they are loose from the printer frame (Figure 23).

81. **Platen Assembly.**

CAUTION

Never backfeed Permasleeve material through the printer with sleeves removed from the carrier. The exposed adhesive will cause damage to the printer mechanism.

a. Clean the drive roller using isopropyl alcohol and a clean rag using steps in paragraph 85.

b. Install bottom door.

CAUTION

Excessive force on the optic eye bracket will cause misalignment of the optic eye and the printer will have to be sent for repair.

c. Remove bottom ribbon.

82. When printing Permasleeve markers, it is recommended to run the printer with the adapter/charger connected to assure proper feeding of markers. Also assure printhead gap is set to 6.

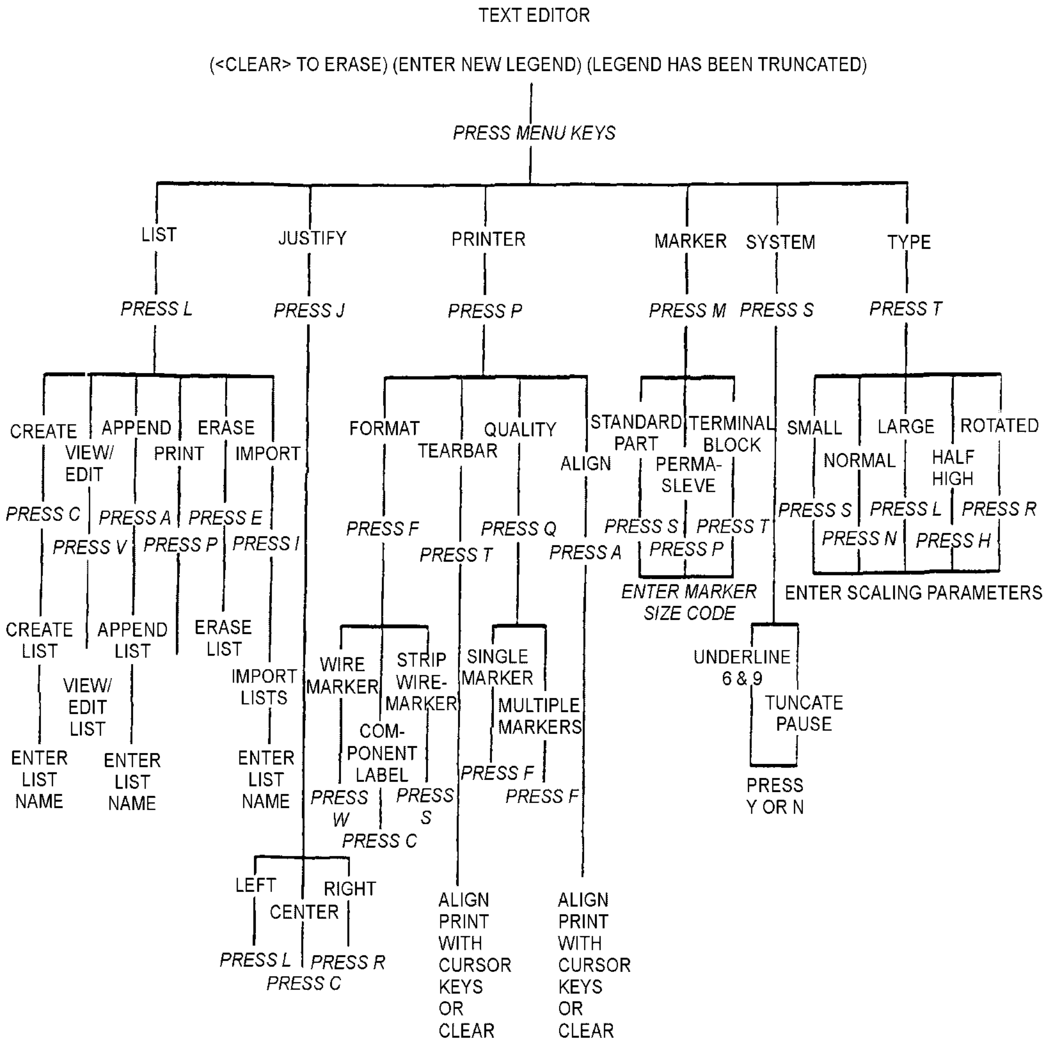


Figure 22. Menu Tree

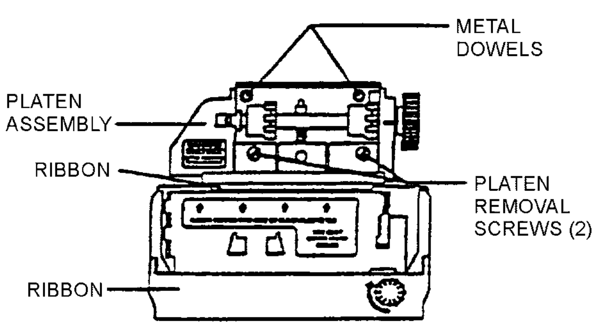


Figure 23. Platen Assesmbly

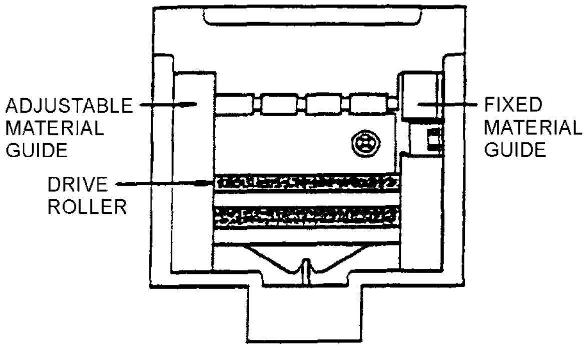


Figure 24. Drive Roller

83. **MAINTENANCE AND CLEANING.**

CAUTION

Isopropyl alcohol TT–I–735, is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

84. **Drive Roller.** Lint and dust may build up on the drive roller resulting in the slipping of material when feeding it through the printer. To clean the drive roller, complete the following steps.

a. Remove the bottom door located on the underside of the printer.

b. The drive roller is a rubberized roller located directly under the fixed and adjustable material guide Push down on adjustable material guide and slide left/right in order to access the entire drive roller (Figure 24).

c. Gently lift platen assembly up until platen assembly frame clears metal dowels.

d. Remove platen from printer withoug disturbing optic eye.

e. Remove any lint, ink, or adhesive build–up on the face using isopropyl alcohol and a clean rag.

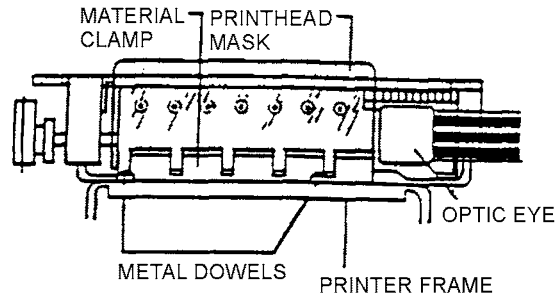


Figure 25. Material Clamp

f. Before installing platen assembly, clean printhead and material clamp.

85. **Printhead Mask.** The printhead mask is a clear, thin plastic shield with 7 holes punched in it. It is located between the platen and printer assemblies. With platen assembly removed, clean outside surface of printhead mast using isopropyl alcohol and a cotton swab. Remove any black, lint around printer (Figure 25).

86. **Material Clamp**. The material clamp is a thin metal foil that forces the label material against the platen assembly during operation. Clean tabs of material clamp using isopropyl alcohol and a cotton swab. Assure material clamp fingers are not excessively flexed.

87. **Platen Assembly Installation.**

CAUTION

Do not bend the material clamp down or bend the optic eye bracket.

a. Gently place platen assembly onto printer frame by aligning holes of platen assembly frame over metal dowels on printer frame (Figure 23).

b. Tighten platen removal screws into printer frame.

c. Install printer ribbon.

88. **Tear–Off Blade Cover Bar.** The cover bar shields the label material from the tearbar during printing process. It is located along the ribbon cover door on top of printer. Clean cover bar using isopropyl alcohol and a clean rag.

89. **TROUBLESHOOTING.** Refer to Table 11 for printing problems and probable corrective actions.

Table 11. Troubleshooting

Symptom	Probable Cause	Corrective Action
Labels not advancing	Label is stuck on material.	Remove label from path by removing the platen assembly.
	Labels are not inserted into material guides correctly.	Reinsert material if necessary.
	Dirty drive roller, platen, mask, or material clamp.	Clean printer.
	Adjustable material guide is not in grooved clamp.	Move guide into one of the slots and try feeding. Ensure guide is centered in slot.
	Bent material clamp.	Check platen assembly; remove the assembly. Inspect the material clamp fingers for damage. If bent down, send the printer to a depot maintenance repair facility.
Printing is faint and hard to read.	Ribbon is worn.	Change ribbon. (Ribbon should last approximately 250,000 characters or 3 to 6 months, depending on environment.)
	Batteries are low.	Connect adapter charger to printer. Attempt to print while still connected. If printer works, charge for at least 16 hours.
	Wrong printhead gap setting.	Adjust printhead setting.
	Ribbon is installed incorrectly.	Remove ribbon and reinstall.
	Ribbon is not advancing due to broken printer gear.	Send the printer to a depot repair facility.
Printing runs off the label.	Incorrect material size code entered.	Check the material size code on inside of the roll core or marker packaging and enter the correct size code. Be sure not to enter a zero in the size code if not specified. Use spacebar to remove the unwanted character.
	Printing not aligned properly.	Align the print on the label.
	Optic eye failure.	Send the printer to a depot repair facility.
Label is missing characters.	Printing over ribbon weld.	Printer will periodically strike the ribbon weld. Turn the manual ribbon advance knob on the ribbon clockwise to advance the ribbon past the weld.
	Broken printhead pin or inoperative solenoid. Markers will consistently have missing areas of print.	Send printer to a depot maintenance facility.
	Broken printhead pin or inoperative solenoid. Markers will consistently have missing areas of print.	Send printer to a depot maintenance facility.
	Platen assembly was installed incorrectly	Check the platen assembly; inspect. the material clamp fingers for damage. If bent down, send printer to a depot maintenance facility.
Printer is smearing labels.	Printhead gap is too small.	Adjust printhead setting.
	Platen, mask, material clamp, or tearbar cover is dirty.	Clean printer.
	Ribbon is not installed correctly.	Remove the reinstall ribbon.
Printer will not operate on batteries.	Batteries are not charged.	Connect the adapter/charger to the printer. Charge the battery for at least 16 hours before operating solely on battery power.
	Battery's life has expired.	Battery life is approximately two to three years, depending on use and care of battery.

Table 11. Troubleshooting (Cont.)

Symptom	Probable Cause	Corrective Action
	Blown fuse.	Send printer to a depot maintenance facility.
Scanning error or feed malfunction message.	Wrong product selection.	Change product selection.
	Label is stuck inside printer.	Remove the bottom cover and inspect for a stuck label. If not found in this compartment, remove the label from the printer by removing the platen assembly.
Errors:	Optic eye failure	Send printer to a depot maintenance facility.
Markers skewed right or markers skewed left.	Material is wandering right or left.	Verify that adjustable material guide is in the correct position and resting in a groove along the guide shaft. Check that the printer cover is closed and the outfeed guide is properly adjusted.
Printer is emitting a beeping tone.	Optic eye bracket has been bent.	Send printer to a depot maintenance facility.
	Battery power is low.	Connect the adapter/charger to the printer. Charge the battery for at least 16 hours before operating solely on battery power.
Continuous tone coming from unit and printer has locked−up .	Label is stuck in printer.	Inspect for proper gap setting. Adjust the setting and then turn the printer OFF, then ON. If this does not solve the problem, inspect to see if a label is stuck inside the printer. Remove the label by removing the bottom cover or the platen assembly.
	Ribbon cartridge has locked−up.	Remove ribbon cartridge from printer and attempt to free it by pulling on the ribbon and advancing the ribbon gear, or change the ribbon.

90. **BRADY MARKER SLEEVE INSTALLATION.** To install the marker sleeves after printing, perform the following:

a. Press FEED to move last printed sleeve above tear bar and tear sleeve along perforation to remove from printer (Figure 26).

NOTE

If wire has been stripped, use a scrap piece of unstripped wire to open end of marker.

b. Hold marker, printed side up, and press end of wire on lip of sleeve to open sleeve (Figure 27).

c. Push sleeve onto wire with gentle twisting motion.

d. Shrink marker sleeve, using heat gun with shrink tubing attachment (Figure 28).

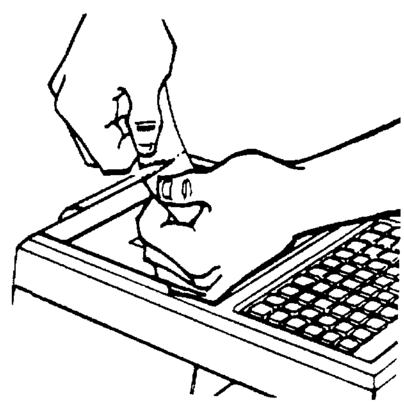


Figure 26. Removing Marker from Printer

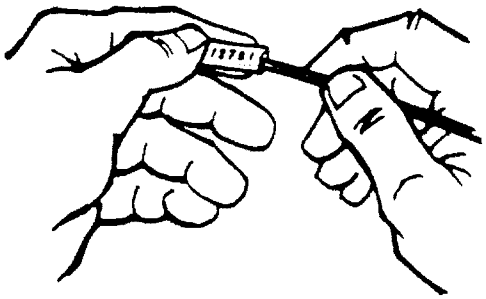


Figure 27. Inserting Wire Into Marker

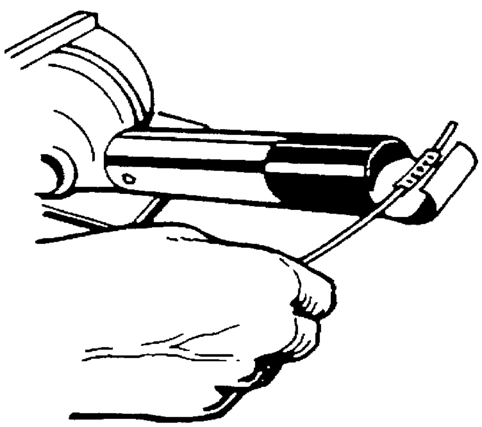


Figure 28. Shrinking Marker on Wire

91. WIRE OR HARNESS MARKING USING TAPE.

92. Wires and harnesses may be marked by using tape and an indelible marker following the procedure listed below (Figure 29):

a. Ensure wire/harness is clean, (WP 026 00).

b. Install tape wire marker using marking tape NSN: 7510–01–127–0648. Wrap tape around with minimum 50% overlap for larger harnesses, or longer ID numbers for wire, or harness identification.

c. Using blac, fine tip permanent marker (NSN: 7510–01–504–8938) print the wire number or designator on the label tape.

d. Wrap tape at appropriate location (refer to paragraphs 30 and 31, this WP).

e. Ensure tape has good adhesion and that the wire number/harness designator is visible.

f. Secure with lacing tape spot tie at each end (WP 010 00).

93. MARKER INSTALLATION WITH LACING TAPE.

94. A marker may be secured to the cable with lacing tape (Figures 30 through 32).

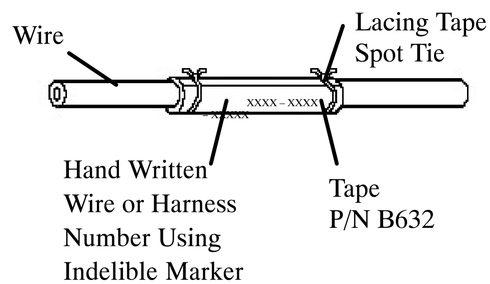


Figure 29. Tape Wire Identification Marker

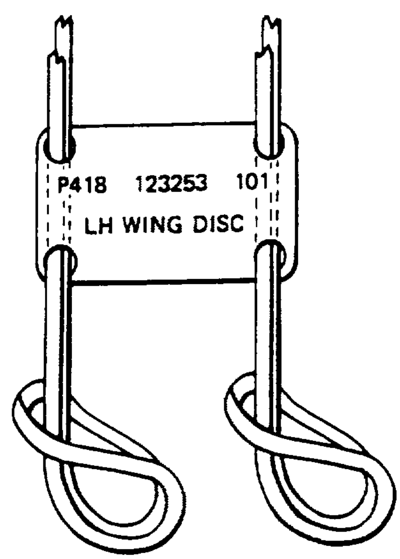


Figure 30. Installing Tape to Marker

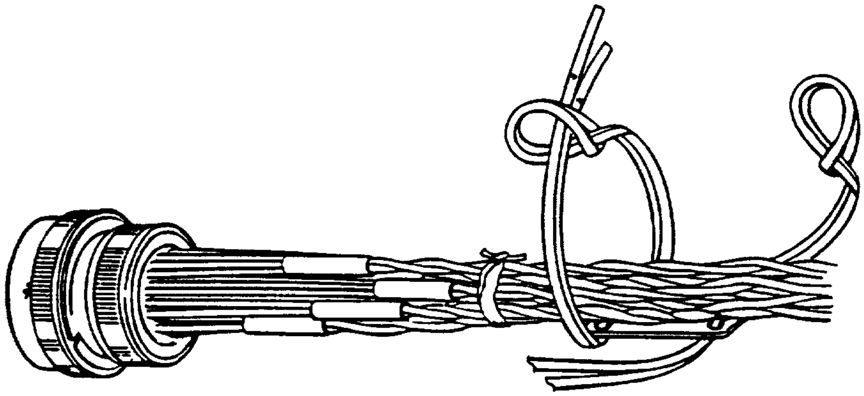


Figure 31. Installing Marker to Harness

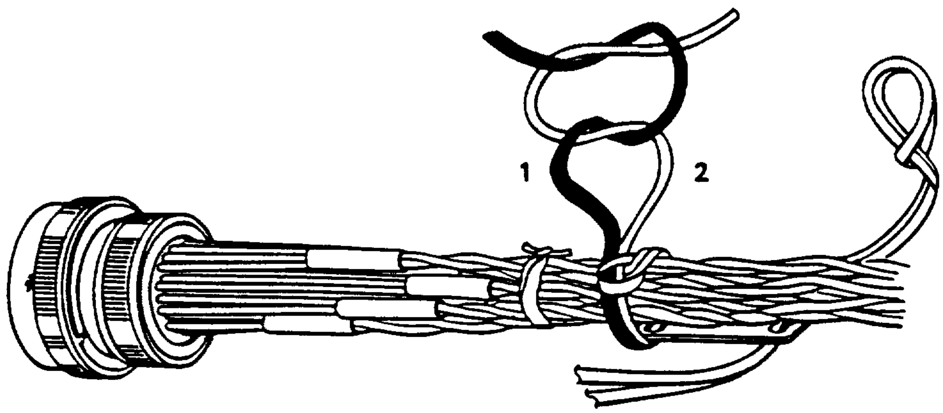


Figure 32. Securing Marker to Harness

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WIRE AND CABLE STRIPPING

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Low Frequency, Multiconductor Round Cable Description and Replacements 005 00
Wire Characteristics and Substitutions 004 00
Cable, Electric, Filter Line, Radio Frequency Absorptive MIL–C–85485
Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane–imide Polymer or
Polyarylene Insulated Copper or Copper Alloy MIL–W–81044
Wire, Electric, Fluoropolymer Insulated Copper or Copper Alloy MIL–W–22759
Wire, Electric, Polyimide Insulated Cooper or Copper Alloy MIL–DTL–81381
Wire, Electric, Polyvinyl Chloride Insulated MIL–W–5086

Alphabetical Index

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) covers the procedures, tools, and specifications required for the proper preliminary preparation and stripping of wires and cables. Wire and cable selection are covered in WP 004 00, WP 005 00 and WP 006 00. Before wires and cables can be assembled to connectors, terminals, and splices the insulation and shielding, if applicable, must be stripped to expose the center conductor. Additional wire stripping tool information is available in SAE AS 5457.

3. WIRE PREPARATION.

CAUTION

Ensure that proper cutting tools are used and that cutting surfaces are clean, sharp, and free from nicks.

Support Equipment Required

Part Number / Type Designation	Nomenclature
AS5768/1–T1 thru T24	Tool, Stripper, Manually Actuated, Electrical Insulation, Round Wire, Size 10 to 30
AS5768/2–T1 thru T13	Tool, Stripper, Manually Actuated, Small Grip, Electrical Insulation, Round Wire, Size 16 to 30
(As listed in Table 1)	Custom Stripmaster Wire Strippers
(As listed in Table 2)	Custom Stripmaster Lite Wire Strippers
45–128	Cable Stripper
45–129	Cable Stripper
45–162	Coaxial Cable Stripper
45–163	Coaxial Cable Stripper
45–164	Coaxial Cable Stripper
45–165	Coaxial Cable Stripper
45–100	V–Notch Stripper
45–101	V–Notch Stripper
45–123	T–Cutter
45–350	Lite–Strip Optical Fiber Stripper
35–053	Cable Shear, Hand
	Cable Shear, Bench
	Vise, Saw

4. STRIPPING PROCEDURES.

5. **MILITARY COPPER AND ALUMINUM WIRE STRIPPING PROCEDURES**. The procedure and proper use of the hand stripping tools are discussed in the following text. Refer to the general stripping procedures for proper methods.

NOTE

For coaxial cable stripping procedures and tools, refer to the section on coaxial cable stripping at the end of the WP.

a. Failure to use the correct type of stripper blade may damage wire strands, or not strip insulation as indicated in Figure 1. Ensure that the stripper blade installed in the stripping tool matches the type and size of wire to be stripped by inspecting the tool handle for the correct AS specification part number or for the Stripmaster tool blade number. Refer to Tables 1 or 2 to determine the correct tool and replaceable worn blade for the wire being stripped. For obsolete Stripmaster tool and blades see Tables 3 and 4. When authorized, Stripmaster stripper tools and blade sets may be replaced with the AS5768 tools and blade sets as shown in Tables 3 and 4.

CAUTION

Ensure the stripper blade installed in the stripping tool matches the type and size of wire to be stripped. Refer to Table 1 for a typical example. Replace with correct type stripper blade as needed. Failure to use the correct type of stripper blade may damage wire strands, or not strip insulation correctly.

b. Ensure that blades are clean, sharp, and free of grease, oil and solvents.

c. Ensure that all insulation is removed from the stripped wire as some wire has a transparent layer between the conductor and the insulation.

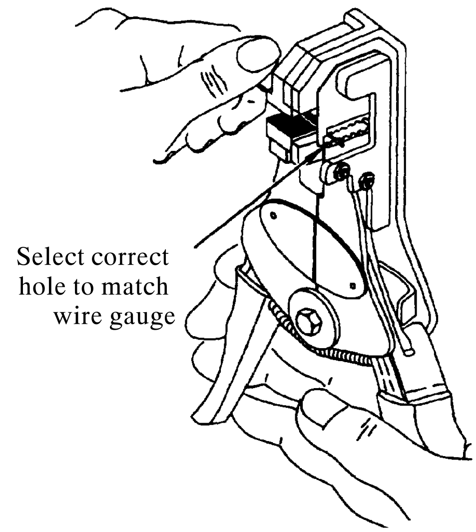
Table 1. Hand Stripping Tools (see Table 3 for Obsolete Stripmaster Tools)

Wire Specification Number	Gage	Stripper Tool Part No.	Blade Set Part No.
AS22759/9 /10	16−26 10−14	AS5768/1−T6 AS5768/1−T5	AS5768/1−B6 AS5768/1−B5
AS22759/11 /12/16/17	16−26 10−14	AS5768/1−T8 AS5768/1−T5	AS5768/1−B8 AS5768/1−B5
AS22759/18/19	16−26 10−14	AS5768/1−T10 AS5768/1−T11	AS5768/1−B10 AS5768/1−B11
AS50861/1 and /2*	16−26 10−14	AS5768/1−T2 AS5768/1−T1	AS5768/1−B2 AS5768/1−B1
AS50861/4 /5 and /7*	16−26 10−14	AS5768/1−T2 AS5768/1−T1	AS5768/1−B2 AS5768/1−B1
AS50861/6*	16−26	AS5768/1−T2	AS5768/1−B2
AS22759/32 and /33	26−30 16−26 10−14	AS5768/1−T7 AS5768/1−T9 AS5768/1−T5	AS5768/1−B7 AS5768/1−B9 AS5768/1−B5
AS22759/34 /35/41/42/43	16−26 10−14	AS5768/1−T9 AS5768/1−T5	AS5768/1−B9 AS5768/1−B5
AS81044 /6/7	16−26 10−14	AS5768/1−T17 AS5768/1−T16	AS5768/1−B17 AS5768/1−B16
AS81044 /9/10	16−26 10−14	AS5768/1−T19 AS5768/1−T18	AS5768/1−B19 AS5768/1−B18
AS81044 /12/13	26−30 16−26 10−14	AS5768/1−T7 AS5768/1−T20 AS5768/1−T5	AS5768/1−B7 AS5768/1−B20 AS5768/1−B5
MIL−DTL−81381/11 /12 /13 /14 /22 KAPTON (8.4 MIL)	16−26 10−14	AS5768/1−T8 AS5768/1−T11	AS5768/1−B8 AS5768/1−B11
MIL−DTL−81381 /1/2/5/6/7/8/9/10/21 KAPTON (5.8 MIL)	16−26 10−14	AS5768/1−T10 AS5768/1−T21	AS5768/1−B10 AS5768/1−B21
MIL−DTL−81381/17 /18/19/20 KAPTON (4.6 MIL)	16−26	AS5768/1−T22	AS5768/1−B22
MIL−DTL−81381/3 and /4 KAPTON	16−26 10−14	AS5768/1−T20 AS5768/1−T5	AS5768/1−B20 AS5768/1−B5
AS85485/9 /10/11/12	16−26 10−14	AS5768/1−T20 AS5768/1−T5	AS5768/1−B20 AS5768/1−B5
AS85485/5/6/7/8	16−26	AS5768/1−T24	AS5768/1−B24
55A6251, 55A6283, 55A6315	16−26	AS5768/1−T20	AS5768/1−B20
Wire wrapping (thin insulation) solid wire	24−30 30	45−169 45−179	L−9300 L−7625
General purpose stripping of plastic, fiberglass and other hard to strip insulations	26−30 16−26 10−14	45−172 AS5768/1−T2 AS5768/1−T1	L−5436 AS5768/1−B2 AS5768/1−B1

* AS50861 was previously MIL−W−5086

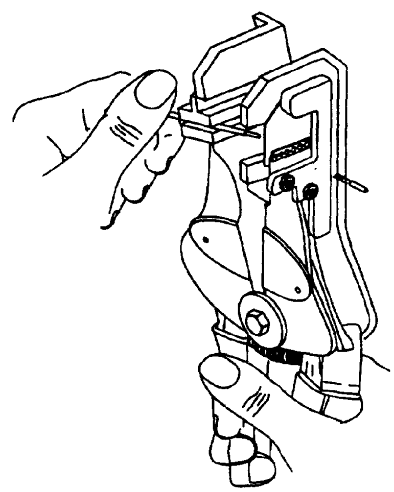
Table 2. Small Grip Hand Stripper Tools (see Table 4 for Obsolete Stripmaster Lite Tools)

Wire Specification Number	Gage	Small Grip Stripper Tool Part No.	Small Grip Blade Set Part No.
MIL–DTL–81381/3 /4	16–22	AS5768/2–T1	AS5768/2–B1
	24–30	AS5768/2–T2	AS5768/2–B2
MIL–DTL–81381/11–/14, /17–/22	24–30	AS5768/2–T3	AS5768/2–B3
	16–22	AS5768/2–T13	AS5768/2–B13
AS81044/6/7	16–22	AS5768/2–T9	AS5768/2–B9
	20–26	AS5768/2–T10	AS5768/2–B10
AS81044/12/13	16–24	AS5768/2–T11	AS5768/2–B11
AS22759/9 /10	16–22	AS5768/2–T1	AS5768/2–B1
	24–30	AS5768/2–T2	AS5768/2–B2
AS22759/32/34/35/41/42/43	24–30	AS5768/2–T3	AS5768/2–B3
	16–24	AS5768/2–T4	AS5768/2–B4
AS22759/33	16–24	45–2128	45–2128–1
	16–24	45–2129	45–2129–1
	16–24	45–2131	45–2131–1
AS22759/18/19	24–30	45–640	LB–920
	20–26	45–2114	45–2114–1
	16–24	45–2132	45–2132–1
	16–22	45–2124	45–2124–1
	20–26	45–2125	45–2125–1
AS22759/11/12	16–24	45–2138	45–2138–1
	18–26	45–2139	45–2139–1
	24–30	45–640	LB–920
AS22759/16/17	16–24	45–2131	45–2131–1
	20–26	45–2112	45–2112–1
AS81044/9/10	16–22	45–635	LB–915
	20–26	45–636	LB–916
	24–30	45–637	LB–917
General purpose stripping of plastic, fiberglass, and other hard to strip insulations	16–22	45–632	LB–912
	20–26	45–633	LB–913
	24–30	45–634	LB–914



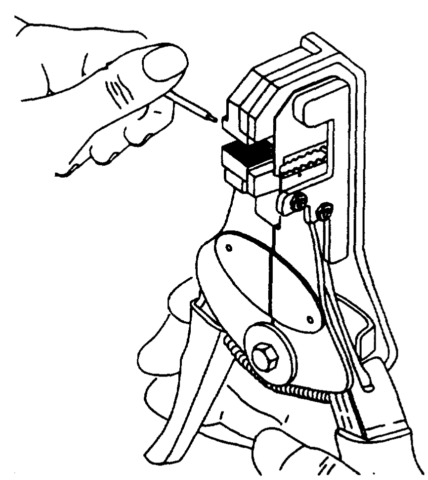
A. Select proper wire stripper from Table 1.

B. Place wire into exact center of correct cutting slot for wire sized to be stripped. The exposed end is amount of insulation to be stripped, a just wire in slot to strip correct amount of insulation.



C. Slowly partially close handles and allow wire to center itself in size slot as the wire gripper or jaws apply pressure to wire.

D. Close handles with firm steady pressure and strip insulation from wire.



E. Partially release handle pressure to allow jaws to open and remain separated. Remove stripped wire from stripper. Partial pressure release is a mechanical feaure which prevent jaws from fully closing and damaging or bird caging of stripped end of wire.

F. After stripping, twist strands of wire firmly together in same direction as normal lay of wire.

G. Inspect wire for broken or nicked strands (see Table 5) and frayed or ragged insulation. Restrip wire if necessary (see Figure 2).

Figure 1. Wire Stripping

Table 3. Stripmaster Obsolete Hand Stripping Tools (Replace with SAE ”AS” Part Number Tools)

Wire Specification Number	Gage	Stripmaster Obsolete Stripper Part No.	SAE ”AS” Stripper Tool Replacement Part No	Obsolete Stripmaster Blade Set Part No.	SAE ”AS” Blade Set Replacement Part No.
AS22759/9/ /10	16–26 10–14	45–174 45–173	AS5768/1–T6 AS5768/1–T5	L–5563 L–5562	AS5768/1–B6 AS5768/1–B5
AS22759/11 /12/16/17	16–26 10–14	45–1654 45–1611	AS5768/1–T8 AS5768/1–T5	45–1654–1 45–1611–1	AS5768/1–B8 AS5768/1–B5
AS22759/18/19	16–26 10–14	45–1551 45–1608	AS5768/1–T10 AS5768/1–T11	45–1551–1 45–1608	AS5768/1–B10 AS5768/1–B11
AS50861/1/2*	16–26 10–14	45–171 45–170	AS5768/1–T2 AS5768/1–T1	L–5211 L–5210	AS5768/1–B2 AS5768/1–B1
AS50861/6*	16–26	45–171	AS5768/1–T2	L–5211	AS5768/1–B2
AS22759/32/33	26–30 16–26 10–14	45–178 45–1513 45–1611	AS5768/1–T7 AS5768/1–T9 AS5768/1–T5	L–5561 45–1513–1 45–1611–1	AS5768/1–B7 AS5768/1–B9 AS5768/1–B5
AS22759/34/35/41/42/43	16–26 10–14	45–1610 45–1611	AS5768/1–T9 AS5768/1–T5	45–1610–1 45–1611–1	AS5768/1–B9 AS5768/1–B5
AS81044 /6/7	16–26 10–14	45–171 45–170	AS5768/1–T17 AS5768/1–T16	L–5211 L–5210	AS5768/1–B17 AS5768/1–B16
AS81044 /9/10	16–26 10–14	45–174 45–173	AS5768/1–T19 AS5768/1–T18	L–5563 L–5562	AS5768/1–B19 AS5768/1–B18
AS81044 /12/13	26–30 16–26 10–14	45–178 45–1513 45–1611	AS5768/1–T7 AS5768/1–T20 AS5768/1–T5	L–5561 45–1513–1 45–1611–1	AS5768/1–B7 AS5768/1–B20 AS5768/1–B5
MIL–DTL–81381/11 /12 /13 /14 /22 KAPTON (8.4 MIL)	16–26 10–14	45–1654 45–1608	AS5768/1–T8 AS5768/1–T11	45–1654–1 45–1608–1	AS5768/1–B8 AS5768/1–B11
MIL–DTL–81381 /1/2/5/6/7/8/9/10/21 KAPTON (5.8 MIL)	16–26 10–14	45–1551 45–1609	AS5768/1–T10 AS5768/1–T21	45–1551–1 45–1609–1	AS5768/1–B10 AS5768/1–B21
MIL–DTL–81381/17 /18/19/20 KAPTON (4.6 MIL)	16–26	45–1672	AS5768/1–T22	45–1672–1	AS5768/1–B22
MIL–DTL–81381/3 and /4 KAPTON	16–26 10–14	45–1610 45–1611	AS5768/1–T20 AS5768/1–T5	45–1610–1 45–1611–1	AS5768/1–B20 AS5768/1–B5
AS85485/9/10	16–26 10–14	45–1610 45–1611	AS5768/1–T20 AS5768/1–T5	45–1610–1 45–1611–1	AS5768/1–B20 AS5768/1–B5
AS85485/11/12	16–26 10–14	45–1610 45–1611	AS5768/1–T20 AS5768/1–T5	45–1610–1 45–1611–1	AS5768/1–B20 AS5768/1–B5
AS85485/5 /8	16–26	45–1924	AS5768/1–T24	TBD	AS5768/1–B24
55A6251 55A6283 55A6315	16–26	45–1610	AS5768/1–T20	45–1610–1	AS5768/1–B20
General purpose stripping of plastic, fiberglass and other hard to strip insulations	16–26 10–14	45–171 45–170	AS5768/1–T2 AS5768/1–T1	L–5211 L–5210	AS5768/1–B2 AS5768/1–B1

* AS50861 was previously MIL–W–5086

Table 4. Stripmaster Lite Obsolete Hand Stripping Tools (Replace with SAE ”AS” Small Grip Part Number Tools)

Wire Specification Number	Gage	Obsolete Lite Wire Stripper Part No	SAE ”AS” Stripper Tool Replacement Part No.	Obsolete Lite Wire Stripper Blade Set Part No.	SAE ”AS” Blade Set Replacement Part No.
MIL−DTL−81381/3 /4	16−22	45−635	AS5768/2−T1	LB−915	AS5768/2−B1
	20−26	45−636	NONE USE AS5768/2−T1 (20−22) OR AS5768/2−T2 (24−26)	LB−916	NONE USE AS5768/2−B1 (20−22) OR AS5768/2−B2 (24−26)
	24−30	45−637	AS5768/2−T2	LB−917	AS5768/2−B2
MIL−DTL−81381/17	16−22	45−2124	AS5768/2−T13	45−2124−1	AS5768/2−B13
	20−26	45−2125	NONE USE AS5768/2−T13 (20−22) OR AS5768/2−T3 (24−26)	45−2125−1	NONE USE AS5768/2−B13 (20−22) OR AS5768/2−B3 (24−26)
	24−30	45−640	AS5768/2−T3	LB−920	AS5768/2−B3
MIL−DTL−81381/18 /19 /20	16−22	45−2124	AS5768/2−T13	45−2124−1	AS5768/2−B13
	20−26	45−2125	NONE USE AS5768/2−T13 (20−22) OR AS5768/2−T3 (24−26)	45−2125−1	NONE USE AS5768/2−B13 (20−22) OR AS5768/2−B3 (24−26)
	20−26	45−2118	NONE USE AS5768/2−T13 (20−22) OR AS5768/2−T3 (24−26)	45−2118−1	NONE USE AS5768/2−B13 (20−22) OR AS5768/2−B3 (24−26)
MIL−DTL−81381/11 /12 /13 /14 /22	24−30	45−640	AS5768/2−T3	LB−920	AS5768/2−B3
	20−26	45−2114	NONE USE AS5768/2−T13 (20−22) OR AS5768/2−T3 (24−26)	45−2114−1	NONE USE AS5768/2−B13 (20−22) OR AS5768/2−B3 (24−26)
	16−24	45−2132	AS5768/2−T13	45−2132−1	AS5768/2−B13
	16−22	45−2124	AS5768/2−T13	45−2124−1	AS5768/2−B13
	20−26	45−2125	NONE USE AS5768/2−T13 (20−22) OR AS5768/2−T3 (24−26)	45−2125−1	NONE USE AS5768/2−B13 (20−22) OR AS5768/2−B3 (24−26)

Table 4. Stripmaster Lite Obsolete Hand Stripping Tools (Replace with SAE "AS" Small Grip Part Number Tools) (cont.)

Wire Specification Number	Gage	Obsolete Lite Wire Stripper Part No	SAE "AS" Stripper Tool Replacement Part No.	Obsolete Lite Wire Stripper Blade Set Part No.	SAE "AS" Blade Set Replacement Part No.
MIL–DTL–81381/1 /2 /5 /6 /7 /8 /9 /10 /21	16–22	45–2124	AS5768/2–T13	45–2124–1	AS5768/2–B13
	20–26	45–2125	NONE USE AS5768/2–T13 (20–22) OR AS5768/2–T3 (24–26)	45–2125–1	NONE USE AS5768/2–B13 (20–22) OR AS5768/2–B3 (24–26)
	24–30	45–640	AS5768/2–T3	LB–920	AS5768/2–B3
AS81044/6/7	16–22	45–632	AS5768/2–T9	LB–912	AS5768/2–B9
	20–26	45–633	AS5768/2–T10	LB–913	AS5768/2–B10
	24–30	45–634	NOT NEEDED	LB–914	NOB NEEDED
AS81044/12/13	16–24	45–2131	AS5768/2–T11	45–2131–1	AS5768/2–B11
	16–24	45–2138	AS5768/2–T11	45–2138–1	AS5768/2–B11
	16–24	45–2132	AS5768/2–T11	45–2132–1	AS5768/2–B11
	16–24	45–2133	AS5768/2–T11	45–2133–1	AS5768/2–B11
AS22759/9 /10	16–22	45–635	AS5768/2–T1	LB–915	AS5768/2–B1
	20–26	45–636	NONE USE AS5768/2–T1 (20–22) OR AS5768/2–T2 (24–26)	LB–916	NONE USE AS5768/2–B1 (20–22) OR AS5768/2–B2 (24–26)
	24–30	45–637	AS5768/2–T2	LB–917	AS5768/2–B2
AS22759/34/35/41/42/43	24–30	45–640	AS5768/2–T3	LB–920	AS5768/2–B3
	16–24	45–2133	AS5768/2–T4	45–2133–1	AS5768/2–B4
	20–26	45–2118	NONE USE AS5768/2–T4 (20–22) OR AS5768/2–T3 (24–26)	45–2118–1	NONE USE AS5768/2–B4 (20–22) OR AS5768/2–B3 (24–26)
AS22759/32	16–24	45–2133	AS5768/2–T4	45–2133–1	AS5768/2–B4
	16–24	45–2132	AS5768/2–T4	45–2132–1	AS5768/2–B4

d. Where stripped insulation remains on the wire, remove by twisting the insulation in the direction of the natural lay.

e. Ensure that insulation is cut clean with no frayed edges and trim if necessary (see Figure 2).

f. In cases where insulation to be stripped is greater than 3/4 inch long, it is easier to accomplish in two or more operations.

g. Retwist conductor strands by hand, if necessary, to restore the natural lay and tightness of strands.

CAUTION

When using pliers to retwist conductor strands, use with care to prevent damaging or cutting wire strands. When using hands to retwist conductor strands, assure hands are clean and free of oil, grease, and solvents before handling stripped conductor as these affect solderability and conductivity.

h. Nicked or broken strands must be within tolerance (Table 5). Longitudinal scratches in copper wire are not considered cause for rejection or rework (see Figure 1).

i. The length of the stripped portion is application sensitive. Additional requirements may apply, as for soldering applications, the length of the stripped portion of the conductor must also include a length between 1−2 conductor widths to ensure flexibility and reduce insulation overheat (WP 016 00). For contacts and terminal lugs it is typically 1/32” − 1/16” depending on the size (see WP 013 00 and 014 00).

6. **Tool And Blade Inspection.** Prior to wire stripping examine the tool and blade. Slowly squeeze the handle until blade open. The stripping jaws must begin to open after the blade is closed. Continue to squeeze the handle. The blade must open prior to the jaws releasing and closing. If tool does not operate correctly, replace the tool. With a light source behind and in the middle of the closed blade visually examined the blade cavity as shown in Figure 3. Inspect for imperfections or blade misalignment. The blade cavity shall be cylindrical and form a complete perimeter. A slight asymmetry of the two halves of the blade is acceptable if the blade does not damage the conductor when stripped. Asymmetrical shapes that do not form complete perimeters or cylinders are not acceptable. Realign blade and repeat inspection. If problem persist replace blade and repeat inspection. If problem still persist replace tool.

Table 5. Allowable Nicked or Broken Strands of Wire

Number of Strands per Conductor*	Total Allowable Nicked or Broken Strands
1 and 7	None Nicked, Broken or Severed
19	2 Nicked, None Broken or Severed
37	4 Nicked, None Broken or Severed
More than 37	6 Nicked, None Broken or Severed

*No nicked or broken strands are permitted for aluminum conductor regardless of the number of conductor strands.

NOTE

Some tools will have automatic stops or an automatic wire release to prevent bird−caging.

a. Select the proper hand stripping tool by wire type to be stripped (See Table 1).

b. The handles must be fully open and the stripping jaws open prior to stripping. When either the handles or jaws are closed, recycle the handles and start the procedure again.

c. Upon determination of the proper wire size, place the wire perpendicular in the corresponding size slot in the stripper. The exposed end is the amount of insulation to be stripped, adjust the wire in the size slot to strip the correct amount (See Figure 1).

d. Slowly, partially close the handles and allow the wire to center itself in the size slot as the wire gripping feature or jaws apply pressure to the wire.

e. Close the handles with a firm steady pressure to strip the insulation from the wire (see Figure 1).

f. Upon completion of the stripping partially release the handle pressure to allow the jaws to open and remain separated. Remove the stripped wire. The partial pressure release is a mechanical feature which prevents the jaws from fully closing and damaging or bird−caging the stripped end of the wire (see Figure 1).

NOTE

Some tools will have automatic stops or an automatic wire release to prevent bird−caging.

g. With the stripped wire removed, sharply squeeze the handles closed to release the mechanical lock and release handles to allow stripper to return to the starting position.

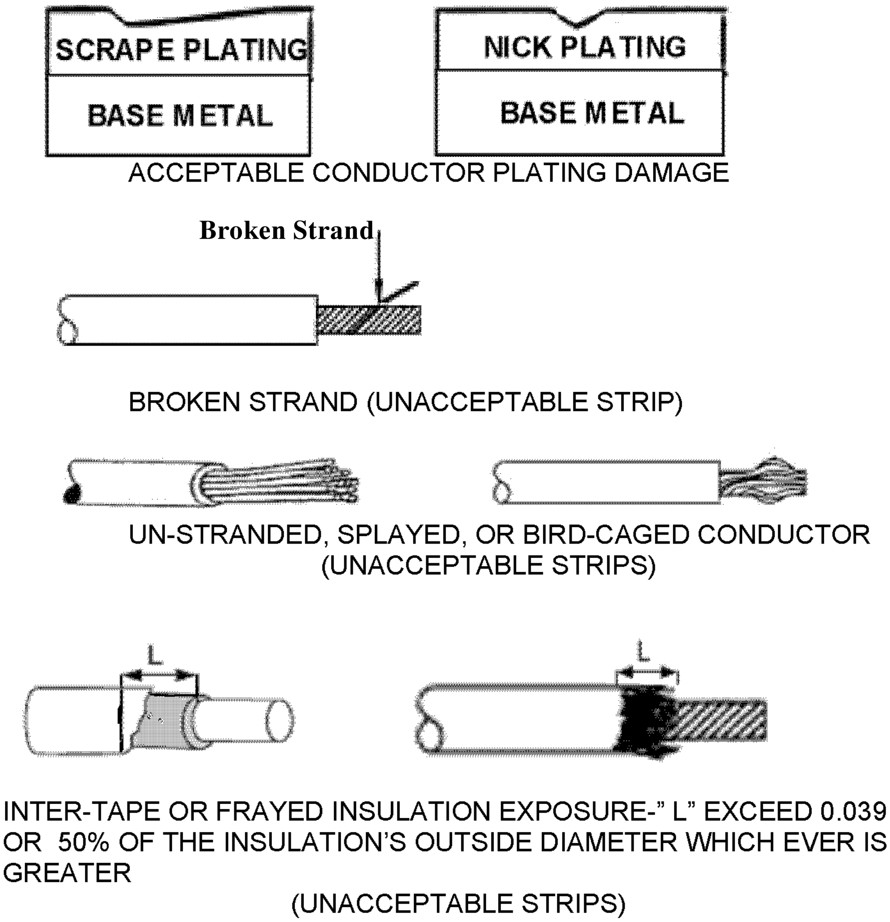


Figure 2. Unacceptable Stripped Wire Conditions

7. **Inspection Of Stripped Wire.** Inspect stripped wire as follows:

a. Visually inspect the wire and determine if any of the following conditions exist (see Figure 2).

(1). Nicked or cut strands (see Table 5).

(2). Frayed or inter–tape insulation exposure.

(3). Broken wire strands (see Table 5)

(4). Un–stranded, splayed, or Bird cage strands (see Figure 1).

(5). Exposed conductor length shall be in accordance with WP 013 00 and/or 014 00 (as per application).

CAUTION

Care should be exercised when smoothing insulation or twisting conductors as nicked, frayed, or broken strands can cause injury.

b. When the above conditions exist and are within the limits of Table 5, correct and reshape conductor strands by twisting the strands in the same direction of the normal lay of wire. Do not over twist. Some scraping or longitudinal scratches are permissible provided the base metal is not exposed when viewed without magnification.

c. If only untwisting or birdcaging occurs due to human error, correct and reshape conductor strands by twisting the strands in the same direction on the normal lay of the wire. The conductor is recommended only to be twisted by hand. If pliers are required due to the size of the strands, caution shall be taken to prevent damage to the conductor. The conductor shall not be over twisted.

d. The wire insulation shall not be punctured, crushed, or cut by the tool. The insulation deformation shall not exceed 20% of the insulation thickness. The insulation shall not have gouges, ragged edges, be loose nor frayed. The end of the insulation shall be cut as squarely and cleanly as required to meet any soldering or crimping requirements.

e. When the insulation stripped conditions are unacceptable in accordance with Figure 1, replace the blade and attempt a clean strip as close to the end of the insulation as possible. If the problem persists, cut off stripped portion and start the procedure again, wire length permitting. When wire length does not permit, start again with a new length of wire.

8. **Aerospace Standard Wire Stripping Tools.** The SAE International Aerospace Standard AS5768 provides technical information for wire stripper tools used to strip aerospace wire sizes 10–30 AWG.A description of various stripping tools are provided in the detail specifications AS5768/1, AS5768/2, etc.

9. **Thermal Stripper Tool.** When blade strippers are not available, wires with low temperature rated insulations may be stripped using thermal stripping tools. These types of wires may be used in a few off the shelf commercial equipment. Nearly, if not all, aircraft electrical distribution wires are rated at 150°C or higher. Thermal stripper will not strip these wires.

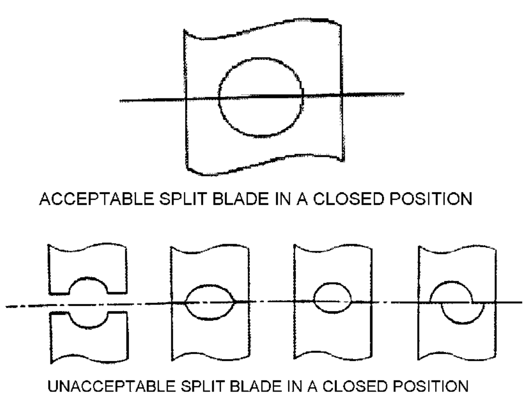


Figure 3. Strip Blade Cavity Inspection

WARNING

Thermal strippers can cause serious burns. Keep flammables away from thermal strippers. Do not leave thermal strippers unattended during operating or cool down.

Insulation emits toxic fumes during thermal stripping. Use adequate ventilation to avoid breathing toxic fumes. Overexposure will cause dizziness or headaches.

a. Ensure that stripping blades are free and clear before power is applied.

b. Insert wire into proper size slot in stripping blades.

c. Close stripping blades to apply heat.

d. Apply slight pulling pressure on wire to separate insulation.

e. When insulation is separated, pull wire from stripping blades.

f. Allow wire to cool before handling. Inspect for the following:

(1). Insulation is not charred or blistered.

(2). Installation is not pulled in strings adhering to the conductor.

(3). All insulation is removed from the conductor.

(4). Conductor is not damaged.

g. Allow the thermal stripping tool to cool before cleaning.

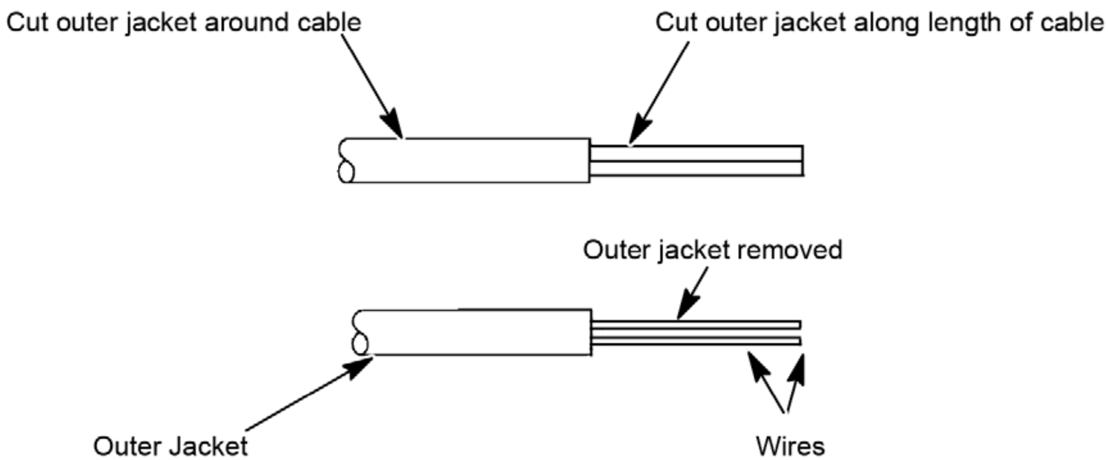


Figure 4. Removing Outer Jacket of Multi−conductor Cable

10. **Stripping Thermocouple Wire.** The procedure for stripping thermocouple wire is the same as for conventional wire using hand stripper tools.

CAUTION

Assure no damage to the insulation of individual conductors beneath outer jacket occurs during stripping.

Assure that equal amounts of both wires are removed when cutting thermocouple wiring. If lengths removed are not equal, wrong temperature indications will occur.

a. Cut the outer jacket of the thermocouple cable using a sharp blade or knife. Slit the outer jacket between parallel conductor wires. Remove the outer jacket (see Figure 4).

b. Insert the wire into the correct stripping die to strip 3/8 ± 1/16 inch of insulation. Squeeze the handles as far as they will go to strip insulation (see Figure 5 and paragraph 7).

c. Release handles slightly to remove the wire from the stripper. Assure the strands are twisted together in the normal direction of lay with no broken strands (see Figure 2).

11. **CABLE STRIPPING.** Cut all cables to proper length as directed by the applicable drawings or wiring diagrams. Exercise care and cut wire so that cut is clean, square, and not deformed, see Figure 6.

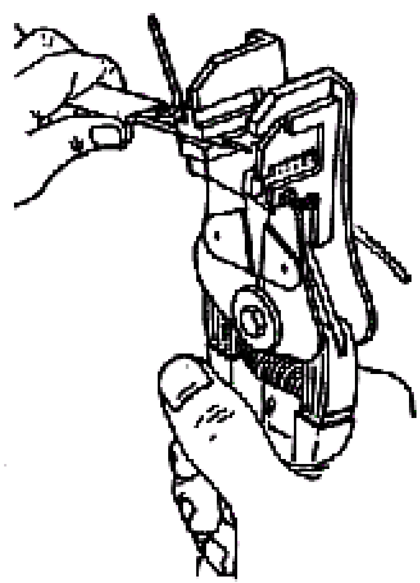


Figure 5. Multi−conductor Insulation Removal

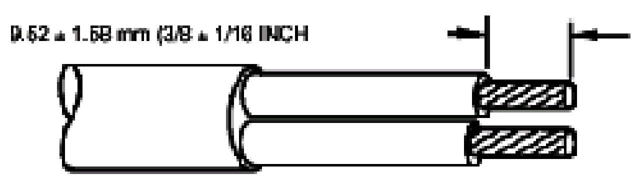


Figure 6. Completed Strip

12. **Cable Jacket Stripping, Swivel Blade Stripper Tool.** The swivel blade stripper (see Figure 7) is a hand tool used to strip cable jackets with cable diameters of 1/4 to 1 1/2 inches and is available in three sizes. This tool has a swivel blade which automatically turns to the direction the tool is moved, which enables circular cuts to be made or axial cuts to be made. This type of tool may be used to strip a variety of insulations including, but not limited, to PVC, rubber, neoprene, Teflon, nylon, fiberglass, and fabric. As with all hand tools, exercise care to avoid injury and damages to wires and wire strands.

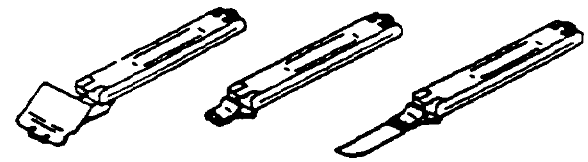


Figure 7. Swivel Blade Cable Strippers

13. **Cable Jacket Circular Cut, Swivel Blade Stripper Tool.** The procedure and proper use of this tool is discussed in the following:

a. Adjust blade depth by turning the adjustment knob on the end of the tool.

b. Place wire on tool to gage cutting depth required, adjust blade depth to cutting depth required. See Figure 8.

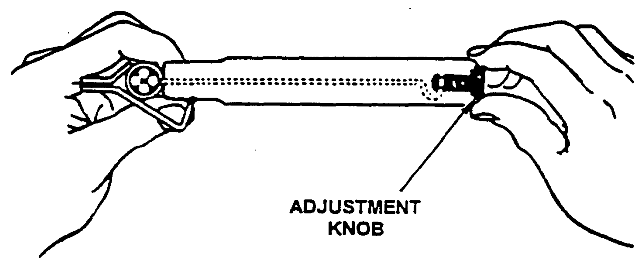


Figure 8. Blade Depth Adjustment

c. Push spring tension guide open and place wire in the tool where stripping is to be accomplished. Release spring tension guide. Jacket is now ready to be stripped.

d. Rotate tool around cable jacket to complete circular cut (see Figure 9. If cut is not complete readjust blade depth and repeat the procedure.

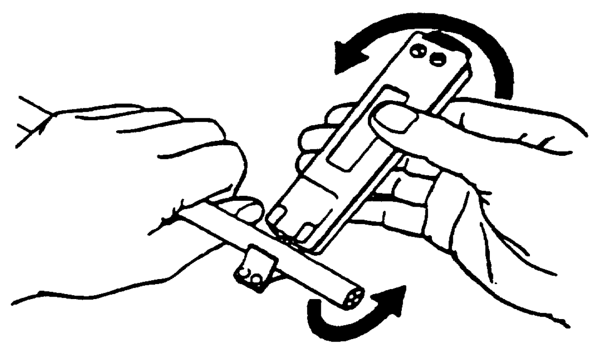


Figure 9. Swivel Blade Stripper Tool, Circular Cut

e. Non-concentric cable is not uncommon and can be stripped as concentric cable. Blade adjustment is set for the thinnest part of the jacket. Proceed as above; when cut is completed remove jacket with pliers.

14. **Cable Jacket Axial Cut, Swivel Blade Stripper Tool.** The procedure and proper use of the tool is discussed as follows:

a. Adjust the blade as for the circular cut.

b. Push spring tension guide open and place wire in the tool as for the circular cut.

c. Place thumb firmly on back of the guide to prevent blade from riding out of jacket. Rotate cable slightly and pull tool toward the end of the cable (see Figure 10).

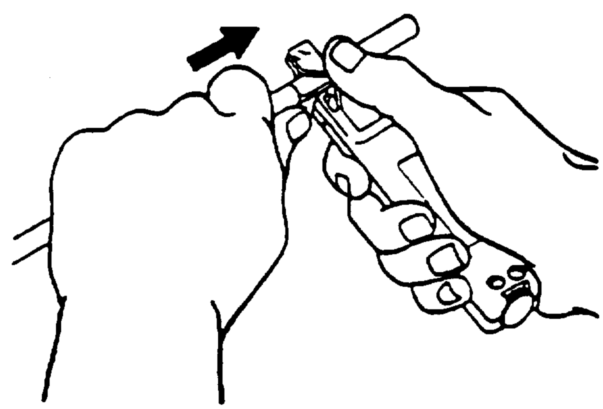


Figure 10. Swivel Blade Tool, Axial Cut

d. Due to the nature of some spongy or extra hard jackets the axial cut is difficult to accomplish. When this situation exists, make a circular cut at the beginning of the axial cut, and flex the cable to severe any remaining jacket.

e. Use a pair of pliers and peel off jacket along the scored lines.

Table 6. Coaxial Cable Stripping Tools

Cable Size O.D.	Stripping Dimensions	Cable Stripper Part No.	Blade Replacement Part No.
up to .125 inch	.230 to .275 inch	45-162	L-9225
.125 to .219 inch	.230 to .275 inch	45-163	L-9225
.25 to .5625 inch	.230 to .275 inch	45-164	L-9226
.188 to .313 inch	.48 to .53 inch	45-165	L-9225

Round Slitting Blade Replacement Part No. for 45-162, 45-163, 45-164, 45-165: L-9214

15. **Stripping Coaxial Cable Step Stripping.** The stripping process of coaxial cable is critical, as damage to the jacket, outer conductor, dielectric, or inner conductor will cause system degradation and possible failure. Refer to general stripping procedures for proper methods and safety precautions.

16. **Coaxial Cable Hand Stripper Tool.** Coaxial cable strippers are unique in that they have two blades located on each side of the tool and a round blade attached to the front (see Figure 11). Circular stripping blades are located on each side of the tool. These may be adjusted individually for the type of strip desired. By flipping one or both of these blades the stripping dimension can be varied. Wider dimensions can be obtained by spacing with blades. The depth of the cut is also adjustable. An axial stripping blade is the round blade attached to the front of the stripper, and is used to slit the cable axially. There are four types of coaxial cable strippers. Table 6 lists the part number, cable outer diameter size, and the stripping dimensions.

17. **Coaxial Cable Stripping, Coaxial Cable Stripping Tool.** The procedure and proper use of the coaxial cable stripping tool as follows:

a. Adjust the blades to the applicable stripping dimensions. Do not tighten the screws (see Figure 12).

b. Adjust the cutting depth of the blades so that the jacket will be scored without damage to the shield. Tighten the screws.

c. Position the tool on the cable so that an excess length of cable will be left when stripping operations are complete.

d. Spin the tool around the cable until maximum cutting depth is obtained (see Figure 13).

e. With the rounded blade installed in front of the tool, place the cable in the front notch and pull through.

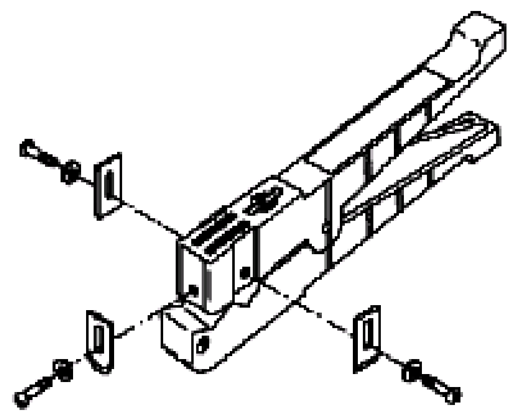


Figure 11. Coaxial Cable Strippers

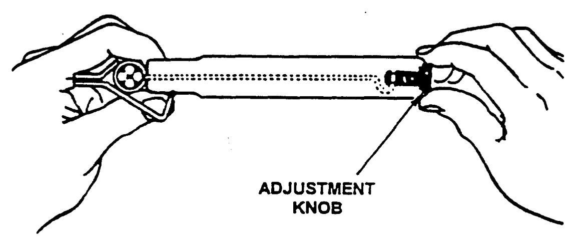


Figure 12. Coaxial Stripper Blade Adjustment

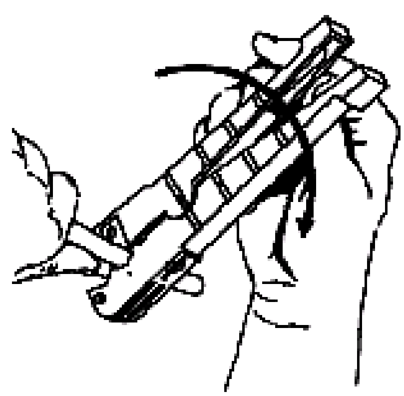


Figure 13. Coaxial Cable Stripping

f. Peel off the jacket.

g. Adjust the blades to the dimension of exposed dielectric needed. Do not tighten the screws.

h. Adjust cutting depth of the blades so that the shield will be scored without damage to the dielectric. Tighten screws.

i. From cable jacket, measure applicable shield strip dimension (see WP 015 00). The inside blade must score shield at this point.

j. Position the tool on cable in accordance with step i.

k. Spin tool around cable until maximum cutting depths obtained (see Figure 13).

l. Pull off excess shield.

m. The dielectric may be stripped using a hand strip tool, or by insertion of stripped portion of cable in tool opposite of step c and repeat operations.

n. Flex dielectric to severe score cuts and pull off dielectric.

18. **Triaxial Cable Stripping.** Triaxial cables are cut and stripped the same as coaxial cables.

19. **HAND STRIPPING TOOLS.**

a. Select the proper hand stripping tool by wire type to be stripped (Table 1 and 2).

b. Use the correct tool for the task.

c. Assure that blades are clean, sharp and free of grease, oil and solvents.

d. Assure that all insulation is removed from the stripped wire. Some wire has a transparent layer between the conductor and the insulation.

e. Where stripped insulation remains on the wire, remove by twisting the insulation in the direction of the natural lay.

f. Assure that insulation is cut clean with no frayed edges (see Figure 14). Trim, if necessary.

g. In cases where insulation to be stripped is greater than 3/4 inch long, it is easier to accomplish in two or more operations.

h. Twist conductor strands by hand or by pliers, if necessary, to restore the natural lay and tightness of strands.

i. Nicked or broken strands must be within tolerance (Table 5). Longitudinal scratches in copper wire are not considered cause for rejection or rework.

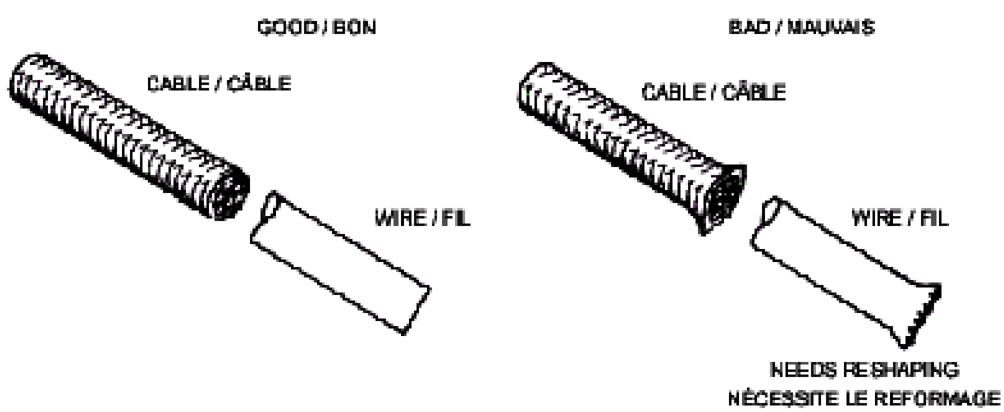


Figure 14. After Cutting

20. **T−Cutter.** T−Cutter mold features hardened−steel, shear type blades that cut up to 1/2 inch fine stranded cable and AWG 10 solid wire. Its primary application is construction/maintenance production (Figure 15).

21. **V−Notch Stripper.** V−notch stripper model both strips and cuts solid and stranded copper and aluminum wire from AWG 10 to 28. Features a convenient dial−type adjustment. Its primary application is construction/maintenance production (Figure 16).

22. **Shear Type Cutters.** A shear type cutter is one where the blades pass each other. This type cutter will preserve the symmetry of the wire (Figure 17).

23. **Lite−Strip Optical Fiber Stripper.** Lite−strip optical fiber stripper model precisely strips outer cable jacket insulations, tight buffer tube installations, and mechanically strippable coatings (Figure 18). Features of this model are as follows:

a. Blades are knife−type, made of hardened steel and replaceable.

b. Precision−ground, dual V−Notch blades strip a wide range of outer cable jacket insulation sizes.

c. Built−in blade guides ease positioning of optical fiber in the proper stripping hole.

d. Strips buffer and cladding to within 1/4 inch of outer cable insulation.

e. Plastic grips offer comfort and handling ease.

f. Convenient flat design fits easily into pocket, pouch, or tool kit.

g. Has an optional, adjustable wire stop.

24. **Stripmaster Wire Stripper.** Stripmaster wire stripper is a versatile production workhorse featuring single−squeeze operation. It strips wire clean up to a full 7/8 inch. Automatic feature holds jaws open for removing wire without crushing end. Ideal for lighter−gage wire (Figure 19). Features of this model are as follows:

a. Knife−type stripping blades penetrate the insulation like a knife for a clean cut.

b. Sturdy, die−cast body and frame.

c. Comfortable, cushioned hand grips.

d. Has an optional, adjustable wire stop.

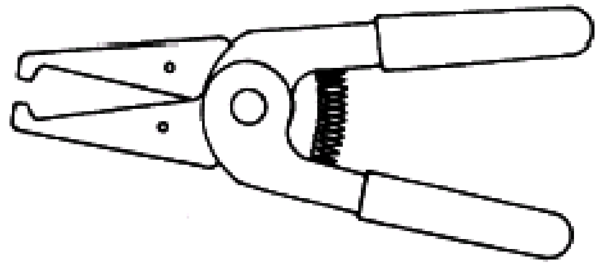


Figure 15. T−Cutter

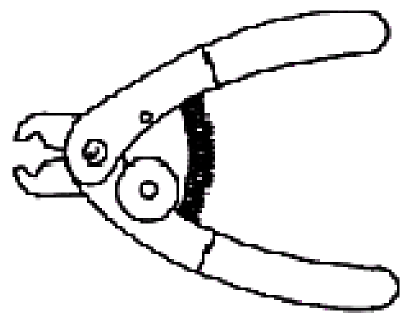


Figure 16. V−Notch Stripper

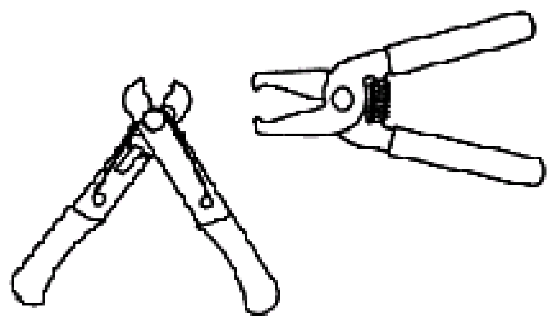


Figure 17. Shear Type Cutter

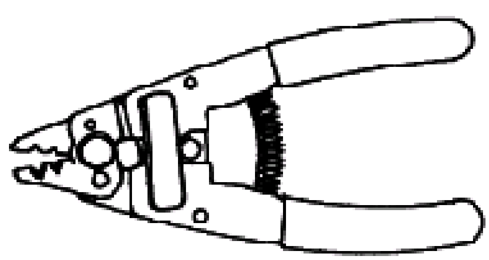


Figure 18. Lite−Strip Optic Fiber Stripper

25. **Swivel–Blade Cable Stripper.** Swivel–blade cable strippers are used for both end or center stripping of coaxial and power cables from 1/4 inch to 1 1/2 inches outside diameter (OD). Strips insulation up to 5/32 inch thick including PVC, rubber, Neoprene, Teflon, polyethylene, Nylon, Kapton, fiberglass, fabric, and others (Figure 20).

a. 45–128. Cable stripper for 1/4 inch to 3/4 inch OD.

b. 45–129. Cable stripper for 3/4 inch to 1 1/2 inches OD.

26. **Coaxial Cable Strippers.** Coaxial cable strippers are unique in that they have two blades located on each side of the tool, and a round blade attached to the front (Figure 11).

a. Circular Stripping Blades. These blades are the two blades located on each side of the tool. These may be adjusted individually for the type of strip desired. By flipping one or both of these blades the stripping dimension can be varied. Wider dimensions can be obtained by spacing with blades. The depth of cut is also adjustable.

b. Axial Stripping Blade. This blade is the round blade attached to the front of the stripper, and is used to slit the cable axially. To slit the cable place cable in front notch of the tool and pull the cable through.

c. Types. There are four types of coaxial cable strippers (Table 6). This table lists the part number, cable outer diameter size, and stripping dimensions.

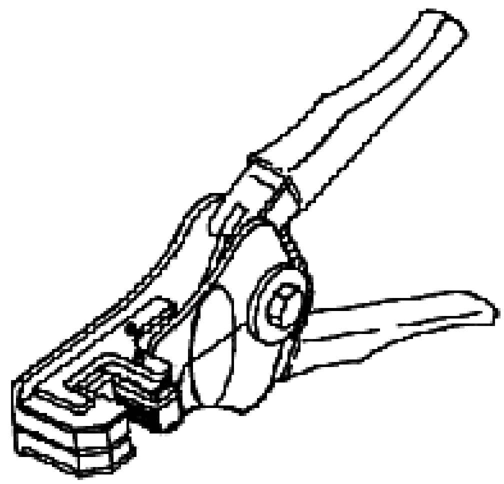


Figure 19. Stripmaster Wire Stripper

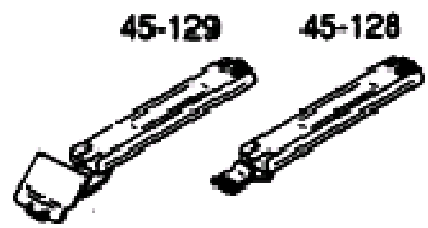


Figure 20. Swivel–Blade Cable Strippers

27. **CUTTING COPPER WIRE.**

CAUTION

Do not use diagonal pliers to cut wire as conductor will be deformed.

Ensure the cutting surfaces are free of oil, grease, solvents and metal chips to ensure proper solderability, prevent corrosion and aid in conductivity.

28. **LIGHT GAGE OR COPPER ALLOY.** Copper wire or copper alloy of light gage should be cut with a shear type cutter to ensure the cut is clean, square and not deformed. Wire sizes 8 and larger should be cut with cable shears.

29. **HEAVY GAGE.** Heavy gage wire may be cut with a fine tooth hacksaw. A fine tooth hacksaw blade consists of 20 teeth or more per inch. A bench vise may be used to protect the wire and to avoid personal injury.

30. **CUTTING COAXIAL CABLE.**

CAUTION

Ensure the cutting surfaces are free of oil, grease, solvents and metal chips to ensure proper solderability, prevent corrosion and aid in conductivity.

31. When cutting coaxial cable or triaxial cable, care must be exercised not to damage the dielectric as severe system degradation will occur. A diagonal type cutter shall not be used as crimping will occur before the cutting action and is not repairable. A fine tooth hacksaw maybe used to cut cable, but the use of a vise is not recommend, as pressure applied will damage the dielectric. A swivel−blade stripper or shear type cutter maybe used as a clean cut is afforded at a controlled rate Table 7).

Table 7. Round Cable Slitting and Ringing Tools

Cable Size O.D.	Cable Stripper Part No.	Blade Replacement Part No.
.25 in. to .75 inch	45−128	L−7486
.75 in. to 1.5 inch	45−129	L−7486

HARNESS INSTALLATION
INSTALLATION AND REPAIR PRACTICES FOR AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Lockwiring and Shearwiring	018 00
Wire, Cable,and Harness Marking	008 00
Clamp, Cushioned Metal	AS21919
Clamps, Plastic	AS25281
Grommet, Cushion, Composition, Edging	NASM22529/2
Grommet, Cushion, Composition, Edging	NASM22529/3
Grommets, Synthetic and Silicone Rubber, Hot-Oil and Coolant Resistant	MS35489
Insulation Tape, Electrical, Plastic, Pressure-Sensitive	MIL-I-24391
Straps, Tiedown, Electrical Components, Identification, Adjustable, Self-Clinching, Plastic, Type II, Class I	AS33681
Structural Hardware	NA 01-1A-8
Tape, High-Temperature Pressure-Sensitive	A-A-59474
Tape, Lacing and Tying, Glass	A-A-52083
Tape, Lacing and Tying, Aramid	A-A-52084
Wiring Aerospace Vehicle	SAE-AS50881

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

NONE

Support Equipment Required

Nomenclature	Part Number/Type Designation
Hand Tool, Strap Installation	MS90387
Loop, Strap Fastener	GE21E1
Pliers, Padded Conduit	AT508K
Pliers, Slip Joint	---
Shears, Full Bypass	MFE—100
Tool, Clamp Assembly	ADEL560
Wrench, Strap	BT—BS—609 or BT—BS—610

Materials Required

Nomenclature	Part Number/Type Designation
Bag, Plastic	---
Clamp, Cushioned Metal	AS21919
Clamp, Plastic	AS25281
Grommet, Caterpillar	NASM22529
Grommet, Donut	MS35489
Shipping Cap, Plastic	MS90376, NAS831 or NAS837
Tape, Black Non-Adhesive Self-Bonding	A-A-59163 TYPE II, 5970-00-955-9976
Tape, Finish C, Glass Tying, Size 2 or 3	A-A-52083
Tape, High-Temperature Pressure-Sensitive	A-A-59474
Tape, Lacing and Tying Aramid	A-A-52084
Tape, Non-Adhesive Silicone	---
Tape, Red Non-Adhesive Self-Bonding	A-A-59163 TYPE II, 5970-00-955-9976
Tape, Self-Adhesive, Color	---
Tubing, Plastic	---

1. INTRODUCTION.

2. This Work Package (WP) provides general instruction for the removal and installation of a harness or cable from the aircraft for the purpose of repair. When available, maintenance personnel should always look first to the aircraft specific maintenance manual for guidance. The information provided herein should not be used for design or modification on the electrical wiring. Design and modifications should be performed in accordance with SAE-AS50881.

3. DESCRIPTION.

4. Harnesses are an assembly of wires and/or cables and their terminations fabricated so that it may be installed or removed as a unit. Harnesses are either open or protected (overbraided).

5. **OPEN HARNESS.** Open harnesses are preferred for maintenance considerations. The wires or cables within the harness are uncovered which enables visual inspection and ease of repair when necessary (Figure 1).

6. **PROTECTED HARNESS.** Protected harnesses are typically the same as open harnesses except the wall thickness of the wires within the harness are thinner, which requires the harness to have a protected covering. The thin wall wire, called lightweight wire, has small diameters and weighs less than unprotected wires. The protected harness will be smaller and weigh less than an open harness for the same number of wires used except at selected specialized Intermediate Maintenance Activities (IMA). Refer to WP 011 00. Protected harnesses are not conducive to maintenance support.

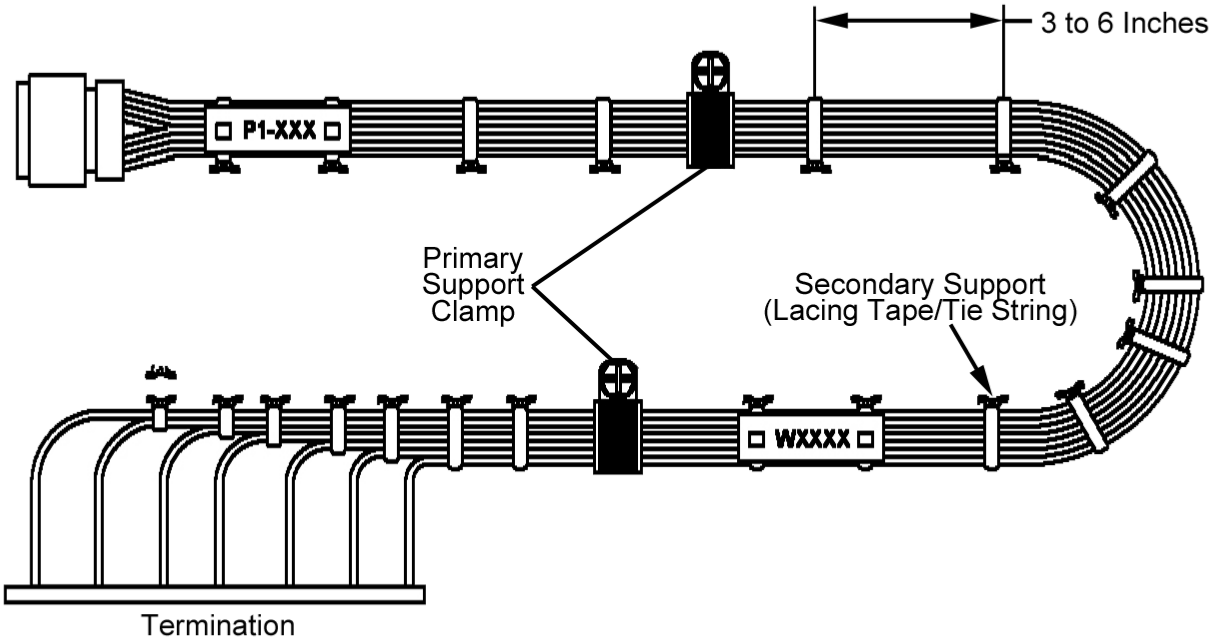


Figure 1. Typical Open Harness Installation

7. GROUP. A group is a number of wires and/or cables and their terminations secured together within the structure of a harness. A group is typically secured together and contains wires and/or cable routed to a single item of equipment or aircraft area. The diameter of a group is typically two inches or less.

8. BUNDLE. A bundle is any number of harnesses, or branches routed and supported together along some distance within the aircraft.

9. HARNESS OR BUNDLE REMOVAL. The removal of any harness or group of terminated wires should be performed in accordance with the aircraft maintenance manual. The information provided herein is for guidance when the manual is not available. Remove harness or bundle as follows:

WARNING

Ensure aircraft external electrical and battery power are disconnected before performing any of the following instructions or maintenance. Failure to do so, can result in severe injury or death to personnel, and/or damage to equipment.

a. Make sure all connecting points have identifying markers. If the marker is not present, replace the lost marker (WP 008 00). This includes each wire when singular contacts must be removed (Figure 1).

b. When several wires are grouped at junction boxes, terminal boards, panels, etc., retain the identity of the group within a bundle by spot ties, as shown in Figure 2.

c. At each clamp location, wrap the harness or bundle with a self-adhesive color tape. In some cases the bundle may already be build-up with a tape.

d. Remove the wired contacts from terminal blocks and/or connectors shared with other bundles or harnesses in accordance with the appropriate terminal block or connector work package. Replace all unwired cavities with appropriate contacts and sealing plugs. (WP 020 00)

e. As each connector is disconnected protect/cap/stow as per WP 007 00. (Electrical connector and waveguide protection and stowage). Removed contacts should also be similarly protected unless the harness is planned to be totally replaced. Loosen or remove the clamps to release the bundle or harness. Clamps which are removed should be remounted with all accessories included, unless the clamp needs replacement.

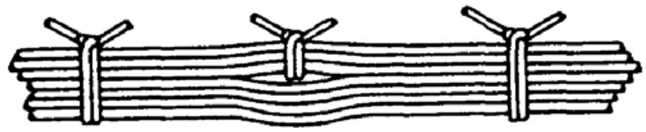


Figure 2. Group and Bundle Ties

f. When a connector is not removed from the bundle or harness to extract the bundle or harness from the aircraft, protect the connector as per WP 007 00. Attach connector to the nearest primary support location.

g. Make sure all connecting points have identifying markers. If the marker is not present, replace the lost marker (WP 008 00). This includes each wire when singular contacts must be removed (Figure 1).

10. BUNDLE OR HARNESS REPAIR. Repair the bundle or harness as required by the appropriate component work package. The repair of the harness or group as an assembly is provided in WP 011 00.

11. BUNDLE OR HARNESS INSTALLATION.

WARNING

Make sure all electrical and hydraulic power systems are off.

12. Install the repaired or new harness as follows:

CAUTION

Avoid excessive tightening of cable, clamps and spot ties on coaxial (coax) cable. The dielectric of some coax cables is made of soft material and can easily be damaged. Route coax cable as directly as possible. Avoid unnecessary or sharp bends to preserve dielectric integrity.

a. Lay the bundle or harness out loosely in the clamp areas.

b. Loosely secure the bundle or harness in the clamps. If clamps are missing or require replacement, see paragraph 42 for more guidance.

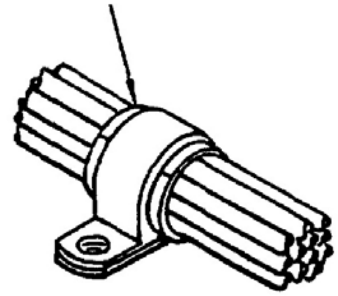


Figure 3. Tape Support

c. Inspect the connection or contact for damage then couple the connectors. Insert the contacts in their respective locations in accordance with the appropriate connector work package and verify that the connectors are completely mated and contacts securely inserted. Each connector type has an indicator.

d. At each mating location, adjust the bundle or harness to accommodate drip loops (paragraph 22), proper bending of the wires at the connector or terminal block interfaces (paragraph 60), and minimum wire bending requirements (paragraph 55).

e. Tighten the clamps at the nearest mating locations. The bundle or harness should not be moveable through the clamp. If the bundle or harness is loose, wrap with red or black non-adhesive, self-bonding tape until sufficiently built up to permit the clamp to secure the wire bundle or coaxial cable, A-A-59163 TYPE II, NSN 5970-00-955-9976 or NSN5970-00-955-9976 (Figure 3).

f. Between each remaining clamp, adjust the bundle or harness to accommodate minimum bending, (paragraph 55), flexing (paragraph 55), slack (paragraph 50), and chafing (paragraph 25). Tighten the clamps. For wires and harnesses installed in locations that can be subject to chafing after being closed (cowlings, doors, coverings, etc.) perform adjustment using MIL-PRF-8116, NSN 8030-00-145-0300 and in accordance with paragraph 13.

g. Inspect the bundle or harness for wire bird caging and general wire separation. Tighten the bundle or harness diameter with lacing tape (paragraph 64).

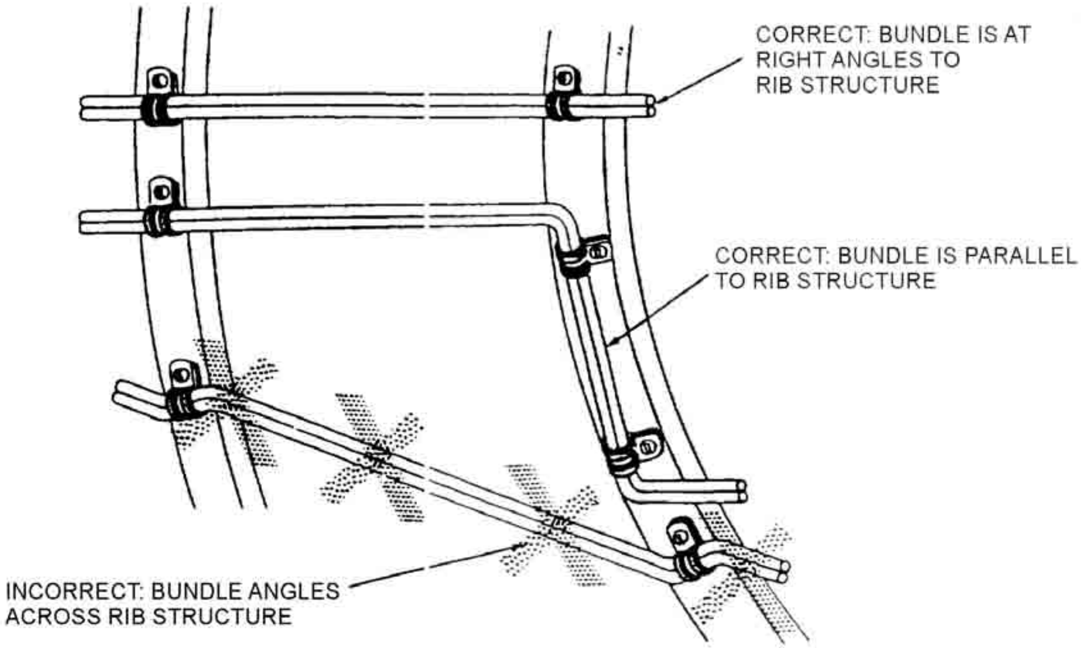


Figure 4. Routing Bundles

13. INSPECTION OF WIRING AND HARNESSES FOR PROPER CLEARANCE BEHIND ACCESS DOORS OR COVERINGS. All wiring harnesses that are in close proximity to any movable structure or covering shall be inspected for proper clearance when the structure (covering, panel, door, etc.) is closed per the following steps:

a. Using MIL-PRF-8116 putty, NSN 8030-00-145-0300, make a 3/8 inch shaped block and perform step (1) or (2) below as applicable.

(1) Place the block on the door/panel perpendicular (at a 90° angle) to the harness. Block should be long enough (approximately 3/8" x 3/8" x 4") to ensure contact with the harness when the door or panel is closed or (this is the easier method for cleaning after the procedure),

(2) Encircle the harness under test and wrap it around the harness (3/8" x 3/8" x circumference).

NOTE

This may need to be done in several areas of the harness if the harness is exposed to the surface more than a few inches.

b. Slowly close the structure/cover. Ensure structure/cover is completely closed and latched to get an accurate measurement.

c. Open structure/cover.

d. Inspect putty for impression or change.

e. If no impressions are present, proceed to step i. If impressions are present, continue to step f.

f. Reposition wiring harness as required to obtain minimum 3/8 inch clearance.

g. Remold putty to dimensions in step a.

h. Repeat steps b-e.

i. Tighten any hardware loosened to reposition harness and remove putty.

14. GENERAL INSTALLATION INSTRUCTIONS. Install wiring so that it is mechanically and electrically sound, and neat in appearance. Wherever practicable, route wires and bundles parallel with, or at right angles to, the stringers or ribs of the area involved (Figure 4).

NOTE

Route coaxial cable as directly as possible. Avoid unnecessary bends in coaxial cable. When possible, locate attachments at each frame rib on runs along the length of the fuselage, or at each stiffener on runs through the wings.

15. GENERAL ROUTING PRECAUTIONS. When installing electrical wiring in aircraft, observe the following precautions:

a. Do not permit wire or wire bundles to have moving, or frictional contact with any other object.

b. Do not permit wire or wire bundles to contact sharp edges of structure, holes, etc. (paragraph 25).

c. Do not damage threads of attaching hardware by over-tightening or cross threading.

d. Do not subject wire bundles to sharp bends during installation. (paragraph 23).

e. Do not allow dirt, chips, loose hardware, lacing tape scraps, etc., to accumulate in enclosures or wire bundles.

f. Do not hang tools or personal belongings on wire bundles.

g. Do not use installed wire bundles or equipment as footrests, steps, or handholds.

h. Do not compensate for wires that are too long by folding wire back on itself and hiding such folds within bundles.

i. Do not twist or pull wire bundles during assembly or installation so that pins are pulled from connectors, or connectors or wires are otherwise damaged.

j. Do not stretch wires to mate connectors; and allow sufficient slack to permit easy mating.

k. Do not paint electrical wires, connectors (unless specifically authorized), switches or other electrical devices.

l. Do not use any installation tools other than those specifically authorized.

m. Do not install fuel quantity indicating wiring with power distribution wiring or system power wiring.

CAUTION

Never support any wire or wire bundle from a plumbing line carrying flammable fluids or oxygen. Clamps may be used only to insure separation.

n. Wire or wire bundles shall not make contact with any part of a grommet in any application. Failure to maintain clearance could result in wire or wire bundle chafe damage.

16. FLAMMABLE LINES. When wiring must be routed parallel to flammable lines for short distances, maintain as much fixed separation as possible, six inches or more (Figure 5). When a six inch clearance cannot be maintained, the bundle and flammable line shall be clamped as shown in (Figure 6) so that there will be no relative motion between them. When a two-inch clearance cannot be maintained, the bundle shall be clamped as shown in (Figure 7). The minimum clearance shall be 1/2 inch. Route the wires on a level with, or above, the plumbing lines. Space clamps so that if a wire is broken at a clamp it will not contact the line. If the separation is less than two inches but more than 1/2 inch, use secondary protection (i.e. heat shrink, or wrap-around sleeve) over the wire bundle to provide secondary protection. Use two cable clamps back to back, to maintain a rigid separation (Figure 6).

17. GENERAL INSTALLATION SUPPORT. Where possible, bind and support wire and wire bundles to meet the following requirements:

a. Prevent chafing of cables.

b. Secure wires and wire bundles routed through bulkheads and structural members.

c. Fasten wires in junction boxes, panels, and bundles for proper routing and grouping.

d. Prevent mechanical strain that would tend to break the conductors and connections.

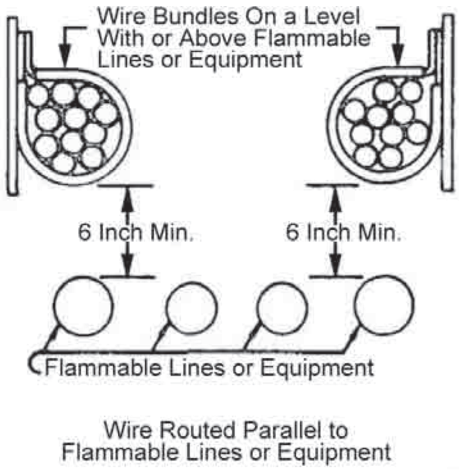


Figure 5. Installation of Wiring Near Flammable Lines

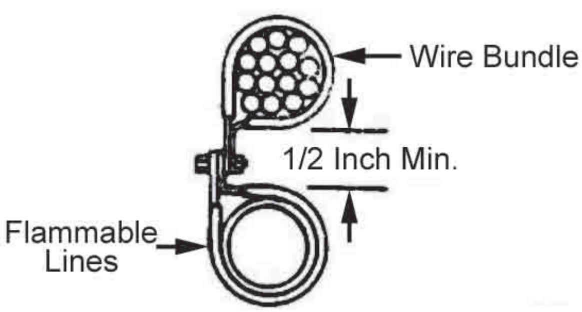


Figure 6. Alternate Installation

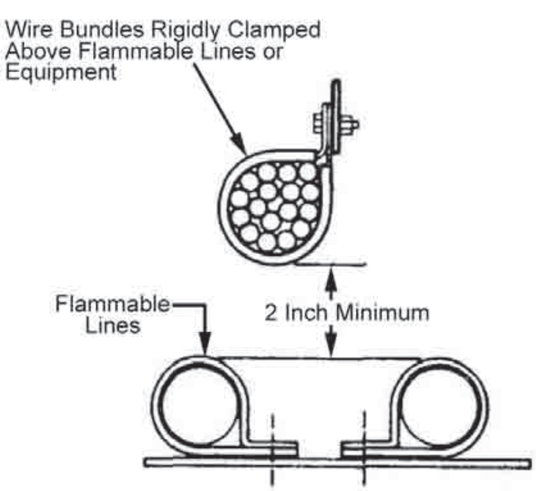


Figure 7. Secondary Alternate Installation

e. Facilitate reassembly to equipment and terminal boards.

f. Prevent interference between wires and other equipment.

g. Permit replacement or repair of individual wires without removing the entire bundle.

h. Prevent excessive movement in areas of high vibration.

18. GENERAL INSTALLATION PROTECTION. Where possible install and route wires and wire bundles to protect them from the following:

a. Chafing or abrasion.

b. High temperature.

c. Use of wire bundles as handholds, or steps, or as support for personal belongings and equipment.

d. Damage by personnel moving within the aircraft.

e. Damage from cargo stowage or shifting.

f. Damage from battery acid fumes, spray, or spillage.

g. Damage from solvents and fluids.

h. Abrasion in wheel wells where exposed to rocks, ice, mud, etc.

19. INSTALLATION OF WIRES IN CONDUIT. Measure the bundle wires before installing in conduit. The bundle diameter must not exceed 80% of the internal diameter of the conduit. (Figure 8).

a. For replacing existing wire/harness in conduit tie cable lacing to end of existing wire and use the lacing to pull the new wire/harness through conduit.

CAUTION

No ties or splices are permitted inside a conduit.

20. FEEDING WIRES INTO CONDUIT. Feed wires through a short length of conduit by taping the end of

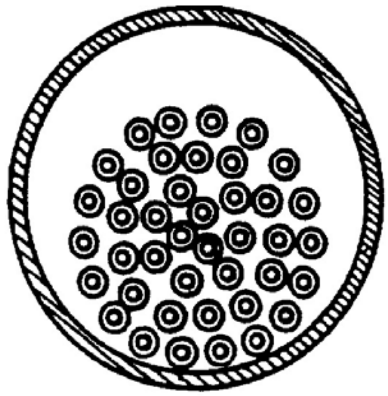


Figure 8. Conduit Capacity

the bundles together and pushing it gently through. Longer runs of conduit or conduit with complex bends will require a leader. Make a leader out of a flannel or other soft cloth patch attached to a string long enough to pass completely through the conduit. The patch should fit loosely in conduit (Figure 9). Use compressed air at no more than 35 psi to blow patch and attached string through the conduit. Tie wire bundle securely to string and tape over junction to cover all wire ends. Pull string through conduit while carefully feeding wires into other end. After wire is installed, remove tape and detach string.

21. SUPPORTING WIRES AT END OF RIGID CONDUIT. MS21919 cable clamp should be available to support wires at each end of conduit. Place the cable clamp in a direct line with the conduit end to prevent chafing of wires at edge of conduit. The cable clamp should be as close to end of conduit as practicable, but never more than 10 inches away (Figure 10).

NOTE

> Do not leave wire slack inside conduit. Wires should be free, but not taut, inside conduit.

22. DRIP LOOP. Where wiring is dressed downward to a connector, terminal block, panel, or junction box, a trap, or drip loop, shall be provided in the wiring to prevent fluids or condensation from running into the above devices. Potted connectors are exempt from this requirement (Figure 11).

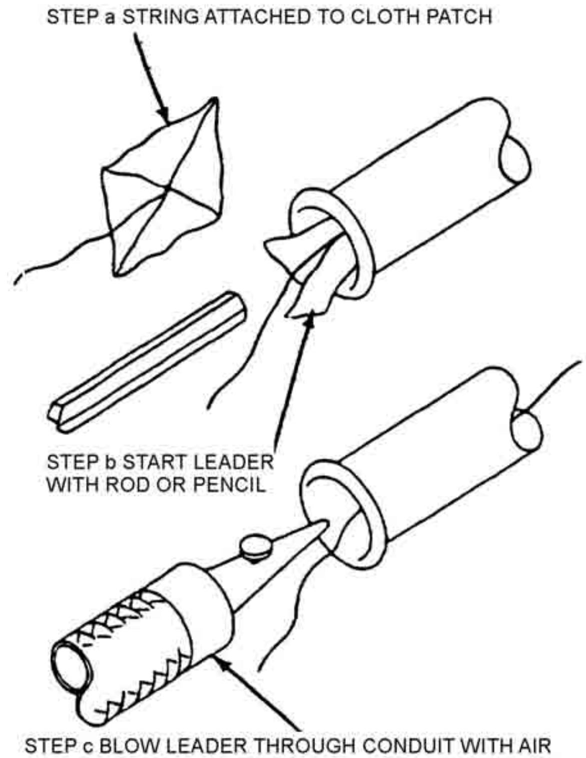


Figure 9. Leader for Conduit

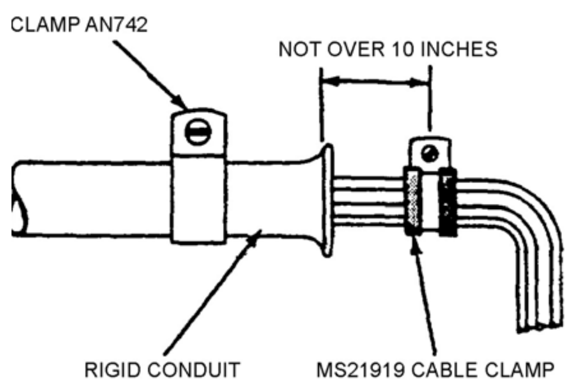


Figure 10. Support for Wire at Conduit End

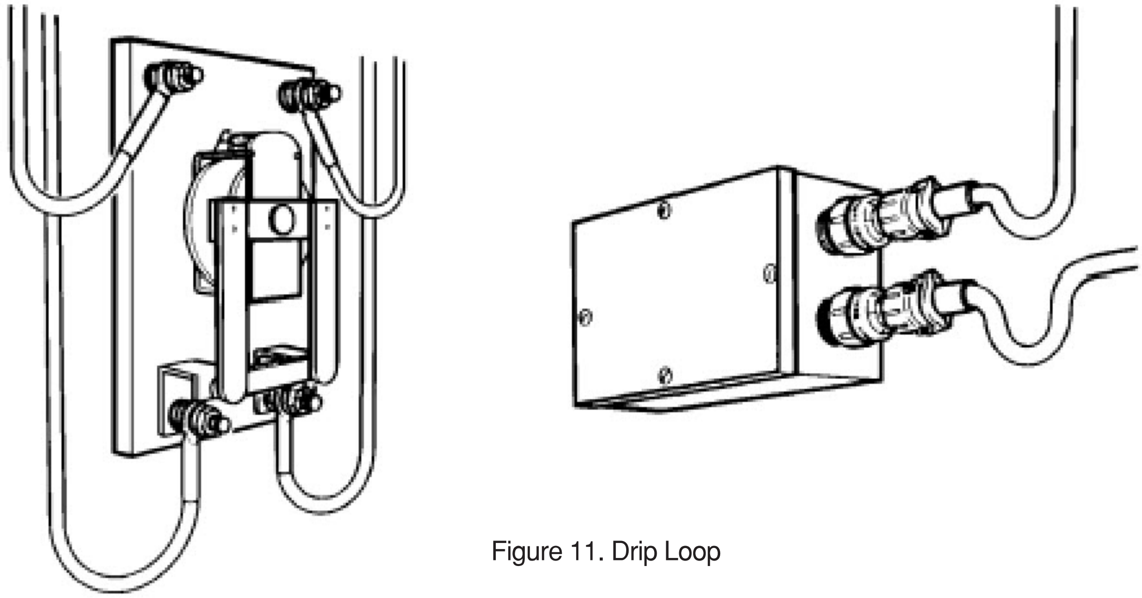


Figure 11. Drip Loop

23. RADIUS OF BEND. Wiring bend radius shall comply with the following requirements, as shown in Figure 12:

Single Conductor Wire	10 times to outside diameter of the wire
Flexible type Coaxial	6 times the outside diameter of the cable
Semi-Rigid Coaxial .	10 times the outside diameter of the cable
Rigid Coaxial .	10 times the outside diameter of the cable
Wire groups, bundles or harnesses	10 times the outside diameter of the largest single wire or cable within the bundle
Shield Terminators or jumpers	3 times the outside diameter of the wire
Protected Harness	6 times the outer diameter of the harness OR 10 time the diameter of the outside diameter of the largest single wire or cable within the bundle

CAUTION

Never bend coaxial cable to a smaller radius than six times the outside diameter or damage to the center conductor or cable core will occur.

Many specialty wires/cables/harnesses have specific bend radius requirements that vary from above. Refer to platform manuals or Cognizant Field Authority / Cognizant Engineering Authority for specific bend radius instructions.

a. When it is not possible to hold the bending radius of the single wires to the above limits, enclose the bend in tight plastic tubing for at least two inches each side of the bend.

b. For wiring groups, bundles or harnesses and cables individually routed and supported, the minimum bend radius shall be ten times the outside diameter of the largest included wire or cable. At the point where wiring breaks out from the group, harness or bundle, the minimum bend radius shall be ten times the diameter of the largest included wire or cable, provided the wiring is suitably supported at the breakout point. If wires used as shield terminators or jumpers are required to reverse direction in a harness, the minimum bend radius of the wire shall be three

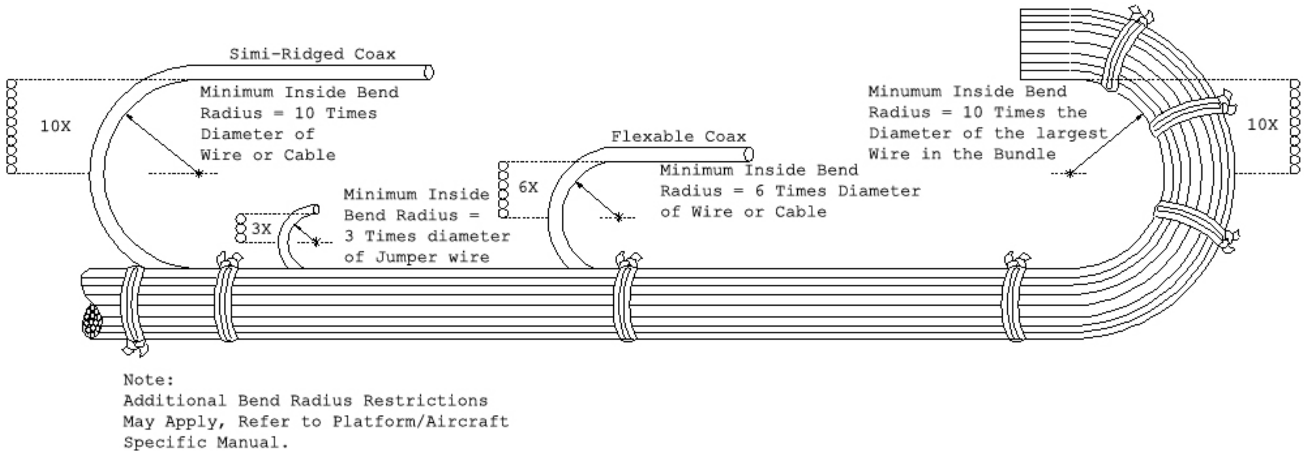


Figure 12. Bend Radius

times the diameter at the point of reversal provided the wire is adequately supported.

c. The minimum bend radius, as measured on the inside radius of a protected harness, shall be six times its outside diameter. In no case shall the bend radius of a protected harness be less than ten times the diameter of the largest included wire or cable.

CAUTION

Never bend coaxial cable to a smaller radius than six times the outside diameter.

d. The minimum radius for flexible type coaxial cables shall not be less than six times the outside diameter. For semi-rigid types, the radius shall not be less than ten times the outside diameter.

e. When it is not possible to hold the bending radius of the single wires to the above limits, enclose the bend in tight plastic tubing for at least two inches each side of the bend.

24. WIRING NEAR MOVING PARTS. Wiring attached to assemblies where relative movement occurs (such as at hinges and rotating pieces; control sticks, control wheels and columns, and flight control surfaces) shall be installed, or protected in such a manner as to prevent deterioration of the wiring by the relative movement of the assembly parts. This deterioration includes abrasion of one wire or cable upon another and stress twisting and bending. Bundles shall be installed to twist instead of bending across hinges. Cables in the vicinity of line replaceable units (LRU) and weapon replaceable assemblies (WRA) shall be protected against damage caused by flexing, pulling, abrasion, and other effects of frequent removal and replacement of equipment (Figure 13).

25. CHAFING. Chafing shall be prevented by routing and clamping bundles to prevent contact with edges of equipment and structure. Where physical separation of at least 3/8-inch cannot be maintained, the edges shall be covered with suitable protection.

NOTE

Silicone tape shall not be used for chafing

Spiral Chafe Wrap may be used in high temperature areas (up to 500°F). protection.

CAUTION

The following procedures shall be used only after every effort has been made to obtain physical separation between wiring harnesses and equipment or structure. Failure to observe this caution may result in damage to equipment and loss of one or more aircraft systems.

a. Installation of Spiral Chafe Wrap (Figure 14).

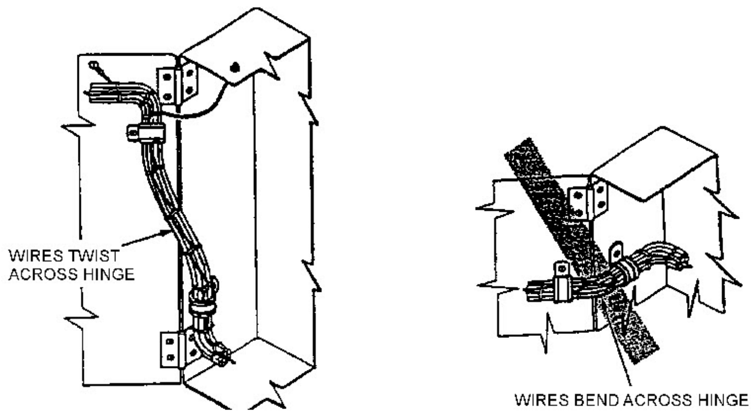


Figure 13. Support at Hinged Areas

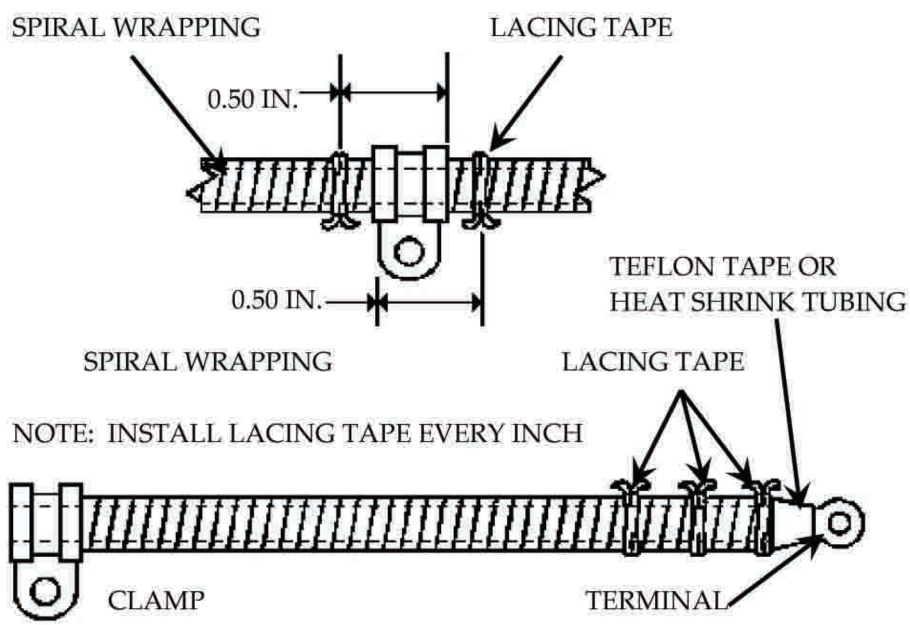


Figure 14. Spiral Wrapping Installation

CAUTION

Spiral wrapping is not recommended for use in wheel wells or other areas exposed to air stream. Spiral wrapping shall not be used for chafing protection against sharp pointed objects such as screw threads. Gaps in spiral wrapping may occur, allowing a chafing condition. Failure to observe this caution may result in damage to equipment and loss of one or more aircraft systems.

(1) For single harness applications, spiral wrapping may be used to provide chafing protection. Use T12T for 1/8 in. diameter (NSN: 9330-01-201-0658), T25T for 1/4 in. diameter (NSN:9330-01-169-5995), T50T for 1/2 in diameter (NSN: 9330-01-179-0242).

(2) Spiral wrapping shall be installed butted or with a gap not to exceed the material width. For most applications, butted installation is preferred. Ends of spiral wrapping shall be secured with lacing tape/tie string (A-A-52083). In addition, it is recommended that the ends of spiral wrapping be secured with Teflon tape (A-A-59474, NSN 5970-01-012-4280), or adhesive-backed heat shrink tubing prior to installation of lacing tape.

b. Installation of Teflon Chafe Protective Pads (Figure 15).

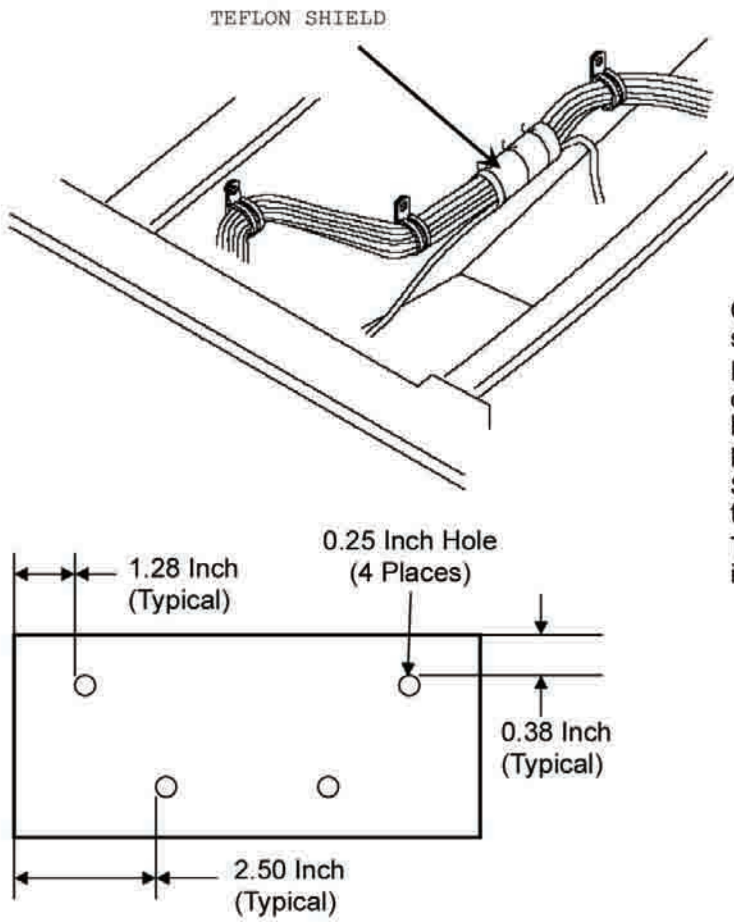
(1) For harness bundles over 3/4 inch, Teflon sheet may be used to provide chafing protection (refer to Figure 13).

(2) It shall be secured with lacing tape/tie string (A-A-52083) at approximately 1-inch intervals. The Teflon sheet shall be wrapped around the bundle with a minimum of 50 percent overlap.

26. Continuous/Expandable Chafe Protection Sleeving. This type of chafe protection is a continuous, tube-like, expandable sleeve. It is intended to be installed at the initial build of the harness. Installation of this sleeve while harness is in service may be accomplished if the connector is not too large. If too large, to fit over connector, it may have to be removed (de-pinned) to allow the sleeve to slide over the harness first. Select one of three sleeve types best suited for the application (see Table 1). Refer to Figure 16 for installation of expandable sleeving. To secure, use lacing tape/tie string A-A-52083 or A-A-52084, apply tape to ends (A-A-59474 TY2CL1 0.050W). Refer to Figure 17.

27. Wrap-Around Chafe Protection Sleeving. Wrap around sleeving may provide protection for wire and cable bundles against: mechanical/abrasion, high temperature, fluid, vapors and fire (depending on the type employed). The self-wrapping feature allows for easy installation and re-entry while reducing the risk of damage to connectors and contacts by eliminating the need for removing contacts (de-pinning connector). There are three types of wrap around sleeving for various applications and one for shielded harness protection for EMI applications. Use applicable product tables (see Tables 2-8) to identify the correct product and size for the application.

28. Installation of Medium, Elevated and High Temperature Application Wrap Around Sleeving. Using sharp scissors, trim adequate length for the application. Trim off any excess strands, or filaments to prevent it from fraying. (Figure 18). This sleeving requires a 90 degree overlap of material to ensure protection and prevent creating a FOD hazard. Wrap-around sleeving sizing is based on the nominal size of the wire bundle, determined by wrapping the material around the bundle and ensuring a 90 degree overlap. In order to accommodate bends in the wire harness and ensure uniform coverage, one full revolution (twist) per foot of the wrap around sleeving is required. Secure using lacing tape (A-A-52084, or A-A-52083) within one inch of both ends and every two inches throughout the length.



NOTE

Cut Teflon to required size for installation

Position shield on outboard side of wiring harness for chafing protection

Secure shield with lacing tape through holes

Tie lacing tape at 1 inch intervals

Thickness	Length	Width	NSN
0.035	72	12	9330-00-141-4647
0.031	60	24	9330-00-993-0767
0.063	24	24	9330-00-242-6215

Figure 15. Teflon Chafe Shield Installation (Typical)

Table 1. Sleeving Applications

Application	Maximum Temp	Product * (Basic Part No. and Name)	CAGE
Expandable Sleeve (Elevated Temp)	200° C	521100XXXXS, Expando 686DM, or 504630XXXXS, PPS	81851
Expandable Sleeve (High Temp)	240° C	534100XXXXS, Expando HTNS-L/HO.	81851
Wrap-Around (Medium Temp)	175° C	562200XXXXS, Roundit PPS.	81851
Wrap-Around (Elevated Temp).	200° C	567600XXXXS, Roundit 2000NX.	81851
Wrap-Around (High temp).	260° C	567710XXXXS, Roundit 2000NX HT	81851
Wrap-Around, (Shielded Harness, Elevated Temp)	200° C	567810XXXXS, Roundit 2000 NX EMI B	81851
* **NOTE** Refer to Tables 2 through 8 for complete part number breakdown.			

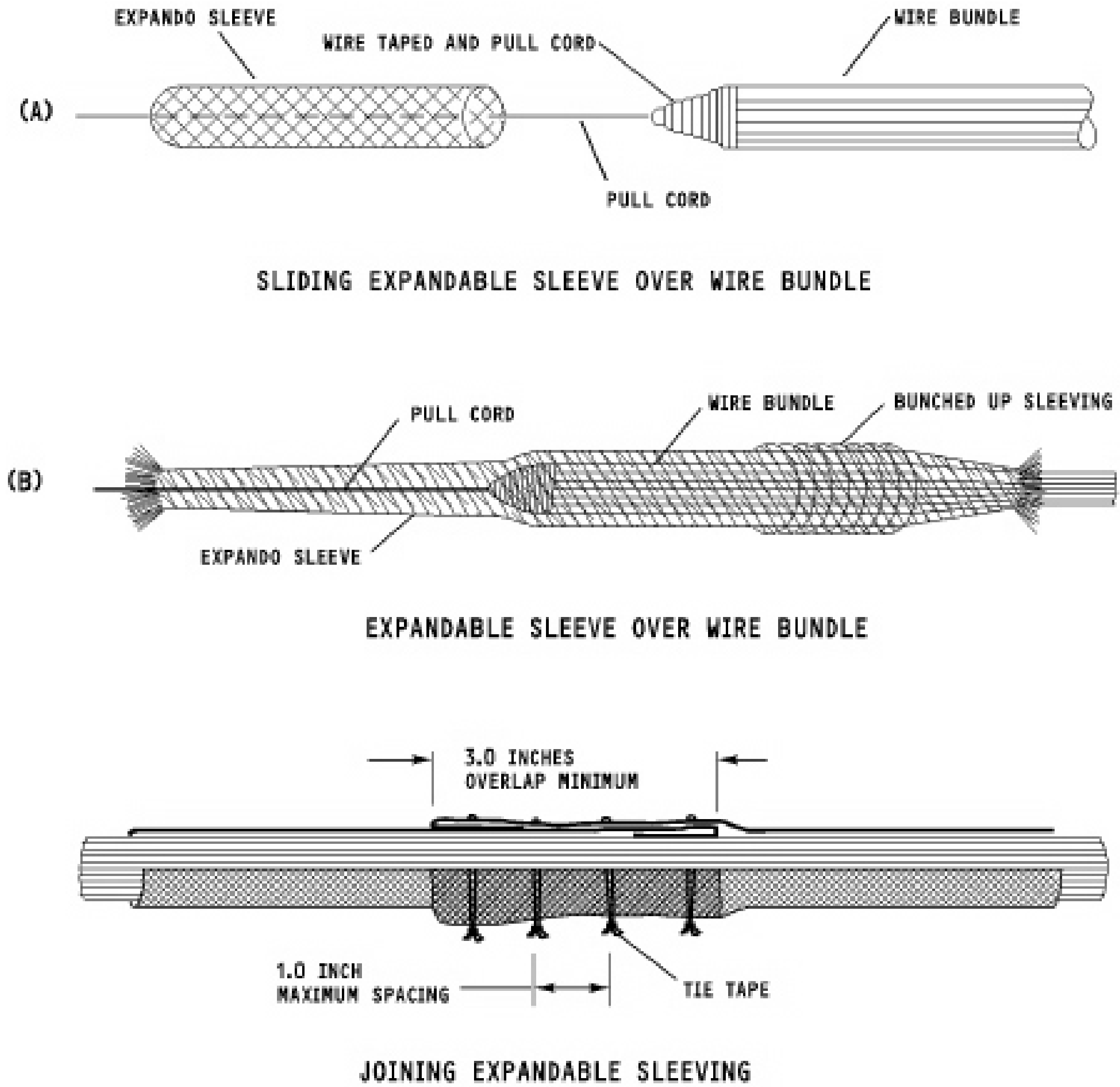


Figure 16. Expando Sleeve Installation

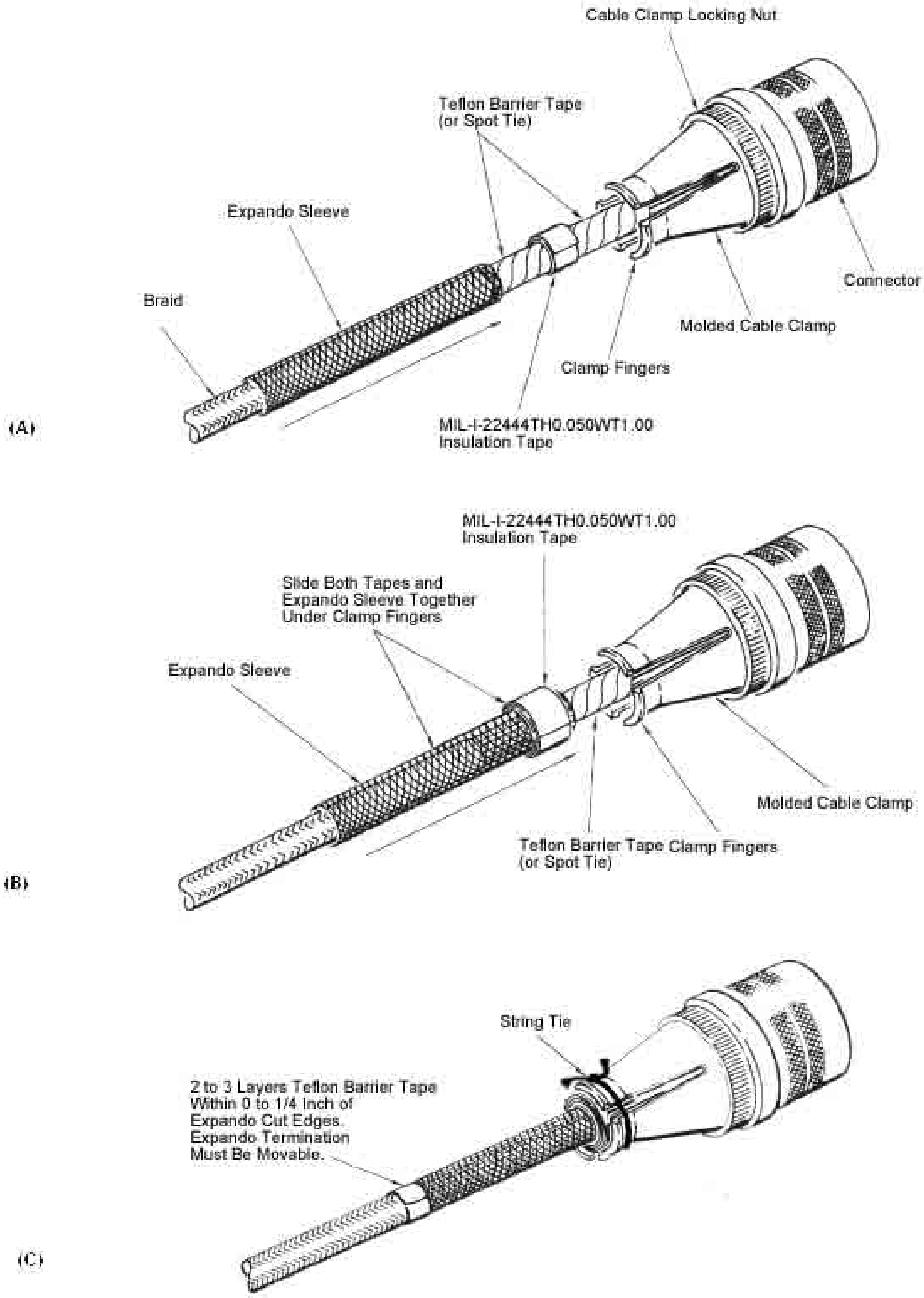


Figure 17. Expando Sleeve Termination

Table 2. Expandable, Elevated Temperature Sleeving PPS (Black)

Minimum Diameter (in.)	Maximum Diameter (in.)	Part Number	CAGE
1/4	1/4	5046300303S	81851
1/2	5/8	5046300603S	81851
3/4	7/8	5046301303S	81851
1 1/4	1 3/8	5046301903S	81851
1 3/4	1 3/4	5046303203S	81851
2 1/2	2 1/4	5046304503S	81851

Table 3. Expandable, Elevated Temperature Sleeving 686DM (Natural)

Minimum Diameter (in.)	Maximum Diameter (in.)	Part Number	CAGE
3/32	1/4	5211000301S	81851
1/8	5/8	5211000601S	81851
3/16	3/4	5211001001S	81851
1/4	7/8	5211001301S	81851
1/2	1 3/8	5211001901S	81851
5/8	1 3/4	5211003201S	81851
3/4	2 1/4	5211004501S	81851
1 1/2	2 1/4	5211005101S	81851
1 7/8	3	5211006401S	81851

Table 4. Expandable, High Temperature Sleeving HTNS-L/HO (Green)

Minimum Diameter (in.)	Maximum Diameter (in.)	Part Number	CAGE
0.4	0.08	5341000207S	81851
0.08	0.16	5341000407S	81851
0.16	0.314	5341000607S	81851
0.236	0.47	5341000807S	81851
0.314	0.63	5341001007S	81851
0.39	0.79	5341001507S	81851
0.47	0.94	5341002007S	81851
0.59	1.18	5341002507S	81851
0.79	1.57	5341003007S	81851

Table 5. Wrap-Around, Medium Temperature Sleeving PPS (Black)

Minimum Diameter (in.)	Part Number	CAGE
3/16	5622000532S	81851
5/16	5622000832S	81851
1/2	5622001332S	81851
3/4	5622001932S	81851
1	5622002532S	81851
1 1/4	5622003232S	81851
1 1/2	5622003832S	81851

Table 6. Wrap-Around, Elevated Temperature Sleeving Roundit 2000NX (Green)

Minimum Diameter (in.)	Part Number	CAGE
3/16	5676000507S	81851
5/16	5676000807S	81851
1/2	5676001307S	81851
5/8	5676001607S	81851
3/4	5676001907S	81851
1	5676002507S	81851
1 1/4	5676003207S	81851
1 1/2	5676004007S	81851

Table 7. Wrap-Around, High Temperature Sleeving Roundit 2000NX HT (Green with White Stripe)

Minimum Diameter (in.)	Part Number	CAGE
3/16	5677100572S	81851
5/16	5677100872S	81851
1/2	5677101372S	81851
3/4	5677101972S	81851
1	5677102572S	81851
1 1/4	5677103272S	81851
1 1/2	5677104072S	81851

Table 8. EMI Shielded, Wrap-Around Sleeving, Roundit 2000NX EMI B (Green)

Minimum Diameter (in.)	Part Number	CAGE
1/4	5678300607S	81851
7/16	5678101107S	81851
9/16	5678101407S	81851
1 1/16	5678101707S	81851
7/8	5678102307S	81851
1 3/16	5678103007S	81851
1 1/2	5678103807S	81851

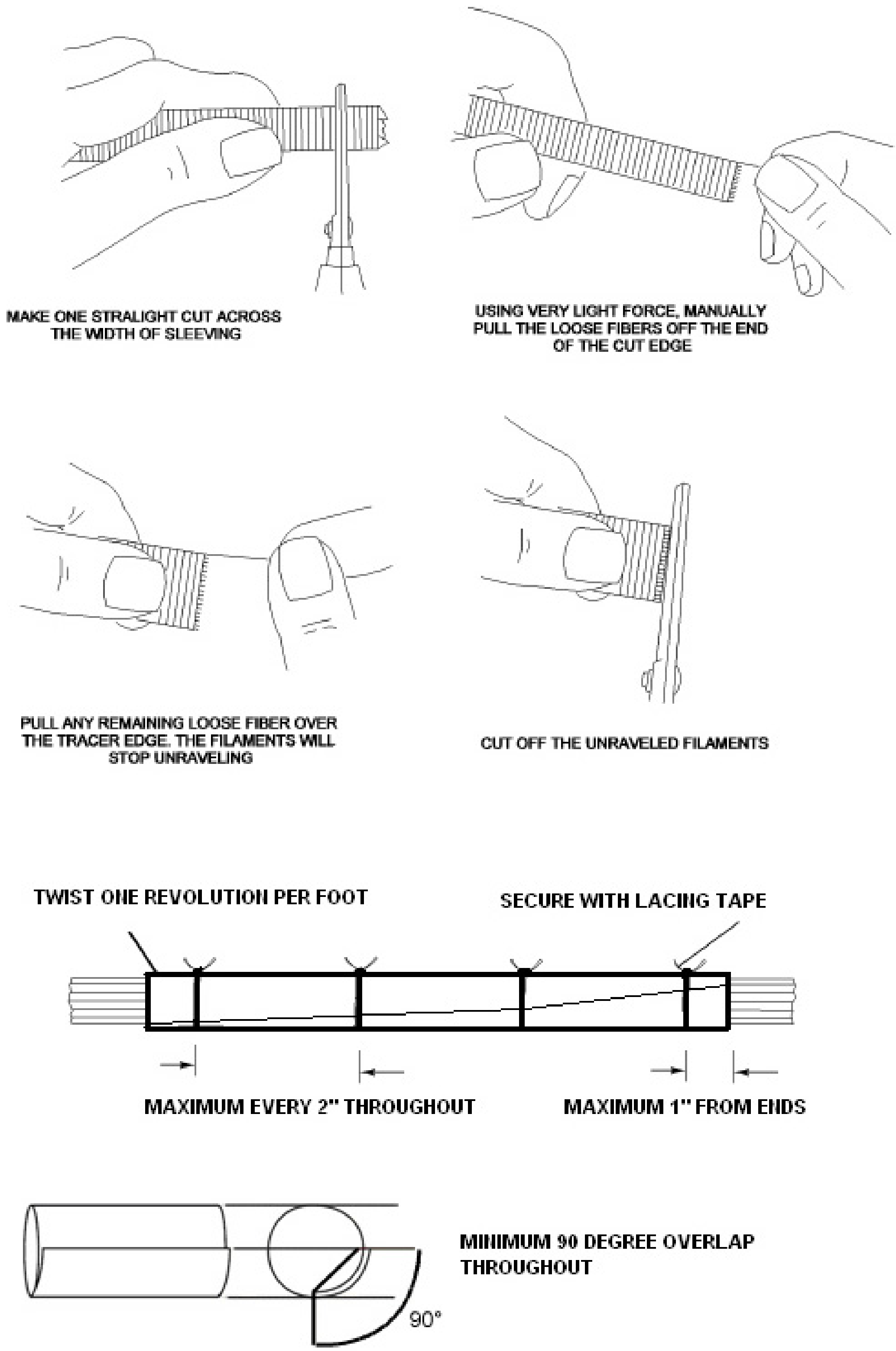


Figure 18. Wrap around Sleeving Installation

Table 9. NASM22529 /2 & /3 Caterpillar Grommets

M22529/2 –XX–XX	M22529/2– Sheet Thickness (in)	M22529/3– –XX–XX	M22529/3– Sheet Thickness (in)
N/A	N/A	–0C–85	.020 – .030
–1C–85	.025 – .036	–1C–85	.029 – .045
–2C–85	.036 – .063	–2C–85	.044 – .056
–3C–85	.059 – .074	–3C–85	.055 – .069
–4C–85	.070 – .093	–4C–85	.069 – .090
–5C–85	.090 – .111	–5C–85	.089 – .114
–6C–85	.105 – .134	–6C–85	.113 – .130
–7C–85	.178 – .198	N/A	N/A
–8C–85	.240 – .260	N/A	N/A
N/A	N/A	–0C–*	.020 – .030
–1C–*	.025 – .036	–1C–*	.029 – .045
–2C–*	.036 – .063	–2C–*	.044 – .056
–3C–*	.059 – .074	–3C–*	.055 – .069
–4C–*	.070 – .093	–4C–*	.069 – .090
–5C–*	.090 – .111	–5C–*	.089 – .114
–6C–*	.105 – .134	–6C–*	.113 – .130
–7C–*	.178 – .198	N/A	N/A
–8C–*	.240 – .260	N/A	N/A
NOTES * Indicates the number of castles listed in Table 3 for the mounting edge Thickness (–1, –2, etc.) and the length required. (this WP, paragraph 36)			

29. GROMMET INSTALLATION.

CAUTION

Grommets are designed for incidental contact only and shall not be used as a primary or secondary means of chaffe protection.

30. Grommets for maintenance usage and replacements are provided in Table 9. The grommets consist of two types: donut and caterpillar.

31. DONUT GROMMET. Donut grommets should be in accordance with MS35489. Donut grommets consist of rubber and are resistant to hot oils and coolants. The grommet has a maximum temperature application of 250°F. Replacement donut grommets are to be split when installing a new donut grommet through fiber optic cables, cable bundles and cable harnesses. Fiber optic cable bundles and cable harnesses are to be disturbed only if a maintenance action is required on these fiber optic items themselves or when removal MUST be done as part of another maintenance action. Split a donut grommet by making one radial cut from the center (hole) to the periphery. (To reverse the direction of the cutting action and reduce any chance of cutting the harness). See Figure 19 for example of installed and cut grommet.

32. MS35489 Part Number. An example of the part number is as follows:

a. Example: MS35489-14X

b. MS35489: Basic and detail specification number representing NASM3036 basic specification and MS35489 detail specification for a donut grommet.

c. -14: Represent a specific size grommet for a particular hole size and edge thickness.

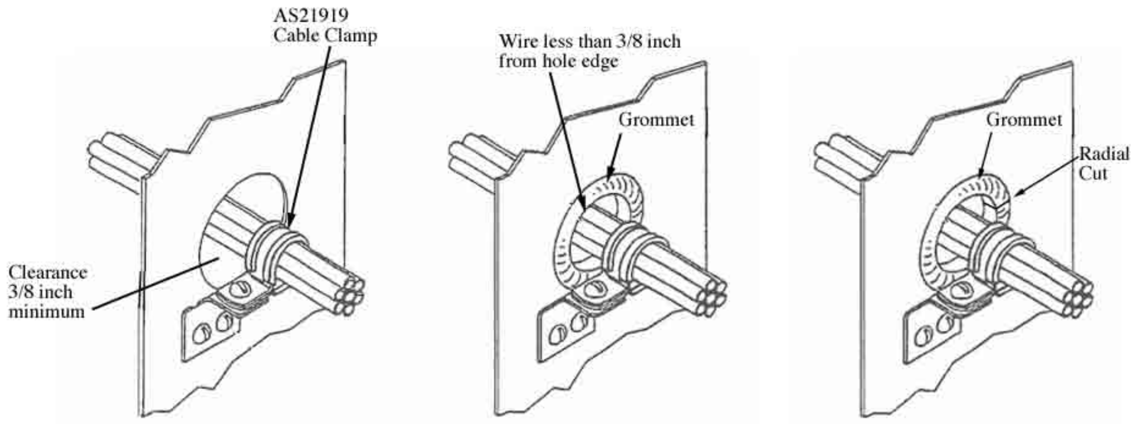


Figure 19. MS35489 Donut Grommet Installation

d. x: When present represents a silicone rubber. No letter represents a synthetic rubber.

33. MS35489 Grommet Replacement. When an engineering drawing, maintenance manual, etc. or no information on the grommet is provided, use the silicone rubber grommet (i.e. MS35489-14X).

34. MS35489 Grommet Installation. The grommet should be installed as follows:

a. Measure the diameter of the hole and edge wall thickness.

b. Using the information provided in MS35489 specification, choose the correct silicone rubber grommet.

c. Pressure inserts the grommet in the hole.

CAUTION

Do not damage the grommet.

d. Verify the grommet is installed without being damaged. Correct size donut grommet does not need to be cut to be installed with no damage. Grommet is to be cut only when installing a new donut grommet over fiber optic cables, cable bundles and cable harnesses or if existing obstacles (at the hole) prevent complete installation. See Figure 19.

35. CATERPILLAR GROMMET INSTALLATION. Caterpillar grommets should be in accordance with NASM22529/2 and /3 detail specifications. The composite coated steel grommet has a maximum temperature application of 185°F. When the NASM21266 nylon caterpillar grommet is specified in an aircraft manual or engineering drawing, use the NASM22529/2 or /3 caterpillar grommet. Grommet designation based on sheet thickness is listed in Table 9. For a specified sheet thickness, substitute the NASM21266 grommet with the NASM2259/2 or /3 grommet as shown in Table 9 and Table 10.

36. NASM22529 Part Number. The caterpillar part number is as follows:

a. Example: M22529/2-1C-85

(1) M22529: Basic specification number representing NASM22529, which defines the general requirement for caterpillar grommet.

(2) /2: Detail specification number representing NASM22529/2 which defines the specific details of a particular caterpillar grommet.

(3) -1: Thickness of the material on which the grommet can be mounted.

(4) C: Denotes a precut length requirement.

(5) -85: Represents the number of castles in a precut length at intervals of 0.015 inches (Figure 20).

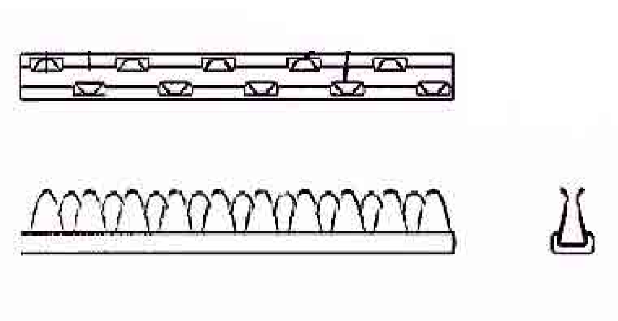
b. Example: M22529/2-4R-25

(1) M22529: Basic specification number (see previous example).

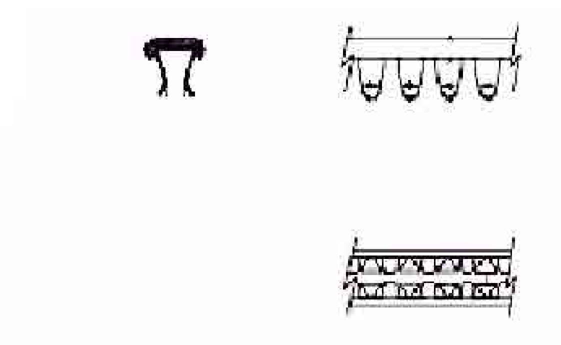
Table 10. Caterpillar Grommet Replacement

Obsolete NASM21266–	NASM21266– Sheet Thickness (in)	Replacement M22529/2–	M22529/2– Sheet Thickness * (in)	Replacement M22529/3–	M22529/3– Sheet Thickness * (in)
–1	.015 – .052	–1C–85	.025 – .036	–0C–85	.020 – .030
		–2C–85	.036 – .052	–1C–85	.029 – 0.45
				–2C–85	.044 – .052
–2	.052 – .085	–2C–85	.036 – .063	–2C–85	.052 – .056
		–3C–85	.059 – .074	–3C–85	.055 – 0.69
		–4C–85	.070 – .085	–4C–85	.069 – .085
–3	.085 – .128	–4C–85	.085 – .093	–4C–85	.085 – .090
		–5C–85	.090 – .111	–5C–85	.089 – .114
		–6C–85	.105 – .128	–6C–85	.113 – .128
–4	.128 – .192	–6C–85	.128 – .134	–6C–85	.128 – .130
		–7C–85	.178 – .192	None	None
–5	.192 – .255	–7C–85	.192 – .198	None	None
		–8C–85	.240 – .255	None	None
–6	.255 – .318	None	None	None	None
–7	.318 – .380	None	None	None	None
–8	.380 – .510	None	None	None	None

NOTES
* Indicates the compatible sheet thicknesses in which the NASM22592 grommet falls into the range of the NASM21266 grommet. See Table 1 for the sheet thickness range of each NASM22529 grommet size.



NASM22529/2
(Alternating/Staggered Castles)



NASM22529/3
(Paired/In-Line Castles)

Figure 20. Caterpillar Grommet Types

(2) /2: Detail specification number (see previous example).

(3) -4: Thickness of the material on which the grommet can be mounted.

(4) R: Indicates grommets are mounted on a reel.

(5) -25: Indicates the length of the reel grommet (i.e. 25 feet).

c. Grommet sheet thickness selection in overlap region. For the grommet designations in Tables 9 and 10, there is an overlap between the largest sheet thickness for the previous range and the smallest sheet thickness specified for the next range. Selection criteria in this overlap region are based on the “hole or edge configuration” and on the type of surface finish. The term “smaller size grommet at overlap” refers to the selection in an overlap of the smaller (previous) range with the overlap being at the largest value for the sheet thickness. Likewise, the term “larger size grommet at overlap” refers to the selection in an overlap of the larger (next) range with the overlap being at the smallest value for the sheet thickness.

(1) Hole or edge configuration.

(a) Axis, single. Single axis (one straight surface). Try grommets both for the smaller size at the overlap and the larger size at the overlap. Select grommet based on strength of hold.

(b) Axes, multiple (such as a lightening hole). Try grommets both for the smaller size at the overlap and the larger size at the overlap. Select grommet based on strength of hold.

(c) Edge, radius. Use larger size grommet at overlap.

(d) Edge, sharp corner (sharp corner = radius less than 1/8 inch for an inside radius and less than 1/4 inch for an outside radius). Use larger size grommet at overlap.

(e) Hole, circular. Use larger size grommet at overlap.

(f) Hole, rectangular. Use larger size grommet at overlap.

(2) Type of surface finish.

(a) Coated. Use larger size grommet at overlap.

(b) Coated, non-stick (Teflon, nylon or other non-stick, slippery surface). Use smaller size grommet at overlap.

(c) Uncoated, high gloss (mirror) finish. Use smaller size grommet at overlap.

(d) Uncoated, rough (matt) finish. Use larger size grommet at overlap.

37. NASM22529 Description. An illustration of the grommet is provided in Figure 20. The grommet is a green, epoxy coated stainless steel strip with teeth (castles) staggered on each side of the strip. From center to center the castles are 0.15 inches apart. The surface, opposite castles is a gray elastomer cushion used to reduce the abrasion characteristics of the hole or edge on which the strip is mounted. The strip is secured on the edge of the hole by separating the castles (spring loaded) when pressing on the strip.

38. NASM22529/2 Flat Edge Hole Installation. To install grommets on non-lightening, flat edge feed through holes as shown in Figure 20 perform the following:

CAUTION

Do not use NASM22529/2 grommet in horn shaped lightening hole (paragraph 39).

a. Examine the NASM21266 nylon grommet, which is glued to the feed through hole, for breaking of teeth or (due to glue failure or metal tooth fatigue) separation from the edge.

b. Remove the old grommet when needed. Be sure all old excess material is removed and discarded to avoid FOD.

c. Measure the diameter of the hole and edge wall thickness. Determine the length needed to cover the hole from Table 11 for the measured wall thickness.

Table 11. Circular Hole Grommet Edging Cut Lengths

Cut Length		
Nominal Hole Diameter	L Length	In Castles
2.000	6.00	40
2.250	6.90	46
2.250	7.65	51
2.750	8.40	56
3.000	9.15	61
3.250	10.05	67
3.500	10.80	72
3.750	11.55	77
4.000	12.30	82
4.250	13.20	88
4.500	13.95	93
4.750	14.70	98
5.000	15.45	103
5.250	16.35	109
5.500	17.10	114
5.750	17.85	119
6.000	18.60	124

d. Measure the required grommet length.

e. Using a full bypass shears (part number MFE-100) shown in Figure 21, hold the grommet as shown in Figure 22.

CAUTION

Safety glasses should be used.

f. Determine cut angle. The NASM29529/2 grommet may be cut between the castles on either a 90° or a 45° angle. The NASM22529/3 grommet must be cut on a 90° angle. Cutting of the NASM229529/2 grommet on a 90° or a 45° angle may be determined based on if a gap is present when installed into the hole. Either cut angle may be used whether or not a gap is present. The advantage of cutting on a 45° angle is less of a chafing impact on the cabling (since the gap is not in line with the cabling).

NOTE

A gap will be present if the circumference of the hole is larger than the cut length in increments of the pitch (0.15 inches). (The pitch is the distance between centers of opposing castles, see Figure 20.) Use Table 11 to determine cut length. Use of the cut length listed in Table 11 may result in a gap. The number of castles listed in Table 11 is rounded down to the nearest whole number. Cut length must account for grommet thickness along with hole circumference.

g. Cut the grommet between the castles at a 90° or a 45° angle as shown in Figure 23. To assure the absence of deformation of adjacent castles close to the cut-off, be sure to grip both sides of the cut as shown in Figure 22.

h. Install the grommet by compressing the grommet firmly on the hole edge with the gap between the two ends of the grommet located at the top of the hole. If it appears that the bundle wire could become

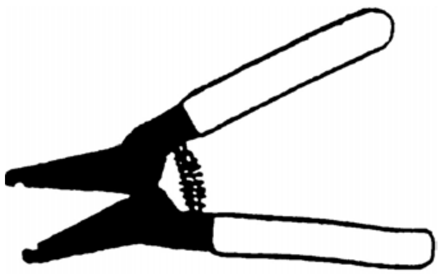


Figure 21. Bypass Shears

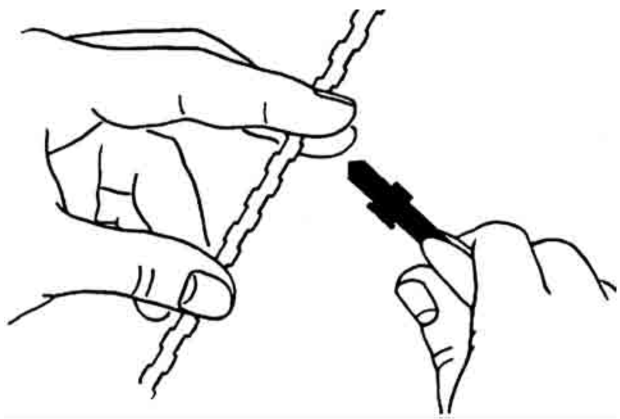


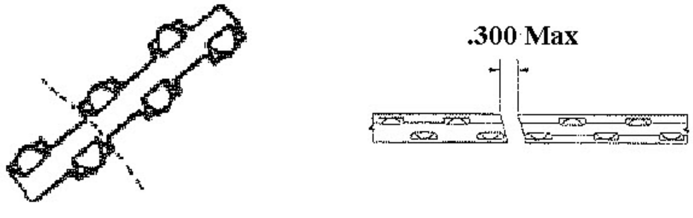
Figure 22. Gripping Grommet

loose and rub against the gap, it should be located in such a manner that the wire pressure will be on the opposite side from the gap. Be sure the grommet is completely compressed on the edge of the hole (Figure 24).

i. If the width of the gap is greater than 0.3 inches, replace the grommet.

39. <u>NASM22529/3 Lightening Hole Installation</u>. To install grommets in horn shaped lightening holes as shown in Figure 24, follow the same procedure as for the NASM22529/2 flat edge hole except use a M22529/3 grommet. The NASM22529/3 part number format is the same as for the NASM22529/2 part number. However, the NASM22529/3 grommet must be cut at a 90° angle instead of a 45° as shown in Figure 23.

40. TAPE OR TUBE PROTECTION. If there is a possibility that the wire without a protective outer jacket may be soaked or chafing in any location, use plastic tubing or tape to protect it. This tubing or tape should extend past the area in both directions and be tied at each end. If the wire has a low point between the tubing ends, the lowest point should have a 1/8-inch drainage hole as shown in Figure 25. Punch the hole in the tubing after the installation is complete and the low point definitely established. Use a hole punch to cut a half circle. Be careful not to damage any wires inside the tubing or tape when using the punch. The tape shall be non-adhesive silicon tape.



90° cut for staggered castle type (NASM22529/2) caterpillar grommets

45° cuts at "terminal" ends for staggered type (NASM22529/2) caterpillar grommets

Figure 23. Cut Caterpillar Grommet

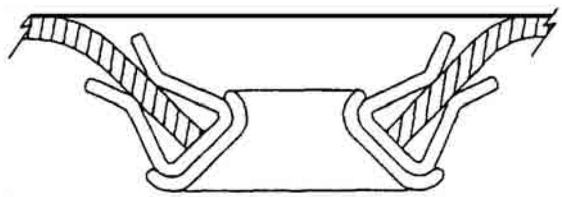


Figure 24. Lightening Hole Grommet Mounting

CAUTION

If it is necessary to move or repair wires which have a protective jacket with a drainage hole at the low point, make sure drainage hole is still at the low point afterward. If the location of the low point has changed, punch a new hole in the protective jacket at the new low point.

41. WIRING CLAMPS. Wires, cables, bundles, and harnesses are clamped to the aircraft structure by AS21919 cushioned metal clamps for primary support and SAE-AS25281 plastic clamps for secondary support.

42. AS21919 Part Number. An example of a AS21919 part number is as follows:

a. Example: AS21919 WDG-8.

b. AS21919: Basic specification describing the clamps.

c. Indicates the base of the open end of the loop has a wedge to assist locking the clamp together (Figure 26). Applicable for sizes 2 through 48 only.

d. Defines the band material (Table 12).

e. Defines the cushion material (Table 12).

f. Defines the cable thickness, which the band can hold (Table 13).

43. Clamp Replacements. When engineering drawings, mainframe manuals, etc. specify the canceled part numbers as shown in Tables 14 and 15, replace the clamp as indicated.

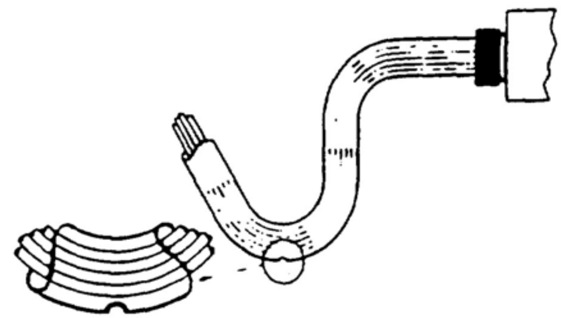


Figure 25. Drainage Hole in Low Point of Tubing or Tape

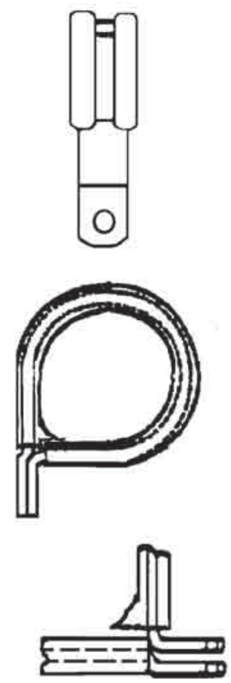


Figure 26. AS21919 Clamp

Table 12. Material Codes for AS21919 Clamp

Material Codes 7/	Authorization Status	Max Temperature
DE = Aluminum Band with Ethylene Propylene Cushion 2/	Authorized	(212 °F)
DF = Aluminum Band with Nitrile Cushion 3/	Authorized	(212 °F)
DG = Aluminum Band with Chloroprene Cushion 4/	Authorized	(212 °F)
CE = CRES Band with Ethylene Proplene Cushion 2/	Authorized	(275 °F)
CF = CRES Band with Nitrile Cushion 3/	Authorized	(212 °F)
CH = CRES Band with Silicone Cushion 5/	Authorized	(400 °F)
CG = CRES Band with Chloroprene Cushion 4/	Authorized	(212 °F)
CJ = CRES Band with Fluorosilicone Cushion 6/	Authorized	(450 °F)
F = Low Carbon Steel Bands with Nitrile Cushion 3/	Not Authorized 1/	(212 °F)
G = Low Carbon Steel Bands with Chloroprene Cushion 4/	Not Authorized 1/	(212 °F)
H = Low Carbon Steel Bands with Silicone Cushion 5/	Not Authorized 1/	(400 °F)

1/ MS21919 clamps with low carbon steel bands were inactive for new aircraft design as of 1 October 1982. AS21919 superseded MS21919. AS21919 clamps are specified only with aluminum or CRES (stainless/corrosion resistant steel) bands.

2/ Ethylene Propylene (purple cushion). For use in areas contaminated with phosphate ester hydraulic fluid and other synthetic fluids. Excellent ozone resistance. Not resistant to petroleum based fluids.

3/ Nitrile (yellow cushion). For use primarily in fuel immersion and fuel vapors. Good ozone resistance. Not resistant to phosphate ester based fluids. Not for use on titanium tubing.

4/ Chloroprene (black cushion). For general purpose use in areas contaminated with petroleum based hydraulic fluids and occasional fuel splash. Excellent ozone resistant. Not resistant to phosphate ester based fluids. Not for use on titanium tubing.

5/ Silicone (white cushion). For elevated temperature use in phosphate ester based fluid and other synthetic fluid contaminated areas. Unaffected by ozone. Not resistant to petroleum based fluids.

6/ Fluorosilicone (blue cushion). For elevated temperature use in petroleum based fluid contaminated areas. Unaffected by ozone. Not resistant to phosphate ester based fluids.

7/ Do not select band/cushion combinations not listed.

Table 13. Clamp Sizes

Size Code/ Dash No.	Cable OD 1/, 2/, 3/ (inch)	Size Code/ Dash No.	Cable OD 1/, 2/, 3/ (inch)
1	1/16	27	1–5/8
2	1/8	28	1–3/4
3	3/16	29	1–3/4
4	1/4	30	1–7/8
5	5/16	31	1–7/8
6	3/8	32	2
7	7/16	33	2
8	1/2	34	2–1/8
9	9/16	35	2–1/8
10	5/8	36	2–1/4
11	11/16	37	2–1/4
12	3/4	38	2–3/8
13	13/16	40	2–1/2
14	7/8	42	2–1/2
15	16/16	43	2–1/2
16	1	44	2–3/4
17	1–1/16	45	2–3/4
18	1–1/8	46	2–3/4
19	1–3/16	48	3
20	1–1/4	50	3
21	1–5/16	52	3–1/4
22	1–3/8	54	3–1/4
23	1–7/16	56	3–1/2
24	1–1/2	58	3–1/2
25	1–9/16	64	4
26	1–5/8	66	4

1/ Cable = cable, cable bundle or cable harness outside diameter (OD). Cable OD (or thickness) found by determining the circumference and dividing by 3.14. Circumference may be found by wrapping a string around the cable bundle/harness, then measuring that distance with a ruler.
2/ OD constraint. This cable OD pertains to rigid tubing. For cable bundles, open cable harnesses and cable harnesses protected with cable wrap, may need to go up or down one clamp size. Replacement cable clamp must be sized so that cable will not slide in the clamp. Test is to hold cable on either side of the clamp and try to “lightly” move it on either side of the clamp.
3/ Guideline. This cable OD is given as a guideline and may need to be adjusted for non–circular cable OD and clamp cushion compression.
4/ Cable deformation. For braided cable harnesses (those with both electrical wire and fiber optic cable), the clamping must not deform the braid (since tight braid transmits stress directly to cables). For other cables with protective covers, tighten until constriction observed.
5/ AS25281 – F* is not available in sizes – 21 through 66.
AS25281 – R* is not available in sizes – 33 through 66.

Table 14. AS21919 Clamp Replacement for -2 through -48

Cancelled Part Number	Replacement Part Number
MS21919WB(F,G,H)( )	AS21919WC(F,G,H)( ) or AS21919WD(F,G,H)( ) 2/
MS21919B(F,G,H)( )	AS21919WC(F,G,H)( ) or AS21919WD(F,G,H)( ) 2/
MS21919W(F,G,H)( )	AS21919WC(F,G,H)( ) or AS21919WD(F,G,H)( ) 2/
MS21919(F,G,H)( )	AS21919WC(F,G,H)( ) or AS21919WD(F,G,H)( ) 2/
MS21919D(E,F,G)( )	AS21919WD(E,F,G)( )
MS21919WD(E,F,G)( )	AS21919WD(E,F,G)( )
MS21919C(E,F,G,H,J)( )	AS21919WC(E,F,G,H,J)( )
MS21919WC(E,F,G,H,J)( )	AS21919WC(E,F,G,H,J)( )
MS21919DH( ) 3/	AS21919WCH( )
MS21919WDH( ) 3/	AS21919WCH( )

1/ ( ) represents the same dash number for MS & AS part number (see Table 7). For the AS part number, a “0” (zero) must be added to the dash number for dash numbers less than 10.

2/ Letter “B” only in Rev D of MS21919 or no letter in other revisions to MS21919 = carbon steel. For replacement, use either C = CRES or D = aluminum

3/ Do not select band/cushion combinations not listed (see Table 4).

Table 15. AS21919 Clamp Replacement for -50 through -66

Cancelled Part Number	Replacement Part Number
MS21919WB(F,G,H)( )	AS21919C(F,G,H)( ) or AS21919D(F,G,H)( ) 2/
MS21919B(F,G,H)( )	AS21919C(F,G,H)( ) or AS21919D(F,G,H)( ) 2/
MS21919W(F,G,H)( )	AS21919C(F,G,H)( ) or AS21919D(F,G,H)( ) 2/
MS21919(F,G,H)( )	AS21919C(F,G,H)( ) or AS21919D(F,G,H)( ) 2/
MS21919D(E,F,G)( )	AS21919D(E,F,G)( )
MS21919WD(E,F,G)( )	AS21919D(E,F,G)( )
MS21919C(E,F,G,H,J)( )	AS21919C(E,F,G,H,J)( )
MS21919WC(E,F,G,H,J)( )	AS21919C(E,F,G,H,J)( )
MS21919DH( ) 3/	AS21919CH( )
MS21919WDH( ) 3/	AS21919CH( )

1/ ( ) represents the same dash number for MS & AS part number (see Table 7). For the AS part number, a “0” (zero) must be added to the dash number for dash numbers less than 10.

2/ Letter “B” only in Rev D of MS21919 or no letter in other revisions to MS21919 = carbon steel. For replacement, use either C = CRES or D = aluminum

3/ Do not select band/cushion combinations not listed (see Table 4).

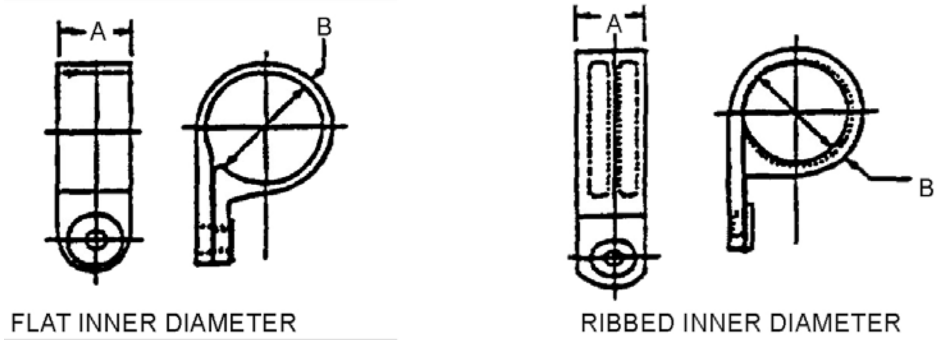


Figure 27. SAE-AS25281 Clamp

WARNING

AS25281 nylon cable clamps may only be used to support wire bundles up to two inches in diameter in open wiring, or inside junction boxes and on the back of instrument panels.

CAUTION

Do not use plastic cable clamps where the ambient temperature may exceed 185°F.

NOTE

AS25281 plastic cable clamps, spaced at intervals not to exceed 24 inches, may be used for wire support provided every fourth clamp is a rubber cushion type (AS21919). The use of plastic cable clamps on other than horizontal runs should be avoided.

44. AS23190/4 Locking Clamp. This clamp's locking feature provides for easier installation. It may be used as a substitute for the general purpose AS21919 Series Loop Clamp. Although this clamp can be used as a direct replacement, it is primarily intended for difficult to access areas. It may be employed in all locations where the AS21919 clamp is used provided that the correct cushion and clamp material type meets the application requirements.

45. AS25281 Part Number. Examples of AS25281 nylon clamps are as follows (Figure 27):

a. Example: AS25281-F6.

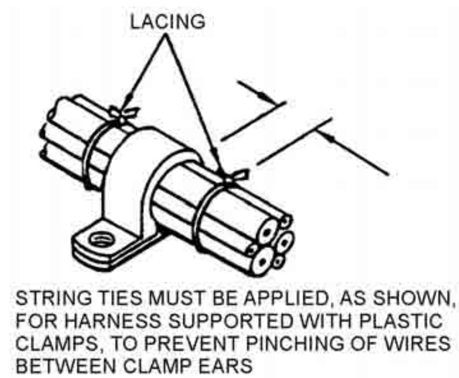


Figure 28. Plastic Clamp

b. AS25281: Detail specification representing the details of the clamp and the SAE-AS23190 performance characteristics.

c. - F: One digit code indicating whether the clamp has a flat center surface (-F) or has ribs (-R) (Figure 28).

d. 6: Define the cable thickness, which the clamp can hold (Table 13).

46. CLAMP INSTALLATION.

47. CLAMP SIZE AND RESTRICTIONS. If a clamp needs to be replaced and is not specified by the aircraft maintenance manual, use AS23190/4S-(02 thru 66)FWS snap clamps in place AS21919(-02 thru -66) and AS25281(-02 thru -32). AS21919 To AS23190 Part Number Comparison.

48. RF Coaxial Cable Restriction. Support of the individual coaxial cables and of bundles containing coaxial cables shall be subject to the following additional clamping restrictions:

a. Both primary and secondary clamps shall be installed so as not to exert greater pressure on the cable than the minimum required to prevent slipping.

b. The clamp shall not deform the cables so that the electrical characteristics of the cables are degraded.

c. Pressure shall be evenly distributed around bundles containing coaxial cables, or around the coaxial cables, if individually supported.

WARNING

The use of flexible filler rods to fill the empty space in a clamp is strictly prohibited, as these can fall out and create a FOD hazard.

CAUTION

Do not install clamps of any type over existing tie string/lacing tape applications. Clamp installation over the lacing tape/tie string may induce a premature wire insulation failure.

49. Installing Clamps. Install AS21919 cable clamps as shown in Figure 29. The mounting screw should be above the wire bundle, if possible. It is also desirable that the back of the cable clamp rest against a structural member. Use hardware, as shown in Figure 30, to mount cable clamps to structure. Be careful not to pinch wires in cable clamp. If the wire bundle is smaller than the nearest clamp size, or if a clamp of the proper size is not available, wrap the wire bundle with the necessary number of turns of non-adhesive insulating tape (Figure 5) so that the bundle will be held securely in the clamp. Typical examples of how clamps are to be mounted are shown in Figure 28 and Figures 31-35. For the installation of AS25281 Nylon Clamps, secure the wires with lacing tape/tie string to prevent pinching of wires. Tie string shall be installed on both sides of the nylon clamp within the distance equivalent to a clamp width.

NOTE

AS21919 cable clamps are cushioned with insulating material to prevent abrasion of wires. Never use metal clamps without cushions to hold wires.

When installing plastic cable clamps, use a large diameter metal washer under the screw head or nut adjacent to the clamp.

50. CABLE CLAMP TOOLS.

51. PLIER, SLIP JOINT. This tool to facilitate the installation of cable clamps is shown in Figure 36. Similar to conventional multiple slip joint pliers, the tool compresses and holds the clamp with the securing bolt in place while a nut is being installed on the bolt.

52. ADEL560 ASSEMBLY TOOL. The ADEL560 clamp assembly tool simultaneously closes and holds the clamp in position while both hands are free to secure the harness in place. After clip is bolted in place, the tool is easily removed by depressing handle until prongs clear (Figure 37).

WARNING

The loop possesses a potential FOD hazard if lost in the aircraft during the removal or installation of clamps in confined spaces.

NOTE

This loop is to be used only with metal cushioned clamps (AS21919).

53. GE21E1 LOOP, STRAP FASTENER. A loop can be used as an aid to hold the clamp closed (Figure 38).

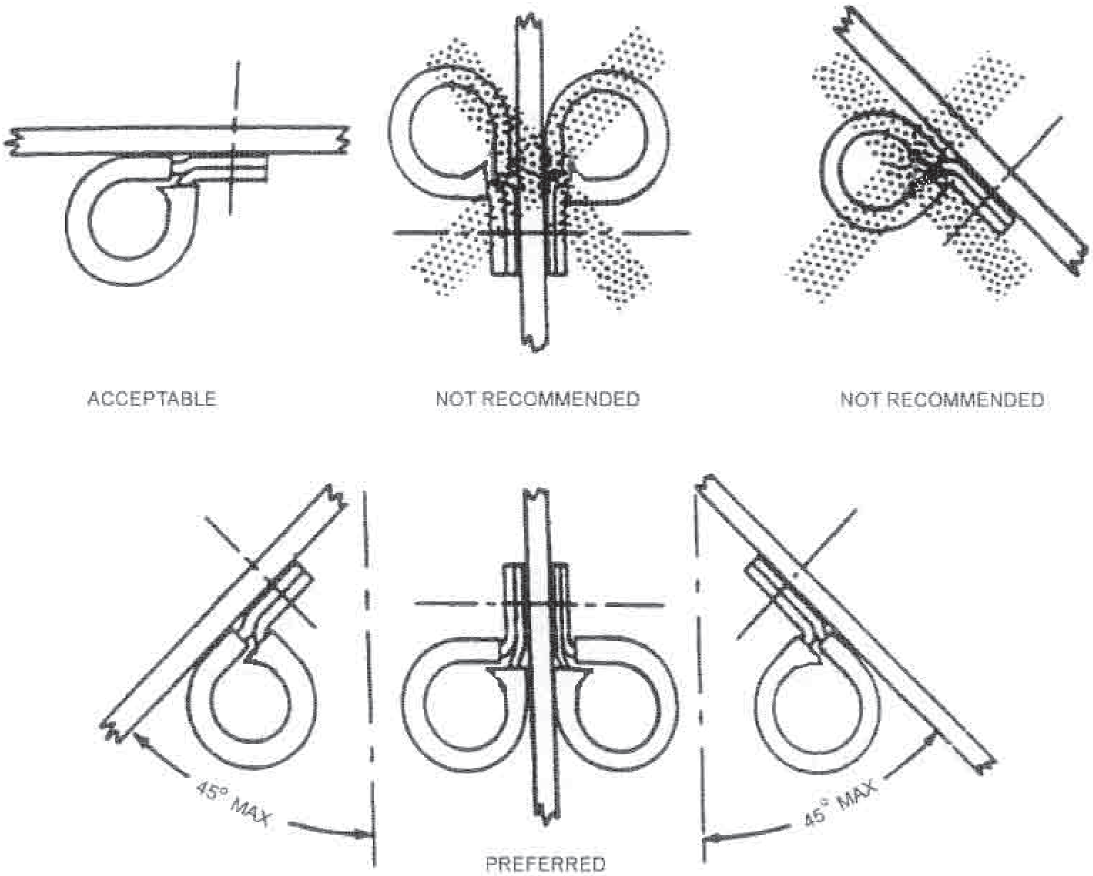
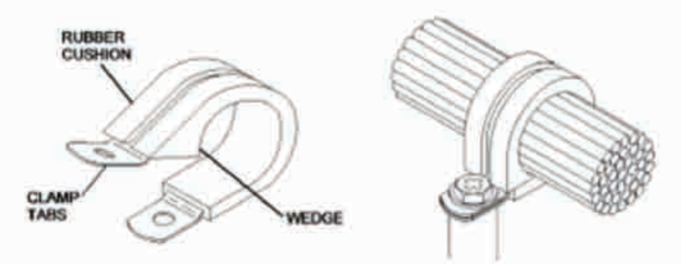


Figure 29. Preferred Angle for Cable Clamps



Hardware Options

Option	Flat Washer	Lock Washer	Nut
1	AN960-	MS35338-	MS35690-
2	AN960-	MS35335-	MS35690-
3	AN960-	-	MS21042-

Note:
1. Refer to NA 01-1A-8 for dash number.
2. Ensure similar materials are used to reduce corrosion potential.

Figure 30. Typical Mounting Hardware for AS21919 and AS23190/4 Cable Clamps

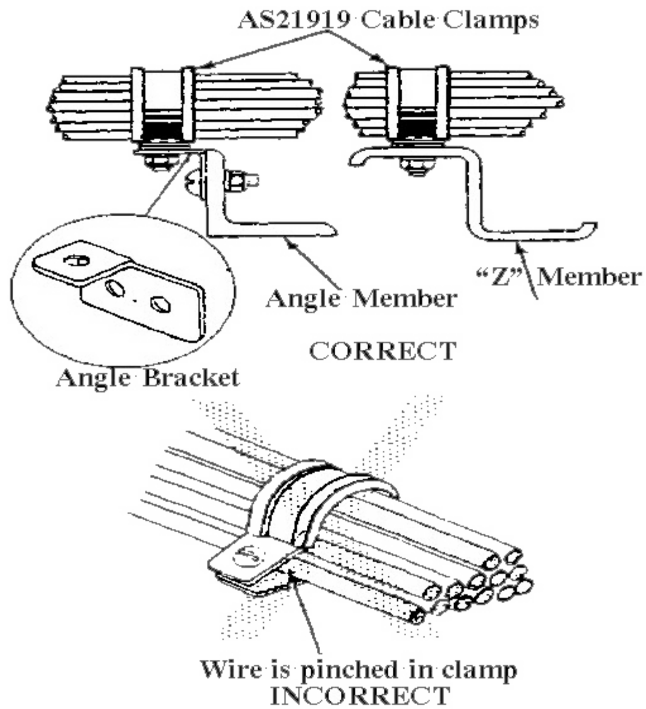


Figure 32. Attachiung Cable Clamp to Structure

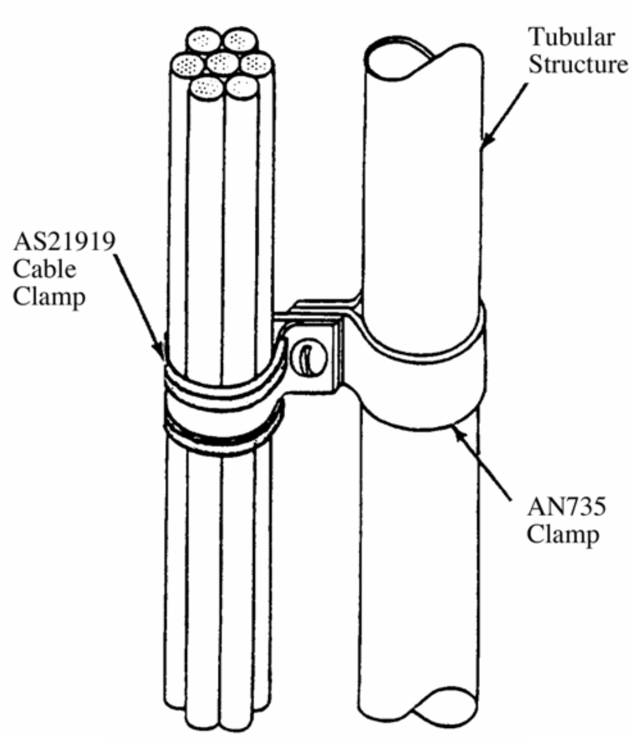


Figure 31. Installing Cable Clamps to Tubular Structure

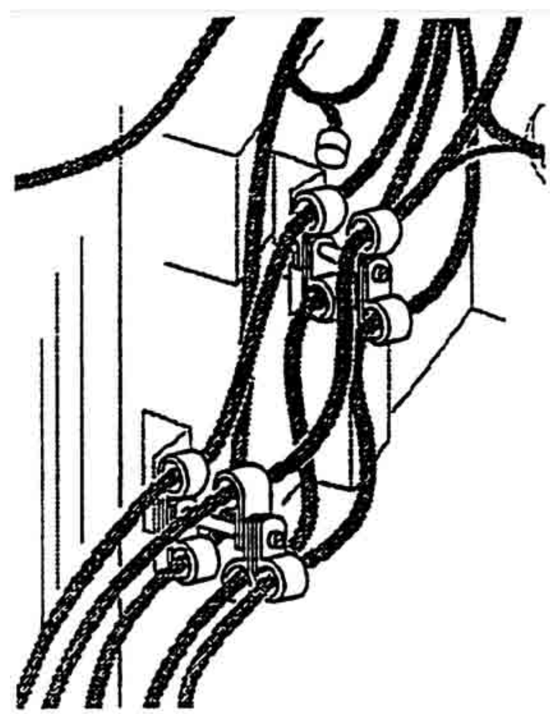


Figure 33. Plastic Clamps Routing

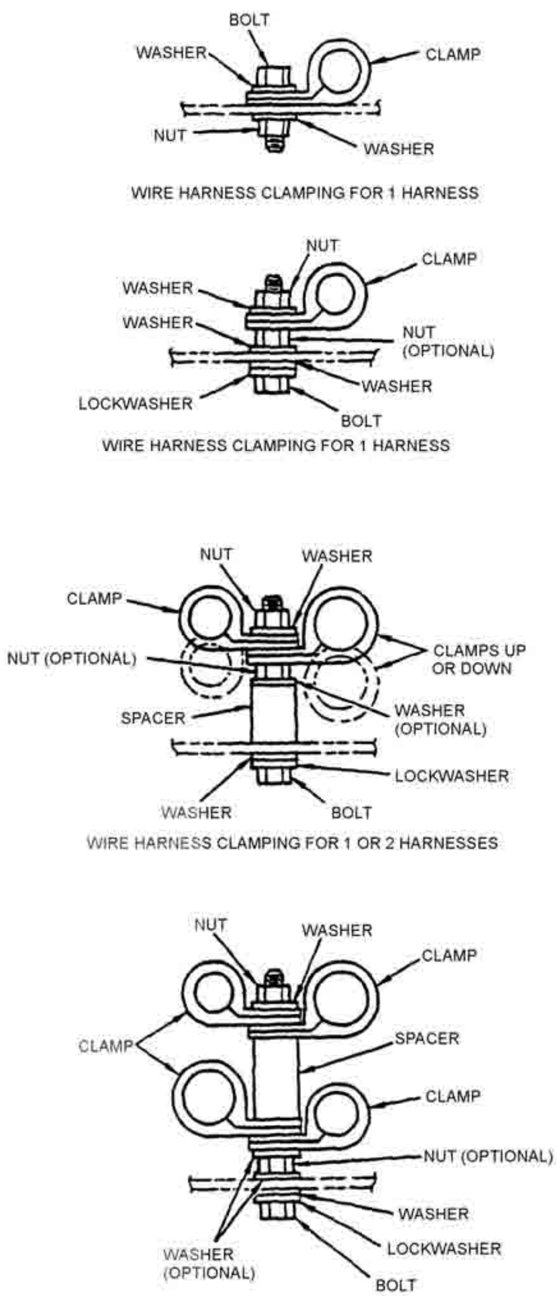


Figure 34. Typical Wire Harness Clamping

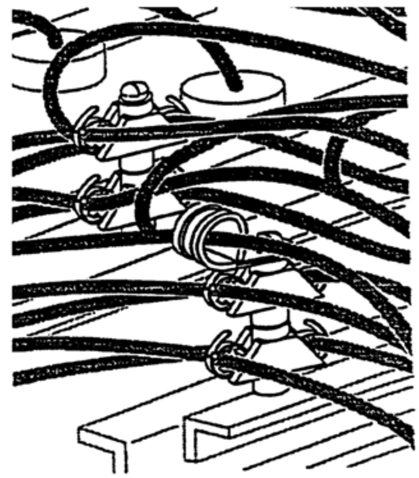


Figure 35. Cushion Clamps Routing

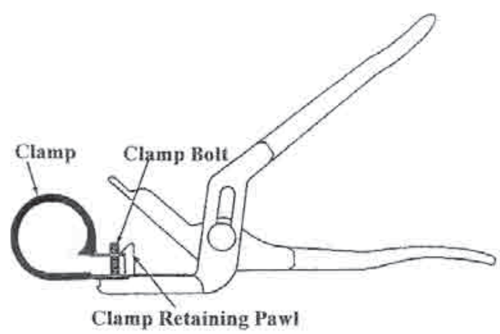


Figure 36. Slip Joint Pliers

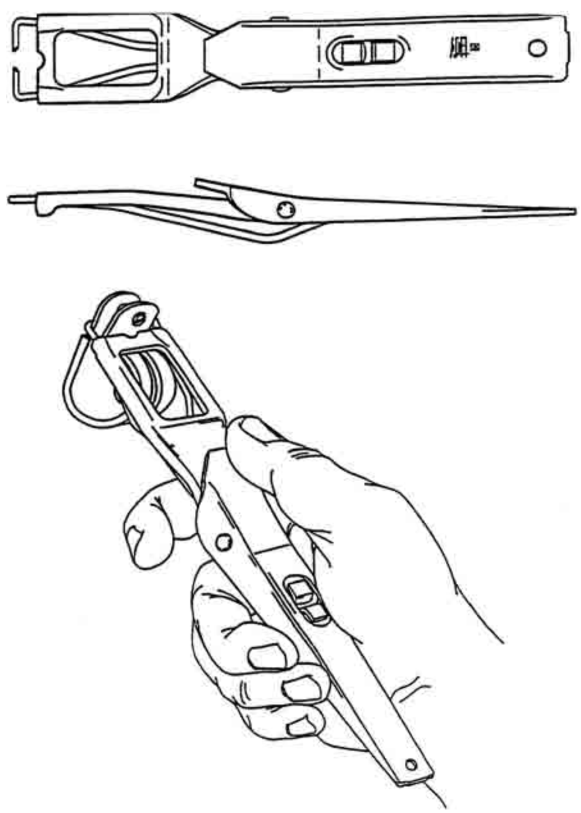


Figure 37. ADEL 560

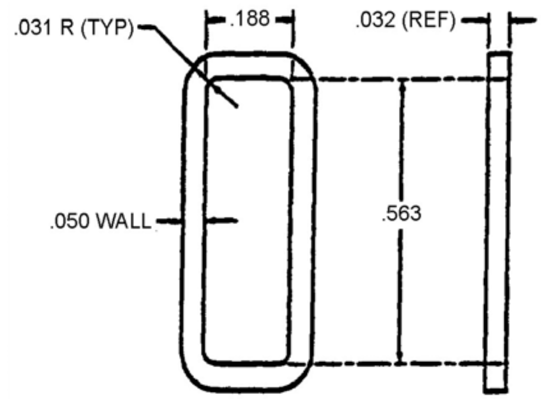


Figure 38. GC21E1 Loop, Strap Fastener

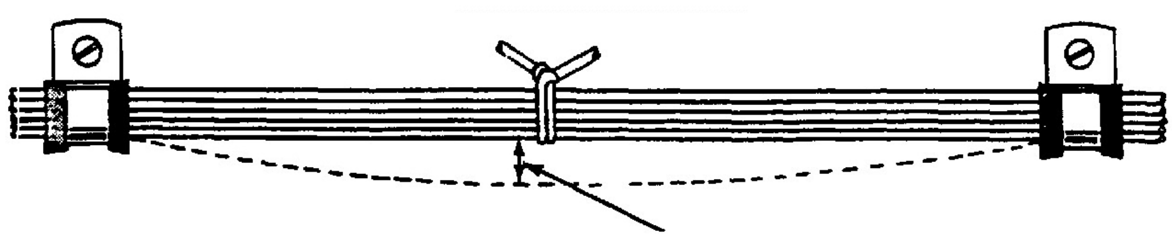


Figure 39. SlackBetween Supports

54. SLACK.

55. Do not install single wires or wire bundles with excessive slack. Slack between support points such as cable clamps should normally not exceed 1/2-inch. (Figure 39). This is the maximum that it should be possible to deflect the wire with moderate hand force. This may be exceeded if the wire bundle is thin and the clamps are far apart, but the slack must never be so great that the wire bundle can touch any surface against which it may abrade. Between the last support point and the connectors, sufficient slack should be provided to preclude any wire tension at the wire termination points. Where appropriate, and especially for wires and/or wire bundles that slope downward as they lead into a backshell, connector or termination, ensure that you include a drip loop (Figure 13) or a drip depression to allow fluids from condensation and other sources to drip off the wire (bundles) prior to entering a backshell, connector or terminal block. Allow a sufficient amount of slack near each end for any or all of the following:

a. To permit ease of maintenance.

b. To allow replacement of terminals at least twice.

c. To prevent mechanical strain on the wires, cables, junctions, and supports.

d. To allow fluids from condensation and other sources to drip off the wire (bundle) prior to entering a backshell, connector or terminal block.

56. CONNECTOR INSTALLATION.

57. **CONNECTOR INSPECTION.** Inspect the connector in accordance with the appropriate WP 020 00, 021 00, 023 00 or 024 00 before mating. Be sure all contacts are seated, and all unwired contact cavities have contacts and sealing plugs. Examine for bent or splayed contacts. Be sure the accessory is tight on the back of the connector, and the saddle clamp is tight on the wire bundle.

58. **CONNECTOR COUPLING.** Assemble connector to the receptacle as follows:

WARNING

Unless otherwise required by specific equipment technical data, power should be removed from the affected circuit to avoid shock hazard and possible arcing of connector.

CAUTION

Do not use excessive force to mate connector to receptacle.

a. Locate the proper position of the plug in relation to the receptacle by aligning the key of one part with the groove or keyway of the other part. (Figure 40).

CAUTION

Do not twist wire bundle excessively to achieve proper mating of plug and receptacle.

Do not misconnect plug and receptacle by forcing pins into the resilient insert, either by misalignment of properly mating connector or by joining connectors with identical shells but differently keyed insert arrangements.

b. Start the plug into the receptacle with a light forward pressure and engage the threads of coupling ring and receptacle.

(1) BEFORE COUPLING, MATING HALVFS MUST BE EXAMINED FOR:
- A. PROPERLY SEATED CONTACTS
- B. ALL CAVITIES FILLED WITH CONTACTS (EXCEPT UNUSED COAX)
- C. NO VISIBLE BENT CONTACTS
- D. ALL UNWIRED CAVITIES WITH ENVIRONMENTAL SEALS WITH PROPER SEALING PLUGS
- E. APPLICABLE BACKSHELL TIGHTENED ON CONNECTOR, AND, WHERE CABLE CLAMP CLAMP IS USED, SADDLE BARS TIGHTEN

(2) AFTER EXAMINATION AND MATING, VERIFY CONNECTOR HAS LOCKED AND/OR IS TIGHT, DEPENDING ON TYPE.

NOTE

WHEN A THREAD CONNECTOR HAS NO INDICATOR LINE, MAKE CERTAIN THAT IT HAS BEEN SUFFICIENTLY TIGHTENED.

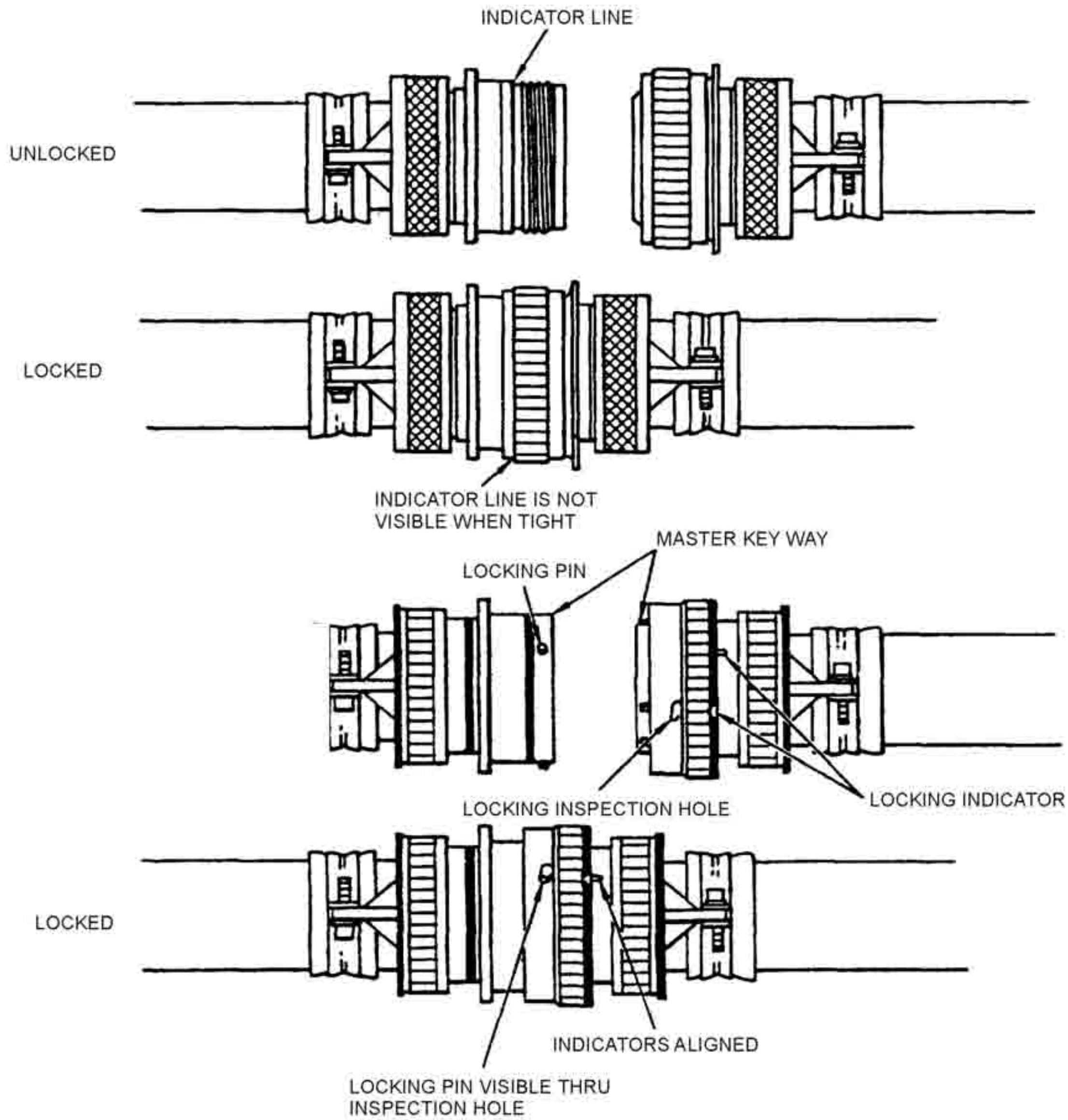


Figure 40. Mating or Coupling Connectors

c. Alternately push in the plug and tighten the coupling ring until the plug is completely seated.

d. When mating a connector with bayonet lock coupling, make sure that all locking rivets of the coupling are engaged.

59. CONNECTOR CODING (CROSS-MATABLE/ INTERCHANGABLE). As a design objective, receptacles whose plugs are interchangeable are not located in close proximity to each other. However, when installation requirements are such that these receptacles are in adjacent locations, use clamps on the wires to make it physically impossible to connect a plug into the wrong receptacle. Also, the connector plug body may be color coded on the flange or mounting area of the receptacle.

a. Use one bright color, such as red, green, or yellow, for each matching pair.

b. Paint only the shell of plugs - not the coupling rings.

c. Paint only the mounting flange of the receptacle.

NOTE

Avoid painting the threaded surface or insert of plug or receptacle.

60. CONNECTOR MATED INSPECTION. After the connector is completely mated, inspect the assembly as follows:

a. Inspect connector and contacts for damage prior to mating. To mate, align the connector master keyway to that of the receptacle and couple the connector. Ensure that it is fully and securely mated, refer to Figure 41 for examples of most typical connector mating inspections. If red indicator band is visible on MIL-DTL-38999 connectors, perform additional steps in following paragraph 61.

b. After mating connector, ensure that connector wiring is correctly routed, properly strain relieved and secure to ensure wiring system integrity. Reposition as neccessary to achieve best wire routing.

61. RED INDICATOR BAND SHOWING ON MIL-DTL-38999 CONNECTORS. Connectors require to be fully seated and secure to provide wiring system integrity. In rare instances, on MIL-DTL-38999, Series 3 receptacles, the red (fully mated) indicator band has been mis-marked. When this condition exists, the connector and receptacle appear not to be fully mated as the red band shows. This is a non-conformance issue with the connector, which does not require connector replacement if, after measuring, it is found within tolerance and it is correctly marked as follows:

a. In condition one, the red band has been mislocated on the receptacle but the connection system shall otherwise function as designed.

b. In condition two, the red band is correctly located on the receptacle but receptacle, plug, or equipment replacement is not likely to resolve the red band issue due to in-spec tolerances on the individual plug and receptacle as defined in MIL-DTL-38999K.

NOTE

This procedure is applicable to equipment-mounted receptacles as well as structure-mounted receptacles.

c. Verify that the plug and receptacle are properly mated and fully coupled such that the receptacle red band is covered by the plug's coupling ring (Figure 41).

d. If the red band is not covered (Figure 41), then using measuring device, gage, etc., verify location of the red band. The length from the end of the receptacle to the far edge of the red band is 12.7-13.2 mm (.499-.519 in.) per MIL-DTL-38999 (Figures 42 and 43).

e. If the red band is found to be mislocated (greater than 13.2 mm or .519 in.) then the connector requires to be marked with a yellow stripe on the receptacle only (Figure 44).

f. If measured within tolerances, then both the connector and receptacle shall be marked with a yellow stripe (Figure 45).

g. Perform follow-on maintenance and test of affected system or component to assure operational and / or functional performance.

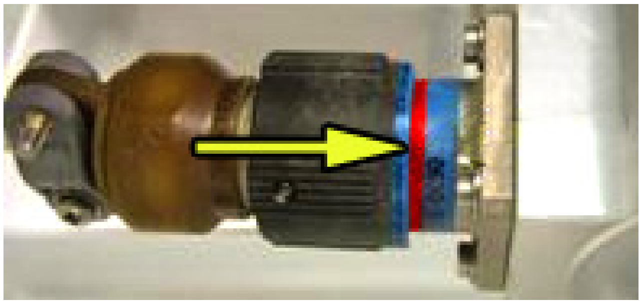


Figure 41. Exposed Red Band

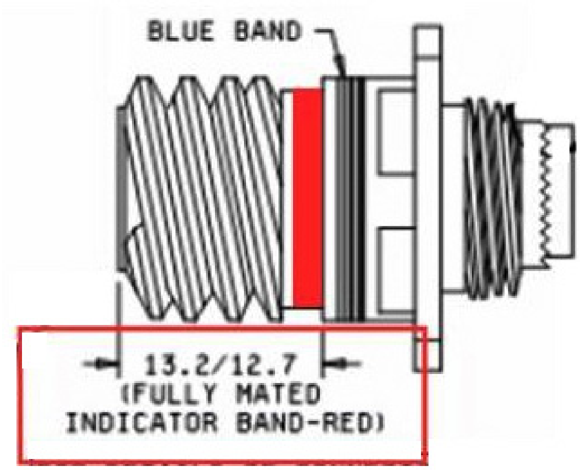


Figure 42. Verify Red Band Location

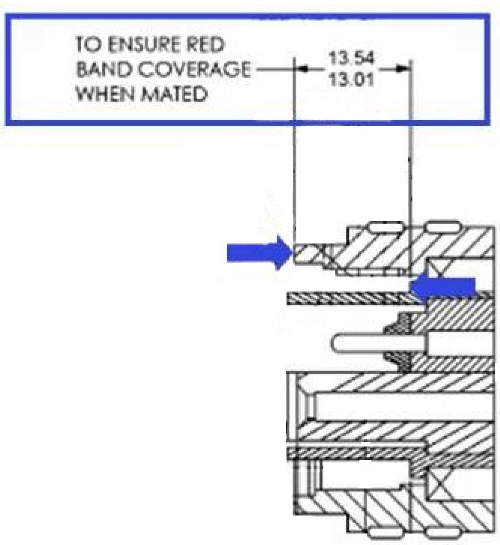


Figure 43. Verify Receptacle

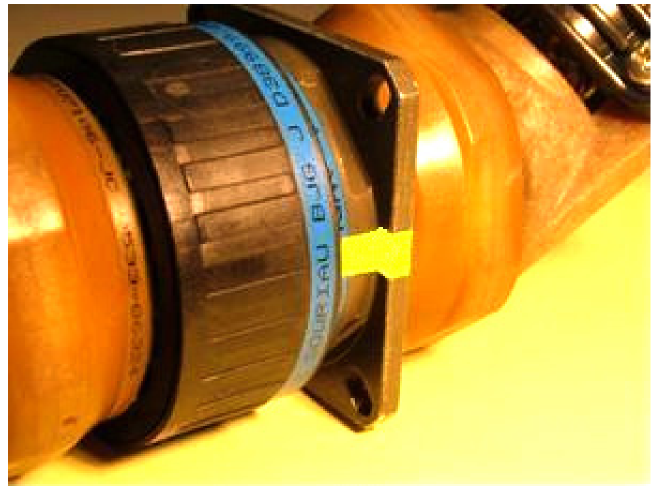


Figure 44. Applied Yellow Stripe For Condition One

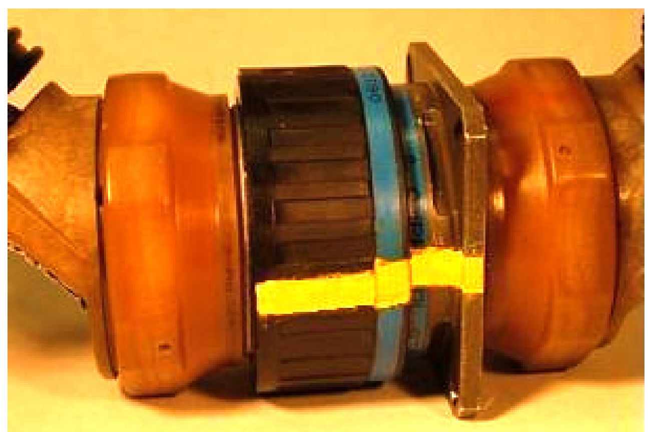


Figure 45. Applied Yellow Stripe For Condition Two

h. Upon successful functional test (All applicable systems pass) a yellow stripe shall be marked on the receptacle (Condition one) and/or plug indicating a known mislocated red band on an otherwise functional receptacle (Condition two).

i. Marking. For both conditions, the stripe shall be .13-.25 inches wide, perpendicular to the red band and shall extend from approximately the edge of the red band to the mounting flange (If present) extending outward to the edge of mounting flange (If present) as shown in Figure 44. If no mounting flange is present, the stripe shall extend from the receptacle .50 inches max.

j. Prior to applying the stripe, the surface of the receptacle shall be cleaned with IPA, or equivalent, and allowed to dry.

k. Apply a coat of MIL-F-18264 Primer, .25-.30 inches wide, in the location of the stripe. Finally, apply the stripe using MIL-F-18264 Polyurethane or Epoxy Topcoat. The color shall be Yellow number 13655 per FED-STD-595.

l. For condition two, the yellow stripe shall extend continuously from the receptacle onto the plug coupling ring over its full length. See Figure 45.

62. CONNECTOR UNCOUPLING. Uncouple connector as follows:

a. Use a strap wrench or padded conduit pliers to loosen coupling rings which are too tight to be loosened by hand.

b. Alternately, pull on the plug body and unscrew coupling ring until connector is separated.

CAUTION

Do not pull on attached wires.

c. Protect disconnected plugs and receptacles as shown in WP 007 to keep debris from entering and causing faults.

63. WIRE COMBING AT TERMINATION. After the connector is completely mated, inspect the assembly as follows:

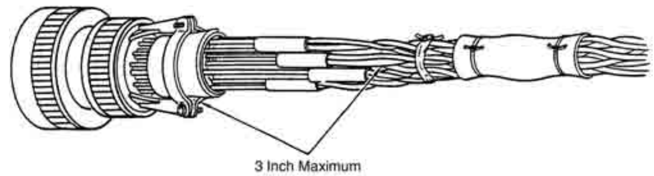


Figure 46. Comb Twisted Wires

a. Comb out all wires, except when directed otherwise, so that wires will be parallel to each other in the group or bundle. Twisted wire terminating into a connector with a cable clamp may be untwisted from its original lay a maximum of 3 inches from clamp. Twisted wire may be closer than 3 inches as long as it does not cause interference with servicing of contacts, and is interwoven properly (Figure 46). A useful tool for combing out wires is shown in Figure 47. Make this tool from a piece of 1/8-inch nylon or other smooth insulating material. Be sure all sharp edges are rounded to protect wire insulation.

b. Examine assembly to ensure all marking sleeves are present (see WP 008 00).

c. Examine connector and accessory to confirm the wires are routed correctly from the back of the connector as shown in Figure 46.

64. <u>TYING WIRE GROUPS OR BUNDLES</u>.

65. INTRODUCTION. Wire groups and bundles may be required to be laced or tied to provide ease of installation, maintenance, and inspection. This section describes and illustrates the recommended procedures for lacing and tying wire groups or bundles.

66. LACING TYPES. The following tying types may be used to provide secondary support to harnesses and bundles:

a. For low vibration or general applications, use finish C, Aramid tying tapes, size 2 or 3 in accordance with A-A-52084.

b. For medium or high vibration or high temperature (up to 8005F) applications, use finish C, glass typing tapes, sizes 2 or 3 in accordance with A-A-52083.

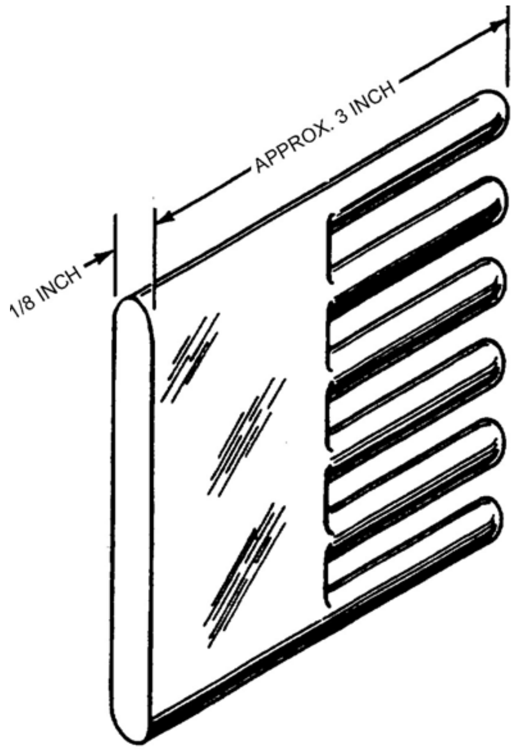


Figure 47. Comb for Straightening Wires in Bundles

c. Order using the information above and the following; basic part number is AA5208 (3 or 4) - Class-Size. Example AA52083-C-2 is a medium and high vibration or high temperature (up to 8005F), Class “C”, Size “2” tape.

67. GENERAL PRECAUTIONS. When lacing or tying wire groups or bundles, observe the following precautions:

a. Lace or tie bundles tightly enough to prevent slipping, but not so tightly that the cord or tape cuts into or deforms the insulation. Be especially careful when lacing or tying coaxial cable, which has a soft dielectric insulation between the inner and outer conductors.

b. Do not use ties on the part of a wire group or bundle located inside a conduit.

c. When tying wire bundles behind connectors, start ties far enough back from the connector to avoid splaying of contacts (Figure 46).

68. TYING.

a. Select correct type of lacing tape (tie string). Refer to paragraph 66.

b. Wrap lacing tape around wire bundle and install a clove hitch knot (Figure 48).

c. Complete with a square knot.

CAUTION

Cut lacing tape using sharp diagonal cutters or scissors only, do not use knife as collateral damage to wire may occur.

d. Trim free ends of lacing tape square, to 3/8-inch minimum.

e. Install lacing ties as secondary wire support every 3" to 6" along the entire wire bundle.

f. Spot ties shall not be closer to any primary support clamp than a distance equal to the width of the clamp.

g. For 90 degree bundle applications see instructions in (Figure 49).

h. For wire bundle breakout applications see instructions in (Figure 50).

69. SELF-CLINCHING CABLE STRAPS (ZIP TIE). The use of plastic cable straps is strictly prohibited in all instances (refer to AS50881). When maintenance is to be performed on a wire bundle secured with plastic cable straps, only remove enough straps to affect the appplicable repair. Upon restoration, install lacing tape/tie string (A-A-52084, or A-A-52083) (refer to paragraph 68). Specific installations requiring plastic straps are to be called out in platform/aircraft-specific manuals.

70. INDIVIDUAL WIRE INSTALLATION TOOL (WIRE SPOON PART NUMBER: WHS-1). This tool may be employed to install individual wires under existing tie string, or plastic cable straps (Figure 51).

CAUTION

Extreme care must be taken so as not to damage wires by applying too much pressure onto existing wire harness. Damage to wires, and subsequent system failure may occur.

a. Insert the tip of the tool with the bowl facing out toward the operator.

b. Insert the tip far enough under the tie or clamp so that a gap opens between the tie or clamp large enough for a wire to pass through.

c. Holding the tool in place, thread the wire along the bowl and through the gap created by the tool.

NOTE

If individual tie string/lacing tale is loose, or if plastic cable ties break, replace with new lacing tape (A-A-52083, or A-A-52084).

d. Remove tool and inspect security of lacing tape / tie string, or plastic strap. Replace if loose or damaged.

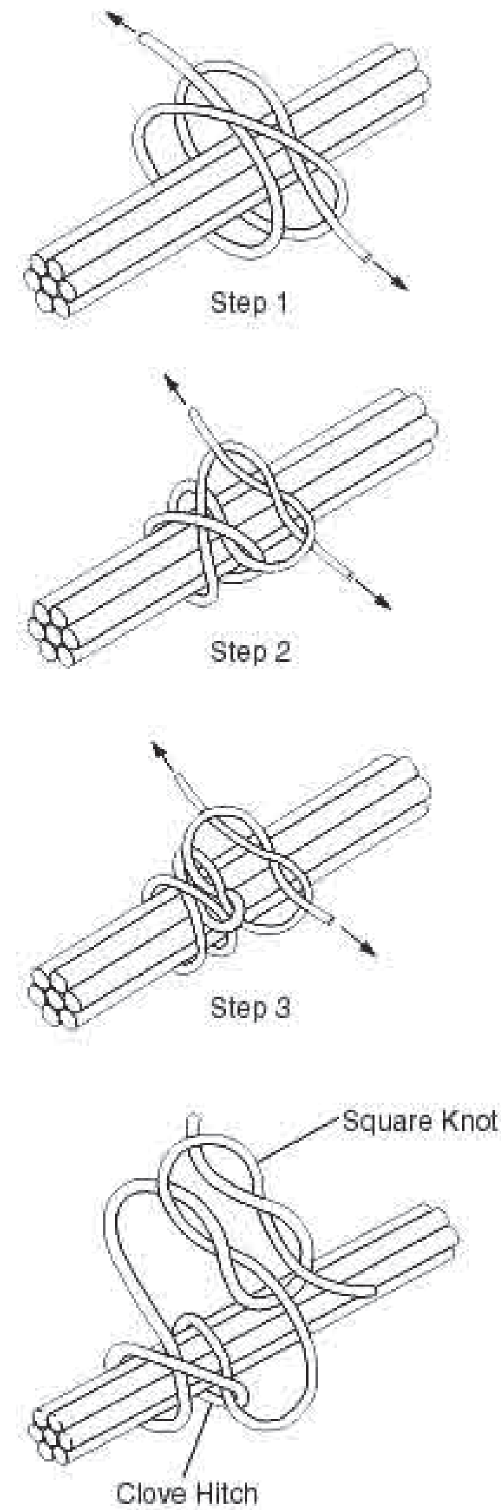


Figure 48. Bundle Ties

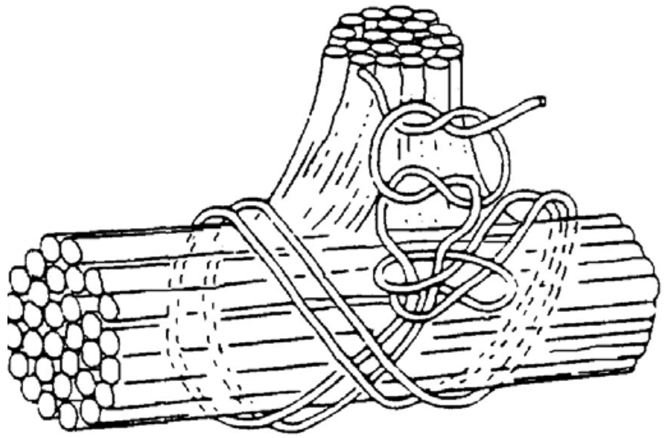


Figure 49. 90° Bundle Tie

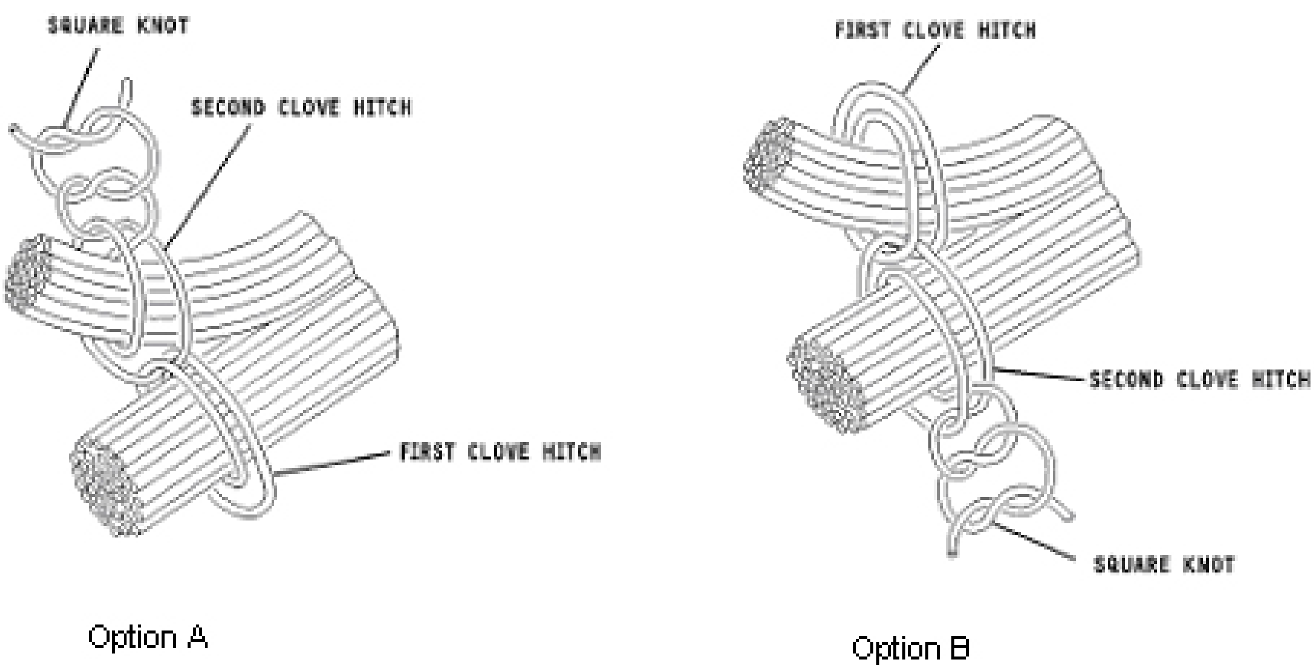


Figure 50. Bundle Breakout

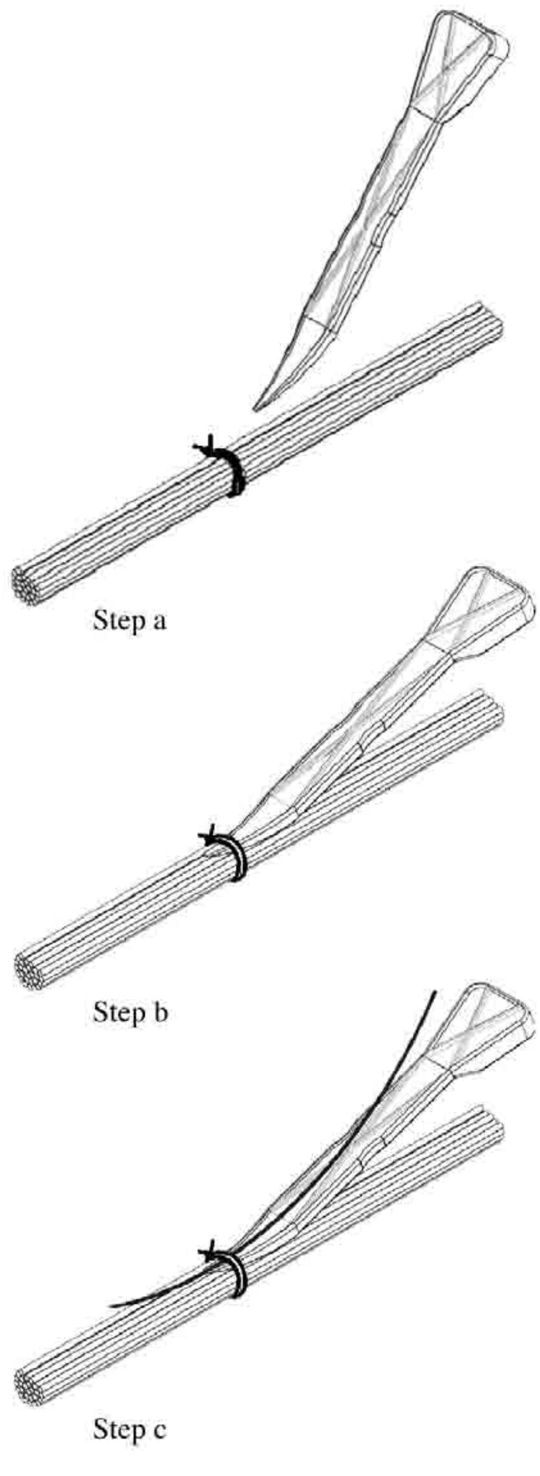


Figure 51. Individual Wire Installation Tool (Wire Spoon)

OPEN AND OVERBRAIDED HARNESS REPAIR

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Banding Tool DBS–1100 Use and Adjustment Installation and Repair Practices	011 02
Environmental Sealed Harness Repair	011 01
Low Frequency, Multiconductor Round Cable Description and Replacements	005 00
Military Standard Circular Connectors Summary of Actions	020 00
Shield Terminations	015 00
Soldering	016 00
Wire, Cable, and Harness Marking	008 00
Wire and Cable Splicing Repair	014 00
Wire and Cable Stripping	009 00
Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for	SAE AMS–DTL–23053
Shield Termination, Solder Style, Insulated, Heat–Shrinkable, Environment Resistant With Preinstalled Leads for Cables Having Tin Or Silver Plated Shields (Class I)	AS83519/2

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation	Nomenclature
AMP Crimp Tool	49935	Inspection Gage	M22520/3-9
AMP Crimp Tool	69335–0	Inspection Gage	M22520/3-10
Heat Gun	HT-900B	Crimp Tool	M22520/5-01
Heat Gun	HT-920B	Die Set	M22520/5-100
Heat Gun	HT–71002	Crimp Tool	M22520/37-01
Heat Gun	MCH–100–A	Inspection Gage	M22520/39-01

Materials Required

Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation	Nomenclature
Alcohol, Isopropyl	TT-I-735	Tape, Non-Adhesive Self-Bonding	A–A–59163 TYPE II, NSN 5970-00-949-4846
Cap, End	SAE–AS25274-1	Tape, Non-Adhesive Self-Bonding	A–A–59163 TYPE II, NSN 5970-00-955-9976
Cap, End	SAE–AS25274-2	Tape, Non-Adhesive, Self-Bonding, Black	A–A–59163 TYPE II, NSN 5970-00-955-9976
Cap, End	SAE–AS25274-3	Tape, Non-Adhesive, Self-Bonding, Red	A–A–59163 TYPE II, NSN 5970-00-949-4846
Cap, End	SAE–AS25274-4	Tape, Self Bonding Silicone Rubber	A–A–59474
Sleeving, Heat Shrink	CRN-T	Tubing, Heat Shrink	SAE–AMS–DTL–23053
Solder Sleeve Shield Termination	SAE–AS83519	Wire, Heavy Wall	SAE-AS22759
Solvent, Dry Cleaning	MIL–PRF–680, Type II	Wire Mesh, Knitted	SM–B–450436–3, Rev B
Tape, Lacing and Tying	A–A–52080 thru A–A–52084		

1 . **INTRODUCTION.**

2 . A harness assembly is basically a point(s)-to-point(s) electrical distribution system consisting of various components, such as wire, cable, connectors, etc. The repair or replacement of these typical components is covered in appropriate work packages (WP) of this manual. This WP will cover those components and processes most directly related to the harness protection and construction. Examples are; harness forming, external protection methods, boots, sleeves, tapes, etc.

3 . **HARNESS TYPES.**

4 . A harness is either open (unprotected), or protected (covered). An open harness is usually a round group of wires and cables bundled together by ties, straps or sometimes tape, and has no protective jacket. The harness could also be square with wires stacked as flat cables or ribbons. The wire has a thick insulation wall to provide mechanical protection. The protected harness is constructed similarly to an open harness except it has a protected jacket. The wires have thinner insulation, because the jacket provides the mechanical protection. The jacket could be metal, cloth, insulation, or a combination of these. The types of harnesses that will be discussed herein are as follows:

a. Open Harness

b. Round Overbraided Harness

c. Round Metallic Overbraided Harness

5 . The Environmental Sealed Harness Repair (WP 011 01) and Banding Tool DBS–1100 Use and Adjustment Installation and Repair Practices (WP 011 02) are discussed in separate Work Packages, because of their unique characteristics. The actual repairs of the components in these unique harnesses are covered in the various work packages for the components or herein.

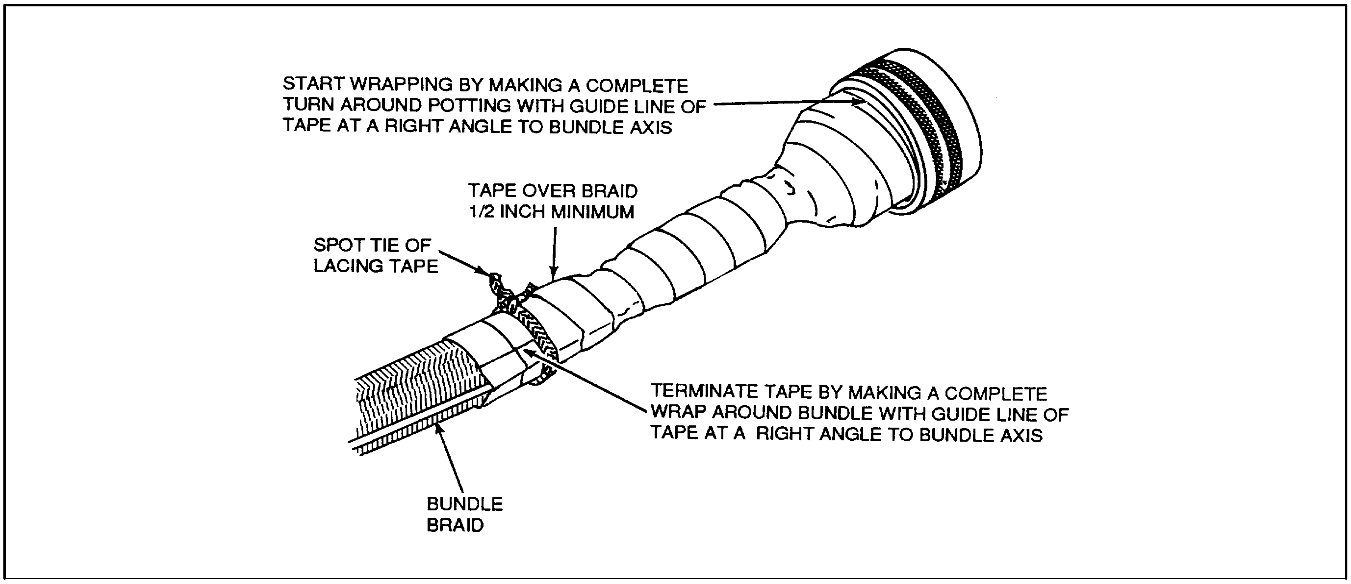


Figure 1. Tape Protective Boot

CAUTION

Any time wire processing equipment is employed on wire size 26−20 AWG, an inspection is required. Failure to inspect the wire for damaged insulation, may result in premature wire system failure.

6. **HARNESS REPAIR.** When building a new, or repairing an existing wire harness with wire which was processed using any wire processing equipment (such as the ARTOS CS−336), a close inspection of wire size 26−20 AWG is required. Using a 10X magnifying device, inspect the wire insulation for serration, abrasions or cuts. Replace with new wire lengths and discontinue the use of the equipment until condition is corrected.

7. **OPEN HARNESS REPAIR.** An open harness should be repaired in accordance with the appropriate work package for the component that is damaged. For example, if a wire or a cable is chafed or broken, repair it in accordance with (WP 014 00). The few unique repair characteristics, which are more associated with the harness components, are covered under the other harness repair sections. Examples are as follows:

a. Multiple Splicing
b. Additional Mechanical Protection
c. New Wire Additions
d. End Caps

8. **ROUND OVERBRAIDED HARNESS REPAIR.**

9. **Protected Potting Boot Repair.** Since most overbraid ends near the end of the connector termination point, a boot must be fabricated from the end of the braid over the wire and over the back of the potting compound, which is connected to the connector. A protective boot (Figure 1) or a shrink protective boot (Figure 2) may be used.

CAUTION

Use a red or black non-adhesive self-bonding tape, A−A−59163, TYPE II NSN 5970-00-949-4846 or NSN 5970-00-955-9976.

NOTE

For best results when using non-adhesive self-bonding tape, the hands should be completely free from dirt and oil.

10. **Fabricating Tape Protective Boot.** When a new boot must be fabricated use self−bonding tape as described below (Figure 1).

NOTE

When using silicone self-bonding tape, the hands should be completely free from dirt or oil.

a. Starting at the connector, wrap tape one complete turn around the potting.

b. Using the same continuous length of tape wrapped around the connector, spiral-wrap, with a 50% overlap, a single layer over exposed wires and onto braid.

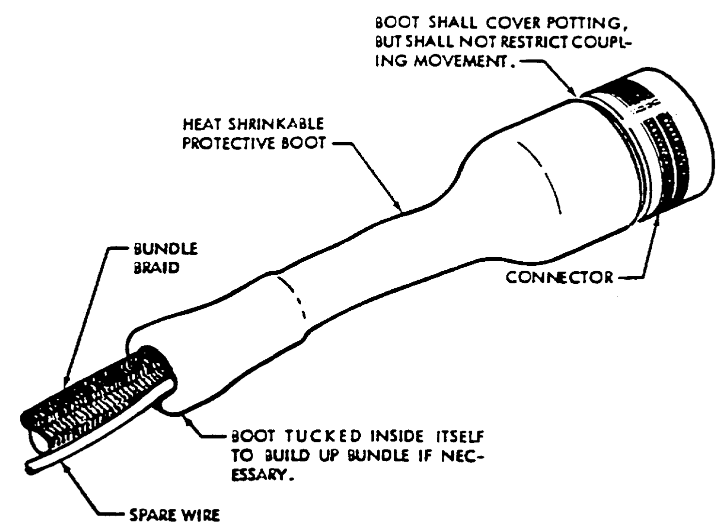


Figure 2. Shrink Protective Boot

NOTE

To achieve a neat appearing boot, follow guide line on tape and keep tape stretched tightly.

c. Overlap the tape onto the bundle braid a minimum of 1/2 inch to prevent wire exposure even when flexing the bundle.

d. Terminate the silicone tape by wrapping at least a full turn of tape around the bundle, keeping the guide line at a right angle to the horizontal axis of the bundle.

NOTE

Do not keep tape under tension while applying this last wrap.

e. With lacing tape, make a spot tie on the tape termination at the braid end (WP 010 00).

11 . **Shrink Boot Repair.** Repair the shrink boot as shown below. The figures demonstrate the technique on a connector accessory although it is also applicable to potted connectors.

12 . **Boot Removal and Reinstallation.** Remove and reinstall a boot from a cable assembly as follows:

WARNING

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Nozzle and output air of heat gun get very hot. Use extreme care while operating heat gun to avoid serious burns.

Use of nitrogen with the HT−900B/HT−920B/HT−71002 heat gun in an enclosed area can be hazardous. discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from aircraft being repaired. Use electrical power from ground power unit.

a. Heat the convoluted boot (Figure 3) with heat gun until warm to the touch, then pull the loosened adapter away from the connector exposing the wire conductors that are entering the connector. Hold in retracted position until cool and boot remains retracted (Figures 4 and 5).

b. Heat the shrink boot with heat gun until warm to touch, then pull the adapter and boot back exposing the connector backside with enough clearance to allow repair (Figure 6).

c. In some cases the boot may have to be cut off. When a boot has to be cut off, score (cut) the boot lengthwise, taking care not to cut through the boot into the cable jacket (Figure 7).

d. Peel the boot from the cable jacket and connector with pliers (Figure 8).

e. Heat the boot with a heat gun until warm to touch.

f. Reinstall convoluted and shrink boots by heating the boot with a heat gun until warm to the touch, slide backshell and boot up to rear of connector and tighten backshell coupling ring.

13 . **New Boot Installation.** The following steps should be followed when installing a new boot on a connector harness assembly:

a. Degrease connector backshell or adapter with suitable cleaning solvent.

b. Apply adhesive to cable and connector bonding areas in accordance to the manufacturer's instructions only if needed. Some boots are pre-coated with an adhesive in the bonding areas.

c. Install new boot over end of cable.

NOTE

Boots can be installed over connectors in most cases. Occasionally, it may be necessary to disassemble a connector to install the repair boot.

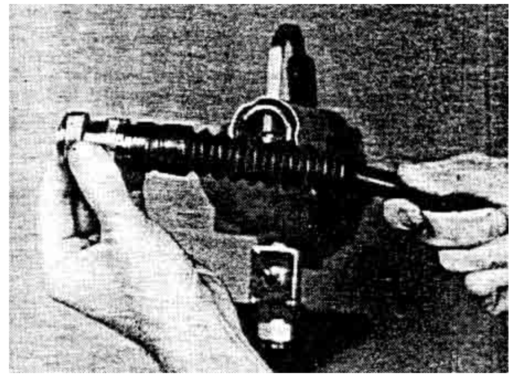


Figure 3. Heating Convoluted Boot

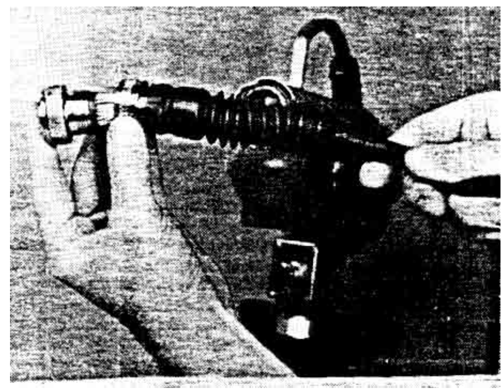


Figure 4. Heating & Retracting Convoluted Boots

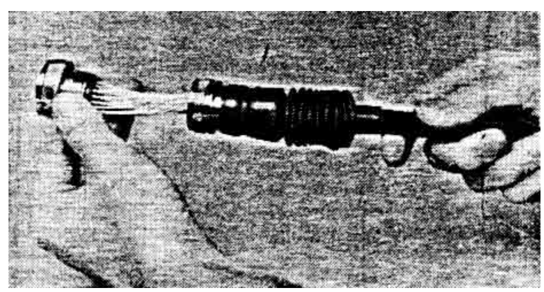


Figure 5. Convoluted Boot in Retracted Position.

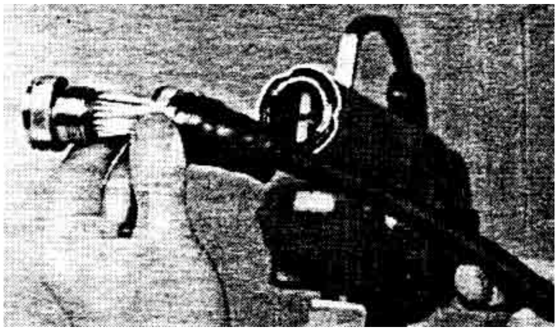


Figure 6. Heating and Retracting Shrink Protective Boot

Figure 7. Cutting Standard Boot

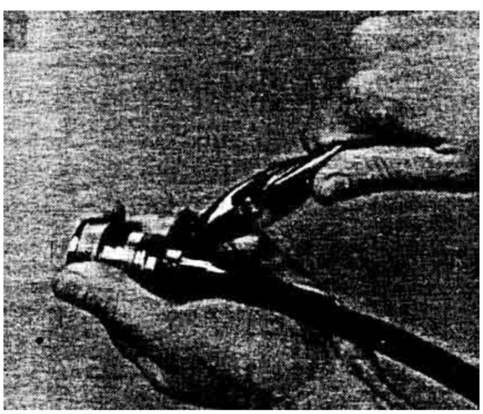


Figure 8. Peeling Standard Boot Off of Cable Assembly

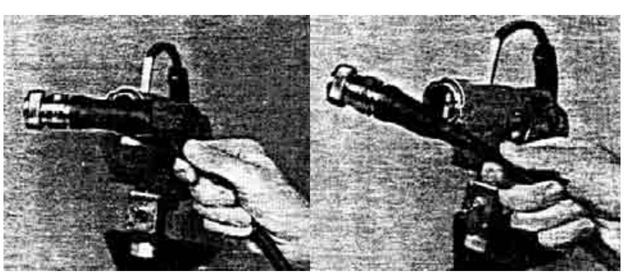


Figure 9. Shrinking Boot With Heat Gun

WARNING

The HT-900B, HT-920B, HT-71002, MCH-100-A and IR-1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Nozzle and output air of heat gun get very hot. Use extreme care while operating heat gun to avoid serious burns.

Use of nitrogen with the HT-900B/HT-920B/HT-71002 heat gun in an enclosed area can be hazardous. discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from aircraft being repaired. Use electrical power from ground power unit.

d. Shrink the boot starting at the connector end and proceeding to the cable end with a heat gun (Figure 9).

e. If required, cure the adhesive according to recommended curing instructions.

14. **Protected Braid Repair.** When the braid must be partially replaced, the braid may be replaced by non-adhesive self-bonding tape or shrink sleeving.

15. **Tape Braid Repair.** The tape shall be attached to the braid as follows:

CAUTION

Use extreme care when removing braid to prevent wire damage. When using scissors or knife, carefully cut along harness to distance required. Ensure cutting edges face outboard to prevent wire damage.

a. Cut braid axially (lengthwise) along harness to distance required. Ensure cutting edge faces outboard to prevent wire damage.

b. At required distance cut braid circumference at each end of axial cut and remove braid.

c. Inspect harness for possible damage incurred during cutting and repair as necessary.

NOTE

The HT–900B, HT–920B, HT–71002, MCH–100–A, IR–1759 are the recommended heat sources and are qualified for use on fueled aircraft.

d. Repair the bundle braid exposed area as follows (Figure 10):

NOTE

For best results when applying non-adhesive tape, the hands should be free of dirt or oil.

e. Wrap tape around braid for one complete turn beginning within 1/2 inch of braid end.

f. Using the same continuous length of tape, spiral wrap, with a 50% overlap, a single layer over wires and onto the opposite braid end for a minimum of 1/2 inch.

g. Terminate the tape by wrapping it a full turn around braid, keeping the guide line at a right angle to axis of the bundle.

NOTE

Do not keep tape under tension while applying this last wrap.

h. Make a spot tie of lacing tape at both ends of tape (WP 010 00).

16 . **Heat Shrinkable Sleeve Braid Repair.** Heat shrinking insulation sleeving is an electrical insulating sleeving that will shrink to a predetermined size upon the application of heat. There are many varied sizes, colors, compositions, and uses. Refer to the applicable SAE AMS–DTL-23053 specification when selecting heat shrinkable insulation sleeving. The braid shall be repaired with a sleeve as follows:

WARNING

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Nozzle and output air of heat gun get very hot. Use extreme care while operating heat gun to avoid serious burns.

Use of nitrogen with the HT–900B/HT–920B/HT–71002 heat gun in an enclosed area can be hazardous. discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from aircraft being repaired. Use electrical power from ground power unit.

a. Select proper size and constructed heat shrinkable insulation sleeving from appropriate military specification.

b. The item to be covered must be clean and free of grease and oil.

c. Wire and braid strands must lie smooth and flat so as not to pierce the tubing.

d. Select correct reflector for heat gun in accordance with manufacturer's instructions.

e. Begin shrinking the tubing at the end where it overlaps the braid. Heat the end of the tubing until it shrinks fully onto the braid, thus locking the tubing in place. Continue by moving the hot air gradually along the length of the tubing, shrinking each portion fully over the bundle before continuing on.

f. If there is an excess length of tubing when the end is reached, the excess can be cut off before shrinking is completed. Finish shrinking the tube so that the entire length of tubing is shrunk fully and tightly onto the bundle.

g. Allow the heat-shrink to cool before handling.

h. If the heat-shrinkable item is fully shrunk and does not fit tight, it is too large. Remove it and try a smaller size.

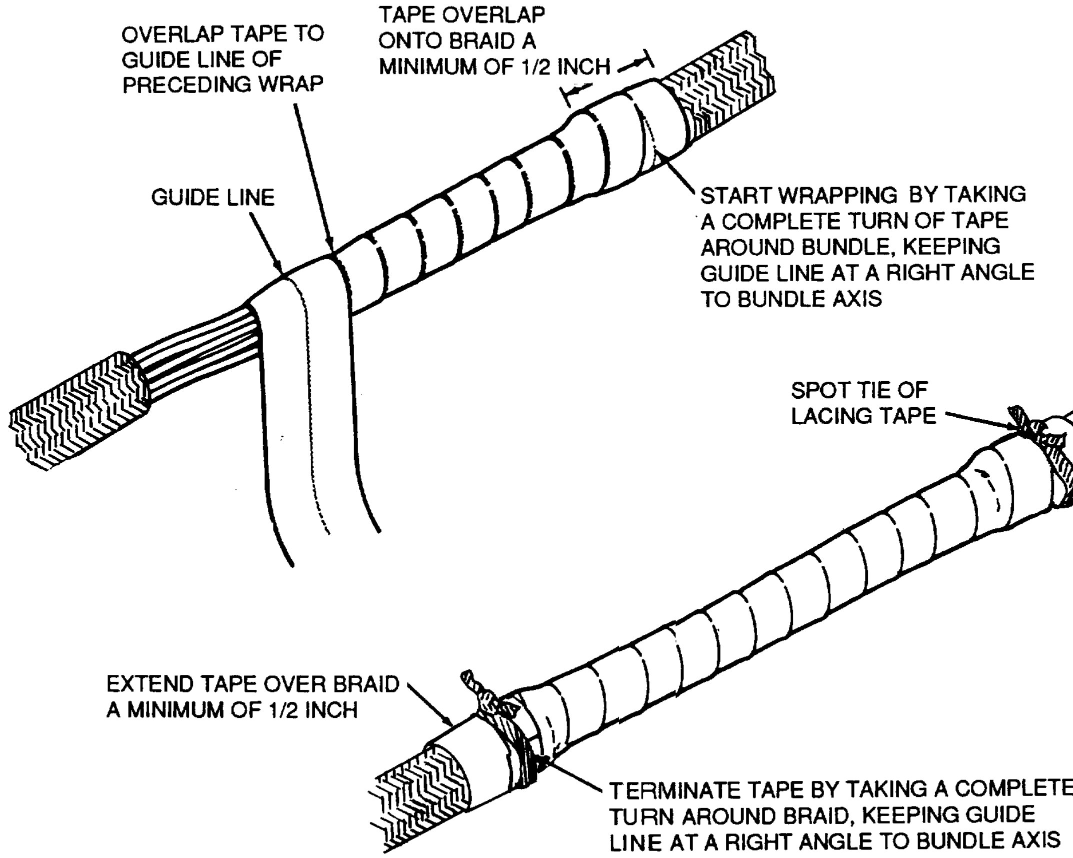


Figure 10. Tape Braid Repair

17. **Harness Shielded Cable Splicing.** Repair a shield cable in a harness in accordance with WP 014 00. Follow the procedure in paragraph 12 to repair the harness after making the cable repair.

18. **Adding Unshielded Wires.** When it becomes necessary to add wires to the harness, route added wires parallel and external to the existing harness. Secure added wires to the harness using lacing tape. The listed procedures should be followed (Figure 11):

a. If necessary, remove protective tape.

b. Cut spare wire directly behind end cap.

c. Identify both pigtail and new wire using proper marking procedures (WP 008 00).

d. Cut existing wire 1 1/2 inches from connector potting or connection insert (Figure 12, Detail A).

e. Identify added wire using proper marking procedure (WP 008 00).

f. Prepare both ends of existing wire and added wire (WP 014 00).

g. Twist existing wire in harness with added wire and slide sealing sleeve over these twisted wires.

h. Splice added wire (22 AWG) to spare wire with M81824/1 splice (WP 014 00).

i. Secure added wire with lacing tape.

j. If protective boot has been removed, replace boot (Paragraphs 13 and 14).

19. **Adding Wire To Existing Wire.** When it becomes necessary to add a wire to an existing wire in the harness, route added wire parallel and external to the existing harness. Secure added wires to the harness using lacing tape and proceed as follows (Figures 12 and 13).

a. Remove protective tape.

b. Remove 2 inches of braid (paragraph 16).

c. Slip the crimp barrel of the splice over the wires as shown in Figure 12, Detail B. Crimp as specified in WP 014 00.

d. Shrink sleeve over crimp barrel as shown in Figure 12, Detail C.

e. Replace protected boot (Paragraph 14).

CAUTION

Only heavy wall SAE-AS22759/34, /35, /41-/46 wire size 22 and larger shall be routed outside the protected harness.

20 . **Adding Shielded Wires.** When shielded wires need to be added for changes or modification route parallel and external to the harness. Secure the added wires to the harness with lacing tape. The following procedures should be followed (Figure 14):

a. Remove protective tape or boot.

b. Remove 2 inches of braid (paragraph 16).

c. Cut spare wire 2 inches from connector potting or connect insert.

d. Identify added wire using proper marking procedures (WP 008 00).

e. Prepare spare wire and added wire (WP 014 00).

f. Terminate shield (WP 015 00).

g. Splice added wire to spare wire with M81824/1 splice (WP 014 00).

h. Terminate shield termination wire to a spare wire, or to another shield termination wire (paragraph 37).

i. Repair bundle braid (paragraph 16).

j. Replace or repair protective boot (paragraphs 13 and 14).

CAUTION

Only heavy wall MIL-W-22759/34, /35, /41-/46 wire size and larger shall be routed outside the protected harness.

21 . **Replacing Wires.** Wires that need to be replaced shall be routed parallel and external to the harness. Secure replaced wires to the harness using lacing tape. Wires to be replaced shall be due to one of the following:

a. Wires damaged to an extent where splicing would be impractical.

b. Electrically open wires.

c. Shielded wires with the shield shorted to the conductor at some unknown point under the braid.

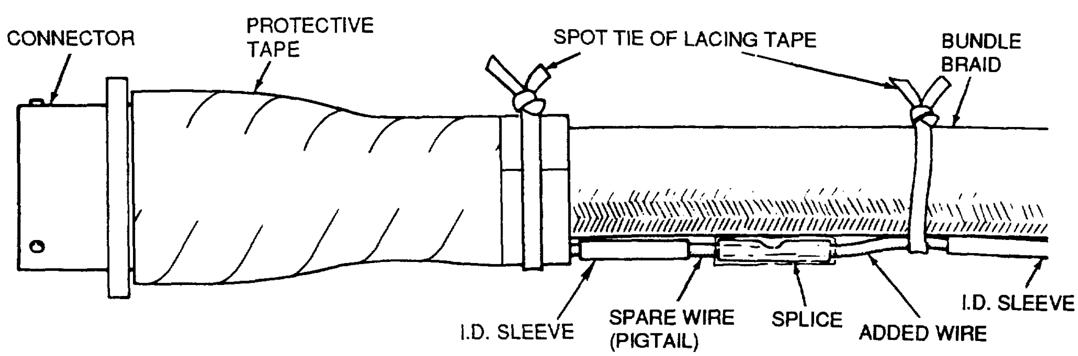


Figure 11. Adding Unshielded Wire

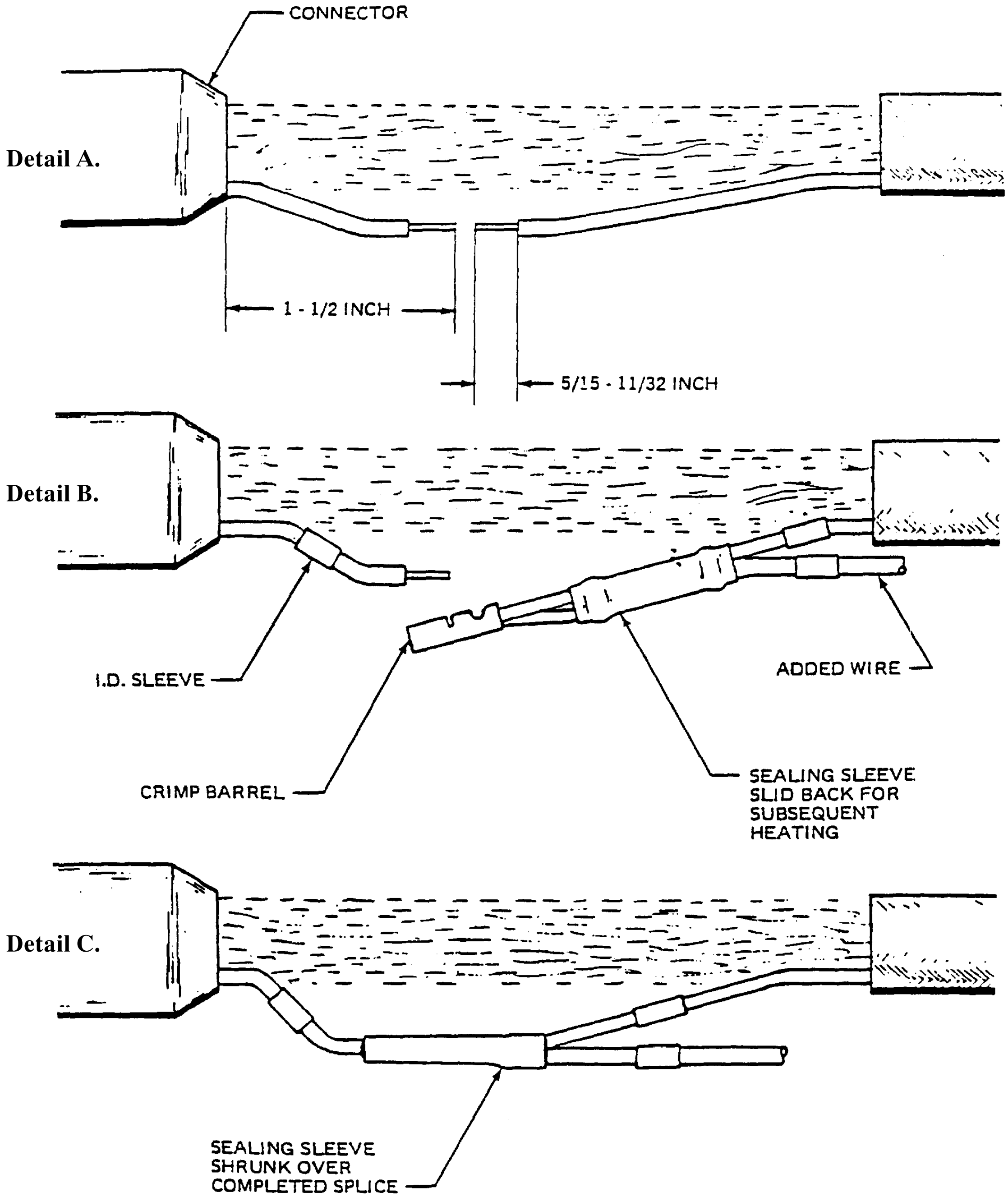


Figure 12. Adding Wire to Existing Wire Using Environmental Seals Splice

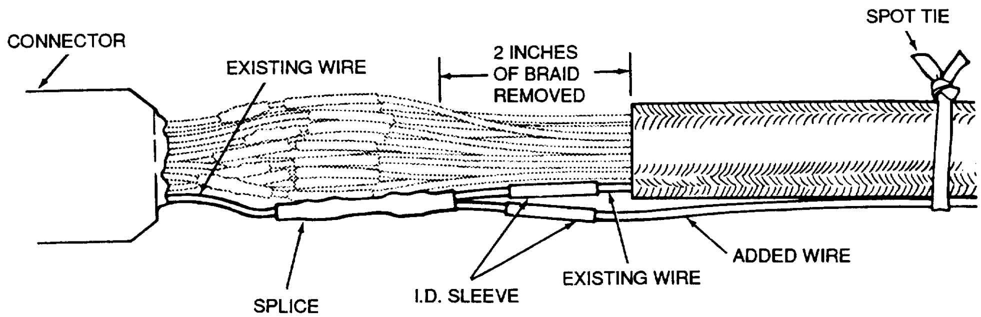


Figure 13. Adding Wire to Existing Wire

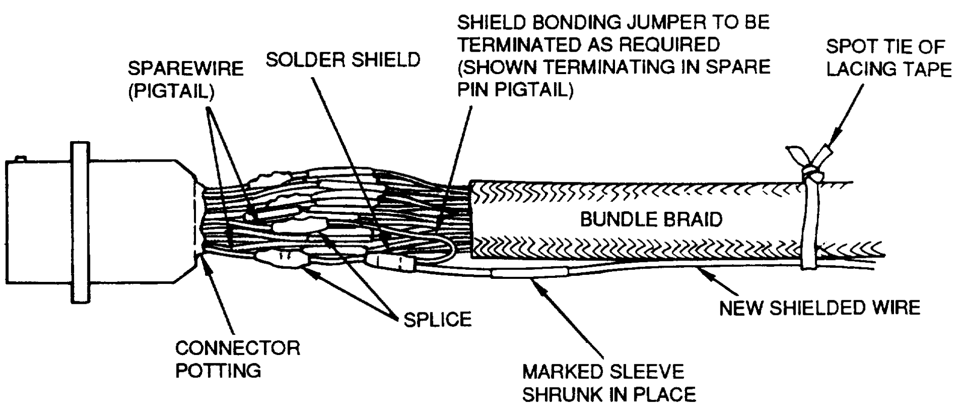


Figure 14. Adding Shielded Wire

22. **Replace Unshielded Wires.** The procedure to replace unshielded wires is as follows. The new wires shall be routed parallel and external to the harness and secured with lacing tape (Figures 15 and 16).

a. Remove protective tape, or boot.

b. Cut wire to be replaced 1 inch from braid.

c. Identify new wire using proper marking procedure (WP 008 00).

d. Prepare end of new wire and end of old wire to be spliced (WP 014 00).

e. Cap end of wire to be replaced that protrudes from braid.

f. Splice new wire and cut wire using M81824/1 splice (WP 014 00).

g. Replace protective tape (Paragraphs 13 and 14).

23. **Replace Shielded Wires.** Use the following procedure for replacement of a shielded wire. The new shielded wire shall be parallel and external to the harness and secured with lacing tape (Figure 17).

a. Remove protective tape, or boot.

b. Cut wire to be replaced 1 inch from braid.

c. Cut shield termination wire 1 inch from and braid.

d. Identify new wire using proper marking procedure (WP 008 00).

e. Prepare cut wire, cut shield termination wire, and new wire in accordance with WP 009 00.

f. Cap end of wire to be replaced that protrudes from braid.

g. Terminate shield (WP 015 00).

h. Splice new wire to cut wire and shield termination wire to cut shield termination wire using M81824/1 splice (WP 014 00).

i. Replace protective boot (paragraphs 13 and 14).

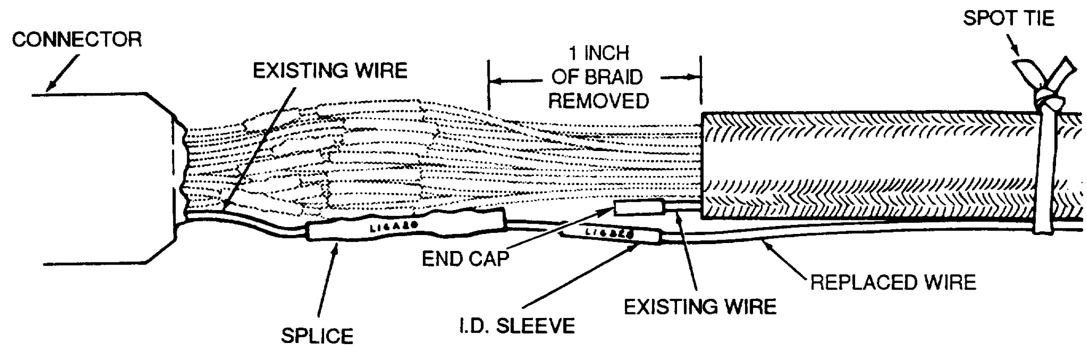


Figure 15. Replacing Unshielded Wire at Potted

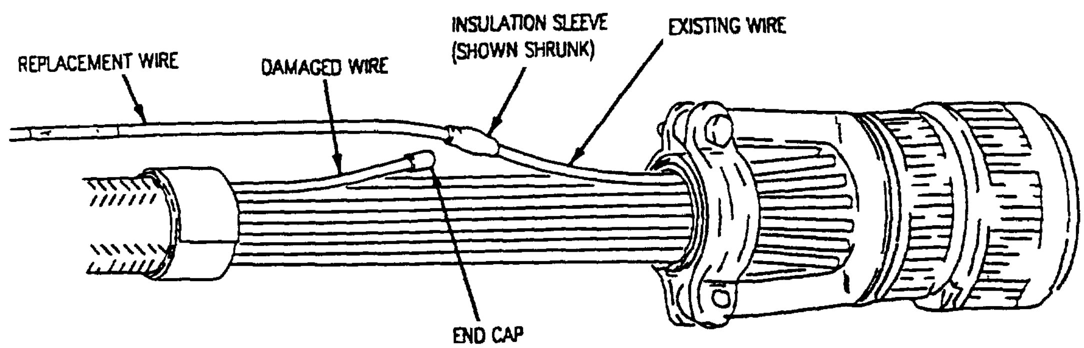


Figure 16. Replacing Wire Behind Connector Accessory

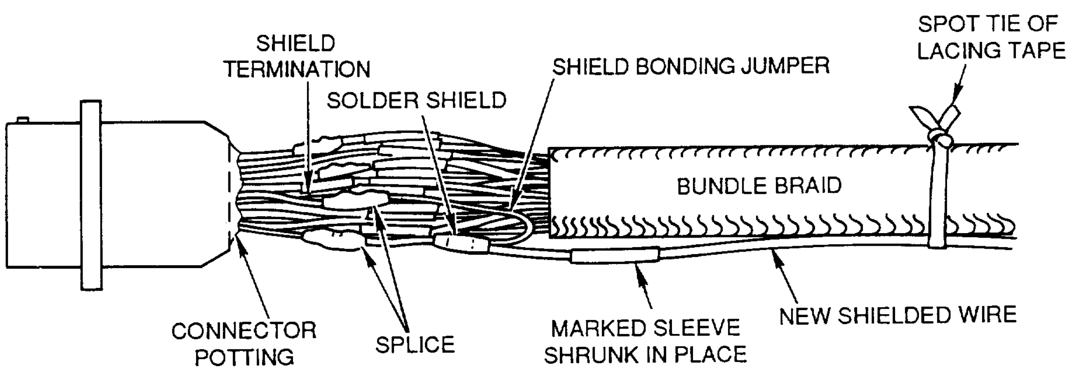


Figure 17. Repairing Shielded Wires

24 . **Terminating Overbraided Harnesses.**

25 . **Termination of Shielded Harness in Connector with EMI Backshell.**

a. Slide ferrule/cable clamp and adapter/backshell over harness.

NOTE

Tubular braid may be used in place of the wire mesh on wire harnesses containing four or less wires.

b. If used, slide tubular braid over harness.

c. Install connector using procedures as detailed in the NAVAIR 01−1A−505−2, −3, or −4 or aircraft connector repair manual.

d. Maintaining a 50% overlap, wrap wire bundle with silicone adhesive teflon tape under any area where metal mesh tape will be applied (Figure 18, Detail A).

NOTE

Use A−A−59474 TYPE I CLASS 4 Teflon tape (NSN 5970-01-012-4280).

e. Install adapter/back shell and tighten using procedures as detailed in the NAVAIR 01−1A−505−2, −3, or −4 or aircraft connector repair manual.

f. Build up outside diameter of harness to inside diameter of an adapter/backshell assembly with silicone rubber tape (Figure 18, Detail B).

CAUTION

Overheating may cause damage to wiring beneath shield.

g. Solder (WP 016 00) wire mesh tape/tubular braid to shield (Figure 18, Detail B).

h. Wrap wire mesh tape toward connector over tapered portion of adapter and secure with silicone adhesive teflon tape (P/N: SM−B−450436−3, Rev B) (Figure 18, Detail C).

i. If tubular braid is used, trim excess length.

j. Secure wire mesh tape with ferrule/cable clamp (Figure 18, Detail D).

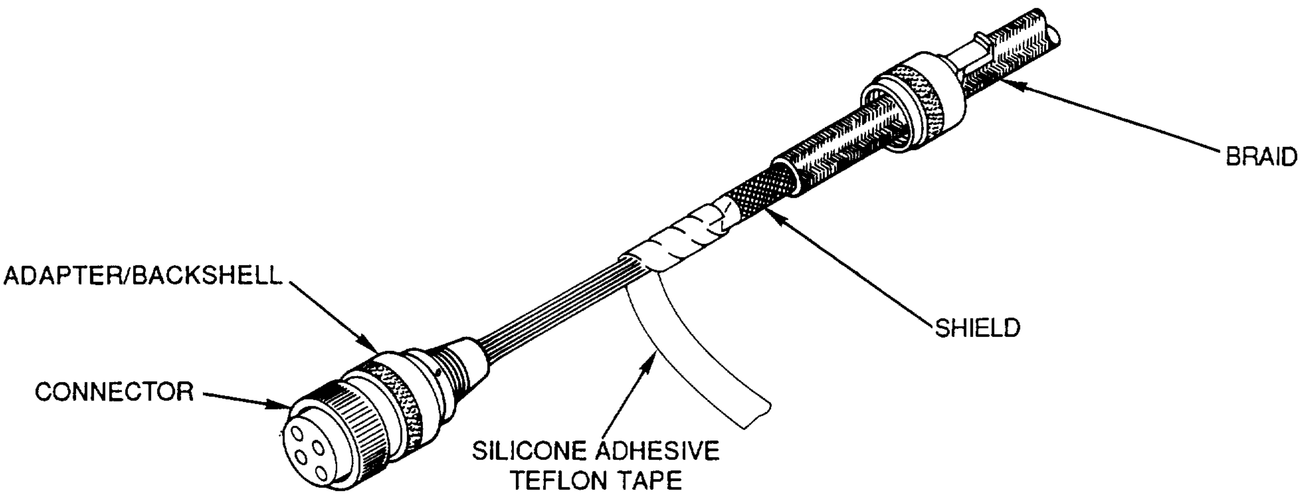
k. Secure harness to cable clamp using 1/4” EMI Metal Band (M85049/128−1, or −2, 4−1380) as per WP 011 02 (Figure 18, Detail E).

CAUTION

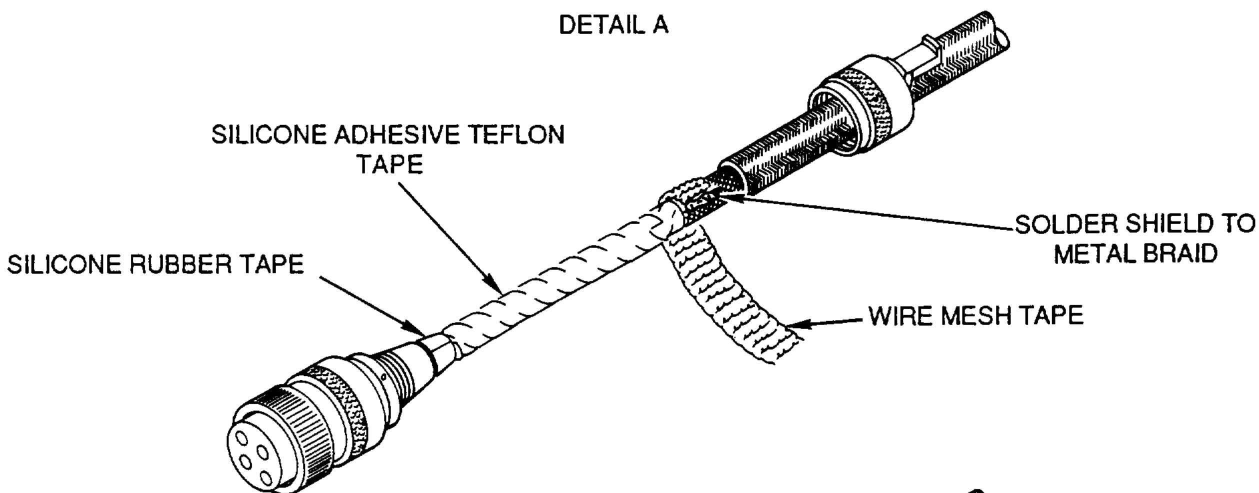
Do not cover backshell drain holes when wrapping with self-bonding silicone tape.

l. Wrap silicone rubber tape one complete turn around the cable clamp and maintaining 50% overlap, continue wrapping until 1 inch of the overbraid is covered (Figure 18, Detail F).

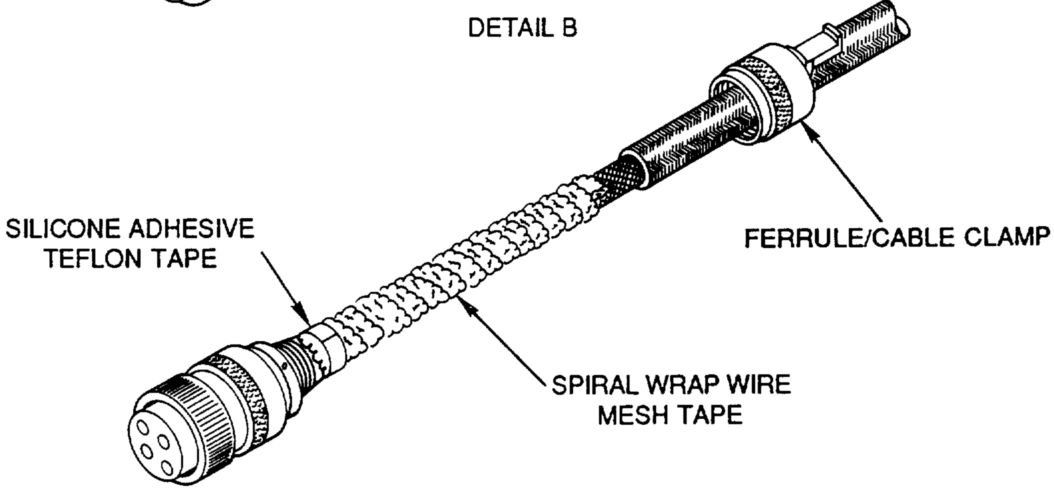
m. Secure silicone rubber tape end with polyester lacing tape (Figure 18, Detail F).



DETAIL A

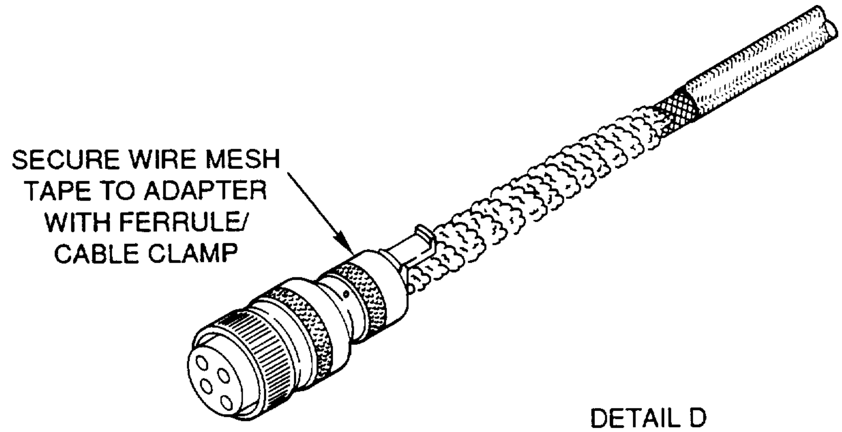


DETAIL B

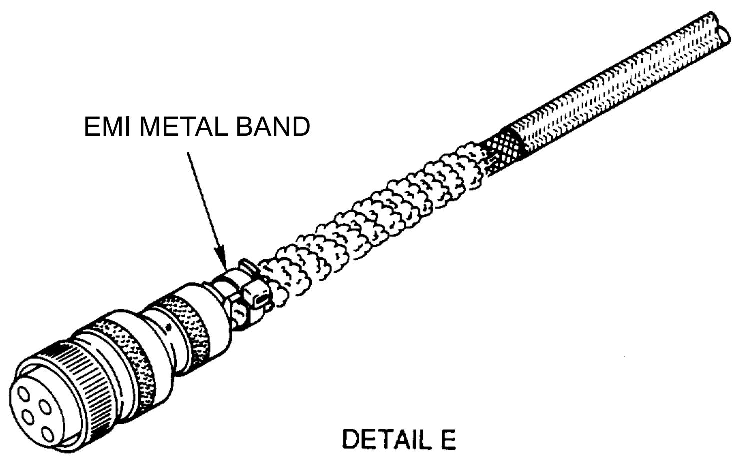


DETAIL C

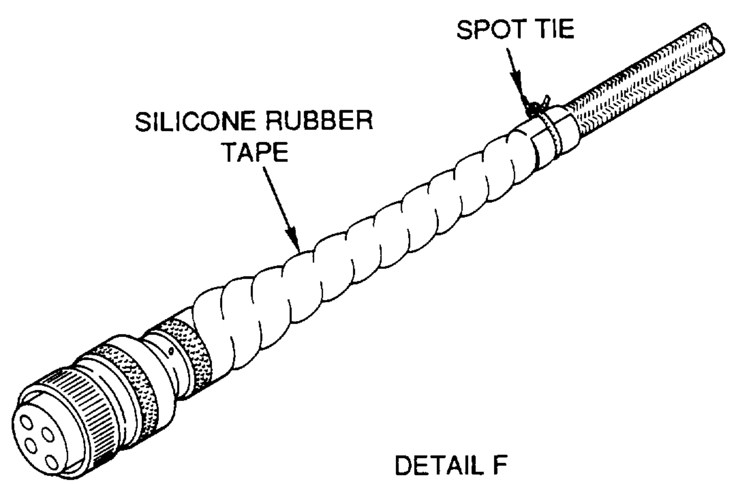
Figure 18. Fabrication of Harness Terminated with EMI Backshell (Sheet 1 of 2)



DETAIL D



DETAIL E



DETAIL F

Figure 18. Fabrication of Harness Terminated with EMI Backshell (Sheet 2)

26. **Termination of Overbraided Harness in Environmental Type Connector with Molded Plastic Cable Clamps.**

a. Slide cable clamp locking nut and molded cable clamp overbraided harness.

b. Install connector using procedures as detailed in the NAVAIR 01–1A–505–2, –3, or –4 or aircraft connector repair manual.

c. Cut silicone rubber tape into triangular section (Figure 19, Detail A).

d. Wrap silicone rubber tape, cut portion parallel to connector insert one complete turn starting 1/8 inch forward of cable clamp support area.

e. Using 50% overlap, continuously wrap silicone rubber tape over exposed wiring until a minimum of 1/2 inch of overbraid is covered (Figure 19, Detail B).

f. Keeping tape guideline perpendicular to cable axis, terminate silicone rubber tape by wrapping one full turn around cable assembly.

g. Cut silicone rubber tape and tie with polyester lacing tape.

h. Build up cable diameter under cable clamp fingers with silicone rubber tape to provide good clamping between clamp fingers and cable assembly.

NOTE

Tape buildup under cable clamp fingers will separate to provide a strain relief condition.

i. Plastic cable clamp should be cut if necessary to enable cable clamp to slide freely over cable assembly.

CAUTION

Apply force on cable assembly toward connector to prevent stress on grommet or contacts.

j. Position cable clamp over back of connector and tape buildup.

k. Slide cable clamp locking nut over cable clamp and screw onto connector finger tight. Ensure edge of clamp fingers are even with tape buildup.

l. Install lacing tape/tie string (A–A–52083 or A–A–52084) and trim (Figure 19, Detail C).

27. **Termination of Shielded Harness in Connector With 90° Backshell.**

a. Slide backshell nut, backshell and adapter over harness.

NOTE

Tubular braid may be used in place of the wire mesh on wire harnesses containing four or less wires.

b. If used, slide tubular braid over harness.

c. Install connector using procedures as detailed in the NAVAIR 01–1A–505–2, –3, or –4 or aircraft connector repair manual.

d. Install adapter and backshell and tighten (Figure 20, Detail A).

e. Maintaining a 50% overlap, wrap wire bundle with silicone adhesive teflon tape under any area where metal mesh tape will be applied (Figure 20, Detail B).

f. Buildup outside diameter of harness to inside diameter of backshell assembly with silicone rubber tape and install backshell cover with lock washer and screw (Figure 20, Detail C).

CAUTION

Overheating may cause damage to wiring beneath shield.

g. Solder (WP 016 00) wire mesh tape/tubular braid to shield.

h. Wrap wire mesh tape toward connector over tapered portion of backshell assembly and secure with silicone adhesive teflon tape (Figure 20, Detail D).

i. If tubular braid is used, trim excess length.

j. Secure wire mesh tape with backshell nut (Figure 20, Detail E).

k. Install 1/4” EMI metal band (M85049/128–1, or –2, 4–1380) as per WP 011 02 (Figure 20, Detail E) and trim.

l. Wrap silicone rubber tape, AA59163–1, MIL–I–46852 (NSN: 5970–00–955–9976), one complete turn around backshell nut and maintaining a 50% overlap, continue wrapping until one inch of the overbraid is covered (Figure 20, Detail F).

m. Secure silicone rubber tape with polyester lacing tape.

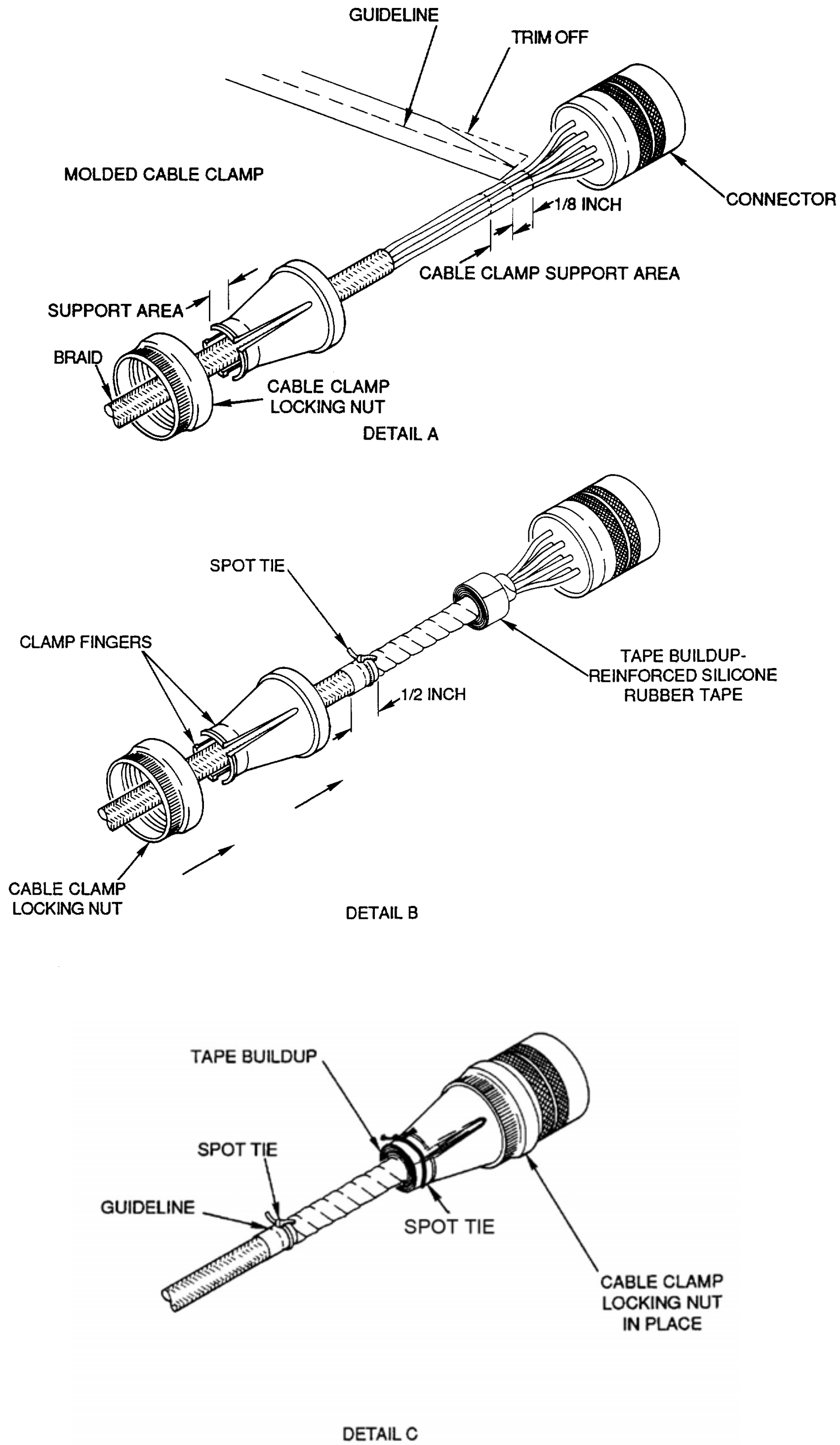


Figure 19. Termination of Overbraided Harness with Environmental Connector with Molded Plastic Cable Clamp

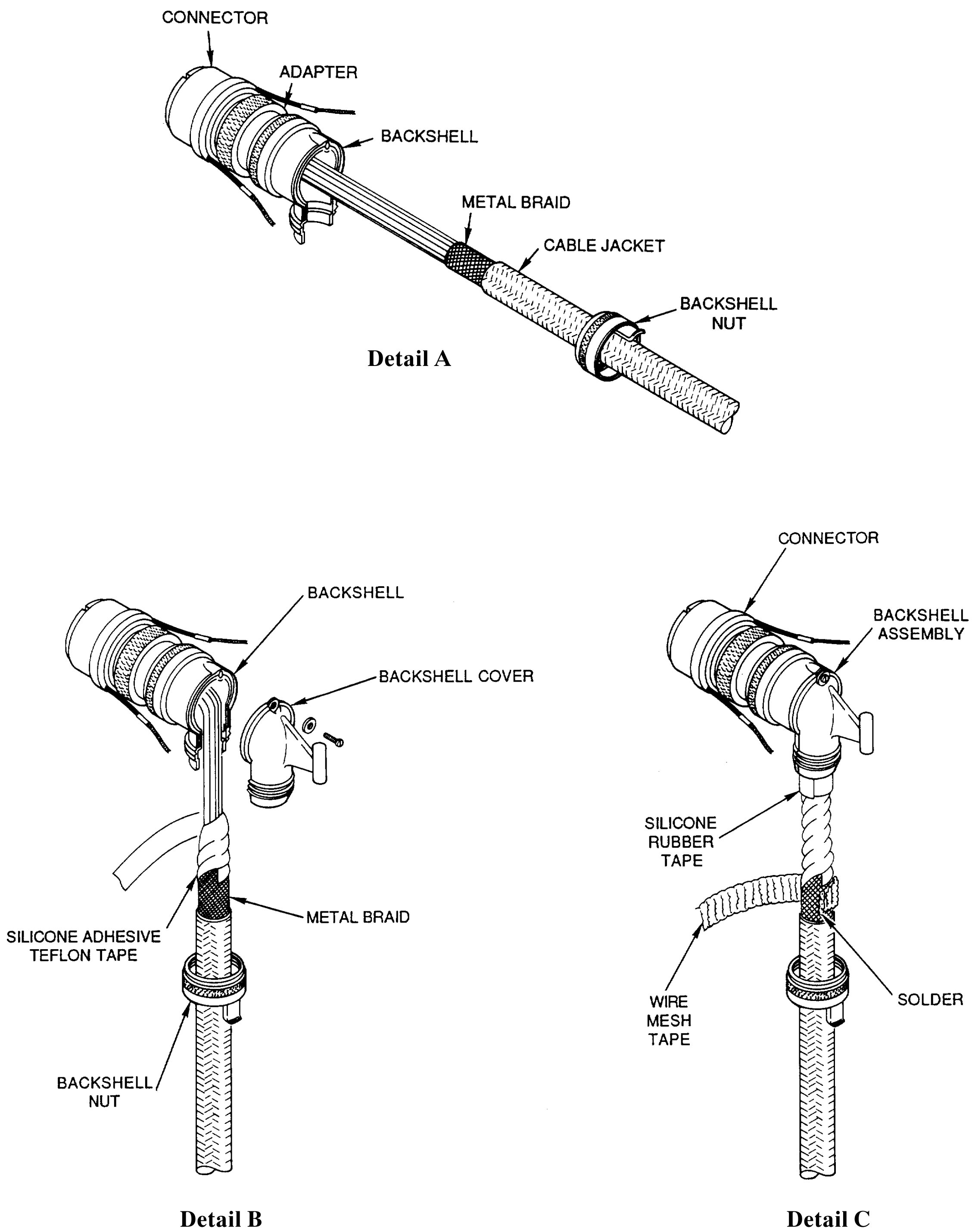


Figure 20. Termination of Overbraided Harness with Connector with 90° Backshell (Sheet 1 of 2)

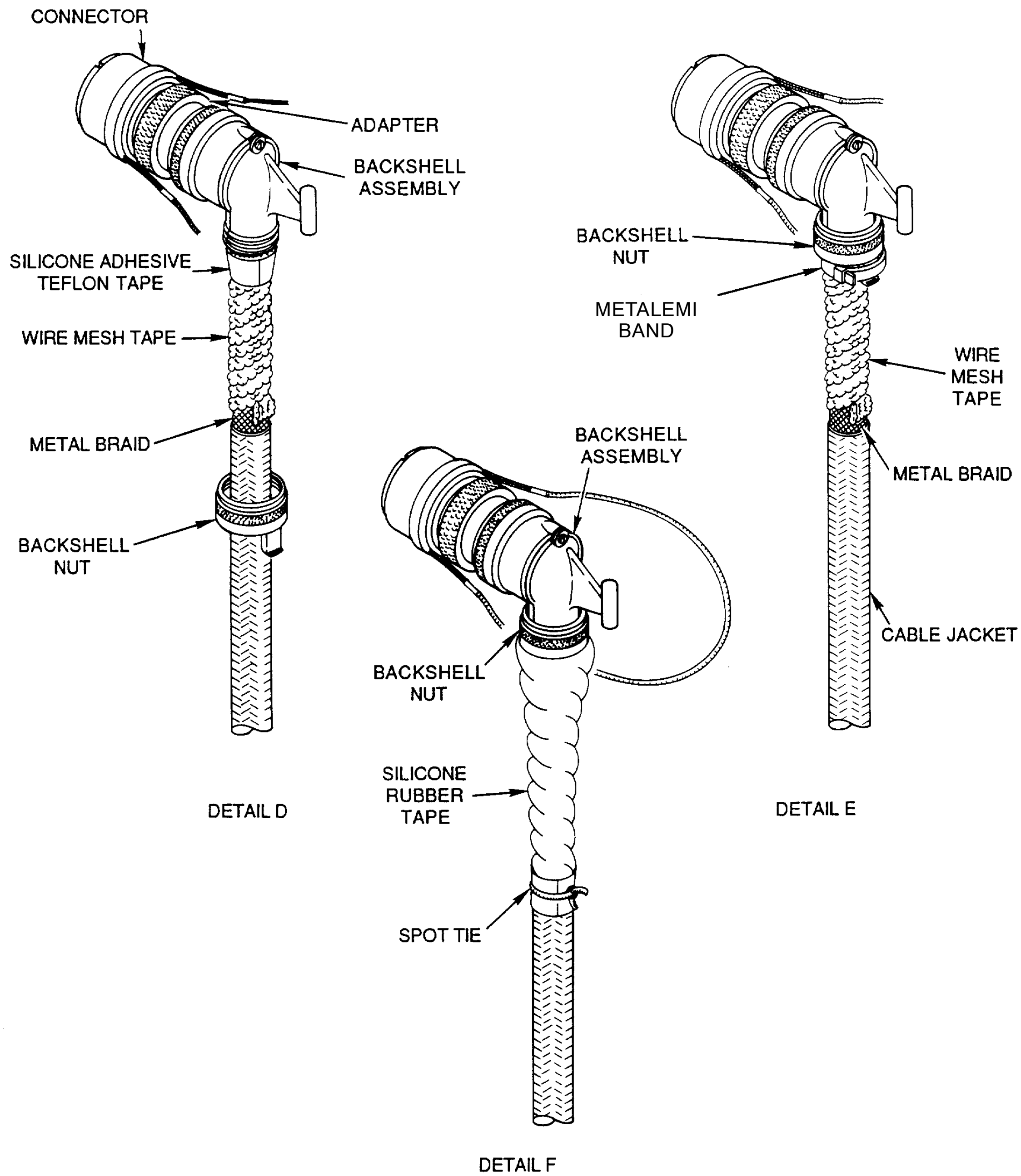


Figure 20. Termination of Overbraided Harness with Connector with 90° Backshell (Sheet 2)

28. **METALLIC OVERBRAIDED HARNESS REPAIR.** A metallic overbraided harness is a harness with a metal shield covered by an overbraided cloth. Repair a metallic overbraided harness as follows:

a. Using scissors cut completely around outer harness covering, pull back each side at least 6 inches from damage and secure with lacing cord. A minimum of 12 inches is required for repairs (Figure 21).

b. Using wire cutters/scissors cut completely around metallic overbraid, pull back each side at least 4 inches from damage and secure with lacing cord. A minimum of 8 inches is required for repairs (Figure 22).

c. Uncover all areas of wire damage (Figure 23).

d. Determine the length of the damaged area (Figure 24), and pull the braid and shield further back in accordance with Table 1.

e. Using a sharp knife, carefully score cable shield jacket around cable diameter and along area to be removed (Figure 25).

f. Flex the wire until shield jacket separates, then remove jacket.

g. Repair the damaged wire in accordance with WP 014 00 and paragraph 38 or 39. If wire is damaged at a single point, and there is some slack in the wire, the existing wire can usually be repaired with a sealed splice (Figure 26). If a wire has damage along its length, the damaged segment must be cut out and replaced by a jumper wire installed using two splices (Figure 27).

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

h. Cut temporary lacing cord that secured the metallic overbraid, then milk both ends as close together as possible. Using scissors, trim frayed areas to allow for smooth repair (Figure 28). Using isopropyl alcohol clean and dry metallic overbraid 2 1/2 inches on both sides of damaged area to ensure adhesion of copper foil tape (P/N: SM−B−450436−3, Rev B).

i. Using adhesive knitted wire mesh tape (P/N: SM−B−450436−3, Rev B) beginning 2 inches on either side of damage and extending 2 inches beyond damage, wrap copper foil tape around metallic overbraid while applying pressure to ensure adhesion of foil to overbraid, overlapping each wrap 50 percent (Figure 29).

j. Cut lacing cord securing outer harness covering, milk both ends as close together as possible. Using scissors trim frayed areas to allow for smooth repair (Figure 30).

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

k. Using isopropyl alcohol remove any dirt and/or moisture from outer harness covering.

l. Using self−bonding silicone tape, beginning 3 inches on either side of damage and extending 3 inches beyond damage, wrap tape around harness, overlapping each wrap 50 percent (Figure 31).

m. Secure ends of tape with lacing cord (Figure 32).

Table 1. Harness Area Removal

Length of Damaged Area (Inches)	Length of Outer Jacket to Be Removed (Inches)
Less Than 2	5
2 To5	8
5 To 8	11

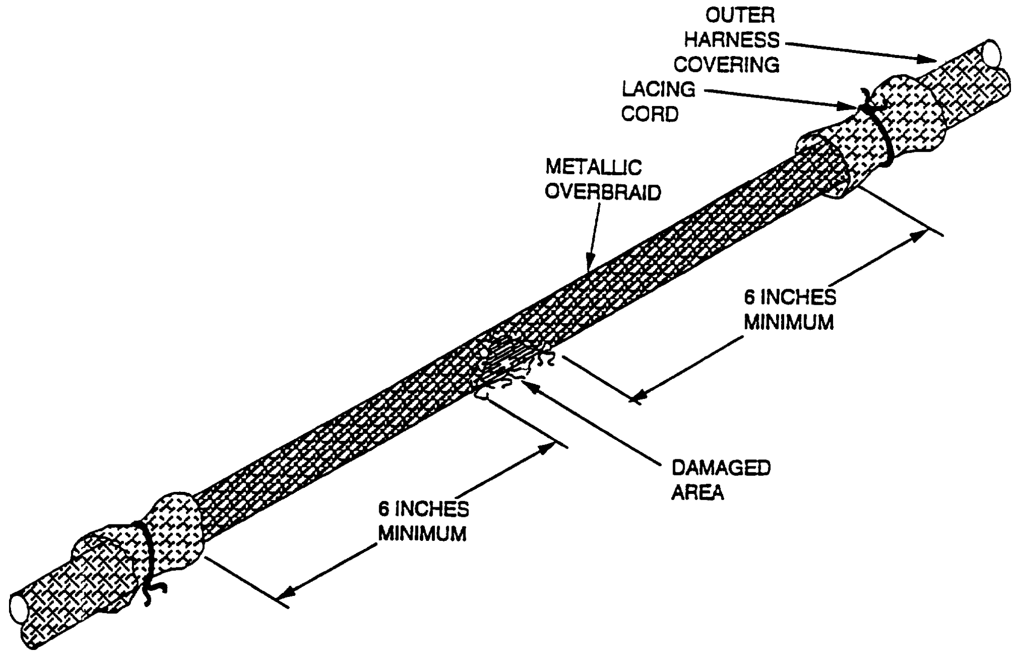


Figure 21. Harness Covering Removed

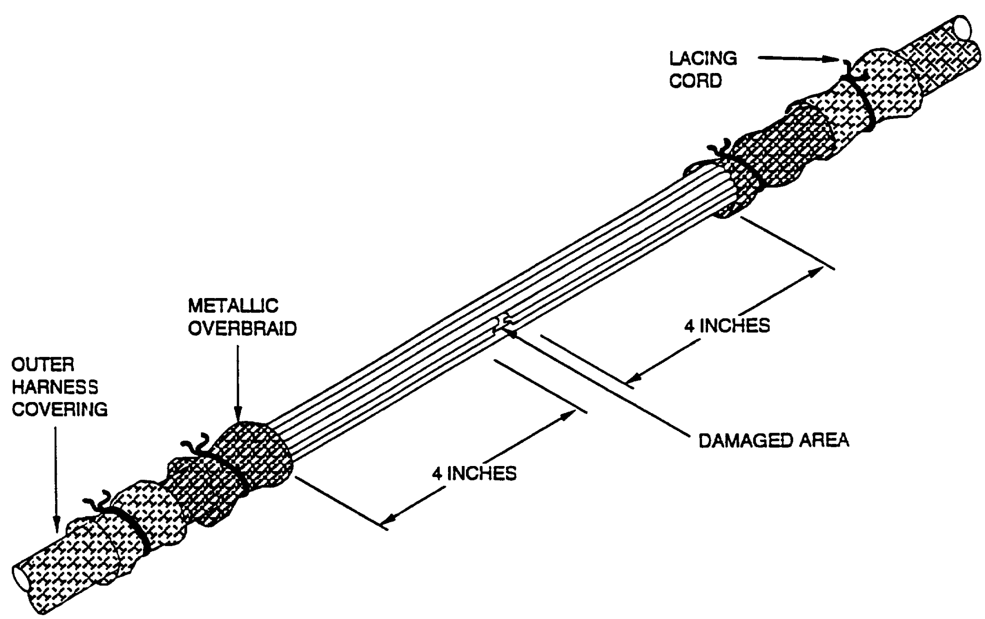


Figure 22. Harness Shield Removed

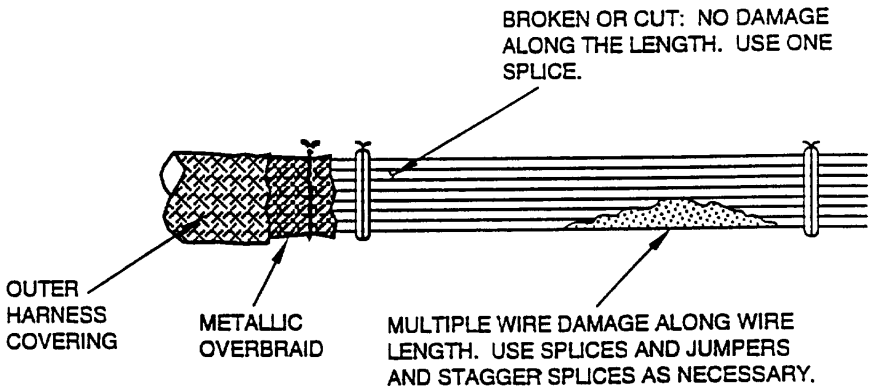


Figure 23. Examine Wire for Damage

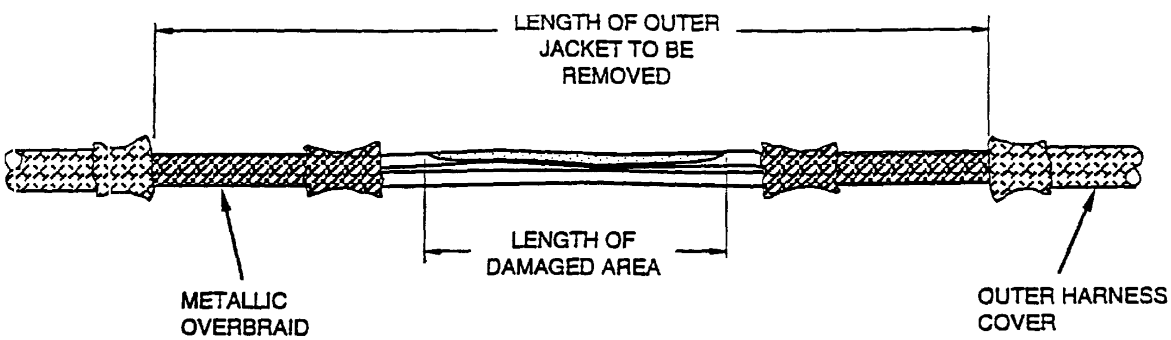


Figure 24. Wire Damaged Area

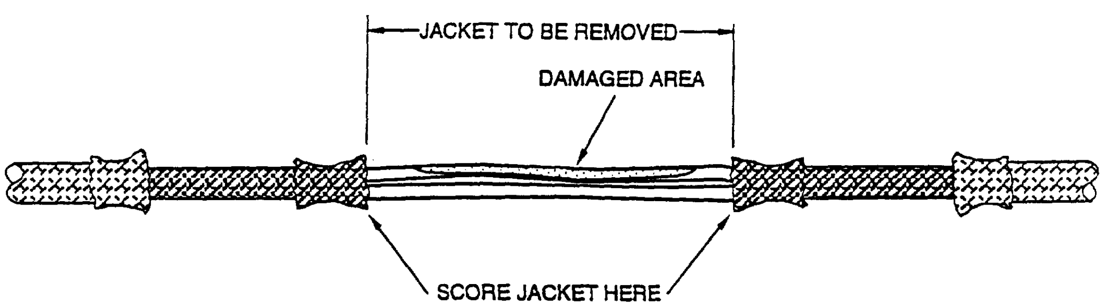


Figure 25. Shield Jacket Removal

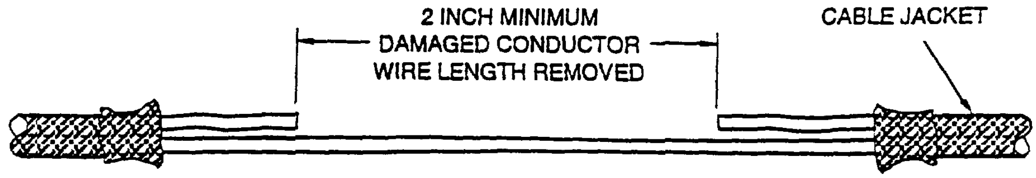


Figure 26. Single Wire Splice Repair

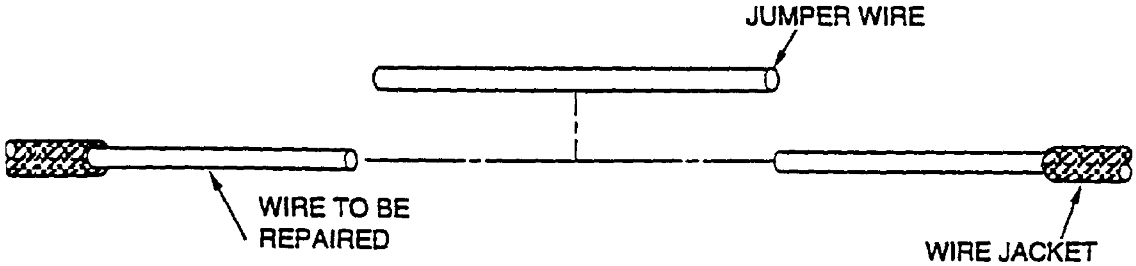


Figure 27. Jumper Wire Splice Repair

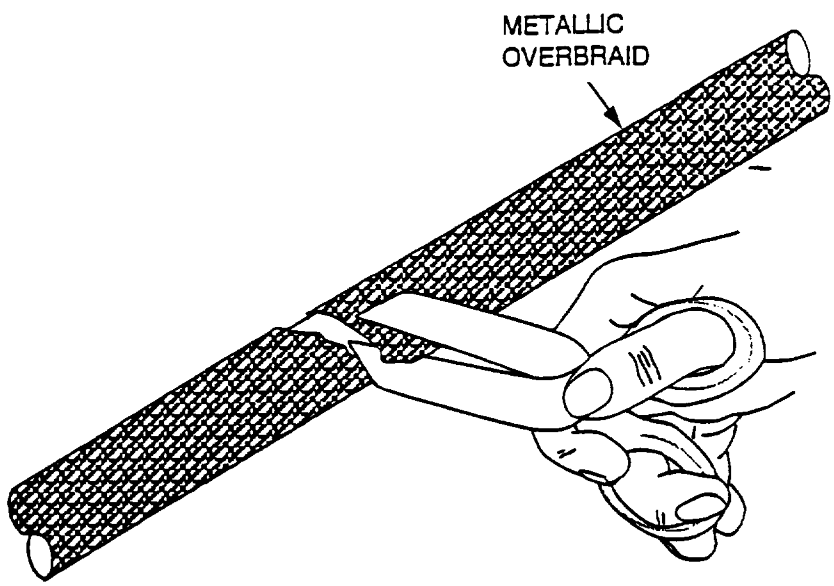


Figure 28. Trimming Metallic Shield

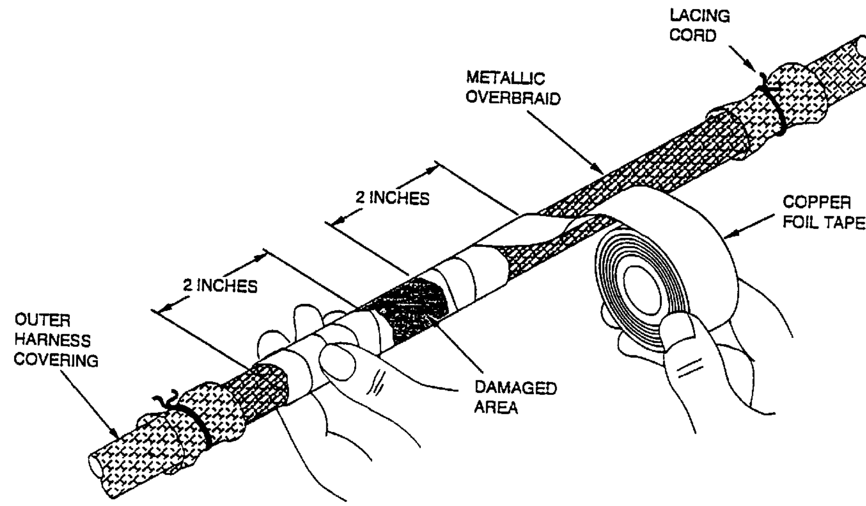


Figure 29. Repair Metallic Overbraid (Shield)

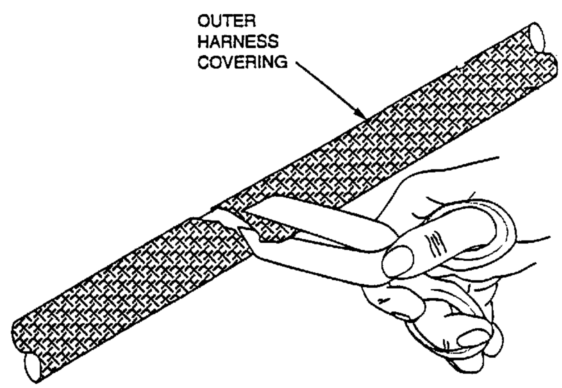


Figure 30. Overbraid Trimming

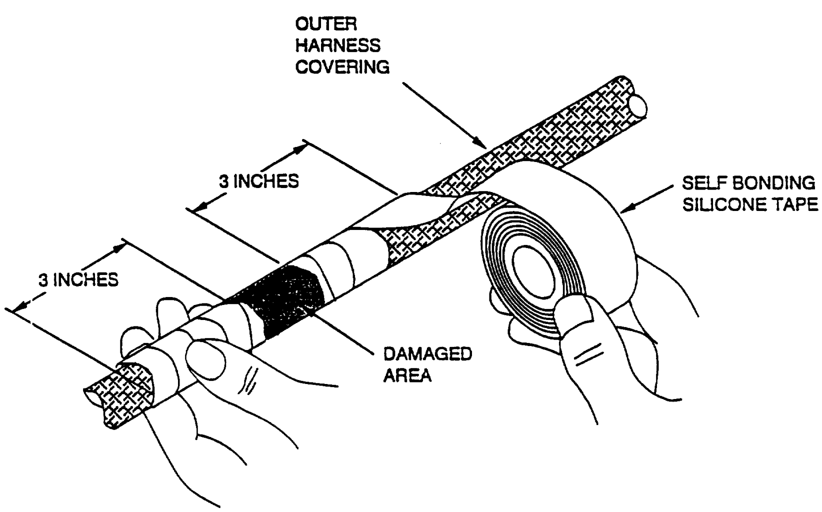


Figure 31. Overbraid Repair

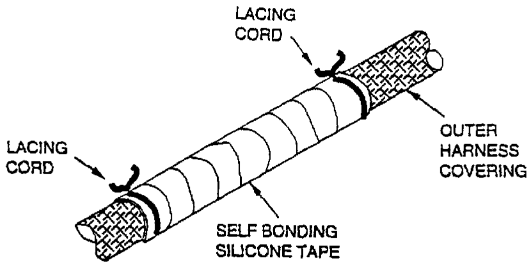


Figure 32. Securing Overbraid Tape

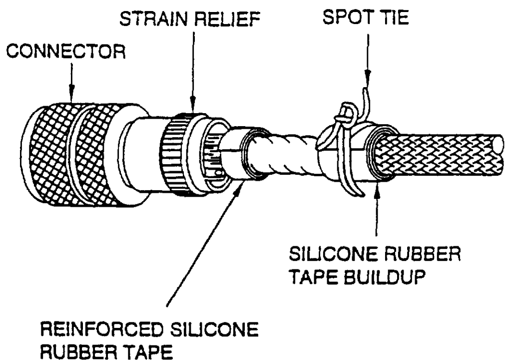


Figure 33. Saddle Clamp Removal

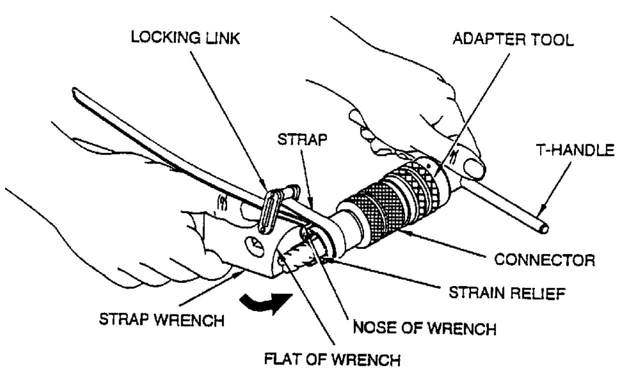


Figure 34. Accessory Removal

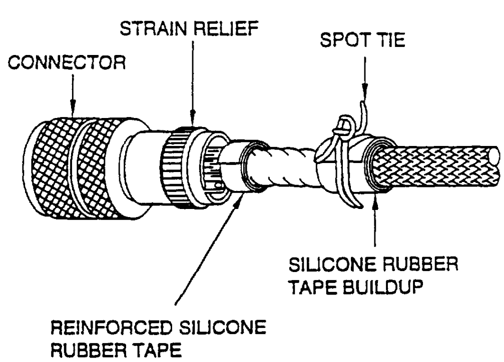


Figure 35. Typical Accessory Protection

29 . **Connector Accessory Entry Protection.** On a protected harness the rear entry of connector should be protected as shown in Figure 33. To repair wires or cable in this area, remove the accessory as follows:

a. Hold connector stationary with adapter tool and T–Handle. Install strap wrench around strain relief and apply counter clockwise force to loosen strain relief (Figure 34).

b. Loosen the cable clamp screws. If necessary, remove one side of the saddle clamp but retain the loose screw in the saddle clamp (Figure 33).

c. Cut and remove any spot tie or straps (Figure 35).

d. Cut and unwrap tapes (Figure 36).

CAUTION

When cutting boot material extreme care must be taken not to nick or scrape insulation.

e. Mate adapter tool (Figure 37) into the front of the connector (Figure 38). The adapter tool part breakdown as follows:

(1) Example: CM389L–9.

(2) CM: Daniels Manufacturing Corporation Product Identification.

(3) 389L: Abbreviated connector part number for which adapter fit (i.e. 3891 fit M38999L connectors, 5015 fit M5015 connectors, etc.). WP 024 00 for details.

(4) –9: Connector shell size.

f. Remove strain relief from connector and slide back on cable (Figure 39).

g. Repair the wire in accessory area as needed.

h. Assemble cable (harness) by sliding strain relief along cable assembly. Engage threads of strain relief to connector. Hand tighten to connector. Hold connector stationary with applicable adapter tool and T–Handle. Install strap wrench around strain relief. Apply force clockwise, as viewed from rear of connector, an additional 1/4 turn (Figure 40).

i. Torque strain relief according to the shell size as per WP 011 01, Table 1. See WP 024 00 for complete torque information.

j. Wrap 1 to 2 turns of non–adhesive rubber tape over exposed wires and buildup layers of rubber tape near cable clamp (Figure 41).

k. Install cable clamp. Do not tighten screws. Slide both tapes forward under cable clamp.

l. Tighten screws until metal to metal contact is obtained.

m. Continue to wrap tape over exposed wire and onto cable jacket one width of tape (Figure 42).

n. Spot tie tape buildup.

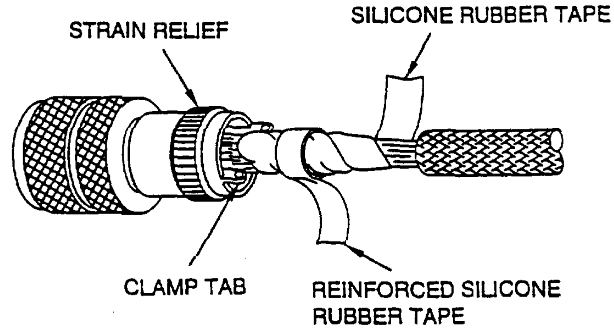


Figure 36. Accessory Tape Removal

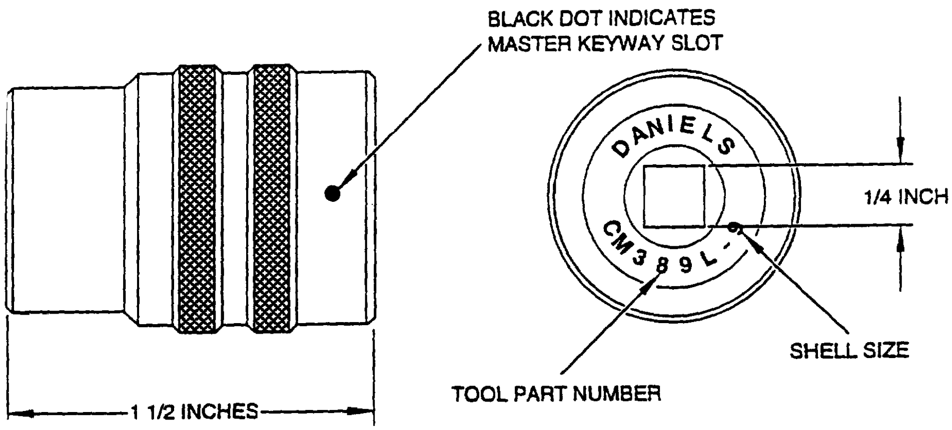


Figure 37. Daniels Accessory Adapter

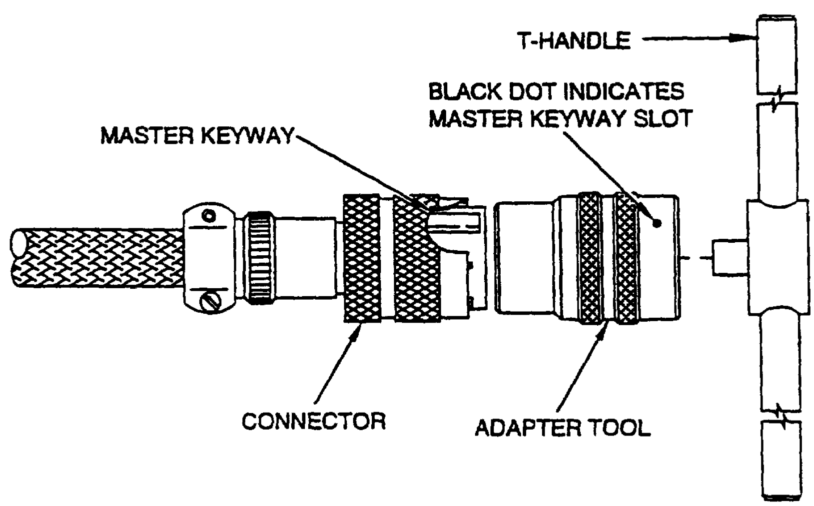


Figure 38. Accessory Adapter In Connector

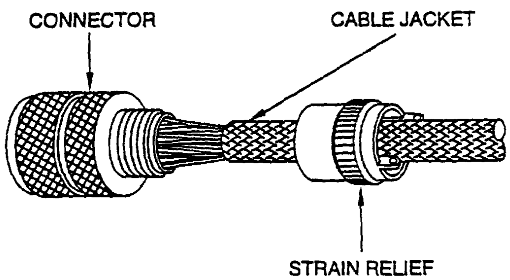


Figure 39. Accessory Removed

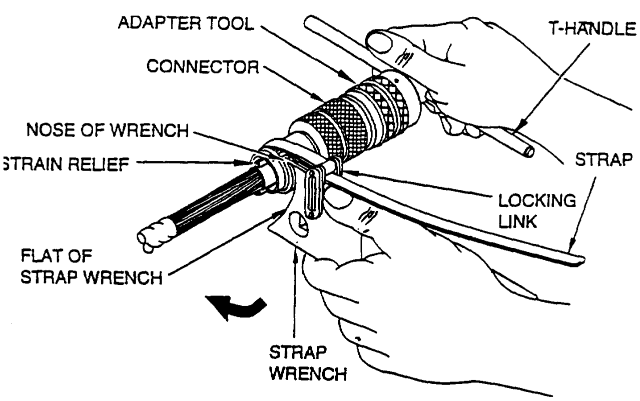


Figure 40. Assembly Accessory

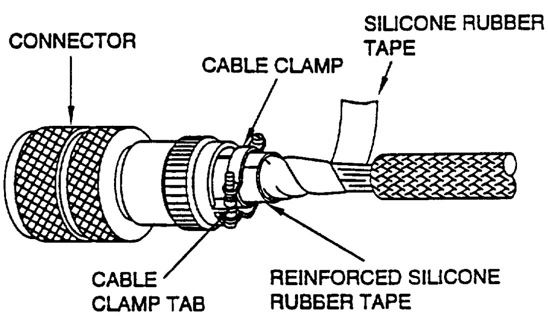


Figure 41. Accessory Tape Wrapping

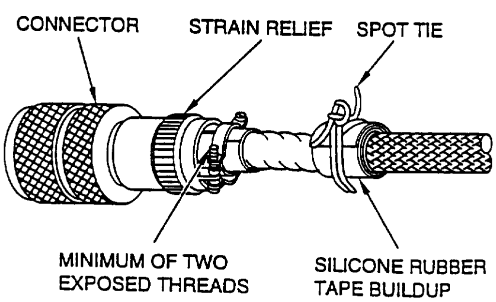


Figure 42. Final Rear Accessory Assembly

30 . **EMI Shielded Wrap–around Repair with Two Layer Sleeving.** This sleeving (Roundit 2000NXEMI) (Figure 43) is a flexible, two–layer product combining Mechanical Protection and EMI shielding (Figure 44). It has passed EMI testing as per Mil–Std 461 and 464, meets specifications of EN 6049–006 and is rated for temperatures between −55°C to 200°C. This application is intended for repair, or use on single shielded wire harnesses only. It is not for use on double shielded harnesses, or EMP hardened cables. The sleeving is best suited for: EMI protection and bundling for electrical harnesses in all aircraft zones, modification in the original shielded harness and for repair of damaged EMI shielded harnesses. Two versions of the sleeving are available:

a. Roundit 2000NXEMI–B with PTFE tape layer inside; used to avoid contact between cables and the metal braid.

b. Roundit 2000NXEMI–A without PTFE, used when the cables are already protected by Nomex, or by a PTFE Tape.

31 . Select the correct size for the application (Table 2).

32 . **Preparation of the Sleeving.**

a. The sleeving must be prepared prior to application to a wire harness.

NOTE

For this application, the Roundit 2000NX EMI–B sleeving is shown. It uses an inner layer of PTFE tape for wire harness chafe protection.

b. To help with installation, some breakout bundles can be tied to hold the wires in place. Use only the minimum amount of lacing tape as possible, since the complete harness with the sleeve will be tied after the installation of the sleeving.

c. Cutting the sleeve (Figure 45).

NOTE

The two layers of sleeving are cut with sharp scissors. Good quality paper scissors are required in order not to damage the sleeving during cutting.

d. Separate the sleeving from the metal braid, into 2 independent layers by removing the green string seam (Figure 46).

CAUTION

For EMI applications, enough of the PTFE tape must be removed to expose metal braid so that metal on metal contact is made. Failure to remove enough of the PTFE will prevent effective shielding protection.

e. Trim the inner PTFE tape layer to ensure minimum metal to metal contact (Figure 47).

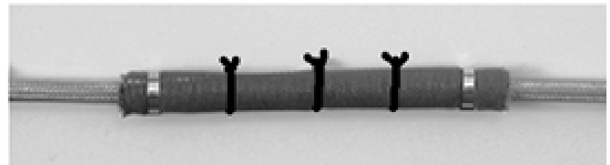
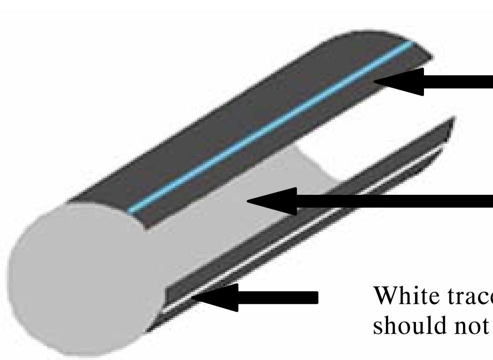


Figure 43. Installed Two Layer Sleeving

Table 2: EMI Shielded, Wrap−Around Sleeving, Round−it 2000NX EMI B

Nominal Diameter (in.)	Part Number	CAGE
1/4	5678300607S	81851
7/16	5678101107S	81851
9/16	5678101407S	81851
1 1/16	5678101707S	81851
7/8	5678102307S	81851
1 3/16	5678103007S	81851
1 1/2	5678103807S	81851

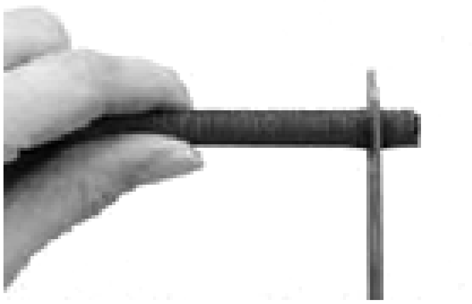


NOTE:

This type sleeving has a blue tracer in the center, to differentiate it from the unshielded version (Roundit 2000NX) and it also serves as a means of identifying the amount of twist in the sleeving.

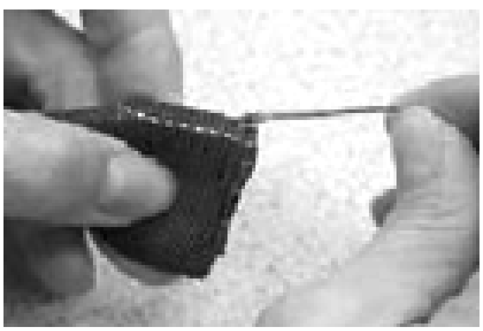
The green string seam on the edge is used to secure the metal braiding to the Nomex outer cover.

Figure 44. EMI Shield Repair with Two Layer Sleeving



1. Make one straight cut across the width of sleeving.

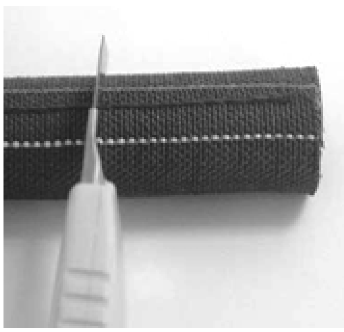
2. Using very light force, manually pull the loose fibers off the end of the cut edge.



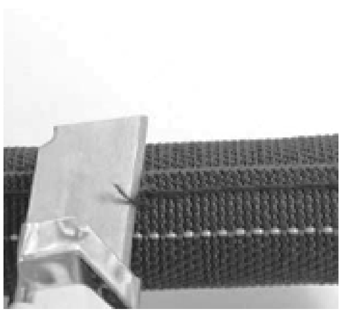
3. Pull any remaining loose fiber over to tracer edge of sleeving. Filaments will stop unraveling. Cut off with scissors.

Figure 45. Cutting Sleeving

1. Locate the green meta–aramid sewn string seam, used to join the Nomex sleeve and the metal braid.



2. Unpick and remove this green string, using a sharp knife.

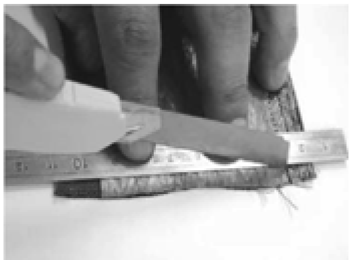


3. Lengthwise, separate the textile sleeve from the metal braid, by rubbing the knife on the green string to cut it.

4. Remove the pieces of cut string.

5. The sleeve is now separated into two independent layers.

Figure 46. Separate Sleeving Layers



1. Use a sharp knife to cut the PTFE tape minimum 1/2” from the end of the sleeve.

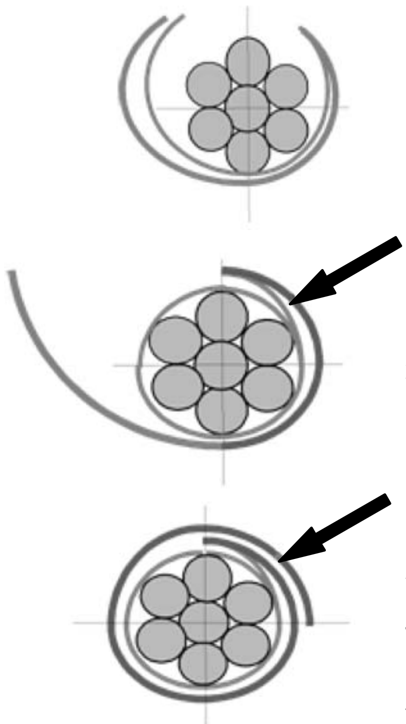
NOTE

This method prevents the metal braid from being damaged during PTFE removal.

2. Use scissors and ruler to cut the PTFE tape.

3. Remove the length of unwanted PTFE tape strip.

Figure 47. Trim PTFE Tape Layer



1. Insert wire bundle in the open sleeve.

90° overlap

2. Close metal braid layer. Ensure a minimum overlap of metal braid.

90° overlap

3. Close Nomex layer. Ensure a minimum 90° overlap.

4. Ensure proper twisting on harness. The twist shall be on average 1 to 2 turns per yard of the wire bundle (Figure 54).

5. Secure with lacing and tying tape (A–A–52084, or A–A–52083) every 2 +/– 0.5”.

6. Terminate the sleeving within 0.5” of the ends onto the connector accessory (i.e. AS85049 EMI backshell) using EMI metal bands as per WP 011 02.

Figure 48. Installation of Sleeving on Harness

33 . **Installation of Sleeving on Harness.**

NOTE

Sleeving on the bundle must be tight in order to avoid folds.

To make it easier for multi–branch harnesses, it is better to start covering the smallest bundle and finish with the biggest. This makes it possible to cover the small size by a bigger size on the break–out.

In order to use the maximum diameter indicator correctly, respect the position of the white tracer line on the overlap direction. This line should not be visible if correct size was employed with the required overlap.

a. Wrap around the install sleeving over affected area of the wire bundle (Figure 48).

NOTE

If the sleeving is to be installed such that it is terminated onto connector accessories (such as an EMI backshell AS85049), then terminate with EMI metal bands as per WP 011 02, this manual. If the sleeving is to be installed onto the wire harness, proceed with the following steps.

34 . Repair of Shielded Wire Harness. This application is intended for repair, or use on single shielded wire harnesses only. It is not for use on double shielded harnesses, or EMP hardened cables.

a. Identify scope of shielded harness area to be repaired (Figure 49).

b. Remove damaged section of EMI shielding (Figure_50).

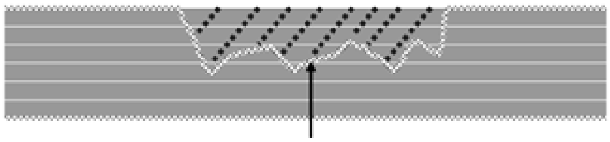


Figure 49. Shielding Damage

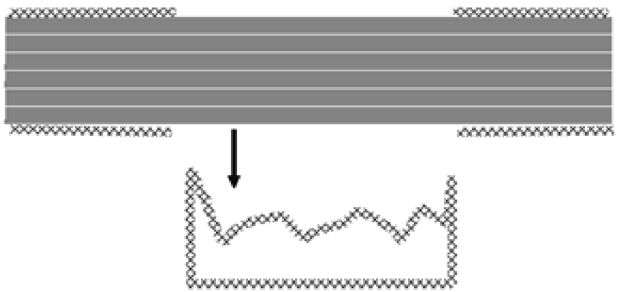


Figure 50. Remove Damaged Shielding

c. Inspect wiring and affect any repair to ensure serviceable condition before installing the sleeving.

d. Inspect affected area, ensuring it is clean. If cleaning required, clean faying surfaces 1” past the damaged area using Isopropyl Alcohol TT−I−735 (or equivalent).

e. Select the correct size composite banding split ring (M85049/93−XX) such that it snaps snug over the shielded harness to be repaired (see Table 3). Do not force ring to close, as damage to harness wiring may occur.

Table 3: Composite Band Split Ring

Size, Nominal Diameter (in.)	Part Number	CAGE
1/4	M85049/93−04	81349
7/16	M85049/93−06	81349
9/16	M85049/93−08	81349
1 1/16	M85049/93−10	81349
7/8	M85049/93−12	81349
1 3/16	M85049/93−14	81349
1 1/2	M85049/93−16	81349
Note: Larger sizes are also available (i.e. −18 and −20)		

NOTE

The sizes and diameter of the banding split ring are the same as those for the sleeving in Table 3.

f. Apply one revolution of Self−Sealing tape A−A−59163, Type II (Figure 51).

g. Install split ring over tape, allowing enough shielding material to completely overlap it (Figure 51).

h. Fold over existing harness shielding material (Figure 52).

i. Wrap around the prepared shielding as per paragraphs 30 thru 32. Install sleeving using EMI metal bands (WP 011 02) as per paragraph 33 above (Figure_53), observing sleeve twist and overlap requirements (Figure 54).

Figure 51. Installation of Split Ring

Figure 52. Folding Shielding

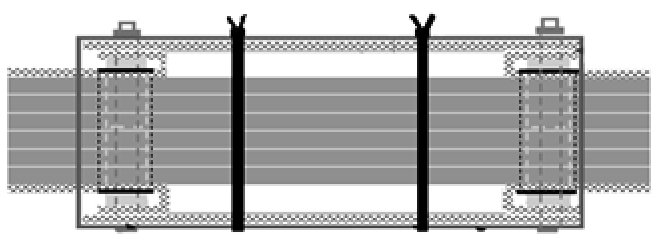


Figure 53. Sleeving Installation

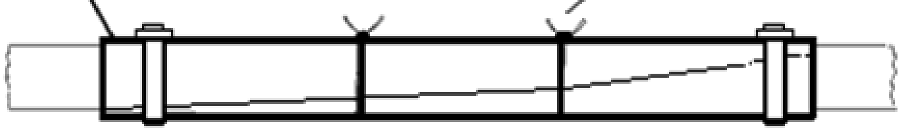


Figure 54. Installation of Sleeving on Wire Harness

ENVIRONMENTAL SEALED HARNESS REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Part Number/ Type Designation	Nomenclature
Paddle, Wooden	—
Wrench, Torque 0-150 in. lbs.	—
Wrench, Torque 150-250 in. lbs.	—
Gun, Sealing	—
Tip, Boot and Tubing Gun, Sealing	979648
Heat Gun	AA-400
Heat Gun	CV-5700
Reflector	MG-2
Pliers, Connector	Model 11-6147-1
Knife, Thermal	Model 2A
Reflector	TG-12
Reflector	TG-13
Reflector	TG-13A
Reflector	TG-21
Reflector	TG-22
Reflector	TG-23
Reflector	TG-24
Tool, Heating	MCH–100–A
Tool, Heating, Infrared	IR-550

Materials Required

Part Number/ Type Designation	Nomenclature
Adhesive	RTV-108
Adhesive	S-1009
Adhesive	S-1030
Adhesive	S-1125
Alcohol, Isopropyl	TT–I–735
Boot, Bulbous	202A100 Series
Boot, Bulbous	202D100 Series
Boot, Low Profile	200D200 Series
Compound, Molding	—
Compound, Thread Coating	—
Cord, Lacing	—
Emery Cloth #320	—
Sandpaper	—
Spot Tie	—
Tape	—
Tubing	RP-4800
Tubing	VPB-RT
Uni-Boot	202C600 Series

1. **INTRODUCTION.**

2. **DESCRIPTION.** Cable harness components feature controlled wall thicknesses that permit small, lightweight cable assemblies without sacrificing performance. Heat-shrinkable components conform to components being covered to present an attractive appearance.

3. Cable harness tubings and molded shapes protect wire bundles and provide connector terminations maximum support and mechanical protections. Adhesives are used to ensure rugged bonding and sealing in severe environments. Adapters with spin couplings provide easy access to the back sides of connector for repairs.

4. **CABLE HARNESS ASSEMBLY.** When building a new, or repairing an existing wire harness with wire which was processed using any wire processing equipment (such as the ARTOS CS–336), a close inspection of wire size 26–20 AWG is required. Using a 10X magnifying device, inspect the wire insulation for serrations, abrasions or cuts. Replace with new wire lengths and discontinue the use of the equipment until condition is corrected.

CAUTION

Any time wire processing equipment is employed on wire size 26−20 AWG, an inspection is required. Failure to inspect the wire for damaged insulation, may result in premature wire system failure.

5 . **WIRE LAYUP.** Layup wire forming harness using the following procedure:

a. Layup harness but do not terminate the connector.

b. Twist cables to provide flexibility (Paragraph 7).

c. Select and cut appropriate size shrinkable tubing to desired length allowing 10 percent shrinkage for each leg of harness. Refer to WP 014 00 for heat shrink selection

NOTE

The practice of wire bunch twisting provides the finished harness with increased flexibility and improved strain relief especially in sharp harness bends. It however will add weight to the finished harness, as longer wires are needed and may also increase the harness diameter. This practice needs to be considered carefully for each specific application.

6 . **WIRE TWISTING.** Wire bunch twisting is to be employed only on wire harnesses which require it as per drawing. Wire bundles shall have an amount of twist sufficient for flexibility only. Do not twist wire harnesses in the following categories:

a. Wire bundles or branches shorter than four inches in length.

b. Branches containing five or less wires.

c. Any wires 10 AWG, or larger in diameter.

d. Wire harnesses less than, or equal to 5/8 inch diameter.

7 . **Bunch Twisting Wire Bundle.** To bunch twist a wire bundle, proceed as follows:

a. Gather wires to be twisted and anchor at one end.

b. Spot tie cable close to anchor and draw tight to form a compact bundle.

c. Apply a second spot tie close to first tie that will be moved along the cable as it is twisted maintaining a compact bundle.

d. Separate bundle into two equal groups and using a rod (such as a soldering aid) to maintain separation twist two groups (Figure 1).

e. Move second spot tie along twisted portion of cable to maintain round compact bundle. Additional spot ties may be required to maintain compactness.

f. Comb wires as twisting is continued and allow individual wire to rotate removing any buildup of twist in wires. For maximum flexibility remove as much of inducted twist as possible.

g. Continue twisting wires until required cable length is obtained.

8 . **Cable/Harness Fabrication Twisting.** Cable or harness fabrication twisting is accomplished by performing procedure (Figure 2).

9 . **Taping Harness Breakouts.** Taping harness breakouts by performing procedure (Figure 3).

10 . **SHRINK TUBING INSTALLATION.** To install heat-shrinkable tubing over twisted wire bundle perform the following procedure:

a. Slide tubing over wire bundle.

b. Starting at the inside and working toward connector end, shrink tubing with heat gun and reflector (Figure 4).

c. Ensure enough wire has been left at connector end to terminate wires to connector.

11 . **TRANSITION INSTALLATION.** To install transitions, perform the following procedure:

a. Pass jacketed wire bundles through legs in transition and position over wire junction. If more than one transition is used, do not begin bonding and shrinking until all transitions are properly positioned.

b. Beginning with innermost transition, abrade with sandpaper the portion of tubing to be covered by transition.

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean abraded area and inside of transition with Isopropyl Alcohol to ensure secure bonding.

d. Coat tubing with adhesive and ensure transition is properly positioned.

e. Starting at center of transition and proceeding to each leg, completely shrink transition using heat gun with or without reflector (Figure 5).

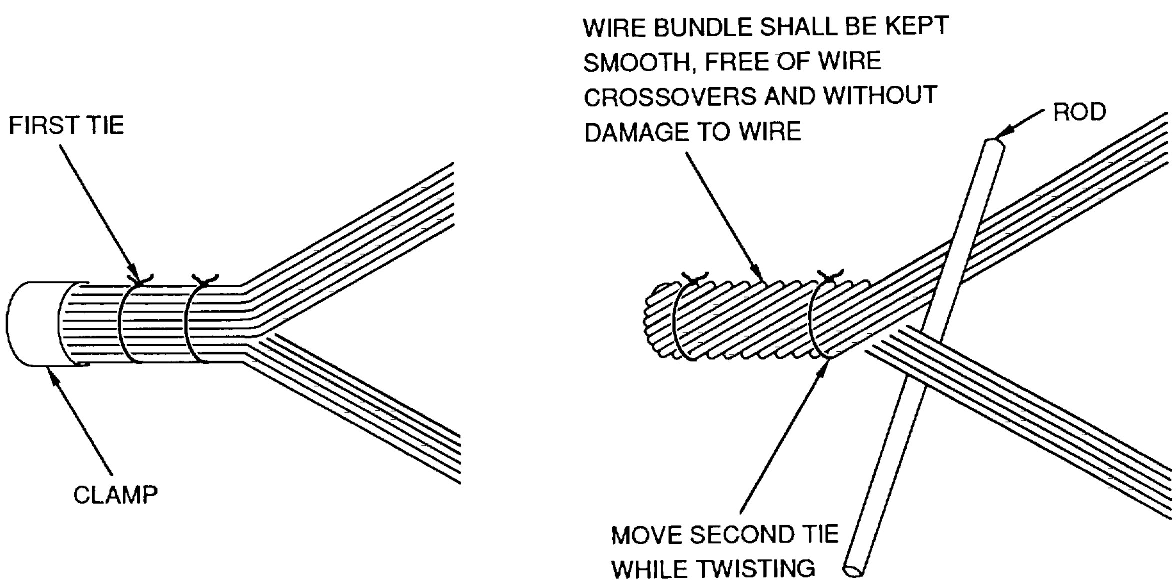
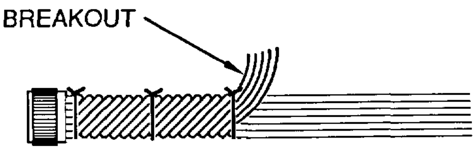
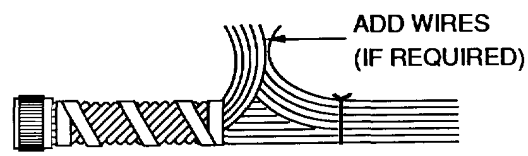


Figure 1. Bunch Twist Wire Bundle

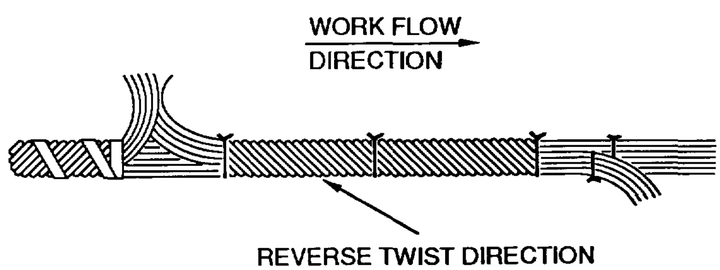
A. TWIST TO FIRST BREAKOUT AND SPOT TIE.



B. REPLACE SPOT TIES ON TRUNK WITH TAPE. IF WIRES ARE TO BE ADDED TO BREAKOUT, LAY THEM IN AND SPOT TIE BREAKOUT. DO NOT TWIST BREAKOUT AT THIS TIME.



C. REVERSE TWIST DIRECTION AND TWIST TO NEXT BREAKOUT SPOT TYING AS REQUIRED. SPOT TIE BOTH SIDES OF BREAKOUT.



D. REPLACE SPOT TIES ON TRUNK. TWIST BRANCH IN DIRECTION WHICH WILL TIGHTEN BREAKOUT AND TAPE.

E. REVERSE TRUNK TWIST DIRECTION. TWIST AND SPOT TIE TO NEXT BREAKOUT. REPLACE TRUNK SPOT TIE WITH TAPE.

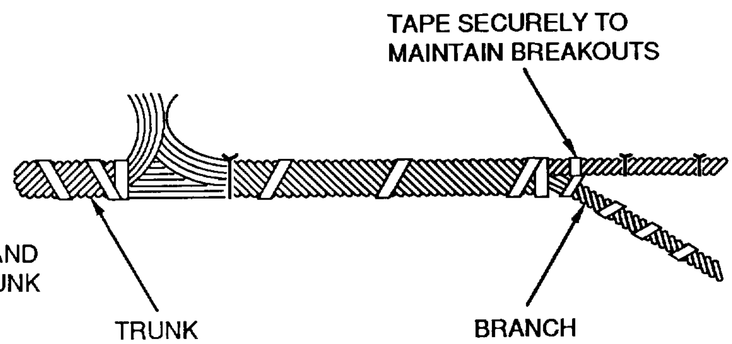
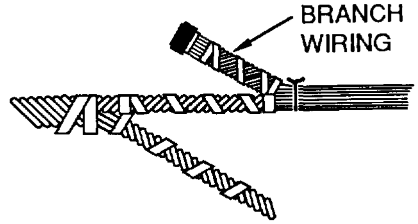


Figure 2. Cable/Harness Fabrication Twisting (Sheet 1 of 2)

F. LAY IN BRANCH WIRING (MAY BE PRETWISTED). SPOT TIE BREAKOUT AND CONTINUE TO TWIST TRUNK.



G. TWIST BRANCH AFTER TRUNK ON BOTH SIDES OF BRANCH ARE TWISTED. IF BREAKOUTS EXIST ON BRANCH REPEAT STEPS A THRU F.

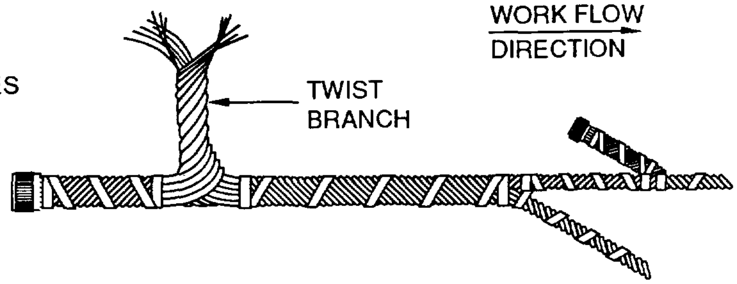


Figure 2. Cable/Harness Fabrication Twisting (Sheet 2)

A. START TAPING BY APPLYING 2 TO 3 WRAPS IN STEP 1.

B. FOLLOW TAPING SEQUENCE AS ILLUSTRATED IN STEPS 1 THRU 4.

C. COMPLETE TAPING BY APPLYLING 2 TO 3 WRAPS OF TAPE SHOWN IN STEP 5.

D. FOR DIFFICULT TO ANCHOR BREAKOUTS, STEPS 1 THRU 5 MAY BE REPEATED.

NOTE

JUNCTIONS MUST BE TAPED SECURELY TO MAINTAIN BREAKOUT ORIENTATION AND HARNESS INTEGRITY.

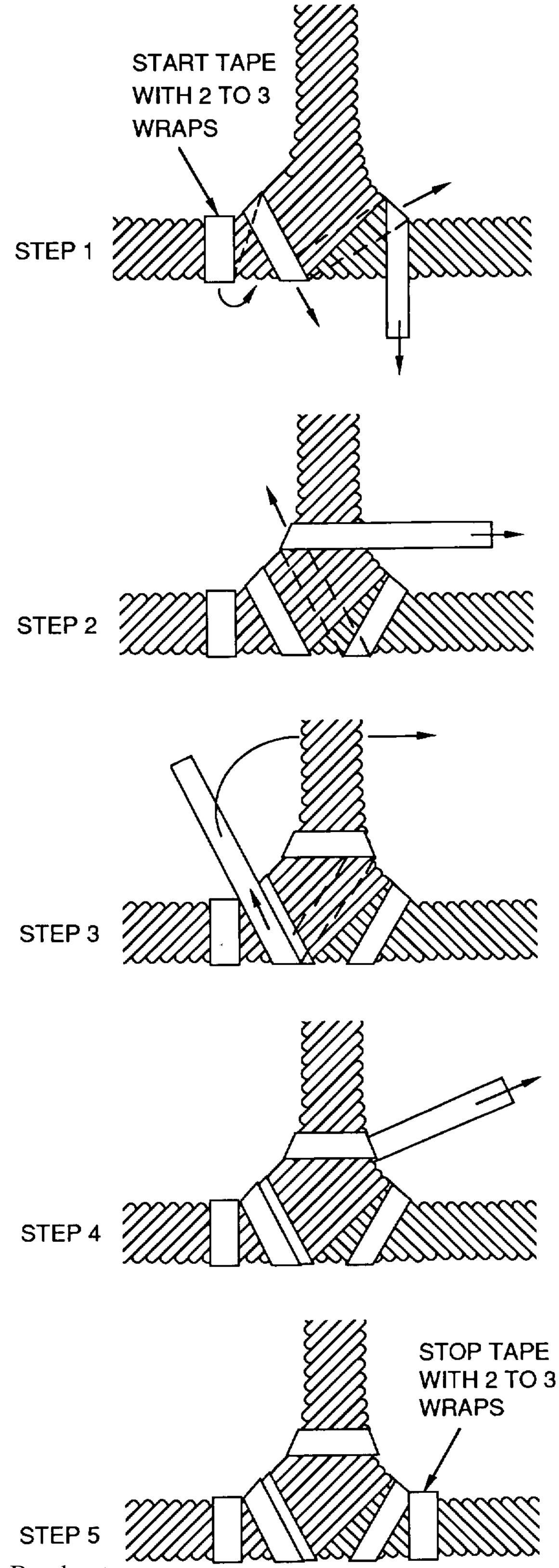


Figure 3. Taping Harness Breakouts

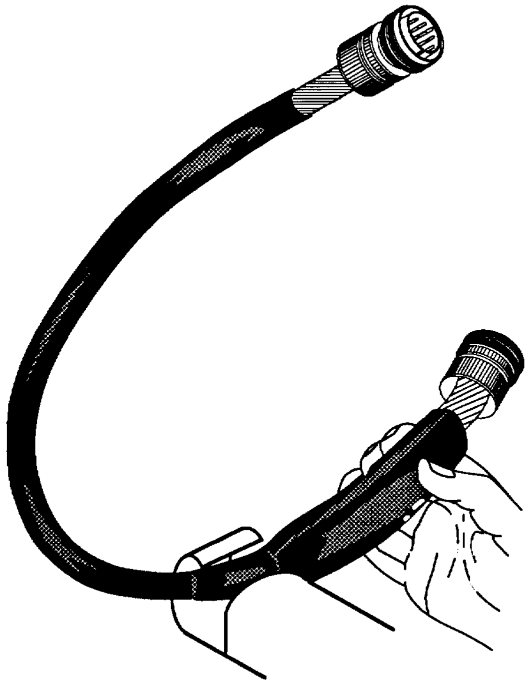


Figure 4. Heat Shrink Tubing Installation

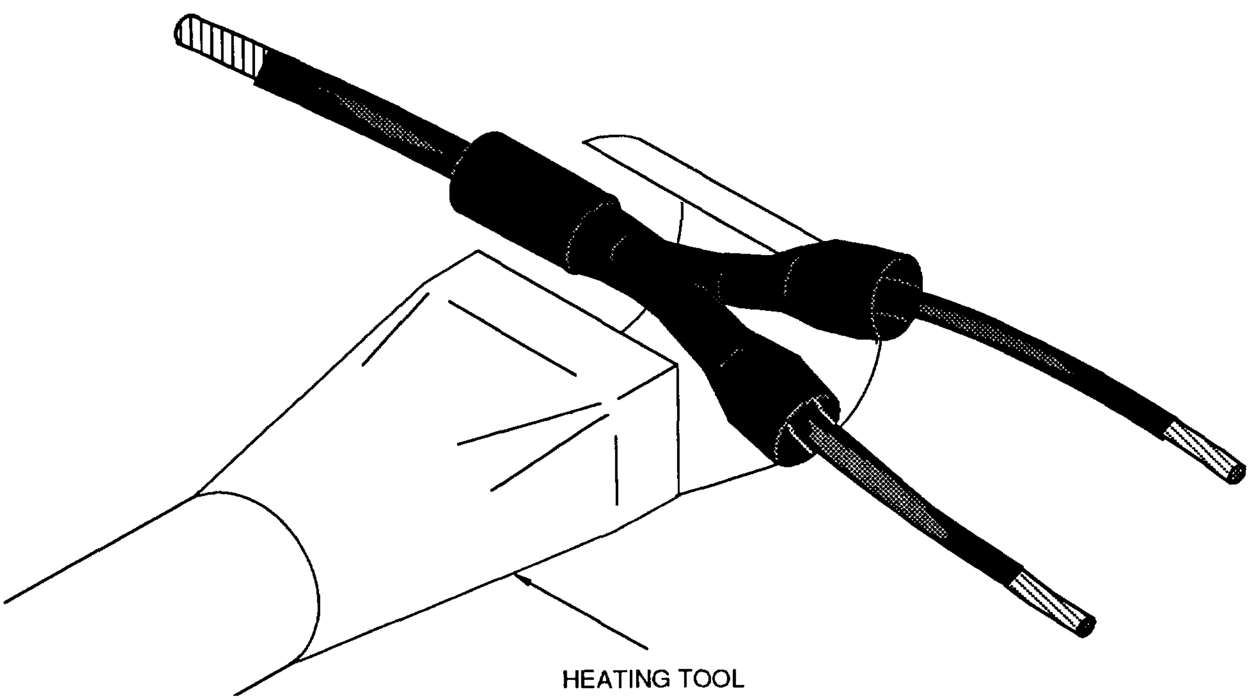


Figure 5. Transition Installation

12 . **CONNECTOR TERMINATION, JACKET AND ADAPTER PREPARATION.** To prepare harness assembly for termination, perform the following procedure:

a. Slip boot, grooved adapter and A or E type backshell over cable assembly wiring.

b. Crimp or solder wires to connector in accordance with WP 013 00 and WP 016 00.

c. After terminating wires to connector slide backshell and grooved adapter forward and thread in place.

d. If jacketed cable is used slip boot, grooved adapter and A or E type backshell over jacketed cable assembly.

e. Crimp or solder wires to connector in accordance with WP 013 00 and WP 016 00.

WARNING

Isopropyl Alcohol, TT–I–735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

f. Abrade end of tubing with sandpaper and clean with Isopropyl Alcohol.

g. Abrade inside of boot with sandpaper and clean with Isopropyl Alcohol.

13 . **HEAT-SHRINKABLE BOOT INSTALLATION.** To install the heat shrink boot, perform the following procedure:

a. Coat end of tubing and adapter with thin coat of adhesive.

(1) If using a grooved adapter coat knurled area behind groove.

(2) If A type backshell is used coat threaded area of backshell with adhesive.

(3) If E type backshell is used coat entire outside surface, ensure no excess adhesive makes contact with connector coupling nut.

b. Position heat-shrinkable boot over adapter or backshell.

(1) If using a lipped boot and grooved adapter position boot over groove.

(2) If using A type backshell position boot completely over threaded area.

(3) If using E type backshell position boot as close as possible to front of backshell without interfering with coupling nut.

(4) If using 90 degree boot position angle in respect to polarizing key.

c. Using heat gun and reflector, start at large end of boot and shrink until boot contacts A or E type backshell or boot is fully seated on adapter.

d. When large end is fully recovered over appropriate adapter begin moving heat toward small end of boot until boot shrinks on cable.

WARNING

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e. Remove excess adhesive immediately after shrinking with cloth moistened with Isopropyl Alcohol.

f. Leave undisturbed until adhesive cures.

14 . **ENVIRONMENTAL HARNESS MOLDING.** The boots and transitions are injected with molding compound which provide a complete environmental seal at wire junctions. Use the following procedure to environmentally seal these junctions (Figure 6).

a. Place cone-shaped riser in hole of boot or transition and inject molding compound into boot or transition until riser is filled.

b. Withdraw sealing gun from molded components and insert small plug in hole.

WARNING

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c. Clean excess compound from molded components using Isopropyl Alcohol.

d. Allow molding to cure at room temperature or with heat depending on type compound used.

e. After compound is completely cure, cut riser flush with surface of component (Figure 7).

15. <u>CONNECTOR AND CONTACT REPAIR.</u>

16 . **RE-ENTRY TO CONNECTORS WITH SPIN COUPLING ADAPTERS.** Uni-boots and bulbous boots can usually be reused. Low profile boots, however, may not provide enough access to rear of connector, and may have to be cut off and replaced. Perform the following procedure to gain entry to the connector.

a. Disconnect cable.

b. Using connector pliers with plastic jaws, turn coupling ring counterclockwise (Figure 8).

c. Using heat gun and appropriate reflector, heat boot until it is warm to touch and becomes flexible (Figure 9).

d. Pull adapter and boot back from connector, exposing wiring, and hold boot back until cool (Figure 10).

e. If boot is damaged, boot must be replaced.

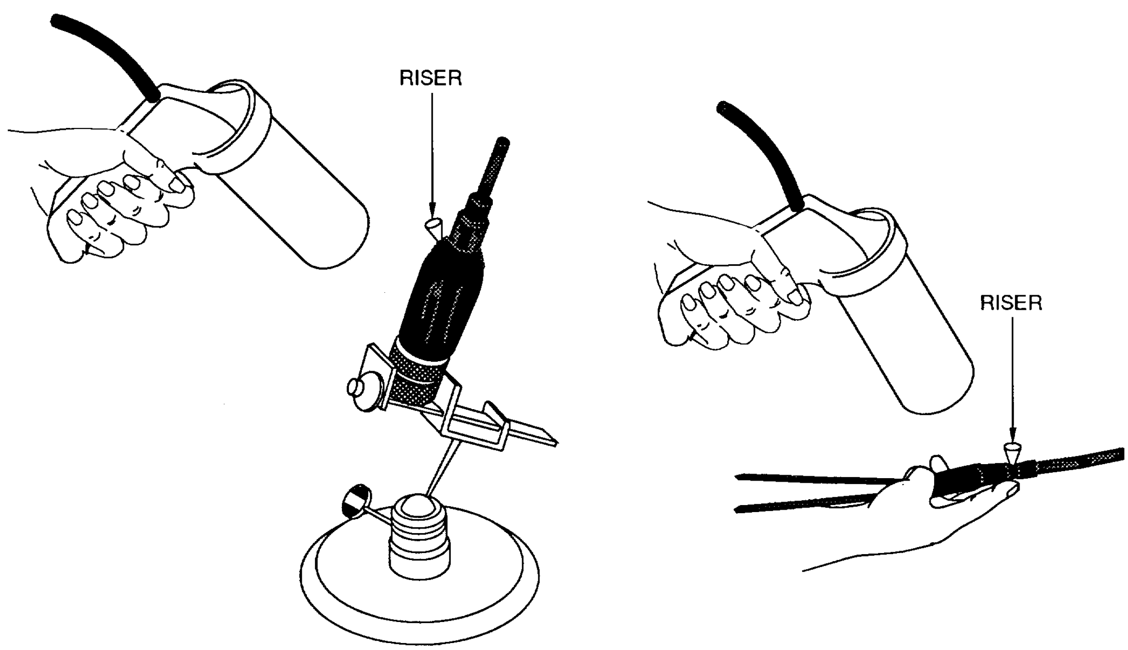

Figure 6. Molding Compound Injection

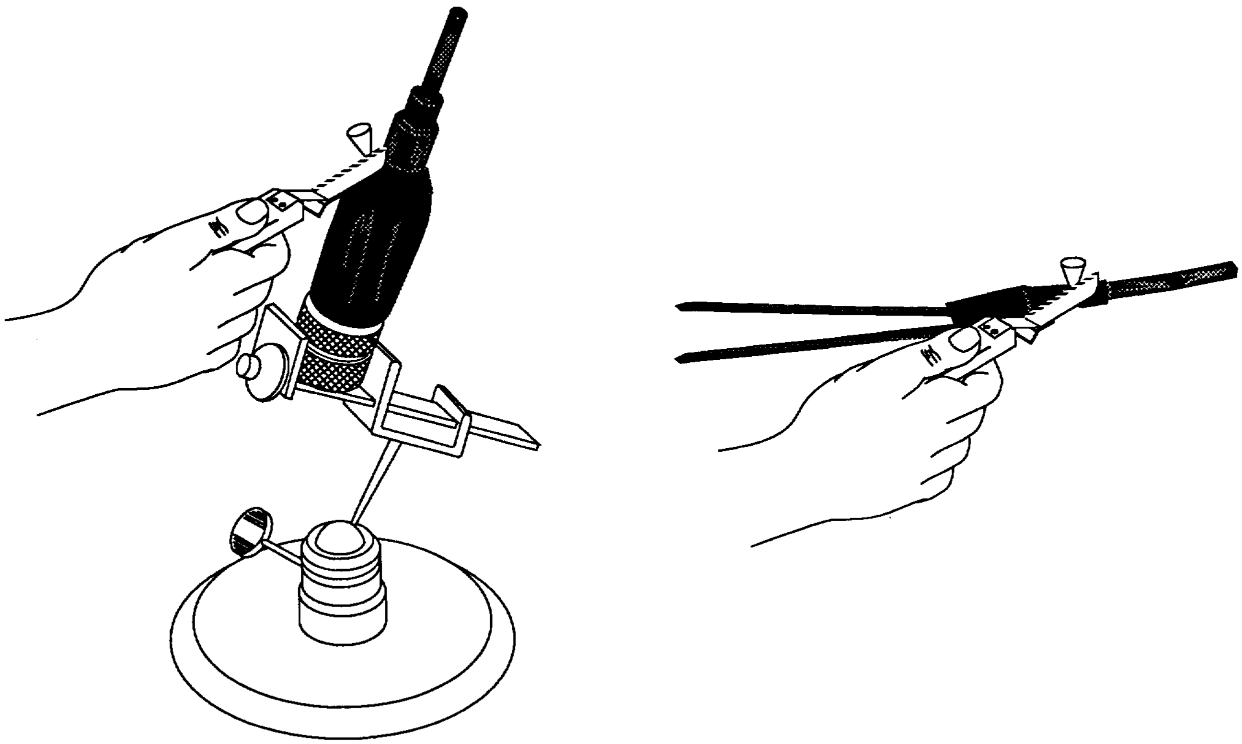

Figure 7. Cutting Riser

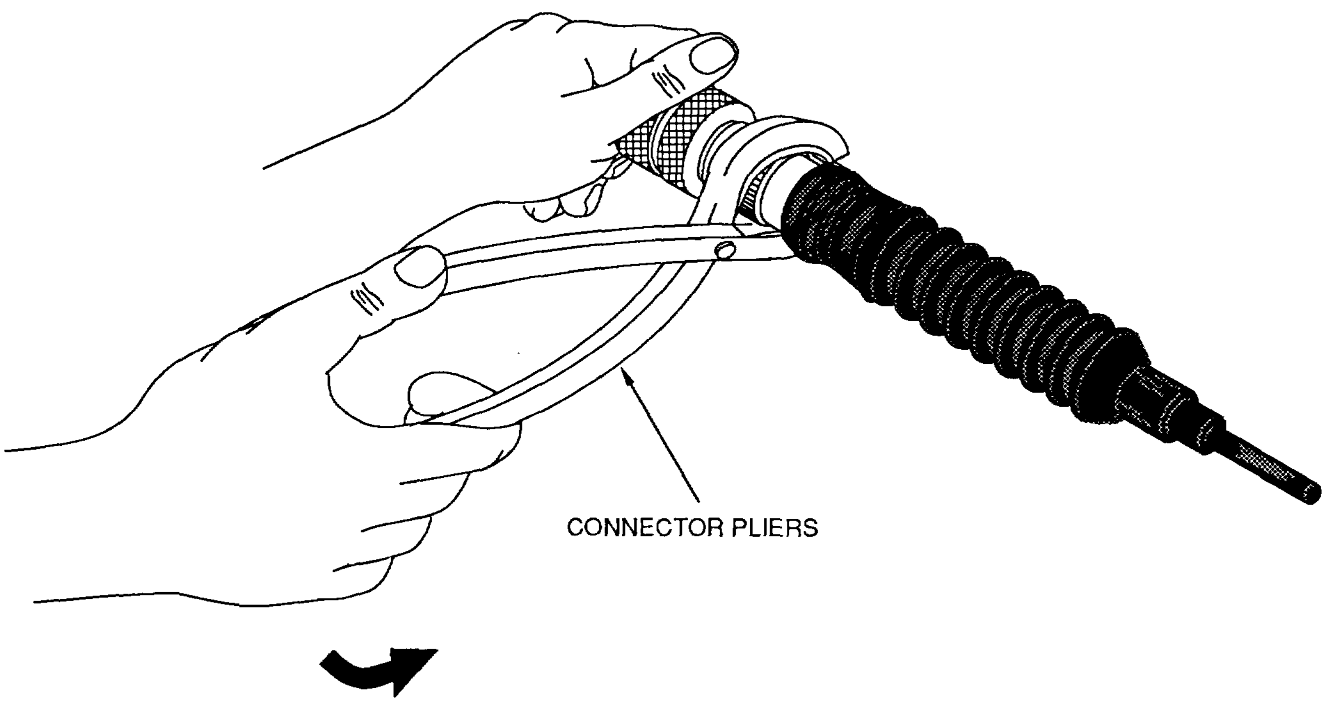

Figure 8. Removing Coupling Ring

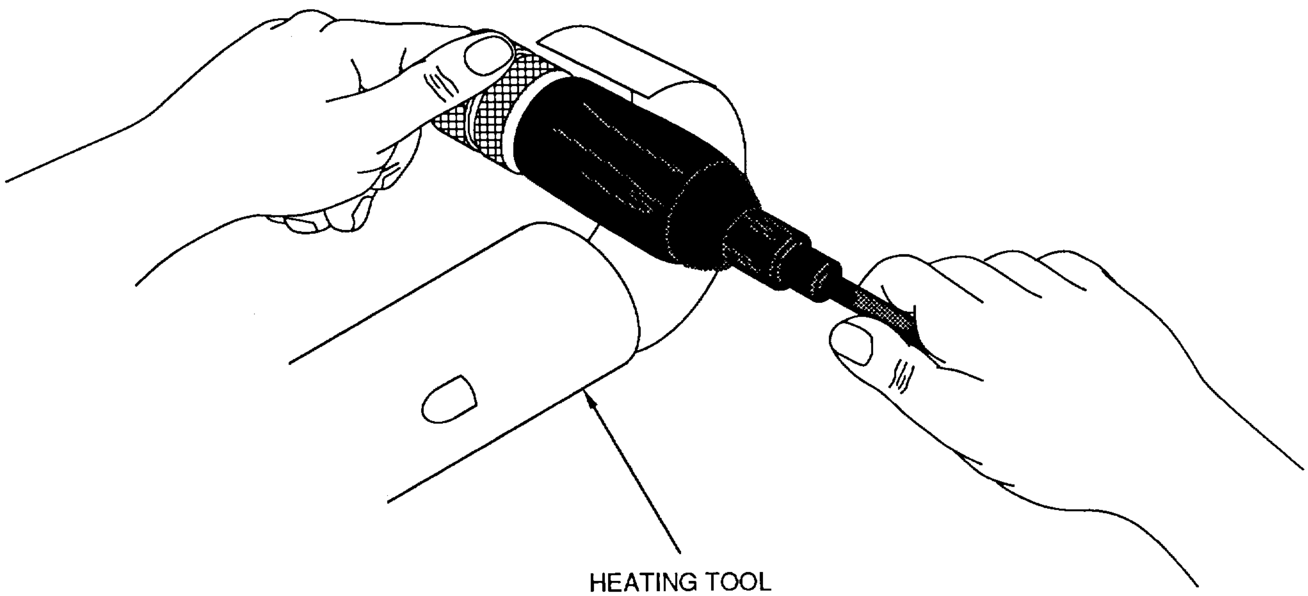

Figure 9. Heating Boot

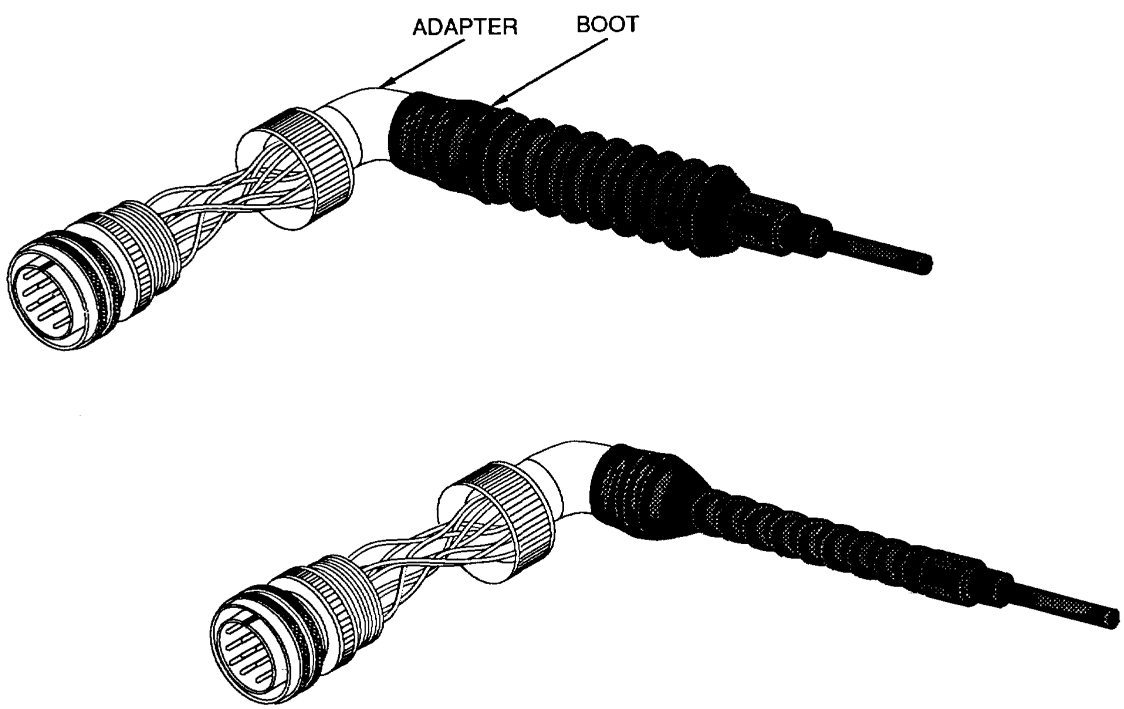

Figure 10. Adapter and Boot Pulled Back

17 . **RE-ENTRY TO CONNECTORS WITHOUT SPIN COUPLING ADAPTERS.** To gain access to rear of connectors having solid or no adapter, the boot must be removed and a new boot installed. Perform the following procedure:

a. Disconnect cable.

b. Remove boot.

18 . **CONTACT REMOVAL AND INSERTION.** Use the following procedure to remove and install contacts in the connector:

a. Re-enter connector.

b. Identify and mark conductors as required to permit proper contact reinstallation.

c. Remove, repair and insert contacts in accordance with WP 013 00.

d. Insert contacts and sealing plugs into any unused contact cavities.

e. Reclose connector.

19 . **CONNECTOR RECLOSING WITH SPIN COUPLING ADAPTERS.** Use this procedure to reattach a spin coupling adapter with boot to rear of connector where boot was folded back.

CAUTION

Do not direct hot air at ends of boot where adhesive joints are located.

a. Using heat gun with reflector, heat boot until it is warm and flexible.

b. Pull adapter to connector while boot is warm and flexible.

c. Orient connector and adapter so connector will mate without twisting harness.

d. Coat threads with thread coating compound.

e. Screw coupling ring onto connector (Figure 11).

f. Tighten coupling ring to torque values specified in Table 1.

20 . **CONNECTOR RE-ORIENTATION.** If connector is attached to a spin coupling adapter such that cable is twisted or bent in wrong direction, re-align connector and adapter as follow:

a. Loosen adapter coupling ring with connector pliers.

b. Rotate connector to proper position.

c. Tighten coupling ring to torque value specified in Table 1.

21 . **HARNESS REPAIR.**

22 . **BOOT REPLACEMENT.** The following procedures are for the replacement of damaged boots and for gaining access to rear of a connector which has a non-reenterable boot and/or adapter.

23 . **Boot Removal.** To remove the boot use the following procedure:

a. Score boot lengthwise with cutting tool ensuring not to cut through boot into cable jacket.

b. Using heat gun with reflector heat entire boot including the adhesive bond areas at both ends.

Table 1. Adapter Coupling Ring Torque Values:
(Applies to SAE AS 85049 Metal and Composite Backshells)

Connector Shell Size	Torque Value (In-Lbs) Heavy Duty	Torque Value (In–Lbs) Light/ Medium Duty	Connector Shell Size	Torque Value (In-Lbs) Heavy Duty)	Torque Value (In–Lbs) Light/ Medium Duty
8	65–70	40–45	22	150–155	85–90
10	85–90	40-45	24	150–155	85–90
12	120–125	40-45	28	165–170	N/A
14	130–135	40-45	32	165–170	N/A
16	130–135	40-45	36	165–170	N/A
18	130–135	40-45	40	180–185	N/A
20	150–155	85–90	44	180–185	N/A
			48	180–185	N/A

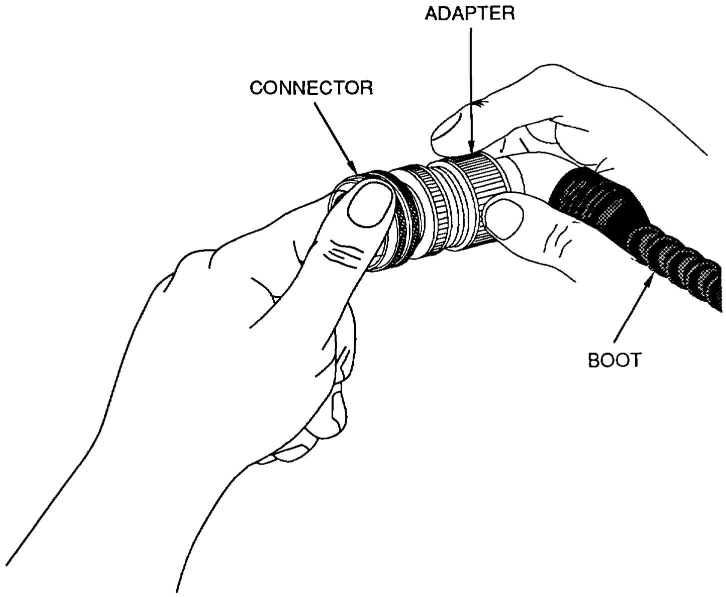

Figure 11. Coupling Installation

c. Peel boot from connector or adapter and cable jacket.

d. Clean excess adhesive from connector or adapter.

24 . **Boot Installation.** To install a new boot, perform the following procedure:

a. Determine material, size, and configuration of boot to be installed.

b. Select repair boot (Table 2 or Table 3).

c. If inside diameter of new boot is too small, either remove connector or select larger size boot.

d. Abrade bonding surfaces of jacket and boot using emery cloth (Figure 12).

e. Wipe loose particles from abraded surfaces with clean cloth.

WARNING

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f. Clean boot attachment surface of adapter or connector with Isopropyl Alcohol.

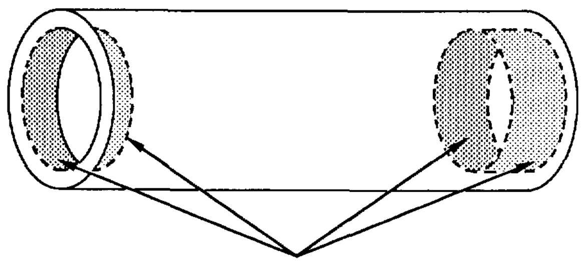
g. Select proper adhesive from Table 3 and apply adhesive to bonding areas of cable jacket and connector/adapter.

Table 2. Repair Boot Selection

Connector or Adapter Dia. at Boot Interface	Jacket Min. Dia.	Non-Adapter Bulbous Boot	Bulbous	Adapter Boots	
				Low Profile	Uni-Boot
.35 - .40 inch	.20 inch	202A111	—	—	202C611
.40 - .50 inch	.25 inch	202A121	202D121	—	202C611
.50 - .60 inch	.30 inch	202A132	202D121	202D211	202C621*
.60 - .70 inch	.30 inch	202A132	202D132	202D221	202C621*
.70 - .80 inch	.30 inch	202A142	202D142	202D221	202C632*
.80 - .90 inch	.35 inch	202A142	202D142	202D232	202C632*
.90 - 1.0 inch	.40 inch	202A153	202D153	202D242	202C642*
1.0 - 1.2 inch	.45 inch	202A153	202D153	202D242	202C642*
1.2 - 1.4 inch	.55 inch	202A163	202D163	202D253	202C653*
1.4 - 1.6 inch	.65 inch	202A174	202D174	202D263	202C653*
1.6 - 1.8 inch	.65 inch	202A174	202D174	202D263	202C653*
1.8 - 2.0 inch	.80 inch	202A185	202D185	202D274	202C653*
2.0 - 2.2 inch	.80 inch	202A185	202D185	202D285	—
2.2 - 2.4 inch	.80 inch	202A185	202D185	202D285	—
2.4 - 2.6 inch	1.1 inch	202A196	202D196	202D296	—
*Requires shimming at J end Use short length of heat-shrinkable jacket material or repair tubing.					

Table 3. Boot Material Selection

Harness System Nomenclature	Harness Jacket Material	Boot Material	Adhesive
10	RT-102 Polyolefin	Flexible Polyolefin -4, -71	S-1030
15	NT-FR Neoprene	Semi-rigid Polyolefin-3	S-1009
20	NT-FR Neoprene	EPB-51	S-1009
25	DR-25	-25 Elastomer	S-1125
30	VPB	VPB-50	S-1125
Silicone	SFR	SFR-6	GE RTV-108



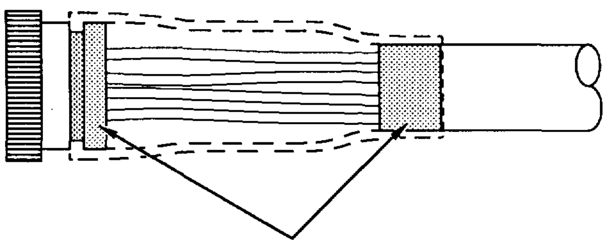


Figure 12. Abrading Bonding Surfaces

h. Slide new boot over harness and position boot over connector or adapter. Ensure end of boot marked H is toward connector and J is toward cable jacket (Figure 13).

i. Using heat gun and reflector shrink boot onto backshell adapter or connector first, then work toward cable end of boot (Figure 14).

j. Clean excess adhesive from each end of boot For hot melt adhesive use wooden paddle.

(1) For hot melt adhesive use wooden paddle.

(2) For thermosetting (epoxy) adhesive use clean cloth or tissue.

k. Cure adhesive. Ensure bond line is not moved or stressed.

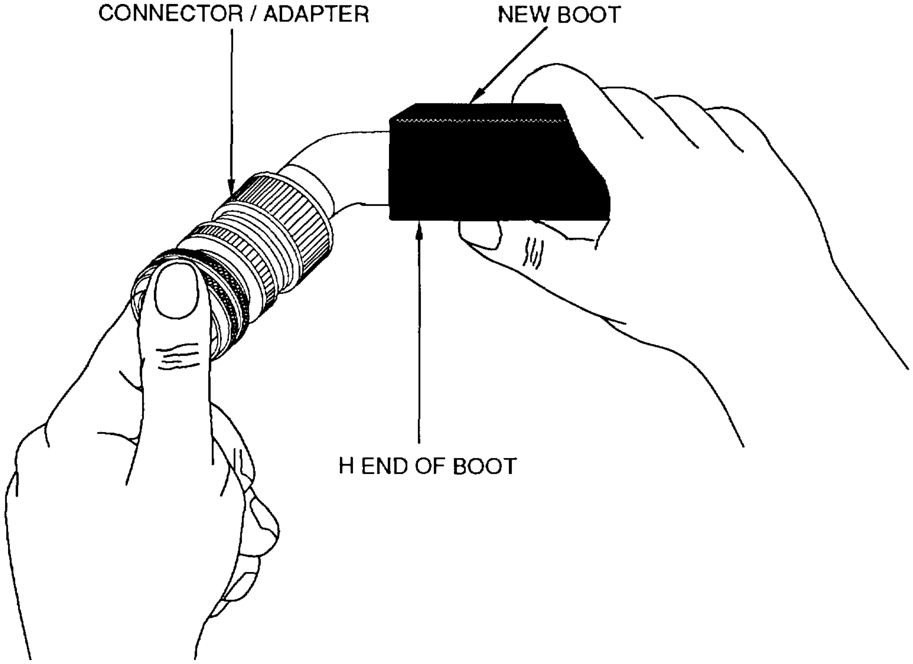


Figure 13. Shrinking Toward Cable End

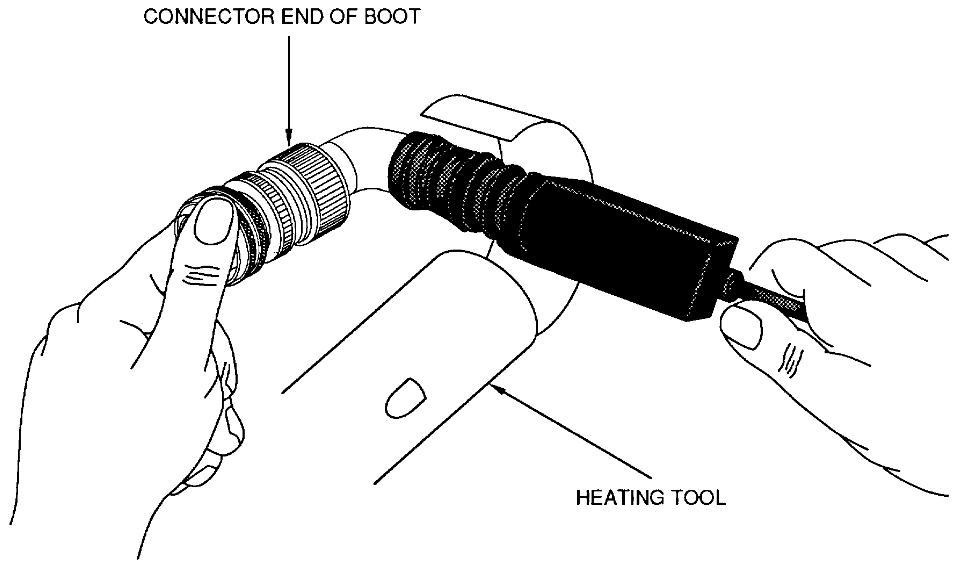


Figure 14. Shrinking Boot Over Connector Adapter

25 . **ADAPTER REPLACEMENT.** Use the following procedures to replace solid, spin-coupling, and shield adapters. If adapter is replaced the attached boot must also be replaced (Paragraph 24).

26 . **Adapter Removal.**

a. Disconnect connector.

CAUTION

Take care not to cut into cable jacket.

b. Score boot lengthwise with cutting tool.

c. Using heat gun with reflector heat entire boot including adhesive bond areas, until boot is warm and flexible.

d. Using pliers peel boot from jacket.

e. Using connector pliers with plastic jaws turn adapter or coupling ring counterclockwise and remove (Figure 15).

f. Identify and mark conductors to permit proper re-installation.

g. Remove contacts or unsolder wires from connector in accordance with WP 020 00 and WP 025 00.

h. Remove adapter (Figure 15).

(1) For adapters without shields simply remove adapter.

(2) For shielded adapters separate adapter shield from cable shield and remove adapter from cable.

(3) If shields are tied together with lacing cord cut cord and pull adapter from cable.

(4) If shields are tied together with wire whipping unsolder and unwrap wire.

(5) If shields are soldered together use infrared or hot air heating tool to melt solder while carefully pulling adapter.

27 . **Adapter Installation.** If cable has shield braid ensure that the braid is straightened out and smoothed. Remove excess solder from braid.

a. Slide new heat-shrinkable boot back over cable, ensure the end marked J goes on first and the end marked H goes toward adapter (Figure 16).

b. If braid splice is used, slide splice onto cable.

c. Slide new adapter over cable (Figure 17).

d. Using procedures in WP 020 00 and WP 024 00, insert contacts into proper contact cavities in connector or resolder wire to connector terminals.

NOTE

All unused cavities in circular and rectangular connectors shall be filled with unwired contacts and appropriate MS27488 sealing plugs (see WP 020 00, para 33 Sealing Plug Selection). The unwired contacts and sealing plugs are required to preserve the environmental sealing characteristics of the connectors.

e. Fill all unused cavities with contacts and sealing plugs.

f. Coat threads of adapter with thread coating compound.

g. Attach adapter to connector so harness does not twist (Figure 18).

h. Tighten adapter or coupling ring to proper torque (Table 1).

i. Install new boot (Paragraph 24).

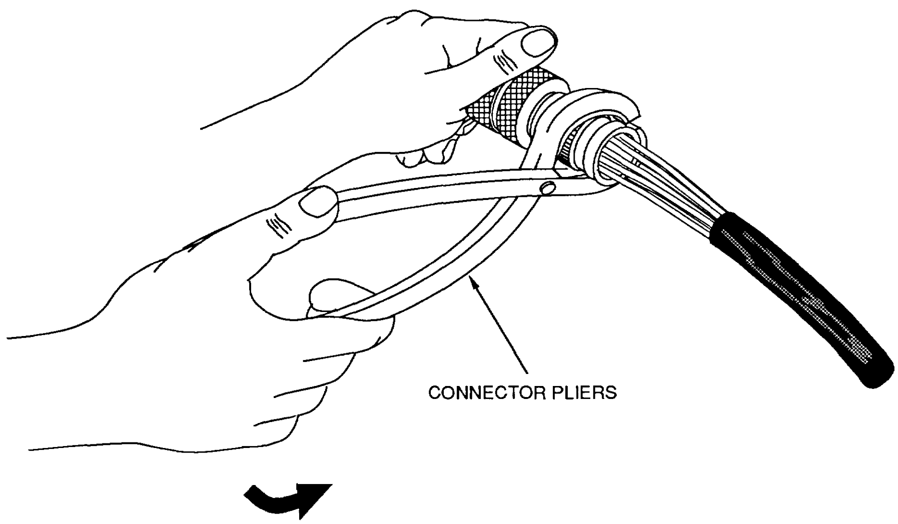


Figure 15. Removing Adapter or Coupling Ring

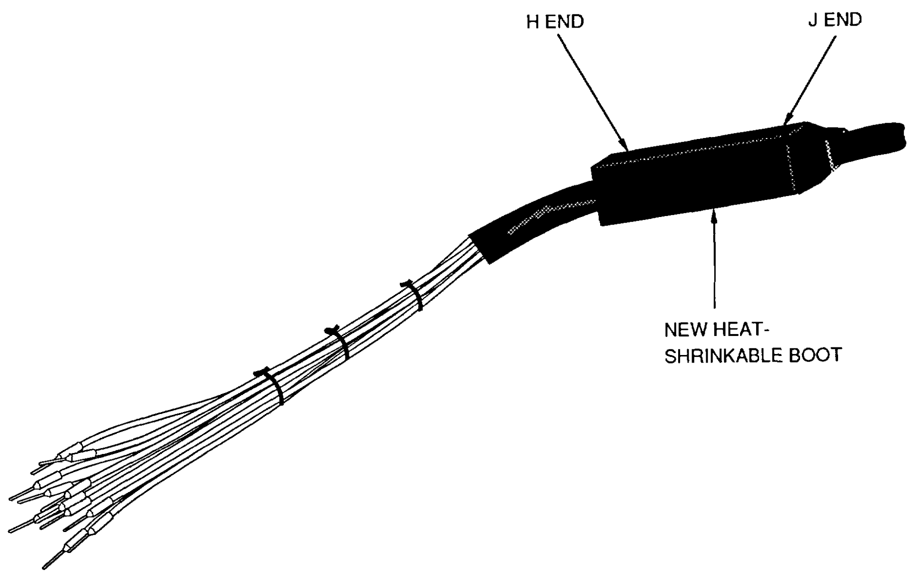


Figure 16. Installing New Boot

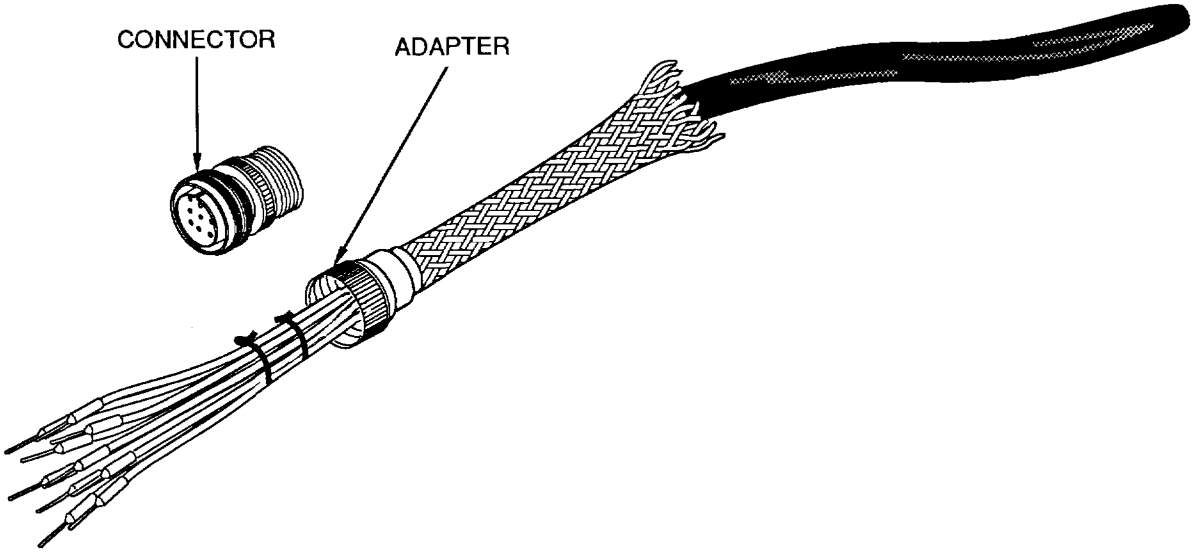


Figure 17. Adapter Removal and Installation

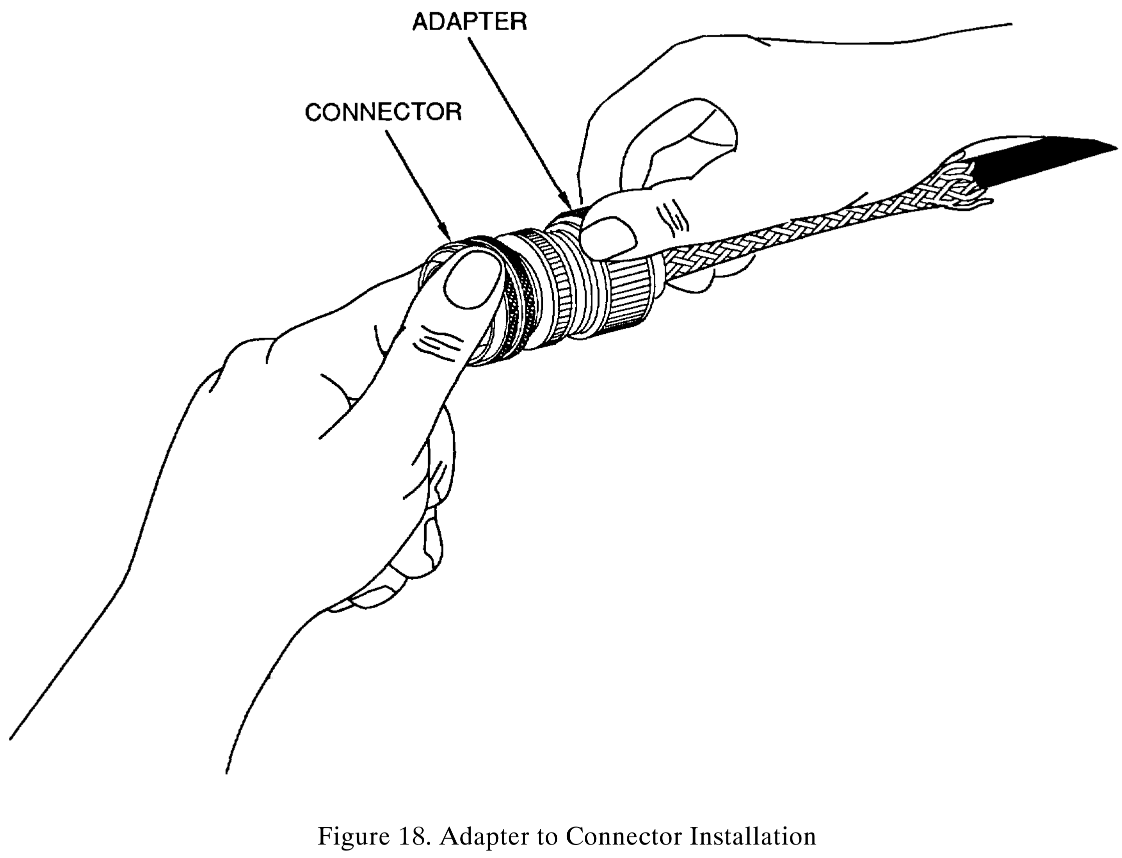


Figure 18. Adapter to Connector Installation

28 . **JACKET REPAIR.** This procedure is for using heat-shrinkable repair tubing to make moisture tight repairs to damaged harness jacketing without removing connectors.

a. Inspect shield and component wiring for damage.

(1) If shield is damaged refer to WP 011 00.

(2) If wiring is damaged, refer to WP 014 00.

b. Clean any oil, dirt, or grease from repair area.

c. Abrade cable jacket with emery cloth in repair area.

d. Wipe loose particles from abraded surface with clean cloth or tissue.

e. Using lacing cord spiral wrap damaged area and tie at both ends and center.

f. Select repair tubing material and adhesive (Table 4).

g. Select diameter of repair tubing (Table 5 and Table 6).

h. Select repair tubing installed length.

(1) Six-inch if damaged area is less than one inch long.

(2) Twelve-inch if damaged area is one to six inches long.

(3) VPB tubing increases slightly in length as it shrinks in diameter.

(4) RP-4800 tubing shrinks considerably in length as it shrinks in diameter. Installed length is marked on tubing in six inch increments.

i. Using heat gun with reflector shrink tubing starting at center of repair area and work toward each end (Figure 19).

WARNING

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j. Clean excess adhesive from each end of repair tubing.

k. Cure adhesive. Bond must be moved or stressed during cure time.

29 . **TRANSITION REPAIR.** Transitions with minor damage, such as a cut or hole, can be repaired using tubing if the damaged area is located so the repair tubing will extend a minimum of one inch each way from damaged area. Transitions with major damage, such as splitting, must be replaced.

30 . **TRANSITION REPLACEMENT.** A transition with major damage can be covered with a new transition of the same size and material. Refer to Figure 20, Table 7 and Table 8 for information on transition size and type selection.

31 . **TRANSITION REMOVAL.**

a. Score transition lengthwise along each leg with cutting tool. Ensure not to cut through transition into cable.

b. Use heat gun with reflector heat r\transition until warm and flexible.

c. Using pliers, remove warm transition from cable.

d. Inspect cable for damaged shield and component wiring.

(1) If shield is damaged, refer to WP 011 00.

(2) If wiring is damaged, refer to WP 014 00.

Table 4. Repair Tubing Material Selection

Harness Jacket System Nomenclature	Harness Jacket Material	Repair Tubing Material	Adhesive
10	RT-102 Polyolefin	RP-4800	S-1030
—	RT-876 Polyolefin	RP-4800	S-1030
15, 20	NT-FR Neoprene	RP-4800 or VPB-RT	S-1009, S-1030
25	DR-25 Elastomer	VPB-RT	S-1125
30	VPB-Elastomer	VPB-RT	S-1125
—	SFR Silicone	RP-4800	Silicone

Table 5. VPB-RT Repair Tubing Diameter Selection

Cable Jacket Diameter Range	Maximum Connector Diameter	VPB-RT Repair Tubing Part Number
.25 - 0.35 in.	.7 in.	VPB-RT-3/4 -*
.35 - 0.50 in.	.9 in.	VPB-RT-1 -*
.50 - 0.70 in.	1.4 in.	VPB-RT-1 1/2 -*
.70 - 1.00 in.	1.9 in.	VPB-RT-1 -*
1.00 - 1.75 in.	2.8 in.	VPB-RT-3 -*
*Length callout: -6 = 6 inch; -12 = 12 inch. See Step 10.		

Table 6. RP-4800 Repair Tubing Diameter Selection

Cable Jacket Diameter Range	Maximum Connector Diameter	RP-4800 Repair Tubing Part Number
.3 - 0.6 in.	1.0 in.	RP-4800-1
.6 - 0.8 in.	2.0 in.	RP-4800-2
.8 - 1.1 in.	3.0 in.	RP-4800-3
1.1 - 1.6 in.	4.0 in.	RP-4800-4

Table 7. Transition Tubing Material Selection

Harness System or Material Type Selection	Harness Jacket Material	Transition Material	Adhesive
–51	Elastomer	Elastomer	S–1124
–71	RT–102 Polyolefin	Flexible Polyolefin	S–1017 or S–1048
–125	Fluoropolymer	Fluoropolymer	S–1125–04

Table 8. Transition Dimension and Item Selection

Part Number	H		J & K		W	P	R & S
	Min	Max	Min	Max	Nominal	Nominal	Nominal
381A301	.78	.26	.52	.26	.04	1.60	1.60
381A302	1.35	.45	.90	.45	.05	2.48	2.48
381A303	2.37	.79	1.58	.79	.06	3.73	3.73
381A304*	3.28	1.31	2.16	1.31	.07	5.27	5.27
Note: Coating is optional. When added entry diameter is reduced by .06" All dimensions in inches							
* Not available in –125 Fluoropolymer material							

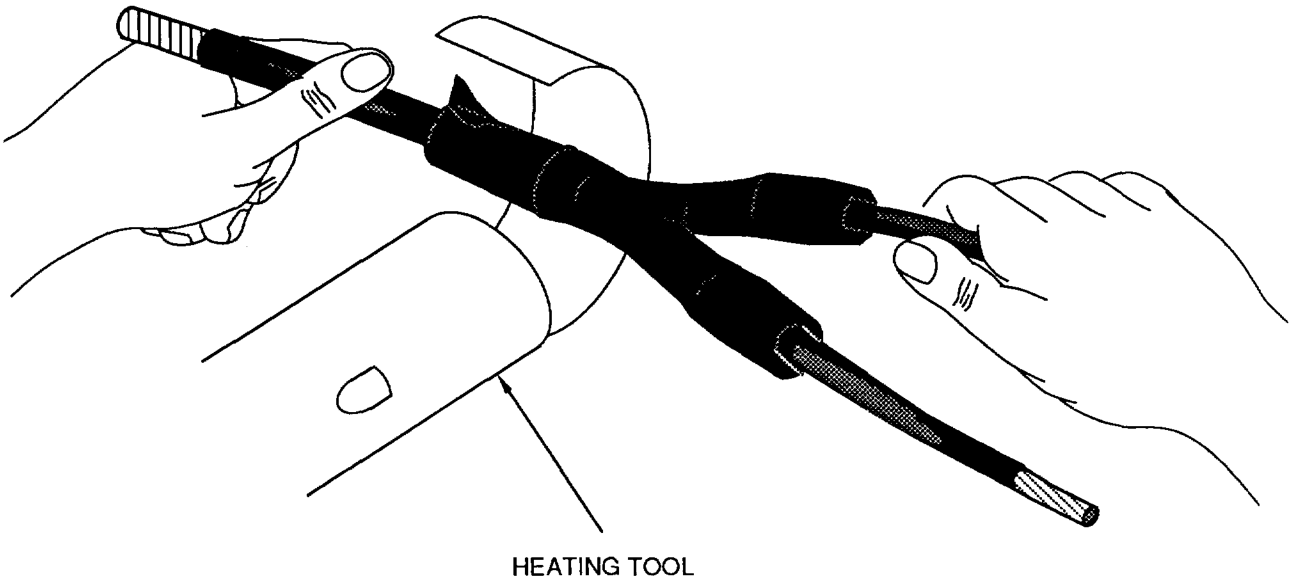

Figure 19. Heating Transition

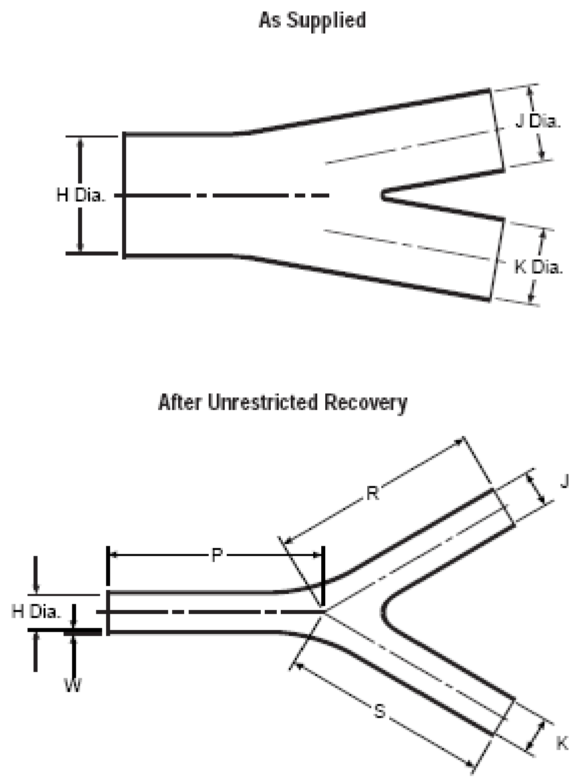

Figure 20. Transition Dimensions

32 . **TRANSITION INSTALLATION.**

a. Abrade surfaces to be bonded (jacket and transition) using emery cloth.

b. Clean loose particles from abraded surface with clean cloth or tissue.

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Degrease inner surface of transition with Isopropyl Alcohol.

d. Apply adhesive to repair area.

e. Place repair tubing over cable and center over repair area (Figure 21).

f. If harness is shielded ensure that shield in transition area is smooth and uniform with no frayed ends which could split new transition.

g. Slide new transition over harness (Figure 22).

(1) If connector and boot are too large to permit transition to pass over remove connector in accordance with WP 016 00 and WP 020 00.

h. Apply adhesive to bonding areas (Figure 23).

i. Position transition onto cable so junction occurs within transition.

j. Using heat gun with reflector shrink transition.

k. Clean excess adhesive from each end of transition

l. If connectors and boots were removed, reinstall.

(1) Install boot (Paragraph 24).

(2) Install connector in accordance with WP 016 00 and WP 020 00.

m. Cure adhesive. Ensure bond line is not moved or stressed during cure time.

33 . **ADHESIVE BOND JOINT REPAIR.** Joints where boots and transitions are bonded to cable jackets require repair if any gap is visible at the interface. To repair perform the following procedure:

a. Wipe off any dirt, oil, or grease in area to be repaired.

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

b. If oil or grease is present or suspected, clean area to be bonded with Isopropyl Alcohol and allow to dry for a minimum of five minutes.

c. Use an applicator stick to work adhesive into space between jacket and boot or transition (Figure 24).

d. Using heat gun heat bond area to ensure that boot or transition is fully shrunk onto jacket.

e. Clean excess adhesive from bond area.

f. Cure adhesive. Ensure bond line is not moved or stressed during cure time.

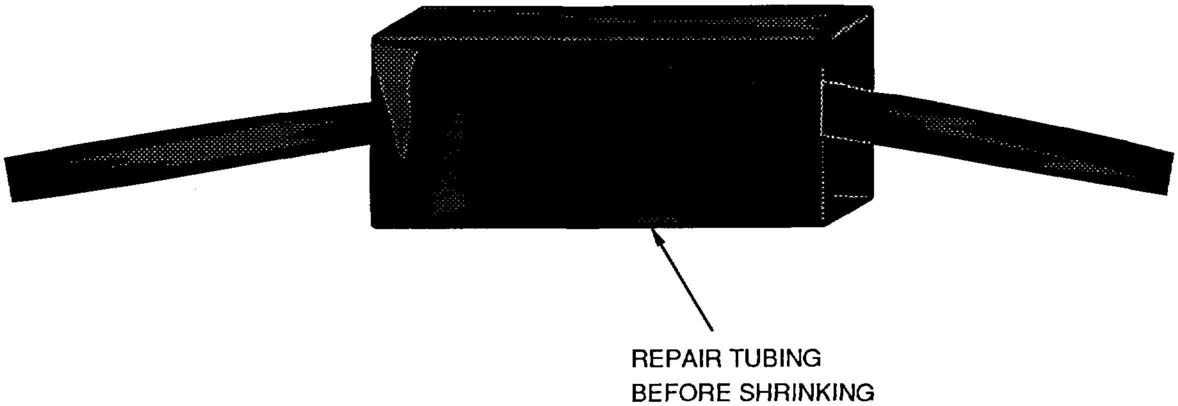

Figure 21. Repair Tubing Before Shrinking

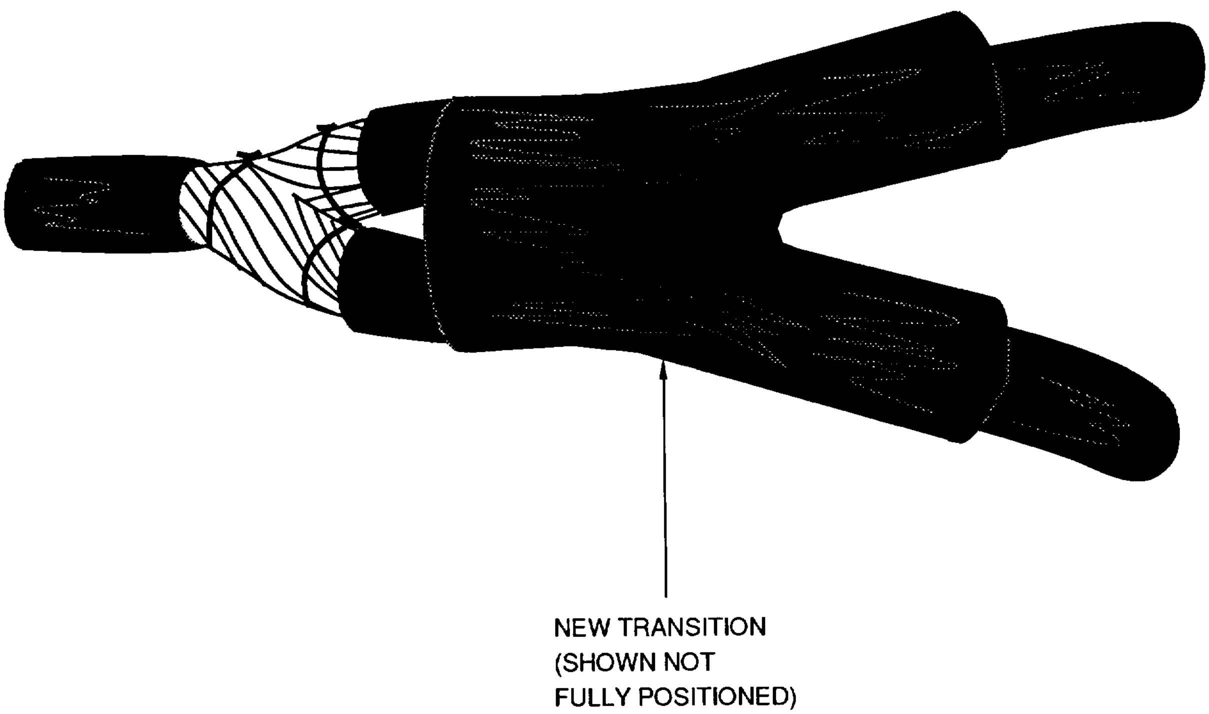

Figure 22. Transition Installation

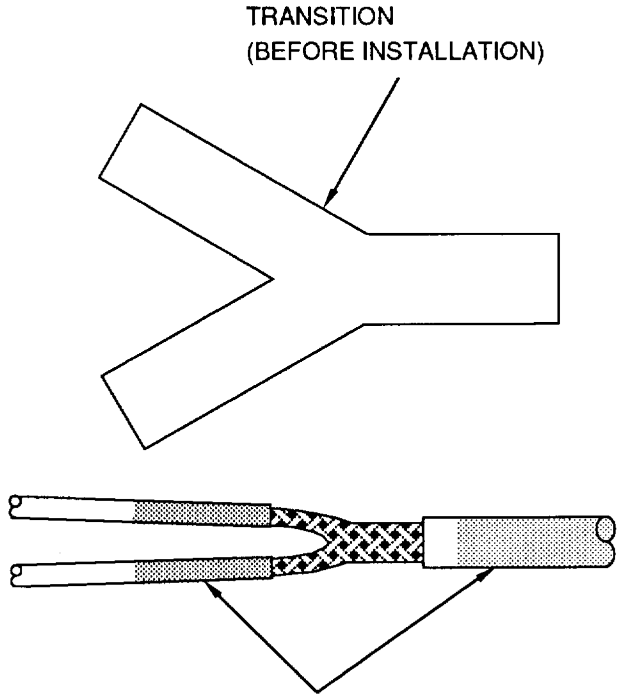

Figure 23. Adhesive Application

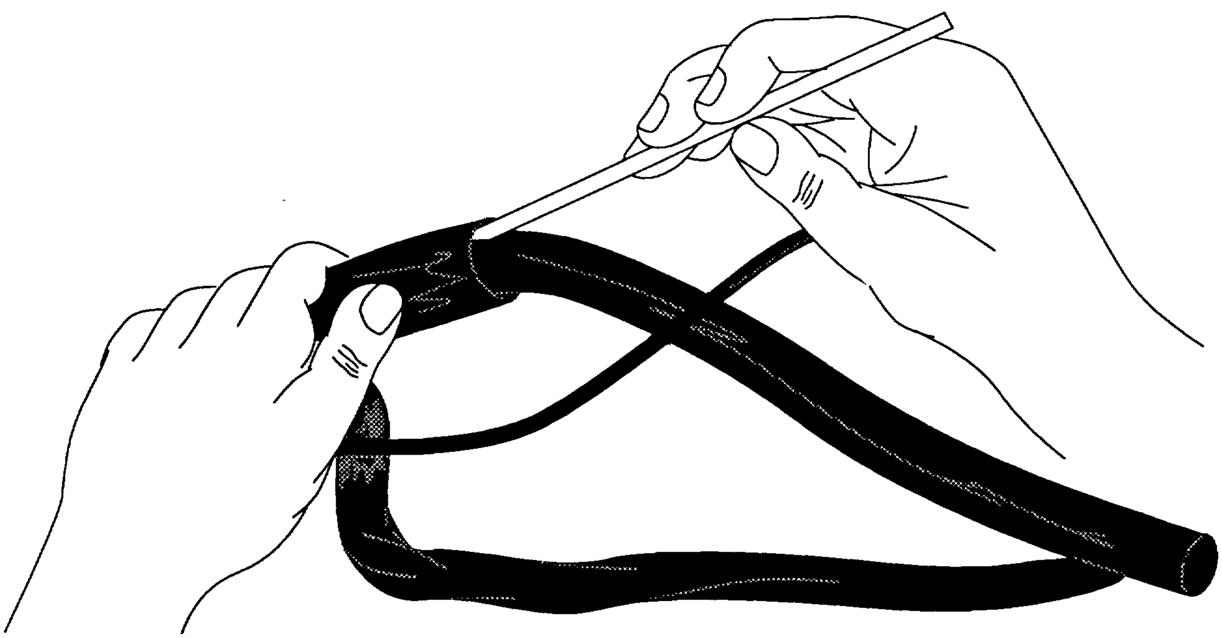

Figure 24. Inserting Adhesive

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BANDING TOOL DBS−1100 USE AND ADJUSTMENT

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Connector Accessories, Electrical Backshell, Shield Band, Cat: 7 (FOR AS85049/82 − /90, /93, /109 − /117 Accessories)	SAE AS85049/128
Wiring Installation Hand Tools for Metal and Plastic Straps	SAE AS90387
Wiring Installation Tools for Bands and Straps	SAE AS81306

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part. No./Type Designation
Band Removal Tool	4DBS−BR1
Fixture, Calibration, Inspection	DBS−CG2
Gage, Inspection	AD−1386
Rollover Tool	DBS−RO3
Wrench, Adjustment	DBS−1102−32
Wrench, Hex, 1/16 inch	74003
Wrench, Hex, 3/32 inch	74005

Materials Required

Nomenclature	Part. No./Type Designation
Bands, 1/4 Inch	M85049/128−1, or −2 (4−1380)

1. <u>INTRODUCTION.</u>

2. This work package (WP) addresses the calibration, use and operation of the DBS−1100 Banding tool used to terminate the metal over braid shielding for cables and wiring harnesses.

3. **GENERAL DESCRIPTION.** The DBS−1100 banding tool is used to install the metal bands used to terminate and secure metal, or cloth over braid (Figure 1).

4. **GO/NO−GO TEST AND CALIBRATION.** Prior to use, ensure the DBS−1100 banding tool operates properly by inspecting it and using the Go−No−Go gage AD−1386. Refer to Figure 2 for instructions on the Go−No−Go test. If the test passes, the tool is properly adjusted and ready for use. Adjust the tool if the Go−No−Go test does not pass by using the Calibration Tool DBS−CG2 (Figure 3).

5. **OPERATION AND USE.** Operation and use of the DBS−1100 banding tool is addressed in Figure 4. Refer to Figure 5 for detailed band installation instructions for metallic or cloth shielding/over braid termination.

6. Use 1/4” band part number: M85049/128−1, or −2 . The dash number is the configuration type for coiled or uncoiled, either is acceptable. If −1 used, then coil in two loops (the −3 will not work with the DBS−1100 tool) (see Figure 4 and Figure 5). Refer to SAE AS 85049/128, AS81306 and AS90387 for additional information.

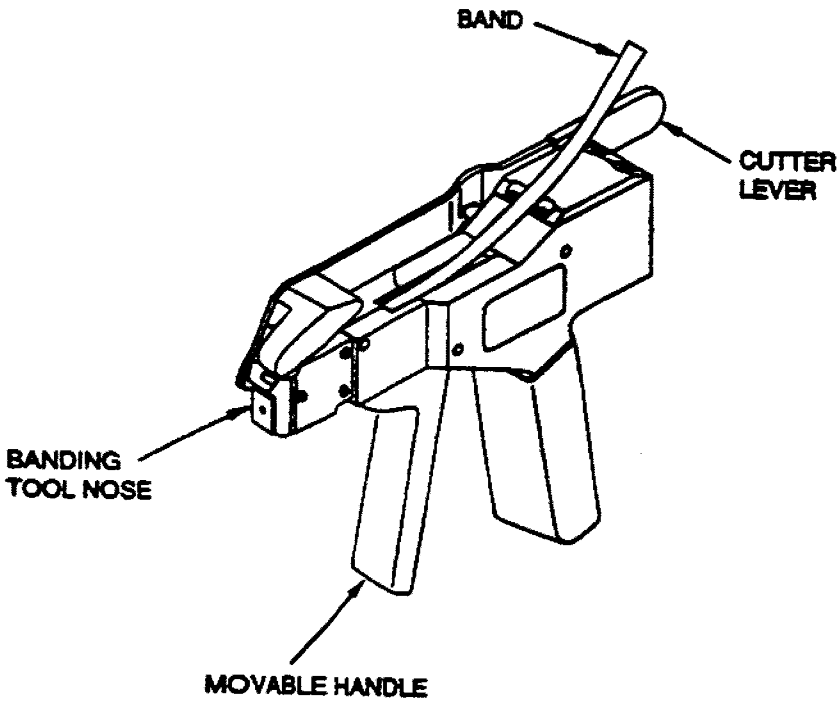
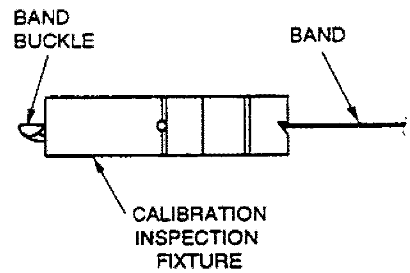


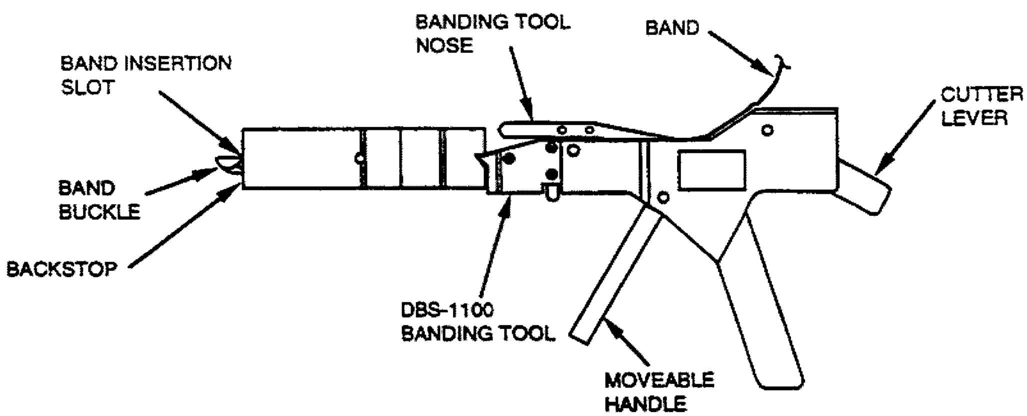
Figure 1. Banding Tool DBS−1100

A. UNCURL A BAND INTO A FLAT POSITION AND INSERT THROUGH THE BAND INSERTION SLOT OF CALIBRATION INSPECTION FIXTURE UNTIL IT EXTENDS COMPLETELY THROUGH THE FIXTURE AND THE BAND BUCKLE IS RESTING AGAINST THE BACKSTOP.



B. INSERT BAND INTO NOSE OF BANDING TOOL.

C. REPEATEDLY ACTUATE THE MOVABLE HANDLE, AS THE FIXTURE COMES CLOSER TO THE NOSE OF BANDING TOOL, USE SHORT STROKES UNTIL THE BAND IS SNUG. THEN USE ONE FULL STROKE AND THE MOVEABLE HANDLE WILL LOCK.



D. INSERT THE GO MEMBER OF THE GO/NO-GO GAGE INTO THE GAGE VERIFICATION SLOT OF THE CALIBRATION INSPECTION FIXTURE. IF THE GO MEMBER DOES NOT INSERT FREELY, THE TOOL IS EXERTING EXCESSIVE FORCE. LIKEWISE, IF THE NO-GO MEMBER FREELY ENTERS THE GAGE VERIFICATION SLOT, THE TOOL IS BELOW THE MINIMUM FORCE LIMIT. IF CALIBRATION IS REQUIRED, REFER TO FIGURE 3.

Figure 2. Banding Tool DBS-1100 Calibration (Sheet 1 of 2)

E. TO SEPARATE, ACTUATE THE CUTTER LEVER.

F. REMOVE SPENT BAND PIECES FROM CALIBRATION INSPECTION FIXTURE AND BANDING TOOL.

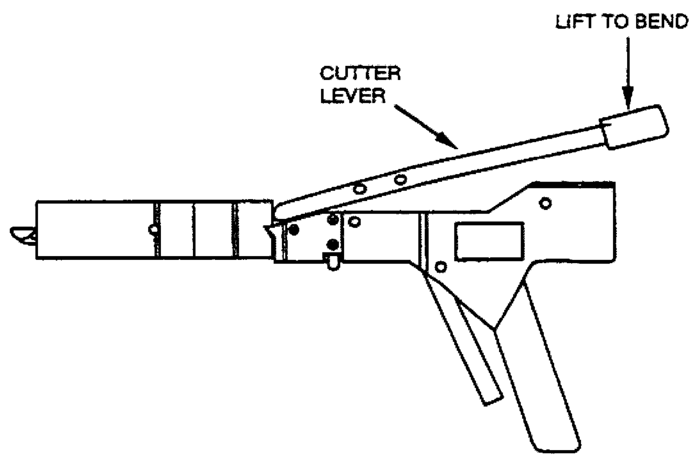
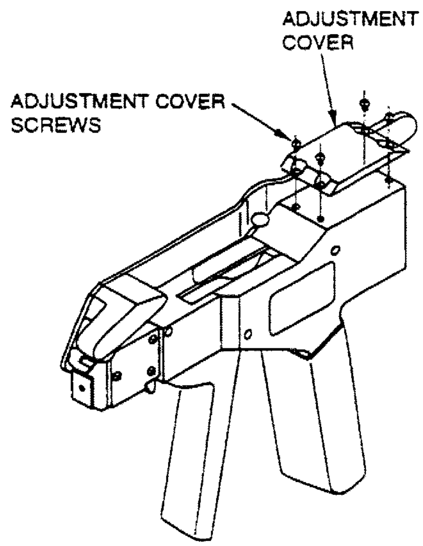


Figure 2. Banding Tool DBS−1100 Calibration (Sheet 2)

A. USING 3/32 INCH HEX KEY, REMOVE ADJUSTMENT COVER SCREWS AND ADJUSTMENT COVER.

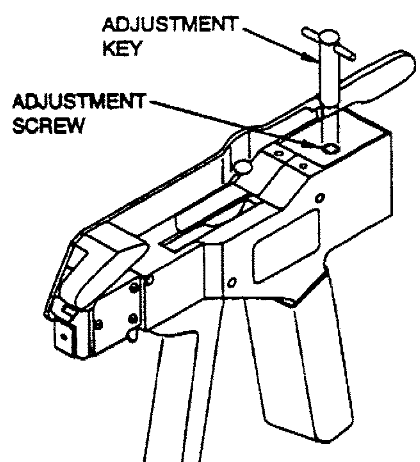


B. ADJUST TOOL CALIBRATION WITH ADJUSTMENT KEY. TO INCREASE TENSION, TURN ADJUSTMENT SCREW CLOCKWISE. TO DECREASE TENSION, TURN ADJUSTMENT SCREW COUNTERCLOCKWISE.

C. REPEAT CALIBRATION IN FIGURE 2.

D. IF BANDING TOOL IS NOT WITHIN PROPER CALIBRATION, REPEAT STEPS A THRU C UNTIL CALIBRATION IS CORRECT.

E. USING 3/32 INCH HEX KEY, INSTALL ADJUSTMENT COVER WITH ADJUSTMENT COVER SCREWS.



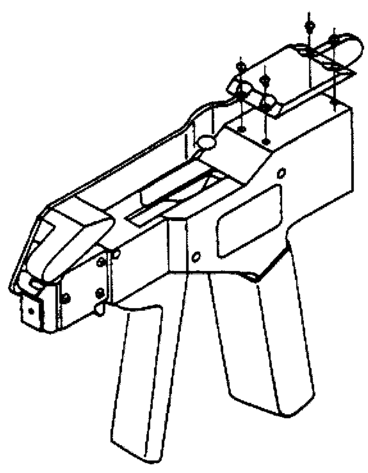
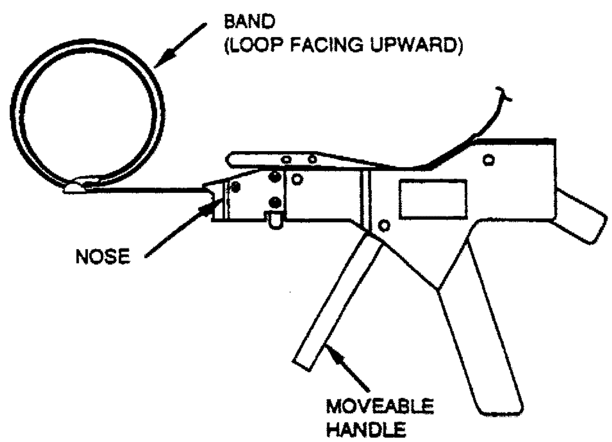


Figure 3. Adjusting Calibration Tool

A. INSERT BAND INTO BANDING TOOL AT LEAST 1.75 INCHES. THE BAND LOOP SHALL BE ORIENTED ON THE UPPER SIDE OF THE TOOL NOSE. ACTUATE THE MOVABLE HANDLE OF THE TOOL ONE COMPLETE STROKE TO INSURE THAT THE BAND HAS BEEN CAPTURED BY THE GRIPPING MECHANISM.

B. POSITION THE CONNECTOR AND THE SHIELD ASSEMBLY THROUGH THE BAND ALLOWING THE CONNECTOR TO BE ON THE LEFT SIDE OF THE TOOL.



C. REPEATEDLY ACTUATE THE MOVABLE HANDLE. AS THE FIXTURE COMES CLOSER TO THE NOSE OF THE BANDING TOOL, USE SHORT STROKES UNTIL THE BAND IS SNUG. THEN USE ONE FULL STROKE AND THE MOVEABLE HANDLE WILL LOCK.

D. AT ANY POINT IN THE OPERATION PRIOR TO THE LOCKING OF THE MOVABLE HANDLE, THE BAND MAY BE LOOSENED OR REMOVED BY DISENGAGING THE RETENTION PAWL. WHEN ACTUATING THE RETENTION PAWL, APPLY A FORCE ON THE BAND IN AN OPPOSING DIRECTION FROM THE TOOL TO LOOSEN OR REMOVE THE BAND.

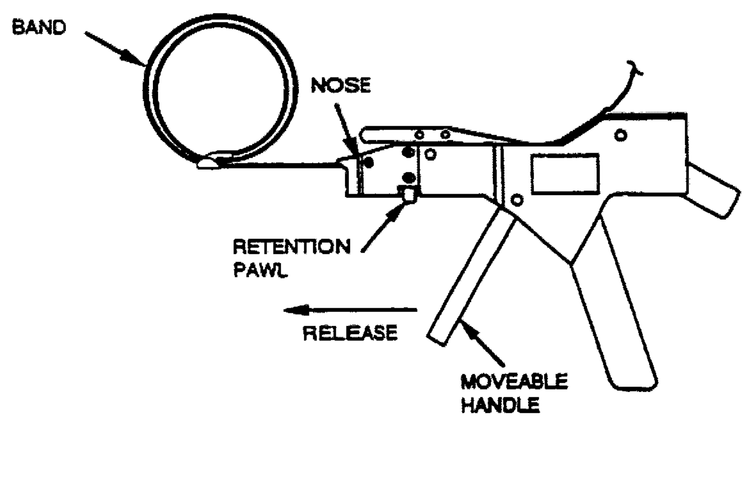
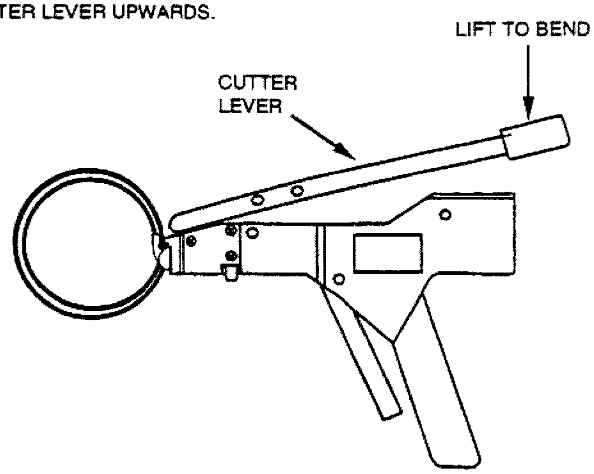


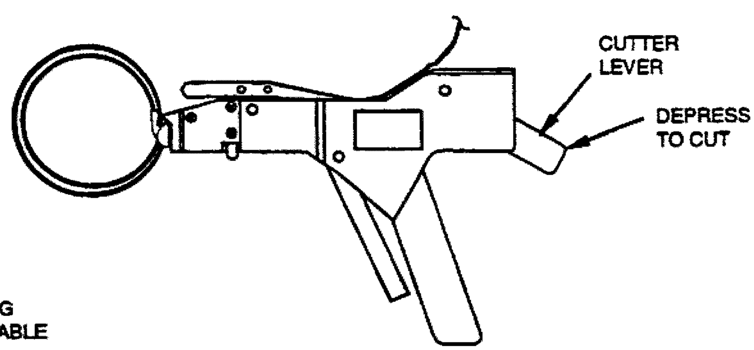
Figure 4. Operation of Banding Tool DBS−1100 (Sheet 1 of 2)

E. TO COMPLETE THE TERMINATION, THE BAND MUST BE BENT 90° BY LIFTING THE CUTTER LEVER UPWARDS.



F. CUT BAND BY DEPRESSING THE CUTTER LEVER DOWNWARDS.

G. WHEN THE CUTTING OPERATION HAS STARTED, IT MUST BE COMPLETED PRIOR TO ANY FURTHER MOVEMENT OF THE BAND IN THE TOOL.



NOTE

PREMATURE RELEASE OF THE MOVABLE HANDLE DURING THE BENDING CYCLE IS ACCEPTABLE

H. REMOVE EXCESS BAND MATERIAL FROM THE TOOL BY PULLING AWAY.

I. THE CUT OFF TAB MUST BE ROLLED OVER A TOTAL OF 180° IN A MANNER WHICH WILL NOT ALLOW SLIPPAGE.

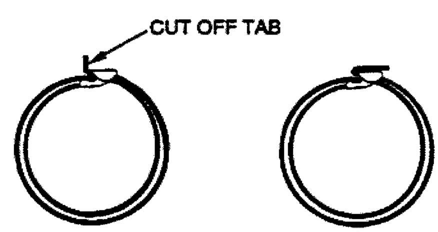
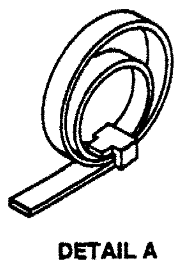
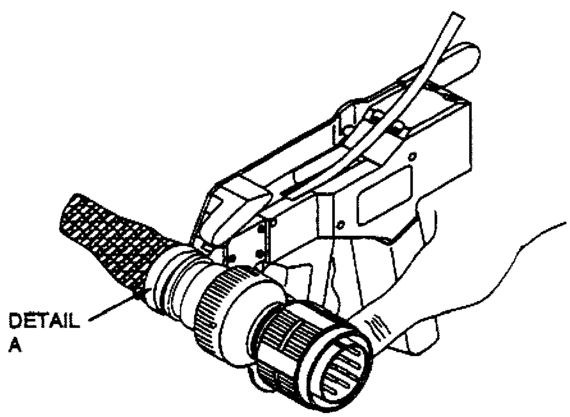


Figure 4. Operation of Banding Tool DBS–1100 (Sheet 2)

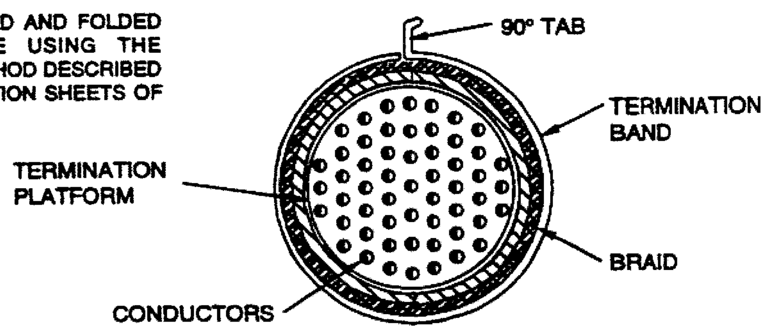
BRAIDED, JACKETED CABLE.

A. THE BRAID IS PUSHED INTO POSITION OVER THE BACKSHELL TERMINATION PLATFORM. CARE MUST BE TAKEN TO MAKE SURE THE WEAVE IS UNIFORM AND NO LARGE "WINDOWS" ARE PRESENT. A SHIELD TERMINATION BAND IS THEN LOADED INTO THE APPLICATION TOOL USING THE METHOD DESCRIBED IN THE OPERATION INSTRUCTION SHEETS OF THIS TOOL KIT. THE BAND IS THEN SLID OVER THE CONNECTOR/BACKSHELL ASSEMBLY INTO A POSITION OF ALIGNMENT WITH THE TERMINATION PLATFORM. APPLY AN ADEQUATE AMOUNT OF PRESSURE IN LINE WITH THE CABLE AS IT ENTERS THE BACKSHELL TO ALLOW THE 1/8 INCH SPACE TO BE REDUCED TO ZERO. THE TOOL IS THEN ACTIVATED TO THE PRESET TENSION. THE BAND IS THEN BENT SHARPLY AT THE BUCKLE APPROXIMATELY 90°, THEN CUT OFF USING THE CUT LEVER ON THE TOOL. IF BAND IS UNCURLED FOR ANY REASON, IT MUST BE DOUBLE LOOPED THRU BUCKLE BEFORE TERMINATION.





B. THE 90° TAB IS THEN CURLED AND FOLDED BACK OVER THE BUCKLE USING THE ROLL-OVER TOOL IN THE METHOD DESCRIBED IN THE OPERATION INSTRUCTION SHEETS OF THIS TOOL KIT.



C. THE EXCESS BRAID LENGTH IS THEN FOLDED BACK OVER THE BAND AND HEAT SHRINKABLE TAPE OR HEAT SHRINKABLE BOOT IS USED TO FINISH THE TERMINATION.

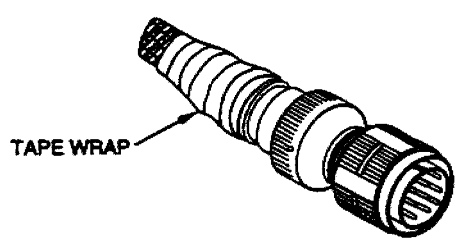
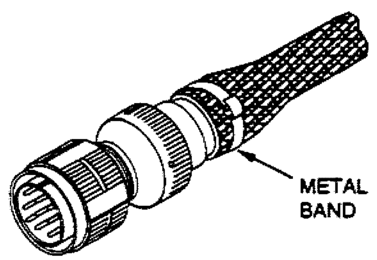


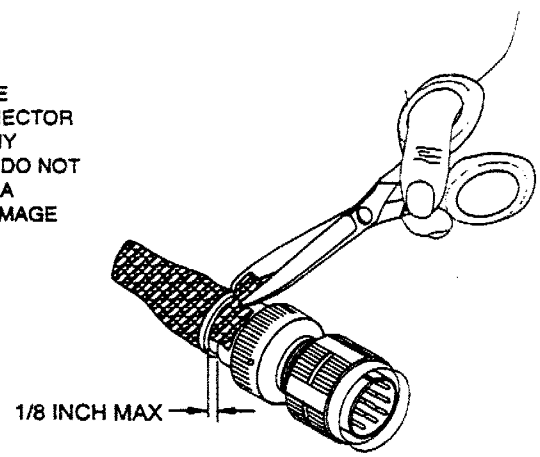
Figure 5. Installing EMI/RFI Shielded Connector/Backshell System (Sheet 1 of 2)

BRAIDED, NON-JACKETED CABLE.

A. REPEAT BRAIDED JACKETED CABLE PROCEDURES (STEPS A THRU C), WITH THE EXCEPTION OF THE REMOVAL OF THE CABLE JACKET.

B. USING THE FINE POINT SHEARS FROM TOOL KIT, THE EXCESS BRAID IS TRIMMED AS CLOSE TO THE CONNECTOR SIDE OF THE BAND AS POSSIBLE. DO NOT LEAVE ANY UNSECURED BRAID WIRES LONGER THAN 1/8 INCH. DO NOT ALLOW THE TRIMMED WIRES TO FALL INTO ANY AREA WHERE THEY MAY PRESENT A FOREIGN OBJECT DAMAGE (F.O.D.) HAZARD.





C. TAPE WRAPING OR APPLYING A BOOT OVER THE BAND TERMINATION AREA IS PERMISSIBLE, BUT IT IS NOT REQUIRED.

NOTE

THE HEAVY SHEARS ARE USED TO CUT OFF PORTIONS OF SHIELDING MATERIAL AS SHOWN WHEN ADDITIONAL LENGTH OF SHIELDING IS REQUIRED FORSPLICING, BREAKOUTS OR EXTENDING THE WIRE BUNDLE LENGTH.

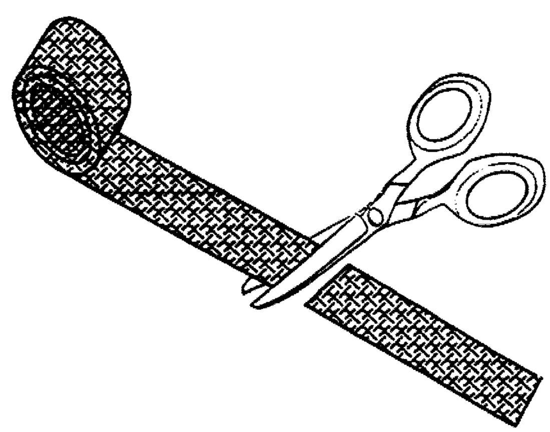


Figure 5. Installing EMI/RFI Shielded Connector/Backshell System (Sheet 2)

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HEATING TOOLS

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Fuel Cells And Tanks NAVAIR 01–1A–35
Electromagnetic Environmental Effects Requirements For Systems MIL–STD–464
Environmental Test Methods for Aerospace and Ground Equipment MIL–STD–810
Requirements For The Control Of Electromagnetic Interference
Characteristics of Subsystems And Equipment MIL–STD–461
Inspection And Repair Of Aircraft Integral Tanks And Fuel Cells . . . . AFTO 1–1–3

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1 . **INTRODUCTION.**

2 . This work package (WP 012 00) provides information on heating tools used for build–up and repair of aircraft wiring system. This work package provides general information on both categories of heating tools for on Aircraft Use (Work Package 012 01) and In Shop Use (Work Package 012 02).

3 . **GENERAL.**

4 . Performing maintenance on an aircraft can be very hazardous to personnel and equipment. Extreme caution must be observed while using heating tools with electric motors on aircraft, for this reason all heating tools used on aircraft must pass requirements in MIL–STD–461, MIL–STD–464 and MIL–STD–810 as a minimum. The

following paragraphs list the procedures that shall be adhered to while performing wiring maintenance.

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electro–magnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electro–magnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AFTO 1–1–3), and there are no EMI restrictions.

Use of nitrogen with the HT–900B/HT–920B heating tool in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

Nozzle and output air of heating tools get very hot. Use extreme care while operating heating tool to avoid serious burns.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

5. **SAFETY PRECAUTIONS.** Prior to performing repair procedures on any aircraft wiring system using heating tools with brush type electric motors, refer to NAVAIR 01–1A–35 for procedures concerning gas–free certifications. For definitions of confined spaces, refer to paragraph 7.

6. **MOTORIZED HEAT GUNS USAGE POLICY.** The policy for use of motorized heating tool on aircraft not strictly considered confined space is:

a. Do not perform any other maintenance during defueling, depuddling, purging, or inerting operations. See NAVAIR 01–1A–35.

b. Aviation Gas Free Environment (AVGFE) check spaces for Oxygen, (19.5% to 23.5%) and 0% flammables.

c. (0% Lower Explosive Limit [LEL]) whenever any of the following conditions exist:

(1) Any fuel cell is open.

(2) Any fuel line is open.

(3) Any fuel system component has been re−moved anywhere on the aircraft.

d. If there are no open fuel cells, no fuel lines have been broken, and no fuel system components have been removed, it is not necessary to check Oxygen, and LEL.

NOTE

This policy also applies to drop tanks and support equipment. For confined spaces, refer to NAVAIR 01−1A−35.

7 . **CONFINED SPACE.** Confined space is defined as:

a. A space large enough and so confined maintenance personnel can bodily enter and perform assigned work.

b. A space having limited or restricted means for entry or exit.

c. A space not designed for continuous maintenance personnel occupancy.

8 . **PERMIT REQUIRED CONFINED SPACE.** Permit required confined space means a confined space that has one or more of the following characteristics:

a. A space that contains, or has the potential to contain a hazardous atmosphere.

b. A space that contains a material that has the potential for engulfing an entrant.

c. A space that has an internal configuration such that an entrant could be trapped and asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a small cross section.

d. A space that contains any other recognized serious safety hazard.

9 . **On Aircraft/Flight Line Heating Tool**. The following heating tools are authorized for use on aircraft. These tools are not restricted from in shop use, but if connected to nitrogen, technician must ensure adequate ventilation to prevent oxygen displacement in the workspace. Refer to work package 012 01 for operation.

a. Heat Gun, Compressed Air/Nitrogen, HT−900B (see Note)

b. Heat Gun, Compressed Air/Nitrogen, HT−920B (see Note)

c. Compressed Air/Nitrogen Heat Gun, HT−71002

d. Heating Tool, Infrared, IR−1759

e. Heat Gun, Battery Powered, MCH−100−A

NOTE

HT−900 and HT−920 are the only authorized heating tools for repairs inside fuel tanks and fuel cells.

10 . **In Shop Heating Tools.** The following heating tools are authorized for off aircraft use such as in shop. The do not meet explosive or EMI testing requirements for use on aircraft or on the flight line/flight deck. Refer to work package 012 02 for operation.

a. Heating Tool, Radiant IR−500

b. Heating Tool, Infrared IR−550

c. Heating Tool, Thermogun CV−5000

d. Mini−Gun Hot Air Tool CV−5300

e. Mini−Gun Hot Air Tool CV−5302

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HEATING TOOLS FOR ON AIRCRAFT MAINTENANCE

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Fuel Cells And Tanks NAVAIR	01–1A–35
Electromagnetic Environmental Effects Requirements For Systems	MIL–STD–464
Environmental Test Methods for Aerospace and Ground Equipment	MIL–STD–810
Requirements For The Control Of Electromagnetic Interference Characteristics of Subsystems And Equipment	MIL–STD–461
Inspection And Repair Of Aircraft Integral Tanks And Fuel Cells	AFTO 1–1–3

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

Part. No./Type Designation	Nomenclature
Compressed Air/Nitrogen Heat Gun	HT–71002
Heat Gun, Compressed Air/Nitrogen	HT–900B
Heat Gun, Compressed Air/Nitrogen	HT–920B
Heating Tool, Infrared	IR–1759
Heat Gun, Battery Powered	MCH–100–A
Nitrogen Bottle	

Materials Required

None

1. **INTRODUCTION**.

2. This work package (WP) provides information on heating tools used for build–up and repair of aircraft wiring system. This work package provides heating tools authorized for use on aircraft and for flight line use. These tools are not restricted from in shop use, but if connected to nitrogen, technician must ensure adequate ventilation to prevent oxygen displacement in the space. Refer to Work Package 012 02 for heating tools restricted to in shop use ONLY. Tools listed in this work package, 012 01 may also be employed in shop provided all safety precaution are adhered to.

3. **GENERAL.**

4. Performing maintenance on an aircraft can be very hazardous to personnel and equipment. Prior to performing any procedure in this work package, or use of any tools listed here it is critical that all personnel involved have a thorough understanding of all warnings, cautions and notes in work package 012 00.

5. **ON AIRCRAFT HEATING TOOLS**. The following are the only authorized heating tools for use on aircraft.

a. Heat Gun, Compressed Air/Nitrogen HT–900B (see Note).

b. Heat Gun, Compressed Air/Nitrogen HT–920B (see Note).

c. Compressed Air/Nitrogen Heat Gun HT–71002

d. Heating Tool, Infrared IR–1759

e. Heat Gun, Battery Powered MCH–100–A

NOTE

HT–900 and HT–920 are the only authorized heating tools for repairs inside fuel tanks and fuel cells.

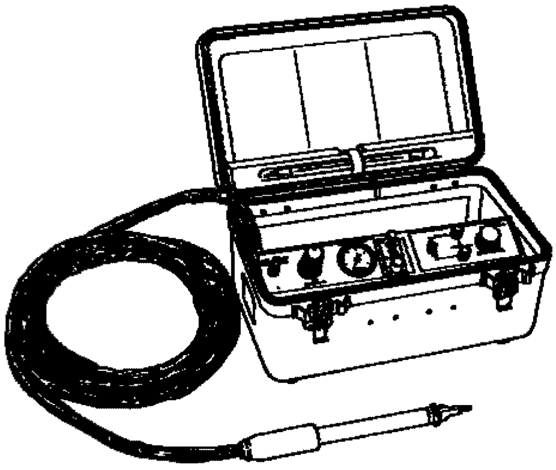


Figure 1. Compressed Air/Nitrogen Heating Tool With Case

6. **HT−900B/HT−920B COMPRESSED AIR/NITROGEN HEATING TOOL.**

WARNING

Use of nitrogen with the HT−900B/HT−920B heat gun in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

7. Compressed air/nitrogen heating tool (Figure 1), is a portable source of heat for use with heat−shrinkable tubing, meltable solder fittings, and is qualified for use on fueled aircraft. With the exception of a source of compressed air/nitrogen, the HT−900/920 is self−contained. Specifications are listed in Table 1. Tool contains several safety features as follows:

a. If the air/nitrogen pressure monitored at the heating tool falls below a preset minimum, a safety switch shuts off power to the heating element.

b. Cool air passes between the heating element and heating tool handle, keeping the handle cool.

c. If the heating tool is inadvertently connected to an air source in excess of 200 psi, an air safety valve protects both the equipment and the operator.

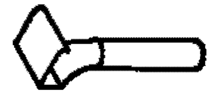


Figure 2. Termination Sleeve Reflector

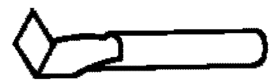


Figure 3. Miniature Termination Sleeve Reflector

Table 1. Specification

Electrical Power, HT−900B	115 VAC, 50−400 Hz, Single−phase, 7 Amps
Electrical Power, HT−920B	220 VAC, 50−400 Hz, single−phase, 3.5 Amps
Heat gun output temperature	550−920°F (290−495°C)
Compressed air/nitrogen (Dry and oil−free)	80−200 psig, 4 SCFM

8. **Pre−Operation.** Prior to using compressed air/nitrogen heating tool (Figure 1), proceed as follows:

CAUTION

Do not connect the heating tool to a compressed air/nitrogen source greater than 200 psig.

a. Push down and fully turn AIR REGULATOR ccw.

b. Remove dust cap from AIR INLET nipple. Connect nipple to pressurized air/nitrogen source.

c. Push down and turn AIR REGULATOR cw until pressure of 5 to 7 psig is registered on AIR PRESSURE GAGE.

9. Reflector Selection. The attachments for the air/nitrogen heater consist of five reflectors. These reflectors are attached to the tip of the heat gun and concentrate the heated air/nitrogen output around the material. The uses of the various reflectors are as follows:

10. Termination Sleeve Reflector. Used for heating solder termination sleeves and shrinking small−diameter tubing (Figure 2).

11. Miniature Termination Sleeve Reflector. Used for heating small solder termination sleeves and making terminations in a confined area (Figure 3).

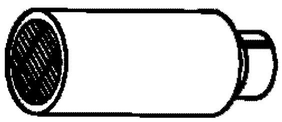


Figure 4. Boot and Tubing Reflector

Figure 5. NeedlePoint Reflector

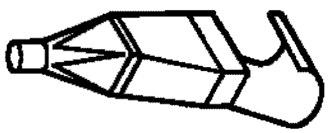


Figure 6. Large Boot and Tubing Reflector

12 . Boot and Tubing Reflector. Used for shrinking tubing and molded components such as strain−relief boots and potting caps (Figure 4).

13 . Needle Point Reflector. Used where a lower precise air−flow is required to terminate microminiature connectors, or to repair or modify low temperature insulated wire termination (Figure 5).

14 . Large Boot and Tubing Reflector. Used for installing large diameter tubing and molded parts (Figure 6).

15 . **Operation.** To operate compressed air/nitrogen heating tool (Figure 7), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01−1A−35 or AFTO 1−1−3.

Only the HT−900B/HT−920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01−1A−35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH−100−A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas−free environment criteria (NAVAIR 01−1A−35 or AF T.O. 1−1−3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

a. Push reflector over gun tip.

b. Plug in power cord to 115 VAC, 50−400 Hz, single−phase, 7 AMPs minimum power source, for the HT−900 tool, and to 220VAC, 50−400 Hz, single phase, 3.5 AMPs minimum power source for the HT−920B tool.

c. Set POWER switch to ON. POWER lamp and HEATED AIR ON lamp should light.

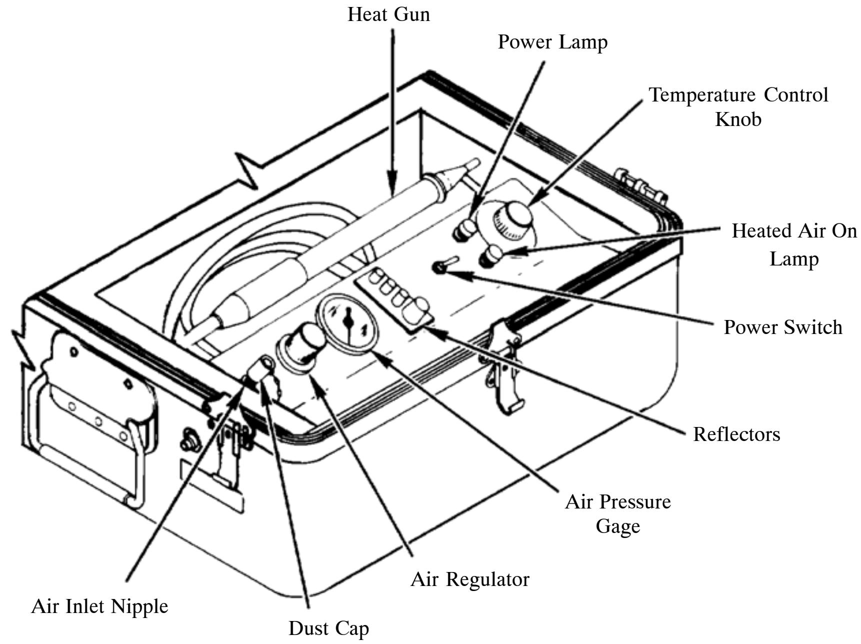


Figure 7. Compressed Air/Nitrogen Heating Tool

NOTE

The HEATED AIR ON lamp does not light unless the switch in the heat gun handle is in the forward position. Heated air can be removed from the heat gun at any time during operation, without powering down the control module, by positioning the switch to the rear of the handle.

d. Allow one minute warm− up. After warm− up, air pressure will be 10−15 psig.

16. **Post−Operation.** After using compressed air/nitrogen heating tool (Figure 7), proceed as follows:

a. Push down and fully turn AIR REGULATOR ccw. Observe that AIR PRESSURE GAGE registers 0 psig and HEATED AIR ON lamp goes out.

b. Position heat gun handle switch to rear of handle.

c. Position POWER switch to OFF. Observe that POWER lamp goes out.

d. Adjust TEMP CONTROL knob to desired setting.

e. Apply heat to desired application.

f. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

CAUTION

Failure to cool the gun, as directed below, will shorten heating element life.

g. Cool heat gun, for a minimum of one minute, by allowing air/nitrogen to flow until cool.

h. Disconnect power connector from power source.

i. Disconnect compressed air/nitrogen source from AIR INLET nipple. Install dust cap.

j. Allow a few minutes for reflector to cool.

k. Remove reflector and store in case.

17 . **HT–71002 NITROGEN/COMPRESSED AIR HOT AIR TOOL.**

a. The HT–71002 hot air tool is designed to operate in a potentially hazardous/explosive environment as spelled out in MIL–STD–810, Method 511.3, Procedure 1. This device produces hot air at temperatures up to 950° F, utilizing compressed air/nitrogen passing through a high resistance electric heat element and is directed or diffused through various types of special purpose nozzle attachments. Some examples of application are: heat shrinkable tubing, solder sleeve electrical connectors, drying and curing applications.

b. This unit comes packaged in a fiberglass/aluminum carrying case and consists of two major parts: The control unit and heat pistol (Figure 8). When operating the HT–71002 in a potentially explosive atmosphere, the following instructions must be followed explicitly.

18 . **Pre–Operation.**

19 . Observe warning on power cable.

WARNING

Failure to observe connection procedures as described in paragraphs a. and b. may result in explosion and or fire.

Before applying power to the HT–71002, the following procedures must be adhered to exactly.

a. Disconnect power at the source.

b. If using hangar or ships power, disengage the supply circuit at the circuit breaker panel, connect up the extension cord to the HT– 71002 supply at the circuit breaker panel, activate the 115Vac (50 – 400 Hz) and observe the control unit panel indicator that AC is present.

20 . **Connecting Air/Nitrogen Supply.** Air input Maximum 150 psi. Air input operating range: 60–150 psi.

21 . **Compressed Air.**

a. Air supply must be water and contaminant free. The HT–71002 employs a three (3) stage filtration system that purges water from the system automatically, however in order to minimize contamination of the extremely fine particulate and water filtration system of the HT–71002, the air supply (compressor) should be drained of water prior to connecting up the HT–71002 to the air supply.

b. Connect the air supply to connection nipple marked AIR INPUT. Observe the Air Pressure gauge and LOW AIR indicator. The minimum operational pressure for the HT–71002 is 3.5 psi. The LOW AIR lighted indicator will illuminate at approximately 2.0 psi, however steady state operation requires a pressure setting of 3.5 psi minimum.

c. If there is no pressure indicated on the control unit pressure gauge and the air supply to the unit is

Figure 8. HT– 71002 Nitrogen/Compressed Air Hot Air Tool

present at 60–150 psi, rotate the pneumatic control pressure regulator clockwise until pressure is indicated on the pressure gauge, to a setting of 3.5 psi. At approximately 2.0 psi, the LOW AIR lamp will illuminate, indicating that the low limit air protection circuitry has determined that air is insufficient and that the tool cannot be powered up.

22 . **Nitrogen Gas Supply.**

WARNING

Bottled nitrogen is usually contained in high pressure cylinders with pressures in excess of 2000 psi. Be certain that the appropriate input line pressure to the HT–71002 is observed. Proper regulation of the high pressure nitrogen is mandatory.

a. Connect the Nitrogen supply to connection nipple marked AIR INPUT. Observe the air pressure gauge and LOW AIR indicator. The minimum operational pressure for the HT– 71002 is 3.5 psi. The LOW AIR lighted indicator will illuminate at approximately 2.0 psi, however steady state operation requires a pressure setting of 3.5 psi minimum.

b. If there is no pressure indicated on the control unit pressure gauge and the Nitrogen supply to the unit is present at 60–150 psi, rotate the pneumatic control pressure regulator clockwise until pressure is indicated on gauge of 3.5 psi. At approximately 2.0 psi, the LOW AIR lamp will illuminate, indicating that the low limit Nitrogen protection circuitry has determined that Nitrogen is insufficient and that the tool may not be powered up.

23 . **Operation.**

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

24 . **Powering Up The HT–71002.**

a. Once the required electrical and air/nitrogen connections have been made, the HT– 71002 is ready for operation.

(1) Set Air/nitrogen air pressure 3.5 psi minimum.

(2) Set Temperature control on heat tool at “0”.

(3) Observe that the LOW AIR lamp is extinguished.

(4) Depress POWER ON switch and indicator will illuminate.

25 . **Air/Temperature Settings.**

a. The working environment of the HT−71002 will affect the resultant temperature at the nozzle of the heat tool. Such conditions are:

(1) Wind and air turbulence.

(2) Ambient temperatures that are below freezing and above 70 degrees F.

(3) Air compressor supplied input where the compressor is subjected to ambient temperatures.

b. Normal operating air pressure range of the HT−71002 is between 3.5 and 9.0 psi. With a constant temperature setting and an increased airflow, the resultant nozzle temperature will decrease, therefore a higher temperature setting will be required to achieve the desired temperatures.

c. With an ambient temperature of 70 degrees F, a “0” setting on the heat tool equals ambient temperature at 3.5 psi and “10” setting on the heating tool at 3.5 psi equals approximately 975 degrees F.

26 . **Shrinking/Curing.**

a. Set temperature control on tool between ”4” and “6” with air pressure set between 3.5 – 4.0 psi.

b. If shrinking or curing operation requires more heat, leave air pressure at initial setting and increase temperature.

c. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

27 . **Solder Sleeve Connectors.**

a. Install spoon reflector nozzle on heat tool.

b. Set temperature control between “5” and “8” on heat tool, with air pressure between 3.5 and 4.0 psi.

c. Depending on the connector and wire size, either a higher or lower setting will be required. Observe the solder ring in the connector for reflow. Do not leave heat on connector longer than is required to achieve a high integrity connection.

28 . **IR−1759, MINIRAY INFRARED HEATING TOOL.**

29 . MiniRay infrared heating tool, IR−1759 (Figure 9), is a small, lightweight, medium−duty hand heating tool designed for quiet, efficient operation. It can significantly reduce installation time on a variety of heat−shrinkable products. It is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. It is however, very useful for solder sleeves and environmental splices. The low profile allows product installation where work space is restricted. Specifications are listed in Table 2. The IR−1759 is available in two power configurations, one with an internal chargeable battery (XXX) and requiring external power (110VAC / 230 VAC). The controller box houses the battery (i.e. YYYY). This type may be employed for 30 typical applications.

30 . **PRE−OPERATION.** Prior to using infrared heating tool (Figure 9), proceed as follows:

a. Visually check aperture reflector for foreign material accumulation.

b. If accumulation is found, remove aperture reflector by removing screw, under reflector, and taking aperture reflector off heating tool.

Table 2. Electronic Control Unit Specifications

Electrical Power	115 VAC, 60 Hz, 11 Amps
Infared Heating Tool	
Lamp Type	Tungsten−Halogen
Lamp Power	250W, 24VAC, 50−60 HZ
Normal Lamp Life	Average time continuous use 50 hours

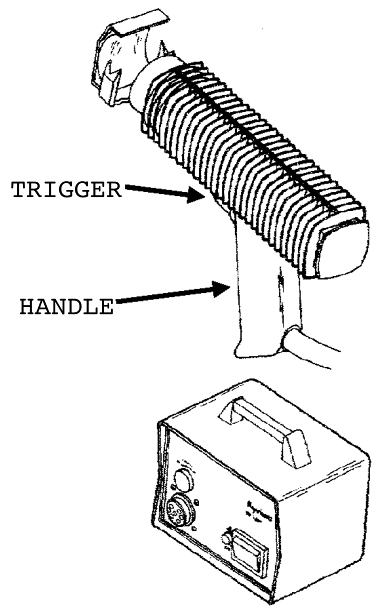


Figure 9. Infrared Heating Tool, IR-1759 with Standard Electronic Control ED-7-004

WARNING

Isopropyl Alcohol, TT-I-735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean foreign material off reflector surface with soft cloth and isopropyl alcohol.

d. Install aperture reflector, being careful not to touch reflective surface.

31 . **Reflector Selection.** The attachments for the infrared heating tool consist of two reflectors. These reflectors are attached to the front end of the tool housing and concentrate the heated infrared output around the material. The uses of the various reflectors are as follows:

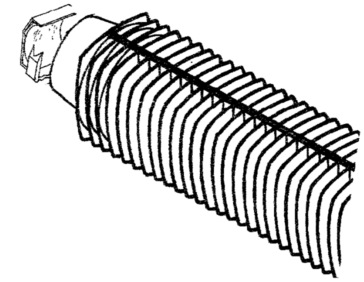


Figure 10. Standard Aperture Reflector Assembly

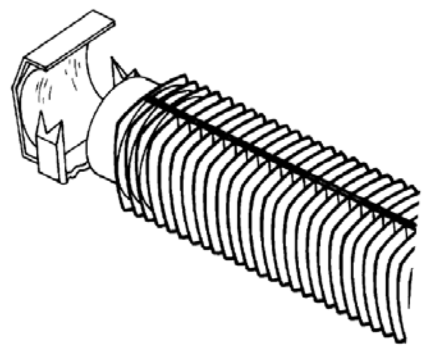


Figure 11. AE-897 Wide Aperture

32 . **Standard Aperture Reflector Assembly.** Used for heating solder termination sleeves and shrinking small diameter tubing. Used on devices having a maximum outside diameter of l/4 inch and a maximum length of 1 inch and comes with heating tool when ordered (Figure 10).

33 . **AE-897 Wide Aperture**. Used for heating solder termination sleeves and shrinking small-diameter tubing. Used on devices having a maximum outside diameter of 3/8 inch and a maximum length of 2 inches and has to be ordered separately (Figure 11).

34 . **OPERATION.** To operate infrared heating tool (Figure 9), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

CAUTION

The IR–1759 is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. Failure to comply with this restriction may result in overheat damage to heat shrink sleeve and wiring in repair area.

a. Select the appropriate aperture for the application

b. Attach the aperture to heating tool by using screw under front tip of heating tool.

NOTE

Omit step c below for the IR–1759 heat gun version with internal battery capability.

c. Plug in power cord to 115 VAC, 60 Hz, 11 Amps minimum power source.

d. Prepare the assembly to be heated.

e. Place the assembly into heating area.

f. Turn heat lamp on by squeezing trigger on handle.

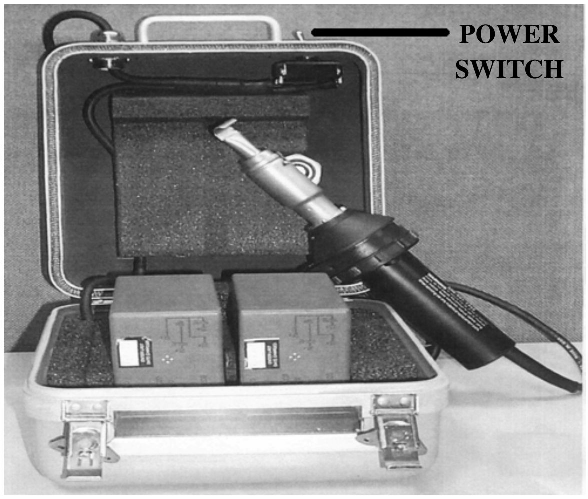
WARNING

During use the aperture may become hot. Do not touch as operator injury may occur.

g. Observe assembly during heating. After assembly has received proper amount of heat, stop heat cycle by releasing trigger on handle.

h. Remove assembly from heating area and inspect.

i. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.



Item	Function
ON−OFF switch on battery box	Turns power on and off to the hot air tool. The fan starts up in the tool when the switch is on.

Figure 12. MCH−100 On/Off Switch Located on Power Pack

35 . **POST−OPERATION.** After using infrared heating tool (Figure 12), proceed as follows:

a. Disconnect power connector from power source.

b. Allow a few minutes for aperture to cool.

c. Visually check aperture reflector for foreign material accumulation. If material is found, clean as follows:

WARNING

Isopropyl Alcohol, TT-I-735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

(1) Clean contaminated surfaces of front reflector and outer face of lamp filter with a soft cloth and isopropyl alcohol.

(2) Install front reflector being careful not to contaminate inner reflective surface.

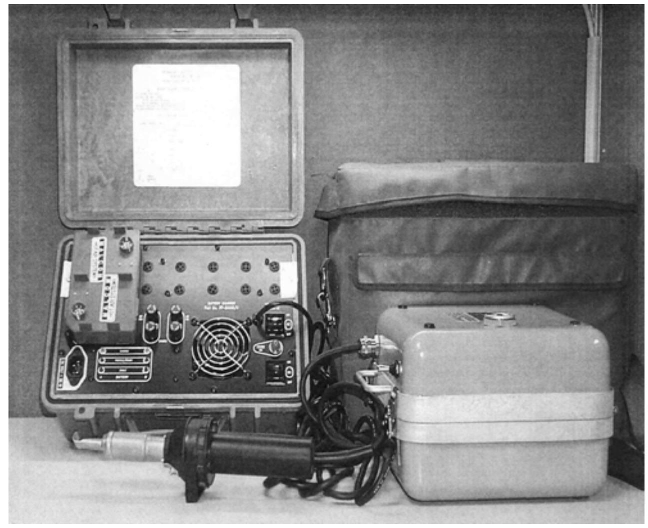


Figure 13. MCH−100−1

36 . **MCH−100−A BATTERY POWERED HEAT GUN.**

37 . **Introduction.**

38 . Portable battery powered hot air tool MCH−100−A is a lightweight portable unit designed for field deployment or shop usage. It is to be used for various applications such as contactless soldering and desoldering, shrink tubes, plastic welding, drying, and many more applications that would require hot air.

39 . The MCH−100−A consists of a heat gun, power cord, 16 mm spoon reflector, 10 mm sleeve reflector, carrying case, battery charger with adapter plate, and battery case with two batteries (Figure 13). The battery case and the two rechargeable batteries are displayed in (Figure 14).

40 . **Pre−Operation.**

41 . Unpacking Tool.

a. Inventory the MCH−100−A and check it against the contents chart to ensure all items are present.

b. Pressure release valves are installed on the power pack and charging case to equalize pressure where an imbalance may have occurred during transportation. The valve on the power pack is a push button type, simply push the red button to equalize the pressure. The valve on the charger is located on the bottom of the case and requires a flat head screwdriver to activate.

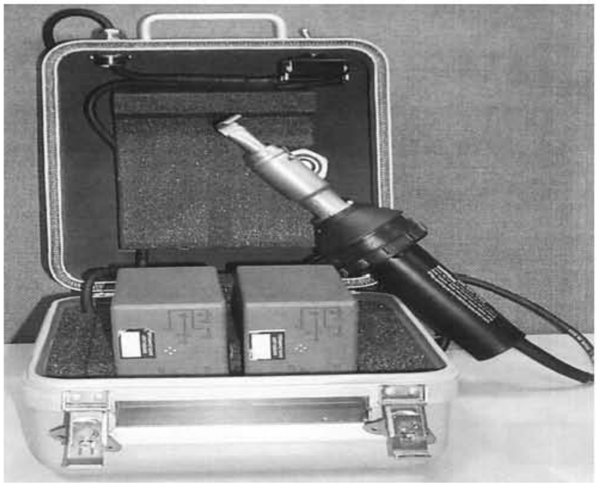


Figure 14. MCH−100−A and Batteries

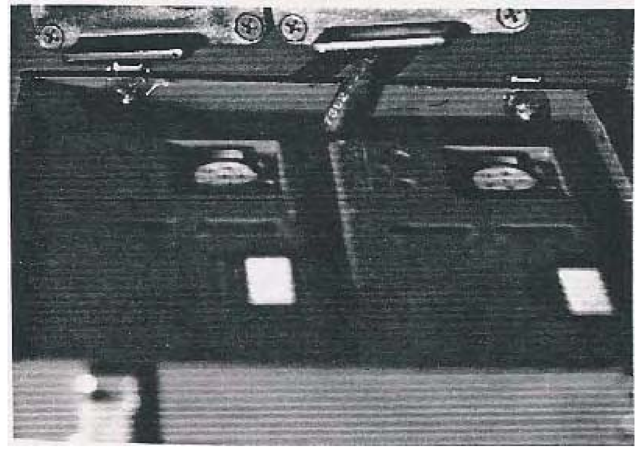


Figure 15. MCH−100 Battery Installation

42 . Installation Of Batteries Into Power Pack. Batteries should be fully charged before they are placed into the power pack.

a. Install two batteries into the foam slots provided inside the power pack. The connector plug on both batteries must be on the top. Figure 15.

b. Push fit the battery connector onto the batteries. It fits only one way. Figures 16 and 17.

c. Close the power pack lid and secure the latches.

d. Place the power pack into its slot in the carry case.

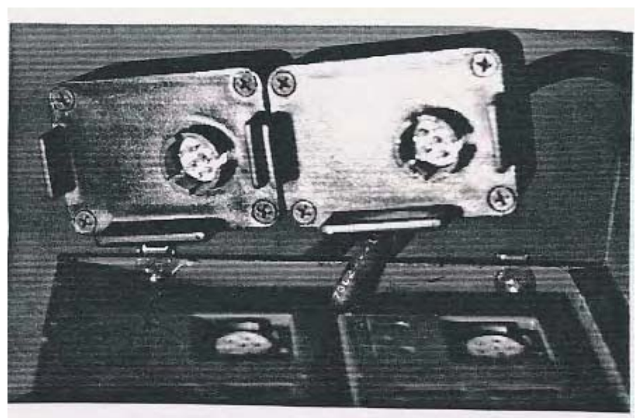


Figure 16. MCH−100 Battery Connection

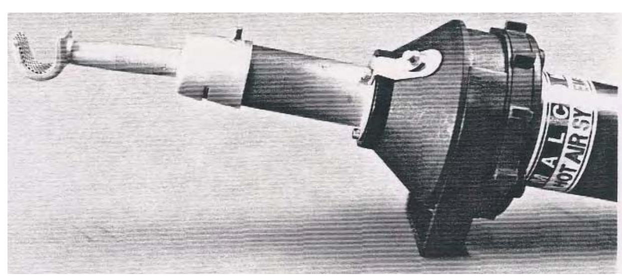


Figure 17. Nozzle Installation

43 . **Operation.**

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

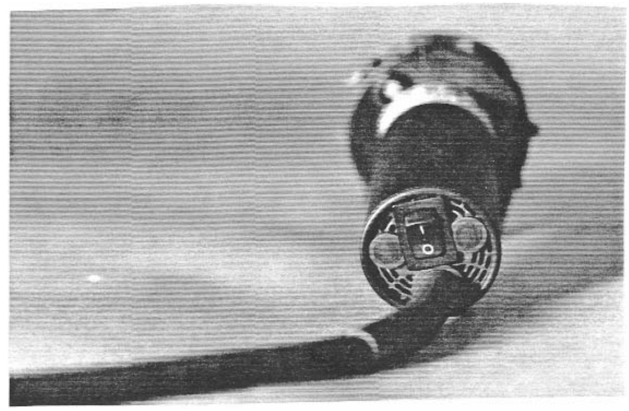
Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.



Power Switch

Figure 18. MCH–100 On/Off Switch Located on Handle of Tool

44 . **Hot Air Tool Controls.**

45 . The MCH–100–A hot air tool has two simple controls which are described below and shown in Figure 12 and Figure 18. Figure 12 shows the on/off switch located on the power pack that activates the power to the heat gun. When this switch is on, the fan in the hot air tool will be running. Figure 19 shows the on/off switch located on the handle of the hot air tool. This provides power to the heating element. Also shown is the air intake filter.

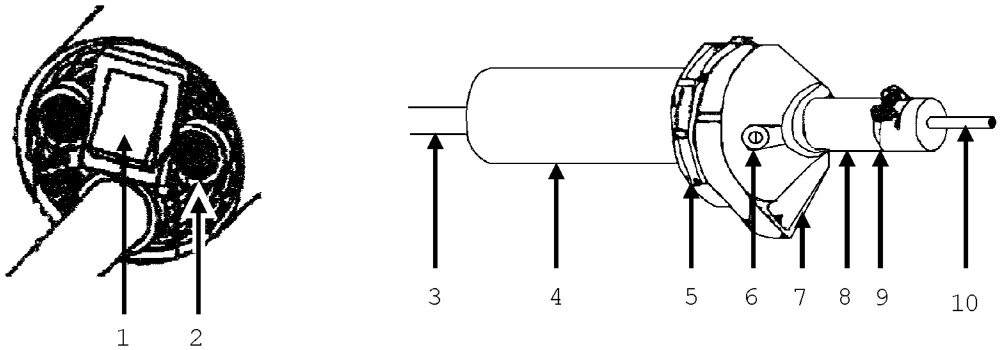
WARNING

Use only MIL–STD–810 qualified heat guns (HT–900B/HT–920B, HT–71002, MCH–100–A) when working on aircraft that have not been defueled and purged. Only after defueling and purging of the aircraft can other motorized heat guns listed in this manual be used.

46 . **Setup Procedures.**

a. Select appropriate nozzle (Figure 19, Item 10) and install (push & twist) onto the hot air tool.

b. A clip is provided on the tool for Electrostatic Discharge (ESD). If you are using the tool on printed circuit boards where static discharge may cause damage to the electronics, then you will need to ground the tool via the ESD lead connection located on the hot air tool (Figure 19, Item 6).



1. On/off switch
2. Air filter
3. Cable to main DC power
4. Handle
5. Rubber stand
6. ESD−lead connection
7. Tool stand (can be removed, rotated and fixed)
8. Element housing
9. Push−fit nozzle with twist lock
10. Nozzle

Figure 19. MCH−100 Controls

c. Switch on the power at the power pack (Figure 12).

d. d. Switch on the power at the hot air tool (Figure 19, Item 1). It should reach full operating temperature in less than one minute.

47 . **Changing Hot Air Nozzles.**

WARNING

HOT AIR TOOL CAN CAUSE BURNS. Avoid contact with the hot air tool stainless steel heating element cover and attached nozzles during operation. This part of the tool becomes very hot and can cause burns. Do not point the hot air flow in the direction of personnel.

a. It is recommended that before changing nozzles the operator allow the tool to cool down by turning off the heat (Figure 19, Item 1) and let the fan cool the nozzle down, or turn off the power to the tool and use only combination pliers and or insulated gloves to remove the hot nozzle. When you install a nozzle it is recommended that the fan to the tool be turned off. Push the new nozzle onto the tool and turn it to lock into place (Figure 17).

WARNING

Do not touch hot nozzle with bare hands. Place the hot nozzle onto a heat resistant surface or drop it into the insulated pocket in the MCH−100−A carrying case.

b. Only nozzles specifically designed for this tool should be used.

48 . **Charging Batteries.**

a. Remove batteries from battery pack.

b. Place batteries onto the supplied charger adapter plate as outlined in Operating Manual AG−BOHGAOPM−000.

c. Charge batteries using only the supplied battery charger (PP− 8444A/U) IAW AG−BOHGA−OPM−000.

49 . **Operation In Unusual Weather Conditions.** Observe these precautions when the hot air tool MCH−100−A heat gun is operated in area where severe climatic conditions may exist:

a. Operation in Arctic Climates. The hot air tool performance will be diminished at lower temperatures. The following precautions should be observed:

(1) Handle equipment carefully.

(2) Keep equipment clean and dry.

(3) Prevent ice from forming on the equipment. Ice formations may prevent proper electrical connections.

(4) Battery and hot air tool performance decreases as temperature drops.

b. Operation in Desert Climates. Temperature extremes of 122°F(50°C) and dryness associated with desert environment will not affect equipment usage. However, the built in thermal safety switch inside the batteries will automatically shut the power off if the interior battery temperatures reach 158°F (70°C). In order to prevent thermal shutdown, turn off the hot air tool once your work is complete. Try to avoid running the tool longer than 10 minutes at one time in the hot desert conditions. Dust storms associated with desert climates may cause poor electrical connections and prevent proper operation. When operating in these conditions, the filter on the back of the hot air tool should be kept clean by periodically brushing it off as it gets blocked.

c. Operation in Salt Spray. Keep equipment clean and dry at all times and immediately wipe salt spray from exposed surfaces, cables and connectors. When not in use, be sure that cover is fully latched, and the hot air tool is stored it the storage bag with the bag flaps in place.

50 . **Post Operation.**

51 . Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

52 . **Preparation For Movement After Use.**

a. Set POWER switch to OFF on the hot air tool to let the tool cool down.

b. Set POWER switch to OFF on the battery box to stop the fan in the tool.

c. Remove any installed nozzles and place them into the appropriate storage pockets in the carrying bag (Figure 20).

d. Coil DC power cable.

e. Insert hot air tool into appropriate pocket in carrying bag (Figure 20).

f. Insert coiled power cable into appropriate pocket in carrying bag.

g. Close cover to carrying bag and secure.

Figure 20. Hot Air Tool Installed in Carrying Bag

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HEATING TOOLS FOR SHOP USE ONLY

INSTALLATION AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Fuel Cells And Tanks NAVAIR	01−1A−35
Electromagnetic Environmental Effects Requirements For Systems	MIL−STD−464
Environmental Test Methods for Aerospace and Ground Equipment	MIL−STD−810
Requirements For The Control Of Electromagnetic Interference Characteristics of Subsystems And Equipment	MIL−STD−461
Inspection And Repair Of Aircraft Integral Tanks And Fuel Cells	AFTO 1−1−3

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

Part. No./Type Designation	Nomenclature
Heating Tool, Radiant	IR–500
Heating Tool, Infrared	IR–550
Heating Tool, Thermogun	CV–5000
Mini–Gun Hot Air Tool	CV–5300
Mini–Gun Hot Air Tool	CV–5302

Materials Required

Part. No./Specification	Nomenclature
TT−I−735	Isopropyl Alcohol

1 . **INTRODUCTION**.

2 . This work package (WP) provides information on heating tools used for build−up and repair of aircraft wiring system. This work package provides heating tools restricted to in shop use ONLY. Tools listed in work package 012 01 may also be employed in shop provided all safety precaution are adhered to.

3 . **GENERAL**.

4 . Performing maintenance with heating tools can be very hazardous to personnel and equipment. Prior to performing any procedure in this work package or use of any tools listed here it is critical that all personnel involved have a thorough understanding of all warnings, cautions and notes in work package 012 00.

5 . **IN SHOP HEATING TOOLS**. The following heating tools are authorized for OFF aircraft use. The do not meet explosive or EMI testing requirements for use on aircraft, or on the flight line/flight deck. Refer to work package 012 02 for operation.

a. Heating Tool, Radiant IR−500

b. Heating Tool, Infrared IR−550

c. Heating Tool, Thermogun CV−5000

d. Mini−Gun Hot Air Tool CV−5300

e. Mini−Gun Hot Air Tool CV−5302

CAUTION

The IR–500 and IR–550 is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. Failure to comply with this restriction may result in overheat damage to heat shrink sleeve and wiring in repair area.

6 . **IR−550 MARK II, INFRARED HEATING TOOL.**

7 . Infrared heating tool, IR−550 Mark II (Figure 1), is a portable electric heating tool designed for fast reliable installation of solder devices and other heat shrinkable products. It can be used as a hand tool or as a bench heater. As a hand tool, it is operated by a switch on the handle; as a bench heater, it is operated by a foot switch or the handle switch. This tool provides an unobstructed view of work in process and quiet, hands free operation. Instant on/off heat is generated by an optically filtered, commercially available tungsten−halogen lamp. Reflectors focus the heat from the lamp, concentrating heat energy within the work area of the front reflector. Optical filter between the lamp and the work area eliminates glare from the lamp, allowing the operator to observe the heating process. Tool is also equipped with a viewing window to ensure operator eye comfort. These features minimize operator errors and fatigue, significantly reducing installation time and costs. Specifications are listed in Table 1.

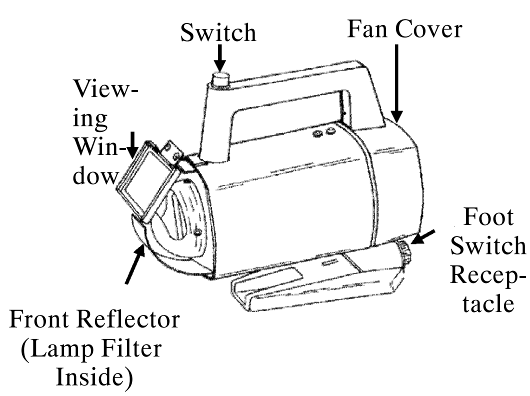

Figure 1. Infrared Heating Tool, IR−550 Mark II

8 . **PRE–OPERATION.** Prior to using infrared heating tool (Figure 1), proceed as follows:

a. Visually check front reflector and outer face of lamp filter for contamination.

b. If contamination is found, remove front reflector by lifting upper nose plunger from hole in reflector; tilt reflector away from housing, lift the reflector off lower plunger and slide it out of the housing.

WARNING

Isopropyl Alcohol, TT–I–735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean contaminated surfaces of front reflector and outer face of lamp filter with a soft cloth and isopropyl alcohol.

d. Install front reflector being careful not to contaminate inner reflective surface.

9 . **REFLECTOR SELECTION.** The attachments for the infrared heating tool consist of four reflectors. These reflectors are attached to the front end of the tool housing and concentrate the heated infrared output around the material. The uses of the various reflectors are as follows:

a. RG–2. Used for heating solder termination sleeves and shrinking large–diameter tubing. Has a 3/4 inch wide aperture and comes with heating tool when ordered.

b. RG–6. Used for heating solder termination sleeves and shrinking large–diameter tubing. Has a 3/4 inch wide aperture and has to be ordered separately (Figure 2).

c. RG–10. Used for heating solder termination sleeves and shrinking small–diameter tubing. Has a 3/8 inch wide aperture and has to be ordered separately (Figure 3).

d. RG–11. Used for heating solder termination sleeves and shrinking small–diameter tubing. Has a 1/2 inch wide aperture and has to be ordered separately (Figure 4).

Table 1. IR–550 Specifications

Electrical Power	115 VAC, 50–60 Hz, 4 1/2 Amps
Normal Lamp Life	Over 1000 hours of intermittent use
Duty Cycle	80%, 90 Second Heating Times

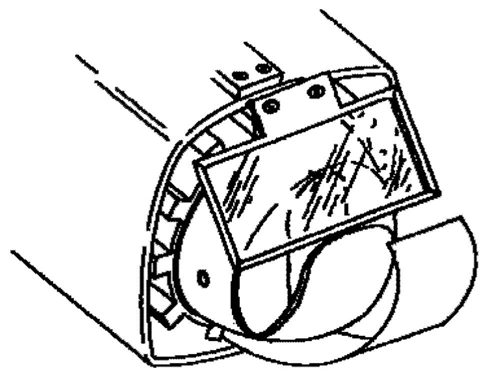

Figure 2. RG–6 Reflector

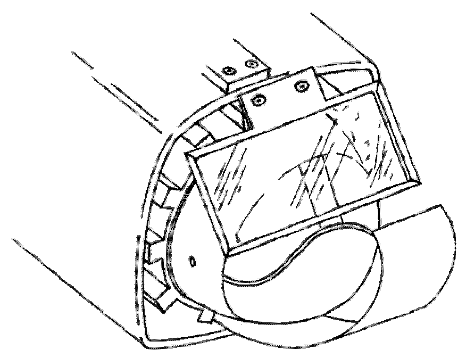

Figure 3. RG–10 Reflector

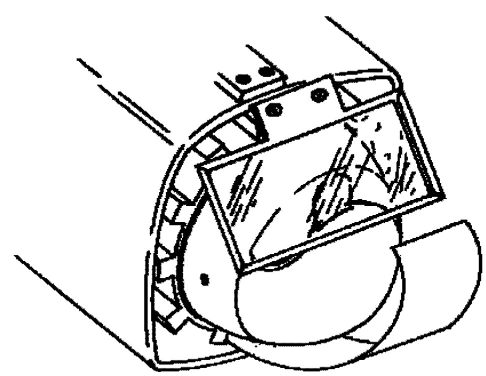

Figure 4. RG–11 Reflector

10. **OPERATION.** To operate infrared heating tool (Figure 3), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3.

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

a. Select the appropriate front reflector for the application.

CAUTION

The IR–550 is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. Failure to comply with this restriction may result in overheat damage to heat shrink sleeve and wiring in repair area.

b. Clip the front reflector onto the front end of the lamp housing by sliding the reflector between the upper and lower nose plungers until the bosses on the clips snap into the upper and lower holes in the reflector.

c. Plug in power cord to 115 VAC, 50–60 Hz, 4 1/2 Amps minimum power source. (For foot switch operation, foot switch must first be plugged into receptacle on rear of tool before plugging into power source.)

d. Prepare assembly to be heated.

e. Place the assembly to be terminated into slot of front reflector.

f. Turn heat lamp on by depressing switch on handle or by depressing foot switch.

WARNING

Since front reflector is outside the cooling air stream, it may get hot during the long heating cycles. Therefore, front reflector should not be touched when tool is in use.

g. Observe assembly during heating. After assembly has received proper amount of heat (or maximum of 90 seconds), stop heat cycle by releasing switch on handle or removing pressure from foot switch. Repeat if necessary if additional heating time is required.

h. Remove assembly from front reflector and inspect.

i. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

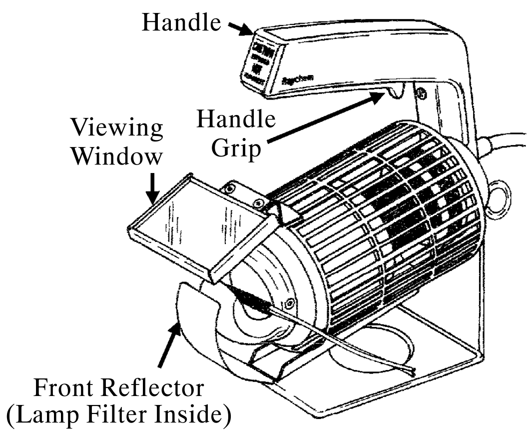

Figure 5. Radiant Heating Tool, IR–500

11 . **POST–OPERATION.** After using infrared heating tool (Figure 1), proceed as follows:

a. Disconnect power connector from power source.

b. Allow a few minutes for reflector to cool.

c. Visually check front reflector and outer face of lamp filter for contamination. If contamination is found, clean contamination using steps in paragraph 8.

d. Safely store reflector.

e. Periodically check the fan area to see if any dirt or lint has accumulated, when necessary clean with a soft brush. To facilitate cleaning, simply remove two mounting screws located on the rear of the fan cover.

12 . **IR–500, RADIANT HEATING TOOL.**

13 . Radiant heating tool, IR–500 (Figure 5), is a portable lightweight electric heating tool designed for fast and reliable installation of heat–shrinkable products. It can be used as a hand tool or as a bench tool and operated with a foot switch. The ellipsoidal reflector focuses the heat produced by halogen quartz lamp into the heating zone in front of the unit. Lamp is optically filtered to eliminate glare which allows the operator to observe the heating process, minimizing faulty installation and thereby assuring a quality finished product (Table 2).

Table 2. IR–500 Specifications

Electrical Power	115 VAC, 50–60 Hz, 5 Amps
Duty Cycle	0%, 30 Second Heating Times

CAUTION

The IR–500 and IR–550 is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. Failure to comply with this restriction may result in overheat damage to heat shrink sleeve and wiring in repair area.

14 . **PRE–OPERATION.** Prior to using radiant heating tool (Figure 5), proceed as follows:

a. Visually check reflector and outer face of lamp filter for foreign material accumulation.

b. If accumulation is found, remove reflector by lifting the reflector plunger, and tilting reflector away from housing and off reflector anchor pin.

WARNING

Isopropyl Alcohol, TT– I– 735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean foreign material off surfaces of reflector and outer face of lamp filter with a lint free, soft cloth or paper dampened with isopropyl alcohol.

d. Install reflector, being careful not to touch inner reflective surface.

15 . **REFLECTOR SELECTION.** The attachments for the radiant heating tool consist of three reflectors. These reflectors are attached to front end of the tool housing and concentrate the heated radiant output around the material. The uses of the various reflectors are as follows:

a. RG–1. Used for installing solder termination sleeves on non–heat sensitive wires; has to be ordered separately.

b. RG–2. Used for installing solder termination sleeves on heat sensitive wires; comes with heating tool when ordered.

c. Tubing Reflector. Used for installing heat shrinkable tubing and molded parts; comes with heating tool when ordered.

16. **OPERATION.** To operate radiant heating tool (Figure 5), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01−1A−35 or AFTO 1−1−3.

Only the HT−900B/HT−920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01−1A−35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH−100−A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas−free environment criteria (NAVAIR 01−1A−35 or AF T.O. 1−1−3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

a. Select the appropriate reflector for the application.

CAUTION

The IR−500 is not to be used to heat shrink/recover dark colored heatshrink sleeve of any kind, as it will tend to quickly overheat and damage it. Failure to comply with this restriction may result in overheat damage to heat shrink sleeve and wiring in repair area.

b. Install the reflector onto the front end of the lamp housing by putting the bottom of the reflector on the reflector anchor pin and tilting reflector up until it snaps onto reflector plunger.

c. Plug in power cord to 115 VAC, 50−60 Hz minimum power source. (For foot switch operation, foot switch must first be plugged into heating tool power cord before being plugged into power source.)

d. Prepare the assembly to be heated.

e. Place the assembly into heating area.

f. Turn heat lamp on by squeezing handle grip. Handle grip trigger actuates the on−off switch.

WARNING

During use the reflector may become hot. Do not touch as operator injury may occur.

g. Observe assembly during heating. When heating operation is complete (or maximum of 30 seconds) turn lamp off by releasing the handle or removing pressure from foot switch. Repeat as necessary if additional heating time is required.

h. Remove assembly from heating area and inspect.

i. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

j. If using foot switch for operation, trigger must be moved forward to take it out of its locked position, then released to turn heating tool completely off.

17. **POST−OPERATION.** After using radiant heating tool (Figure 5), proceed as follows:

a. Disconnect power connector from power source.

b. Allow a few minutes for reflector to cool.

c. Visually check reflector and outer face of lamp filter for foreign material accumulation. If material is found, clean using steps in paragraph 14.

d. Store reflector in proper place.

18 . **CV−5000, THERMOGUN MARK II HEATING TOOL.**

19 . ThermoGun Mark II heating tool, CV−5000 (Figure 6), is a rugged stand mounted or hand held hot−air tool engineered with a turbo fan driven blower and double jacketed element housing for heavy duty use. Combining features and options such as adjustable side vents, a wide variety of reflectors, and two temperature ranges (determined by model selected). ThermoGun provides precise control when terminating abroad range of heat shrinkable products, including boots and tubing up to 3 inches in diameter. Specifications are listed in Table 3.

Table 3. CV−5000 Specifications

Model 500B & 502B	
Electrical Power Model 500B	115 VAC, 60 Hz, 14 Amps
Electrical Power Model 502B	220 VAC, 50−60 Hz, 7 Amps
Output Temperature	500° − 700° F (260° − 371°C)
Model 750B & 752B	
Electrical Power Model 750B	115 VAC, 60 Hz, 18 Amps
Electrical Power Model 752B	220 VAC, 50−60 Hz, 9 Amps
Output Temperature	750º − 1000ºF (399º − 538ºC)

20 . **PRE−OPERATION.** Prior to using heating tool (Figure 6), Proceed as follows:

a. Visually check reflector for foreign material accumulation.

b. If accumulation is found, remove reflector by pulling it straight off ThermoGun nozzle.

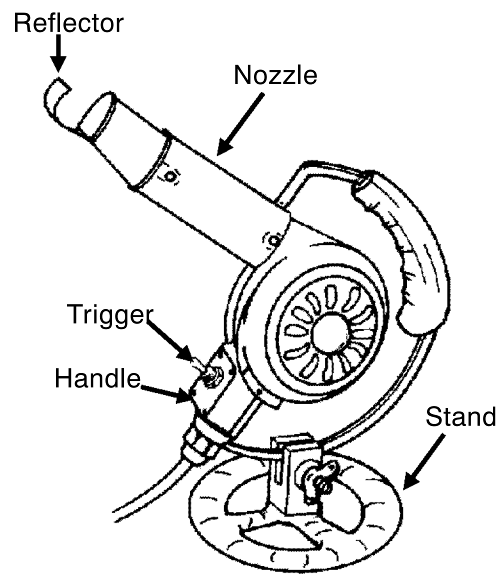

Figure 6. ThermoGun Mark II Heating Tool, CV−5000 with Stand

WARNING

Isopropyl Alcohol, TT− I− 735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean foreign material off surfaces of reflector with a soft cloth and isopropyl alcohol.

d. Install reflector, being careful not to touch reflective surface.

21 . **REFLECTOR SELECTION.** The attachments for the heating tool consist of six reflectors. These reflectors are attached to nozzle of heating tool and concentrate heated output around the material. The uses of the various reflectors are as follows:

a. TG−12. Used for heating solder termination sleeves and shrinking small−diameter tubing. Used for short lengths of tubing up to 3/4 inch diameter and comes with heating tool when ordered (Figure 7).

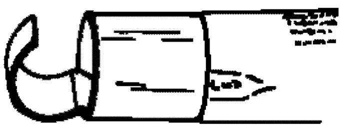

Figure 7. TG−12 Reflector

b. TG−13. Used for heating solder termination sleeves and shrinking large−diameter tubing. Used for short lengths of tubing from 3/4 inch to 2 inches in diameter and has to be ordered separately (Figure 8).

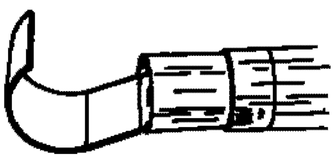

Figure 8. TG−13 Reflector

c. TG−13A. Used for heating solder termination sleeves and shrinking small−diameter tubing. Used for splice covers where wires must be shielded from heat and has to be ordered separately (Figure 9).

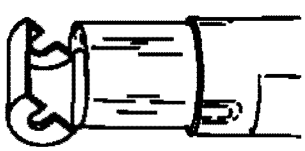

Figure 9. TG−13A Reflector

d. TG−23. Used for heating solder termination sleeves and shrinking medium−diameter tubing and boots. Used for boots up to 1 3/4 inches in diameter and has to be ordered separately (Figure 10).

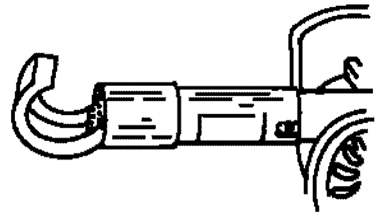

Figure 10. TG−23 Reflector

e. TG−24. Used for heating solder termination sleeves and shrinking large−diameter tubing and boots. Used for boots up to 3 inches in diameter and has to be ordered separately (Figure 11).

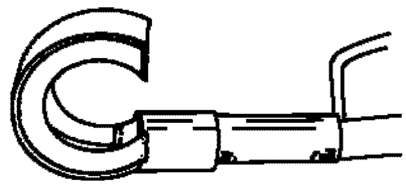

Figure 11. TG−24 Reflector

f. TG−135. Used for heating solder terminations sleeves and shrinking small−diameter tubing. Has to be ordered separately (Figure 12).

Figure 12. TG−135 Reflector

22 . **OPERATION.** To operate heating tool (Figure 6), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AFTO 1–1–3.

Only the HT–900B/HT–920B, HT–71002, MCH–100–A heating tools are authorized for use on any aircraft whenever AVGAS, JP–4 or the presence of fuel is imposing an immediate danger.

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

a. Select the appropriate reflector for the application.

b. Install the reflector on front of ThermoGun nozzle by pushing reflector straight on nozzle.

c. Plug in power cord to 115 VAC, 60 Hz, 14 or 18 Amps minimum power source, or 220 VAC, 60 Hz, 7 or 9 Amps minimum power source, depending on the model selected.

d. Prepare the assembly to be heated.

e. Place the assembly into heating area.

f. Turn the heat on by squeezing trigger on handle.

WARNING

During use the reflector may become hot. Do not touch as operator injury may occur.

g. Observe assembly during heating. After assembly has received proper amount of heat, stop heat cycle by releasing trigger on handle.

h. Remove assembly from heating area and inspect.

i. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

23 . **POST–OPERATION.** After using heating tool (Figure 6), proceed as follows:

a. Disconnect power connector from power source.

b. Allow a few minutes for reflector to cool.

c. Visually check reflector for foreign material accumulation. If material is found, clean using steps in paragraph 20.

d. Store reflector in proper place.

24 . **CV–5300/CV–5302, MINI–GUN HOT AIR TOOL.**

25 . Mini–Gun hot air tool, CV–5300/CV–5302 (Figure 13), is a lightweight hand–held tool used for applying a variety of heat–shrinkable products and solder termination products. It provides a continuous flow of heated air at temperatures of 450°–700°F (232°–371°C), depending on the hot–air reflector used. Specifications are listed in Table 4.

Table 4. CV−5300/5302 Specifications

Electrical Power Model 5300	115 VAC, 60 Hz, 7 Amps
Electrical Power Model 502B	220 VAC, 50 Hz, 3.5 Amps
Output Temperature	
Without Adapter	450°F (232°C)
With Adapter Only	550°F (288°C)
With MG−1 Reflector	700°F (371°C)
With MG−1 Reflector	450°F (232°C)

26 . **PRE−OPERATION.** Prior to using mini−gun heating tool (Figure 13), proceed as follows:

a. Visually check reflector for foreign material accumulation.

b. If accumulation is found, remove reflector by pulling it straight off mini−gun adapter.

WARNING

Isopropyl Alcohol, TT− I− 735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean foreign material off surfaces of reflector with a soft cloth and isopropyl alcohol.

d. Install reflector, being careful not to touch reflective surface.

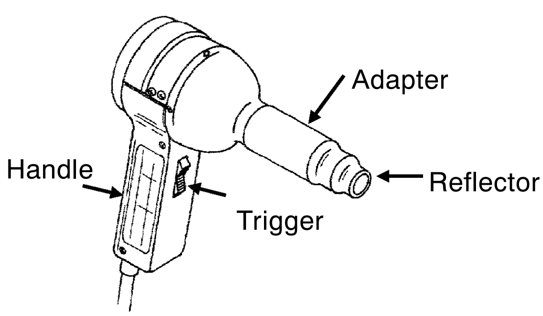

Figure 13. Mini−Gun Hot Air Tool, CV−5300/CV−5302

27 . **REFLECTOR SELECTION.** The attachments for the heating tool consist of two reflectors. These reflectors are attached to adapter on nozzle of heating tool and concentrate heated output around the material. The uses of the various reflectors are as follows:

a. MG−1. Used for heating solder termination sleeves and shrinking small−diameter tubing. Used for concentrated, high−temperature heating and tubing reflector and comes with heating tool when ordered (Figure 14).

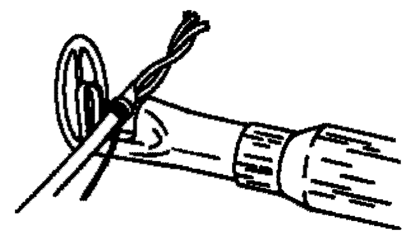

Figure 14. MG−1 Reflector

b. MG−2. Used for heating solder termination sleeves, molded parts, and shrinking large−diameter tubing. Used for surrounding heat−shrinkable tubing and molded parts with lower−temperature air, and has to be ordered separately (Figure 15).

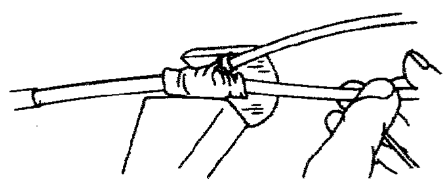

Figure 15. MG−2 Reflector

c. Barrel Adapter. Permits attachment of either reflector to the mini−gun.

28 . **OPERATION.** To operate heating tool (Figure 13), proceed as follows:

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01−1A−35 or AFTO 1−1−3.

Only the HT−900B/HT−920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01−1A−35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH−100−A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas−free environment criteria (NAVAIR 01−1A−35 or AF T.O. 1−1−3), and there are no EMI restrictions.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

a. Mount the mini−gun on its stand or operate it as a hand held tool (Figure 16).

(1) Bench stand clips into back of the heat gun body and onto nozzle, providing for various operating positions.

b. While the power is off and nozzle is cool, attach barrel adapter and appropriate reflector for the application to mini−gun.

(1) Reflector opening should face upward with mini−gun in its operating position.

c. Plug in power cord to 115 VAC, 60 Hz, 7 Amps minimum power source, or 220 VAC, 50 Hz, 3.5 Amps minimum power source.

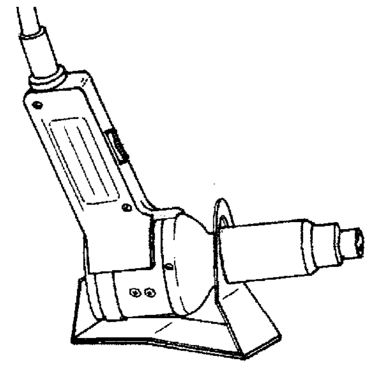

Figure 16. Mini−Gun Hot Air Tool, CV−5300/CV−5302

d. Move switch to hot.

e. Allow heat gun to warm up for at least 30 seconds.

CAUTION

Nozzle, barrel adapter and reflector are hot. Do not adjust or remove them without first moving switch to cool and allowing blower to operate until reflector is cool (at least 90 seconds).

f. Prepare the assembly to be heated.

g. Place assembly into heating area.

h. Observe assembly during heating. After assembly has received proper amount of heat, stop heat cycle by removing assembly from heating area.

i. Inspect assembly.

j. Inspect shrunk / recovered item for uniform application and for no signs of overheating, such as brown, black, or charred areas. Replace product if signs of overheat are displayed. Inspect affected area and wire under it and replace, or repair as applicable.

29 . **POST−OPERATION.** After using heating tool (Figure 16), proceed as follows:

a. Move switch to cool position and allow blower to run until output air is cool. Then move switch to off:

b. Disconnect power connector from power source.

c. Allow a few minutes for reflector to cool.

d. Visually check reflector for foreign material accumulation. If material is found, clean using steps in paragraph 26.

e. Store reflector in proper place.

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CONTACTS AND TERMINALS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Definitions and Symbols 003 00
Open and Overbraided Harness Repair 011 00
Soldering 016 00
Wire and Cable Splicing and Repair 014 00
Wire and Cable Stripping 009 00
Connectors, Electrical, Rectangular, Rack and Panel, Solder Type and Crimp Type Contacts MIL–DTL–28748
Connectors, General Purpose, Electrical, Miniature, Circular, Environment Resisting, General Specification for FSC 5935 . . . . MIL–DTL–26500
Crimping Tools, Pre–insulated. Uninsulated, and Aluminum Terminal Lugs and Splices MS25441
Crimping Tools, Hand or Power Actuated, Wire Termination and Tool Kits, General Specification for FSC5935 . . . . MIL–DTL–22520
Electrical Contacts SAE–AS–39029
Military Standard Circular Connectors 01–1A–505–2
Radio Frequency Connectors . . . . WP 021 00
Terminals: Lug and Splice, Crimp Style, Aluminum, for Aluminum Aircraft Wire, General Specification for SAE–AS–70991

Alphabetical Index

Subject Page No.

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation
Crimp Tool	AD–1377 *	Holding Fixture	AT–1319–17
Inspection Gage	AD–1378 *	Holding Fixture	AT–1319–18
Holding Fixture	AT–1319–11	Holding Fixture	AT–1319–19
Holding Fixture	AT–1319–14	Inspection Gage	G125 *

Support Equipment Required (Cont.)

Nomenclature	Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation
Inspection Gage	G682 *	Die	HD51–107–1 *
Inspection Gage	G683 *	Die	HD51–113–1 *
Inspection Gage	G684 *	Die Set	HD51–128 *
Inspection Gage	G726 *	Die Set	HD51–129 *
Inspection Gage	G744 *	Die	HD51–130–1 *
Inspection Gage	G745 *	Die	HD51–131–2 *
Inspection Gage	G746 *	Die	HD51–132–2 *
Inspection Gage	G747 *	Die	HD51–133–2 *
Inspection Gage	G801 *	Die	HD51–133–2 *
Inspection Gage	G854 *	Die	HD51–134–2 *
Inspection Gage	G855 *	Die Set	HD51–154 *
Crimp Tool Frame	HD51 *	Crimp Tool Frame	HH80C *
Die	HD51–105–1 *	Heat Gun	HT–900B/HT–920
Die	HD51–106–1 *	Crimp Tool Frame	M22520/10–01
Die	HD51–107–1 *	Die Set	M22520/10–05
Die	HD51–113–1 *	Die Set	M22520/10–06
Die Set	HD51–128 *	Die Set	M22520/10–100
Die Set	HD51–129 *	Die Set	M22520/10–101
Die	HD51–130–1 *	Die Set	M22520/10–103
Die	HD51–131–2 *	Die Set	M22520/10–104
Die	HD51–132–2 *	Crimp Tool Frame	M22520/19–01
Inspection Gage	G125 *	Positioner	M22520/19–02
Inspection Gage	G682 *	Positioner	M22520/19–04
Inspection Gage	G683 *	Crimp Tool Frame	M22520/20–01
Inspection Gage	G684 *	Positioner	M22520/20–02
Inspection Gage	G726 *	Positioner	M22520/20–03
Inspection Gage	G744 *	Crimp Tool Frame	M22520/2–01
Inspection Gage	G745 *	Crimp Tool Frame	M22520/21–01
Inspection Gage	G746 *	Positioner	M22520/21–02
Inspection Gage	G747 *	Positioner	M22520/21–04
Inspection Gage	G801 *	Positioner	M22520/2–24
Inspection Gage	G854 *	Positioner	M22520/2–28
Inspection Gage	G855 *	Positioner	M22520/2–29
Crimp Tool Frame	HD51 *	Positioner	M22520/2–30
Die	HD51–105–1 *	Pneumatic Crimper	M22520/23–01
Die	HD51–106–1 *	Die	M22520/23–02

Support Equipment Required (Cont.)

Nomenclature	Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation
Die	M22520/23−03	Die Set	MS23002−03
Die	M22520/23−04	Die Set	MS23002−04
Die	M22520/23−05	Die Set	MS23002−1
Die	M22520/23−06	Die Set	MS23002−2
Die	M22520/23−07	Die Set	MS23002−4
Locator	M22520/23−09	Die Set	MS23002−6
Locator	M22520/23−10	Die Set	MS23002−8
Locator	M22520/23−11	Inspection Gage	MS23003−01
Locator	M22520/23−12	Inspection Gage	MS23003−02
Locator	M22520/23−13	Inspection Gage	MS23003−03
Locator	M22520/23−14	Inspection Gage	MS23003−04
Locator	M22520/23−15	Inspection Gage	MS23003−1
Locator	M22520/23−16	Inspection Gage	MS23003−2
Positioner	M22520/2−33	Inspection Gage	MS23003−4
Pneumatic Crimper	M22520/28−01	Inspection Gage	MS23003−6
Air Supply Hose	M22520/28−02	Inspection Gage	MS23003−8
Pneumatic Crimper	M22520/29−01	Head	MS25441−1
Bench Mount	M22520/30−01	Hydraulic Hose	MS25441−3
Foot Valve	M22520/30−02	Hydraulic Pedal Pump	MS25441−5
Inspection Gage	M22520/3−09	Die Set	MS25442−01A
Inspection Gage	M22520/3−10	Die Set	MS25442−02A
Inspection Gage	M22520/3−12	Die Set	MS25442−03A
Inspection Gage	M22520/3−13	Die Set	MS25442−04A
Inspection Gage	M22520/3−14	Die Set	MS25442−1A
Crimp Tool	M22520/37−01	Die Set	MS25442−2A
Crimp Tool	M22520/38−01	Die Set	MS25442−4A
Inspection Gage	M22520/39−01	Die Set	MS25442−6A
Crimp Tool Frame	M22520/5−01	Die Set	MS25442−8A
Die Set	M22520/5−08	Die Set	MS90485−01
Die Set	M22520/5−10	Die Set	MS90485−02
Die Set	M22520/5−100	Die Set	MS90485−03
Die Set	M22520/5−102	Die Set	MS90485−04
Die Set	M22520/5−103	Die Set	MS90485−1
Crimp Tool Frame	M22520/7−01	Die Set	MS90485−2
Die Set	MS23002−01	Die Set	MS90485−4
Die Set	MS23002−02	Die Set	MS90485−6

Support Equipment Required (Cont.)

Nomenclature	Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation
Die Set	MS90485–8	Inspection Gage	MS90486–2
Inspection Gage	MS90486–01	Inspection Gage	MS90486–4
Inspection Gage	MS90486–02	Inspection Gage	MS90486–6
Inspection Gage	MS90486–03	Inspection Gage	MS90486–8
Inspection Gage	MS90486–04	Pneumatic Crimper	WA22 *
Nomenclature	Type Designation	Pneumatic Crimper	WA27F *
Inspection Gage	MS90486–1	* Tool or commercial equivalent	* Tool or commercial equivalent

Materials Required

Nomenclature	Part Number/ Type Designation	Nomenclature	Part Number/ Type Designation
Methyl Ethyl Ketone (MEK)	ASTM D740 or other approved solvent	Sleeving, Insulation, Heat Shrinkable	SAE AMS–DTL–23053

1 . **INTRODUCTION.**

2 . This work package (WP) provides information for crimping contacts and terminals with the required crimp tool. Preparation of the tool for crimping is also provided.

3 . **CRIMP CONTACT.**

4 . A contact is used in a connector to transfer electrical energy from one mating half of a connector to the other mating half of a connector pair (WP 003 00). A crimp contact is typically removable from the front or rear of a connector (01–1A–505–2 or 01–1A–505–3). A contact can generally be grouped into four categories: signal, power, thermocouple and high frequency.

5 . **POWER/SIGNAL CONTACT.** A power contact and signal contact are usually grouped together for discussion purposes, because other than perhaps size, the contact configuration is basically the same for most applications. Typically a smaller size contacts are used for signal, and a larger contact is used for power. For future discussion in this WP, the term power contact will be used for both. A power contact is usually gold-plated copper alloy for sizes 28 through 12, and silver-plated copper alloy for sizes 12 through 04. Size 12 contacts are either silver-plated copper alloy or gold–plated copper alloy, depending on the application.

6 . **THERMOCOUPLE CONTACT.** A thermocouple contact is unplated, although sometimes coated, and consists of the same material as the thermocouple conductor on which the contact is being crimped. The thermocouple contact has the same configuration as the power contact.

7 . **HIGH FREQUENCY CONTACT.** A high frequency contact is more commonly known as a coaxial or triaxial contact. These contacts are usually gold-plated copper alloy. A high frequency contact has a variety of configurations depending on the manufacturer. Because of the variety, often times the assembly procedure for the contact must be in accordance with the manufacturer's assembly instruction. The assembly instructions provided herein may not be the only means of assembly.

8 . **SAE AS39029 SPECIFICATION AND PART NUMBER.** Most crimp contacts, power and thermocouple, used in military connectors are standardized in MIL-C-39029. The SAE AS39029 contact is identified by a Basic Identification Number (BIN) which represent three color bands marked on the crimp barrel of the contact (Figure 1).

a. Example: M39029/33-463

b. M39029: Basic specification defining the contact performance requirement.

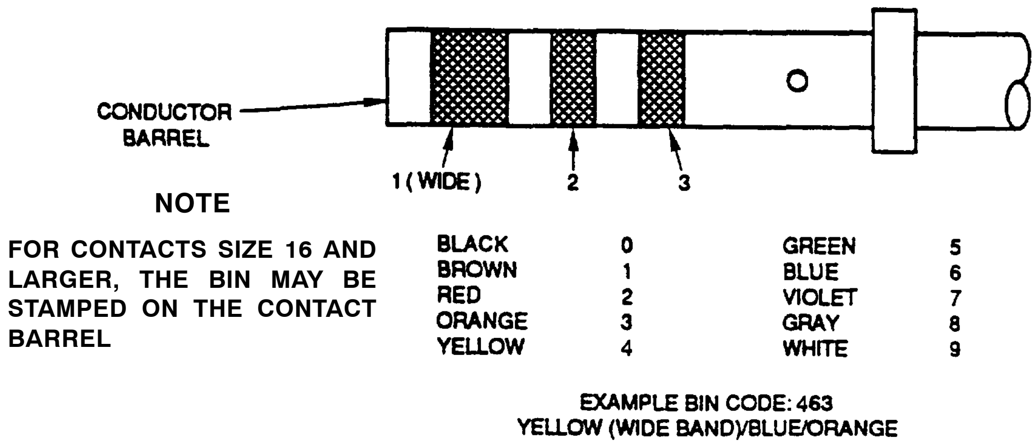


Figure 1. Basic Identification Number and Color Bands

c. /33: Detail specification defining the contact configuration, the connector application, the crimp tool, and other detail characteristics.

d. -463: BIN Number (Figure 1).

9 . **POWER AND THERMOCOUPLE CONTACT CRIMPING PROCEDURE.** Since a power contact and a thermocouple contact has the same configuration, the crimping procedure is the same and is as follows:

a. Select the correct crimp tool in accordance with the appropriate connector requirement (the appropriate NAVAIR 01–1A–505–2 or –3 Connector Volumes or SAE–AS–39029).

b. Prepare the conductor in accordance with WP 009 00.

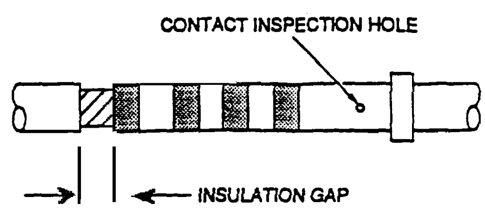
c. Prepare the crimp tool in accordance with paragraphs 48, 59, or 70.

d. Insert stripped wire into contact conductor barrel. Ensure all wire strands are inside contact conductor barrel and the conductor is completely visible in contact inspection hole (Figure 2).

e. If insulation gap is greater than 1/64, trim conductor as required. If insulation gap is too small, trim insulation as required.

f. Crimp contact to wire in accordance with paragraphs 58 or 69.

g. Remove contact from crimp tool and inspect for the following:



CONTACT SIZE	WIRE AWG	INSULATION GAP
22D	26	
22M		
22	24	1/64" MAX
	22	
20	20	
16	20	
	18	
	16	
12	14	
	12	1/32" MAX
8	10	
	8	1/32" MAX

Figure 2. Insulation Gap

(1) Two series of four indents shall secure contact to wire (Figure 3).

(2) Wire strands shall be visible in contact inspection hole, indicating that wire is crimped into contact at correct depth.

(3) Verify insulation gap is within limits specified in applicable work package.

(4) Wire strands shall not he nicked or loose.

(5) New contact shall not be nicked, bent, or distorted. Refer to WP 004 01 for minor repairs to in–service contacts.

h. Refer to applicable connector work package or volume for contact insertion procedure.

10. **COAXIAL CONTACT CRIMPING AND ASSEMBLY.** A coaxial contact may be crimped and assembled in numerous ways. The assembly procedures provided herein are for general assemblies. Refer to applicable connector series work package in NA01 1A–505–2 for specific tooling and procedures. A typical example of a coaxial contact assembly is shown in Figure 4.

11. **COAXIAL CONTACTS.** Coaxial contacts are used in circular connectors. Each connector series uses different coaxial contacts and are covered in the applicable connector series work package in NA01–1A–505–2.

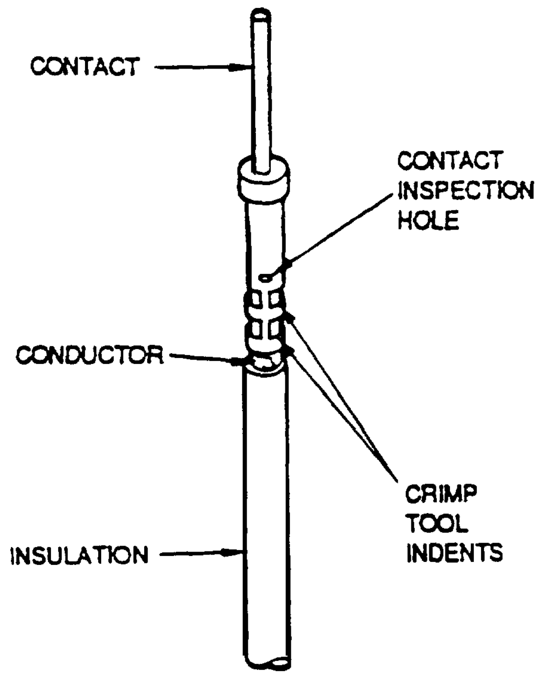


Figure 3. Crimp Joint Inspection

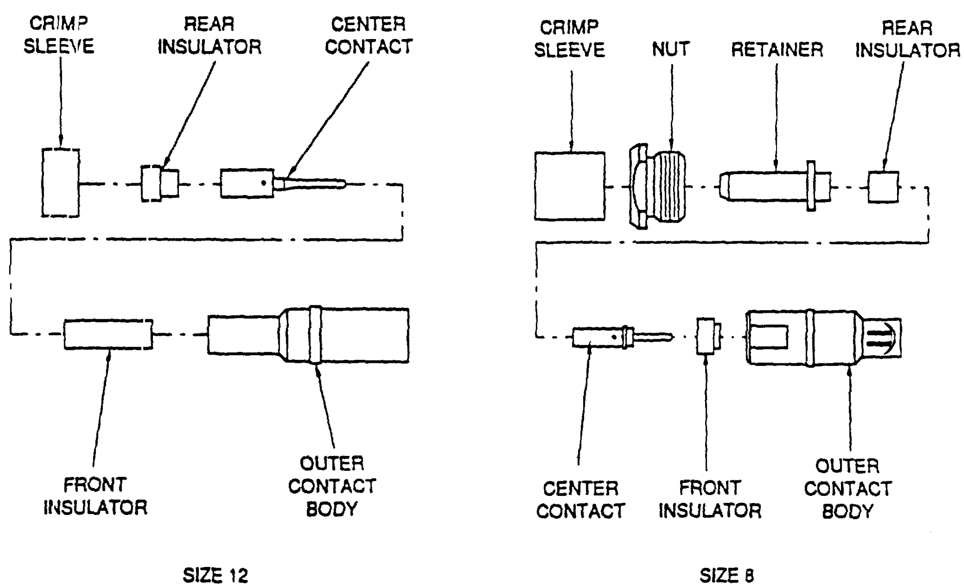


Figure 4. Typical Coaxial Shield Assembly

12. <u>**COAXIAL CONTACT CRIMPING PROCEDURE.**</u> Crimp and assemble the size 12 contacts as follows:

a. Cut cable end square, leaving enough cable for adequate strain relief without excess slack.

b. Slide crimp sleeve over cable. Using coaxial cable stripper, strip jacket dimension A from end and trim shield to dimension B from jacket, as shown in Figure 5.

c. Flare the shield back as shown in Figure 6. Do not comb out individual shield strands. Using a sharp knife, strip dielectric to dimension C in Table 2.

d. Slide rear insulator, large diameter first, over center conductor, then seat rear insulator against dielectric as shown in Figure 7.

e. Insert center conductor into center contact and trim center conductor as required to seat center contact against rear insulator. Ensure center conductor remains visible in contact inspection hole (Figure 7).

f. Crimp center contact using the specified crimp tool frame, and positioner and selector knob setting required for the cable (Figure 8).

g. If front insulator is not captivated inside contact body, slide front insulator, large inside diameter first, over center contact (Figure 8).

h. Slide contact body over center contact assembly and under shield until fully seated (Figure 9).

i. Arrange shield as close to original lay as possible. Slide crimp sleeve over shield and obtain 1/4 to 9/32-inch dimension. Trim excess shield ahead of crimp sleeve (Figure 10).

j. After correctly locating crimp sleeve, perform crimp using tooling specified in Table 2 (Figure 11).

k. Assemble the M39029/50 contact in the same manner as the M39029/51 contact.

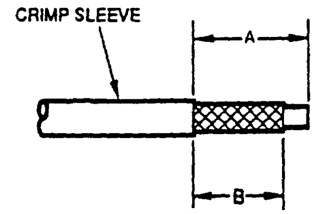


Figure 5. Cable Strip Length

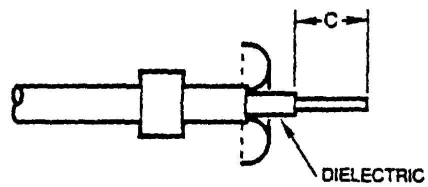


Figure 6. Braid Fold-Back

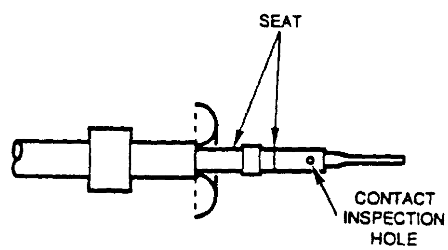


Figure 7. Contact Seating

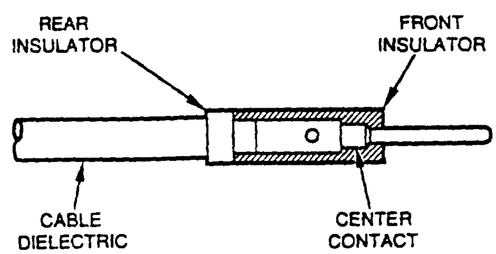


Figure 8. Contact Insulator

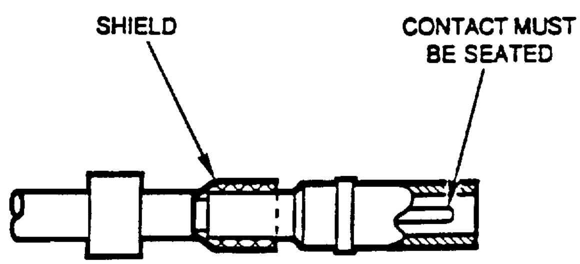


Figure 9. Shield Preparation

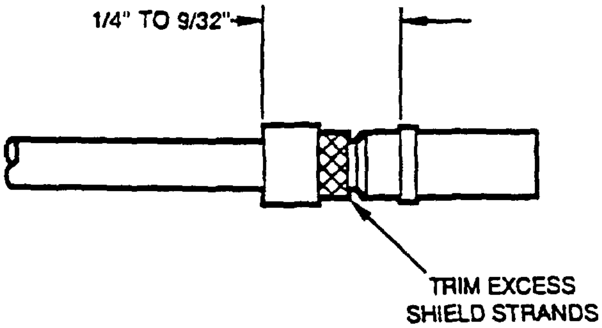


Figure 10. Trim Shield

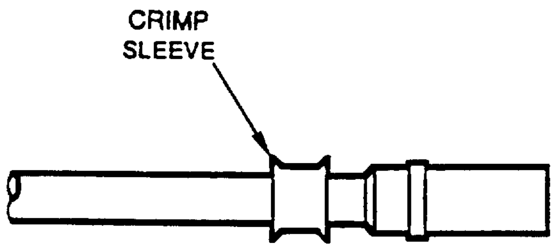


Figure 11. Crimp Sleeve

13 . <u>**COAXIAL SOLDER CONTACT INSTALLATION.**</u>

14 . Introduction To Solder Contacts. Removable solder-type contacts are used with connectors conforming to MIL-C-26482, MIL–DTL–83723, MIL-DTL–83733, MIL-DTL-26500, and, MIL-DTL–28748. These contacts contain prefluxed solder preforms and heat-shrinkable insulation material, which is available for twisted pair wire, coaxial cable (Figure 12), or single conductor shielded cable.

15 . When the contact is heated, the solder melts and the heat-shrinkable insulation shrinks, terminating the wire or cable to the contact, insulating and strain relieving the conductors.

16 . **CONTACT SELECTION.** To select the proper contact, use the following procedure:

a. Determine connector specification, cavity size, and wire type (Table 1 and 2).

b. Select appropriate solder contact (Table 1).

c. Verify contact is compatible with size of cable to be terminated (Table 2).

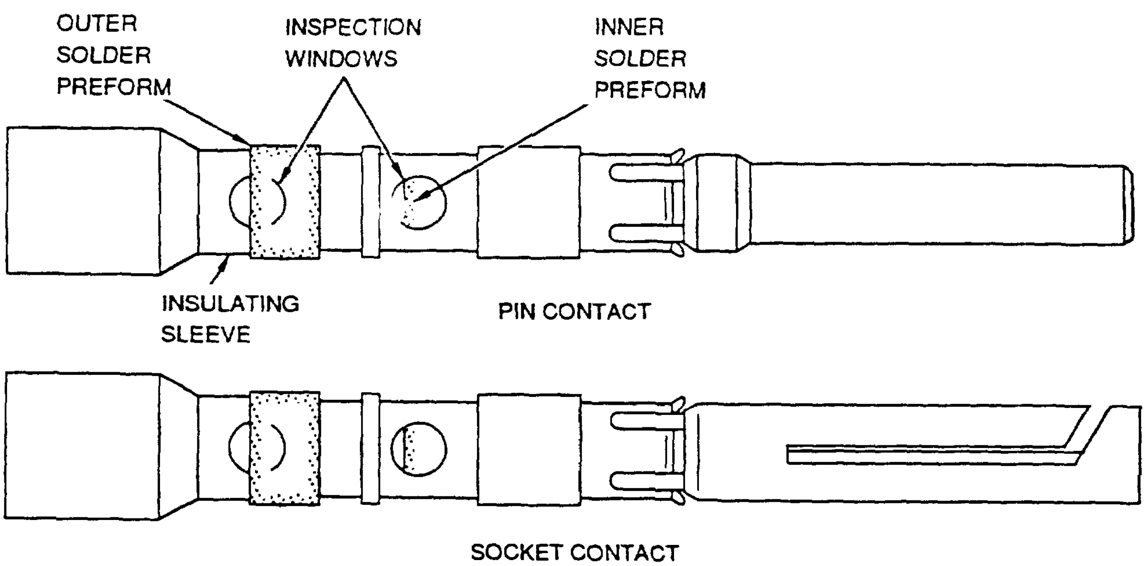


Figure 12. Typical Coaxial Solder Contact

Table 1 . Solder Contact Selection

Connector Specification	Contact Cavity Size	Wire or Cable Type	Contact Type	Raychem Solder Contact No.	Raychem Holding Fixture Adapter Number
MIL-C-26482 MIL-DTL–26500	12	Coaxial Cable	Pin	D-602-17	AT-1319-11
MIL-C-26482 MIL-DTL–26500	12	Coaxial Cable	Socket	D-602-16	
MIL-DTL–28748	16	Coaxial Cable	Pin	D-602-44	AT-1319-14
			Socket	D-602-45	
		Twisted Pair	Pin	D-602-54	
			Socket	D-602-55	
MIL-C-26482 MIL-DTL–26500	16	Coaxial Cable	Pin Socket	D-602-46 D-602-47	AT-1319-17
		Twisted Pair	Pin Socket	D-602-56 D-602-57	
MIL–DTL–83723 MIL–DTL–83733	12	Coaxial Cable	Pin	M39029/74–400 M39029/74–399	AT-1319-19
			Socket	M39029/73–397 M39029/73–396	
		Twisted Pair	Pin	M39029/74–401	
			Socket	M39029/73–398	
MIL-DTL-28748	16	Coaxial Cable	Pin	D-602-72	AT-1319-18
			Socket	D-602-73	

Table 2 . Coaxial Solder Contact Cable Accommodation Cable Dimensions

Solder Contact No.	Type of Cable Preparation	Cable Dimensions: NOTE 1 Center Conductor Diameter	Dielectric Diameter	NOTE 1 Shield Braid Diameter	Jacket Diameter
Raychem/Tyco P/N D-602-16, D-602-17	Conventional Strip	.011-.020	.033-.067	.074-.095	.131 MAX.
	Braid Foldback	.011-.020	.033-.067	.110 MAX. Over Folded Back Braid	—
Raychem/Tyco P/N D-602-72 D-602-73 D-602-44, D-602-45, D-602-46, D-602-47	Conventional Strip	.012-.026	.036-.066	.066-.082	.110 MAX.
	Braid Foldback	.012-.026	.036-.066	.086 MAX Over Folded Back Braid	—
M39029/74–400	Conventional Strip	.011-.026	.034-.081	.072-.098	.130 MAX.
M39029/73–397	Braid Foldback Note 2	.011-.026	.034-.081	.099 MAX Over Folded Back Braid	—
M39029/74–399	Conventional Strip	.012 NOM.	.102 .103 NOM.	.124 NOM.	.145 MAX.

NOTES:

1. Conductors must be silver-or tin-plated.
2. To achieve an environmental seal, install P/N CTA-0042 immediately adjacent to end of metallic body.

17 . **CABLE PREPARATION.** To prepare the cable, use the following procedure:

a. Determine method of cable preparation (Table 2).

b. Determine cable stripping dimensions (Figure 13).

c. Strip cable in accordance with NAVAIR 01-lA-505–1, WP 009 00.

d. Straighten center conductor and smooth shield-braid tightly against cable.

e. If stranded or unplated copper, tin center conductor.

18 . **ASSEMBLY.** To assemble the solder contact to the coaxial cable perform the following procedure:

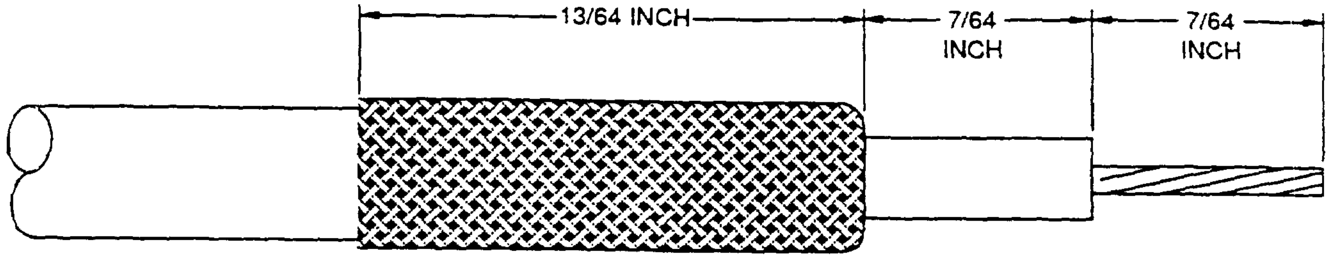
NOTE

For conventionally stripped cable, slightly rotate contact during cable insertion to prevent shield-braid strands from splaying.

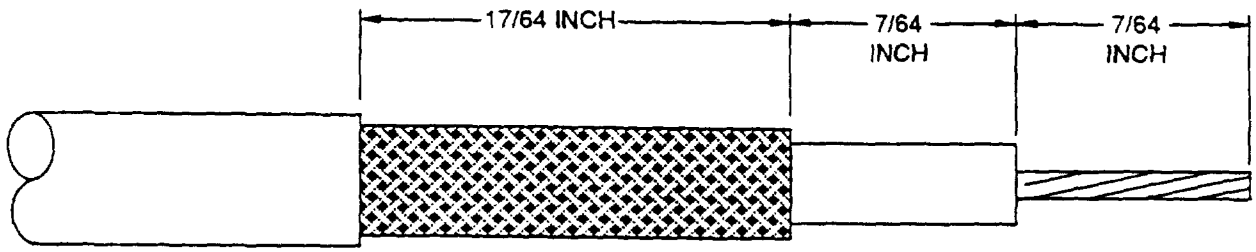
a. Slip solder contact carefully over end of prepared cable and push contact onto cable until it stops.

b. Inspect assembly to see that shield-braid aid center conductor are both visible through the respective inspection windows (Figure 12).

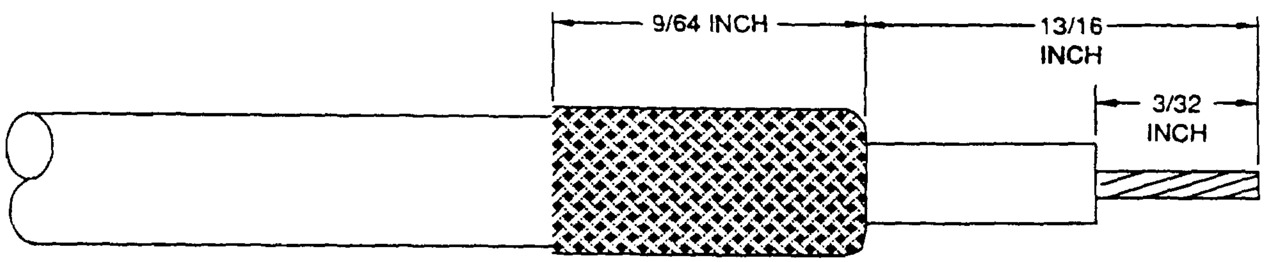
c. If shield braid and center conductor are not visible, remove contact from cable and check for incorrect strip dimension, splayed shield braid, or bent center conductor.



FOR CONTACTS NO. D-602-16, D-602-17
BRAID FOLDED BACK



FOR CONTACTS NO. D-602-16, D-602-17
CONVENTIONAL STRIPPING



FOR CONTACTS NO. D–602–44, D–602–45, D–602–46, D–602–47, D–602–72, D–602–73,
M39029/74–400, M39029/73–397
BRAID FOLDED BACK

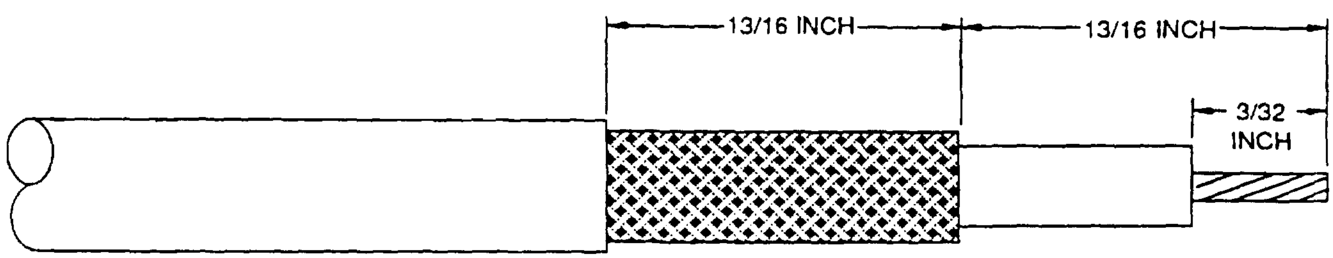
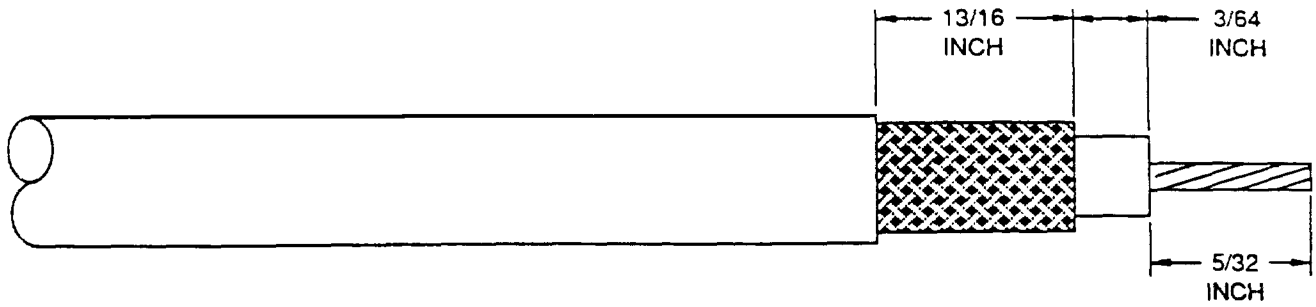


Figure 13. Strip Dimensions for Coaxial Solder Contacts (Sheet 1 of 2)



FOR CONTACTS NO. M39029/74–400, M39029/73–396
CONVENTIONAL STRIPPING

Figure 13. Strip Dimensions for Coaxial Solder Contacts (Sheet 2)

19 . **HEATING.** To attach the solder contact to the cable, use the following procedure:

a. Select appropriate adapter (Table 1).

b. Set up holding fixture and adapter as shown (Figure 14).

c. Insert contact and cable assembly into holding fixture and adapter (Figure 15). End of adapter marked P is for plug (pin) contacts and end marked R is for receptacle (socket) contacts.

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01-1A-35 or AF T.O. 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas-free environment criteria (NAVAIR 01-1A-35 AF T.O. 1–1–3), and there are no EMI restrictions.

Use of nitrogen with the HT-900B/HT-920B heating tool in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

Nozzle and output air of heating tools get very hot. Use extreme care while operating heating tool to avoid serious burns.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

NOTE

Both inspection windows must be in hot air stream facing air flow.

d. Heat contacts using hot-air heating tool with solder termination sleeve reflector. Apply heat until large outer solder ring melts and flows and outer sleeving is shrunk over cable.

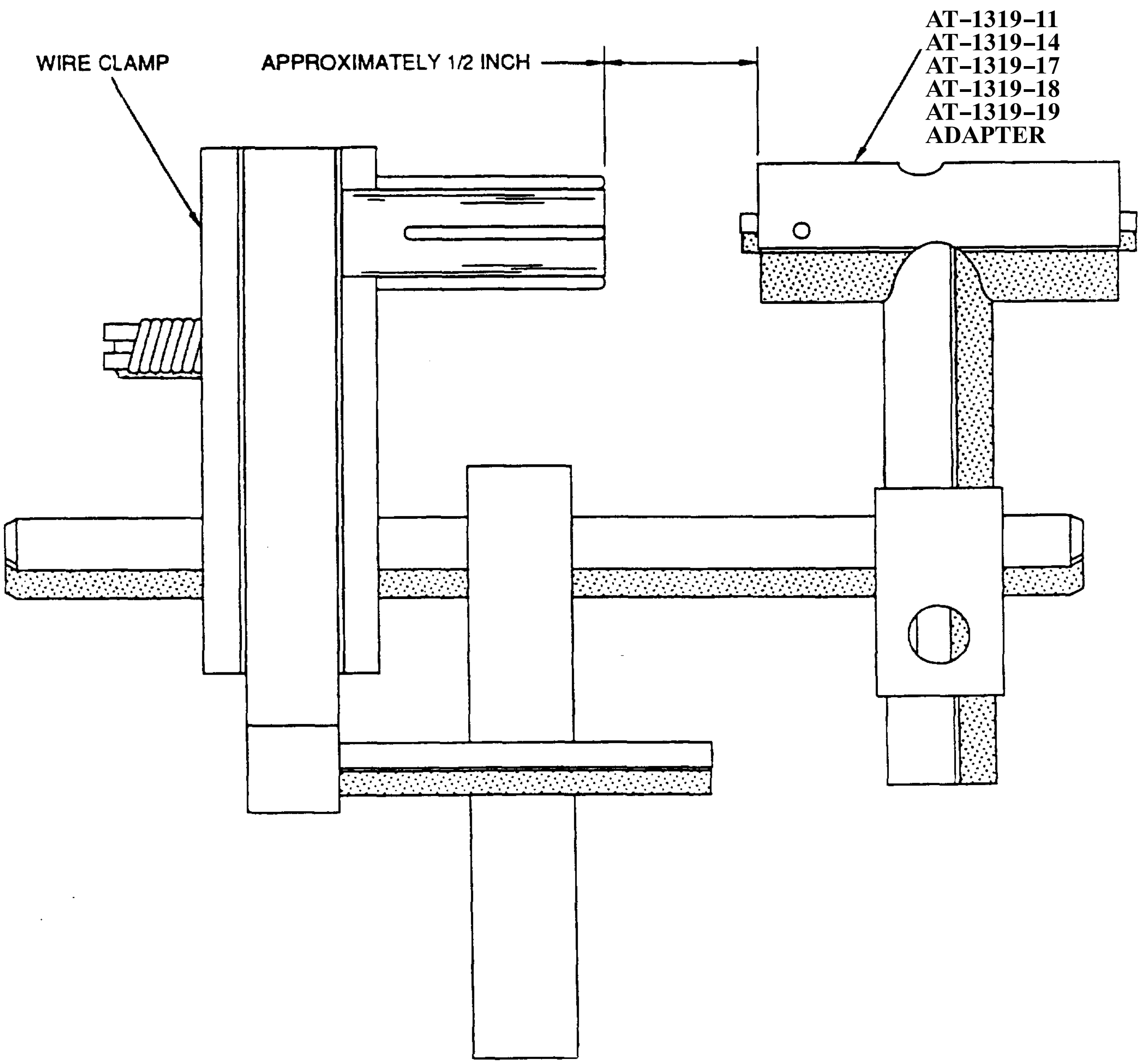


Figure 14. Holding Fixture and Adapter Setup

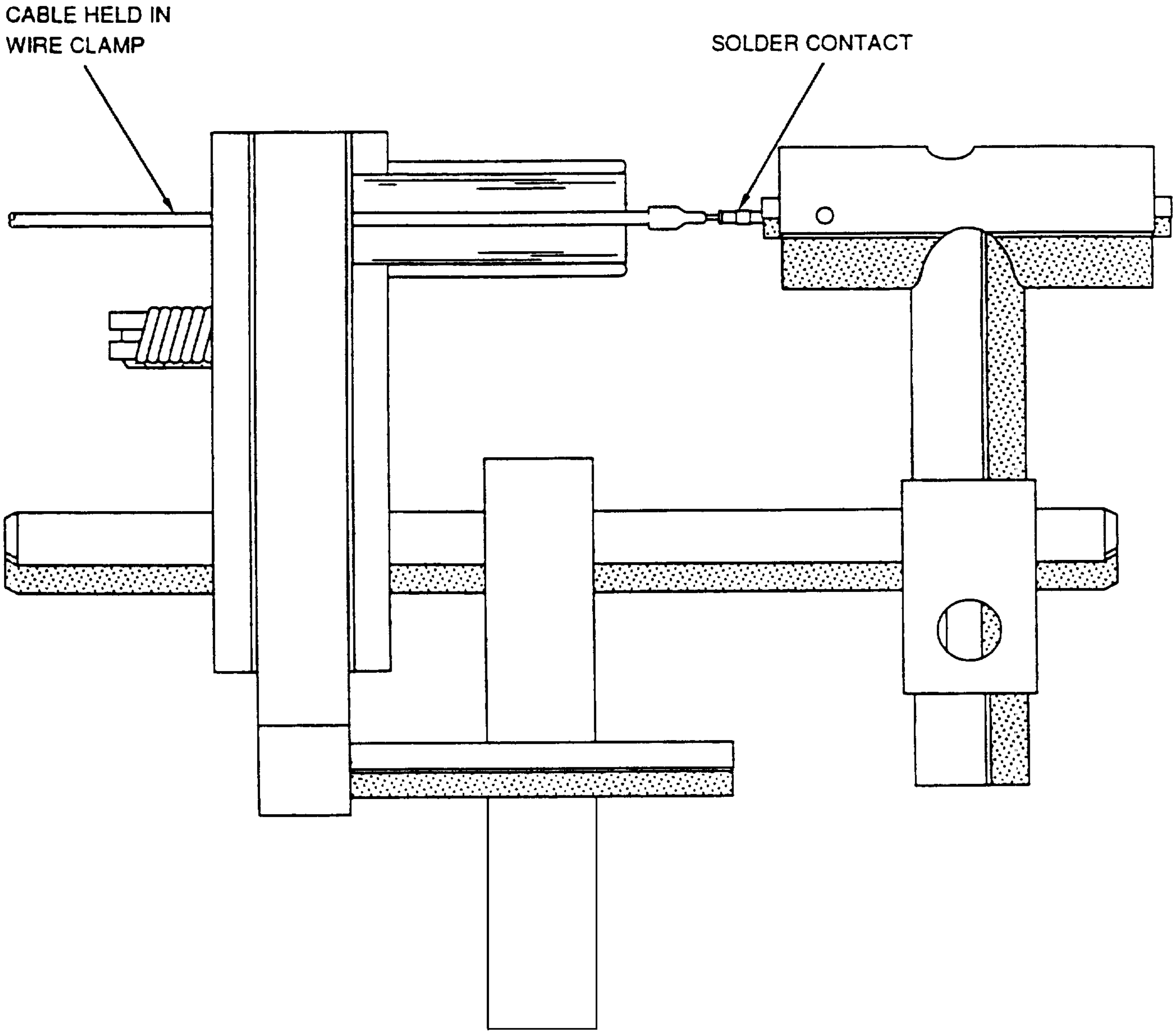


Figure 15. Solder Contact and Cable Prepared for Heating

e. Inspect small inner solder ring. If it has not melted and flowed, continue heating until it flows.

f. Allow assembly to cool at least five seconds before removing from holding fixture.

20 . **INSPECTION.** Inspect solder flow through two inspection windows.

21 . **REPAIR PROCEDURES.** An underheated contact can be reheated to flow solder properly. An overheated contact must be removed and a new contact installed. The procedure is as follows:

a. Using a sharp knife, slit insulation lengthwise at two points and peel off sleeve.

b. Using heating tool, heat contact until solder melts and quickly pull off heated contact with pliers.

c. Install new contact (Paragraphs 17 and 18).

22 . **TWISTED PAIR SOLDER CONTACT INSTALLATION.**

23 . **CONTACT SELECTION.** To select the proper contact, use the following procedure:

a. Determine connector specification, cavity size, and wire type.

b. Select appropriate solder contact (Table 3).

c. Verify contact is compatible with gage (AWG) size of twisted pair wire to be terminated (Table 3 and Table 4).

Table 3 . Twisted Pair Solder Contact Accommodation

Solder Contact No.	Twisted Pair Wire Size	NOTE 1 Conductor Type
Raychem/Tyco P/N D-602-54 D-602-55 D-602-56 D-602-57	30 thru 24 AWG	Stranded Or Solid
NOTE 2 M39029/74–401 M39029/73–398	24 thru 26 AWG	Stranded Or Solid

NOTES:

1. Conductors must be silver- or tin-plated.
2. To achieve an environmental seal, install P/N CTA-0006 immediately adjacent to end of inner insulation sleeve.

Table 4 . Coaxial Cable with Air/Polyethylene Dielectric Solder Sleeve Termination

Part Number	Primary Lead Color Code	Ground Lead Color Code	Dielectric O.D. (in) max	Jacket O.D. (in)	Lead Wire Gage
D-500-0089	White	Blue	.130	.145-.290	22AWG
D-500-0114	White	Blue	.080	.090-.215	24AWG
D-500-0120	Yellow	White	.130	.145-.290	22AWG
D-500-0121	Yellow	White	.130	.145-.290	24AWG
D-500-0122	Yellow	White	.130	.145-.290	26AWG
D-500-0134	White	White with Black Stripe	.157	.200-.290	22AWG

24 . **WIRE PREPARATION.** To prepare the twisted pair, use the following procedure:

a. Strip wire in accordance with Figure 16.

b. Twist conductors into normal lay and straighten.

c. Tin all stranded and non-plated solid wire.

d. After tinning, ensure wire ends are straight.

25 . **ASSEMBLY**. To assemble the solder contact to the twisted pair, use the following procedure:

a. Insert signal lead into center insulating sleeve and ground lead into outer insulating sleeve. Ensure wires bottom in contact (Figure 17).

b. Ensure signal lead is visible through forward inspection window inside inner solder preform.

c. Position ground lead so that it is not located directly in rear inspection windows.

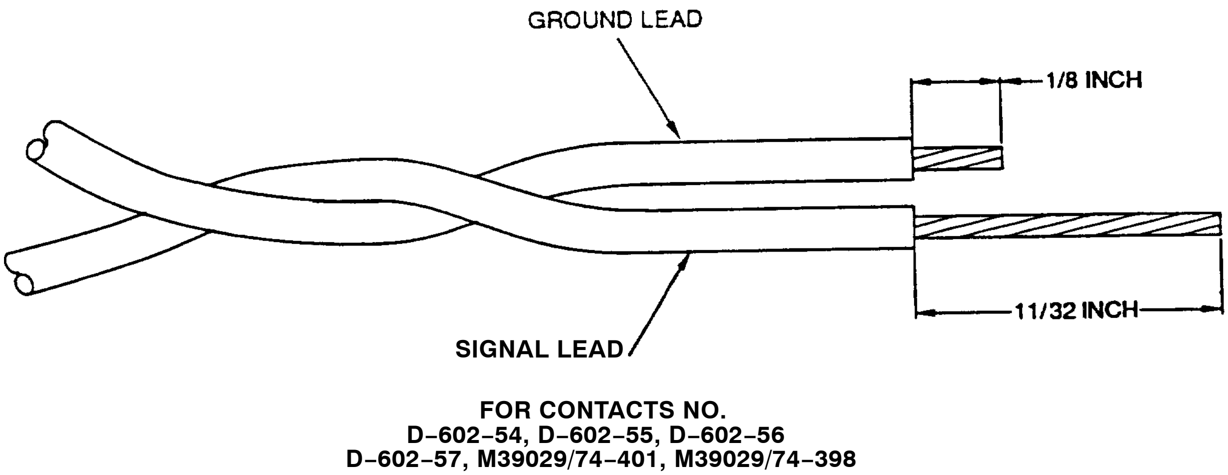


Figure 16. Strip Dimensions for Twisted Pair Solder Contacts

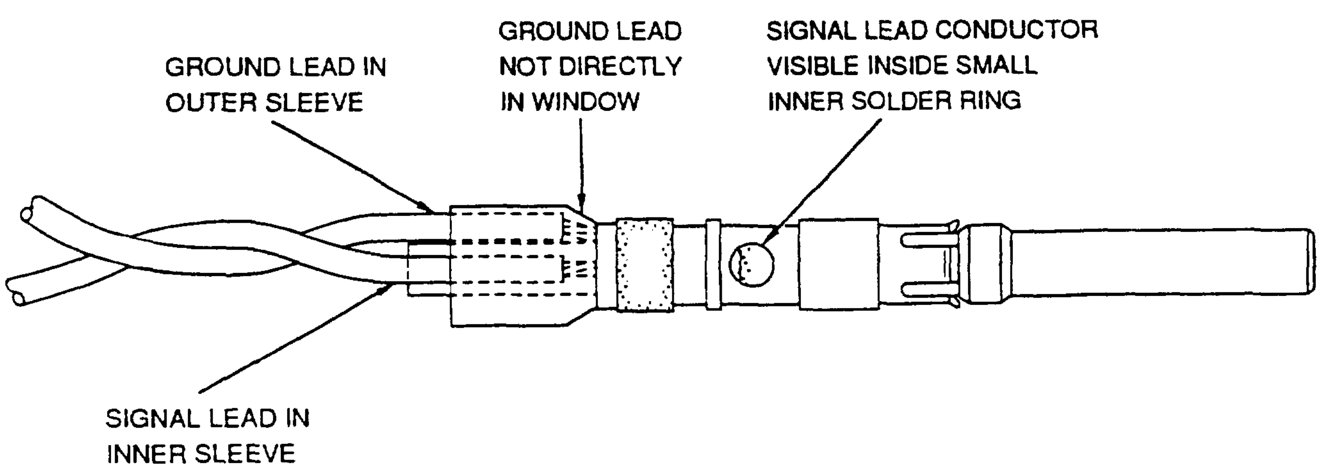


Figure 17. Inserting Twisted Pair into Solder Contact

26. **HEATING.** To attach the solder contact to the twisted pair, use the following procedure:

a. Select appropriate adapter (Table 1).

b. Set up holding fixture and adapter as shown (Figure 14).

c. Insert contact and twisted pair assembly into holding fixture and adapter (Figure 15). End of adapter marked P is for plug (pin) contacts and end marked R is for receptacle (socket) contacts.

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01-1A-35 or AF T.O. 1–1–3. Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

When using heat guns with electric motors, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

The MCH–100–A heat gun has been electromagnetic interference (EMI) qualified for flight line or flight deck use. All other electric motor type heat guns are not authorized for flight line or flight deck use due to electromagnetic interference (EMI). The electric motor type heating tools are safe for use by personnel at the organizational maintenance level to repair aircraft wiring in a hangar or hangar deck environment, provided the aircraft meets the gas-free environment criteria (NAVAIR 01-1A-35 or AF T.O. 1–1–3), and there are no EMI restrictions.

Use of nitrogen with the HT-900B/HT-920B heating tool in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not perform wire repair while using explosive solvent/paint products on the aircraft.

Nozzle and output air of heating tools get very hot. Use extreme care while operating heating tool to avoid serious burns.

When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

NOTE

Both inspection windows must be in hot air stream facing air flow.

d. Heat contacts using hot-air heating tool with solder termination sleeve reflector. Apply heat until small inner solder ring melts and flows and sleeving is shrunk over wires.

e. Inspect large outer solder ring to see if it has melted and flowed. If it has not melted and flowed, continue heating until it flows.

f. Allow the contact and wire assembly to cool for at least five seconds before removing from holding fixture.

27. **INSPECTION.** Inspect assembly as per instructions below. If inspection quality not met, see paragraph 28 for repair, or replace with new contact (Paragraphs 24 and 25).

a. Outer solder preform must be completely melted and flowed into rear inspection window.

b. Inner solder preform must be completely melted and flowed, forming a fillet of solder between signal wire conductor and inner soldering surface.

c. Both insulation sleeves should be fully shrunk onto wire insulation.

28 . **REPAIR PROCEDURES.** An underheated contact can be reheated to flow the solder properly. An overheated contact must be removed and a new contact installed. The procedure is as follows:

a. Using a sharp knife, slit the insulating sleeve lengthwise at two points and peel off sleeve.

b. Using heating tool, heat contact until solder melts and quickly pull off heated contact with pliers.

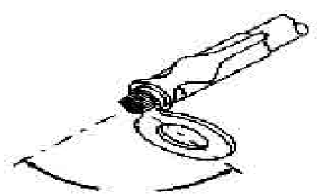
c. Install new contact (Paragraphs 50 and 51).

29 . <u>**CRIMP TERMINAL LUGS**</u>

30 . Wires terminated with solderless terminal lugs provide easy and efficient connections and disconnections from terminal boards, bus bars, and other electrical equipment. The solderless terminal lugs are either copper or aluminum, insulated or uninsulated, and in various styles and wire sizes. The terminal tongue of a straight lug may be bent up to 90 degrees maximum, provided the bend radius is not less than twice the thickness of the lug tongue, and the distance from the tip of the tongue to the beginning of the bend is not less than the diameter across the lug. Bending shall not be required to remove the fastening screw or nut. Terminal lugs may only be bent once (at installation) and shall not be unbent and then re–bent to facilitate removal and installation on terminal post (Figure 18). When selecting a terminal lug for multiple wires, a maximum of 4 wires may be crimped in a terminal lug as long as all wires fit into the crimp barrel (meeting the CMA of the lug). A maximum of 4 terminal lugs per post is allowed provided proper stack up is adhered to (WP 019 00). .

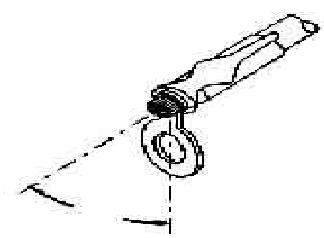
31 . **SAE AS7928 TERMINALS: LUG AND SPLICES, CONDUCTORS CRIMP STYLE COPPER.** This specification covers insulated and uninsulated crimp style copper terminal lugs for stranded conductors (Table 5).

32 . <u>**Standards**</u>**.** The SAE AS7928 terminal specifications also list the Military Standards for the different types and styles as listed (Table 6).



90 Degrees
MAX

For copper terminals size 24–14, straight terminals only, 90° maximum bend away from barrel



45 Degrees
MAX

For copper terminals size 12–10, straight terminals only, 45° maximum bend away from barrel.

Figure 18 Maximum Allowable Copper Terminal Lug Bend

Table 5 . M7928/ Applicable Specifications

Part No. M7928/	Description
1	Terminals, Lug And Splices, Conductor, Crimp Style, Copper Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, For Thin Wall Wire, Type II Class 1, (for 105°C total conductor temperature)
2	Terminals, Lug And Splices, Conductor, Crimp Style, Copper, Insulated, Rectangular Tongue, For Thin Wall Wire, Type II Class 1 (for 105°C total conductor temperature)
4	Terminals, Lug And Splices, Conductor, Crimp Style, Copper Terminal, Lug, Insulated, Ring Tongue, Bell–Mouthed, Type II Class 1 (for 150°C total conductor temperature)
7	Terminal Lug And Splices, Conductor, Crimp Style, Copper, Terminal Lug, Crimp Style, Copper, Uninsulated, Ring Tongue Type I Class 1 (for 175°C total conductor temperature)
8	Terminals, Lug And Splices, Conductor, Crimp Style, Copper Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, For Thin Wall Wire, Tin Whisker Resistant, Type II Class 1 (for 105°C total conductor temperature)
9	Terminals, Lug And Splices, Conductor, Crimp Style, Copper, Insulated, Rectangular Tongue, Tin Whisker Resistant For Thin Wall Wire, Type II Class 1 (for 105°C total conductor temperature)
11	Terminal, Lug, Crimp Style, Copper, Uninsulated, Ring Tongue, Tin Whisker Resistant, Type I, Class 1 (for 175°C total conductor temperature)
12	Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell–mouthed, Tin Whisker, Type II, Class 1 (for 105°C total conductor temperature)
13	Terminals, Lug And Splices, Conductor, Crimp Style, Copper Terminal, Lug, Insulated, Tin Whisker Resistant, Ring Tongue, Bell–mouthed, Type II Class 1 (for 150°C total conductor temperature)

Table 6 . M7928/ Military Standards

Part No.	Description
MS17143	Terminal, Lug, Crimp Style, Copper, Insulated, Rectangular Tongue, Type II, Class 1
MS20659	Terminal, Lug, Crimp Style, Copper, Uninsulated, Ring Tongue, Type I. Class 1
MS21004	Terminal, Lug, Uninsulated, Rectangular Tongue, Crimp Style, Copper, Type I. Class 1
MS25036	Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell-Mouthed, Type II, Class 1
MS25189	Terminal, Lug, Flag Type, Crimp Style, Copper, Class 1
MS25274	Cap Electrical (Wire End, Crimp Style, Type II, Class 1)

Table 7 . Applicable Standards

Part No.	Description
MS25435	Terminal Lug, Crimp Style, Straight Type for Aluminum Aircraft Wire, Class 1
MS25436	Terminal Lug, Crimp Style, 90 Degree Upright Type for Aluminum Aircraft Wire, Class 1
MS25438	Terminal Lug, Crimp Style, Right Angle Type for Aluminum Aircraft Wire, Class 1
M81824/1	Splices, Electrical, Permanent, Crimp Style, Copper, Insulated, Environment Resistant, Class 1
MS25493	Splice, Permanent Crimp Style, 2 Way Type for Aluminum Aircraft Wire Class 1

33 . **SAE AS70991 TERMINALS: LUG AND SPLICE, CRIMP STYLE, ALUMINUM, FOR ALUMINUM AIRCRAFT WIRE.** This specification covers crimp style aluminum terminals for aluminum aircraft wire.

34 . Only aluminum terminal lugs conforming to SAE−AS70991 shall be crimped to aluminum wire. The tongue of the aluminum terminal lugs or the total number of tongues of aluminum terminal lugs when stacked, shall be sandwiched between two MS25440 flat washers when terminated on terminal studs. Spacers or washers are not permitted between the tongues of terminal lugs. Terminals shall be of the types specified on the applicable standards specified in (Table 7).

CAUTION

Use copper terminations only on copper wire. Use aluminum terminations only on aluminum wire.

35 . **COPPER TERMINAL LUGS.** Terminals and conductor splices listed in this specification shall be of the following types and class.

a. Type I − Uninsulated

b. Type II − Insulated

c. Class 1 − Terminals and conductor splices which conform to all of the requirements of SAE AS7928 (Table 6) when installed with the crimping tool or crimping dies shown on the applicable MS standard or specification sheet. Copper terminal lugs are available in two styles for use under different space conditions and requirements: Straight (Figure 19) and Flag.

36 . **Size.** Some pre-insulated terminals accommodate more than one wire size. The insulation is color-coded and the range of wire sizes is marked on the tongue to identify the wire sizes that can be terminated with each of the terminal lug sizes (Table 8).

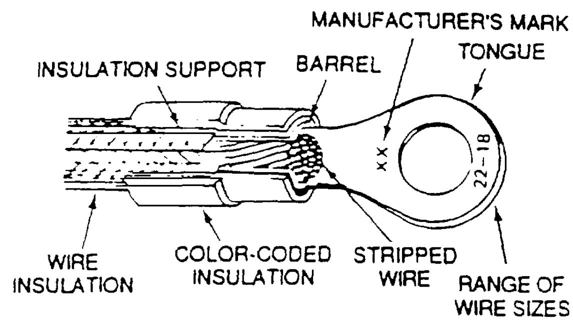


Figure 19. Typical Terminal Lug

Table 8 . Color Coding of Copper Terminal Lug Insulation

Terminal Lug Insulation Color	Wire Sizes (AWG) Used With
Yellow	#26 - #24
Red	#22 - #20, #18
Blue	#16-#14
Yellow	#12 - #10

37 . **Insulation.** Uninsulated type terminal lugs may be insulated (after assembly to wire) by heat-shrinkable tubing or by lengths of transparent tubing, called sleeves. These methods of insulation provide electrical and mechanical protection at the connection.

38 . **HIGH TEMPERATURE TERMINAL LUGS.** High temperature terminal lugs conform to SAE AS7928 and are available in two types. M7928/4 and M7928/7.

39 . **ALUMINUM TERMINAL LUGS.** Aluminum terminal lugs are used only to terminate aluminum wires. Aluminum terminal lugs are available in three types:

straight, 90 degree upright, and angle (left or right). The barrels of aluminum terminal lugs may be filled with a petroleum-based abrasive compound. This compound, by a grinding process during the crimping operation, removes the oxide film and prevents reforming in the completed connection. All aluminum terminals have an inspection hole to allow checking the depth of wire insertion. This inspection hole may be sealed with a removable plastic plug, which also serves to retain the oxide-inhibiting compound. Each aluminum terminal lug is marked with the letters AL indicating it is for use with aluminum wire. and also with the wire size it will accommodate (Figure 20).

40 . **Insulation.** Aluminum terminal lugs are not pre–insulated; therefore, they may be required to be insulated with heat shrink (refer to WP 014 00 for heat shrink selection and procedures).

WARNING

Methyl Ethyl Ketone is highly flammable. Avoid prolonged breathing of vapors and ensure there is adequate ventilation.

41 . Tight fitting sleeves are expanded in methyl ethyl ketone solvent before installation. When the solvent evaporates, the sleeve will shrink tightly over the terminal lug.

42 . **COPPER TERMINAL LUG/CAP TOOLS.** There are numerous types of lugs by size, style, and type. Proper tooling is essential in the crimp procedures to ensure proper contact. The tooling information is provided for each type terminal lug and electrical caps (Tables 9 through 16).

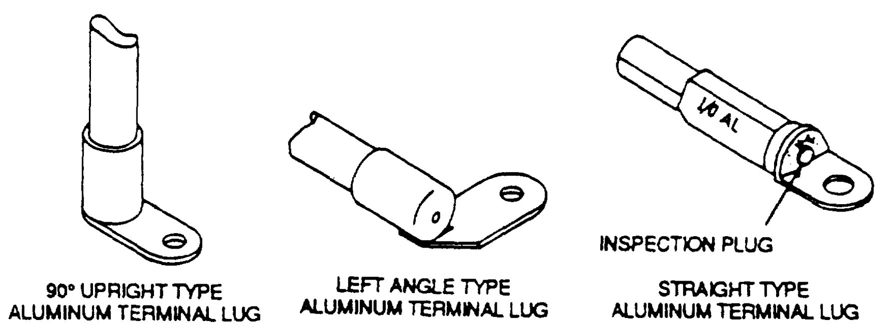


Figure 20. Solderless Aluminum Terminal Lugs

Table 9 . M7928/1 and M7928/8 Preinsulated Lug and Crimp Tool

Part No. M7928/1 or M7928/8	Wire Size Range	Stud Size	Insulation Sleeve Color	Wire Size Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–1	26	2	Yellow	Black	26 – 10 26 – 14	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–2		4						
–3		6						
–4		6						
–5		10						
–6	24	2	Yellow	Blue		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–7		4						
–8		6						
–9		8						
–10		10						
–70	22	2	Red	Green		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–11		4						
–12		6						
–13		6						
–14		8						
–15		10						
–16		1/4						
–17		5/16						
–18		3/8						
–19		1/2						
–71	20	2	Red	Red		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–20		4						
–21		6						
–22		6						
–23		8						
–24		10						
–25		1/4						
–26		5/16						
–27		3/8						
–28		1/2						
–72	18	2	Red	White		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–29		4						
–30		6						
–31		6						
–32		8						
–33		10						
–34		1/4						
–35		5/16						
–36		3/8						
–37		1/2						

See Footnotes at the end of the Table

Table 9 . M7928/1 and M7928/8 Preinsulated Lug and Crimp Tool (Continued)

Part No. M7928/1 or M7928/8	Wire Size Range	Stud Size	Insulation Sleeve Color	Wire Size Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–38	16	4	Blue	Blue		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–39		6						
–40		6						
–41		8						
–42		10						
–43		1/4						
–44		5/16						
–45		3/8						

Footnotes

1. M7928/8 terminal lugs are ”Tin Wisker Resistant” and are interchangeable with the same dash numbers as M7982/1.
2. Refer to NA 01–1A–8 for explanation of stud size.

Table 10 . M7928/2 and M7928/9 Preinsulated Lug and Crimp Tool

Part No. M7928/2 Or M7928/9	Wire Size Range	Stud Size Note 1	Insulation Sleeve Color	Wire Size Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–1	22	4	Red	Green	22 – 10 22 – 14	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–2		4						
–3		5						
–4		6						
–5		6						
–6		8						
–7		8						
–8	20	4	Red	Red		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–9		4						
–10		5						
–11		6						
–12		6						
–13		8						
–14		8						
–15	18	4	Red	White		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–16		4						
–17		5						
–18		6						
–19		6						
–20		8						
–21		8						

See Footnotes at the end of the Table

Table 10 . M7928/2 and M7928/9 Preinsulated Lug and Crimp Tool (Continued)

Part No. M7928/2 Or M7928/9	Wire Size Range	Stud Size Note 1	Insulation Sleeve Color	Wire Size Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–22	16	4	Blue	Blue		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–23		4						
–24		5						
–25		6						
–26		6						
–27		8						
–28		8						
–29	14	4	Blue	Green		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–30		4						
–31		5						
–32		6						
–33		6						
–34		8						
–35		8						
–36	12	4	Yellow	Yellow	22 – 10 12 – 10	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–100	M22520/3–9
–37		4						
–38		5						
–39		6						
–40		6						
–41		8						
–42		8						
–43	10	4	Yellow	Brown		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–100	M22520/3–9
–44		4						
–45		5						
–46		6						
–47		6						
–48		8						

Footnotes

1. M7928/9 terminal lugs are ”Tin Wisker Resistant” and are interchangeable with the same dash numbers as M7982/2.
2. Refer to NA 01–1A–8 for explanation of stud size.

Table 11 . M7928/4, M7928/12 and M7928/13 Terminal Lug and Crimp Tool

Part No. M7928/4	Wire Size Range	Stud Size	Insulation Sleeve Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–143	26 – 24	2	Yellow	26 – 10 26 – 14	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–144		4					
–145		6					
–146		8					
–147		10					
–159	22 – 18	2	Red		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–148		4					
–101		6					
–102		6					
–149		8					
–103		10					
–150		1/4					
–104		5/16					
–105		3/8					
–151		1/2					
–152	16 – 14	4	Blue		M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–106		6					
–107		6					
–153		8					
–108		10					
–154		1/4					
–109		5/16					
–110		3/8					
–155		1/2					
–111	12 – 10	6	Yellow	26 – 10	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–100	M22520/3–9
–156		8					
–112		10					
–157		1/4					
–113		5/16					
–114		3/8					
–158		1/2					
–115	8	10	Red	8 – 0000	AS5259/1	MS23002–8	MS23003–8
–116		1/4					
–117		5/16					
–118		3/8					
–119	6	10	Blue	8 – 0000	AS5259/1	MS23002–6	MS23003–6
–120		1/4					
–121		5/16					
–122		3/8					
–123	4	1/4	Yellow			MS23002–4	MS23003–4
–124		5/16					
–125		3/8					

See Footnotes at the end of the Table

Table 11 . M7928/4, M7928/12 and M7928/13 Terminal Lug and Crimp Tool (Continued)

Part No. M7928/4	Wire Size Range	Stud Size	Insulation Sleeve Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–126	2	1/4	Red			MS23002–2	MS23003–2
–127		5/16					
–128		3/8					
–129	1	1/4	White			MS23002–1	MS23003–1
–130		3/8					
–131		1/2					
–132	0	1/4	Blue			MS23002–01	MS23003–01
–133		3/8					
–134		1/2					
–135	00	5/16	Yellow			MS23002–02	MS23003–02
–136		3/8					
–137		1/2					
–138	000	3/8	Red			MS23002–03	MS23003–03
–139		1/2					
–140	0000	3/8	Blue			MS23002–04	MS23003–04
–141		1/2					

Footnotes

1. M7928/12 & /13 terminal lugs are ”Tin Wisker Resistant” and are interchangeable with the same dash numbers as M7928/4.
2. Dash numbers 138 through 141 are applicable to M7928/12 only.
3. Refer to NA 01–1A–8 for explanation of stud size.

Table 12 . M7928/7 Uninsulated Terminal Lug and Crimp Tool

Part No. M7928/7	Wire Size Range	Stud Size	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
-1	22-18	2	22-14	M22520/38-1		M22520/39-1
–2		4				
–3		6				
–4		10				
–5		5/16				
–6		3/8				
–7	16-14	6				
–8		10				
–9		5/16				
–10		3/8				
–11		4				

Table 13 . MS17143 Preinsulated Terminal Lug and Crimp Tool

Part No. MS17143	Wire Size Range	Stud Size	Insulation Sleeve Color	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–26	26–24	2	Yellow	26–14 26–10	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–101	M22520/3–10
–27		4					
–1	22–18	8	Red				
–4		6					
–7		8					
–10		5					
–13		6					
–16		4					
–19		4					
–22		6					
–23		6					
–24		8					
–25		10					
–28		2					
–2	16–14	8	Blue				
–5		6					
–8		8					
–11		5					
–14		6					
–17		4					
–20		4					
–3	12–10	8	Yellow	26–10	M22520/5–01 M22520/10–01	M22520/5–100 M22520/10–100	M22520/3–9
–6		6					
–9		8					
–12		5					
–15		6					
–18		4					

Table 14 . MS25189 Uninsulated Copper Terminal Lug and Crimp Tool

Part Number MS25189–	Wire Size Range	Crimp Tool	Crimp Die HEX	Crimp Die Single Indent	Crimp Die Double Indent	Inspection Gauge
101–106	8	HD51	HD51–105	HD51–114N	HD51–118N	G744
107–111	6		HD51–106	HD51–115N	HD51–119N	G745
112–116	4		HD51–107	HD51–116N	HD51–120N	G746
117–122	2		HD51–113	HD51–117N	HD51–121N	G742
128–132	0		HD51–128	HD51–122N	HD51–123N	G747
133–137	00		HD51–129	–	HD51–124N	–
138–141	000	–	–	–	–	–
142–147	0000	–	–	–	–	–

Table 15 . MS20659 and AS7928/11 Uninsulated Terminal Lug and Crimp Tool

Part No. MS20659 or AS7928/11	Wire Size Range	Stud Size	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
–167	22–18	2	22–10	M22520/38–01 , M22520/24–01	M22520/5–100	M22520/39–01, M22520/3–10
–138		4				
–101		6				
–102		10				
–161		5/16				
–125		3/8				
–162		1/2				
–139	16–14	4				
–103		6				
–126,		6				
–104		10				
–163		5/16				
–127		3/8				
–164		1/2				
–165	12–10	6				
–105		10				
–106		5/16				
–128,		3/8				
–166		1/2				
–140	8	8	8 thru 0000	M5259/1	MS90485–8	MS90486–8
–107		10				
–141		1/4				
–108		5/16				
–129		3/8				
–142		1/2				
–130	6	10			MS90485–6	MS90486–6
–109		1/4				
–131		5/16				
–110		3/8				
–143		1/2				
–144	4	10			MS90485–4	MS90486–4
–111		1/4				
–132		5/16				
–112		3/8				
–145		1/2				
–146	2	10			MS90485–2	MS90486–2
–113		1/4				
–147		5/16				
–114		3/8				
–148		7/16				
–133		1/2				

See Footnotes at the end of the Table

Table 15 . MS20659 and AS7928/11 Uninsulated Terminal Lug and Crimp Tool (Continued)

Part No. MS20659 or AS7928/11	Wire Size Range	Stud Size	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
−115	1	1/4	8 thru 0000	HH80C Or M5259/1	MS90485−1	MS90486−1
−149		5/16				
−116		3/8				
−150		7/16				
−134		1/2				
−117	0	1/4			MS90485−01	MS90486−01
−151		5/16				
−118		3/8				
−152		7/16				
−135		1/2				
−153	00	1/4			MS90485−03	MS90486−02
−119		5/16				
−120		3/8				

Footnotes
1. M7928/11 terminal lugs are “Tin Wisker Resistant” and are interchangeable with the same dash numbers as MS20659.
2. Refer to NA 01–1A–8 for explanation of stud sizes.

Table 16 . MS25036 Insulated Terminal Lug and Crimp Tool

Part No.	Color	Wire Size Range	Crimp Tool Range	Crimp Tool	Crimp Die	Inspection Gage
M25036−143 thru 147	Yellow	26−24	26−14	M22520/5−01 M22520/10−01	M22520/5−100 M22520/10−101	M22520/3−10 M22520/3−10
M25036−101, 102, 103, 104, 105, 148, 149, 150, 151, 159	Red	22−18	26−14	M22520/5−01 M22520/10−01	M22520/5−100 M22520/10−101	M22520/3−10 M22520/3−10
M25036−106, 107, 108, 109, 110, 152, 153, 154, 155	Blue	16−14	22−10	M22520/5−01 M22520/10−01	M22520/5−100 M22520/10−101	M22520/3−9 M22520/3−9
M25036−111, 112, 113, 114, 156, 157, 158	Yellow	12−10	26−10	M22520/5−01	M22520/5−100	M22520/3−9 OR M225/3−10
M25036−115−118	Red	8	8−0000	M5259/1−0001	M23002−8	M23003−8
M25036−119−122	Blue	6	8 −0000	M5259/1−0001	M23002−6	M23003−6
M25036−123−125	Yellow	4	8−0000	M5259/1−0001	M23002−4	M23003−4
M25036−126−128	Red	2	8−0000	M5259/1−0001	M23002−2	M23003−2
M25036−129−131	Clear	1	8−0000	M5259/1−0001	M23002−1	M23003−1
M25036−132−134	Blue	0	8−0000	M5259/1−0001	M23002−01	M23003−01
M25036−136−137	Yellow	00	8−0000	M5259/1−0001	M23002−02	M23003−02
M25036−138−139	Red	000	8−0000	M5259/1−0001	M23002−03	G282
M25036−140−141	Blue	0000	8−0000	M5259/1−0001	M23002−04	G728

Table 17 . Wire Stripping Lengths for Small Copper Terminal Lugs

Wire Size (AWG)	Strip Lengths (In Inches)
#26 and #24	5/32
#22 and #20	3/16
#18-#14	1/4
#12 and #10	9/32

43 . **COPPER LUG CRIMPING PROCEDURE**. The following crimp procedures are recommended.

a. Select terminal crimp tool, crimp die. and inspection gage (Table 9).

b. Strip wire to dimensions (Table 17) in accordance with WP009 00.

c. Check tool with proper gage (Tables 9 through 16) in accordance with tool paragraph listed herein.

d. Insert terminal lug, tongue first. into wire side of tool crimping jaws, until terminal lug barrel butts flush against tool stop on the locator.

e. Squeeze tool handles slowly until tool jaws hold terminal lug barrel firmly in place, but without denting it.

f. Insert stripped wire into terminal lug barrel until wire insulation butts flush against near end of wire barrel (Figure 21).

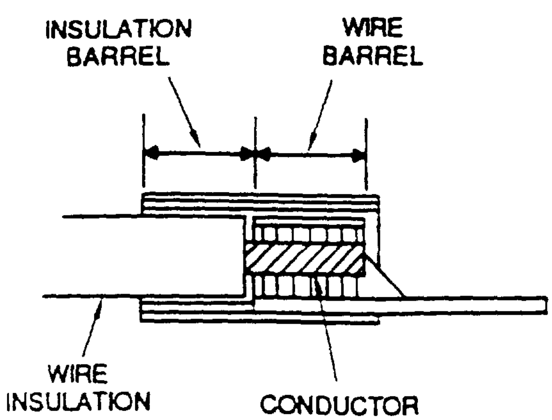


Figure 21 Insertion of Wire Into Insulated Terminal Lug

g. Squeeze tool handles until ratchet releases.

CAUTION

Do not use any connection which is found defective as a result of the visual inspection. Cut off defective connection and remake using a new terminal lug or splice.

h. Examine the crimped condition carefully for the following:

(1) Indent centered on terminal lug barrel.

(2) Indent in line with barrel: not cracked.

(3) Terminal lug barrel not cracked.

(4) Terminal lug insulation not cracked.

(5) Insulation grip crimped.

44 . **ALUMINUM LUG CRIMPING PROCEDURES.** Crimp aluminum terminal lugs as follows:

WARNING

Because of potential hotspots an aluminum terminal should be replaced with an identical terminal. See aircraft CFA for support if terminal is not a MS25435 through MS25438 terminal.

CAUTION

Use care when stripping wire insulation.

a. Using the tool specified in Table 18, select proper die for wire size required. Die is stamped with the wire size on both upper and lower faces and with the letters AL. Install die in tool head (paragraph 145).

b. Strip wire insulation carefully, using recommended stripping practices for aluminum wire described in WP 009 00. Stripping lengths in inches are listed in Table 19.

Table 18 . Aluminum Uninsulated Terminal Lug and Crimp Tool

Wire Size Range	Crimp Tool	Crimp Die HEX	Inspection Gauge
8	MS25441−5(note 1) M5259/1−001(note 2)	MS90485−8* M5259/1−XXX	MS90486−8* M5259/1−XXX
6		MS90485−6* M5259/1−XXX	MS90486−6* M5259/1−XXX
4		MS90485−4* M5259/1−XXX	MS90486−4* M5259/1−XXX
2		MS90485−2* M5259/1−XXX	MS90486−2* M5259/1−XXX
0		MS90485−01* M5259/1−XXX	MS90486−01* M5259/1−XXX
00		MS90485−02* M5259/1−XXX	MS90486−02* M5259/1−XXX
000		MS90485−03* M5259/1−XXX	MS90486−03* M5259/1−XXX
0000		MS90485−04* M5259/1−XXX	MS90486−04* M5259/1−XXX

NOTE
1. Tool may be used until worn out. Do not replace or repair.
2. SAE−AS−5259 has been approved, however, attaching dies and inspection gauges have not been approved as of release of this manual. Refer to specification for updates or contact cognizant engineering authority for additional direction.

Table 19 . Stripping Lengths for Aluminum Wire

Wire Size	MS25435, 25436, 25437, & 25438
8	11/16
6	13/16
4	27/32
2	1-1/32
1	1-1/32
1/0	1-1/32
2/0	1-7/32
3/0	1-9/32
4/0	1-7/16

c. Install insulation sleeve over wire insulation, well back from crimping area.

d. Inspect to see that inner barrel is well coated with compound, if required.

e. Insert wire into terminal barrel.

f. Wipe off any excess compound squeezed out of terminal lug barrel with a clean soft cloth.

CAUTION

If present, do not remove the inspection plug as this keeps the compound in the barrel. When the wire is inserted to the full depth of the barrel, the compound is forced between and around the conductor strands.

g. Insert assembly into the die correctly positioned as shown in Figure 22.

h. Actuate handle for manual hydraulically operated tool. Do not release the button until the dies open automatically.

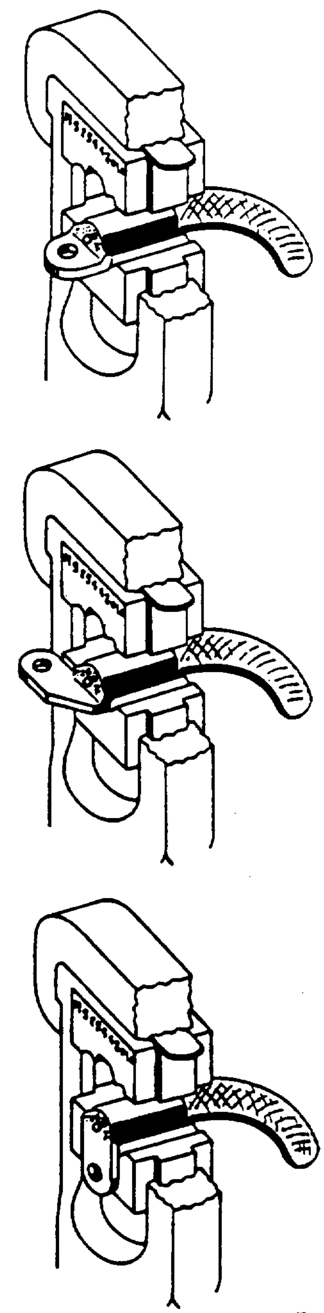


Figure 22. Positioning Aluminum Terminal Lugs in Die Nests

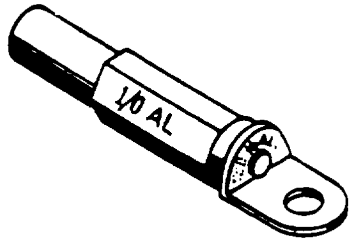


Figure 23. Single Crimp on Aluminum Terminal Lugs

NOTE

Wire sizes No. 8 to No. 2/0 require only one crimp. Wire sizes No. 3/0 and No. 4/0 require two crimps. Locate the second crimp centrally on the portion of the barrel remaining after the first crimp (Figure 23).

i. Check visually to see that the correct wire size is imprinted on the barrel.

j. Remove the inspection plug and check visually or with the aid of a probe to see that wire is fully inserted. Replace the plug after inspection.

k. Slide insulating sleeve, if needed, over the terminal lug barrel and shrink it (WP 014 00).

l. Examine the crimped condition carefully for the following:

(1) Indent centered on terminal lug barrel.

(2) Indent in line with barrel: not cracked.

(3) Terminal lug barrel not cracked.

(4) Conductor is flush or extends not more than 1/32” past end of crimp barrel (See Figure 20).

45 . **MIL-DTL-22520 CRIMPING TOOLS HAND OR POWER ACTUATED, WIRE TERMINATION.**

46 . **PURPOSE.** This specification covers the general requirements for crimp tools, inspection gages and tool kits used for connecting the following:

a. Removable Contacts.

b. Coaxial Connectors.

c. Ferrules.

d. Terminals.

e. End Caps.

f. Splices.

47 . **CLASSIFICATION.** Crimp tools are of the following types:

a. Type 1. Type 1 crimp tools are those which produce an indent crimp.

b. Type 2. Type 2 crimp tools are those which produce a formed crimp.

48 . **CRIMP TOOL M22520/1-01.**

49 . **GENERAL DESCRIPTION.** This tool is considered to be the upper range adjustable crimp tool, with virtually limitless application within the 12 to 26 AWG wire range. The tool measures 9 3/4 inches X 2 1/2 inches X 1 1/4 inches and weighs 15 ounces (Figure 24).

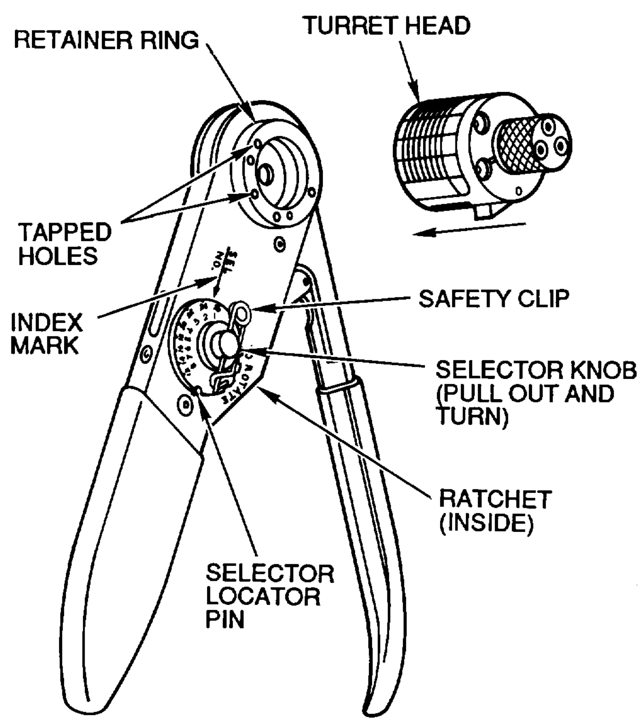


Figure 24. Crimp Tool M22520/1-01

50 . **Use.** The tool is used to crimp removable contacts with a wire barrel size of 12 thru 26. The crimp is the standard 8 impression which affords maximum tensile strength. The 8 impression indent crimp is illustrated (Figure 25).

51 . **Ratchet.** A precision ratchet controls the cycling of the tool in both directions of the handle. This ratchet mechanism ensures the same and accurate crimp for each operation.

52 . **Crimp Depth (Die Closure).** A positive crimp depth is controlled by an 8 position selector knob located on the tool frame. The operator dials in the desired step for the wire being used and locks the setting with a locking pin (Figure 26).

53 . **Turret.** For proper operation the tool frame must be mated with a turret head (Figure 27) which has a 3 index positioner (Figure 28).

a. Turret Head. The turret head is a device that contains more than one positioner which is indexed by rotating a circular barrel when attached to the tool frame.

b. Positioner. The positioner is a device that when attached to the tool frame locates or positions the contact in the correct position.

c. Locator Positioner. The locator on a turret is a 3 index positioner which rotates to accommodate 3 different size wire crimps (Figure 25).

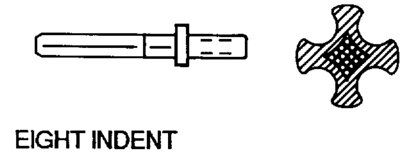


Figure 25. 8 Impression Crimp

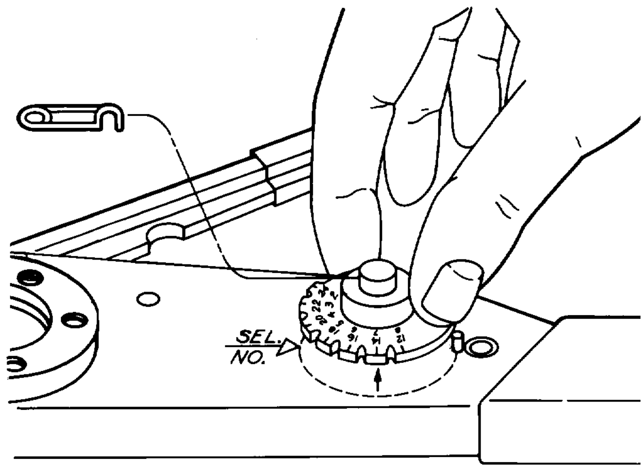


Figure 26. Crimp Depth (Die Closure)

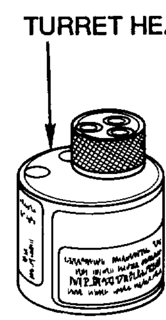
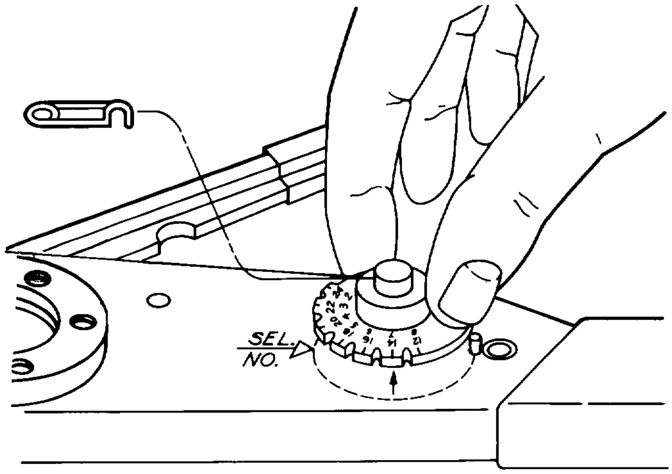


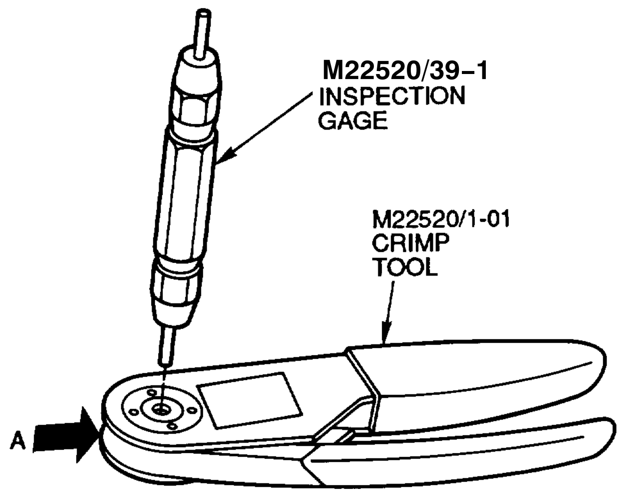
Figure 27. M22520/1-01 Turret Head

A. DIE CLOSURE CHECK.

1. REMOVE SAFETY PIN. RAISE WIRE SIZE SELECTOR KNOB AND ROTATE TO 4. REINSTALL SAFETY PIN.

2. CLOSE HANDLES COMPLETELY AND HOLD IN FULLY CLOSED POSITION.





CAUTION

DO NOT CRIMP THE GAGE PIN. THIS WILL PERMANENTLY DAMAGE THE TOOL AND THE GAGE.

3. AXIALLY ALIGN GO GAGE (GREEN) WITH INDENTER OPENING. SLIDE GO GAGE INTO INDENTER OPENING AND THROUGH INDENTERS. GAGE SHOULD PASS FREELY THROUGH INDENTERS. IF NOT, RETURN TOOL FOR REPAIR.

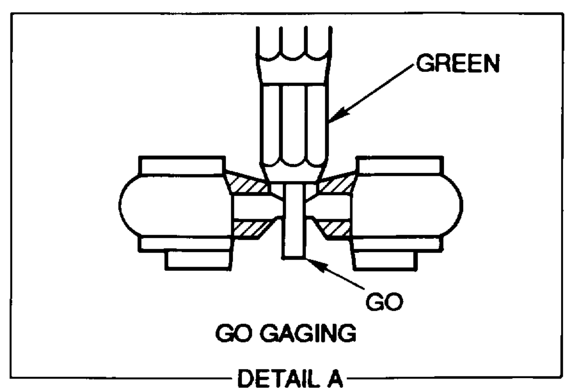
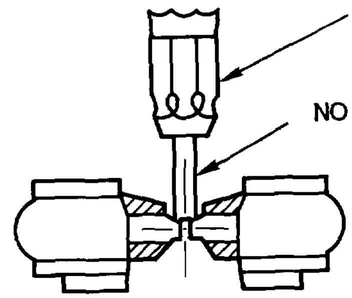
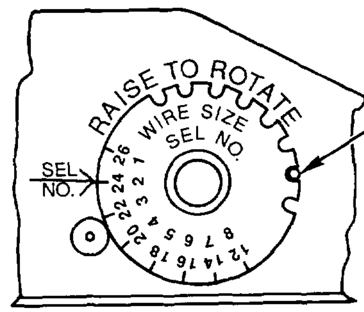


Figure 28. M22520/1-01 Setup, Adjustment, and Operation (Sheet 1 of 4)

4. INVERT INSPECTION GAGE WHILE CONTINUING TO HOLD HANDLES IN THE FULLY CLOSED POSITION. INSERT NO GO (RED) GAGE INTO INDENTER OPENING. GAGE MAY PARTIALLY ENTER, BUT SHOULD NOT PASS BETWEEN INDENTERS. IF NO GO (RED) GAGE PASSES THROUGH INDENTERS, RETURN TOOL FOR REPAIR.





WIRE SIZE SELECTOR KNOB

B. CRIMP TOOL SETUP AND ADJUSTMENT.

1. DETERMINE THE REQUIRED SELECTION SETTING (CRIMP DEPTH) FOR THE WIRE SIZE BY REFERRING TO THE DATA PLATE ON THE TURRET OR POSITIONER.

2. REMOVE SAFETY PIN FROM WIRE SIZE SELECTOR KNOB.

3. RAISE WIRE SELECTOR KNOB AND ROTATE TO SELECTOR SETTING NUMBER. SEE TABLE.

4. LOWER WIRE SIZE SELECTOR KNOB.

5. ENSURE THAT NOTCH ON WIRE SIZE SELECTOR KNOB ENGAGES WITH PIN ON CRIMPING TOOL HANDLE. REINSTALL SAFETY PIN.

CONTACT SIZE	WIRE SIZE	SELECTOR SETTING	TURRET BUSHING
20	24	2	RED
20	22	3	RED
20	20	4	RED
16	20	4	BLUE
16	18	5	BLUE
16	16	6	BLUE
12	14	7	YELLOW
12	12	8	YELLOW

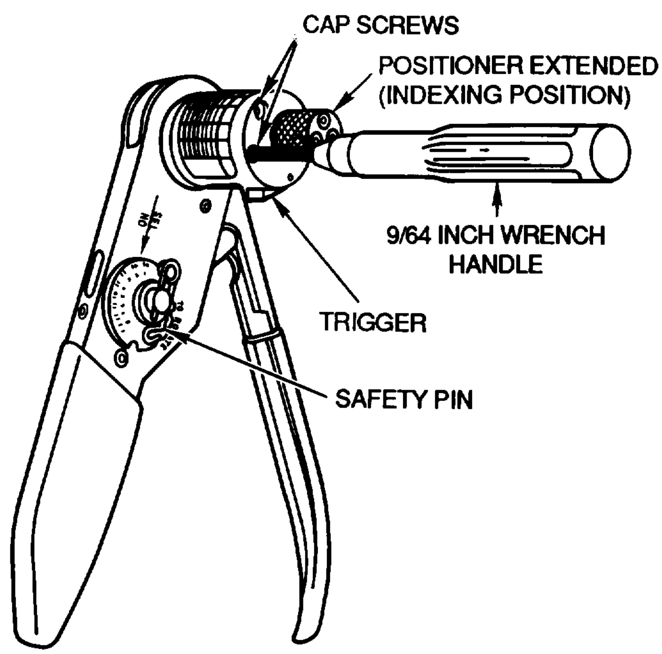
Figure 28. M22520/1-01 Setup, Adjustment, and Operation (Sheet 2)

6. PRESS TRIGGER ON TURRET HEAD RELEASING POSITIONER TO EXTENDED (INDEXING) POSITION.

7. SEAT TURRET HEAD ONTO RETAINER RING ON BACK OF TOOL WITH SCREWS LINED UP WITH TAPPED HOLES.

8. TIGHTEN CAP SCREWS WITH A 9/64 INCH ALLEN WRENCH.

9. TO REMOVE, LOOSEN CAP SCREWS UNTIL THREADS ARE DISENGAGED FROM TAPPED HOLES AND LIFT TURRET HEAD OFF CRIMP TOOL FRAME.



10. OPEN CRIMP TOOL HANDLES. DEPRESS TRIGGER TO UNLOCK AND EXTEND (RAISE) POSITIONER TO INDEXING POSITION.

11. WITH POSITIONER EXTENDED, ROTATE BUSHING OF APPLICABLE CONTACT SIZE AND COLOR TO INDEX MARK.

12. DEPRESS POSITIONER INTO LOCKED DOWN POSITION (FLUSH WITH TURRET).

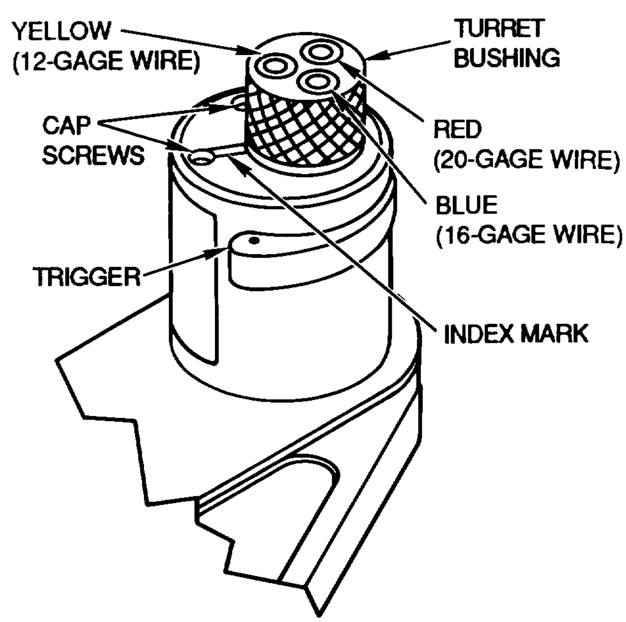
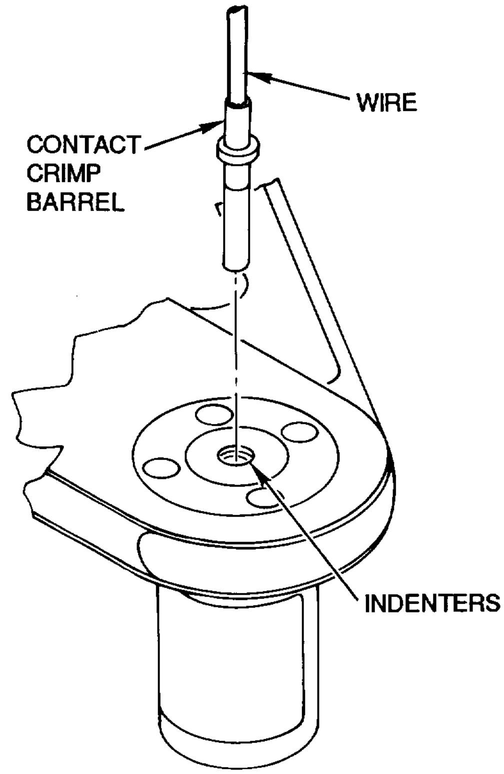


Figure 28. M22520/1-01 Setup, Adjustment, and Operation (Sheet 3)

13. INSERT CONTACT AND WIRE INTO CRIMP TOOL INDENTERS ON FRONT OF TOOL UNTIL CONTACT BOTTOMS IN TURRET HEAD. HOLDING WIRE AND CONTACT IN PLACE, SQUEEZE CRIMP TOOL HANDLES TOGETHER SMOOTHLY UNTIL RATCHET RELEASES AND TOOL OPENS.

NOTE

CRIMP TOOL WILL NOT RELEASE UNTIL CRIMPING CYCLE IS COMPLETED.



14. REMOVE CONTACT FROM CRIMP TOOL AND INSPECT CONTACT AS REQUIRED.

15. REFER TO APPLICABLE WORK PACKAGE FOR CONTACT INSERTION PROCEDURE.

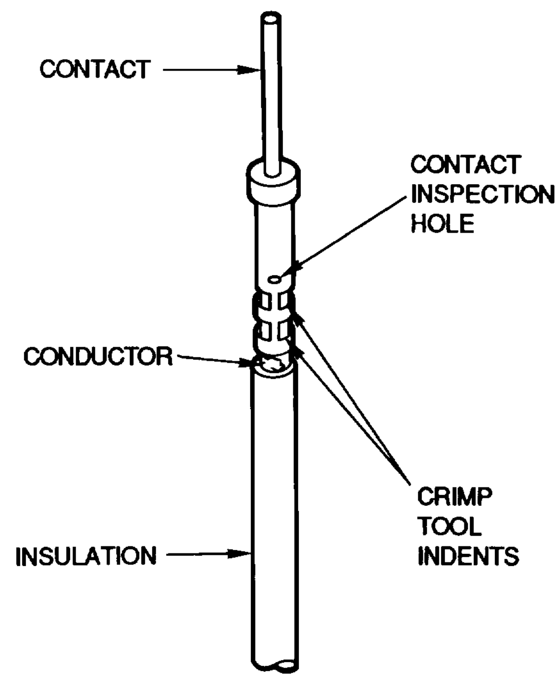


Figure 28. M22520/1-01 Setup, Adjustment, and Operation (Sheet 4)

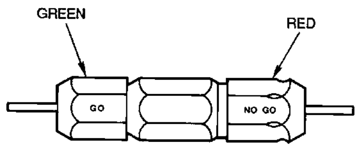


Figure 29. Inspection Gage

54 . **Periodic Gaging.** To ensure accurate calibration, the gaging task shall be performed before each series of crimping operations (such as at the beginning of a task). Periodic gaging is required to ensure proper crimp dimensions and tool calibration, and is performed as per Figure 28 (Sheet 1 and 2) using tool M22520/39-1 (see Figure 29).

55 . **Data Plates.** A permanent data plate is affixed to all positioners. The plate designates which contacts the positioner accommodates for its wire size and indicates selector position.

56 . **Maintenance.** No operator maintenance is required other than proper storage and cleaning.

57 . **Inspection Gage.** The inspection gage is a Go/No Go gage used to ensure accurate crimps. The gage ends are color coded green for Go, red for No Go as illustrated (Figure 29).

58 . M22520/1-01 Crimping Procedure. Correct crimp tool buildup and adjustment are necessary to perform mechanically and electrically sound crimps. Perform buildup and adjustment using the following steps:

a. Select proper turret.

b. Select proper inspection gage.

c. Buildup and adjust tool (Figure 30).

d. Operate (Figure 31).

59 . **CRIMP TOOL M22520/2-01.**

60 . **GENERAL DESCRIPTION.** This tool is considered to be the lower range adjustable crimp tool designed for most miniature and subminiature connector contacts accommodating wire size 20 thru 32 AWG. The tool measures 7.5 inches maximum and weighs 1 pound maximum. The crimp range of this tool overlaps the M22520/1-01 making these tools primary for all crimp contact applications (Figure 30). The tool body color is blue.

61 . **Use.** The tool is used to crimp removable contacts with a wire barrel size of 20 thru 32. The crimp is the standard 8 impression which affords maximum tensile strength as illustrated (Figure 25).

62 . **Ratchet.** A precision ratchet controls the cycling of the tool in both directions of the handle. This ratchet mechanism assures the same and accurate crimp for each operation.

63 . **Crimp Depth (Die Closure).** A positive crimp depth is controlled by an 8 position selector knob located on the tool frame. The operator dials in the desired step for the wire being used and locks the setting with a locking pin as illustrated (Figure 29).

64 . **Positioner.** For proper operation the tool frame must be mated with a positioner.

65 . **Inspection Gage.** The inspection gage is a Go/No Go gage used to ensure accurate crimps. The gage ends are color coded green for Go, red for No Go as illustrated (Figure 31).

66 . **Periodic Gaging.** To ensure accurate calibration as defined in the previous paragraph, the gaging task shall be performed before each series of crimping operations (such as at the beginning of a task). Periodic gaging is required to ensure proper crimp dimensions and tool calibration, and is performedas per Figure 31 using tool M22520/39–1.

67 . **Data Plates.** A permanent data plate is affixed to all positioners. The plate designates which contacts the positioner accommodates for its wire size and indicates selector position.

68 . **Maintenance.** No operator maintenance is required other than proper storage and cleaning.

69 . **M22520/2-01 CRIMPING PROCEDURE.** Correct crimp tool setup and adjustment are necessary to perform mechanically and electrically sound crimps. Perform setup and adjustment using the following steps:

a. Select proper positioner (8).

b. Select proper inspection gage.

c. Setup and adjust tool (Figure 31).

d. Operate (Figure 31).

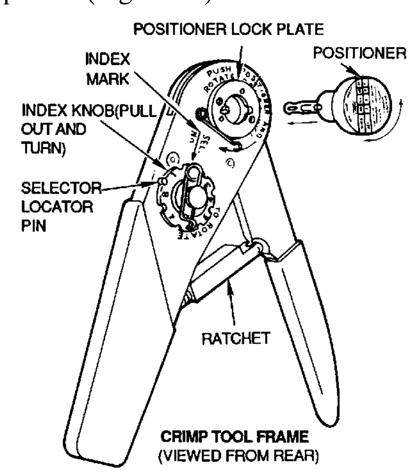
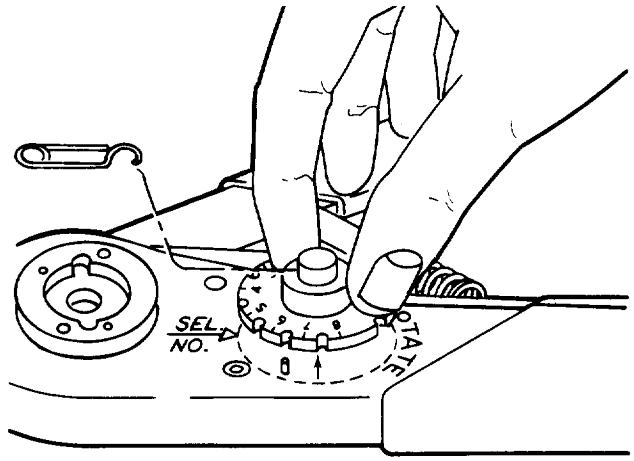


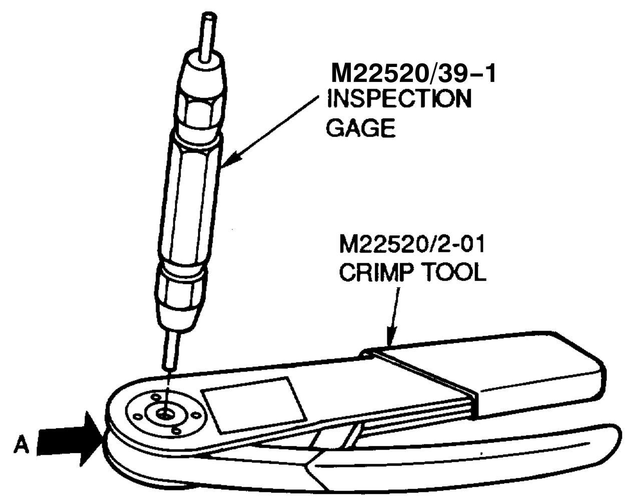
Figure 30. Crimp Tool M22520/2-01

A. DIE CLOSURE CHECK.

1. REMOVE SAFETY PIN. RAISE WIRE SIZE SELECTOR KNOB AND ROTATE TO 8. REINSTALL SAFETY PIN.

2. CLOSE HANDLES COMPLETELY AND HOLD IN FULLY CLOSED POSITION.





CAUTION

DO NOT CRIMP THE GAGE PIN. THIS WILL PERMANENTLY DAMAGE THE TOOL AND THE GAGE.

3. AXIALLY ALIGN GO GAGE (GREEN) WITH INDENTER OPENING. SLIDE GO GAGE INTO INDENTER OPENING AND THROUGH INDENTERS. GAGE SHOULD PASS FREELY THROUGH INDENTERS. IF NOT, RETURN TOOL FOR REPAIR.

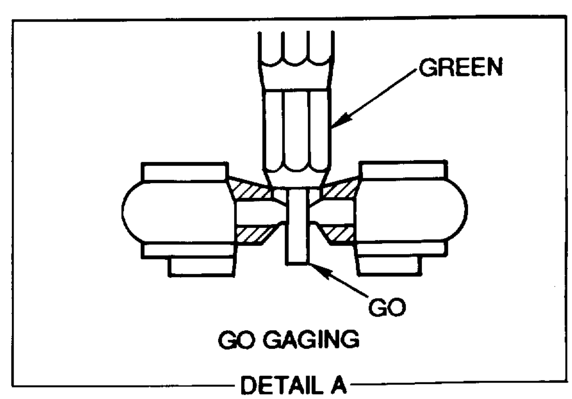
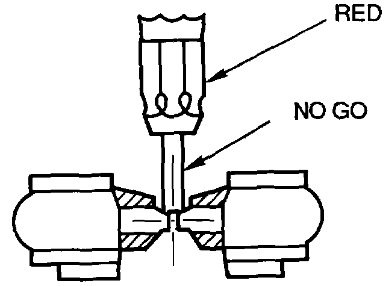


Figure 31. M22520/2-01 and M22520/7-01 Setup, Adjustment, and Operation (Sheet 1 of 4)



4. INVERT INSPECTION GAGE WHILE CONTINUING TO HOLD HANDLES IN THE FULLY CLOSED POSITION. INSERT NO GO (RED) GAGE INTO INDENTER OPENING. GAGE MAY PARTIALLY ENTER, BUT SHOULD NOT PASS BETWEEN INDENTERS. IF NO GO (RED) GAGE PASSES THROUGH INDENTERS, RETURN TOOL FOR REPAIR.

B. CRIMP TOOL SETUP AND ADJUSTMENT

1. REMOVE SAFETY PIN FROM WIRE SIZE SELECTOR KNOB.

2. RAISE WIRE SIZE SELECTOR KNOB AND ROTATE TO SELECTOR SETTING NUMBER. SEE TABLE.

3. LOWER WIRE SIZE SELETOR KNOB.

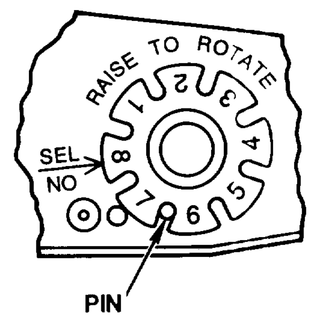
4. ENSURE THAT WIRE SIZE SELECTOR KNOB ENGAGES WITH PIN ON CRIMPING TOOL HANDLE REINSTALL SAFETY PIN.

5. OPEN CRIMPING TOOL HANDLES.

6. REMOVE SAFETY PIN.

7. INSERT POSITIONER SPECIFIED IN CONNECTOR FIGURE OF APPLICABLE WORK PACKAGE IN CRIMP TOOL AS SHOWN.

8. TURN POSITIONER 60 DEGREES CLOCKWISE TO LOCK POSITIONER IN CRIMP TOOL. INSERT SAFETY PIN THROUGH POSITIONER AND CRIMP TOOL.



CONTACT SIZE	WIRE SIZE	SELECTOR SETTING
22	26	3
22	24	4
22	22	5

TYPICAL DATA PLATE

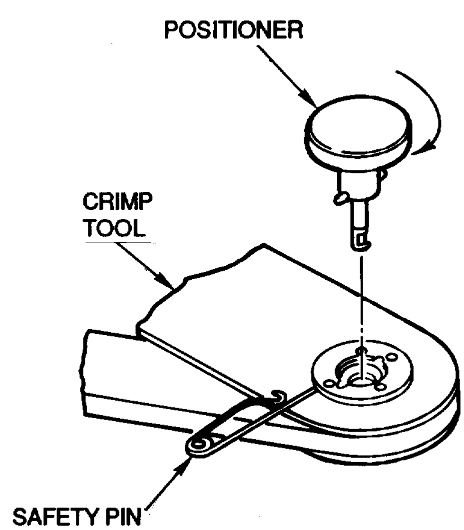
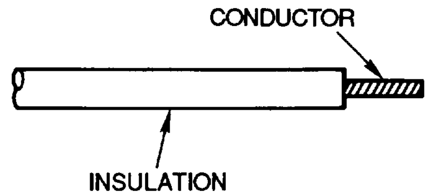


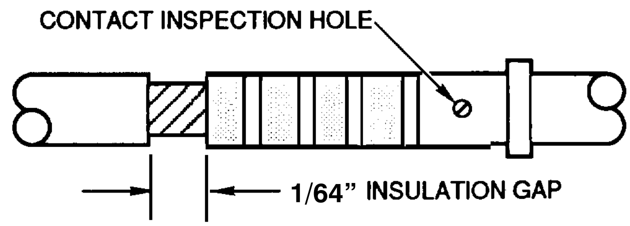
Figure 31. M22520/2-01 and M22520/7-01 Setup, Adjustment, and Operation (Sheet 2)

C. CRIMPING PROCEDURE

1. STRIP INSULATION FROM END OF WIRE (WP 009 00), SELECT SPECIFIED CONTACT.



2. INSERT STRIPPED WIRE INTO CONTACT CONDUCTOR BARREL (PARAGRAPH 9).



3. INSERT CONTACT AND WIRE INTO CRIMP TOOL INDENTERS ON FRONT OF TOOL UNTIL CONTACT BOTTOMS IN POSITIONER. HOLDING WIRE AND CONTACT IN PLACE, SQUEEZE CRIMP TOOL HANDLES TOGETHER SMOOTHLY UNTIL RATCHET RELEASES AND TOOL OPENS.

NOTE

CRIMP TOOL WILL NOT RELEASE UNTIL CRIMPING CYCLE IS COMPLETED.

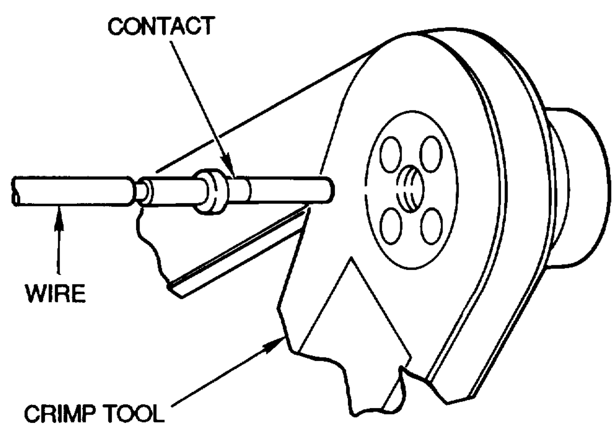


Figure 31. M22520/2-01 and M22520/7-01 Setup, Adjustment, and Operation (Sheet 3)

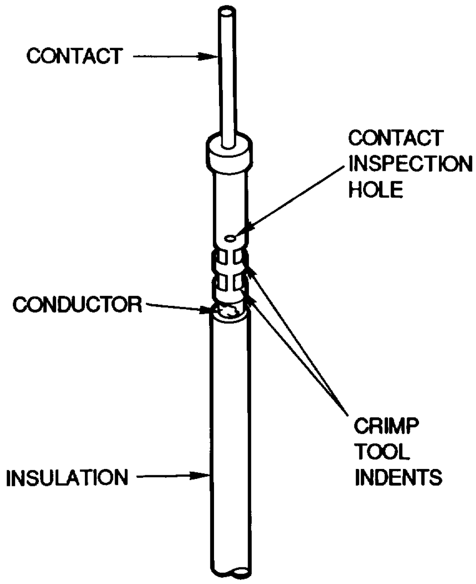


Figure 31. M22520/2-01 and M22520/7-01 Setup, Adjustment, and Operation (Sheet 4)

70 . **CRIMP TOOL M22520/7-01.**

71 . **GENERAL DESCRIPTION.** This tool is considered to be the middle range adjustable crimp tool designed for most miniature and subminiature connector contacts accommodating wire size 16 thru 28 AWG. The tool is the same size, weight, and appearance as the M22520/2-01 (Figure 30). The tool body color is green.

72 . **Use.** This tool is used to crimp removable contacts with a wire barrel size accommodating 16 thru 28 AWG wire. The crimp is the standard 8 impression which affords maximum tensile strength as illustrated (Figure 28, Sheet 4).

73 . **Ratchet.** A precision ratchet controls the cycling of the tool in both directions of the handle. This ratchet mechanism ensures the same and accurate crimp for each operation.

74 . **Crimp Depth (Die Closure).** A positive crimp depth is controlled by an 8 position selector knob located on the tool frame. The operator dials in the desired step for the wire being used and locks the setting with a locking pin as illustrated (Figure 31).

75 . **Positioner.** For proper operation the tool frame must be mated with a positioner.

76 . **Inspection Gage.** The inspection gage is a Go/No Go gage used to ensure accurate crimps. The gage ends are color coded green for Go, red for No Go as illustrated (Figure 31).

77 . **Periodic Gaging.** Periodic gaging is recommended to ensure accurate calibration as defined in previous paragraph.To ensure accurate calibration, the gaging task shall be performed before each series of crimping operations (such as at the beginning of a task). Periodic gaging is required to ensure proper crimp dimensions and tool calibration, and is performed as per Figure 31 using tool M22520/39-1.

78 . **Data Plates.** A permanent data plate is affixed to all positioners. The plate designates which contacts the positioner accommodates for its wire size and indicates selector position.

79 . **Maintenance.** No operator maintenance is required other than proper storage and cleaning.

80 . **SETUP, ADJUSTMENT, AND OPERATION.** Correct crimp tool setup and adjustment are necessary to perform mechanically and electrically sound crimps. Perform buildup and adjustment using the following steps:

a. Select proper positioner.

b. Select proper inspection gage.

c. Setup and adjust tool (Figure 31).

d. Operate (Figure 31).

81 . **Emergency Eye Sight Positioning.**

CAUTION

This procedure should be used only in emergency situations or when crimp performance can be properly evaluated. Crimp impressions that are too deep will cause the wire to break easily at the crimp joint while crimp impressions that are too shallow will allow the wire to pull out.

WARNING

Alternate tools (pliers, diagonal cutting pliers, etc.) are not acceptable crimp tools in any circumstances.

82 . If it becomes necessary to crimp contacts for which no positioning heads, positioners, or universal heads are available. the following procedures may he used:

a. Remove any positioning device installed in tool.

b. Determine and set an approximate selector setting for the contact/wire combination. Some tools have wire sizes on the selector for reference. A setting may be estimated by comparing the combination with other known contact/sizes and materials.

c. Insert the contact into the tool between the indenter tips. Slowly close the handles and grip the contact lightly with the indenters without crimping. At the same time, position the contact so the indenters are located midway between the inspection hole and the end of the contact (or bottom of insulation cup, if present).

d. While still holding the contact lightly with the indenter tips, insert the stripped wire into the contact. making sure wire is fully bottomed.

e. Close the handles to the ratchet release position and open.

f. Remove the contact and inspect for the following:

(1) Wire is visible through the inspection hole in wire barrel.

(2) Position of crimp impressions is midway on wire barrel.

(3) Contact is not bent or distorted.

(4) Contact wire barrel is not cracked and plating is intact.

83 . **CRIMP TOOL M22520/5-01 AND M22520/10-01.**

84 . **GENERAL DESCRIPTION.** These tools are discussed together due to their similarity. These are open frame crimp tools using interchangeable dies. The M22520/5-01 is 11 inches maximum and weighs 2 pounds maximum, and the M22520/10 is 9 inches maximum and weighs 1.5 pounds maximum (Figure 32).

85 . **Use.** The tools are used, with hexagonal dies in a variety of configurations having single, double, and triple cavity design, to crimp most coaxial and triaxial connectors and contacts. Dies of various other crimp patterns are available for insulated and uninsulated terminal lugs, splices, and end caps.

86 . **Ratchet.** A positive precision ratchet controls the cycling of the tool in both directions of the handle. This ratchet mechanism ensures the same and accurate crimp for each operation.

87 . **Tool Die.** M22520/5 dies are illustrated in Figure 33. The available /5 and /10 dies are listed in Table 16.

88 . **Inspection Gage.** The inspection gage is a Go/No Go gage used to ensure accurate crimps. The gage ends are color coded green for Go and red for No Go as illustrated (Figure 34). Gages are to be selected by die used (Table 20).

89 . **Pre–Use Gaging.** Pre–Use gaging is recommended to ensure proper crimp dimensions and tool calibration, and is performed in the following manner (Figure 34):

a. Activate tool to fully mate die surfaces.

b. Go gage should freely pass through die.

c. No Go gage should not pass through die.

d. When either gage fails, reject tool and return for repair or calibration.

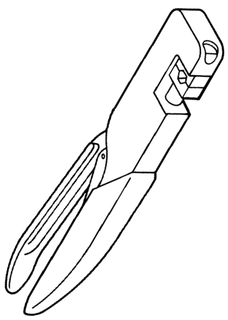


Figure 32. Crimp Tool M22520/5-01 and M22520/10-01

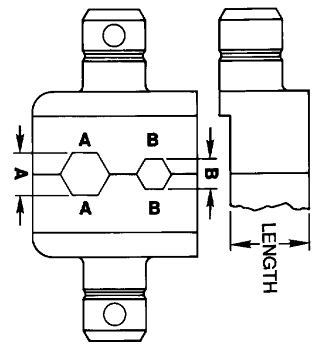


Figure 33. Die Dimensions

Table 20 . Inspection Gage Selection

Part No. Die M22520/	Inspection Gage Die Closure A M22520/	Inspection Gage Die Closure B M22520/
5-02	6-030	6-029
5-03	6-003	6-001
5-04	6-029	6-002
5-05	6-008	6-006
5-06	6-029	—
5-07	6-011	—
5-08	6-003	—
5-09	6-006	6-029
5-10	6-005	—
5-11	6-008	6-029
5-13	6-011	6-029
5-15	6-012	6-029
5-17	6-002	—
5-19	6-011	6-008
5-21	6-025	—
5-23	6-020	—
5-25	6-022	6-031
5-27	6-027	—
5-29	6-017	6-031
5-31	6-026	—
5-33	6-018	6-001
5-35	6-017	6-003
5-37	6-016	6-004
5-39	6-015	6-005
5-41	6-014	6-006
5-43	6-013	6-007
5-45	6-010	6-009
5-47	6-019	—
5-49	6-021	—
5-51	6-023	—
5-53	6-024	—
5-55	6-017	—
5-57	6-008	6-031
5-59	6-011	6-031
5-61	6-022	—

Table 20 . Inspection Gage Selection1 (Continued)

Part No. Die M22520/	Inspection Gage Die Closure A M22520/	Inspection Gage Die Closure B M22520/
5-63	6-012	6-030
10-02	6-030	6-029
10-03	6-011	—
10-04	6-028	6-002
10-05	6-003	6-001
10-06	6-005	—
10-07	6-008	6-006
10-08	6-003	—
10-09	6-002	—
10-10	6-003	—
10-11	6-001	—
10-13	6-003	—
10-15	6-004	—
10-17	6-006	—
10-19	6-007	—
10-21	6-008	—
10-23	6-009	—
10-25	6-010	—
10-27	6-011	—
10-100	3-9	—
10-101	3-10	—
10-102	3-11	—

A. REMOVAL OF DIES.

CAUTION

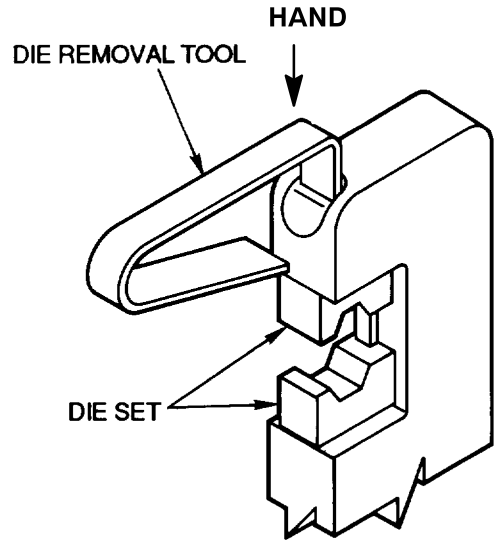
IF DIES HAVE BEEN PERMANENTLY INSTALLED, THE LOCK PINS MUST BE REMOVED FIRST TO PREVENT SERIOUS DAMAGE TO TOOLS.

1. WITH HANDLES IN THE OPEN POSITION, USE THE DIE REMOVAL TOOL AND YOUR HAND TO APPLY A DOWNWARD FORCE TO THE UPPER DIE HALF.

2. THE DIE WILL BE RELEASED FROM THE LOCK SPRING AND EJECTED APPROXIMATELY 1/16 INCH. COMPLETE THE REMOVAL BY HAND.

NOTE

IF DIE REMOVAL TOOL IS UNAVAILABLE, A STEEL ROD 3/16 INCH DIAMETER x 1 3/4 INCH LONG MAY BE USED.



3. CLOSE THE CRIMP TOOL HANDLES AND SLIDE THE REMOVAL TOOL BETWEEN THE LOWER DIE AND TOOL BODY AS SHOWN.

4. PULL THE HANDLES OPEN WITH A SNAP ACTION. THE DIE WILL BE RELEASED FROM THE LOCK SPRING AND CAN BE REMOVED BY HAND.

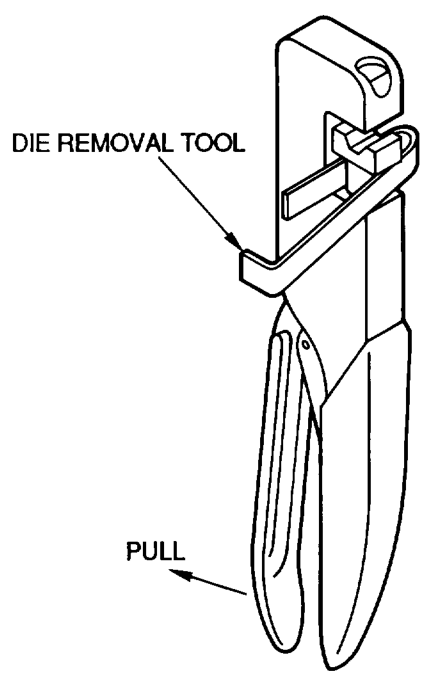


Figure 34. M22520/5-01 and M22520/10-01 Setup, Adjustment, and Operation (Sheet 1 of 4)

B. INSTALLATION OF DIES.

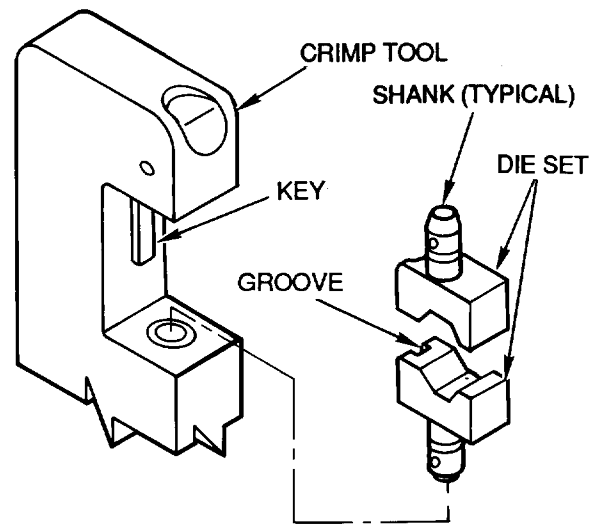
1. SELECT DIE SET SPECIFIED IN APPLICABLE WORK PACKAGE.

2. ALIGN GROOVE IN DIES WITH KEY IN CRIMP TOOL.

3. OPEN HANDLES FULLY.

4. INSTALL DIES BY INSERTING SHANKS INTO HOLES IN TOOL.

5. AFTER CLOSING HANDLES, VISUALLY CHECK TO SEE THAT DIES ARE PROPERLY SEATED, LOCKED IN PLACE, AND ALIGNED WITH EACH OTHER.



WARNING

SAFETY GLASSES SHALL BE WORN WHILE USING HAMMER. SERIOUS EYE INJURY CAN OCCUR.

6. IF A PERMANENT DIE ASSEMBLY IS REQUIRED, DRIVE A 1/8 INCH DIAMETER PIN THROUGH TOOL BODY HOLE AND ANOTHER PIN OF SAME DIAMETER THROUGH PUSH ROD HOLE.

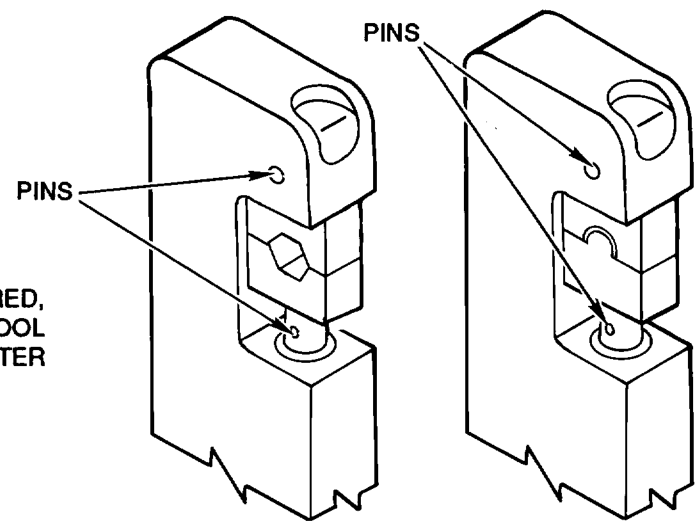
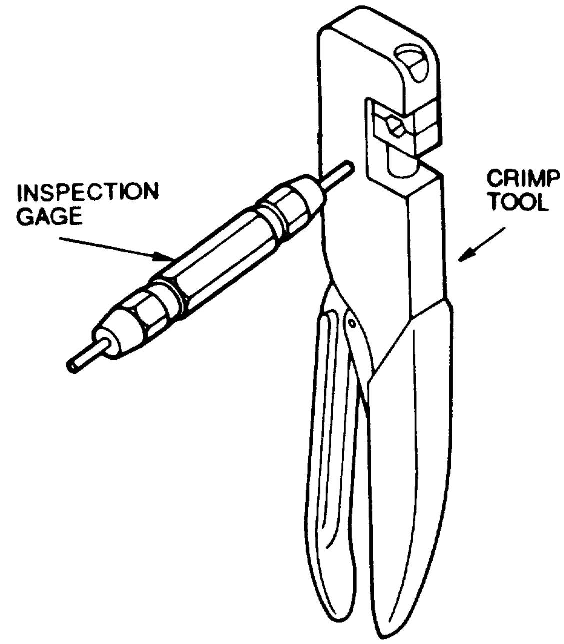


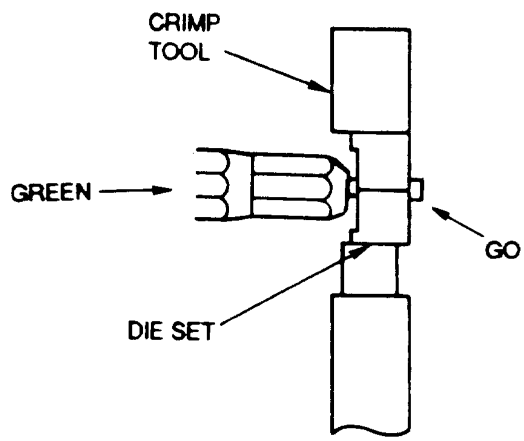
Figure 34. M22520/5-01 and M22520/10-01 Setup, Adjustment, and Operation (Sheet 2)

C. DIE CLOSURE CHECK.

1. CLOSE HANDLES COMPLETELY AND HOLD IN FULLY CLOSED POSITION.



2. AXIALLY ALIGN GO GAGE (GREEN) WITH INDENTER OPENING. SLIDE GO GAGE INTO INDENTER OPENING AND THROUGH INDENTERS. GAGE SHOULD PASS FREELY THROUGH INDENTERS. IF NOT, RETURN TOOL FOR REPAIR.



3. INVERT INSPECTION GAGE WHILE CONTINUING TO HOLD HANDLES IN THE FULLY CLOSED POSITION. INSERT NO GO (RED) GAGE INTO INDENTER OPENING. GAGE SHOULD NOT PASS BETWEEN INDENTERS. IF NO GO (RED) GAGE PASSES THROUGH INDENTERS, RETURN TOOL FOR REPAIR.

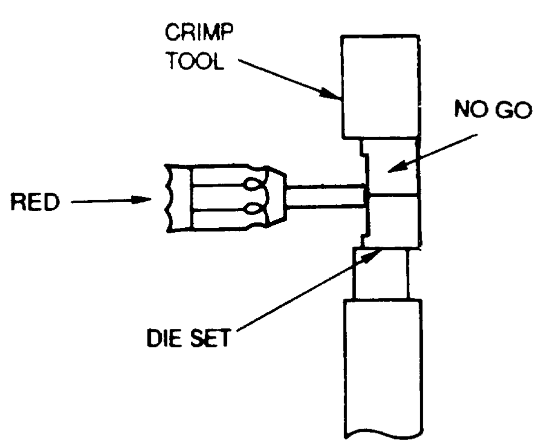
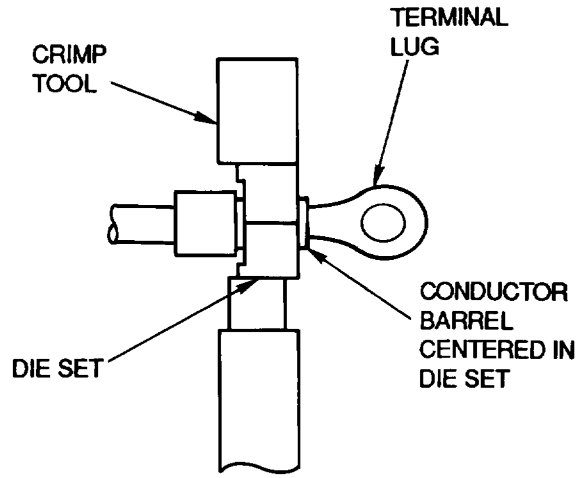


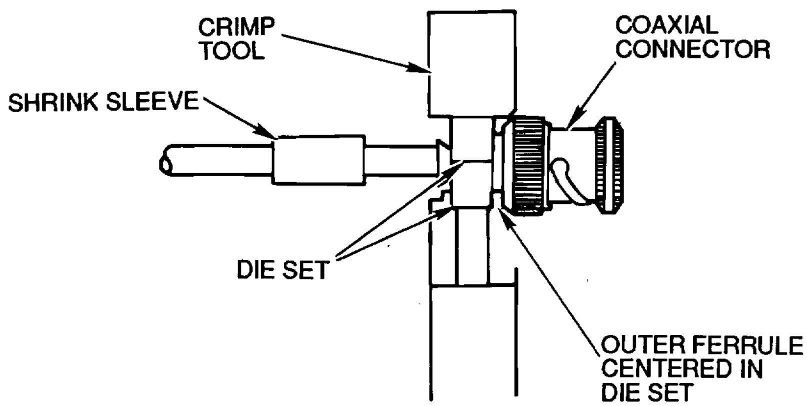
Figure 34. M22520/5-01 and M22520/10-01 Setup, Adjustment, and Operation (Sheet 3)

D. <u>CRIMP TOOLS M22520/5-01 AND M22520/10-01 CRIMPING PROCEDURE</u>.

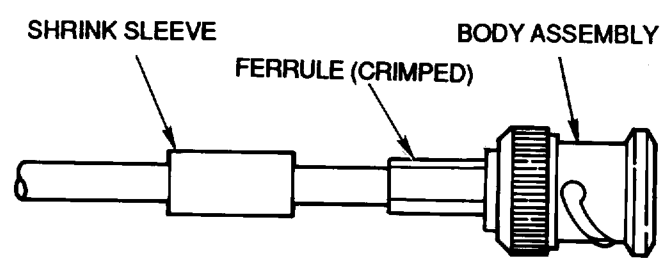
1. PREPARE WIRE/CABLE AND ASSEMBLE CONNECTOR, CONTACT, OR LUG IN ACCORDANCE WITH APPLICABLE WORK PACKAGE.

2. HOLD CRIMP BARREL CENTERED IN DIE SET. SQUEEZE TOOL HANDLES TOGETHER SMOOTHLY UNTIL RATCHET RELEASES.





3. REMOVE CRIMPED DEVICE FROM TOOL AND INSPECT AS REQUIRED BY THE APPLICABLE WORK PACKAGE.



4. REFER TO APPLICABLE WORK PACKAGE FOR INSTALLATION/INSERTION PROCEDURES.

Figure 34. M22520/5-01 and M22520/10-01 Setup, Adjustment, and Operation (Sheet 4)

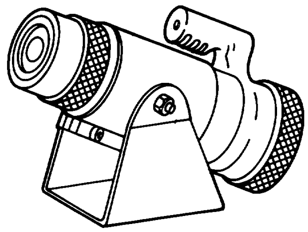


Figure 35. Pneumatic Crimp Tool M22520/23-1

90 . **CRIMP TOOL M22520/23-1 PNEUMATIC.**

91 . **GENERAL DESCRIPTION.** The tool uses use air pressure 90 to 120 PSI to crimp contacts in the range of 8 to 0000 (4/0). The tool measures 12.7 inches X 9.2 inches and weighs 17 pounds less dies and locators (Figure 35).

92 . **Use.** The tool is used to crimp contacts with a wire barrel size of 8 thru 4/0 with the standard 8 impression crimp as illustrated (Figure 37, Sheet 3).

93 . **Full Cycle Control.** Unlike the M22520/1-01, 2-01, 5-01, 7-01 and 10-01 there is no mechanical ratchet mechanism. A full cycle is controlled by internal valves. This full cycle control is tamper-proof and cannot be disengaged prior to or during crimp cycle.

94 . **Crimp Depth.** The crimp depth is controlled by the length of the individual indenters, which are changed as a unit for each cycle is controlled by internal valves.

95 . **Accessories.** For proper operation the tool must be mated with the proper dies and locator (Figure 36).

96 . **ACCESSORY TOOLING.** It is necessary to select the proper accessory to ensure accurate crimps. The proper die must be selected according to size (Table 21). The proper locator must be selected by size and contact part number (Table 22).

97 . **SETUP AND OPERATION.** Correct crimp tool buildup and operation are necessary to perform mechanically and electrically sound crimps. Perform buildup and operation using the following steps:

a. Select proper accessories.
b. Setup tool (Figure 36).
c. Operate (Figure 37).

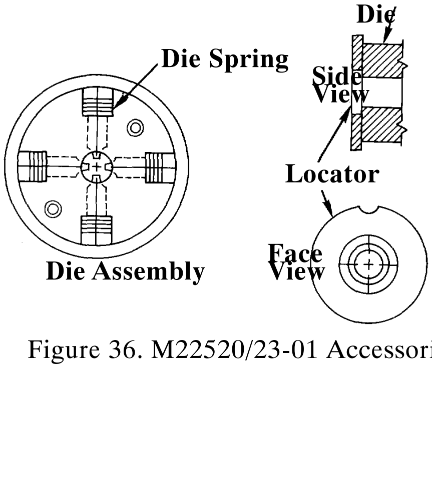


Figure 36. M22520/23-01 Accessories

Table 21 . Die Selection

Part No. M22520/	Contact Size
23-02	8
23-03	6
23-04	4
23-05	0
23-06	00
23-07	0000

Table 22 . Locator Selection

Part No. M22520/	Contact Size	MS Contact Number
23-09	8	M39029/29-8-8 M39029/30-8-8 MIL–C–39029/44 MIL–C–39029/45
23-10	6 6N 6G 6 6G	MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/49 MIL–C–39029/49
23-11	4	M39039/29-4-4 M39029/30-4-4 MIL–C–39029/44 MIL–C–39029/45
23-12	4 4N 4G 4 4G	MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/49 MIL–C–39029/49
23-13	1/0	MIL–C–39029/48 M39029/30-0-0 MIL–C–39029/44 MIL–C–39029/48
23-14	1/0 1/0N 1/0	MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/49
23-15	2/0 2/0N 2/0	MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/49
23-16	4/0 4/0N 4/0	MIL–C–39029/48 MIL–C–39029/48 MIL–C–39029/49

A. CRIMP TOOL SETUP

1. SELECT LOCATOR AND CRIMPING HEAD SPECIFICIED IN CONNECTOR FIGURE WITH APPLICABLE WORK PACKAGE.

NOTE

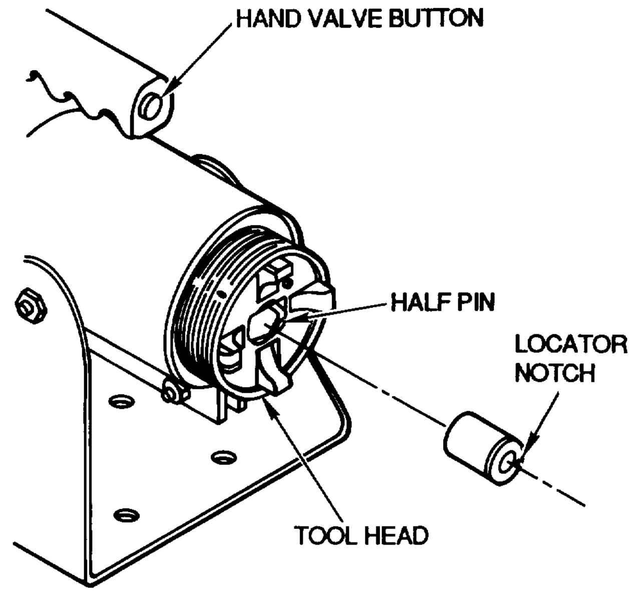
NOTCH IN LOCATOR FLANGE MUST INDEX TO HALF–PIN IN TOOL HEAD.

2. INSTALL LOCATOR IN TOOL HEAD.

NOTE

LOCATING HOLE IN REAR OF CRIMP HEAD MUST INDEX TO LOCATING PIN IN TOOL HEAD.

3. INSTALL CRIMPING HEAD.



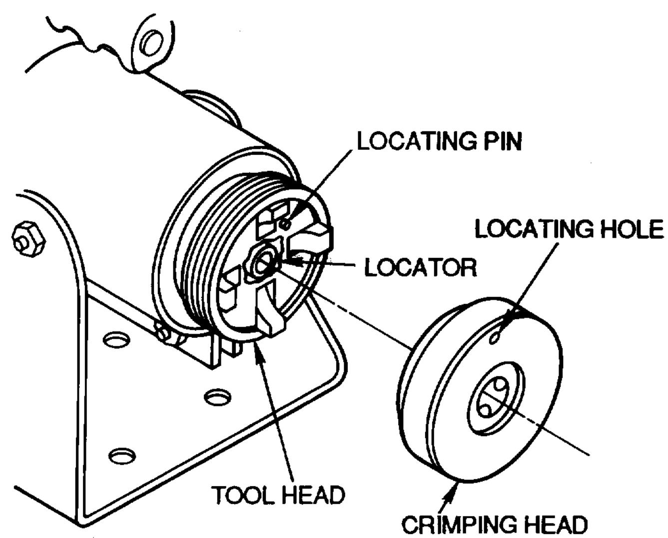


Figure 37. M22520/23-1 Setup and Operation (Sheet 1 of 3)

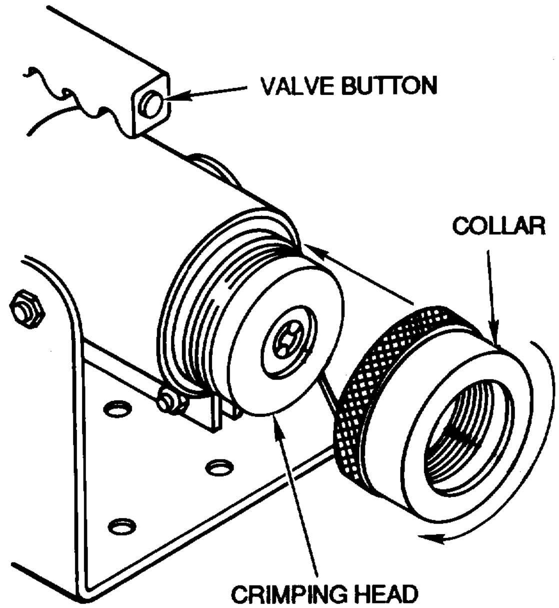
4. SCREW COLLAR ON HAND TIGHT. COLLAR IS COLORED RED FOR SAFETY PURPOSES.

5. CONNECT POWER CRIMPER TO AIR SUPPLY.

6. DEPRESS VALVE BUTTON TO CYCLE TOOL. REPEAT SEVERAL TIMES.

NOTE

THE CRIMPER WILL CYCLE AUTOMATICALLY.



B. CONTACT CRIMPING.

1. PREPARE WIRE AS INSTRUCTED IN WIRE STRIPPING SECTION OF APPLICABLE WORK PACKAGE.

2. INSERT WIRE INTO CONTACT CONDUCTOR BARREL. ENSURE INSULATION GAP IS WITHIN LIMITS SPECIFIED IN CONNECTOR FIGURE WITHIN APPLICABLE WORK PACKAGE.

3. ENSURE WIRE IS VISIBLE IN CONTACT INSPECTION HOLE.

4. RETIGHTEN CRIMP TOOL COLLAR BEFORE PROCEEDING.

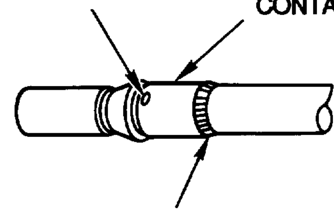
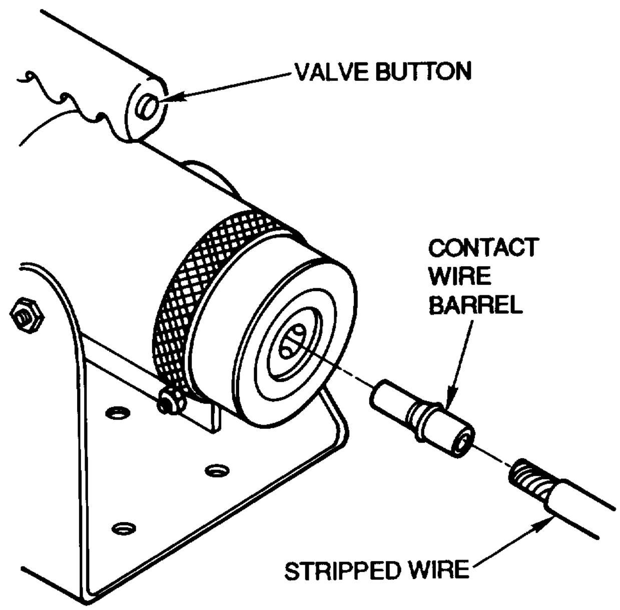


Figure 37. M22520/23-1 Setup and Operation (Sheet 2)



5. INSERT CONTACT INTO LOCATOR.

6. INSERT STRIPPED WIRE INTO CONTACT WIRE BARREL AND HOLD IN PLACE.

7. DEPRESS VALVE BUTTON TO CRIMP CONTACT.

8. REMOVE CRIMPED CONTACT ASSEMBLY FROM POWER CRIMPER AND INSPECT AS REQUIRED.

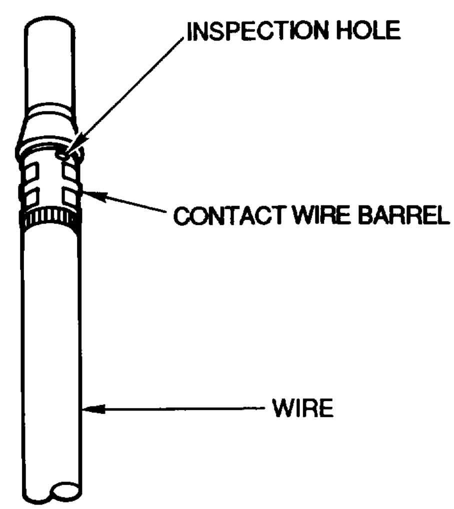


Figure 37. M22520/23-1 Setup and Operation (Sheet 3)

98 . <u>**HD51 CRIMPING TOOL.**</u>

99 . **DESCRIPTION**. The hydraulic tool (Figure 38) is operated by pumping both handles . It can be operated with one hand by laying the stationary handle on a flat surface. It has a force of 5.5 tons and weighs 4.6 Lbs. The tool has an audible ”Click” to prevent over–compression. It also has a 180° rotating head for easy accessibility in confined working areas. An example of tool in use is depicted in Figure 39.

100 . **SELECTION OF CRIMPING DIE.** Determine proper crimping die set to be used for the crimp.

101 . **OPERATING PROCEDURES.**

a. Open head and insert crimping dies (Figure 40). The head assembly has two slots to slide the dies in and out easily.

b. Lock the head over the connector and pump the handle until an audible click is heard.

c. Activate the pressure release trigger to retract the hydraulic ram (Figure 41).

CAUTION

Do not press the pressure release trigger until click is heard and crimp is complete. Damage to tool will occur if mechanism is released before crimp is completed; Do not work the tool without dies.

d. To remove the dies, open head and remove dies by sliding along slot (Figure 42).

e. Replace filler plug and reservoir cover.

f. Perform two full closures with the tool inverted.

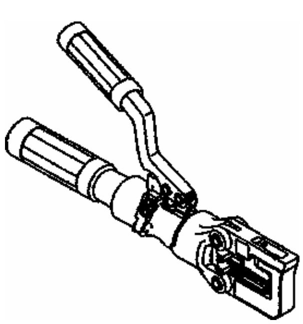


Figure 38. HD51 Crimping Tool

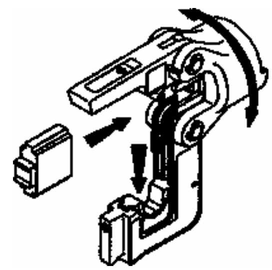


Figure 39. HD51 Crimping Tool Die Insertion

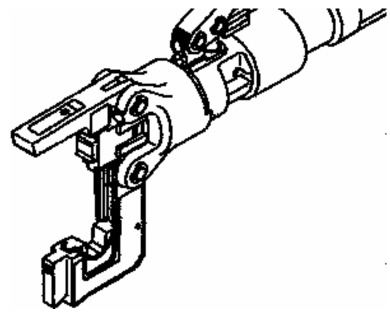


Figure 40. HD51 Open Head for Die Removal

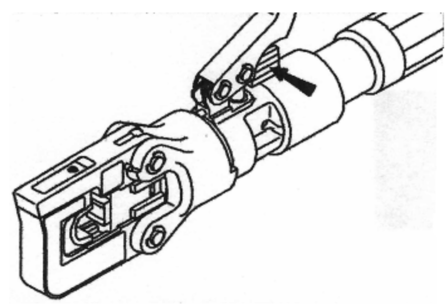


Figure 41. HD51 Pressure Release Trigger

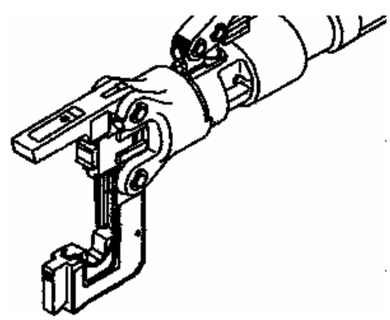


Figure 42. HD51 Open Head for Die Removal

102 . **REFILLING THE RESERVOIR AND BLEEDING THE TOOL.**

a. Fit a set of dies, depress handle until dies are closed, or as far as dies will close.

b. Invert tool and allow air to rise to top of reservoir.

c. Unscrew reservoir cover and remove filler plug, fill with oil (Figure 43).

d. Depress release trigger, excess oil will be ejected from reservoir as ram retracts.

103 . **COLD WEATHER NOTE.** This tool is supplied with Drydene Paradene 46AW hydraulic oil. For operation below 20° F (−6.7° C), refill reservoir with Drydene 22AW Hydraulic oil or equivalent. In cold weather and after periods of non use, O−ring seal sticking may cause non−pumping. Rotate the advance handle clockwise to advance the dies and free any sticking O−rings.

104 . **STORAGE.** When tool is to be stored for any extended period of time, the tool should be pumped up approximately every three weeks to keep O−rings and seals lubricated. The tool should also be stored with the dies in the fully open position.

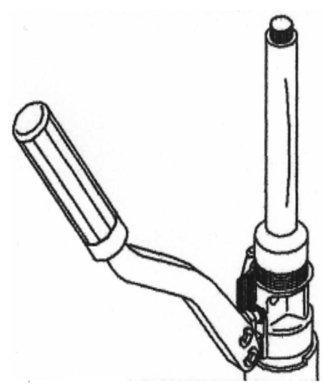


Figure 43. HD51 Oil Reservoir Filler Plug

105 . **HH80C HAND ACTUATED HYDRAULIC CRIMP TOOL.**

106 . **INTRODUCTION.** The HH80C (see Figure 44) is a hand actuated hydraulic crimp tool designed to use interchangeable MS23002−XX dies (for insulated lugs) and MS 90485−XX dies (for un−insulated lugs). It has a two−stage hydraulic system with an automatic relief valve to prevent over−compression.

107 . **GENERAL MAINTENANCE.** The HH80C tool is a hydraulically actuated mechanism which requires well trained, experienced personnel having a clean work area equipped with adequate tools for major repairs, adjustments or maintenance.

a. KEEP THE TOOL CLEAN. Dirt and grit are the worst enemies of hydraulic equipment. Do not lay the tool on the ground. Wipe the entire tool thoroughly with a clean dry or slightly oily cloth after each day's use.

b. DO NOT MAKE ADJUSTMENT TO THE TOOL. There are no adjustments on this tool that can be made in the field.

CAUTION

DO NOT OPERATE THIS TOOL WITHOUT A DIE SET INSTALLED! Damage to the tool can result.

c. STORE THE TOOL PROPERLY. Before storing tools for any length of time, back the rapid advance handle to the fully open position and depress the pump release handle to fully retract the crimping die. This protects the operating ram from moisture condensation and will help assure correct operation at the next period of use.

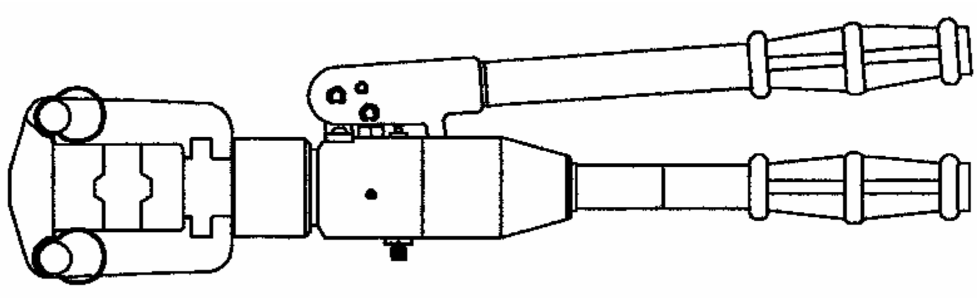


Figure 44. HH80C Hand Actuated Hydraulic Crimp Tool

108 . **OPERATING INSTRUCTIONS.**

a. Pull both pivot and bridge pins to remove bridge as shown in Figure 45.

b. Place the movable die half between the die rails. Carefully lower the die and mate the die snap retainer to the snap retainer located in the ram as shown in Figure 46.

c. Place the stationary die half between the rails and lower it so the flat spring fits into the spring recess of the die rail. Replace the bridge onto the die rails and snap the stationary die into the mating snap located in the bridges.

d. Replace both bridge and pivot pins.

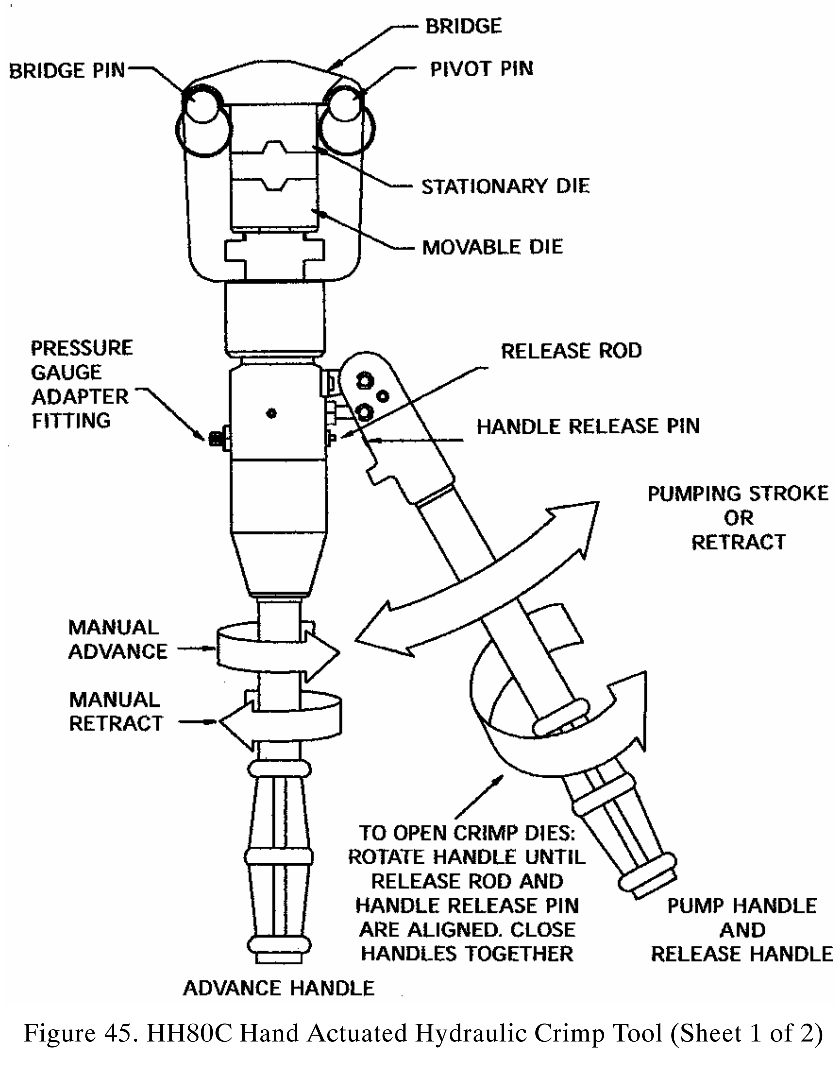


Figure 45. HH80C Hand Actuated Hydraulic Crimp Tool (Sheet 1 of 2)

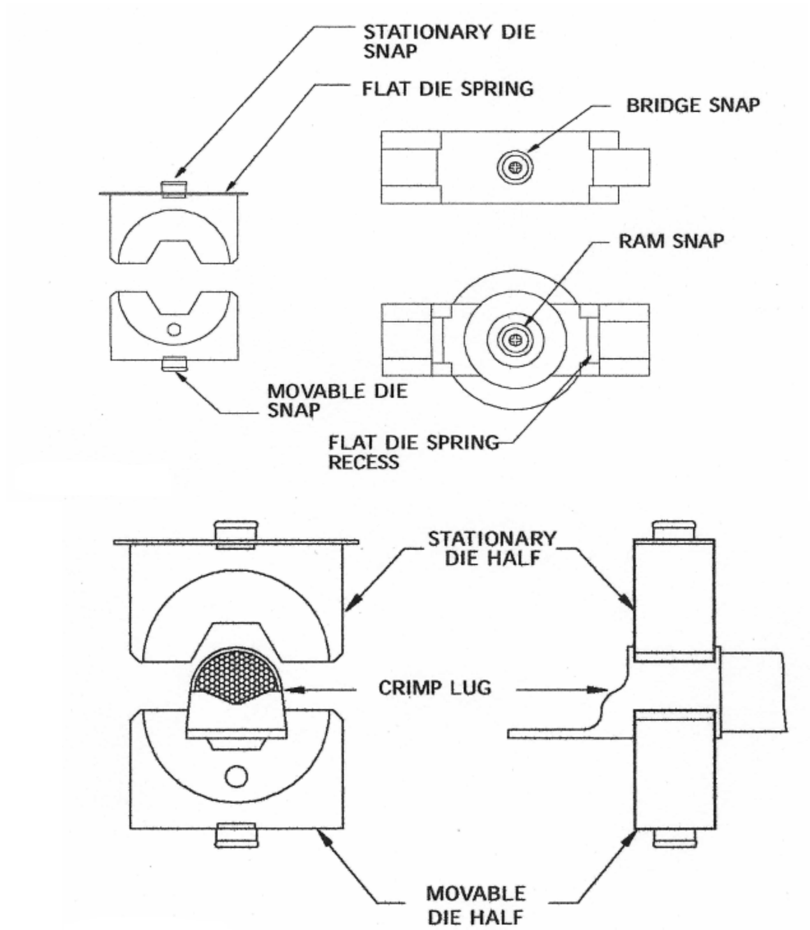


Figure 45. HH80C Hand Actuated Hydraulic Crimp Tool (Sheet 2)

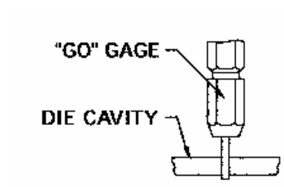


Figure 46. “GO” Gage

WARNING

The fiberglass handles and neoprene grips are not designed to protect the operator in “HOT” line work.

CAUTION

The stationary die snap and bridge snap retainers must be fully engaged before the pins can be installed. Do not operate this tool without a die set installed! Damage to the tool can result.

109 . **CRIMPING A TERMINAL LUG.**

a. Place a lug in the movable die making sure the lug is positioned as shown in Figure 45. Rotate the advance handle clockwise until the die loosely clamps the lug (see Figure 45).

b. Insert the conductor into the lug’s socket making sure that the conductor is pushed fully into the lugs crimping area.

c. Actuate the pump handle and the movable die will start compressing the lug. A positive trip will occur when the crimp is completed. Stop pumping. Back off the rapid advance handle (rotate counterclockwise) approximately two to three turns depending on the size of the lug.

d. Release the movable die from the compressed lug by partially raising the pump handle. Then rotate the handle fully clockwise and push inward (see Figure 1). The movable die will open sufficiently to allow the lug to be removed.

CAUTION

Do not overcompress the die set during the gaging operation.

110 . **GAGING.** The gaging of the MS23002–XX and the MS90485–XX dies (Tables 23 and 24) is accomplished by installing the die set into the tool as described in the operating instructions. Rotate the advance handle clockwise until the die set is completely closed. The dies must be flush against each other with light force only.

111 . **“GO” Gaging**. Insert the “GO” gage end as shown in Figure 46. The gage must pass freely through the cavity in the die set.

112 . **“NO–GO” Gaging.** Try to insert the NO–GO” gage end as shown in Figure 47. The gage may partially enter the cavity but must not pass completely through the opening.

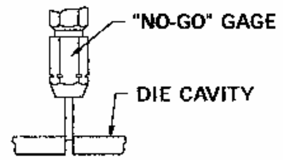


Figure 47. “NO–GO” Gage

Table 23 . MS90485 Die and Corresponding Gage for M22520/23 Tool for Un–Insulated Lugs

DIE P/N	LUG SIZE (AWG)	GAGE P/N
MS90485–01	0	MS90486–01
MS90485–02	00	MS90486–02
MS90485–03	000	MS90486–03
MS90485–04	0000	MS90486–04
MS90485–1	1	MS90486–1
MS90485–2	2	MS90486–2
MS90485–4	4	MS90486–4
MS90485–6	6	MS90486–6
MS90485–8	8	MS90486–8

Table 24 . MS23002 Die and Corresponding Gage for M22520/23 Tool for Un–Insulated Lugs

DIE P/N	LUG SIZE (AWG)	MIL. GAGE P/N
MS23002–01	0	MS23006–01
MS23002–02	00	MS23006–02
MS23002–03	000	MS23006–03
MS23002–04	0000	MS23006–04
MS23002–1	1	MS23006–1
MS23002–2	2	MS23003–2
MS23002–4	4	MS23003–4
MS23002–6	6	MS23003–6
MS23002–8	8	MS23003–8

113 . **Checking Pump Oil Level.** Check reservoir oil level of tool by screwing inward on the advance handle. Oil supply is adequate if the dies touch before the advance handle is completely advanced. Add oil if required (see ADDITION OF HYDRAULIC OIL).

114 . **Loss Of Hydraulic Oil.** Hydraulically actuated tools will gradually lose their hydraulic oil over a period of time. This loss is caused by the adherence of small amounts of oil to the moving parts exposed to the outside, such as plungers, pistons, and rams, and from occasional leakage around mechanical seals. A small loss of hydraulic oil is normal and will not affect the operation of the HH80C tool. However, if the level drops too low, air can become trapped in the hydraulic system causing the tool to develop a "spongy" feel, preventing it from operating. Occasional hydraulic oil checks can be performed as follows:

CAUTION

Caution should be exercised to assure that oil of different types are not mixed when tool reservoirs are replenished. Do not use brake fluid.

115 . **Addition Of Hydraulic Oil.** For cold weather regions, an oil with a viscosity @ 100˚ F, SUS114 should be used.

a. Rotate the advance handle fully counterclockwise to retract the movable die and return the oil to the oil chamber.

b. Actuate the pump release handle and confirm that the die is in the fully open position (see Figure 44).

c. Hold the tool with the crimping head down on a clean surface and remove set screw 2 (see Figure 44), and unscrew cover (Item 40) along with the handle assembly.

d. Remove plunger spring and loosen oil fill screw Do not remove filter screw at this time.

e. Grasp the stem of plunger and lift it so the plunger is no higher than the oil reservoir section of the body .

f. Remove filler screw, O–ring will also be removed with the filler screw.

g. Fill the reservoir with the proper hydraulic oil (see COLD WEATHER NOTE for choice of oils).

h. Apply slight pressure to the plunger to allow the oil to just reach the surface of the fill hole and replace the filler screw and O–ring.

i. Reassemble the tool by reversing the order of operations described above.

CAUTION

Use hydraulic oil as shown below or one that meets the specifications listed below. Do not use brake fluid!

116 . **Hydraulic Oil.** Tool supplied with Drydene Paradene 46AW hydraulic oil. Below 20˚ F (– 6.7˚ C), use Drydene 22AW hydraulic oil (or equivalent). Hydraulic oil manufacturer: Drydene Oil Company, 9300 Pulaski Highway, Baltimore, MD 21220 (USA).

117 . **WA22 PNEUMATIC CRIMP TOOL.**

118 . **GENERAL SPECIFICATIONS.** Pneumatic Tools are designed with up to 8 die closures, changeable by a selector knob. The tool also has a full cycle ratcheting control mechanism (Figure 48).

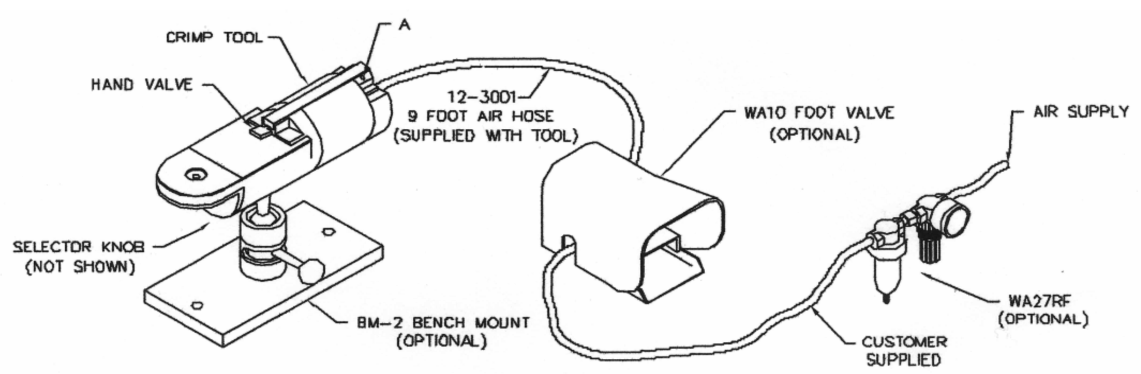


Figure 48. Pneumatic Crimping Tool

119 . Either the hand operated valve or the air foot valve may be used. The working pressure of the tool is 80 – 120 p.s.i. It is recommended that each tool be set up with a regulator and filter. SIZE: Length: 8” Width: 2.25” Weight: 2.2lbs. CRIMPING RANGE: Contacts: Size 20 thru 28 Wire Size: Size 20 AWG thru 32 AWG.

120 . **ACCOMMODATIONS.** Tool will accommodate all MIL SPEC and “K” series Positioners relating to MIL SPEC hand tool part numbers M22520/2–01.

121 . **FOOT VALVE OPERATION.** Attach Foot Valve between air supply and tool air inlet. Depress hand valve and lock in down position with set screw (A) using 1/16 hex Allen wrench.

122 . **CHECKING THE FULL CYCLE RATCHETING MECHANISM.** The ratcheting mechanism can be checked for proper functioning by the following procedure (Figure 49).

a. Adjust the air line pressure to 15 p.s.i.

b. Using a size 20 contact with a size 20 AWG wire, operate the tool until the indenters stop. The indenters will not reach the fully closed position and the contact will be locked in if the ratcheting mechanism is functioning properly.

c. To release the partially crimped contact, increase the air line pressure to 80–120 p.s.i. and operate. The tool will then complete the crimp allowing the indenters to return to the fully open position.

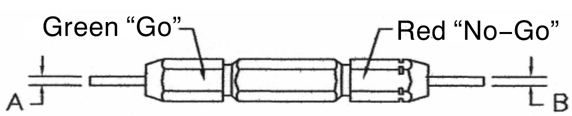
123 . **RELEASING A PARTIALLY CRIMPED CONTACT.** To release a partially crimped contact, proceed as follows:

a. Increase the air pressure to 120 p.s.i. and operate the unit. (If increasing the air pressure does not release the contact, proceed as follows:)

b. Turn the selector knob clockwise to the highest lockable setting. (Selector knob must be in the locked position before proceeding.) Operate the unit.

CAUTION!
DO NOT CRIMP GAGE!

GAGING INSTRUCTIONS



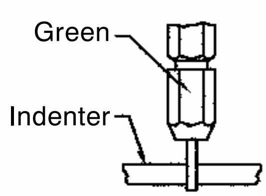
GAGE PART NO.	A GO DIA	B NO-GO DIA	SELECTOR NO.
G125	.0390	.0440	8

“GO” Gaging

Operate tool to fully closed position. Insert “GO” gage end as shown. Gage must pass freely between indenter tips.

“NO–GO” Gaging

Operate tool to fully closed position. Insert “NO–GO” gage end as shown. The “NO–GO” may partially enter the indenter opening, but must not pass completley through the opening.



SELECTOR NO.	A ± .0001 GO DIA	B ± .0001 NO-GO DIA
1	.0130	.0180
2	.0160	.0210
3	.0190	.0240
4	.0220	.0270
5	.0260	.0310
6	.0300	.0350
7	.0340	.0390
8	.0390	.0440

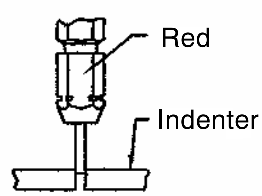


Figure 49. WA22 Pneumatic Crimping Tool GO/NO GO Gaging

124 . **CARE OF TOOL.** There is virtually no maintenance required. However, it is a good practice to keep indenter tips free of residual color band deposits and other debris. A small wire brush may be used for this purpose.It is recommended that you:

1. DO NOT immerse tools in cleaning solutions.
2. DO NOT spray oil into tool to lubricate.
3. DO NOT attempt to disassemble tool or make repairs.

125 . This is a precision crimping tool and should be handled as such.

126 . <u>**WA27F PNEUMATIC CRIMP TOOL.**</u>

127 . **GENERAL SPECIFICATIONS.** Pneumatic Tools are designed with up to 8 die closures, changeable by a selector knob. The tool also has a full cycle ratcheting control mechanism (Figure 50).

128 . Either the hand operated valve or the air foot valve may be used. The working pressure of the tool is 80 – 120 p.s.i. It is recommended that each tool be set up with a regulator and filter.
SIZE:
Length: 8”
Width: 2.25”
Weight: 2.2lbs.

CRIMPING RANGE:
Contacts:
Size 20 thru 28
Wire Size:
Size 20 AWG thru 32 AWG

129 . **ACCOMMODATIONS.** Tool will accommodate all MIL SPEC and “K” series Positioners relating to MIL SPEC hand tool part numbers M22520/2–01.

130 . **FOOT VALVE OPERATION.** Attach Foot Valve between air supply and tool air inlet. Depress hand valve and lock in down position with set screw (A) using 1/16 hex Allen wrench.

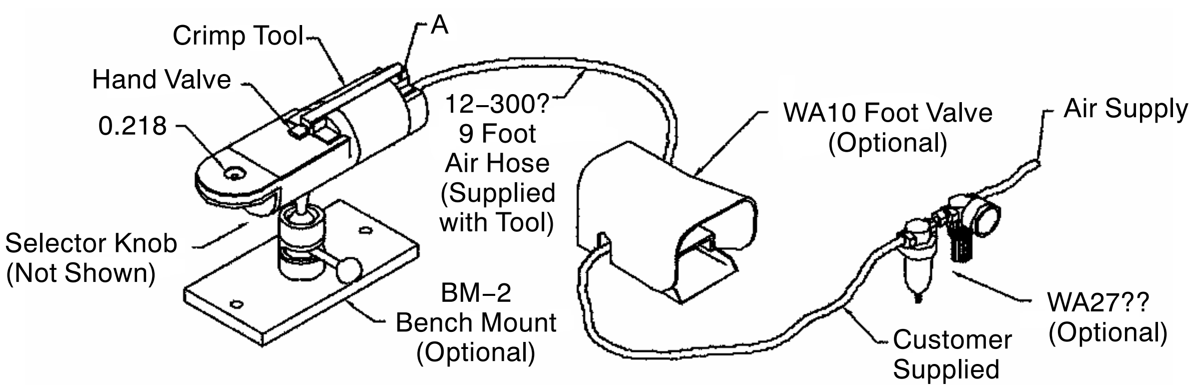
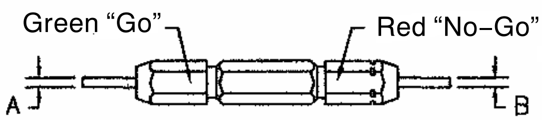


Figure 50. Pneumatic Crimp Tool

CAUTION!
DO NOT CRIMP GAGE!

GAGING INSTRUCTIONS



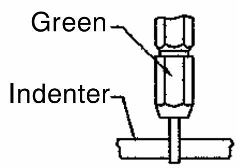
GAGE PART NO.	A GO DIA	B NO-GO DIA	SELECTOR NO.
G125	.0390	.0440	4

"GO" Gaging

Operate tool to fully closed position. Insert "GO" gage end as shown. Gage must pass freely between indenter tips.

"NO-GO" Gaging

Operate tool to fully closed position. Insert "NO-GO" gage end as shown. The "NO-GO" may partially enter the indenter opening, but must not pass completley through the opening.



SELECTOR NO.	A ± .0001 GO DIA	B ± .0001 NO-GO DIA
1	.0280	.0330
2	.0320	.0370
3	.0360	.0410
4	.0390	.0440
5	.0450	.0500
6	.0520	.0570
7	.0590	.0640
8	.0680	.0730

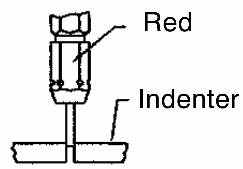


Figure 51. WA27F Pneumatic Crimping GO/NO GO Gaging

131 . **CHECKING THE FULL CYCLE RATCHETING MECHANISM.** The ratcheting mechanism can be checked for proper functioning by the following procedure (Figure 51).

a. Adjust the air line pressure to 15 p.s.i.

b. Using a size 20 contact with a size 20 AWG wire, operate the tool until the indenters stop. The indenters will not reach the fully closed position and the contact will be locked in if the ratcheting mechanism is functioning properly.

c. To release the partially crimped contact, increase the air line pressure to 80-120 p.s.i. and operate. The tool will then complete the crimp allowing the indenters to return to the fully open position.

132 . **RELEASING A PARTIALLY CRIMPED CONTACT.** To release a partially crimped contact, proceed as follows:

a. Increase the air pressure to 120 p.s.i. and operate the unit. (If increasing the air pressure does not release the contact, proceed as follows:)

b. Turn the selector knob clockwise to the highest lockable setting. (Selector knob must be in the locked position before proceeding.) Operate the unit.

133 . **CARE OF TOOL.** There is virtually no maintenance required. However, it is a good practice to keep indenter tips free of residual color band deposits and other debris. A small wire brush may be used for this purpose. It is strongly recommended that you:

1. DO NOT immerse tools in cleaning solutions.
2. DO NOT spray oil into tool to lubricate.
3. DO NOT attempt to disassemble tool or make repairs.

134 . This a precision crimping tool and should be handled a such.

135 . **CRIMP TOOL M22520/28-1 AND M22520/29-1 POWER.**

136 . **GENERAL DESCRIPTION.** These are pneumatic operated crimp tools that utilize the same accessories as the M22520/1-01 and 2-01. They may be operated either by hand or bench mounted with either hand control or foot control. The M22520/28-1 measures 8 inches X 2 1/4 inches and weighs 32 ounces, and the M22520/291 measures 11 inches X 2 3/4 inches and weighs 60 ounces (Figure 52).

137 . **M22520/28-1.** This tool uses the same accessories as the M22520/2-01. The gaging buildup and operation are the same (paragraph 59).

138 . **M22520/29-1.**This tool uses the same accessories as the M22520/1-01. The gaging buildup and operation are the same (paragraph 64).

139 . **Optional Accessories.** There are some accessories used only by M22520/28-1 and M22520/29-1 tools (Table 25).

140 . **CRIMP TOOL, MS25441.**

141 . **USE**. The tool is used to crimp pre-insulated. uninsulated, and aluminum terminal lugs and splices (Table 26).

142 . **PERIODIC GAUGING.** Periodic gaging (Table 26) is required before each crimp to ensure proper crimp dimensions and tool calibration and is performed in the following manner.

a. Activate tool to fully mate die surfaces.

b. Go gage should freely pass through die (Figure 53).

Table 25 . Optional Accessories

Accessory Part Number	Used On M22520/ 28-01	Used On M22520/ 29-01
BENCH MOUNT M22520/30-01	YES	YES
FOOT VALVE M22520/30-02	YES	YES
AIR SUPPLY HOSE M22520/28-02	YES	YES

c. No Go -gage should not pass through die (Figure 53).

d. When either caging fails reject tool to repair or calibration.

143 . **SETUP, ADJUSTMENT, AND OPERATION.** Correct tool buildup and adjustment are necessary to perform mechanically and electrically sound crimps. Perform build up and adjustment using the following steps:

a. Select proper tool (Figure 53).

b. Select proper die.

c. Select proper inspection gage (Table 26).

d. Setup and adjust tool.

e. Operate.

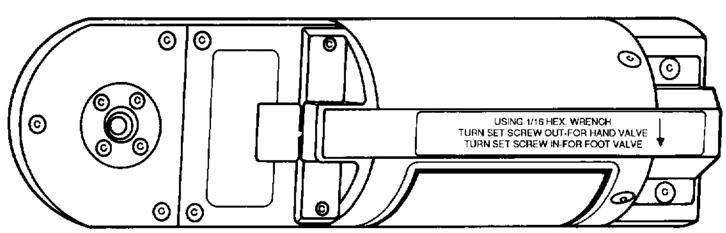


Figure 52. Crimp Tools M22520/28-1 And M22520/29-1

Table 26 . MS25441 Crimp Tool Dies, Gages and Terminal

Terminal Lug Size Insulated Terminals	Die Part Number (For Head MS25441−1)	MS Gauge Part Number
8	MS23002−8	MS23003−8
6	MS23002−6	MS23003−6
4	MS23002−4	MS23003−4
2	MS23002−2	MS23003−2
1	MS23002−1	MS23003−1
0	MS23002−01	MS23003−01
00	MS23002−02	MS23003−02
000	MS23002−03	MS23003−03
0000	MS23002−04	MS23003−04
Uninsulated Terminals		
8	MS90485− 8	MS90486−8
6	MS90485−6	MS90486−6
4	MS90485−4	MS90486−4
2	MS90485−2	MS90486−2
1	MS90485−1	MS90486−1
0	MS90485−01	MS90486−01
00	MS90485−02	MS90486−02
000	MS90485−03	MS90486−03
0000	MS90485−04	MS90486−04
Aluminum Terminals	Die Part Number (For Head MS25441−1)	MS Gauge Part Number
8	MS25442−8A	MS25472− 1
6	MS25442−6A	MS25472−2
4	MS25442−4A	MS25472−3
2	MS25442−4A	MS25472−4
1	MS25442−1A	MS25472−5
0	MS25442−01A	MS25472−6
00	MS25442−02A	MS25472−7
000	MS25442−03A	MS25472−8
0000	MS25442−04A	MS25472−9

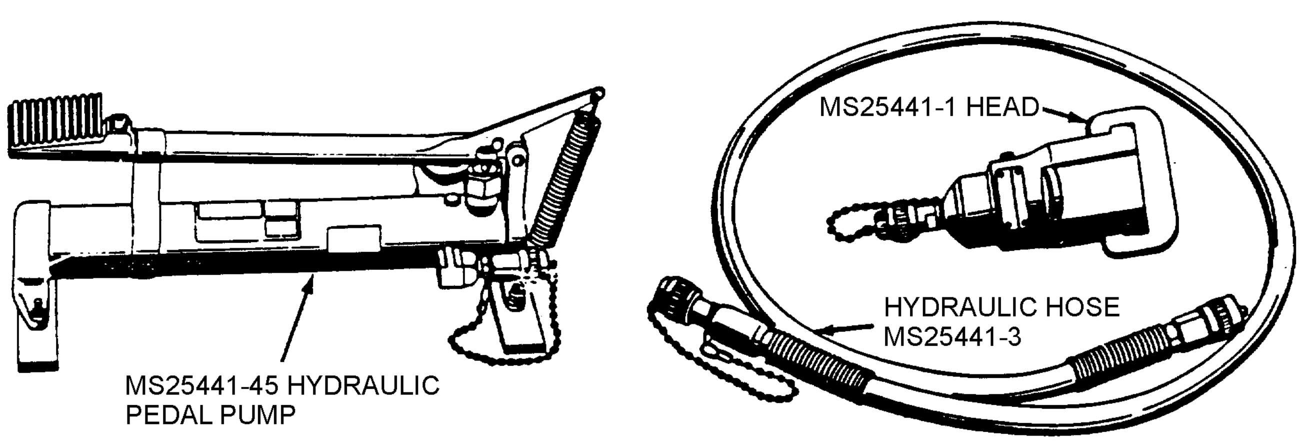


Figure 53. MS25441 Terminal Crimp Tool

WIRE AND CABLE SPLICING AND REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Support Equipment Required

Nomenclature	Part. No./Type Designation	Nomenclature	Part. No./Type Designation
Bristle Brush	–	Crimping Tool	HD–51
Cable Stripper	45–162	Diagonal Cutter/Pliers	–
Cable Stripper	45–163	Heat Guns	Refer to WP 012 00
Cable Stripper	45–164	Inspection Gage	MIL–DTL–22520/39
Cable Stripper	45–165	Knife	–
Crimping Die	HD51–130–1	Safety Glasses	–
Crimping Die	HD51–131–2	Scissors	–
Crimping Die	HD51–132–2	Thermocouple Connector	AN 5537
Crimping Tool	MIL–DTL–22520/37		

Materials Required

Nomenclature	Part Number/Type Designation
Alcohol, Denatured	O–M–232
Alcohol, Isopropyl, Grade A, Technical	TT–I–735 Grade A
Coaxial Cable Splice Kit	AS81824
Standard Application Wrap Around Heat Shrink	ZT98–04–016–#1 through ZT98–04–016–#14
Standard Application Wrap Around Environmentally Sealed Heat Shrink	ZT03–04–010–01/03/05/07/09/11 and ZT03–04–010–13/15/17/19/21/23/25/27
Tape, Lacing and Tying Aramid	A–A–52084
Tape, Lacing and Tying Glass	A–A–52083
Tape, Teflon	—
Tubing, Wire Braid	2194
Wire, 30 AWG Bare	—

WARNING

Soldering may result in the emission of hazardous metallic fumes and vapors from fluxes used. Workers should position themselves so as to not directly inhale the fumes/vapors. Local conditions may require evaluation. (NA 01−1A−23)

CAUTION

Use copper terminations only on copper wire. Use aluminum terminations only on aluminum wire. Mixing the two may result in a corroded connection, inducing premature wiring system failure.

1. **INTRODUCTION**.

2. This work package (WP) includes the repair of wire and various types of cable such as the following:

a. Single Conductor Wire (WP 004 00).

b. Jacket/shielded Cable (WP 005 00).

c. Radio Frequency Cable (WP 006 00).

d. Thermocouple Cable (WP 004 00).

3. **SINGLE CONDUCTOR WIRE REPAIR.**

4. **SPLICE TYPES.** An electrical splice is used for joining multiple wires in a strong mechanical and electrical bond. The two basic types of splices are End Splice and In−Line (also known as a butt splice). Either type of splice can be obtained in an environmental or non−environmental configuration.

a. End Splices are used to join multiple wires traveling from the same direction. This type of splice is typically used to join wire bundles. In this type of splice, both wires enter the splice from the same side of the splice.

b. In−Line Splices are generally used to join multiple wires traveling in a continuous direction. This type of splice is normally used to repair a damaged wire or extend the length of a wire. In this type of splice, the wires enter the splice from both sides.

5. **ENVIRONMENTAL RESISTANT SPLICES.** The environmental resistant splice conforming to AS 81824 or MIL−S−81824 shall be used to splice single conductor wires, single conductor wires within a multiconductor cable, and single conductor wires in ribbon cable size 12 to 26 AWG. These splices may be used in all cases where the total temperature does not exceed 302˚F (150˚C).

NOTE

When splices are used for in−line connections of two or more wires, where disconnect is required, disconnect splices in accordance with AS81714 shall be used. Sealing plugs in accordance with MS27488 shall be installed in unused grommet holes. Use WP 020 00 or 023 00 for installation instructions.

6. **SPLICES FOR ALUMINUM − WIRES.** Aluminum wires shall be repaired using permanent crimp splices MS25439 only. Because aluminum wire diameters have been changing over time, splicing should be performed as a last resort. Whenever practical, replace the wire end−to−end.

7. **LARGE WIRE SPLICE REPAIRS.** Wires size 10 AWG and larger in diameter, shall be replaced in their entirety instead of repairing with splices. Replace affected wire from designed point of origin to the end of the wire run by using the same connection method as original design and installation requirements. If operational commitments do not allow for wire replacement, contact Cognizant Engineering Authority to obtain repair disposition.

NOTE

If temporary splicing is used as directed by cognizant engineering activity, maintenance documentation shall be written to ensure wire is replaced as soon as operational commitments permit and not later than next scheduled major maintenance cycle.

8. **SPLICE RESTRICTIONS.** All splices are subject to the following restrictions (Refer to AS50881 for additional details):

a. Splices in bundles shall be staggered and shall not increase the size of the bundle so as to adversely affect maintenance. Where multiple splices are required in close proximity to each other, their position should be staggered to avoid any increase in loom diameter. Wherever possible, splices are to be positioned on the outside of a harness to allow subsequent identification and inspection.

b. Splices shall not be used to repair wiring inside a fuel tank or within 12 inches on the wires entering or exiting a fuel tank.

c. There shall be no more than one splice in any one wire segment except as follows:

(1) When attaching to a spare lead or pigtail.

(2) To splice multiple wires to single wires.

(3) To adjust wire size to be compatible with contact crimp barrel.

(4) When a repair action requires a jumper wire.

d. Splices shall not be used within 12 inches of a termination device, except as follows:

(1) When attaching to the pigtail spare lead, adding a wire or segment to a potted termination device, splicing multiple wires to a single wire and adjusting the wire sizes so that they are compatible with the contact crimp barrel sizes.

(2) Splices shall not be used on firing circuits or control circuits associated with ordnance or explosive systems.

e. Wires and cables that have a specified Fire Resistance rating require special consideration and are not to be repaired without the authority of the relevant aircraft Cognizant Engineering Activity.

f. Splices shall not be installed under clamps (primary or secondary support).

9. **REPAIR PROCEDURES.**

WARNING

Splices shall not be used on wires inside of fuel tanks/cell or within 12 inches of fuel tank/cell entry.

10. **Wire Damaged at Single Point.** A wire damaged at a single point can normally be repaired with a single splice. To repair single point wire damage, proceed as follows:

a. Locate damaged portion of wire and ensure there is enough slack in wire to make a single splice.

b. Remove damaged portion of wire.

c. Clean last two inches of ends of wire to be spliced to remove any oil or grease. Slide sealing sleeve over one end of stripped wire (Figure 1).

d. Select proper tool (Table 1). Buildup and adjust tool in accordance with Figure 2.

e. Refer to Table 1 for splice selection, strip dimensions, and crimping tool selection. For splice repairs 12–26AWG, use the M22520/37 crimp tool. For splice repairs 10 AWG and larger, refer to paragraph 7 and WP 013 00 for tool selection and procedures.

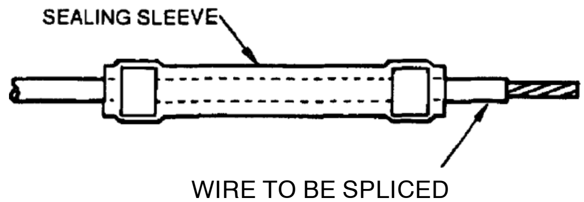
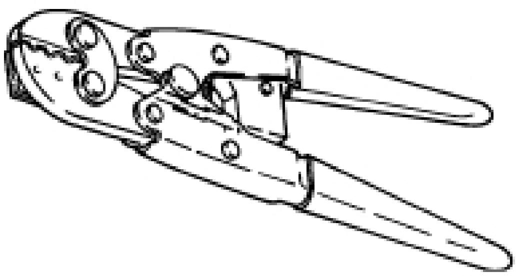


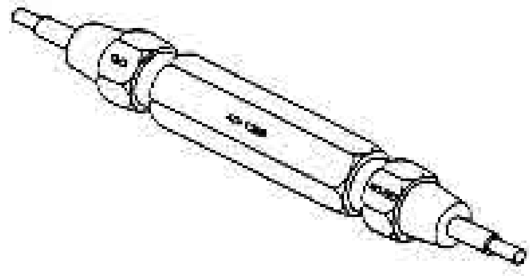
Figure 1. Sealing Sleeve Placed on Wire End

Table 1. Splice Tooling

Wire Gage	Splice Part No.	Color Band	Strip Dimension (+1/16–0)	Crimp Tool	Die Set	Inspection Gage
20 thru 26	M81824/1–1	Red	1/4	M22520/37		M22520/39–01
16,18, 20	M81824/1–2	Blue	5/16	M22520/37		M22520/39–01
12,14, 16	M81824/1–3	Yellow	5/16	M22520/37		M22520/39–01
10	D–436–26	–	5/16	M22520/5–01	M22520/5–100	M22520/39 and 10
8	D–436–0081	–	7/16	HD–51	HD51–131–2 & HD51–130–1	G744
6	AMP324660	–	7/16	HD–51	HD51–132–2 & HD51–130–1	G745



Crimp Tool M22520/37



M22520/39−01 Inspection Gage

1. Fully close tool jaws.

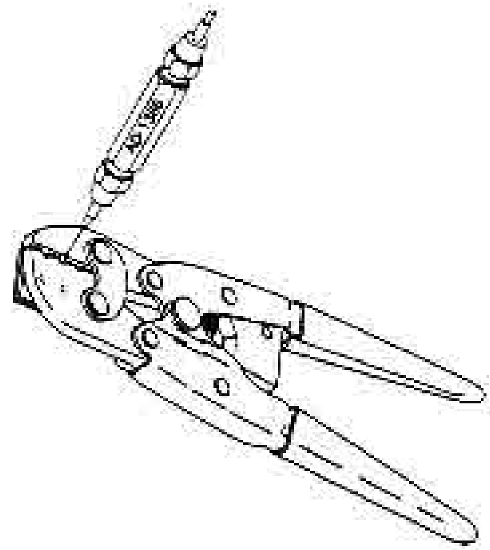
CAUTION

Do not crimp down on gauge pin as this will prevent tool from cycling to ratchet release position.

NOTE

Perform step b and c at the beginning of each crimp operations. If crimping five splices in a row the go – no go inspection is only required prior to the first splice.

2. Axially align Go gauge (Green) with indenter opening. Slide go gauge into indenter opening and through indenter. Gauge should pass freely through indenters. If not, replace with a serviceable tool.



3. Invert inspection gauge while continuing to hold handles in the fully closed position. Insert No−Go gauge (Red) into indenter opening. Gauge should not pass between indenters. If No−Go gauge (Red) passes through indenters, replace with a serviceable tool.

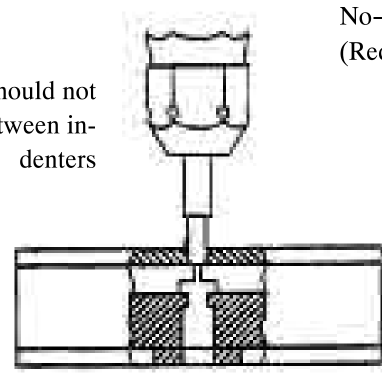
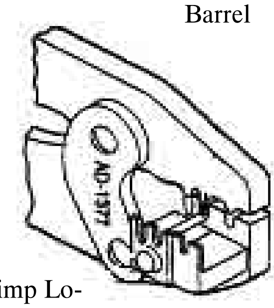


Figure 2. M22520/37−01 Crimping Tool Operation (Sheet 1 of 2)

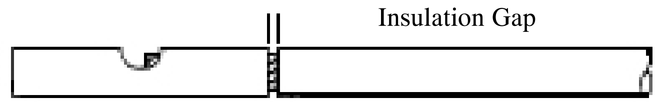
4. Strip wire insulation in accordance with WP 009 00 and as per dimensions in table 1. Slide insulation sleeve over wire (Figure 1).
5. Open crimping tool jaws. Insert crimp barrel in slot corresponding to size of crimp barrel.

NOTE

Slots on crimping tool are labeled with size of applicable crimp barrel.



6. Insert stripped wire in crimp barrel until lead reaches middle of barrel and is visible in contact inspection hole. Assure insulation gap exists and is less than 1/64 inch. For wire gages 12 thru 26, the cavity color code will match the color of the stripe on the crimp barrel.



7 Squeeze handles together smoothly until handles release.
8. Remove crimped splice assembly from crimping tool.
9. Reverse crimp barrel in tool and repeat steps 6 and 7.
10. Refer to paragraph 10 to apply heat and complete splice.

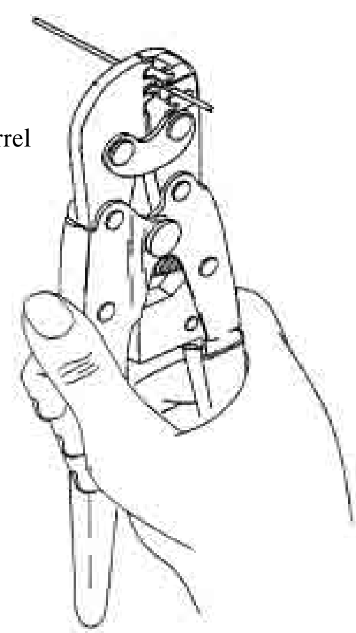


Figure 2. M22520/37–01 Crimping Tool Operation (Sheet 2 of 2)

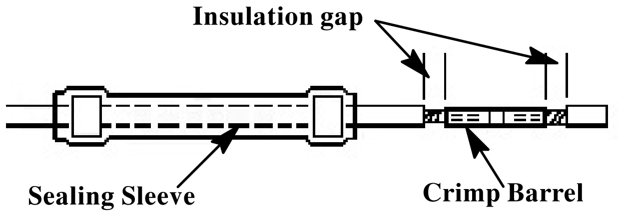


Figure 3. Correctly Installed Crimp Barrel

CAUTION

The only tools approved for the M81824 /1–X environmental splices are the tools qualified and meeting SAE AS22520/37 specification (they are the GMT232 and the AD–1377).

f. Examine crimped connection for the following:

(1) Indent centered on splice barrel.

(2) Indent in line with barrel.

(3) Barrel not cracked.

(4) Wire cannot be pulled out of splice.

(5) (5). Gap of 1/32 to 1/16–inch for wire gages 12 thru 26, exists between crimp barrel and wire insulation (Figure 3).

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listedin this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

g. Center sealing sleeve over crimp barrel (Figure 4).

h. Shrink sealing sleeve using heat gun with small termination sleeve reflector (WP 012 00). Shrink middle first and heat towards end, until sealant melts and begins to flow out end. Repeat for other end. Allow to cool (Figure 5).

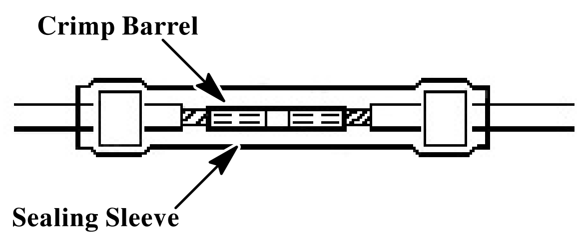


Figure 4. Sealing Sleeve Centered

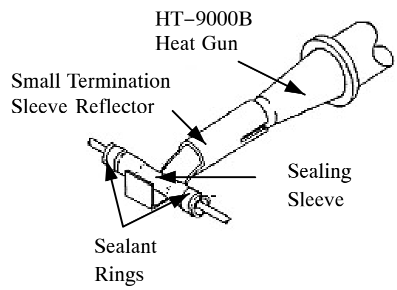


Figure 5. Sealing Sleeve Centered

NOTE

If the metal conductor is not damaged, but only the insulation requires repair, the wraparound (side entry) heat shrink is a suitable repair (paragraph 13).

11 . **Wire Damaged Along Its Length.** When damage exists along the length of a wire, the damaged portion shall be removed and a jumper installed using two splices. To repair a single conductor wire along it length, proceed as follows:

a. Locate damaged portion of wire.

b. Cut a minimum of 6 inches from damaged wire (Figure 6).

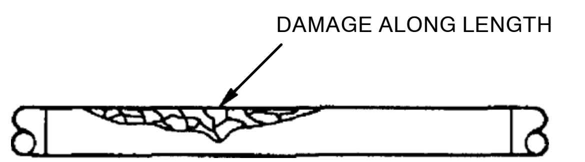


Figure 6. Wire Damage

c. If the damaged wire area is close to a termination point and re−termination is possible using a new contact or terminal, a new wire section and contact or terminal should be installed to avoid using two splices.

d. The jumper wire shall be the same as the wire being repaired, except for MIL−DTL−81381 Kapton wire shall be replaced with wire in accordance with WP 004 00 replacement requirements. Always ensure jumper wire is the same size (AWG).

e. Cut jumper wire 1/2 inch longer than removed damage portion.

f. Install jumper wire in accordance with Paragraph 9, steps c thru n for each end of jumper wire.

NOTE

If the metal conductor is not damaged, but only the insulation requires repair, the wrap−around (side entry) heat shrink is a suitable repair (paragraph 13).

12 . **MULTI-CONDUCTOR WIRE REPAIR**. Multi−conductor cable consists of two or more conductors contained within a common jacket. This common jacket does not provide environmental protection (refer to WP 011 01 for Environmentally Sealed Harness Repair). Splice requirements and restrictions are the same as single conductor wire repair. When more than one wire needs repaired in the same location in a harness the wires shall be repaired as follows:

a. When splices are used for in−line connections of two or more wires, where disconnect is required, disconnect splices in accordance with AS81714 shall be used, sealing plugs in accordance with MS27488 shall be installed in unused grommet holes.

b. If the damaged wire area is close to a termination point and re−termination is possible using a new contact or terminal, a new wire section and contact or terminal should be installed to avoid using two splices.

c. Score cable jacket using sharp knife. Do not cut completely through jacket to prevent damage to wires inside harness.

d. Flex cable at score marks until jacket separates. If necessary, use a sharp knife to complete the cut along the cable.

e. Fold jacket back to gain access damaged area.

f. Remove damaged portion of wire.

g. Clean last two inches of wire ends to be spliced to remove any oil or grease).

h. Refer to Table 1 for splice selection, strip dimensions, and crimping tool selection.

i. Strip wire insulation in accordance with WP 009 00 to dimensions specified in Table 1 for appropriate splice.

j. Slide sealing sleeve over one end of stripped wire (Figure 1).

k. Select proper tool (Table 1). Buildup and adjust in accordance with WP 013 00.

l. Insert crimp barrel into correct cavity of crimp tool. For wire gages 12 thru 26, the cavity color code will match the color stripe on the crimp barrel. Ensure end of crimp barrel is against stop of tool and inspection hole is visible (Figure 2).

m. Insert end of wire into end of crimp barrel opposite stop. Wire must be visible through inspection hole. A gap 1/32 to 1/16–inch for wire gages 10 thru 26, or 1/16 to 1/8–inch for wire gages 6 and 8, must exist between wire insulation and crimp barrel. Trim conductor or insulation as required.

n. Lock crimp barrel in place by partially closing handles without denting crimp barrel.

o. Squeeze handles of crimp tool through complete crimp cycle. Crimp tool will not release until crimp cycle has been completed.

p. Reverse crimp barrel in cavity. Attached wire will fit in slot of stop. Ensure end of crimp barrel is against stop of tool and inspection hole is visible. Repeat steps k thru n.

q. Examine crimped connection for the following:

(1) Indent centered on splice barrel.

(2) Indent in line with barrel.

(3) Barrel not cracked.

(4) Wire cannot be pulled out of splice.

(5) Gap of 1/32 to 1/16–inch for wire gages 10 thru 26, or 1/16 to 1/8–inch for wire gages 6 and 8 exists between crimp barrel and wire insulation (Figure 3.).

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

r. Center sealing sleeve over crimp barrel (Figure 4).

s. Shrink sealing sleeve using heat gun with small termination sleeve reflector (WP 012 00). Shrink middle first and heat towards end, until sealant melts and begins to flow out end. Repeat for other end. Allow to cool (Figure 5).

NOTE

When applying insulating tape, hands should be free of dirt and oil.

t. Repair cable jacket by wrapping with Tape, Non–Adhesive, Self–Bonding, (A–A–59163).

(1) Spot tie both ends of insulating tape using lacing tape (Figure 7).

u. Replace cable clamps and ties.

NOTE

If the metal conductor is not damaged, but only the insulation requires repair, the wrap–around (side entry) heat shrink is a suitable repair (paragraph 30).

13 . **RIBBON CABLE REPAIR.** Ribbon cable should be repaired in the same manner as single or multi wire.

14 . **FLAT CABLE REPAIR.** Flat cable should be repaired in accordance with the aircraft maintenance manual. If no information is available, contact the Cognizant Engineering Activity for support

15 . **MULTI–CONDUCTOR SHIELDED CABLE.** Shielded cables containing one to five primary conductors can be repaired using a shield repair kit and the following procedures (refer to WP 011 01 for shielded and EMI harness repair). The below procedure calls for cutting all the conductors in the cable to allow for the installation of the repair braid and insulation tubing.

a. Cut ties and remove clamps to gain access to, and isolate damaged area.

b. Select shield repair kit according to length of damaged area and diameter of shield braid in damaged cable (Table 2).

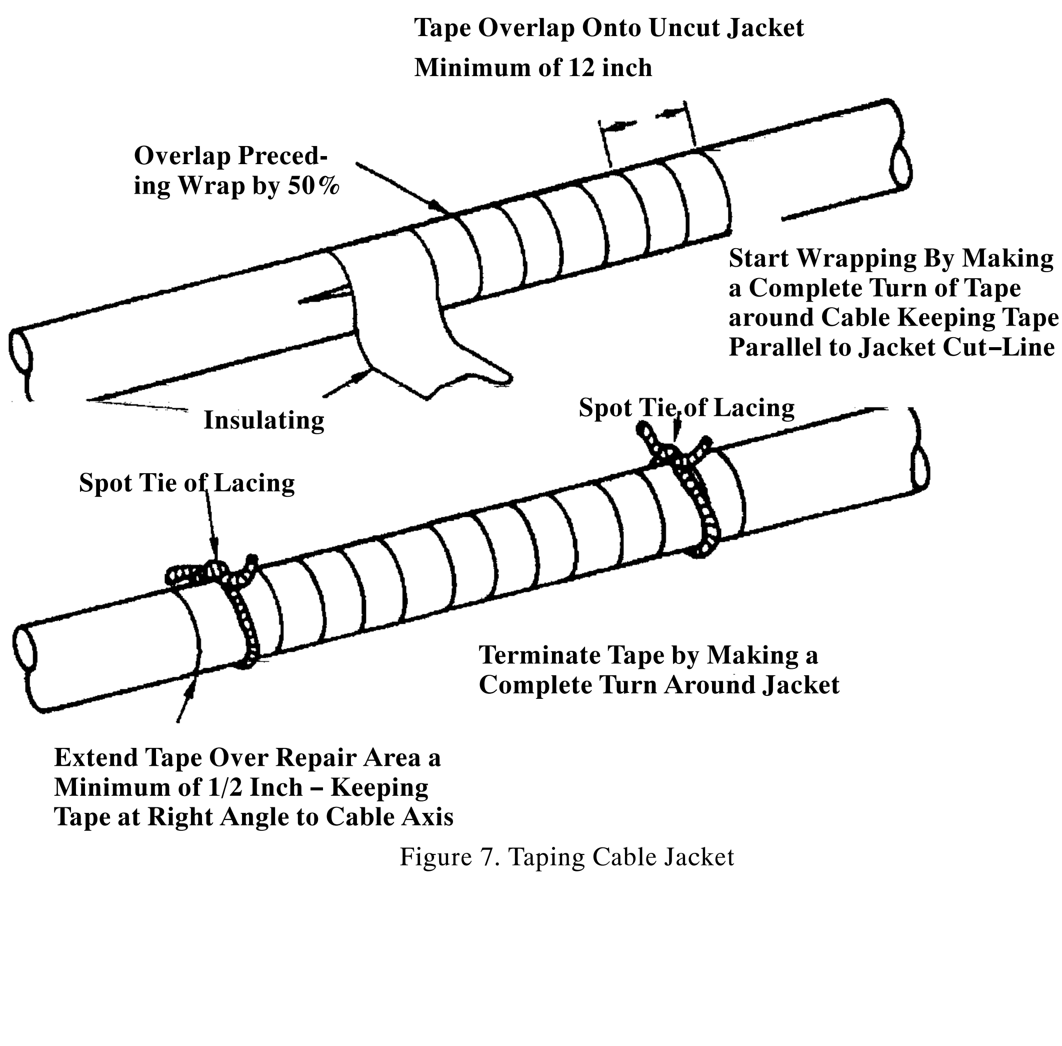


Figure 7. Taping Cable Jacket

Table 2. Shield Repair Selection

PART NUMBER M81824/5	CABLE PARAMETERS		KIT COMPONENTS		
	NUMBER OF CONDUCTORS	CONDUCTOR SIZE RANGE	CONDUCTOR SPLICE PART NO. M81824/1	(QTY)	SHIELD SPLICE PART NO. M81824/
-1	1	24-22-20	-1	(1)	-1
-2	1	20-18-16	-2	(1)	-2
-3	1	16-14-12	-3	(1)	-3
-4	2	26-24-22-20	-1	(2)	-4
-5	2	18-16	-2	(2)	-5
-6	2	14	-3	(2)	-6
-7	2	12	-3	(2)	-7
-8	3 OR 4	26-24	-1	(4)	-4
-9	3 OR 4	22-20	-1	(4)	-5
-10	3 OR 4	18-16	-2	(4)	-6
-11	3 OR 4	14-12	-3	(4)	-7

c. Score jacket carefully around cable and along area to be removed using a sharp blade. Do not cut shield.

d. Flex cable at score marks until jacket separates. Use knife blade, if necessary, to complete jacket removal. Do not cut through shield.

e. Remove separated jacket.

f. Use small scissors or diagonal cutter to remove shield. Do not damage wires (Figure 8).

g. If wires are not color coded, or otherwise identified, tag all wires for identification before proceeding.

h. Cut damaged wire or wires to remove any damaged portions. If damaged wire must be cut out, remove at least 2 inches total length. If damage is at a single point, damaged wire can be cut at the point of damage (Figure 9).

i. Cut undamaged wires at staggered locations (Figure 10).

j. Slide tubing and braid from shield repair kit, over either cable end. Tape tubing and braid to bundle to hold in place (Figure 11).

k. Repair damaged wires and cut wires in accordance with paragraph 8, steps e. thru r. to regain cable integrity.

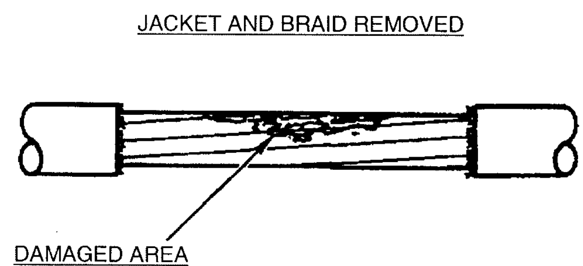


Figure 8. Damaged Multiconductor Wire

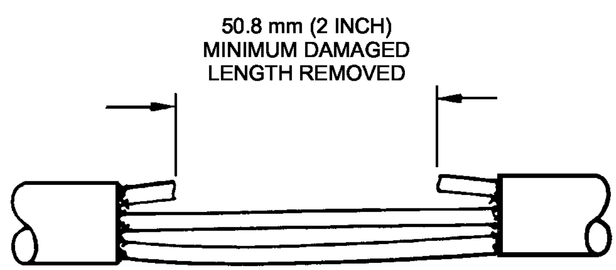


Figure 9. Wire with Damaged Portion Removed

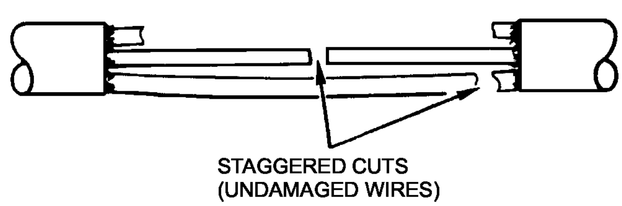


Figure 10. Undamaged Wires Cut at Staggered Locations

l. Carefully score around jacket and along length to permit the removal of 0.5 inch of jacket . Do not cut through jacket.

m. Flex cable at score marks until jacket separates.

n. Peel insulation away from cable (Figure 12).

o. Slide repair braid along cable and center over repaired area (Figure 13).

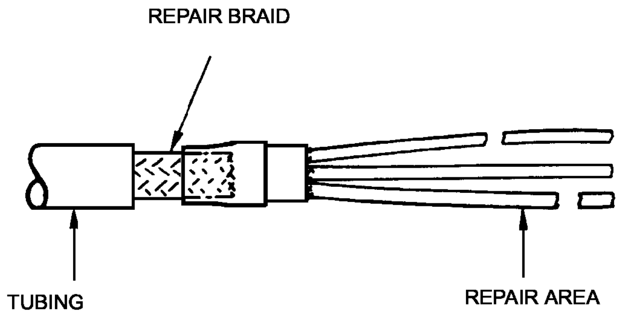


Figure 11. Tubing and Braid Placed on Cable End

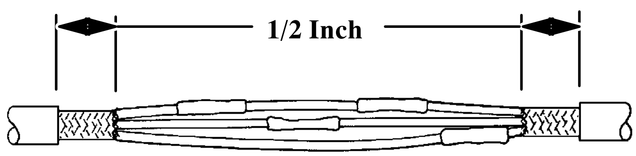


Figure 12. Jacket Peeled Away 1/2 Inch

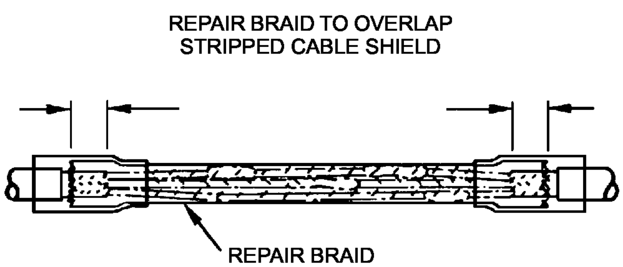


Figure 13. Repair Braid Centered Over Repair Area

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT−900B, HT−920B, HT−71002, MCH−100−A and IR−1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01−1A−35 or AF T.O. 1−1−3.

Only the HT−900B/HT−920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01−1A−35).

The MCH−100−A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH−100−A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas−free environment criteria (NAVAIR 01−1A−35 or AF T.O. 1−1−3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

p. Heat one end of repair braid using HT900B/HT−920B/HT71002/MCH−100−A heat gun with terminal sleeve reflector. Apply heat to overlapping shield area until solder melts and sleeve shrinks down onto cable. Continue heating until solder flows into braid strands. Allow to cool undisturbed until solder solidifies (Figure 14).

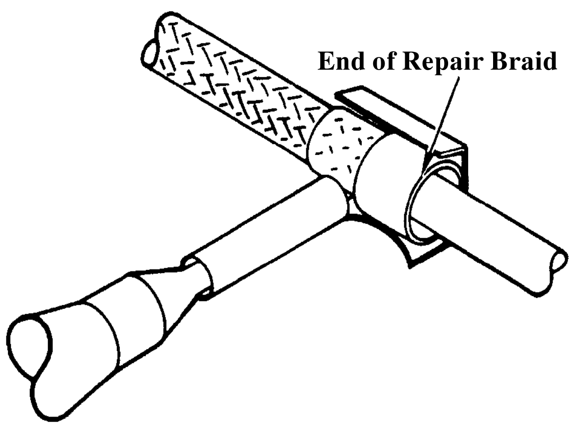


Figure 14. Heating Repair Braid

16. **End Caps (Stub Splices) and In−Line Splices.**

17. **End Caps (Stub Splice).** End caps, also know as stub splices, are used to terminate parallel wires from the same side of the splice (Table 3, Figure 15).

Table 3. End Cap by Wire Size

Wire AWG	Part No.	Color
26 – 24	MS25274−1	Yellow
22 – 18	MS25274−2	Red
16 – 14	MS25274−3	Blue
12 – 10	MS25274−4	Yellow

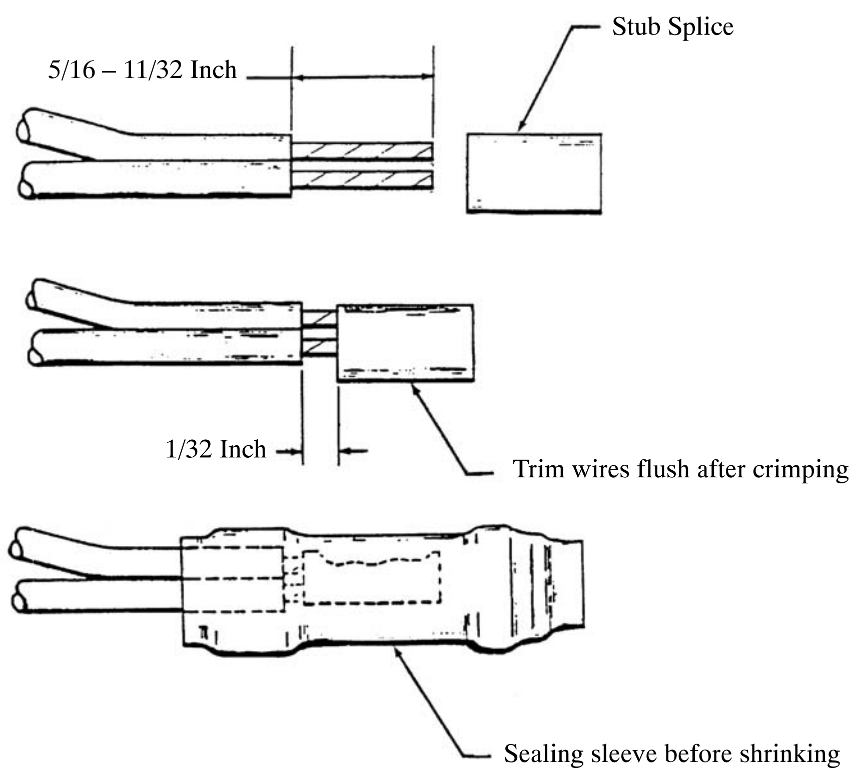


Figure 15. Environmental Sealed Stub Splice Installation

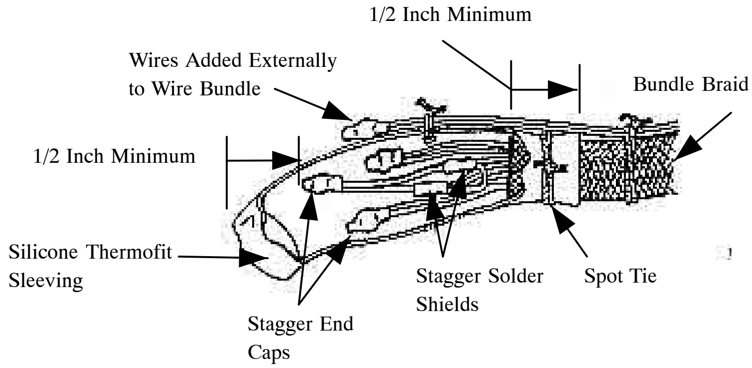


Figure 16. End Cap Area with Parallel Splices

18 . **End Cap Termination.** Perform an end cap splice installation as follows:

a. Select the proper end cap from Table 3.

b. Cut wire to proper length, ensure end is cut square.

c. Insert wire into end cap and crimp using crimp tool M22520/5–01 with die set M22520/5–100.

d. Ensure end cap is securely crimped to wire.

e. When more than one wire in a harness is end capped, ensure wires are cut to stagger end caps to maintain harness dimensions (Figure 16).

19 . **Covering the End Cap.** The end cap must be covered for environmental protection. The caps may be covered with heat shrinkable (Sleeve Covered) insulation which is the preferred method, or with self–bonding tape.

20 . **Sleeve Covered End Cap Method.** When using heat–shrinkable insulation sleeving for environmental protection of the End Caps, proceed as follows:

NOTE

Before covering the splice area, ensure the individual end caps have been completely insulated and splices have been staggered to limit bundle enlargement. Cut sleeving so it will be 1 1/2 inches longer than the exposed splices. This is necessary so the sleeving can be doubled back and string tied.

a. Select proper size heat shrinkable insulation sleeving and approved heat source with proper reflector (WP 012 00).

b. Cut sleeving to a length to overlap braid by 1/2 inch and extend over longest end cap by 1/2 inch after being shrunk.

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3.

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

c. Apply heat to end over braid area first until sleeve grips firmly.

d. Continue to apply heat uniformly around circumference toward free end of sleeve.

e. Shrink each section before proceeding or distortion will result.

f. With lacing tape spot tie sleeve at braid end.

21 . **Tape Covered End Cap Method.** When proper heat shrinkable insulation sleeving or approved heat source is not available, the end caps may be covered by the use of self–bonding tape A-A-59163-1, MIL-I-46852 (NSN 5970-00-955-9976) as follows:

NOTE

For best results when applying tape, hands should be free of dirt or oil.

a. Starting on braid end of the end cap area, wrap the tape one complete turn around braid.

b. Using the same continuous length of tape, spiral wrap, with a 50% overlap, a single layer over wires to the opposite end (free end) of end cap area.

NOTE

To achieve a neat appearing tape wrapping, follow the guide line on the tape and keep the tape stretched tightly.

c. Terminate the tape by wrapping it a full turn around the longest end cap keeping the guide line at a right angle to the end cap area.

NOTE

Do not keep tape under tension while applying this last wrap.

d. Make a spot tie of lacing tape at both ends of the silicone tape.

22 . **In–Line Splice.** In–line splices are used to join two wires side–by–side, either from the same end of the splice or from opposite ends of the splice. In–line splices are installed as follows:

a. Remove insulation from the wire approximately 0.75 inch.

b. Select proper size in–line connector based on number and gage of wires to splice (Tables 4 and 5).

Table 4. Splices, Caps, and Sleeving of Wires of Same Gage

Parallel Connector		Shrinkable End Cap		Shrinkable CRN−T Sleeve	Number of Wires of Same Gage					
AMP Part Number	McDonnell Standard Number	Raychem Part Number	McDonnell Standard Number	Sleeve	#22	#20	#18	#16	#14	#12
34130	5M392−1	D−300 −08	5M250−5	1/4 in. Slate	2, 3	2				
34137	5M392−2	D−300−12	5M250−5	1/4 in. Slate	4, 5	3	2	2		
34138	5M392−3	D−300−12	5M250−5	3/8 in. Brown	6*, 7, 8, 9, 10	4*, 5, 6, 7	3, 4, 5	3, 4	2	
34318	5M392−4	D−300−18	5M250−6	1/2 in. Black			6*, 7, 8	5*, 6, 7	3*, 4	3
*Refer to Paragraph 22.c										

Table 5. Splices, Caps, and Sleeving of Wire of Mixed Gage

Parallel Connector		Shrinkable End Cap		Shrinkable CRN−T Sleeve	Number of Wires of Same Gage						
AMP Part No.	McDonnell Standard No.	Raychem Part No.	McDonnell Standard No.	Sleeve							
34130	5M392−1	D−300−08	5M250−5	1/4 in. Slate	1#22 1#20						
34137	5M392−2	D−300−12	5M250−5	1/4 in. Slate	4 #22 1 #20	3 #22 1#20	2 #22 1 #20	1 #20 1#18	3 #20 1#22	2 #20 2 #22	2 #20 1#18
34138	5M392−3	D−300−12	5M250−5	3/8 in. Brown	9 #22 1# 20	6 #22 1 #20	3 #18 1 #20	1 #22 1 #20 3 #18	6 #22 2 #18	2 #18 1 #20*	
34318	5M392−4	D−300−18	5M250−6	1/2 in. Black	2 #22 1 #20 6 #18	3 #16 1 #12					
*Refer to Paragraph 22.c											

NOTE

If Tables 4 and 5 show an asterisk (*) insert a stripped piece of scrap wire in the connector. After crimping, cut scrap wire flush with connector to prevent connector from cracking and to create a reliable splice. AMP tool, part number 49935 should be used for crimp connectors 34130, 34137 and 34138. For crimp connector 34318 use AMP tool, part number 69355−0.

c. Crimp in−line splice in appropriate nest of hand tool.

NOTE

Connector must be centered in the nest. Connector weld seam must be in the nest section of the crimping tool as shown in Figure 16. Position wires in connector to allow maximum of 0.2 inch between connector and wire insulation after crimping (Figure 17).

d. Remove wire protruding from end of connector. Flush cutoff is necessary to prevent puncture of end cap.

e. The stub splicing procedure completed thus far must meet dimensional requirements (Figure 18).

f. The preferred method for insulating the stub splice is as follows (Figure 19):

(1) Select proper size self−sealing end cap (Table 6).

(2) Position end cap on stub splice and shrink.

g. lternative method for insulating the stub splice is as follows (Figure 20).

(1) Select proper size CRN end cap (Tables 4 and 5).

(2) Position end cap on stub splice and heat shrink.

(3) Select shrinkable sleeving or CRN−T sleeving (Tables 4 and 5).

(4) Cut sleeve approximately 1.2 inches in length.

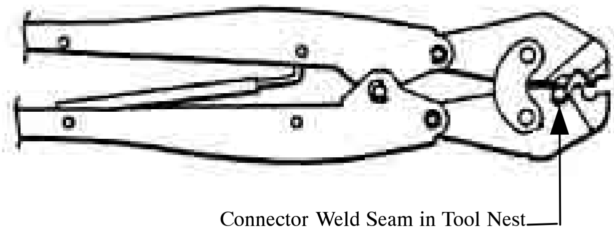


Figure 17. In−Line Splice Crimping

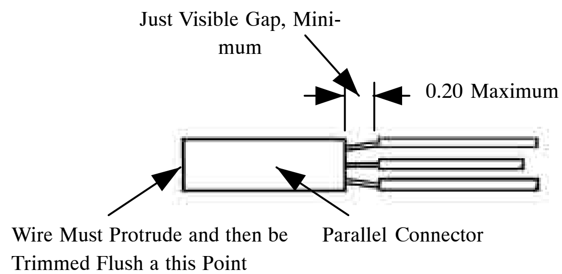


Figure 18. Connector Location and Wire Trimming

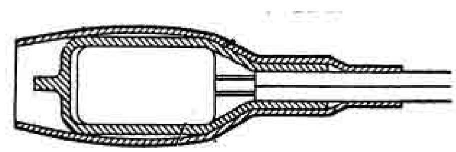


Figure 19. Shrinkable End Caps and Sleeve Installation

Table 6. Splices and Self−Sealing End Caps

AMP Parallel Connector	Self Sealing End−Cap	McDonnell Standard No.
34130	D −300−08	5M904−1
34137	D−300−12	5M904−2
34138	D−300−12	5M904−2
34318	D−300−18	5M904−3

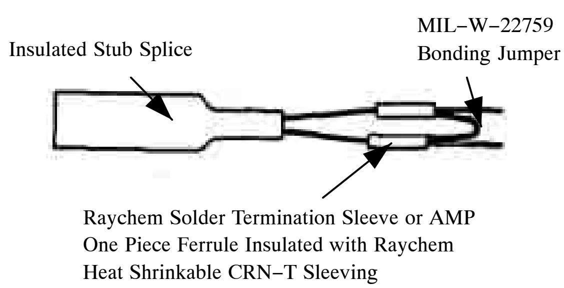


Figure 20. Shielded Stub Splice

(5) Position sleeve over end cap and heat shrink.

h. When shielded wires are stub spliced, shields are also terminated and joined (Figure 20).

i. Completed stub splice assembly must meet dimensional requirements (Figure 18).

j. Stagger splices in stub splice area as much as available space will permit; also, if wires are shielded, stagger shield ferrules.

k. Before covering the splice area, inspect for the following:

(1) Individual stub splices have been completely insulated

(2) Splices have been staggered to limit bundle enlargement

23 . Sealed Stub Splice (End Cap). Sealed stub splice is installed as follows:

a. Remove 5/16 to 11/32 inch of insulation from wire.

b. Select the correct size stub splice by comparing the total Circular Mil Area (CMA) of the wires to be spliced (Table 7) with the CMA range of the crimp barrel (Table 8). The total CMA of the wires to be crimped together must fall within the range listed for a particular crimp barrel.

c. When using sealed stub splices with multi−hole inserts, feed the wires through the multiple holes (2 per hole, max) and out the large single hole before crimping:

d. Insert the wires into the crimp barrel so that the insulation is approximately 1/32 inch from the crimp barrel.

e. Crimp the splice using the M22520/37−01 crimp tool. Calibrate the tool with an M22520/39−01 gauge. Stub−splice crimp barrels must be centered in the indenter jaws, not against the crimp locator (Figure 2).

f. If any wire strands extend from the end of the crimp barrel, trim them flush.

Table 7. Circular Mil Area (CMA) of Common Conductor Sizes

AWG No.	CMA
26	304
24	475
22	754
20	1216
18	1900
16	2426
14	3831
12	6088

Table 8. Sealed Stub Splices and Sealed In−Line Splices Selection Guide

1 Color Code Stripe On Crimp For Tin and Silver Plated Conductor	2 Color Code Stripes On Crimp For Nickel Plated Conductor	Color	CMA Range Of Crimp Barrel		Sealing Insert Type, End 1	Max. No. Of Wires	Sealing Insert End 2	Max No. of Wires
			Min	Max				
D−436−36	D−436−82	Red	304	1510	1	2	1	2
D−436−37	D−436−83	Blue	779	2680	1	2	1	2
D−436−38	D−436−84	Yellow	1900	6755	1	2	1	2
D−436−52	D−436−85	Blue	779	2680	3	6	1	2
D−436−53	D−436−87	Yellow	1900	6755	3	6	1	2
D−436−42	D−436−89	Blue	779	2680	3	6	3	6
D− 436−43	D−436−90	Yellow	1900	6755	3	6	3	6
D−436−58	D−436−75	Blue	779	2680	1	2	1	Stub Splice
D−436−59	D−436−76	Yellow	1900	6755	1	2	1	Stub Splice
D−436−60	D−436−77	Blue	779	2680	5	10 (2 Per Hole)	1	Stub Splice
D−436−61	D−436−78	Yellow	1900	6755	5	10 (2 Per Hole)	1	Stub Splice

g. Slide the sealing sleeve over the crimp barrel until it stops.

h. Heat the sealing sleeve with hot air until it shrinks and the sealing rings melt and start oozing out the ends (WP 012 00) . No further insulation is required.

24 . **Covering In−Line Connectors.** In−Line connectors shall be covered in accordance with paragraph 19 or 20.

25 . **In−Line Splices.** In−line splices are used when it is necessary to splice wires in the boot area of a connector.

26 . **In−Line Splice Installation (End Cap Modification Method).** Install in−line splices and cover with end caps as follows:

a. Determine proper AMP parallel connector per Tables 4 and 5.

b. Determine proper self−sealing end cap per Tables 4 and 5.

c. Remove wire insulation approximately 0.35 inch.

d. Modify self−sealing end cap as shown in Figure 21.

e. Install modified end cap over the wire as shown in Figure 22.

f. Insert stripped wires in AMP connector.

NOTE

For a more dependable splice, and also to eliminate the possibility of the connector cracking during the crimping operation, the connector must be at least 75% filled. Filling the connector may be accomplished by inserting a stripped scrap piece of wire in the connector. After crimping, cut the scrap wire flush with the connector.

g. Crimp the connector in the appropriate nest of the AMP No. 49935 crimping tool. (Figure 17).

h. The crimped splice shall have the ends of the wires visible and flush with the connector.

i. Position self−sealing end cap over crimped connector so that end cap will be approximately centered over the connector.

j. Heat shrink end cap.

k. End cap shall be completely shrunk and have no cracks or tears.

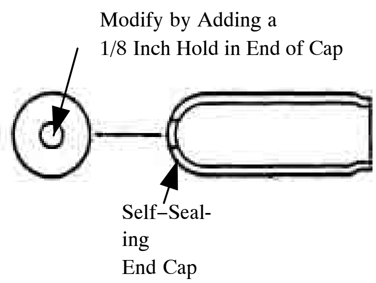


Figure 21. Modifying Self−Sealing End Cap

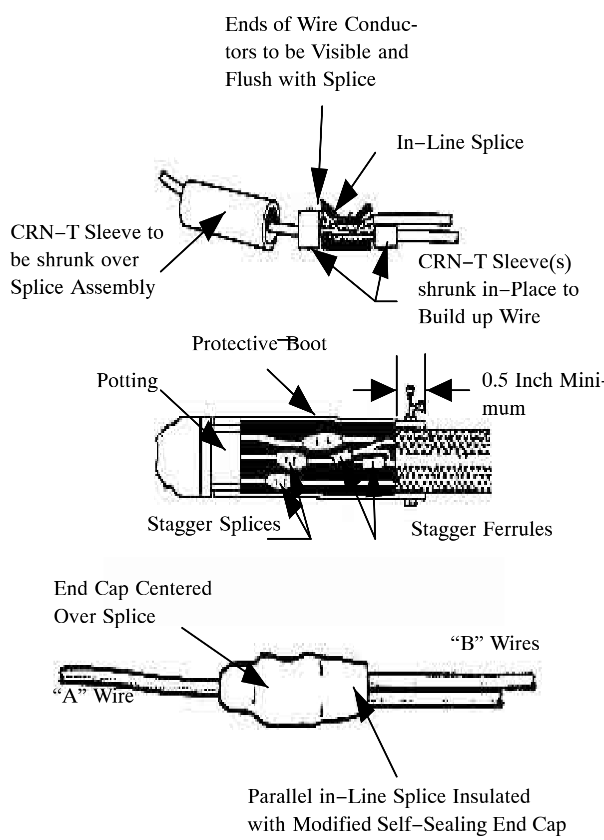


Figure 22. Construction of Modified End Cap Splice

Table 9. In–Line Splice, Tooling and Strip Dimension

Wire Gage	Splice Part No	Color Band	Strip Dimension (+1/16,–0)	Crimp Tool	Inspection Gage
20 thru 26	M81824/1–1	Red	1/4	M22520/37–01	M22320/39–01
16, 18	M81824/1–2	Blue	5/16	M22520/37–01	M22520/39–01
12, 14	M81824/1–3	Yellow	5/16	M22520/37–01	M22520/39–01

27. **SPLICING HARNESS WIRES.** Insulated permanent splices may be used to assemble, incorporate changes, or facilitate repair.

a. Gain access to damaged cable by pulling back outer harness as shown in Figure 23.

b. Choose the correct splice and tool from Table 9.

WARNING

Isopropyl Alcohol, TT–I–735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

c. Clean insulation at ends of wires to be spliced with Isopropyl Alcohol.

d. If multiple wires must be repaired, tag both ends of damaged wires.

e. If a jumper wire is not required, remove a 2 inch section of wire in the damaged area as shown in Figure 24.

f. If jumper wire must be used remove 6 inches of wire as shown in Figure 24.

g. Use a MIL–W–22759 wire with same size conductor as a jumper wire.

h. Cut the jumper wire approximately one–half inch longer than the wire section being replaced.

i. If multiple jumpers are being used, stagger the jumper splices as shown in Figure 25.

j. Splice the wire in accordance with paragraphs 9, 10 or 11 (this WP). Repair the harness in accordance with WP 011 00.

28. **STANDARD HEAT SHRINK**. Heat Shrink is available in many materials and colors. The most common and preferred for aircraft use are covered in Figure 26.

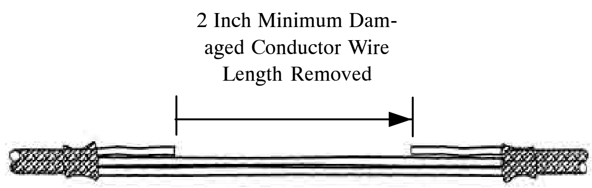


Figure 23. Damaged Wire Removal

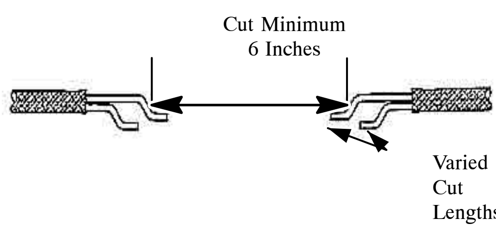


Figure 24. Jumper Wire Repair

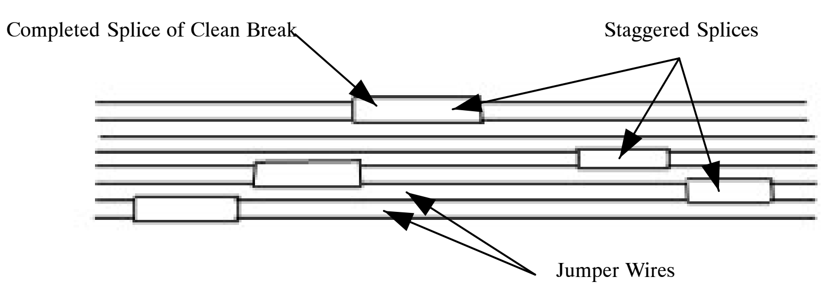


Figure 25. Staggered Splices

M23053/4 − 101 − 0

Specification Sheet

Class/Size

Color

Applicable Slash Sheets Intended Use

SAE−ASM−DTL−23053 Slash Sheet Number	Intended Use
/5	Used for light duty harness jackets, wire color coding, marking, or identification
/6	Used for wire identification, marking, or strain relief
/7	Used for light duty wire identification and component covering
/8	Used for wire or termination strain relief at elevated temperatures
/10	Used for high or low temperature applications or where ablation resistance in high blast fame is required
/11	Used where strain relief is necessary at high temperatures
/12	Used at high temperatures where resistance to flame is important to protect high temperature cable, components, and terminations
/13	Used in elevated temperature applications or where exposure to elevated temperature solvents is expected
/14	Used as component and electronic lead strain relief where low expansion ratios are satisfactory. Operates over fairly wide temperature range
/15	Used for repair of heavy duty cables, splice covers
/16	Used on heavy duty cables and harness systems, which see high levels of physical abuse, and requires resistance to fuels and oils coupled with high and low temperature extremes
/17	Used for see through wire identification where flame resistant properties are required
/18	Used as wire markers, insulation, and wire and component relief. Clear material may be considered for use as replacements for non flame retarded clear sleevings

Color Code

Designator	Color	Designator	Color
0	Black	7	Violet (Purple)
1	Brown	8	Gray (Slate)
2	Red	9	White
3	Orange	C	Clear
4	Yellow	P	Pink
5	Green	T	Tan
6	Blue		

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 1 of 9)

M23053/5− Intended use: Heat shrinkable flexible polyolefin sleeving is used for light duty harness jackets, wire color coding, marking or identification			Longitudinal change:
Class 1 − Flame resistant			
Class & Size	ID as Supplied	ID Recovered	± 5 Percent
101	.046	.023	
102	.063	.031	
103	.093	.046	
104	.125	.062	
105	.187	.093	
106	.250	.125	
107	.375	.187	
108	.500	.250	
109	.750	.375	
110	1.000	.500	
111	1.500	.750	
112	2.000	1.000	
113	3.000	1.500	
114	4.000	2.000	
Class 1 (Over Expanded) − Flame resistant			
115	1.000	.275	+5, −50 Percent
116	2.000	.550	
117	3.000	.810	
118	4.000	1.050	
119	1.000	.462	
120	2.375	.680	
121	3.000	.840	
122	3.750	.930	
123	4.500	1.450	
Class 3 − Highly flame Resistant			
301	.046	.023	+ 1, −10 Percent
302	.063	.031	
303	.093	.046	
304	.125	.062	
305	.187	.093	
306	.250	.125	
307	.375	.187	
308	.500	.250	
309	.750	.375	
310	1.000	.500	
311	1.500	.750	
M23053/6− Intended use: Heat shrinkable semi−rigid polyolefin sleeving is used in wire identification by marking or strain relief applications			Longitudinal change:
Class 1 − Flame resistant			
Class and Size	ID as Supplied	ID Recovered	
101	.046	.023	± 5 Percent
102	.063	.031	
103	.093	.046	
104	.125	.062	
105	.187	.093	
106	.250	.125	
107	.375	.187	
108	.500	.250	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 2 of 9)

M23053/7− Intended use: To provide a tight protective covering for relays, electronic coils and components and small capacitor cans			Longitudinal change:
Class 2 − Spirally wound, resin bonded			
201	.015	.011	35 Percent
202	.020	.015	
203	.025	.019	
204	.030	.023	
205	.042	.032	
206	.046	.035	
207	.062	.047	
208	.093	.070	
209	.125	.094	
210	.187	.140	
211	.250	.188	
212	.312	.234	
213	.375	.281	
214	.500	.375	
215	.625	.469	
216	.750	.563	
217	1.000	.750	
218	1.125	.844	
219	1.250	.938	
220	1.375	1.032	
221	1.500	1.125	
222	1.750	1.313	
223	2.000	1.500	
M23053/8− Intended use: Heat shrinkable semi−rigid polyvinylidene fluoride sleeving is intended for wire or termination strain relief			Longitudinal change:
No Class			
Class and Size	ID as Supplied	ID Recovered	± 10 percent
001	.046	.023	
002	.063	.031	
003	.093	.046	
004	.125	.062	
005	.187	.093	
006	.250	.125	
007	.375	.187	
008	.500	.250	
009	.750	.375	
010	1.000	.500	
011	1.500	.750	
M23053/10− Intended use: Heat shrinkable, flexible, silicone sleeving is intended for use in high or low temperature applications or in ablative applications			Longitudinal change:
No Class			
Class and Size	ID as Supplied	ID Recovered	+3, − 10 percent
001	.125	.071	
002	.250	.143	
003	.375	.214	
004	.500	.286	
005	.625	.357	
006	.750	.428	
007	.875	.500	
008	1.000	.570	
009	1.250	.714	
010	1.500	.857	
011	1.750	1.000	
012	2.000	1.140	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 3 of 9)

M23053/11– Intended use: Heat shrinkable fluorinated ethylene propylene sleevings are intended for use in high temperature applications			Longitudinal change:
Class 1 – Normal shrink ratio, Heavy Wall			
101	.031	.027	± 15 Percent
102	.036	.032	
103	.045	.039	
104	.060	.049	
105	.075	.061	
106	.092	.072	
107	.115	.089	
108	.141	.114	
109	.158	.124	
110	.180	.143	
111	.197	.158	
112	.225	.180	
113	.248	.198	
114	.290	.226	
115	.310	.249	
116	.365	.280	
117	.400	.311	
118	.440	.349	
119	.500	.383	
120	.580	.448	
121	.666	.510	
122	.830	.637	
123	1.000	.764	
124	1.170	.891	
125	1.300	1.000	
126	1.330	1.020	
127	1.700	1.300	
128	2.100	1.700	
129	2.600	2.100	
130	3.100	2.600	
131	3.500	3.100	
132	4.300	3.500	
133	1.500	1.145	
134	1.666	1.270	
135	1.833	1.390	
136	2.000	1.570	
Class 2 – High shrink ratio, Medium Wall			
201	.093	.056	+ 15 Percent
202	.125	.075	
203	.188	.115	
204	.250	.150	
205	.375	.225	
206	.500	.300	
207	.750	.450	
208	1.000	.600	
209	1.500	.900	
210	2.000	1.200	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 4 of 9)

M23053/12− Intended use: Heat shrinkable polytetrafluoroethylene sleeving is intended for use in areas where resistance to flame and high temperature are required			Longitudinal change:
Class 1 − Thick wall sleeving			
Class and Size	ID as Supplied	ID Recovered	± 20 Percent
101	.166	.130	
102	.250	.193	
103	.333	.257	
104	.415	.320	
105	.498	.383	
106	.580	.448	
107	.666	.510	
108	.748	.572	
109	.830	.637	
110	.915	.700	
111	1.000	.764	
112	1.170	.891	
113	1.330	1.020	
Class 2 Standard wall sleeving			
201	.050	.027	± 20 Percent
202	.055	.032	
203	.060	.039	
204	.065	.043	
205	.076	.049	
206	.085	.054	
207	.110	.067	
208	.120	.072	
209	.130	.080	
210	.140	.080	
211	.150	.089	
212	.170	.101	
213	.191	.112	
214	.205	.124	
215	.215	.130	
216	.240	.141	
217	.270	.158	
218	.302	.178	
219	.320	.198	
220	.370	.224	
221	.390	.249	
222	.410	.260	
223	.430	.278	
224	.450	.311	
225	.470	.329	
226	.470	.347	
227	.470	.334	
228	.560	.399	
229	.655	.462	
230	.750	.524	
231	.930	.655	
232	1.125	.786	
233	1.310	.911	
234	1.500	1.036	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 5 of 9)

M23053/12− (cont.)			Longitudinal change:
Class 3 − Thin wall sleeving			
301	.034	.015	± 20 Percent
302	.038	.018	
303	.046	.022	
304	.050	.027	
305	.055	.032	
306	.060	.039	
307	.o65	.043	
308	.076	.049	
309	.085	.054	
310	.093	.061	
311	.110	.067	
312	.120	.072	
313	.140	.080	
314	.150	.089	
315	.153	.096	
316	.170	.101	
317	.191	.112	
318	.205	.124	
319	.215	.130	
320	.240	.141	
321	.270	.158	
322	.302	.178	
323	.320	.198	
324	.370	.224	
325	.390	.249	
326	.410	.260	
327	.430	.278	
328	.450	.311	
329	.470	.329	
330	.470	.347	
Class 4 − Very thin wall sleeving			
401	.050	.025	± 20 Percent
402	.055	.031	
403	.060	.038	
404	.065	.043	
405	.076	.046	
406	.085	.054	
407	.093	.057	
408	.110	.063	
409	.120	.072	
410	.140	.080	
411	.150	.089	
412	.170	.099	
413	.191	.110	
414	.205	.122	
415	.215	.130	
416	.240	.139	
417	.270	.154	
418	.302	.172	
419	.320	.192	
420	.370	.214	
421	.390	.241	
422	.410	.260	
423	.430	.270	
424	.450	.301	
425	.470	.329	
426	.470	.347	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 6 of 9)

M23053/13− Intended use: Heat shrinkable, flexible, fluoroelastomer sleeving is used in high temperature applications or where exposure to high temperature solvents is expected			Longitudinal change:
No Class			
Class and Size	ID as Supplied	ID Recovered	± 20 percent
001	.187	.094	
002	.250	.125	
003	.375	.187	
004	.500	.250	
005	.625	.312	
006	.750	.375	
007	.875	.437	
008	1.000	.500	
009	1.250	.625	
010	1.500	.750	
011	2.000	1.000	
012	.125	.063	
M23053/14− Intended use: Heat shrinkable, semi−rigid, ethylene−tetrafluoroethylene fluoropolymer is intended for use in component cables and electronic lead strain relief where low expansion ratios are satisfactory			Longitudinal change:
No Class			
Class and Size	ID as Supplied	ID Recovered	± 10 percent
001	.093	.062	
002	.125	.083	
003	.187	.125	
004	.250	.166	
005	.375	.250	
006	.500	.345	
007	.750	.500	
008	1.000	.664	
009	1.250	.835	
010	1.500	1.000	
M23053/15− Intended use: Heat shrinkable, flexible, heavy wall, coated sleeving is used for repair of heavy duty cables, splice covers			Longitudinal change:
Class 1 − Heavy Wall			
Class and Size	ID as Supplied	ID Recovered	+1, − 10 percent
101	.750	.220	
102	1.100	.375	
103	1.500	.500	
104	2.000	.750	
105	3.000	1.250	
106	4.000	1.750	
107	.300	.100	
108	.400	.150	
109	1.300	.375	
110	1.700	.500	
111	2.700	.900	
112	4.500	1.750	
Class 2 − Medium Wall			
Class and Size	ID as Supplied	ID Recovered	+1, − 10 percent
201	.400	.150	
202	.750	.220	
203	1.100	.375	
204	1.300	.375	
205	1.500	.500	
206	1.700	.500	
207	2.700	.900	
208	2.000	.750	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 7 of 9)

M23053/16– (Intended use: Heat shrinkable flexible elastomeric sleeving is intended for use on heavy duty cables or harness systems, such as ground support which see high levels of physical abuse and exposure to fuels and oils, coupled with high and low temperature extremes.)			Longitudinal change:
No Class			
Class and Size	ID as Supplied	ID Recovered	± 10 percent
001	.250	.125	
002	.375	.187	
003	.500	.250	
004	.750	.375	
005	1.000	.500	
006	1.500	.750	
007	2.000	1.000	
008	3.000	1.500	
009	4.000	2.000	
M23053/17– (Intended use: Class 1 sleevings are intended for normal use where flame retarded translucent to clear materials are required. Class 2 is intended where thin wall product still provides for adequate electrical insulation and confined spaces require smaller wire diameters.)			Longitudinal change:
Class 1 – Standard wall (Clear Only)			
Class and Size	ID as Supplied	ID Recovered	+2, – 10 percent
101	.046	.023	
102	.063	.031	
103	.093	.046	
104	.125	.062	
105	.187	.093	
106	.250	.125	
107	.375	.187	
108	.500	.250	
109	.750	.375	
110	1.000	.500	
Class 2 – Thin wall (Clear Only)			
Class and Size	ID as Supplied	ID Recovered	+2, – 10 percent
201	.046	.023	
202	.063	.031	
203	.093	.046	
204	.125	.062	
205	.187	.093	
206	.250	.125	
207	.375	.187	
208	.500	.250	
209	.750	.375	
210	1.000	.500	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 8 of 9)

M23053/18− (Intended use: for use as wire markers, insulation and wire and component relief. Clear materials may be considered for use as replacements for non flame retarded clear sleevings.)			Longitudinal change:
Class 1 − Semi−rigid			
Class and Size	ID as Supplied	ID Recovered	+5, − 10 percent
101	.046	.023	
102	.063	.031	
103	.093	.046	
104	.125	.062	
105	.187	.093	
106	.250	.125	
107	.375	.187	
108	.500	.250	
109	.750	.375	
110	1.000	.500	
111	1.500	.750	
112	2.000	1.000	
Class 2 − Flexible			
Class and Size	ID as Supplied	ID Recovered	+5, − 10 percent
201	.046	.023	
202	.063	.031	
203	.093	.046	
204	.125	.062	
205	.187	.093	
206	.250	.125	
207	.375	.187	
208	.500	.250	
209	.750	.375	
210	1.000	.500	
211	.093	.031	
212	.187	.062	
213	.375	.125	
214	.750	.250	
215	1.000	.333	
Class 3 − Very flexible			
Class and Size	ID as Supplied	ID Recovered	+5, − 10 percent
301	.046	.023	
302	.063	.031	
303	.093	.046	
304	.125	.062	
305	.187	.093	
306	.250	.125	
307	.375	.187	
308	.500	.250	
309	.750	.375	
310	1.000	.500	

Figure 26. Heat Shrinkable Sleeving Part Number (Sheet 9 of 9)

29 . **WRAP/AROUND SIDE–ENTRY HEAT SHRINK REPAIR PROCEDURE.**

30 . **Wrap–around/Side–entry Heat Shrink Wire or Cable Repair.** The wrap–around heat shrink repair is suitable for repairing wire and cable insulation or adding secondary protection to in–service electrical systems without the need to remove or disassemble the associated electrical connector and end hardware. A heat gun is used to shrink the material in the same fashion as the standard, non–split, heat shrink tubing.

31 . The heat shrink material is standard MIL–I–23053 which has been extensively tested. The wrap–around heat shrink and its adhesive meet the on–aircraft application requirements with the following restrictions:

a. Install in locations where it will not be subjected to temperatures above 135°C/275°F.

b. Install in locations where it will not be subjected to extended exposure to jet fuels.

32 . **Wrap–Around Heat Shrink Installation.**

NOTE

The following steps provide installation instructions for the standard application, if additional environmental protection is required, use the environmentally sealed wrap–around heat shrink product.

CAUTION

The wrap–around heat shrink tubing requires a two–step heat application process. The adhesive overlap area must be heat–set completing the shrink process. Failure to follow this instruction will result in an improper installation.

Do not use a tubing heat reflector or other device intended to spread heat uniformly around the tubing.

a. Locate damaged portion of wire/cable.

NOTE

Use this material for repairing damaged wire.

b. If the metal conductor is damaged, refer to steps 10, 11, or 12 for conductor section replacement repair.

c. Inspect the damaged area and remove any loose/damaged portion of the insulation.

CAUTION

Isopropyl alcohol is highly flammable. Use only with adequate ventilation. Avoid prolonged breathing of vapors.

d. Clean 2 inches past the affected area with Isopropyl Alcohol (TT–I–735) or suitable solvent. Ensure wire is free of oils or grease.

e. Refer to Table 10 or 11 for application of standard, or environmental wrap–around heat shrink part numbers and ordering information.

f. Install the wrap around heat shrink with 1/2” extension past the damaged area. Secure the adhesive to the opposite side.

Table 10. Standard Application Wrap Around Heat Shrink Selection

Part Number	NSN	Cable Diameter (Inches)	Cage Code
ZT98−04−016−01	5970−01−508−5738	.125 − .187	07240 / 15851 / 9T958
ZT98−04−016−02	5970−01−508−5746	.188 − .249	07240 / 15851 / 9T958
ZT98−04−016−03	5970−01−508−5754	.25 − .37	07240 / 15851 / 9T958
ZT98−04−016−04	5970−01−500−6558	.38 − .49	07240 / 15851 / 9T958
ZT98−04−016−05	5970−01−500−6564	.50 − .62	07240 / 15851 / 9T958
ZT98−04−016−06	5970−01−500−6563	.63 − .74	07240 / 15851 / 9T958
ZT98−04−016−07	5970−01−508−5759	.75 − .87	07240 / 15851 / 9T958
ZT98−04−016−08	5970−01−508−5762	.88 − .99	07240 / 15851 / 9T958
ZT98−04−016−09	5970−01−508−8888	1.00 – 1.12	07240 / 15851 / 9T958
ZT98−04−016−10	5970−01−508−5980	1.13 – 1.24	07240 / 15851 / 9T958
ZT98−04−016−11	5970−01−508−5982	1.25 – 1.37	07240 / 15851 / 9T958
ZT98−04−016−12	5970−01−508−6893	1.38 – 1.49	07240 / 15851 / 9T958
ZT98−04−016−13	5970−01−508−5895	1.50 – 1.62	07240 / 15851 / 9T958
ZT98−04−016−14	5970−01−508−5896	1.63 – 1.75	07240 / 15851 / 9T958

Table 11. Wrap−Around Environmentally Sealed Heat Shrink Selection (For ordering 4 foot roll, or lengths by the foot)

Part Number	NSN	Cable Diameter(Inches)	Cage Code
ZT03–04–010–01	Pending	0.040 – 0.075	07240 / 15851/ 9T958
ZT03–04–010–03	Pending	0.076 – 0.125	07240 / 15851/ 9T958
ZT03–04–010–05	Pending	0.126 – 0.174	07240 / 15851/ 9T958
ZT03–04–010–07	Pending	0.175 – 0.250	07240 / 15851/ 9T958
ZT03–04–010–09	Pending	.25 – .37	07240 / 15851/ 9T958
ZT03–04–010–11	Pending	.38 – .49	07240 / 15851/ 9T958
ZT03–04–010–13	Pending	0.50 – 0.62	07240 / 15851/ 9T958
ZT03–04–010–15	Pending	0.63 – 0.74	07240 / 15851/ 9T958
ZT03–04–010–17	Pending	0.75 – 0.87	07240 / 15851/ 9T958
ZT03–04–010–19	Pending	0.88 – 0.99	07240 / 15851/ 9T958
ZT03–04–010–21	Pending	1.00 – 1.12	07240 / 15851/ 9T958
ZT03–04–010–23	Pending	1.13 – 1.24	07240 / 15851/ 9T958
ZT03–04–010–25	Pending	1.25 – 1.37	07240 / 15851/ 9T958
ZT03–04–010–27	Pending	1.38 – 1.49	07240 / 15851/ 9T958
ZT03–04–010–29	Pending	1.50 – 1.62	07240 / 15851/ 9T958
ZT03–04–010–31	Pending	1.63 – 1.75	07240 / 15851/ 9T958

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

g. Direct the heat source at the adhesive overlap area several inches back from the tubing end.

h. Apply the heat to the adhesive overlap area only. The overlap will tend to curl up into a “U” shape as it is heated. Continue applying heat to this area until the surrounding tubing begins to pull the “U” shape back down flat.

i. Once the overlap area has been fully shrunk, begin shrinking the remainder of the tubing circumference.

NOTE

The outer layer of the overlap tends to lift off of the adhesive and curl back slightly during the initial exposure. With continued heating this lifted area will generally lay back down on its own. If it does not, lightly tap the lifted edge back in place.

j. Shrink the entire overlap length before attempting to shrink the remaining tubing

NOTE

With small diameter tubing sizes most of the remaining tubing has already shrunk.

k. Once the overlap area has been fully shrunk, begin shrinking the remainder of the tubing circumference.

NOTE

While tubing is hot, you may work or form the material and cable as necessary.

l. Inspect the entire circumference of the wrap around heat shrink material and apply localized heat to any areas that show evidence of insufficient heating (fisheyes). (See Figures 27 and 28)

Figure 27. Completed Wrap–Around Heat Shrink Repair on Single Conductor

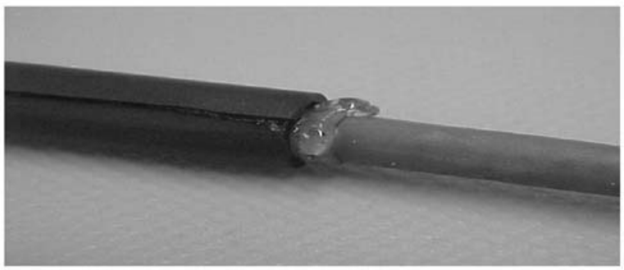


Figure 28. Detail View of Installation on Typical Cable

NOTE

The finished assembly may have a shiny, sticky area, parallel to the overlap seam. This is residual adhesive that was exposed as the overlap material pulled back as it shrunk.

The excess adhesive can be removed, while the tubing is warm to the touch, by rubbing your thumb along the overlap seam line.

Rubbing the seam area will insure good overlap contact and excess adhesive will ball up. Remove excess adhesive as necessary.

Do not attempt to clean the overlap area of excess adhesive with solvents. The adhesive system used is extremely solvent resistant.

m. Once properly positioned, allow the finished assembly to cool to the point of being warm to the touch.

33 . **SINGLE CONDUCTOR/SHIELDED JACKET RADIO FREQUENCY (RF) CABLE REPAIR.** The repair of a RF cable should be viewed as a temporary emergency repair. System degradation is possible whenever RF cable repairs are attempted. Whenever possible the cable should be replaced in its entirety.

NOTE

Point to Point replacement of all RF wires and cables is preferred; however, damaged RF wires and cables may be repaired or replaced at Organizational level maintenance. Damaged RF cables are to be replaced in their entirety at Intermediate and Depot level maintenance (due to increased access).

34 . **RADIO FREQUENCY CABLE STRIPPING.** The RF cable stripping procedure is shown in Figure 29.

35 . **RADIO FREQUENCY CABLE SOLDER METHOD REPAIR.** The RF cable may be repaired by soldering the conductor and shield followed by heat shrink sleeving as shown in Figure 30.

36 . **SINGLE CONDUCTOR / RADIO FREQUENCY CABLE SLEEVE METHOD REPAIR.** The cable may be repaired using solder sleeve kits as shown in Figure 31.

37 . **TRIAXIAL RADIO FREQUENCY CABLE REPAIR.**

38 . **TRIAXIAL CABLE SOLDER METHOD REPAIR.** A triaxial RF cable must be repaired with the solder method only. Repair the cable as shown in Figure 32.

39 . **DATA BUS TWIN AXIAL CABLE REPAIR.** Strip the cable as described in Paragraph 12, this Work Package

40 . **CABLE SPLICING.**

41 . **SINGLE SHIELD, TWIN AXIAL CABLE WITH SOLDER SLEEVE PRIMARY SPLICE.** For single shield cable with solder sleeve primary splice repair procedures see Figure 33.

42 . **DOUBLE SHIELD TWIN AXIAL CABLE WITH SOLDER SLEEVE PRIMARY SPLICE.** For double shield cable with solder sleeve primary splice repair procedures see Figure 34.

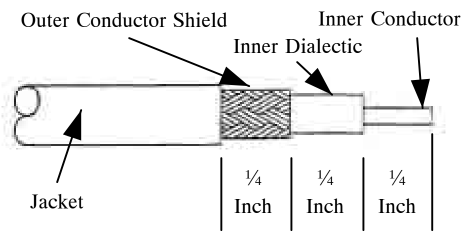
43 . **SINGLE SHIELD TWIN AXIAL CABLE WITH MINI–SEAL CRIMP PRIMARY SPLICE.** For single shield cable with mini–seal crimp primary splice repair procedures, see Figure 35.

44 . **DOUBLE SHIELD TWIN AXIAL CABLE WITH MINI–SEAL CRIMP PRIMARY SPLICE.** For double shielded cable with mini–seal crimp splice repair procedures, see Figure 36.

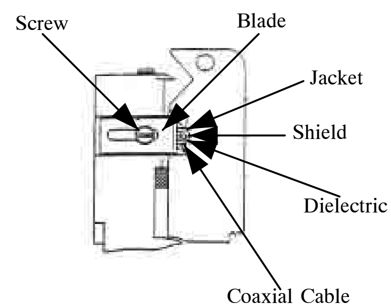
1. Determine the damage location by visual inspection.
2. Cut cable, as required, to eliminate damaged section. Use caution to be sure that length tolerances are maintained.
3. Select correct cable strippers.

Stripper Part No.	Cable SizeOutside Diameter (Inch)
45−162	Up to 1/8
45−163	1/8 to 7/32
45−164	1/4 to 9/16
45−165	3/16 to 5/16

4. Strip cable to be repaired. Check for broken conductor and strip lengths. Any damaged portion shall be cut out and cable restriped.



5. Measure distance between blades. Adding or subtracting two spare blades will change distance between blades by 3/64 inch.
6. Remove screws and add or subtract spare blades as required to obtain correct spacing
7. Install screws and loosely tighten.
8 Adjust cutting depth of blades so that jacket will be scored without damage to the shield. Tighten screws.



9. Position tool around cable so that excess length of cable will be left when stripping operations are complete.

10. Spin tool around cable until maximum depth is obtained.

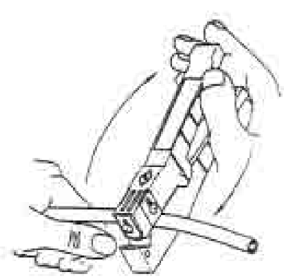
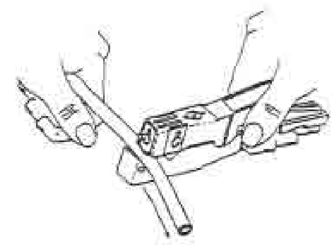


Figure 29. RF Cable Stripping (Sheet 1 of 2)

11. With rounded blade installed in front of tool, place cable in notch and pull through

12. Peel off jacket



13. Adjust blades to dimensions of dielectric required. Do not tighten blades.
14. Adjust cutting depth so that shield will be scored without damage to dielectric. Tighten screws.
15. Position tool on cable at proper strip dimension.
16. Spin tool around cable until maximum cutting depth is obtained.
17. Pull off shield.
18. Strip dielectric by reversing tool and repeating step. 10.
19. Pull dielectric from center conductor.

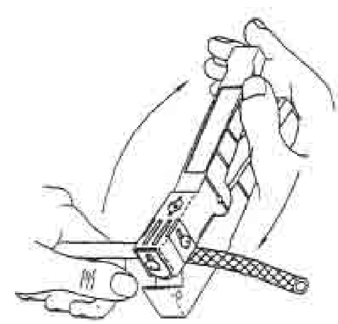
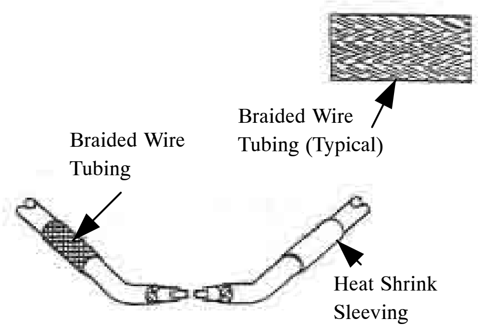


Figure 29. RF Cable Stripping (Sheet 2)

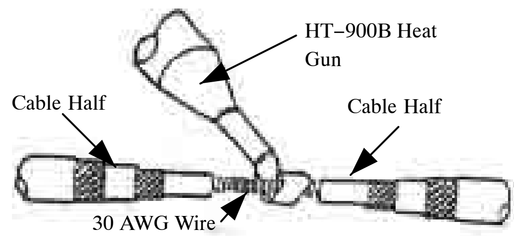
1. Slip a 4 1/2 inch long piece of heat shrinkable sleeving on one cable half and temporarily tape it to prevent loss.

2. Slip a piece of braided wire tubing over other cable half and temporarily secure as above

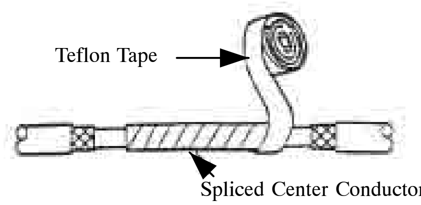


3. Tin two center conductors. Overlap conductors and wrap with a continuous turn of bare 30 AWG wire.

4. Apply a thin coat of solder using the HT−900B Heat gun to secure wire. Avoid excessive solder build up on wire.



5. Wrap spliced center conductors with Teflon tape build up to dielectric diameter. Overlap dielectric with one tape layer on each end to prevent any gap.



6. Slide precut wire braid tubing over taped center conductor splice and conductor shield. Use 30 AWG wire to secure splice at each end. Apply solder lightly to assure a good electrical bond.

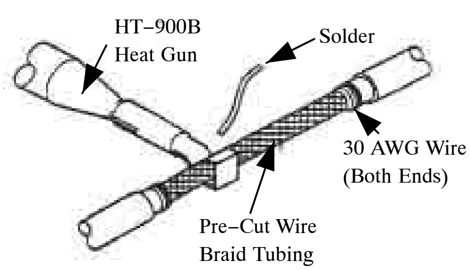
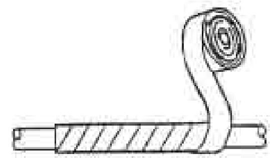


Figure 30. RF Cable Solder Method Repair (Sheet 1 of 2)

7. Wrap spliced conductor shield with Teflon tape. Build up to jacket diameter. Overlap jacket on each end, but not more than one or two layers above jacket OD.



8. Slide heat shrinkable sleeving over repair and center. Heat until sleeve shrinks tightly.
9. Retie wire bundle

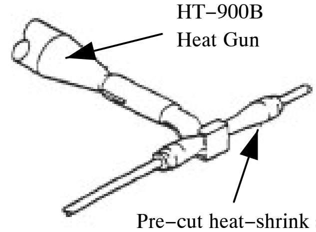
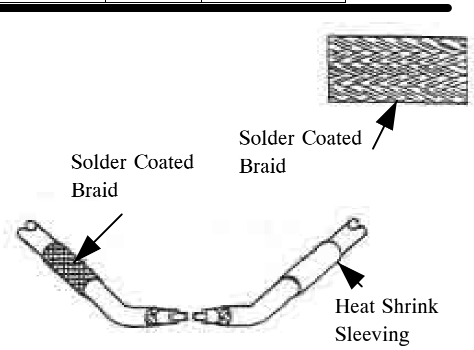


Figure 30. RF Cable Solder Method Repair (Sheet 2 of 2)

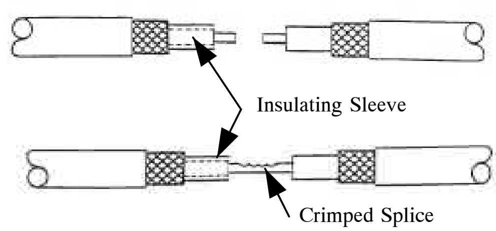
1. Determine the damage location by visual inspection
2. Strip cable in accordance with Figure 29.
3. Select Coaxial cable splice kit

PART NUMBER M81824/5	CABLE PARAMETERS		KIT COMPONENTS		
	NUMBER OF CONDUCTORS	CONDUCTOR SIZE RANGE	CONDUCTOR SPLICE PART NO. M81824/1	(QTY)	SHIELD SPLICE PART NO. M81824/
-1	1	24-22-20	-1	(1)	-1
-2	1	20-18-16	-2	(1)	-2
-3	1	16-14-12	-3	(1)	-3
-4	2	26-24-22-20	-1	(2)	-4
-5	2	18-16	-2	(2)	-5
-6	2	14	-3	(2)	-6
-7	2	12	-3	(2)	-7
-8	3 OR 4	26-24	-1	(4)	-4
-9	3 OR 4	22-20	-1	(4)	-5
-10	3 OR 4	18-16	-2	(4)	-6
-11	3 OR 4	14-12	-3	(4)	-7

4. Slip a 4 1/2 inch long piece of heat shrinkable sleeving on one cable half and temporarily tape it to prevent loss.
5. Slip a 1 1/4 inch piece of solder coated braid over the other cable half and temporarily secure as above.



6. Slide insulating sleeve over one end of cable
7. Using splice selected from solder shield kit, slide one end of center conductor into Splice. Select the correct crimp tool (see paragraph 8 this WP), crimp splice to center conductor. Repeat for other half of cable



8. Slide insulation sleeve over crimped splice and shrink

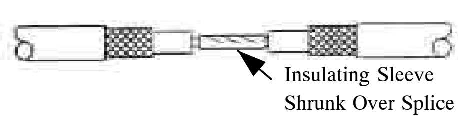
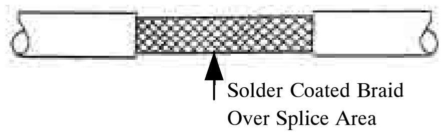


Figure 31. Single Conductor / RF Cable Sleeve Method Repair (Sheet 1 of 2)

9. Slide solder coated braid over insulating sleeve. Ensure each end overlaps cable shield. Apply heat until solder melts.



10. Slide heat shrinkable sleeve over repaired area and shrink.

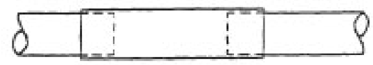
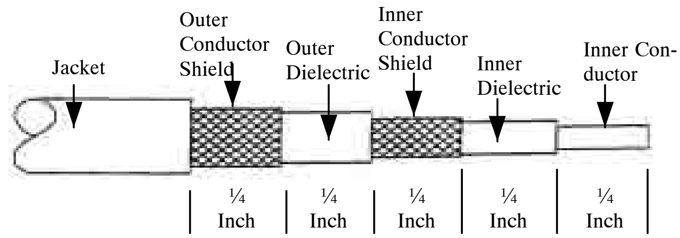


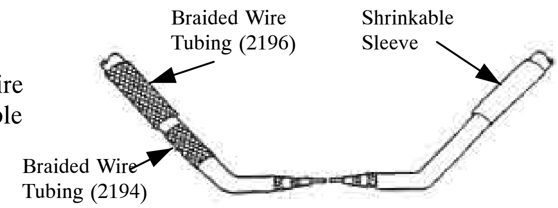
Figure 31. Single Conductor / RF Cable Sleeve Method Repair (Sheet 2 of 2)

1. Cut cable to eliminate damaged area.

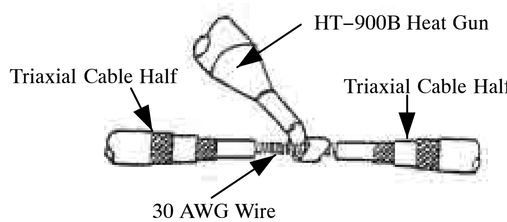
2. Strip both cables to be spliced to dimensions shown



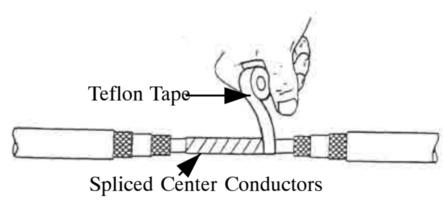
3. Slip a 4½ inch long piece of shrinkable sleeve on one half of the cable
4. Slip a 2½ inch long piece of wire braid (P/N: 2196) and a 1¼ inch long piece of wire braid (P/N: 2194) over the other half of cable



5. Tin center conductors of both cable halves. Overlap conductors and wrap with single continuous turn of bare 30 AWG braided wire
6. Apply a thin coat of solder using the HT–900B to secure the wire. Avoid excessive solder build up on wire.



7. Wrap spliced center conductors with Teflon tape and overlap inner dielectric at both ends



8. Slide wire braid tubing (2196) over taped center conductor splice and inner conductor shields. Wrap both ends of wire braid with 30 AWG wire braid and apply a light coat of solder using the HT–900B Heat Gun

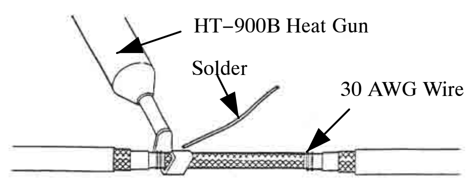
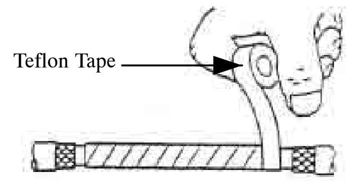
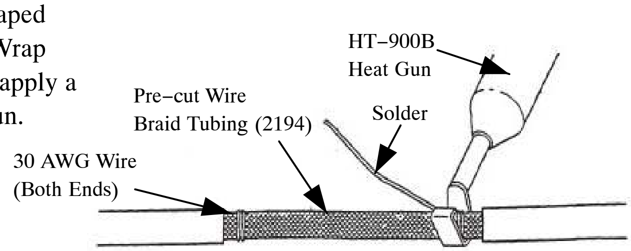


Figure 32. Triaxial Cable Solder Repair (Sheet 1 of 2)

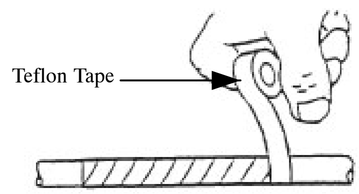
9. Wrap spliced inner shields with Teflon tape. Overlap both ends of outer dielectric.



10. Slide precut wire braid tubing (2194) over taped inner conductor shield splice and outer shield. Wrap both ends of wire braid with 30 AWG wire and apply a light coat of solder using the HT−900B Heat Gun.



11. Wrap spliced outer conductor shield with Teflon tape. Overlap jacket on each end.



12. Slide shrinkable sleeve over repaired area. Shrink sleeve using HT−900B Heat Gun.

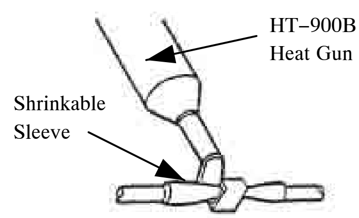
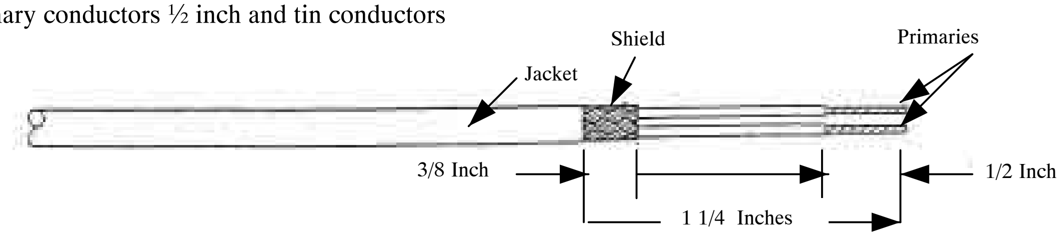


Figure 32. Triaxial Cable Solder Repair (Sheet 2 of 2)

Cable Preparation

1. Strip 1 ¼ inches of cable jacket and trim shield to 3/8 inch from cable jacket

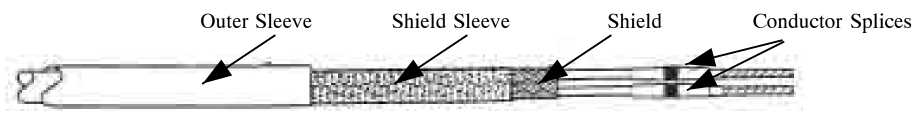
2. Strip primary conductors ½ inch and tin conductors



Cable Repair

1. Slide outer sleeve and shield splice, small end first, onto one half of the cable

2. Insert each primary conductor into primary splices



3. Overlap primary conductors under solder performs. Place in holding fixture to hold wires in alignment.
4. Using the HT−900B Heat Gun, heat solder performs until melted and form a fillet along the wires

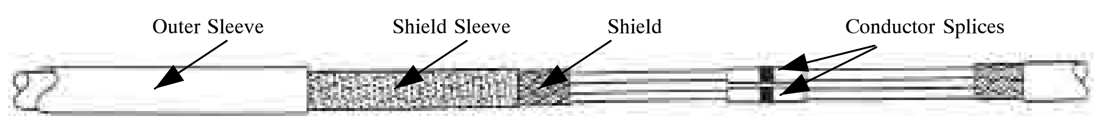
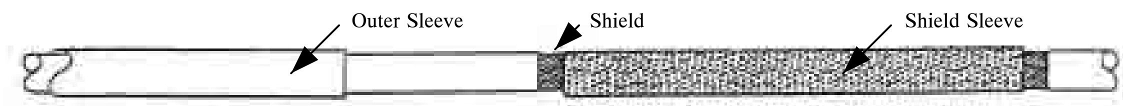


Figure 33. Single Shield Twin Axial Cable Repair with Solder Sleeve Primary Splice (Sheet 1 of 2)

5. Center shield splice over splice area and exposed cable shields
6. Using the HT−900B Heat Gun, heat center of sleeve until solder melts and shield and tube recover. Apply additional heat for 5 to 10 seconds to final 1/2 inch of sleeve shield to assure sufficient heat transfer to cable to make good solder connection. Repeat for other end of sleeve



7. Center strain relief sleeve over completed splice and shrink.

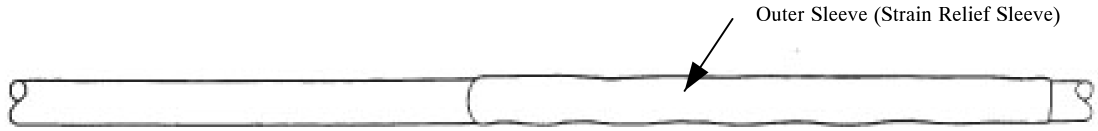
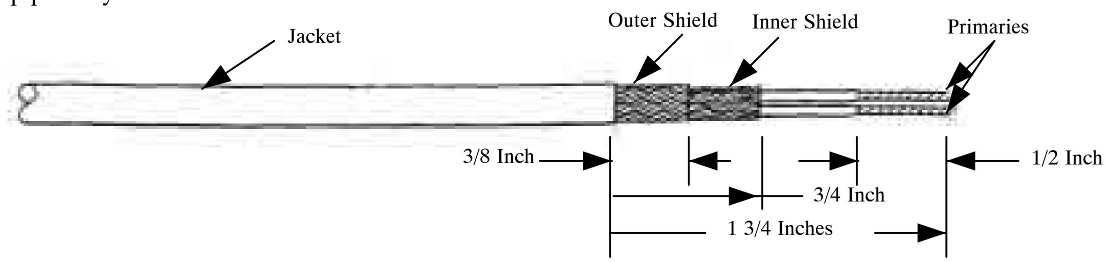


Figure 33. Single Shield Twin Axial Cable Repair with Solder Sleeve Primary Splice (Sheet 2 of 2)

Cable Preparation

1. Strip 1 3/4 inches of cable jacket and trim shield to 3/4 inch from cable jacket. Trim outer shield to 3/8 inch from cable jacket

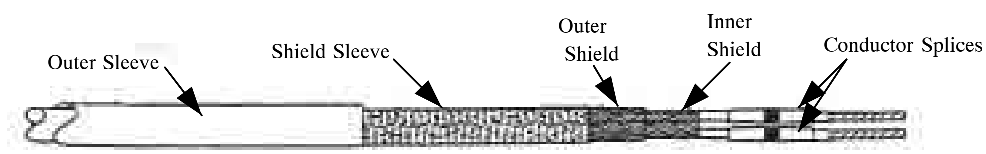
2. Strip primary conductors ½ inch and tin conductors



Cable Repair

1. Slide outer sleeve and shield splice, small end first, onto one half of the cable

2. Insert each primary conductor into primary splices



3. Overlap primary conductors under solder performs. Place in holding fixture to hold wires in alignment.
4. Using the HT–900B Heat Gun, heat solder performs until melted and form a fillet along the wires

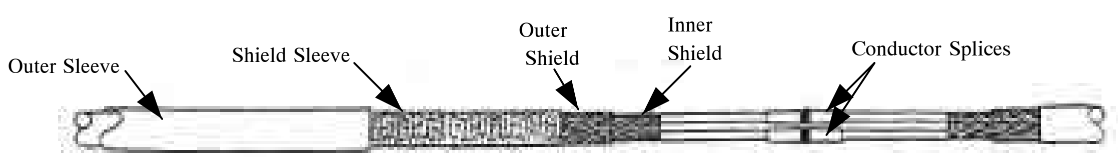
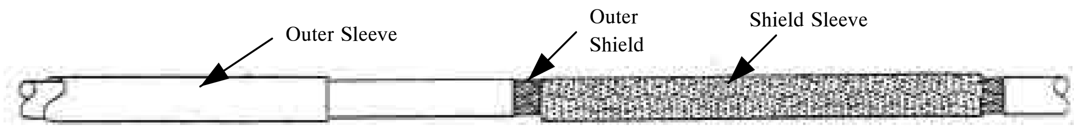


Figure 34. Double Shield Twin Axial Cable Repair with Solder Sleeve Primary Splice (Sheet 1 of 2)

5. Center shield splice over splice area and exposed cable shields
6. Using the HT−900B Heat Gun, heat center of sleeve until solder melts and shield and tube recover. Apply additional heat for 5 to 10 seconds to final 1/2 inch of sleeve shield to assure sufficient heat transfer to cable to make good solder connection. Repeat for other end of sleeve



7. Center strain relief sleeve over completed splice and shrink.

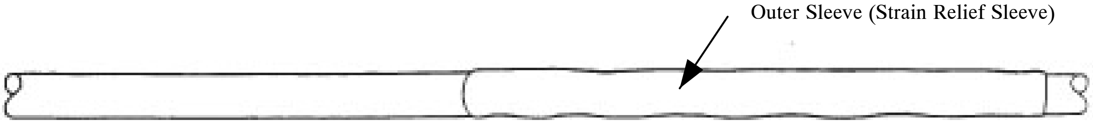
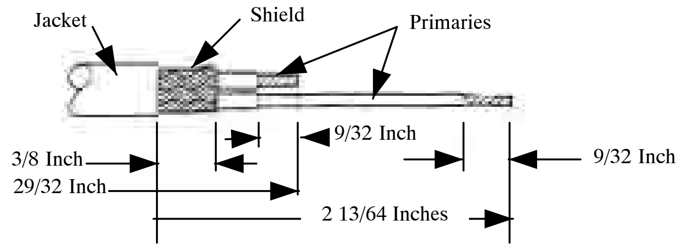


Figure 34. Double Shield Twin Axial Cable Repair with Solder Sleeve Primary Splice (Sheet 2 of 2)

Cable Preparation

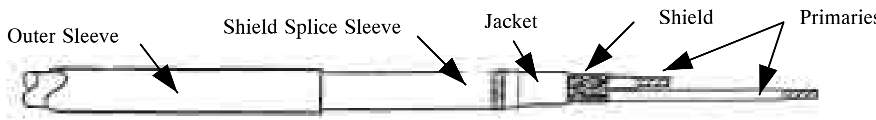
1. Strip 2 13/64 inches of cable jacket and trim shield to 3/8 inch from cable jacket

2. Cut one primary conductor to 23/32 inch from cable jacket, then strip both primaries 9/32 inch.

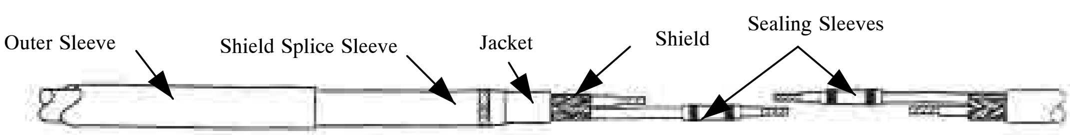


Cable Repair

1. Slide outer sleeve and shield splice, small end first, onto one half of the cable.



2. Slide sealing sleeve onto longer primary lead of each cable half.



3. Insert matching primaries into opposite ends of crimp splice and crimp using proper crimping tool.
4. Center Sealing Sleeves over splices and shrink using HT−900B Heat Gun.

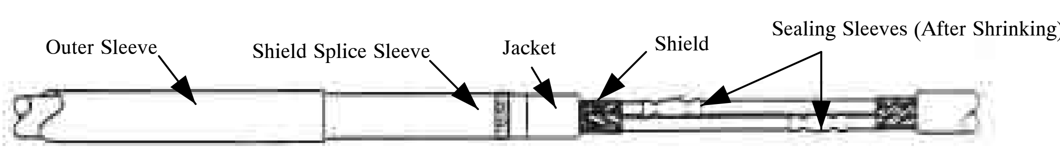
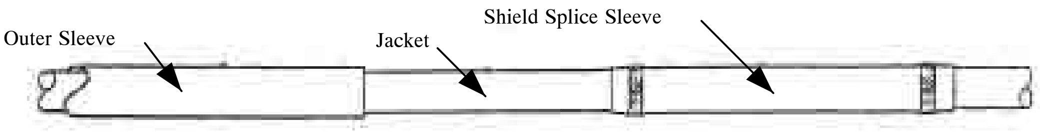


Figure 35. Single Shield Twin Axial Cable Repair with Mini−Seal Crimp Primary Splice (Sheet 1 of 2)

5. Center shield splice sleeve over splice area and exposed shield. Then heat center of sleeve until solder smelts and shield and tube recover.



6. Center outer sleeve over splice area and shrink using HT−900B Heat Gun

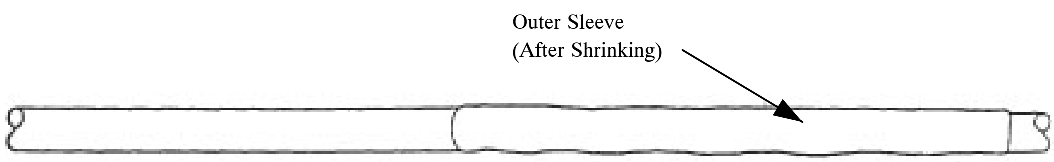
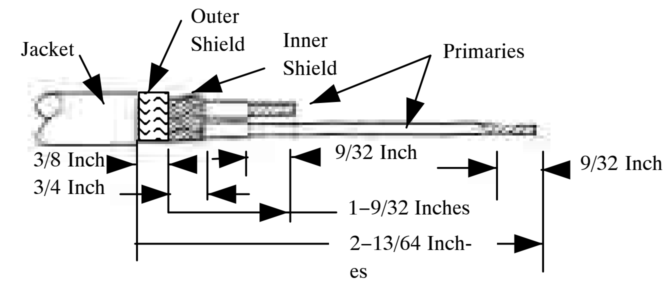


Figure 35. Single Shield Cable Repair with Mini−Seal Crimp Primary Splice (Sheet 2 of 2)

Cable Preparation

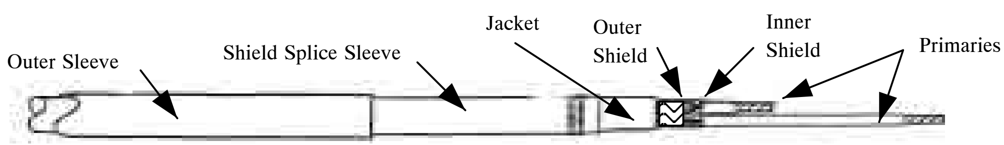
1. Strip 2 13/64 inches of cable jacket and trim shield to 3/4 inch from cable jacket. Trim outer shield to 3/8 inch from cable jacket.

2. Cut one primary conductor to 1 9/32 inches from cable jacket, then strip both primaries 9/32 inch.

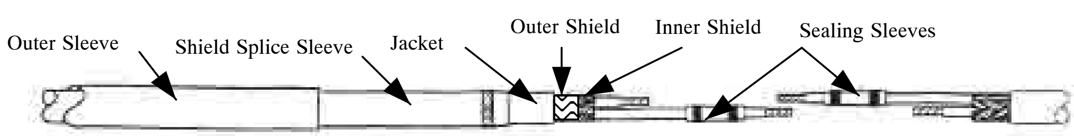


Cable Repair

1. Slide outer sleeve and shield splice, small end first, onto one half of the cable.



2. Slide sealing sleeve onto longer primary lead of each cable half.



3. Insert matching primaries into opposite ends of crimp splice and crimp using proper crimping tool.
4. Center Sealing Sleeves over splices and shrink using HT–900B Heat Gun.

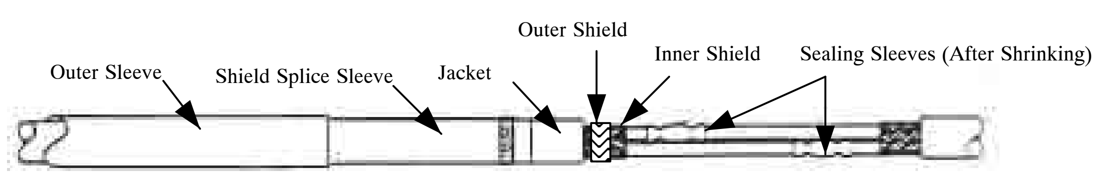


Figure 36. Single Shield Twin Axial Cable Repair with Mini–Seal Crimp Primary Splice (Sheet 1 of 2)

5. Center shield splice sleeve over splice area and exposed shield. Then heat center of sleeve until solder smelts and shield and tube recover.

6. Center outer sleeve over splice area and shrink using HT−900B Heat Gun

Figure 36. Single Shield Twin Axial Cable Repair with Mini−Seal Crimp Primary Splice (Sheet 2)

45 . **SOLDER SLEEVE SPLICES INSPECTION.** Solder sleeve splices must be inspected for the following:

a. Conductors must be overlapped a minimum 3/8 inch.

b. Fillet length must be a minimum 1/4 inch.

c. Sealing rings must have flowed along the wire.

d. Sleeve must not have discolored to the degree that joint cannot be inspected.

e. Sleeve must not be cut or split.

f. Strands of conductor must not be sticking through the sleeve.

46 . **IN−LINE SPLICE INSPECTION.** Splices must be inspected for the following:

a. Conductors must be visible at point where they enter crimp barrel.

b. Both indentations of crimp must be on crimp barrel.

c. Sealing sleeve inserts must have flowed along wire insulation.

d. Sleeve must not have discolored to the degree that crimp barrel cannot be inspected.

e. Sleeve must not be cut or split.

47 . **SHIELD SPLICE INSPECTION.** Shield splices must be inspected for the following:

a. Sleeve/shield must be recovered along its entire length.

b. Sleeve must be recovered tightly around cable jacket.

c. Sealing rings must have flowed along cable jacket.

d. Sleeve must not have discolored to the degree that the joint cannot be inspected.

e. Sleeve must not be cut or split.

f. Strands must not be sticking through sleeve.

48 . **OUTER SLEEVE INSPECTION.** Outer sleeves must be inspected for the following:

a. Sleeves must be recovered tightly onto assembly along its full length.

b. An adhesive bead should be visible at ends of sleeve.

c. Sleeve must not be cut or split.

49 . **THERMOCOUPLE CABLE REPAIR.**

50 . Thermocouples are used throughout the aircraft to detect and measure temperature changes. Thermocouples are prefabricated into spark plug gaskets, bayonets for insertion into oil sumps, and probes for use in exhaust stacks. Thermocouples are supplied with short leads, usually 12 inches long, and end in terminals such as AN5548 or AN5539. The components of a thermocouple system are designed to have a high degree of accuracy.

NOTE

New terminology applies to conductor types. Nickel−Aluminum/Silicon (formerly Alumel), Nickel−chromium (formerly Chromel), Iron, or Copper−Nickel alloy (formerly Constantan).

51 . **THERMOCOUPLE WIRE LEADS.** Thermocouple extension wires (Figure 37) are paired in a braided jacket and color−marked as listed in Table 12. The material for extension leads is the same as the thermocouple material. Iron−Constantan extensions are used for Iron−Constantan thermocouples, Chromel−Alumel extensions for Chromel−Alumel thermocouples, and Copper−Constantan extensions for Copper−Constantan thermocouples.

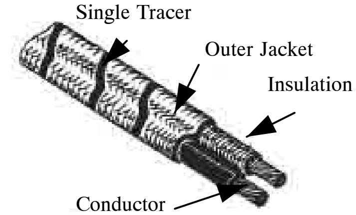


Figure 37. Thermocouple Wire

Table 12. Thermocouple System

Iron Constantan Systems

Conductor	Insulation Color	Polarity
Iron	Black	Positive (+)
Constantan	Yellow	Negative (−)

	Type II − 8 ohms per 100 ft. Class A	Type II − 8 ohms per 100 ft. Class B	Type III − 8 ohms per 200 ft. Class A	Type III − 8 ohms per 200 ft. Class B
Outer jacket base color Tracer color Temperature limit of insulation	Light blue	Light blue	Light blue	Light blue
	None	One red	Two Black	Two red
	120°C (248°F)	230°C (446°F)	120°C (248°F)	230°C (446°F)

Chromel Alumel System

Conductor	Insulation Color	Polarity
Chromel	White	Positive (+)
Alumel	Green	Negative (−)

	Type II, Class A 7 ohms per 25 ft	Type III, Class A 7 ohms per 50 ft	Type IV, Class A 7 ohms per 100 ft
Outer jacket base color Tracer color Temperature limit of insulation	White	White	White
	One green	Two green	Three green
	315°C (600°F)	315°C (600°F)	315°C (600°F)

Copper Constantan System

Conductor	Insulation Color	Polarity
Copper	Red	Positive (+)
Constantan	Yellow	Negative (−)

	Type II 7 ohms per 200 feet	
	Class A	Class B
Outer jacket base color Tracer color Temperature limit of insulation	Black	Black
	One White	Two White
	120°C (248°F)	230°C (446°F)

52. **THERMOCOUPLE TERMINALS AND CONNECTOR.** Selection of terminals for thermocouple wiring is based on location within the airframe, and on temperature conditions (Figure 38). Hot areas are those subject to high temperature, such as engine section, exhaust pipe, etc. Cool areas are those on the side of the firewall away from the engine or other heat producing elements. Where the temperature does not exceed 250°F, use terminals listed in Table 7. Dash letters after basic numbers indicate whether terminal is plain or lock type, except for AN 5538, where dash number indicates change in size only.

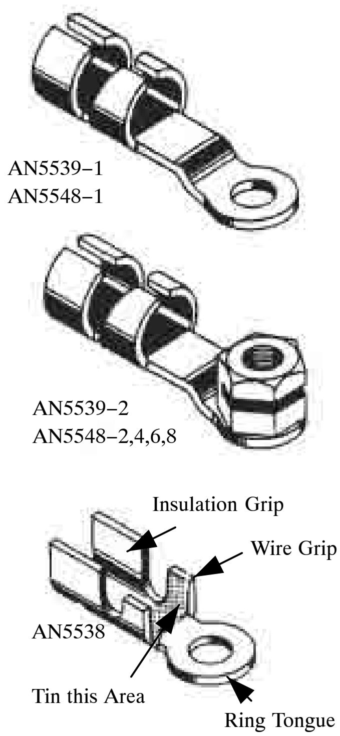


Figure 38 Thermocouple Terminals

53. Thermocouple connector AN 5537 (Figure 39) is used to carry thermocouple connections through firewalls. This is a plug and jack connection, supplied with an insulating plate for attachment to the firewall. Plugs and jacks are supplied in chromel−alumel or iron−constantan combinations. The jack part of the connector is installed on the cool side of the firewall. The pin plug part of the connector is installed on the hot side of the firewall.

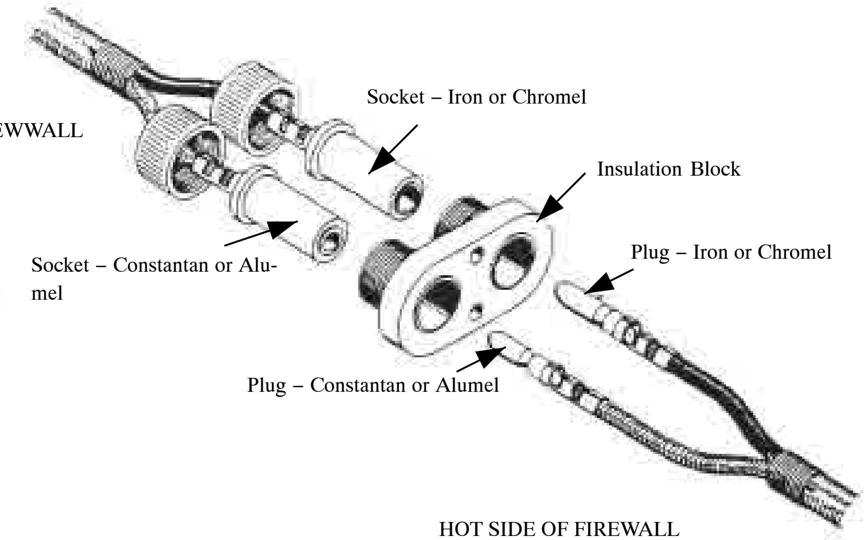


Figure 39. Thermocouple Connector Assembly (AN5537)

54 . **THERMOCOUPLE CONTACTS IN MS CONNECTORS.** MS type connectors may be supplied with iron constantan or chromel–alumel contacts in sizes #12, #16, or #20 in some insert arrangements for thermocouple connections. These contacts are coded to identify the material (Table 13).

Table 13. Coding for Thermocouple Contacts in MS Connectors

Material	Code	Size
Iron	FE	Large
Constantan	CON	Small
Chromel	CR	Large
Alumel	AL	Small

55 . **DEFINITIONS.** The following definitions are needed to repair thermocouples:

a. Soft solder. A mixture of 60% tin and 40% lead, as specified in QQ–B–654. It may be in bar form to be melted for tinning, or in the form of rosin core solder wire for use with soldering iron.

b. Hard solder. Silver alloy with flow point at approximately 635°C (1175°F), as specified in QQ–B–654.

c. Hard solder flux. For use with hard solder, flux is borax or other similar material O–F–499, mixed to a paste–like consistency with water.

d. Soldering and brazing. For purposes of this section, the term "soldering" includes soft soldering, silver (hard) soldering, and brazing.

56 . **CUTTING AND IDENTIFYING THERMOCOUPLE WIRE.** Cut thermocouple wire with diagonal pliers to length specified in drawing. Cut so that end is clean and square. Identify wire as described in WP 008 00.

CAUTION

Do not cut or nick strands of the conductor.

57 . **STRIPPING THERMOCOUPLE WIRE.** Remove outer covering of thermocouple wire with a knife by slitting between parallel conductors and trimming the fabric braid with scissors of diagonal pliers. The stripping dimensions for each use are shown in Figures 40 through 42. Note that longer stripped lengths are required if the wires are to be resistance tinned. Use a hand stripper, as illustrated in WP 009 00, for removing the primary insulation from each conductor.

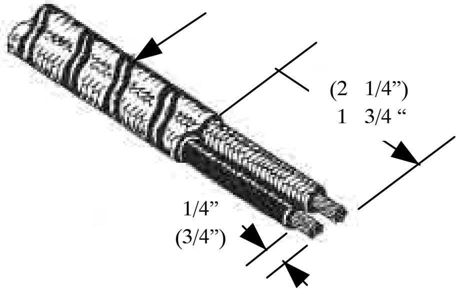


Figure 40. Stripping Thermocouple Wire for Terminal and AN5537 Connector Installation

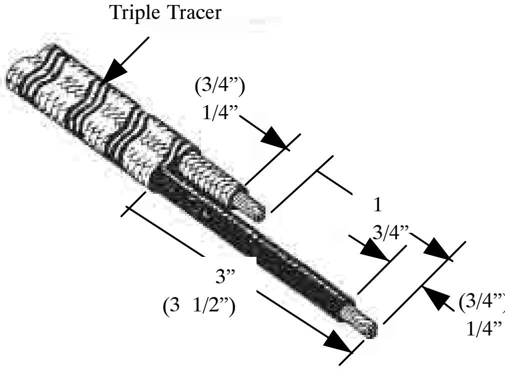


Figure 41. Stripping Thermocouple Wire for Splice Installation

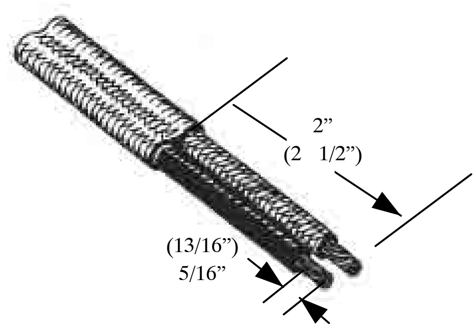


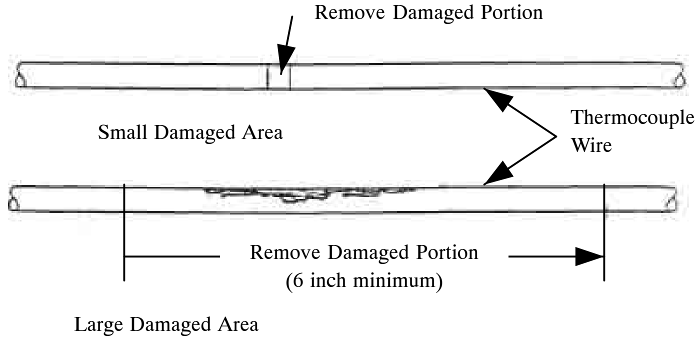
Figure 42. Stripping Thermocouple Wire for MS Connector

58. **SOLDERING OF THERMOCOUPLE TERMINALS AND CONNECTORS.** Refer to WP 016 00 for procedures on the solder connection or thermocouple connections

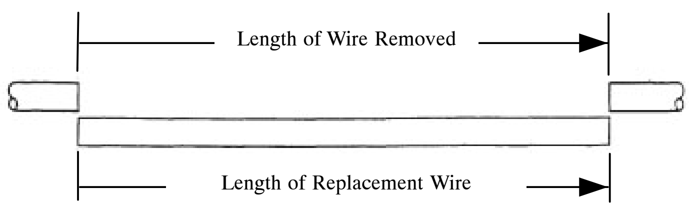
59. **CHROMEL/ALUMEL SIZE 20 CABLE SPLICE REPAIR.** When damage extends along the length of the conductors, the damaged area must be removed and replaced with a thermocouple jumper wire. Ensure jumper wires are installed chromel to chromel and alumel to alumel, For thermocouple wire repair, refer to Figure 43.

Thermocouple Wire Repair

1. Cut spot ties and remove clamps as required to gain access to damaged thermocouple wire.
2. Cut thermocouple wire to remove any damaged portion. If damaged area is small and wire has enough slack, wires can be spliced directly together. If there is a large damaged area or not enough slack, a length of thermocouple wire (6–inch minimum length) must be spliced in.



3. Cut a jumper wire of the same gage, temperature rating and equal to length of damaged thermocouple wire removed



4. Cut jacket carefully around wire, 2 ± 1/16 inch from one end and 1 ± 1/16 inch from other end of wires to be spliced. Use a sharp blade and do not cut into braid. If a length of wire is being added, repeat for jumper wire(s).

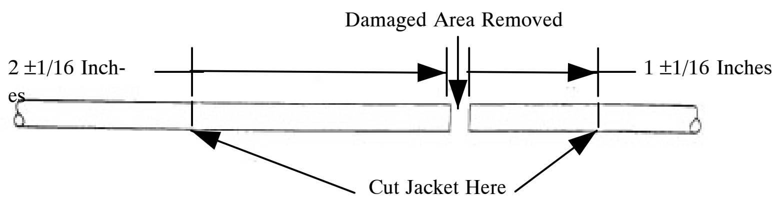
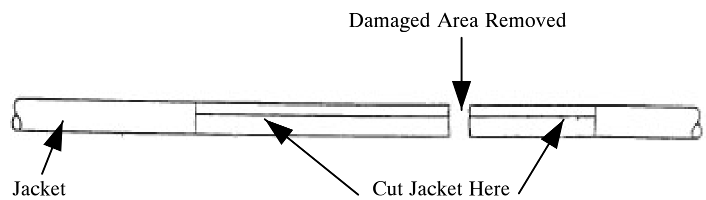
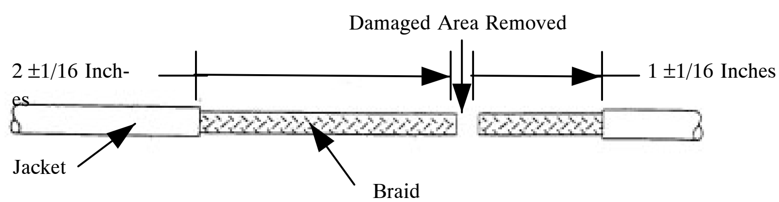


Figure 43. Chromel/Alumel Thermocouple Wire Splice Repair (Sheet 1 of 4)

5. At each end being spliced, Cut jacket lengthwise along area to be removed.



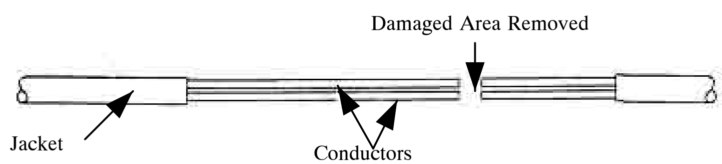
6. Remove Jacket at Prepared Ends



7. Carefully remove braid back to jacket. Use small scissors or diagonal cutter and take care not to damage wire insulation.

CAUTION

Do Not Nick or Damage Insulation When Removing Braid



8. Match jumper wire lengths to wires that were cut out.

NOTE

Jumper Wires Shall Be Added as Matched Pairs ONLY.

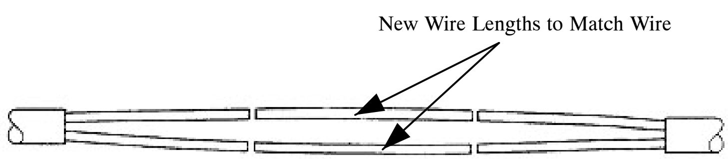
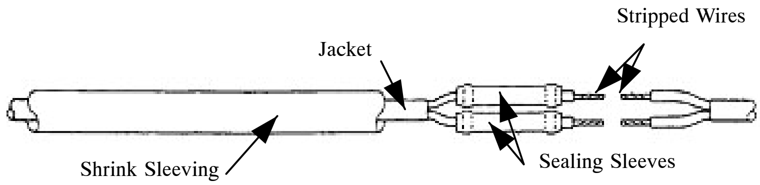


Figure 43. Chromel/Alumel Thermocouple Wire Splice Repair (Sheet 2)

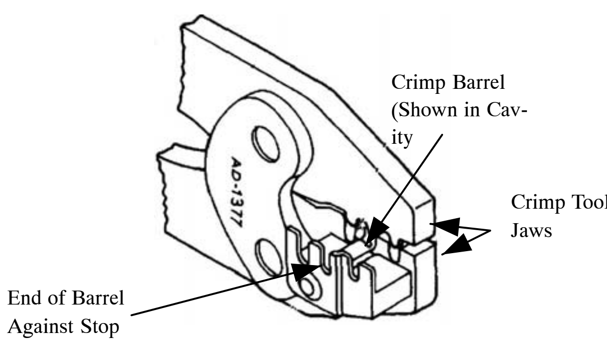
9. Select applicable wire stripper: Part Number 45−1654
10. Strip wires and jumper wires
11. Slide shrink sleeve over cable jacket and sealing sleeves over long end of conductors



CAUTION

Chromel Wire (White Insulation) Must be Spliced to Chromel Wire Using the Grey−Coded Crimp Barrel. Alumel Wire (Green Insulation) Must be Spliced to Alumel Wire Using the Green−Coded Crimp Barrel (D−436−0133)

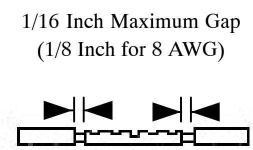
12. Insert crimp barrel into correct crimping cavity of crimp tool. Color code of crimping cavity must match color stripe on crimp barrel (AWG 8 and 10 excepted). Assure that crimp barrel is located correctly in it's crimping cavity.
13. Insert wire end into crimp barrel (into the end between the jaws). Wire must reach middle of crimp barrel and be visible through inspection hole
14. Squeeze handles together to form crimp. Handles will not release until crimp is completed (see WP 013 00).



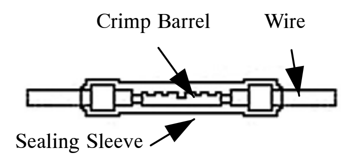
M22520/37−01 Crimp Tool

Figure 43. Chromel/Alumel Thermocouple Wire Splice Repair (Sheet 3)

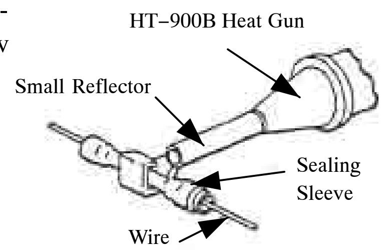
15. Reverse crimp barrel in same cavity. Crimped end must now fit against stop.
16. Insert jumper wire, if applicable, into crimp barrel and crimp.
17. Inspect crimp barrel and wires as shown. Wire insulation must be within 1/16 inch of crimp barrel (1/8 inch for 8 AWG), but insulation must not be touching the crimp barrel (a small gap is necessary)



18. Center sealing sleeve over crimp barrel.



19. Using a heat gun with a small reflector, shrink sealing sleeve. Start in the middle and heat toward one end until sealant melts and begins to flow out. Repeat for other end. Allow to cool before handling



20. Using a heat gun with a large reflector, shrink shrinkable sleeve. Start in middle and shrink towards end.

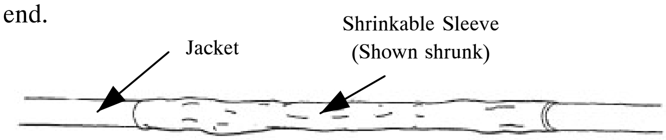


Figure 43. Chromel/Alumel Thermocouple Wire Splice Repair (Sheet 4)

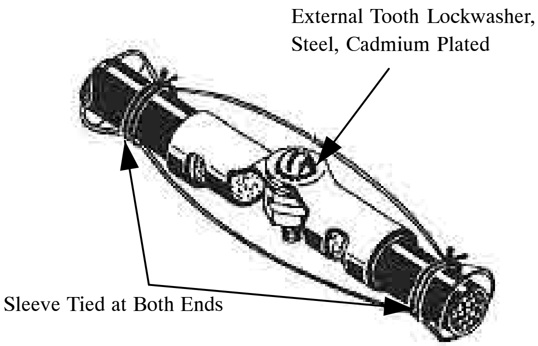


Figure 44. Connecting Thermocouple Splices

60 . **CONNECTING THERMOCOUPLE SPLICES.**

61 . Connect thermocouple splices as follows (refer to Figure 44):

a. Slide sleeve over one lead.

b. Bend locknut of lock terminal slightly before assembly to assure tightness.

c. Bring contact areas of two terminals together; pass screw through plain terminal first, then throughlock– nut of lock terminal.

d. Tighten screw securely.

e. Slide sleeve over terminal and tie securely

f. Slide sleeve over terminal and tie securely.

62 . **ALTERNATE METHOD FOR SPLICING AND CONNECTING MIL–DTL–5846 ALUMEL–CHROMEL THEROCOUPLE CABLE.**

63 . Similar metal terminations are required to connect the connections from the thermocouple probe to the circuitry cable at any point where temperature changes may be expected. Termination of thermocouple cables in areas where all components would be at the same ambient temperature normally would not require similar metal terminations. Splicing and connections of Alumel–Chromel thermocouple cables in engine nacelles, individual cable runs and wire bundles will be made using Alumel–Chromel Butt Splice with Insulation Support. These splices are uninsulated and separate insulation must be provided over the splice at the time of installation. A separate outer jacket must also be provided for cable protection and mechanical support purposes.

64 . **ALUMEL–CHROMEL THERMOCOUPLE BUTT (IN–LINE) SPLICE AND SEALING SYSTEM.**

a. Tools and Equipment:

(1) Heat Gun: Raychem Part Nos. AA–400, CV5700, HT–900 or M83507/14–01 Heat Gun Kit (WP 012 00)

(2) Crimp Tool: Amp Part No. 46673

b. Materials:

(1) Materials Installation Kit: Raychem Part No. D–436–0133.

(2) MIL–W–5846 (M584611E2120–(AC) Alumel–Chromel Thermocouple Cable (as required).

(3) 1 1/2 inch wide fiberglass tape with thermo–setting adhesive (optional).

NOTE

The following materials are contained in the Raychem Part No. D–436–0133 Materials Installation Kit:

(4) 1 ea., D–436–133–01 Chromel Splice, Color Coded Gray

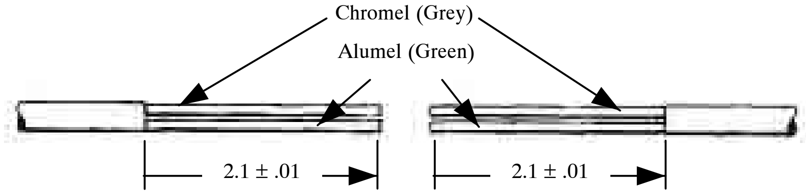
(5) 1 ea., D–436–133–02 Alumel Splice, Color Coded Green

(6) 2 ea., D–436–133–03 Splice Sealing Sleeves

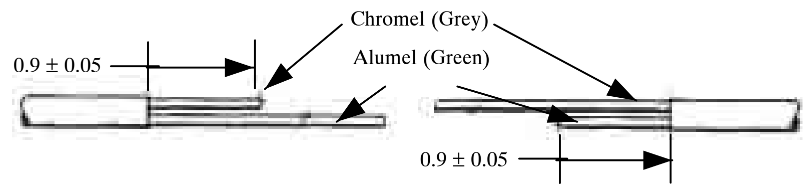
(7) 1 ea., D–436–133–04 Overall Insulation Sleeve

65 . See Figure 45 for Butt Splicing Procedure and Figure 46 for Stub Splicing Procedure.

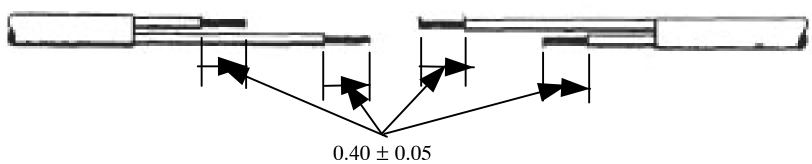
1. Remove 2.1 ± .01 Inches of jacket from cables to be spliced.



2. Cut the chromel lead of one cable and the alumel lead of the other cable to 0.9 ± .05 Inch.

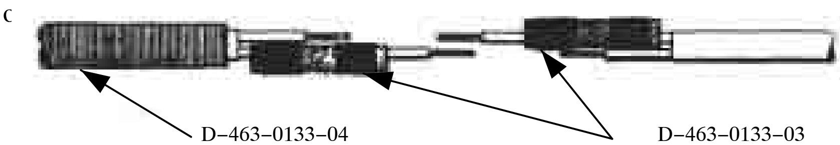


3. Strip 0.40 ± 0.05 Inch from end of each wire



4.a. Place a D−463−0133−04 (Large Sleeve) into opposite ends of the D=463—0013−01 (grey) crimp barrel.

4.b. Place a D−463−0133−03 c



5.a. Crimp chromel leads (grey insulation) onto opposite ends of the D−463−0133−01 (grey) crimp barrel.

5.b. Crimp Alumel leads (green insulation) onto opposite ends of the D−463−0133−02 (green) crimp barrel..

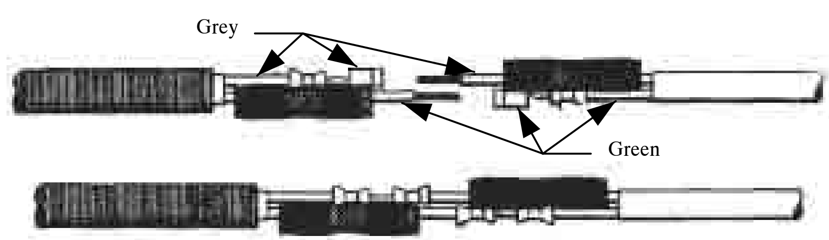
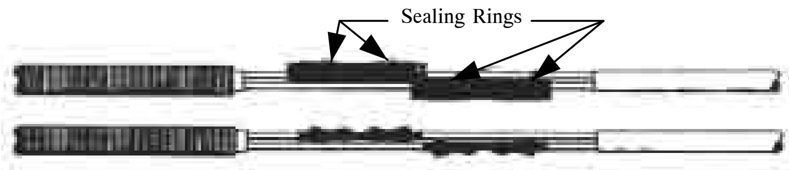
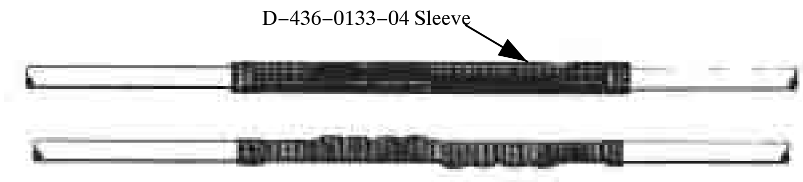


Figure 45. Butt Splicing Procedure (Sheet 1 of 2)

6. Center the D−463−0133−03 sealing sleeves over the splices. Using an HT−900B hot air gun, heat the center of the sleeve until the sleeve begins to shrink and the sealing inserts melt and flow along the wire. Heat must be applied to individual sealing rings until they melt and flow



7. Center D436−0133−04, large sleeve, over the completed splice assembly and heat until shrunk tightly onto the assembly. Sleeve should overlap cable jackets approximately 1/2 inch.



8. Wrap splice area with fiberglass tape if additional protection or support is needed.

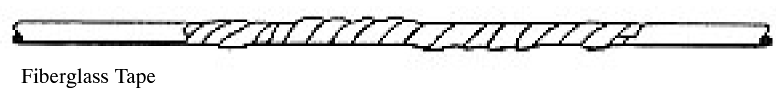
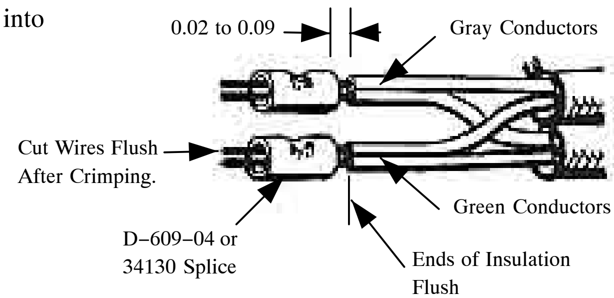


Figure 45. Butt Splicing Procedure (Sheet 2)

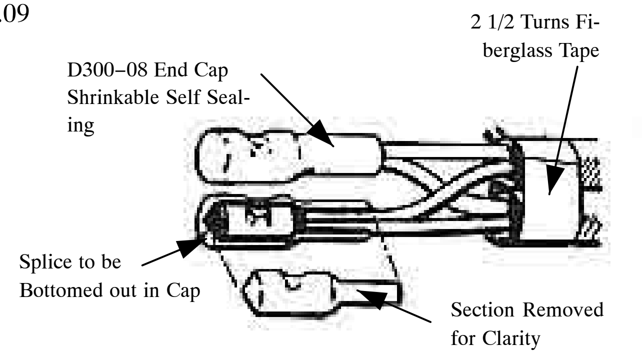
1. Strip thermocouple outer jacket 2.10 ± 0.1 Inch
2. End strip conductors 0.75 ± 0.05 inch

3. Keeping the ends of insulation flush, twist stripped wire ends as necessary to permit their insertion into connectors



4. Position wires in parallel connector so that after crimping there will be a maximum of 0.03 to 0.09 inch between connector and wire insulation.

NOTE:
Use Crimp Tool M22520/37–01 with Splice D–609–04
Use Crimp Tool 49935 with Splice 34130



5. Select correct Crimp Tool
6. Crimp Connector.
7. Cut protruding wire flush with end of connector.

NOTE
Twist Ends of the Same Color Coded Wires Together:
Alumel – Green
Chromel – Grey

Figure 46. Stub Splicing Procedure

66 . **QUALITY ASSURANCE SUMMARY.**

a. Ensure like color– coded wires have been spliced together.

b. Ensure individual stub splices have been completely insulated.

67 . **MOUNTING AN5537 CONNECTOR ASSEMBLY.**

68 . AN5537 firewall connector assemblies are mounted as shown in Figure 39.

a. Attach insulating block to firewall on hot side. Bosses on block should fit into holes in firewall so that block face is flush against wall.

b. Push socket assemblies through holes and lock into place with coupling nuts.

c. Push plugs into socket assemblies from cold side of firewall.

69 . **ROUTING THERMOCOUPLE WIRING.**

70 . Route thermocouple wiring as described generally in WP 010 00. In addition, observe the following special precautions:

a. Support thermocouple wiring so it will not come into contact with heat producing surfaces, such as exhaust pipe or combustion chamber, at any point.

b. Do not bend thermocouple leads sharply.

c. Do not splice thermocouple leads except where specifically indicated, and then only with approved splices.

d. Protect adjacent wiring against abrasion from thermocouple splices.

e. Route thermocouple wiring away from hot spots.

71 . **PROTECTION.**

CAUTION

Do not use sleeving as a substitute for safe routing.

72 . Insulate thermocouple spliced terminal connections with sleeves to protect the insulation of adjacent wires from abrasion. Use plastic sleeving in cool areas and silicon impregnated rubber or glass sleeving in hot areas. Tie sleeving securely at both ends.

73 . **SLACK IN THERMOCOUPLE WIRING.**

CAUTION

Do not bend thermocouple leads to less than a two– inch radius. When calibration resistors are used in the circuit to adjust for short lengths, do not allow any excess slack, except for approximately three inches at each end for maintenance.

74 . Thermocouple wire installations require the use of fixed wire lengths to maintain a specified resistance (see Figure 35). The slack that results should be distributed by one of the following methods:

a. Distribute excess slack evenly between wire supports, as shown in Figure 47, View A.

b. If sufficient slack is available, take it up at a support, in the form of a loop of which the diameter is at least 20 times the thickness of the thermocouple wire, as shown in Figure 47, View B.

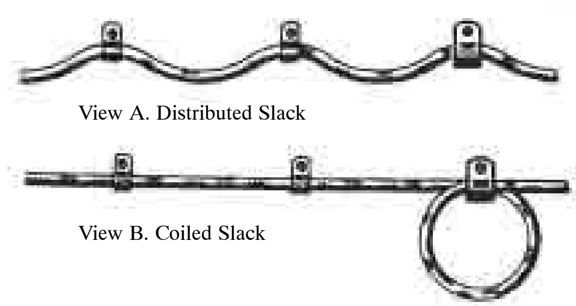


Figure 47. Distributing Slack in Thermocouple Wire

EMERGENCY REPAIRS
(AIR FORCE ONLY)

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

Alodine	MIL-C-81706, Class 3
Tape wire markers	Brady PMW-PK-8
Corrosion Preventing Compound (CPC)	MIL-C-16173, Grade 4
Isopropyl Alcohol	TT-I-735
Stoddard's Solvent	MIL-PRF-680 Type II

1. INTRODUCTION.

2. It is sometimes necessary to make emergency repairs to the aircraft electrical system at advanced fields, where a minimum of tools and equipment is available.

3. SCOPE.

4. This chapter describes and illustrates some recommended procedures for emergency repairs to broken or damaged copper wires, shielded and coaxial cable, and electric connectors, and for replacing terminal board covers.

CAUTION

Emergency repairs not meeting the requirements of the previous chapters of this technical order should be replaced as soon as possible. Also, Air Force activities must comply with the inspection requirement of WP 004 01, this manual.

Do not repair wires with damaged shielding braid by covering with potting compound or sleeves. As it is not possible to seal off severed ends, and these may puncture the wire insulation. For coaxial cable repair, see WPs 011 00 and 014 00, this manual.

Do not use solder to splice broken wires except under emergency conditions and then repair wires with correction solderless splices as soon as possible.

5. METHODS OF REPAIRING WIRE.

6. Repair of small broken wires is accomplished by means of crimped permanent splices. Breaks in large wire (AWG size No. 8 and larger) are repaired by means of terminal lugs bolted together.

7. **SPLICING SMALL COPPER WIRES (SIZES NO. 26 THROUGH NO. 10)**.

8. **Insulated Splices.**

9. Insulated permanent copper splices conforming to MIL−T−7928, MIL−T−7928/3, MIL−T−7928/5 and MIL−S−81824 are used to join small copper wire sizes No. 26 through No. 10. Typical splices are shown in WPs 013 00 and 014 00, this manual. Note that splice insulation extends over the wire insulation. Each splice size can be used for more than one wire size. Splices are color coded in the same manner as insulated small copper terminal lugs.

10. Terminating small copper wires (sizes No. 26 through No. 10) with preinsulated terminal lugs.

a. Small copper wires (sizes No. 26 through No. 10) are terminated with solderless, preinsulated straight copper terminal lugs conforming to MIL−T−7928 (see part of the terminal lug and extends beyond its barrel, this makes the use of an insulation sleeve unnecessary. In addition, preinsulated terminal lugs have an insulation−support (a metal reinforcing sleeve) beneath the insulation for extra supporting strength on the wire insulation.

b. Some preinsulated terminals accommodate more than one size of wire. The insulation is color−coded and the range of wire sizes is marked on the tongue, (WPs 013 00 and 014 00, this manual.) to identify the wire sizes that can be terminated with each of the terminal lug sizes.

11. **Crimping Tools for Sizes 26 Through 10 Splices.**

12. The M22520/5 and M22520/10 crimp tools with appropriate dies are the preferred tools for crimping sizes 26 through 10 splices. MS3316 and MS90413 crimp tools may be used if M22520/5 and M22520/10 tools are not available. When new and/or additional crimp tools are needed M232520/5 and/or M22520/10 crimp tools and dies should be procured for replace of MS3316 and MS90413 tools. The crimp tools listed above will crimp M7928/3 splices. For crimping M7928/5 and M81824 splices only the M22520/5 and M22520/10 crimp tools with appropriate dies can be used. See WPs 013 00 and 014 00, this manual, for splice and crimp tool information.

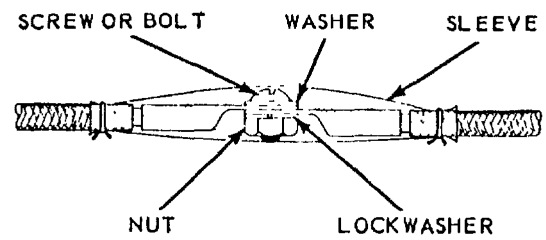


Figure 1. Bolted Terminal Lug Repair of Large Wire

13. **Crimping Procedure for M22520/5 and M22520/10, MS3316 and MS90413 Standard Hand Crimping Tools.**

14. Crimp small preinsulated copper splices in the 26 to 10 wire size range with M22520/5, M22520/10 and MS90413 or the MS3316 tool, as follows:

a. Select the appropriate crimp tool(s) and die(s) from WPs 013 00 and 014 00, this manual, for crimping the splice(s) to be used.

b. Check tool for correct adjustment. Tools out of adjustment must be returned to the manufacturer for repairs WPs 013 00 and 014 00, this manual.

c. Strip wire to length given in WPs 013 00 and 014 00, this manual, following on of the procedures described in Chapter 2, paragraphs 2.37 through 2.44.

d. For the M22520/5 and M22520/10 tools, see Figure 1 for crimping instructions.

e. For the MS90413 tool, with the tool handles fully open (seeWPs 013 00 and 014 00, this manual), set the wire size selector knob to the proper position for the wire size being crimped. Slide the terminal lug locator down below the die surface into the fully retracted position, and insert the splice into the stationary die so that the MS90413−2 location “finger” fits into the locator groove in the splice, and the insulation barrel protrudes from the “wire side” of the tool.

f. For the MS3316 tool, one locator is used for both terminal lugs and 7928/3 splices (see WPs 013 00 and 014 00, this manual). For the M7928/3 splice, insert the splice into the movable dies so that the locator on the tool fits into the groove in the splice, and the insulation barrel on the side of the splice to be crimped protrudes from the “wire side” of the tool.

g. Squeeze tool handles slowly until tool jaws hold splice barrel firmly in place, but without denting the barrel.

h. Insert stripped wire into splice barrel which protrudes from “wire side” of splice until stripped end of wire butts against the stop in the center of the splice. This can be seen through the splice inspection window.

i. Crimp by closing tool handles. Tool will not open until full crimping cycle has been completed.

j. After crimping, check that wire end is still visible through the inspection window.

k. Reverse position of splice in crimping tool (or location of crimping tool on splice) and repeat steps b through h to crimp wire into other side of splice.

15. **Splicing procedure for M81824 environmental splices.**

a. M22520/5 or /10 crimp tool for wear in accordance with WP 013 00, this manual. If the tool is worn out of tolerance, it must be replaced.

b. Select the correct size sealed splice. Choose a size crimp barrel from WP 013 00, this manual, that will accommodate the wire(s) to be crimped in each separate end.

c. Strip 5/16 to 11/32 inch of insulation from wires, following one of the procedures in WP 009 00, this manual.

d. Position the crimp barrel in the appropriate die of the M22520/5 or /10 crimp tool, so that one end of the crimp barrel butts against the crimp locator (see WP 013 00, this manual). Lock in place by partially closing the handles without denting the crimp barrel.

e. Insert the wire fully into the crimp barrel, and crimp by closing the handles until the ratchet releases.

f. Before completing the splice, slide the sealing sleeve, which will be shrunk later, back over one of the wires (M81824/1 splice only).

g. Reverse the position of the crimp barrel in the crimp tool die. The attached wire will extend through the slot in the crimp locator.

h. Lock the crimp barrel in place by partially closing the handles, insert the other wire(s), and crimp as before.

WARNING

Do not use heat guns with electric motors when working on aircraft that have been defueled and purged for extensive maintenance, Mod/PDM, or major modifications, because motor brushes produce sparks, and because air from the immediate work area is passed over the heating element which could cause an explosion or fire. Compressed air/nitrogen heat guns M83521/5–01, M83507/14–01, and M22520/13–20 are the only heat tools approved for use on fueled aircraft.

i. Slide the sealing sleeve over the crimp barrel, center it (M81824/1 splice only), and heat with hot air to shrink the sleeve. Heat the middle first to lock the sleeve in place; then heat the ends until the sealing rings melt and ooze out around the wire. To ensure a good seal, allow to cool before handling.

16. **Splicing high–temperature wires.**

17. Splices for high temperature applications are available in the same wire size ranges as terminal lugs. The tools and crimping procedures are the same for splices as for terminal lugs. Crimp splice at both ends.

18. SPLICING BROKEN WIRES WITH PERMANENT SPLICE.

19. When splicing wires by means of permanent splices, observe the following procedures (see Figure 2):

NOTE

Make sure that only aluminum splices are used when splicing aluminum wire

a. Cut ties and work the broken wire to the outside of the bundle.

b. Pull sufficient slack from the wire run toward the break so that there will be no strain on the splice.

c. Trim the wire as close to the break as possible so that all strands will be of equal length.

d. Clean the wire for a distance of at least one inch from the break with Stoddard’s solvent. This will ensure the removal of foreign particles and debris to provide a good insulating surface.

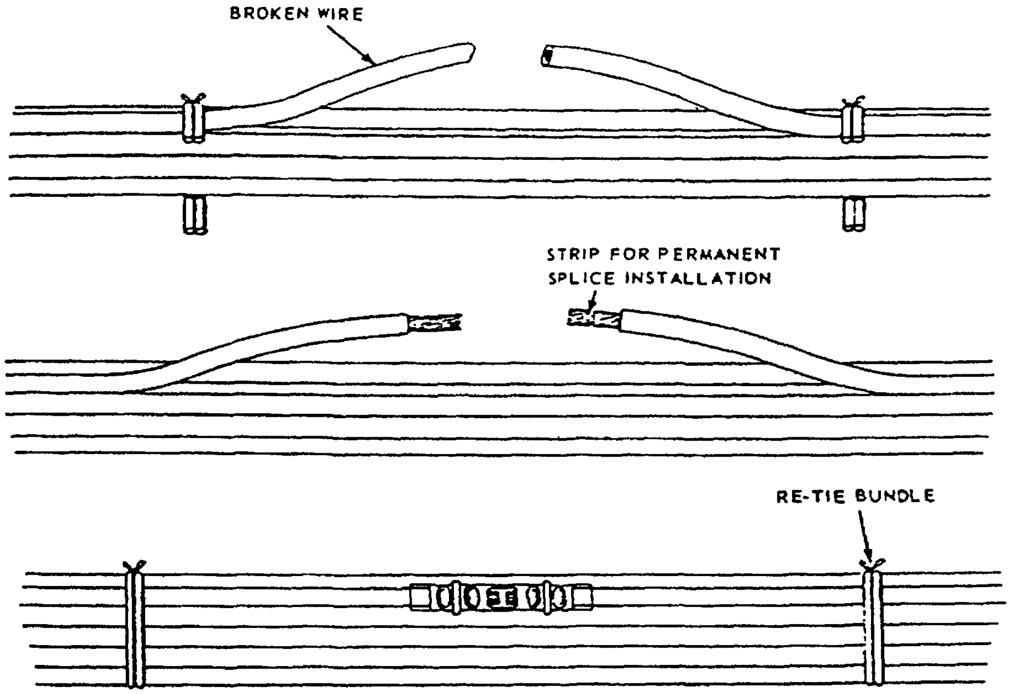


Figure 2. Permanent Splice Repair of Wire

NOTE

If an additional piece of wire has to be spliced in to make the repair, the added wire should be of the appropriate type selected from AS50881 (WP 004 00, this manual). The replacement wire should be equal to or better than the original wire in tensile strength, temperature rating, etc.

e. Select a crimp splice from (WP 013 00, this manual). If a uninsulated splice is used, slide a piece of shrinkable tubing slightly larger in diameter than the OD of the splice being used over one end of the severed wire (see WP 013 00, this manual). If shrinkable tubing is not available, a piece of flexible transparent tubing can be substituted.

NOTE

Environment resistant sealed splices shall be used in areas of severe wind or moisture problems or both (swamp), such as wheel wells, rear wing flaps, wing folds, and other areas specified in the detail specification.

f. Install the splice as described below:

NOTE

The inability to obtain a good tinned surface indicates the wire is not clean.

(1) Dip half of exposed clean conductor into hard solder flux.

(2) Protect wire insulation with noteched copper sheet shield, to prevent scorching.

(3) Apply flame to wire until flux bubbles. Then feed small amount of silver solder in wire form to fluxed area while flame is kept there. After the silver solder has flowed, remove the flame, and allow the wire to cool in the air.

g. Re−tie spliced wire into bundle.

20. SPLICING LARGE WIRE WITH TERMINAL LUGS.

21. Trim the broken ends of the wire and install an insulating sleeve over one end of the wire. Strip wire and crimp an insulated terminal lug of the proper size

to each wire end, following the procedures described in WP 013 00, this manual. Bolt the terminal lugs together as shown in Figure 1. Slide the insulating sleeve over the connection and tie securely to the wire at both ends.

22. REPAIRING DAMAGED WIRE INSULATION.

23. If the wire insulation is damaged but the wire itself is not damaged, repair the insulation in either of the following ways:

a. Dip the damaged portion of the wire insulation into a container of potting compound. Instructions for mixing potting compound are given in Chapter 10. Allow potting compound to dry in air (70° – 75F°) for 4 hours before touching. Full cure and electrical characteristics are achieved in 24 hours.

b. If potting compound is not available, repair damaged wire insulation by using a transparent sleeve of flexible tubing 1-1/2 times the outside diameter of the wire and 2 inches longer than the damaged portion of the insulation. This sleeving is split lengthwise and wrapped 1-1/2 times around the wire at the damaged section. Tic with nylon braid at each end and at one inch intervals over the entire length (see Figure 3).

c. Heat shrink tubing may be used in lieu of transparent sleeve. Avoid creating tight bends in the harness to mitigate chaffing and cracking of the heat shrink tubing, due to movement or vibration (WP 010 00). If the cable is cracking and chaffing, the heat shrink will be more susceptible to the same effects.

24. REPAIRING SHIELDED CABLE.

25. When the shielding braid of shielded cable has been damaged or the cable severed, it can be repaired in the following manner (see Figure 4).

CAUTION

Do not attempt to repair damaged shielding braid by covering with tape, as it is not possible to seal off severed ends, and these may puncture the wire insulation.

a. Select a grounding sheath according to instructions in WP 015 00, WP 016 00, and WP 017 00, this manual.

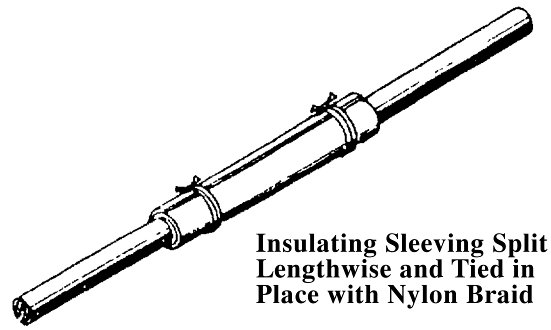


Figure 3. Insulation Repair with Sleeving

b. Prepare the severed ends of the cable for application of a grounding sheath connector as described in section it.

c. Slide over the splice two insulating sleeves, either shrinkable or flexible transparent tubing, the inner one just large enough to pass over the grounding sheath connector and the outer one large enough to accommodate the inner insulating sleeve and the grounding lead. The inner insulating sleeve should be just long enough to completely cover the permanent splice. The outer sleeve must be long enough to extend beyond the two grounding sheath connectors as shown in Figure 4.

d. Attach a grounding sheath connector to one end of the severed wire as described in WP 015 00, this manual. The grounding wire should be long enough to span the repair.

e. Install a grounding sheath connector on the other side of the break. Do not crimp this yet.

f. Use a permanent splice to join the severed inner conductor (see Figure 4).

g. Slide inner insulating sleeve into position as shown in Figure 4. If shrinkable tubing is used apply heat as described in WP 015 00, this manual.

h. Push the free end of the grounding wire, from step c above, into the uncrimped grounding sheath connector. Crimp securely.

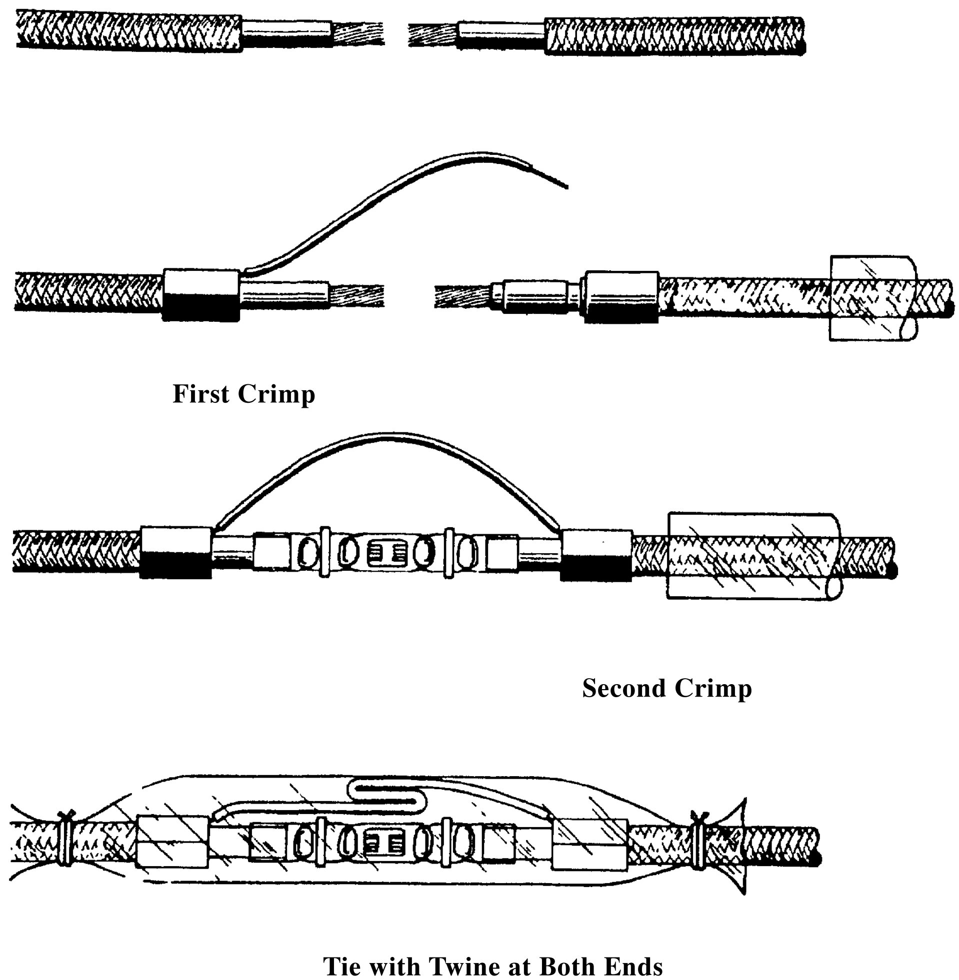


Figure 4. Repair of Shielded Wire

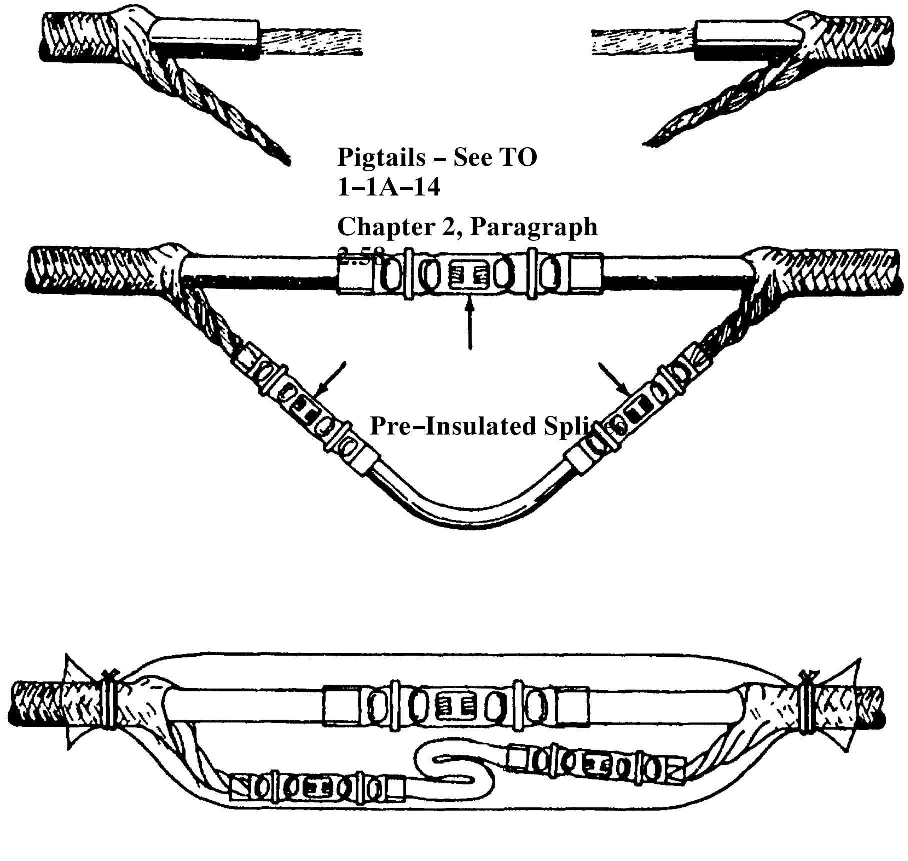


Figure 5. Alternative Method for Repair of Shield Wire

i. Slide outer insulating sleeve into place. If shrinkable tubing is used, proceed as in step g above. If flexible tubing is used, tie both ends with nylon braid as shown.

26. An alternative method of repairing shielded cable is to be used, if grounding sheath connector as described in paragraph 25 is not available. The alternative method (shown in Figure 5) is as follows:

a. Prepare the severed ends of the cable for pigtail method of shield termination as described in WP 015 00, this manual.

b. Use pre–insulated splice connector to join inner conductors as described in WP 013 00, this manual.

c. Use two splice connectors to add short length of insulated wire as extension to complete shield connection.

27. REPAIRING UNPOTTED CONNECTORS.

28. Defective MS connectors which have broken pins can be temporarily repaired in the following manner:

a. Where it is possible to get at both halves of the connector, one of the spare wires provided may be used by splicing the wire from the damaged or broken pin to the spare wire, following the procedures of paragraphs 13–17. This procedure must be followed for the wire leading to both halves of the connector. The unit must then be marked that this repair has been done.

CAUTION

Tag both connector halves with complete information of the modification. Replace both connector halves at the next PAR cycle.

b. Repairing or straightening of a bent pin should be accomplished with a mating socket of the same size. Bent pins should not be straightened with needle nose pliers.

29. REPAIRING POTTED CONNECTORS.

30. Potted connectors are equipped with spare wires on all spare pins. If a pin becomes defective, the repair is made by cutting the wire leading to the defective pin and using a permanent splice (as previously described) to join the wire to a spare wire. The mating connector must also be so modified.

CAUTION

Tag both connector halves with complete information on the modification. Replace both connector halves at the earliest opportunity.

a. Cut away the potting compound (sealant) with a thin knife blade or scalpel. Use long nose pliers to pull the sealant while cutting. Be careful not to cut into wire insulation.

b. Carefully scrape away sealant from defective pin.

c. Use small (pencil) soldering iron to unsolder the wire lead from pin.

d. Use long nose pliers to pull pin out of resilient insert.

e. Solder wire to new pin and push pin into insert from rear.

f. Pour new potting compound into area of repair and air cure at room temperature for 24 hours. The new compound will seal satisfactorily to the old compound remaining in connector.

31. FAILED WIRE.

32. Occasionally, a wire will fail inside the potted area of a connector. When the connector has a back shell, slide a thin knife blade around the outside edge of the sealant and unscrew the shell. This may take considerable force, depending on how tightly the sealant adheres to the shell. Follow the same steps as described above to reach the soldered connection. Do not remove the pin, but solder a new wire to the contact and repot the connector.

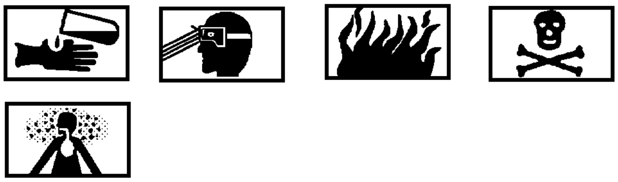
33. CLEANING CORROSION FROM CONNECTORS.

34. If the corrosion has not entered the electrical portion of the connector and if they are electrically functional, the following procedure should be carefully followed:

a. If water is present, apply a light coat of water displacing preservative MIL−C−85054, Grade B, then dry thoroughly. Remove built−up corrosion products by using a soft−bristled brush, a fine abrasive mat, (M1L−A−9962), an aluminum oxide cloth P−C−451, Type 1, 320 grit), or a scraper or picker for hard−to−remove deposits. Avoid damage to the nonmetallic parts of the connector or adjacent nonmetal parts during the cleaning process.

b. After the major portion of corrosion products have been removed, if the connector will not disengage. small amounts of a 10 or 20 weight general purpose lubricating oil or a substance such as, or similar to WD−40 can be applied to the working surfaces of the connector. After the lubricant has worked itself in, it should be possible (by using alternate loosening and tightening motions) to free the working surfaces and disengage the connector halves. (The use of pliers or other configuration−defacing tools should be avoided).

c. With the connector halves apart, immediately remove any excess lubricant from the mating surfaces of the connector shell to keep it from entering the electrical portion of the connector. Also, remove any lubricant which has gotten into the nonmetallic or pin areas of the connector. Using the same tools as in step a, thoroughly clean any remaining corrosion products from the outside of the connector shell. Exercise care so as to prevent corrosion products from entering the electrical portion of the connector. This may be accomplished by holding the connector face against a flat surface which is covered with a clean shop cloth and then brushing the shell. Inspect the connector shells for integrity and function, and replace if required.



1 Alcohol, Isopropyl, TT-I-735

d. If the connector shells are satisfactory, they can be cleaned with a suitable cleaning solvent, such as Isopropyl Alcohol, TT–I–735, to remove any remaining corrosion products and lubricant residue. The entire connector should be inspected, repaired, and cleaned as required at this time.

WARNING

Alodine is moderately toxic to skin, eyes, and respiratory tract. Skin and eye protection is required.

Solvent should only be used in well ventilated areas and eye protection is required.

e. Apply a brush costing of Alodine (MIL–C–81706, Class 3) to the outer surfaces of the connector shell and coupling nut and dry according to the manufacturers' recommendations. Rinse the residue from the connector shell with a spray bottle of deionized water. Use potable water if deionized water is not available. Exercise care to keep the alodine solution and the rinse water from entering the electrical portion of the connector. Dry thoroughly using low–pressure, clean, dry air.

f. Brush a coating of MIL–C–16173, Grade 4, Corrosion Preventing Compound (CPC) on the outer surface of the shell and on the coupling nut. Allow to dry.

g. Mate connectors and touch up any damaged CPC with a light coating of fresh CPC. If the corrosion has entered the electrical portion of the connector and the contacts are corroded or damaged, replace the contacts as required. If this is not feasible, replace the connector.

35. REPLACEMENT OF CONNECTORS.

36. Occasionally, a connector will be damaged to such a degree that the entire connector will require replacement. This usually requires installing a new connector to existing wires. However, if existing wires are too short, splices and wire pigtails must be used to install new connector. The following method is preferred:

NOTE

If wire identifying numbers are not visible use tape wire markers, Brady PMW–PK–8 or equivalent, to identify pin's socket position.

a. Select wire pigtails so that splices can be staggered. Shortest wire should be a minimum of six inches long.

b. Solder or crimp wires to pins/sockets required, then insert pins or sockets into the connector in a shop environment when possible. One end of the splice should be installed in this area also. The pigtailed connector then is spliced into the aircraft wire bundle. If connector is attached to shock–mounted equipment, wires should be of sufficient length to ensure free movement of the equipment on its shock mounts.

37. REPAIR TO A WIRE BUNDLE.

38. Repair to a complete wire bundle should be accomplished using the same crimping techniques previously described. Care should be exercised to stagger splices. Where possible, splices in adjacent wires in a bundle should be separated by at least one splice–length. This may require the use of added jumper wires spliced into the existing wiring. The following rules apply:

a. Always use the proper size splice for the size wire being repaired,

b. Select the correct tool and ensure splice is located in the tool properly before crimping.

c. After repairs are made, ensure all MS21919 cable clamps and wire bundle ties are replaced. NEVER use string or plastic ties for primary wire bundle support.

39. REPLACING TERMINAL BOARD COVERS.

40. When a terminal board cover is lost or damaged so as to be unusable, cover the board with a piece of large insulating tubing, split lengthwise, and tied securely around the terminal board. This procedure is described in WP 013 00, this manual.

WARNING

If it is necessary to clean aircraft electric components, use only approved Military Standard cleaning compounds and approved procedures. The use of ordinary cleaning compounds or the failure to follow proper procedures may cause fires or explosions.

CAUTION

Emergency repairs not meeting the requirements of this manual should be replaced as soon as possible. Air Force activities must comply with the inspection requirements of WP 004 01, this manual (Aircraft Electrical Inspection Procedures).

41. REMOVAL OF REVERTED POTTING COMPOUNDS.

42. The following instructions on the removal of reverted potting compounds are general in nature and require specific instruction before they are implemented. Due to peculiarities in the different aircraft systems the use of these instructions in the aircraft shall be directed by the specific aircraft System Manager (SM). The SM shall ensure that all safety and precautionary measures are accomplished (or can be accomplished) before directing the implementation.

WARNING

Deviations from these instructions can be dangerous to both the aircraft and personnel.

43. REPLACEMENT WITH ENVIRONMENTAL TYPE ELECTRICAL CONNECTORS.

44. The preferred method for repair of potted electrical connectors is replacement with environmental type electrical connectors. If environmental connectors are not obtainable then the next preferred method for repair is replacement with identical connectors and potting with an approved potting compound. If replacement is impossible and depotting becomes necessary, the following procedures are applicable.

45. **TOOLS AND EQUIPMENT**.

a. Soldering iron with modified tip for cutting potting compound (not authorized for use on aircraft other than those defueled and purged for extensive maintenance, IRAN or major modification).

b. Tweezers.

c. Needle nose pliers.

d. Plastic/wood probes.

e. Electrician's pocketknife.

f. Heat Applicator (heat⁄gun) Raychem HT900 (MS3507/14–01) (see paragraph 11.21) or explosion proof equivalent.

g. Respirators (organic vapor type).

h. Small stiff bristle brush.

i. Protective Clothing

(1) Rubber gloves.

(2) Eye protection (safety goggles).

(3) Rubber Apron.

j. Polyethylene Bags.

(1) 4–inch by 4–inch.

(2) 6–inch by 6–inch.

(3) 8–inch by 8–inch.

(4) 10–inch by 10–inch.

(5) 12–inch by 12–inch.

k. Polyethylene sheet, Federal Specifications L–P–378.

l. Absorbent material, Specifications CCC–C–429, DDD–W–101

m. Degasser: vacuum pump and accessories capable of maintaining a vacuum of 25 to 29 mm of mercury.

n. Balance, Harvard trip type, double beam, capable of weighing to 2000 grams and sensitive to 0.1 gram; or equivalent.

o. Sealant gun such as Semco Model 250–6 with retainer.

p. Potting compound cartridges to correspond to potting gun used, such as Semco Number 250–C12, 250–C6, 250–C2 1/2.

q. Cartridge nozzles to correspond to potting gun used, such as Semco Number 420, 440, etc.

r. Timing device, sweep second hand.

s. Stirring paddles, wood or plastic (wide tongue depressors are satisfactory).

t. Spray bottle, Polyethylene 16 oz.

u. Shore Durometer

v. Nylon Cord.

w. Wire (for typing around bags).

x. Portable ventilation equipment for use in confined locations to remove solvent vapors (such ventilation equipment must be explosion proof).

46. **MATERIALS**.

Potting Compound	Specification MIL−S−8516 (for low−temp areas)
Potting Compound	Specification MIL−S−23586 (for hi−temp areas)
Primer A4094	For Dow Corning compounds Silastic 69210 and 69220
Primer SS4004	For General Electric compound RTV 8111

NOTE

Use primer A4094 only with Dow Corning potting compounds and SS4004 only with General Electric potting compounds.

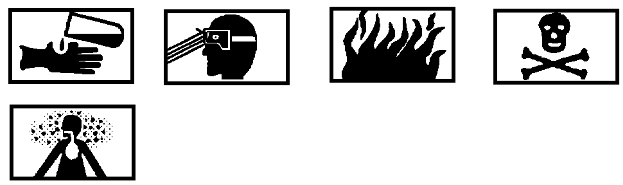
Examine all connectors potted with Pro Seal 777 or EC 2273 for evidence of material deterioration. Connectors shall be replaced or repotted in each instance in which the potted compound has deteriorated to any of the following stages: less than 20 SHore A, soft, spongy, doughy, viscous, or flowing A Shore A hardness of 60 or greater should ensure a 3−year service left before replacement.

Under no circumstances shall Pro Seal 777 or EC 2273 be covered over with another potting compound. It must be removed before repotting.

47. **<u>REMOVAL OF HI−TEMP (300°F) PRO SEAL 77A/B (GREEN) AND EC2273 (BLACK) POTTING COMPOUNDS AND INSTALLATION OF APPROVED POTTING COMPOUNDS.</u>**

48. Procedures for removing PRO SEAL 777 or EC 2273 potting compounds.

a. Prior to cleaning operation, rope off area involved and provide suitable signs indicating unauthorized personnel stay clear of area.



1 Alcohol, Isopropyl, TT-I-735

b. Prepare the area below all items subject to solvent for solvent spillage.

CAUTION

Isopropyl Alcohol, TT−I−735 will damage most paint films.

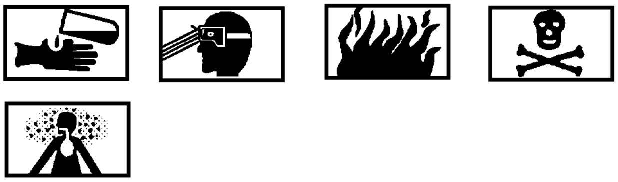
(1) Lay down a sheet of polyethylene covered with compounds absorbent material.

(2) Should any solvent be spilled on the absorbent materials, this material should be removed and disposed of or laundered.

c. Prepare aircraft taking all outlined safety precautions.

d. Remove plastic mold from potting on connector or relay (if installed), using soldering iron to cut plastic (see paragraph 45 step a).

e. Trim excess potting from component using soldering iron (see paragraph 45 step a) with modified tip.



1 Alcohol, Isopropyl, TT-I-735

CAUTION

Use extreme care to prevent damage to wire insulation or to the component body.

NOTE

Soldering iron tip should be modified to resemble a small spoon with no sharp or blunt edges. New tips may be fabricated from brass welding rod (see paragraph 45 step a).

f. Fill the polyethylene bag with enough Isopropyl Alcohol, TT–I–735 to completely immerse the potting compound, and check the bag for leakage. If the bag is leaking, transfer the solvent to a new bag and discard the leaky bag. Label the starting time on the bag with a marking pen to keep an accurate count of the soaking time.

g. Insert the connector or relay in the polyethylene bag. Tie the top of the bag in place with a nylon cord or a wire to prevent evaporation of the solvent.

NOTE

An alternate method is to place the connector in below the connector a large can or bucket, filling the container with enough Isopropyl Alcohol, TT–I–735 to completely immerse the potting compound. Then add about one inch of water to it. The water will stay on top of the Isopropyl Alcohol keeping the vapors from getting into the air. This will also prevent evaporation of the solvent.

Also the use of ZIP–LOCK polyethylene bags in lieu of the tie type bags is permitted.

CAUTION

Be sure the bags are tightly sealed. The laminate procedure must be accomplished in a ventilated booth area approved the by the resident Bio–environmental Engineer.

h. While the compound is soaking, inspect the bags for leaks every 10 to 20 minutes. Leaking bags found during this period shall have a second bag tied around them. This soak period shall be restricted to a maximum of one hour. Connectors which have the potting compound swelled or dissolved in less than one hour should be removed as soon as possible from the solvent to minimize soak time.

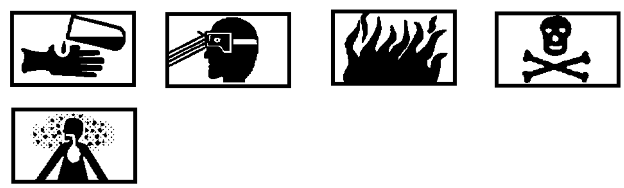
i. After the old potting compound has been dissolved, swelled, or one hour soaking time has been obtained, remove the bag of solvent. Contaminated solvent must be disposed of in an environmentally safe manner. Contact the Bio–environmental Engineer to establish an approved procedure.

j. Using tweezers, needle nose pliers, or picks, remove swollen potting compound.

k. Repeat swelling and picking operation until all potting compound is removed.

CAUTION

Never allow the soaking time to be extended over 2 hours. Prolonged immersion can swell and damage neoprene inserts in connectors. Tie the top of the bag in place with a nylon cord or a wire to prevent evaporation of the solvent.



1 Alcohol, Isopropyl, TT-I-735

l. Brush the connector briskly to remove all residues; rinse while brushing with small quantities of Isopropyl Alcohol, TT–I–735. Allow the solvent to run over the connector and collect in a container or polyethylene bag below the connector.

m. Allow the component to dry for 30 minutes minimum, then apply heat with HT900 (M83507/14–01) (see WP 012 00, this manual) or an explosion proof heat gun starting 6 to 8 inches above the component and work down. Five minutes heating time is sufficient. The applied temperature should not exceed 250°F

n. Let stand for 24 hours. Inspect for cleanliness and check all wires for insulation damage.

49. INSTALLATION OF NEW POTTING COMPOUND.

NOTE

Specification MIL–S–8516 potting compound is authorized for use in all compartments of the aircraft where ambient temperature normally does not exceed 185°F (200°F for naval weapon systems). Specification MIL–S–8516 compound will not be used to pot components in the engine bays, keel area, or areas adjacent to bleed air ducts (Boundary Layer Control and air conditioning).

a. a. Perform necessary rework, making sure that fluorocarbon insulated wires to be installed in the connector pin(s) are treated with a fluorocarbon etching compound to obtain a bondable surface (see WP 025 00, this manual).

CAUTION

Fluorocarbon etchant must not come in contact with a connector assembly or pin.

NOTE

Wires and connectors previously potted will not be treated with the fluorocarbon etching compound. Only newly installed wires are to be treated.

b. Prior to repotting, thoroughly inspect each component as follows:

(1) Inspect for any potting compound between the connector pins or embedded in any pin holes.

(2) Ensure that all depotting solution has been removed, insert has reduced to normal size, and the component is dry.

(3) Inspect for corrosion products on component hardware.

(4) Inspect the component for any liquid bleed out.

(5) Reprocess the component according applicable instructions if any one of the above deficiencies is detected.

(6) Inspect rubber insert in connectors. If insert is lose replace connector.

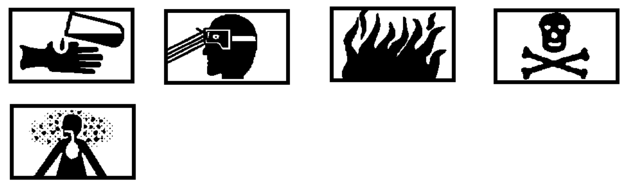
(7) Inspect for any broken, damaged or shorted wiring on the part. If the wiring is damaged, repair as necessary.

(8) Ensure that all wires and components are clean and free of contamination, that is , metal chips, grease, dirt, etc.

(9) Repotting procedure may be instituted if processed part is found to be satisfactory.

c. Potting should be accomplished as follows:

(1) If new wires have been added, clean the complete connector assembly by scraping off rosin and brush vigorously in new dry cleaning solvent or acetone followed by a second rinse of acetone.



1 Alcohol, Isopropyl, TT-I-735

(2) Rinse area to be potted with Isopropyl Alcohol (see paragraph 47) applied from hand operated spray bottle or similar device. Prevent skin contact with the Isopropyl Alcohol and use only with adequate ventilation. Eye protection is required.

NOTE

Complete potting within 2 hours after cleaning.

(3) Place proper size potting mold around the connector; make sure that it fits squarely on the should of the connector. If the proper size mold is not available, take two molds and overlap one over the other. Do not use anything except a commercial manufactured mold.

NOTE

Do not use masking tape as a mold for MIL–S–23586 potting compound.

(4) When the potting mold is placed squarely on the connector, make one wrap around the base on the mold using one inch masking tape to securely fasten the mold to the connector. Mask–off the connector from the top of the mold to the bottom of the connector, making sure to cover the pin sockets to prevent overflowed potting compound from entering.

(5) Thoroughly dry the connector with a heat gun.

NOTE

This drying operation is absolutely necessary to ensure that the connectors are bone dry prior to priming or potting.

(6) Carefully apply RTV primer using a brush or aerosol can to coat all surfaces of the connectors, wires, potting mold, etc., that will come in contact with MIL–S–23586 potting compound. In most cases a thin film of primer will give the best adhesion. If cracks appear in the chalked film, the primer coat is too heavy.

NOTE

MIL–S–8516 potting compound does not require the use of a primer.

(7) Mixing:

(a) The potting compound is stored in paired cans of base compound and accelerator. Use only the accelerator supplied with the base compound. Substitution may produce a sealant with sub–standard electrical properties. To avoid errors, store the base and accelerator together in a carton. Store material in not less than 40°F nor greater than 80°F.

(b) Weigh the desire amount of base compound into a quarter container.

NOTE

Any residue in the bottom of the base compound can should not be used. Do not scrape the can clean.

(c) Mix the catalyst thoroughly before using.

(d) Weigh the correct amount of catalyst into the preweighed base and mix thoroughly to achieve a uniform color. Scrape the mixing paddle, the sides, and the bottom of the container sufficiently to obtain a complete mix. Do not mix compound violently or excessive air bubbles will be entrapped. Refer to Table 1 for the correct mix ratio.

NOTE

A side reaction takes place in MIL–S–23586 potting between the catalyst and the base shortly after mixing. Due to this reaction, there may be a small evolution of gas. This gas must be removed by vacuum de–aeration. Gas evolution will not continue after vacuum de–aeration.

A container three to four times larger than the amount of compound mixed is required due to occluded air expansion in the vacuum chamber.

(e) Place container in vacuum chamber and vacuum deaerate at 25 mm (1 inch) or less of mercury, until the bubbling mass collapses. Continue vacuum for 3 to 5 minutes. Cautiously refill the vacuum chamber with air. Remove container from vacuum chamber.

(f) Immediately place the material in cartridges by pouring the material into the inside wall of the cartridge, while holding the cartridge at an angle. Exercise care to prevent folding in air. When the nozzle portion has filled, hold a finger over the end to prevent the material from running through. The cartridge is then assembled for use.

(8) Potting:

(a) Pot the connector immediately.

NOTE

Potting compound should fill mold and flow between pins, wires, and leave no voids.

(b) Do not attempt to pot any connector without the use of a potting gun. Insert the potting gun nozzle into the center of the wires at the bottom of the mold and inject material slowly, so as to force the material outward and upward to fill the mold from the bottom up. On many connectors it will be necessary to remove the nozzle from the circumference of the bottom edges. When the potting is done properly, the wires and bottom are coated first with the material rising and displacing air. Remove the nozzle slowly, adding a small amount of material to fill the cavity caused from the removal of the nozzle. If the wires are tightly grouped, they may be moved slightly to aid in the elimination of air cells and to aid in the flow of the material about the wires.

(c) Immediately, after filling each connector, tie the wires together loosely about 6 inches back from the connector. Make sure that the wires are centrally located in the connector so that each wire is completely surrounded by potting compound. The potted connectors must be secured in a vertical position so that the new potting material will not run out.

Table 1. Mix Ratio for Potting Compound

Potting Compound	Mix Ratio by Weight	Pot Life at 77° F	Tack Free at 77° F	Cure Time at 77° F
MIL−S−23586				
Type I (RTV8111)	100/3	1/2 hr	8 hrs.	24 hrs.
Type II (69210)	100/10	1 1/2hrs.	16 hrs.	48 hrs.
MIL−S_8516				
Class I	100/10	1/2 hr.	5 hrs.	24 hrs.
Class II	100/10	1 hr.	8 hrs.	48 hrs.
Class III	100/10	2 hrs.	16 hrs.	72 hrs.

(d) Do not disturb connector until potting is cured. Refer to Table 1. Heat may be used to accelerate cure, but do not exceed 120°F. Vulcanization will not be accelerated at the center of the piece until the entire mass has reached the elevated temperature.

(9) After the potting has cured, remove the masking tape, replace the grounding band if necessary, and reidentify the connector.

WARNING

Epoxy Polyamide Primer Coating (MIL−P−23377 and MIL−PRF−85582) are highly toxic to eyes, skin, and respiratory tract. Avoid all contact. Skin and eye protection required. Use only with adequate ventilation.

(10) Where metal surfaces of components have been affected, clean surface affected with a wire brush and paint with Epoxy Polyamide Primer Coating MIL−P−23377 or MIL−PRF−85582. Apply Epoxy Polyamide Primer Coating MIL−P−23377 or MIL−PRF−85582 with brush or aerosol can. Use care not to paint mating surfaces of connector.

d. Failure of potting compound to harden could be caused by any one or a combination of the following conditions:

(1) Improper ratio of potting compound to catalyst.

(2) Poor mixing of potting compound and catalyst. Through mixing is essential for proper hardening. Uniform coloring is an indication of proper mix.

Table 2. Effect of Temperature on Cure TIme

TEMP	TACK FREE	FULL CURE
77° F	8 hrs.	24 hrs.
50° F	24 hrs.	48 hrs.

(3) Low temperature. If temperature is lower than room temperature (70°F), a proportionately longer cure time will be required. See Table 2 for effect of temperature on cure time.

NOTE

The cure times in Table 2 will also very depending on quantity of catalyst used. Low temperature cures should be avoided whenever possible. The 77°F cure will give optimum cure properties.

(4) Fault catalyst or base compound. It is wise to make a 25 gram test sample of each lot of both base and catalyst prior to starting the potting operation.

(5) Organic impurities such as zinc chromatic putty, cleaning solvents or traces of old potting will inhibit cure of MIL−S−23586 potting compounds. Through cleaning will prevent this problem.

50. <u>QUALITY ASSURANCE SUMMARY.</u>

a. Potting adheres firmly to wires and existing potting.

b. No holes or soft spots that would indicate air entrapment in the potting.

c. Potting completely covers all connector contacts.

51. <u>REMOVAL AND INSTALLATION OF POTTING COMPOUNDS. SPECIFICATION MIL−S−23586 AND MIL−S−8516 ACCESS TO CONTACT ONLY.</u>

a. Using a soldering iron (see para 19) with a modified tip as shown in Figure 6, cut away the potting to gain access to the desire contact(s).

CAUTION

Use extreme care not to damage adjacent connector contacts or wire.

b. Using a dull knife, scrape away the remaining potting in the contact area.

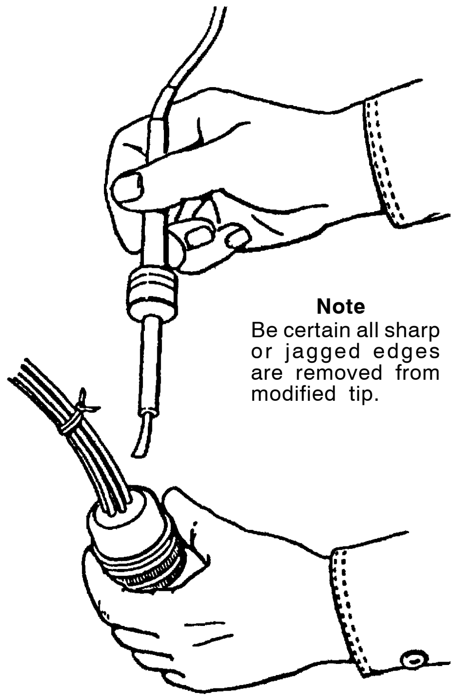
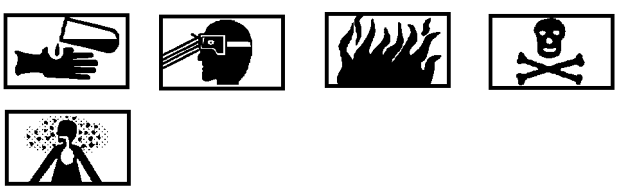


Figure 6. Potting Removal



1 Alcohol, Isopropyl, TT-I-735

c. Wash area thoroughly with Isopropyl Alcohol (TT–I–735) (paragraph 21)

d. Before potting connector, inspect for the following:

(1) Wire satisfactorily solder to contact, or, crimp pins correctly installed.

(2) Adjacent wiring or contacts have not been damaged during rework.

52. COMPLETE REMOVAL OF POTTING COMPOUND.

a. MIL–S–23586 must all be removed using a soldering iron (paragraph 19) and a dull tool.

b. MIL–S–8516 potting may be removed manually or with Isopropyl Alcohol, TT–I–735 (see paragraph 21).

53. INSTALLATION.

a. Construct a potting mold so potting will be at least 1/4 inch above connector contacts.

b. Prime all areas to which potting must adhere when using MIL–S–23586. Use A4094 primer with Dow Coming potting compounds, and SS4004 primer with General Electric RTV8111 potting compound. No primer is required for MIL–S–8516.

c. Mix potting compound, Specification MIL–S–23686, according to manufacturer's instructions (see paragraph 22 step c (7)).

d. Pot connector with potting compound (see paragraph 22).

e. Do not disturb connector for 24 hours after potting.

f. After curing is completed, the potting mold will be retained to provide additional mechanical strength.

g. MIL–S–8516 potting compound may be used to replace old MIL–S–8516 by following the instructions in paragraph 22.

54. QUALITY ASSURANCE SUMMARY.

a. Potting adheres firmly to wires and existing potting.

b. No holes or soft spots that would indicate air entrapment in the potting.

c. Potting completely covers all connector contacts.

55. REMOVAL OF HI–TEMP (500 °F) 3M COMPANY EC 1663 A/B POTTING AND INSTALLATION OF APPROVED POTTING COMPOUNDS.

56. This procedure provides information for correct removal and installation of hi–temp potting, which is used on electrical connectors of compact wire bundles.

57. REMOVAL.

58. Refer to paragraph 21.

NOTE

When a connector, relay, etc., containing potting compound Specification MIL−M−24041 is to be repaired, MIL−M−24041 must be removed completely and replaced with potting compound, Specification MIL−S−23586.

59. ALTERNATE PROCEDURE ONLY FOR PYLE NATIONAL THREADED CONNECTORS.

60. Remove all potting external to the shell per paragraph 21 step 3. Place the connector in a vise, cable end up, holding the wrench flats at the pin end of the connector. Heat the cable support metal shell using a propane torch. Heat the shell until a thin film of potting adjacent to the interior shell liquidifies. Remove heat and unscrew the threaded cable support shell, using a pipe wrench at the cable shell wrench flats. Do not exceed the temperature rating of the various connector components.

WARNING

Do the connector heating only in a well ventilated area.

61. INSTALLATION.

62. Refer to paragraph 22 for procedures and paragraph 23 for quality assurance.

63. POTTING SPLICING.

64. Temporary splicing when no environmental splices are available or splicing is required in a fuel vapor area will be accomplished as follows:

a. Install a piece of sleeving (selected from WP 025 00, this manual) about four inches long and of the proper diameter to fit loosely over the insulation, on one piece of broken wire.

b. Strip appropriate length from each end of the broken wire.

c. Splice both wires with M7928/5 splice.

d. Draw sleeve over wires and tie at one end. Fill sleeve with potting MIL−S−23586 and tie securely.

e. Allow potting compound to set without touching for four hours. Full cure and electrical characteristics are achieved in 24 hours.

FAULT DIAGNOSIS AND FAULT LOCATION EQUIPMENT AND REPAIR PRACTICES FOR AIRCRAFT ELECTRIC AND ELECTRONIC WIRING (ARMY AND NAVY USE ONLY)

Reference Material

Operators Guide for Reflectometer Models ESP, ESP+; Version 1.07E (PN 980–ESP–00256)	T.O. 33DA39–89–11
Instruction with PL –– Time Domain Reflectometer, PN 1502 (TEKTRONIX)	T.O. 33A1–4–73–1

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part No./Type Designation
Digital Multimeter (DMM)	FLUKE 77 / Fluke 77 (or equivalent)
Metallic Time Delay Reflectometer (MTDR)	070–7168–04 / Tektronix 1502c
Tester, ESP + Reflectometer	980–ESP–00256 / ESP +
Tester, 900 AST (Advanced Systems Tester)	80–6113–1157–4 / 900 AST
Insulation Tester (Megger)	MEGGER / Mark 3 (or equivalent)

Materials Required

None

1. **INTRODUCTION.**

2. This work package (WP) provides information on approved wire diagnostics testers. Only use on the aircraft if approved by the appropriate engineering authority. Air Force users shall reference AF Technical Orders for both meters prior to use. For the ESP+ refer to technical manual 33DA39–89–11. The technical manual for the 900AST is under development.

3. **SAFETY.**

WARNING

Use extreme care when testing energized circuits. Coming in contact with energized circuits may result in serious personnel injury.

Ensure that critical / sensitive circuits and components are disconnected and isolated. These may include, but are not limited to: ESDS and/or explosive/ordnance. Failure to disconnect these components may cause damage to equipment and injury to personnel.

CAUTION

Do not connect live / energized circuit cables to the input of the ESP+ Reflectometer. If voltage is detected, the meter will not engage and will display: “Unsafe Voltage Present”.

4. **GENERAL.**

5. Wiring fault diagnostics refers to fault type and location identification in a single conductor, or when built into, a part of a larger harness. Current wire diagnostics capability and technology have shown the reliable ability to determine distance to fault and type of fault (open, or short circuit). At this time this ability is limited to single conductor / single path. For branched circuits, where the conductor is split in two or more circuits or paths, the reliability is reduced, and each circuit will have to be isolated for accurate diagnostics. This WP addresses the currently approved testers. Additional testers with similar or improved capabilities are being evaluated to further refine and improve wiring fault diagnostic capabilities.

5a. Electromagnetic Interference (EMI) Restrictions on WIre Diagnostic Meters.

5b. No recommendations are considered necessary for Air Force Use.

5c. FOR NAVY USE ONLY: The 3M 900AST, Eclypse ESP, and Fluke 77 meter’s electromagnetic characteristics in accordance with shipboard requirements in MIL–STD–461 indicate that use above deck on ships may frequently result in degraded operation and erroneous readings. Also the 900AST may interfere with shipboard communication systems. Below deck on ships, the meters may only be employed during maintenance operations after the aircraft has been safed for maintenance. The Flue 77 may show occasional degradation of operation below deck.

5d. FOR ARMY USERS ONLY: The 3M 900AST, Eclypse ESP, and Fluke 77 meter’s electromagnetic characteristics in accordance with Army Flightline requirements in MIL–STD–461 indicate that use in the vicinity of active antenna–connected transmitters and receivers associated with aircraft, ground vehicles or ground facilities may frequently result in degraded operation and erroneous readings or interference with antenna–connected receivers. They may be employed only when maintenance operations and field conditions have been evaluated and approved by the unit commander.

6. **DIGITAL MULTIMETER (DMM).**

7. The most commonly used wiring diagnostic tool in use is the DMM. It provides the capability to identify whether the circuit is open or shorted. It also provides the specific circuit resistance, voltage, current and some specialized component tests. Refer to the user's manual for detail. It can, and should be used as needed in conjunction with the more complex testers, to arrive at the most accurate fault isolation.

8. **METALLIC TIME DELAY REFLECTOMETER (MTDR).**

9. A reliable tester available from various vendors, such as the Tektronix 1502c, is very versatile in identifying distance to fault and type of fault, along with marginal conductive path failures. It displays a wave form with which the specific failure mode can be identified. The user's manual, and/or technical order 33A1–4–73–1 may be used for additional information.

10. **HIGH VOLTAGE, HIGH RANGE OHM METER (MEGGER).**

11. The Megger, as it is commonly known, is a hand–turned generator used to produce high voltage (low current) input needed to measure the resistance of wire insulation, or other insulators. The megger is not for use on fueled aircraft, and is best suited for off–aircraft wiring testing. The user's manual, and / or technical order for a typical megger 33A1–12–1135–1, or 33A1–4–85–1.

12. **ESP+ REFLECTOMETER.**

13. This Reflectometer uses standing wave reflectometry (SWR) technology to locate distance to short and open faults in various metal wire types. It is MIL–STD–810 certified, as such can be used on fueled aircraft. See the accompanying users' manual and computer based training (CBT) instruction for additional details. The ESP+ uses the Velocity of propagation (Vp) and impedance as variables for each wire type in order to determine the most accurate distance to fault. The Vp identifies the speed of a signal through that specific type of wire, while the impedance identifies the total opposition to that signal. Refer to paragraph 18 for operating instructions of the ESP+, and Table 1 for the recommended Vp values.

14. **900 AST (ADVANCED SYSTEM TESTER) REFLECTOMETER.**

15. This Reflectometer uses time delay reflectometry (TDR) technology to locate distance to short and open faults in various metal wire types. It is also able to determine circuit resistance, voltage, contact resistance, perform a soak test and resistance fault locate. It is MIL–STD–810 certified, as such can be used on fueled aircraft. See the accompanying 900 AST Instruction Manual and computer based training (CBT) instruction on DVD for additional details. The 900AST uses the Velocity of propagation (Vp) and impedance as variables for each wire type in order to determine the most accurate distance to fault. The Vp identifies the speed of a signal through that specific type of wire, while the impedance identifies the total opposition to that signal. Refer to paragraph 23 for operating instructions of the 900AST, and Table 1 for the recommended Vp values.

16. **RECOMMENDED VELOCITY OF PROPAGATION (Vp) VALUES.**

17. The Vp values provided in the following Table 1 identify the recommended values for the listed types of wire/cable. These values where arrived at through extensive testing and are the recommended values if the specific wire Vp is not available. Specialized, or unique wire types require characterization and these new Vp values may be stored in the meters, which may be used to get more accurate distance–to–fault readings.

Table 1. Recommended Velocity of Propagation Values for the 900AST and ESP+ meters

WIRE TYPE	900AST	ESP+
Coax	0.78	0.626
Quad	0.74	0.599
Single Conductor	0.69	0.548
Shielded Quad	0.73	0.565
Shielded Sextuple	0.70	0.528
Shielded Single Conductor	0.70	0.522
Shielded Twisted Pair	0.73	0.568
Shielded Twisted Triple	0.71	0.544
Twisted Pair	0.73	0.580
Twisted Triple	0.73	0.574
Nominal Value	0.72	0.559

18. **ESP+ Operating Instructions.**

WARNING

Ensure that all critical / sensitive circuits and components are disconnected and isolated. These include, but are not limited to: ESDS, explosive, or sensitive. Failure to disconnect these components may cause damage to equipment and injury to personnel.

CAUTION

Do not connect live / energized circuit cables to the input of the ESP+ Reflectometer. If voltage is detected, the meter will not engage and will display: “Unsafe Voltage Present”.

NOTE

This procedure only applies to the model ESP+ software version V1.07e, as displayed upon initial meter power–up.

a. ESP+ should have its batteries charged for at least six hours before initial use.

b. The ESP+ peak output signal is 2 volts, as such standard components will not be damaged, unless: ESDS, explosive, or sensitive.

c. Be familiar with the ESP+ Users Manual before operating the meter.

d. Upon power up, the unit performs a self test. If it passes, “Ready for Test” is displayed. If the test fails, this notification will not be made and screen will be blank. Reset meter, if same results, return to manufacturer for repairs.

e. Since each wire type has its own characteristics, selecting the most accurate velocity propagation (V_p) and impedance (Z) will increase accuracy. Refer to Table 1 for the recommended values, or proceed to paragraph 20 for default settings and operation instructions.

NOTE

The connection method to the wire under test will directly affect the accuracy of the distance to fault reading.

f. The following list identifies from the most accurate method to the least accurate method. Connect both wires of the ESP+ to:

(1) Coax or single, shielded conductor.

(2) Pairs in shields.

(3) One pair to shield.

(4) Twisted pair unshielded.

(5) Adjacent wires, not shielded.

(6) Wires in same bundle.

(7) Wire to aircraft structure.

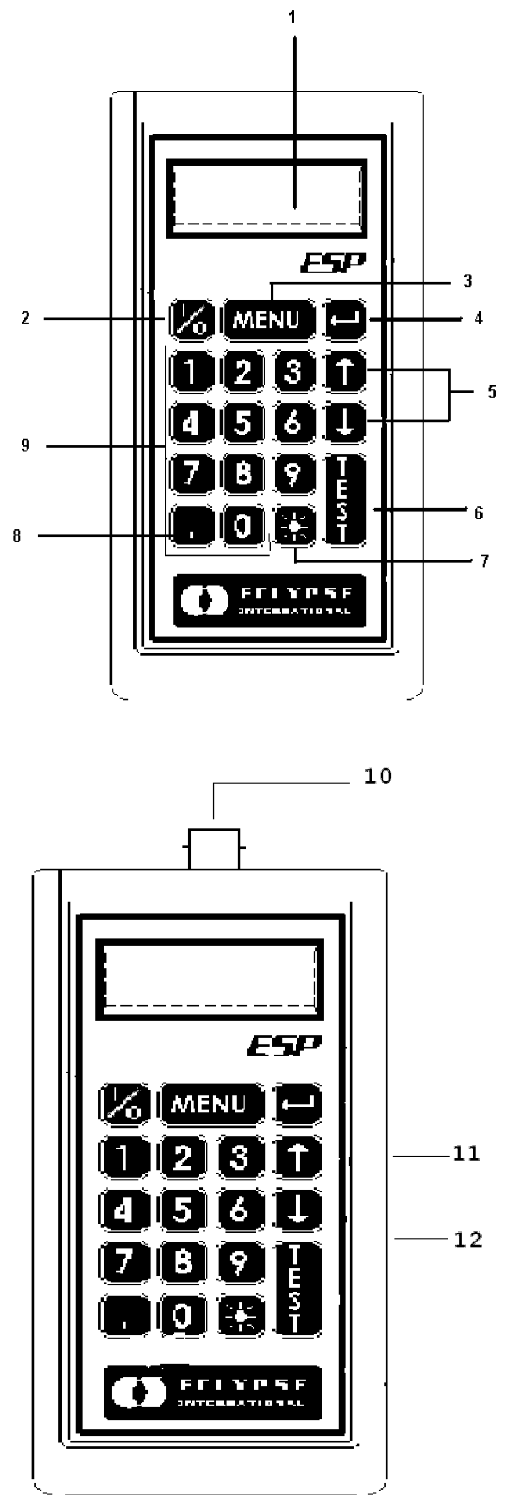


Figure 1. ESP+ Controls and Displays

19. **ESP+ CONTROLS AND DISPLAYS. (See Figure 1).**

a. 1– WINDOW. Displays system status, menu items, cable type, ready for test, etc.

b. 2– I/0 Button. Turns the power on and off.

c. 3– MENU Button. Activates the display of the menu items that the operator may select.

d. 4– ↵ [ENTER] Button. Selects the menu item that is displayed.

e. 5– ARROW Buttons. These buttons permit menu scrolling.

f. 6– TEST Button. This button initiates the automatic test sequence.

g. 7– –ϕ– Button. This button turns the backlights on and off for the display and keypad when depressed for 0.5 seconds.

h. 8– "." Button. This button serves two functions. The primary purpose is to enter the decimal point into numeric values. The alternate use is to enable English or metric display mode by depressing for 3 seconds.

i. 9– Numerical Keys (1–9, 0). Used to enter values for impedance and velocity.

j. 10– Test Lead Connector (BNC–type).

k. 11– RS 232 Port Connector (for optional data retrieval).

l. 12– Battery Charger Connector.

20. **ESP+ OPERATION (Default Settings).**

NOTE

It is recommended to use Vp=.500 and Z=100 values for default settings.

For specialized applications refer to paragraph 22.

a. PWR ON – press (I/0) button on top left.

(1) Meter displays: "Eclypse Intl ESP+ Vs 1.07e" for three seconds, then,

(2) "Ready for Test, Vp=0.500 Z=100"

b. Press MENU button, then down arrow once to "set velocity" and press enter.

c. Press .500.

d. Press MENU button, then down arrow twice to “set impedance” and press ENTER. ↵

e. Press 100.

NOTE

The display will then read “ready for test” VP=0.500 Z=100. The meter is now ready to go to the aircraft or assembly under test.

The average test calculation takes about 4 seconds. For most accurate results, ensure the connection is not disturbed throughout the test. If disturbed, re−test.

f. Connect to aircraft at one end of wiring run.

NOTE

The distance to fault will be displayed in feet (’) and inches (”).

g. On the ESP+ meter, press the **TEST** button, “TEST IN PROGRESS” is displayed. Open or Short Detected at XX’ XX” is displayed.

h. Subtract the length of the test cable (12 inches) connected to the ESP+ meter from the length displayed. This is the distance to a fault, or the end of the good wiring.

NOTE

If display reads “OPEN / SHORT MISMATCH FOUND” at a given value, ensure good meter contact. Retest, and if mismatch still exists increase Z value in increments of 100.

If “MISMATCH” does not go away by Z=400 inspect “MISMATCH” area for possible damage by corrosion, bad splices or connectors.

i. Repeat steps f and g for each wire under test.

j. Disconnect ESP+ meter, press the I/0 button to turn the meter off.

21. ESP+ SETTING THE VELOCITY OF PROPAGATION (Vp)

a. Press MENU.

b. Scroll down and find “SET VELOCITY”

c. Press ↵.

NOTE

Velocity can be set manually or automatically. If selecting AUTO function proceed to step d. For manual selection proceed to step h.

d. From the “ENTER VALUE” screen press the **TEST** button.

e. Enter the length of wire to be tested.

NOTE

Wire length must be at least 10 Ft. If you are in the feet/inches mode enter inches with a decimal. Example L = 27.6.

f. Once length has been entered press ↵.

g. The velocity will be displayed on the screen. This value can be retained as a new Cable Type. Refer to procedure in paragraph 22 for adding and storing cable types.

h. For setting manual velocity values from “ENTER VALUE” screen, enter value using numeric keypad.

NOTE

Typical Vp for specific wire types are listed in Table 1 and Appendix A of the User’s Manual.

i. Press ↵.

j. The new Vp will be displayed on the screen. This value may be retained as a new Cable Type. Refer to the next procedure in paragraph 22 for adding cable types.

22. ESP+ ADDING AND STORING CABLE TYPES.

a. Determine the values for velocity and impedance of the cable to be saved.

b. Press **MENU**.

c. Press ↓ or ↑ buttons to scroll until “ADD CABLE TYPE” is displayed.

d. Press ↵.

e. Result. The display will read “SAVE CURRENT TYPE?”

f. Press ↵.

g. Result. The display will read “ENTER NAME”.

NOTE

ESP+ will store up to 16 characters in alpha or numeric characters by using numbers on the key pad and ↓ or ↑ button to scroll through alpha characters.

h. Once cable type name has been completed press ↵.

23. 900 AST OPERATING INSTRUCTIONS.

WARNING

Ensure that all critical / sensitive circuits and components are disconnected and isolated. These include, but are not limited to: ESDS, explosive, or sensitive. Failure to disconnect these components may cause damage to equipment and injury to personnel.

Use extreme care when testing energized circuits. Coming in contact with energized circuits may result in serious personnel injury.

CAUTION

The 900 AST’s peak output signal is 80 volts, which is current – limited to less than 1 mA (mili Amp). All components shall be disconnected from the wiring to be tested.

The 900 AST meter is capable of measuring up to 300 VDC or 250 VAC. Exceeding the input voltage may cause meter damage.

NOTE

This procedure only applies to the model 900AST (80−6113−1157−4) software version Ver 2.00, as displayed upon initial meter power−up.

The 900 AST utilizes 6 AA batteries. Battery strength is continuously displayed in the upper right corner of the display. When the battery strength becomes too low, the display switches to an octagonal stop sign with a “LOW BATTERY” message underneath it (three beeps will also be heard). If the user chooses to continue, the Enter key may be pressed and the meter will continue to operate until the battery voltage drops to 5.1 volts, at which time the meter shuts down. Battery replacement is recommended at the first “low battery” warning.

Be familiar with the 900 AST Instruction Manual before operating the reflectometer. Use the “Help” ? control key on the 900AST keypad at any time when information is needed.

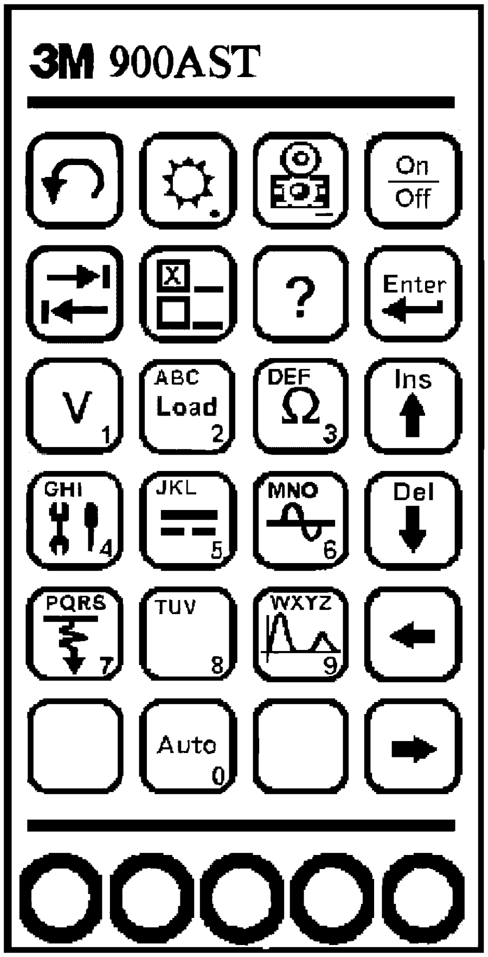
Upon power up, the welcome screen offers access to the tester set up functions, such as: “Help”, “Edit Custom Cable”, and various basic meter functions.

Since each wire type has its own characteristics, selecting the most accurate velocity of propagation (Vp) and impedance (Z) of the wire to be tested, will increase the accuracy. If not specific wire type Vp’s are not available, use the standardized Vp list available in step: 9, table: 1, or the meter’s default Vp settings and Vp adjustment instructions (in the Instruction Manual). To edit the Vp select the TDR function (blue key), and press the yellow set up key.

Always perform a self−calibration when meter has been exposed to a 35° F temperature change, or after the batteries have been replaced. Refer to paragraph 34 for the self−calibration procedure.

A periodic validation of operation within specification should be performed on the 900 AST to ensure it is operating within specifications (refer to paragraph 34).

24. **900 AST KEYPAD** (See Figure 2).



NOTE

The 900AST tester keypad has twelve yellow and red “Control Keys” and nine blue “Function Keys”.

Additional blue keys on the keypad are reserved for future expansion and have no designation or current function.

Refer to sheets 2, 3, and 4 for information on the control keys, edit keys, and function keys.

Figure 2. 900 AST Keypad and Controls (Sheet 1 of 4)

900 AST CONTROL KEYS

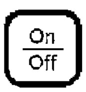
NOTE

Use the red and yellow keys to control and set up the 900AST tester and its functions.

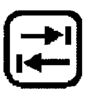
Use the (**Return**) key to return to a previous step in a function.

Use the (**Contrast**) key to adjust the contrast or turn the backlight on or off.

Use the (**Save,** or **Camera**) key for storing TDR traces.



Use the (**On/Off**) key to turn the 900AST power on or off.

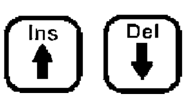


Use the (**Tab**) key to select between different options.

Use the (**Setup**) key to change the setup of a function.

Use the (**Help**) key to get context sensitive help with any screen or function.

Use the (**Enter**) key to accept changes or move to the next step in a function.
To insert a space to the left of the cursor press enter.



Use the (**Up**) and (**Down**) keys to scroll to different menu options or insert/delete characters when editing.

Use the (**Left**) and (**Right**) keys to select different options or move the TDR cursor.

Figure 2. 900 AST Keypad and Controls (Sheet 2)

900 AST EDIT KEYS

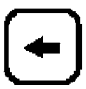
NOTE

Use the following keys to capture information with the 900AST tester.

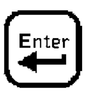
Use the yellow (**Save, or Camera**) key to save a TDR trace (step 27) displayed on the screen.

Press the camera control key to save / place the trace into the meter's memory.

Result: The label box will appear in the lower part of the screen, asking for the ID number to be assigned.



Press the Yellow left key 12 times to move the cursor to the far left of the box.



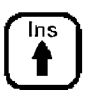
Using the blue keys, enter lower case letters / or numbers to assign a name, or number to the recorded TDR trace. Delete any extra spaces to bring the trace I.D. to the right sight of the I.D., then press the Enter key

NOTE

Use the following keys to edit information with the 900AST tester.

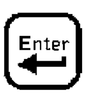
Use the yellow, (**Contrast**) key to assign periods (.)

Use the yellow, (**Save, or Camera**) key to assign a dash (–).



Use the yellow (**Insert**) key to insert a space to the left of the cursor.

Use the yellow (**Delete**) key to delete the character above the cursor.



When entering characters is completed, press the (**Enter**) key to store the trace.

Figure 2. 900 AST Keypad and Controls (Sheet 3)

900 AST FUNCTION KEYS

Use the (**Voltage**) key to measure DC or AC voltage.

Use the (**Load**) key to measure the current through a simulated load lamp.

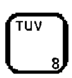
Use the (**Resistance**) key to measure resistance and access the ‘Soak Test’ and ‘Contact Resistance’ functions

Use the (**Toolbox**) key to access: Self Calibration, Stored Results, Special Resistance, and the Ohms to Distance Calculator..

Use the (**Capacitance**) key to measure the capacitance of a component or circuit.

Use the (**Tone**) key to send interrupted tone for circuit identification.

Use the (**RFL**) key to find the distance to a resistance fault between two conductors or a conductor and ground.



This key is used for editing only.

Use the (**TDR**) key to activate the Time Domain Reflectometer.

Use the (**Auto**) key to activate automatic TDR trace analysis.

Figure 2. 900 AST Keypad and Controls (Sheet 4)

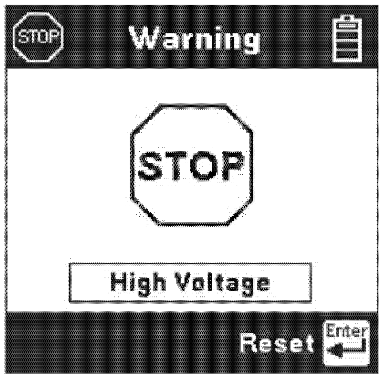


Figure 3. AST900 High Voltage Warning Display

25. **900 AST HIGH VOLTAGE WARNING** (See Figure 3).

WARNING

Use extreme care when testing energized circuits. Coming in contact with energized circuits may result in serious personnel injury.

CAUTION

The 900 AST meter is capable of measuring up to 300 VDC or 250 VAC. Exceeding the input voltage may cause meter damage.

a. If input voltage is higher than the meter's capability, the High Voltage Warning is displayed (see Figure 3).

b. This screen indicates that a high voltage (120VAC/VDC) or greater has been detected between the test leads when not in the Voltage Mode.

c. The 900AST has opened an internal relay to protect itself from damage.

d. Use standard safety practices for disconnecting the test leads since high Voltage may be present.

e. The high voltage warning always triggers at 120VAC or 120VDC, except when the tester is in the voltage function. This is also true for the TDR function.

f. Press the Enter (Enter) key to restart the 900AST tester.

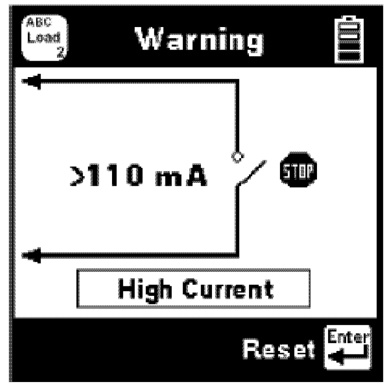


Figure 4. AST900 High Current Warning Display

26. **900AST HIGH CURRENT WARNING** (See Figure 4).

a. If input current in the load is greater than 110 mA, the following current Warning is displayed (see Figure 4).

b. This screen indicates that a high current has been detected between the test leads of the meter.

c. The 900AST tester has opened an internal relay to protect itself from damage.

d. Use standard safety practices for disconnecting the test leads. Correct the problem before restarting the "Load" measurement.

e. Press the Enter (Enter) key to restart the 900AST tester.

27. **900 AST WIRE TESTING: RESISTANCE** (See Figure 5).

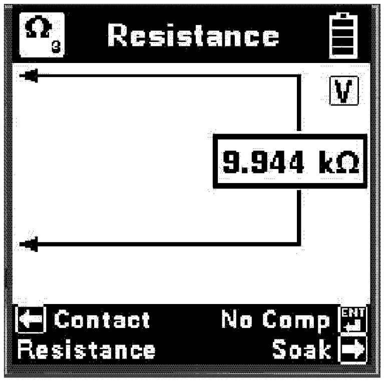


Figure 5. AST900 Resistance Display

NOTE

The following three procedures provide information on specific wiring resistance testing methods.

The Resistance function measures the resistance between the Red and Black test leads.

The Resistance function is also the entry point for accessing the Soak Test and Contact Resistance measurements.

a. Press the (Ohms) key to enter the resistance function.

b. Connect the Red and Black test leads as shown on the display.

NOTE

The "V" in the upper right corner of the screen indicates that the resistance measurement is compensating for any foreign voltage on the line.

The non–compensated measurement is slightly faster, but it is not as accurate if there is voltage on the conductor.

The resistance measurement can be affected by moisture on the test lead contacts or their access points. For the most accurate measurement make sure that these areas are dry.

c. View the resistance value in the display.

28. **900AST WIRE TESTING: SOAK TEST** (Figure 6).

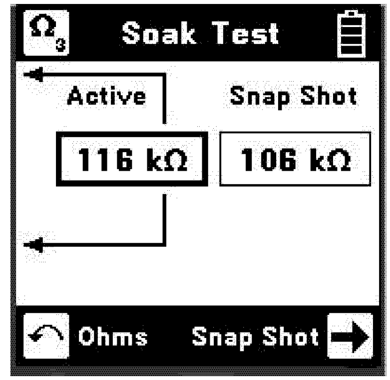


Figure 6. AST900 Soak Test Display

NOTE

Use the Soak Test function to continuously measure the non–compensated insulation resistance of a conductor to another conductor, to shield, or to ground.

This is useful in detecting resistive faults caused by moisture or corrosion.

a. Select (Ohms) key to enter the resistance function (See Figure 5).

b. Press the Right Arrow key at the lower right of the screen to access the Soak test function. (See Figure 6).

c. Connect the Red lead to the conductor under test and the Black lead to the fault reference (usually ground).

NOTE

The soak test box displays two empty boxes: Snap Shot and Active.

This measurement will not be accurate if there is foreign voltage on the conductor.

d. Press the Right Arrow key to save the resistance to the "Snap Shot" box.

e. Result: Monitor the resistance in the Active box

(1) Rising resistance in the active box typically indicates moisture present and falling resistance indicates corrosion.

f. Use the Return key to return to the Resistance (Ohms) measurement.

29. **900AST WIRE TESTING: CONTACT RESISTANCE (BONDING TEST)** (Figure 7).

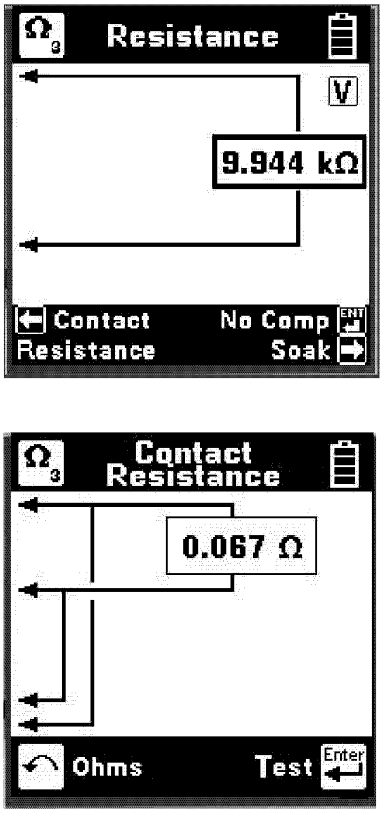


Figure 7. AST900 Contact Resistance Display

NOTE

Use this precision resistance measurement for applications requiring limited range and high accuracy resistance readings.

The Contact Resistance measurement may take a few seconds to stabilize and display the finite result. For a new measurement, press the Enter key. This provides an updated measurement.

If the Contact Resistance is greater than 5 ohms, the test returns immediately with an over–range indication.

For best accuracy, perform the self–calibration (refer to paragraph 34) with the adapters / cables to be used.

a. Press the (Ohms) key to enter the resistance function. (See Figure 5).

b. Press the Left Arrow key to access the Contact Resistance test function.

c. Connect the Red and Blue test leads to one side of the circuit and the Green and Yellow test leads to the other side of the resistance to be measured (see Figure 7).

d. Press the Enter key when you are ready to measure.

NOTE

The Contact Resistance measurement may take a few seconds to stabilize and display the finite result. For a new measurement, press the Enter key. This provides an updated measurement.

If the Contact Resistance is greater than 5 ohms, the test returns immediately with an over–range indication.

e. View the contact resistance value in the display.

f. Use the Return key to return to the Resistance (Ohms) measurement.

30. **900AST VOLTAGE** (Figures 8 and 9.)

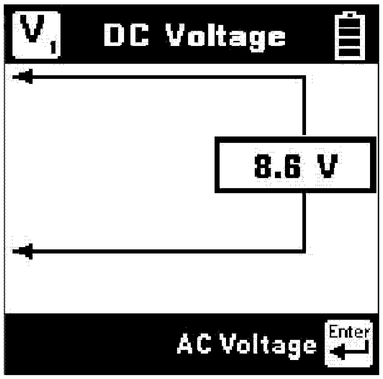


Figure 8. AST900 DC Voltage Display

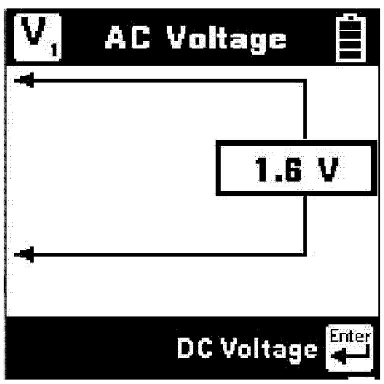


Figure 9. AST900 AC Voltage Display

WARNING

Use extreme care when testing energized circuits. Coming in contact with energized circuits may result in serious personnel injury.

CAUTION

The 900 AST meter is capable of measuring up to 300 VDC or 250 VAC. Exceeding the input voltage may cause meter damage.

NOTE

This function measures AC or DC voltage between the Red and Black test leads.

The readings are 'live' and will vary with the voltage being measured.

DC voltage is displayed first, press Enter to switch to AC voltage mode.

a. Select the V (Voltage) key to enter the voltage measurement function.

b. Connect the red and black test leads as shown on the display in Figure 8.

c. View the DC voltage measurement value in the display. (See Figure 8).

NOTE

The AST900 tester initially measures DC voltage.

d. Presss the Enter Enter key to switch from DC to AC voltage measurement.

e. View the AC voltage measurement in the display.

f. Press the Enter Enter key to switch from the AC to the DC voltage measurement.

NOTE

If voltage reading is above the meter's capability and the internal protection circuit opened, refer to paragraph 25 for additional instructions and reset.

31. **900AST RESISTANCE FAULT LOCATE (RFL)** (Figures 10 and 11).

NOTE

Use this function to locate a Resistance Fault on a pair of conductors or between a single conductor and ground.

a. Select the key to enter the resistance fault locate function.

b. Connect the test leads as shown on the display.

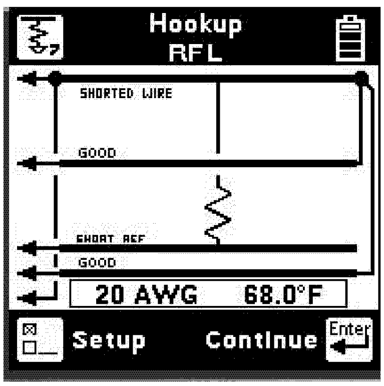


Figure 10. AST900 RFL Hookup Display

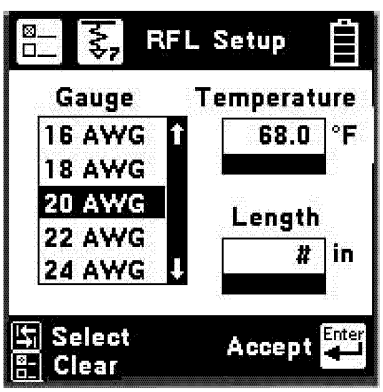


Figure 11. AST900 RFL Setup Display

(1) Connect the far−end of the faulted conductor to the two good reference wires.

(2) The other end of the reference wires are returned to the tester to connect one to the green and one to the yellow test leads.

c. Use the Setup key to show the: gauge, temperature and conductor length.

NOTE

Either the temperature or length of conductor must be selected as unknown.

d. Press the Select key to choose either: the wire gauge, the temperature, or the length of the conductor for editing.

e. To enter the wire gauge, select the Gauge box, then press the or keys to select the desired gauge.

NOTE

To enter the temperature, or wire length, enter the new value using the blue numeric keys.

Always enter the temperature of the wire itself, not the ambient temperature.

Use to enter a minus sign when entering sub−zero temp.

f. To enter the wire temperature, select the Temperature box and type in the estimated wire temperature.

g. To enter the known wire length, select the Length box and delete all the numbers in front of the decimal point, by using the Delete key and enter the new value using the blue keypad.

h. If the wire length value is unknown, press the Setup key so that a “#” is shown in the display.

Figure 12. AST900 RFL Results Display

(1) **Result:** The '**#**'sign will appear in the cleared field.

i. Press the Enter key  to accept the chosen values; press the Enter key  again, to start the test.

NOTE

When the meter is properly set up, it will display the test results (See Figure 12)

The top box displays conductor length.

The results on the second line indicate the "Distance to Fault" and the "Distance to the green and yellow connection".

The resistance value beside the resistor symbol shows the fault resistance.

The wire gauge and temperature are displayed above the bottom bar.

j. Press  to show readings in Ohms instead of distance.

k. Press again to return to distance.

32. **900 AST TIME DELAY REFLECTOMETER (TDR)** (Figures 13 and 14.).

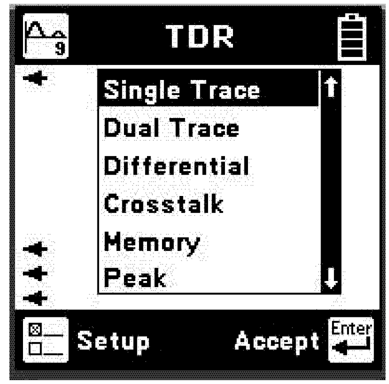


Figure 13. AST900 TDR Display

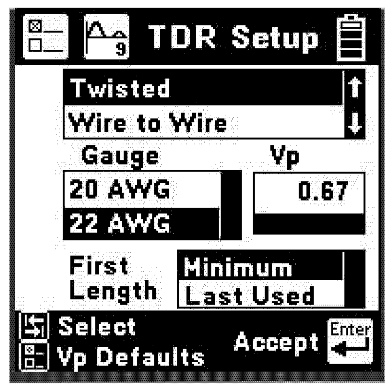


Figure 14. AST900 TDR Setup Display

WARNING

Use extreme care when testing energized circuits. Coming in contact with energized circuits may result in serious personnel injury.

NOTE

Use this function for testing for open and low resistance faults on conductors.

A Time Domain Reflectometer sends an electrical pulse on a conductor, or circuit and measures the distance to “events” (usually caused by some change in the conductor) based on input about the electrical properties of the conductor.

For best operation, use the special coaxial TDR test leads supplied with your 900AST tester to perform TDR measurements. The BNC to 20AWG wire adapters are provided for customization of the coaxial TDR leads to the target environment. The TDR test leads plug into the Red/Black and Blue/Yellow test jacks on the 900AST tester depending on the desired operation.

The readings are ‘live’ and will vary with the circuit being measured

The trace and information displayed do not show the test leads as part of a measurement. The meter is calibrated such that it shows only the circuit being measured.

a. Set Up.

(1) Select the TDR key to enter the TDR function.

NOTE

The TDR function allows the user to select one of the six modes available (shown in Figure 13).

(2) From the TDR Menu, press the Setup key to enter the TDR Setup.

NOTE

The TDR setup function allows the user to input the electrical properties of the circuit under test (shown in Figure 14).

(3) Press the Select key to move between setup parameters.

(4) Use the and keys to select wire type (including custom cables), gauge, and ‘minimum possible’ or ‘last used’ initial measurement length setting.

NOTE

Editing the velocity of propagation (Vp) may cause the TDR to read inaccurately. The meter maintains modified Vp settings in internal memory. Press the Setup key in the TDR Setup screen to restore original default Vp settings for all wire types. Refer to paragraph 21 and table 1 for additional Vp settings and information.

(5) Use the and keys and Blue numeric keys to change the velocity factor for the selected wire type or use the default setting.

b. Single Trace (Figure 15).

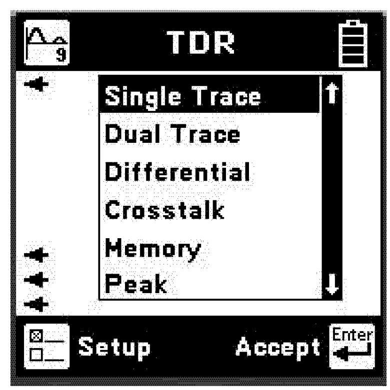


Figure 15. AST900 TDR Single Trace Selection

NOTE

The Single trace mode provides the basic trace display of the circuit under test.

(1) Press the or keys to move to the desired mode (shown in Figure 15).

(2) Insert the supplied coaxial TDR test lead into the Red and Black test jacks on the meter.

(3) Connect one TDR test lead to a single conductor or one side of a pair under test.

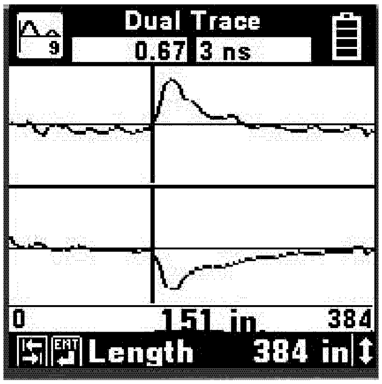


Figure 16. AST900 TDR Dual Trace Selection

(4) Connect the other lead to a reference wire.

(a). **Result:** The reference wire is the other wire in a twisted pair, another wire in a bundle running parallel to your test wire.

(b). Ground or cable shield can also be used for the return if desired, but this often results in a very “noisy” trace and is not recommended.

NOTE

The trace and information displayed do not show the test leads as part of a measurement. The meter is calibrated such that it shows only the circuit being measured.

(5) Press the Enter key to accept the choice (updated in the previous Setup step) and start the measurement.

c. Dual Trace (Figure 16).

NOTE

The Dual Trace mode provides the user with a means of displaying two circuit traces (usually a faulted and a good circuit). This enables the user to compare two like circuits on one screen.

(1) Connect the TDR test leads to the (Red and Black jacks).

(2) Connect the second TDR test lead set to the (Blue and Yellow jacks) of the reference circuit.

(3) Press the Enter key to accept the choice (updated in the Setup step) and start the measurement.

(a). **Result:** The circuit under test is displayed at the top of the display. The reference circuit is displayed at the bottom of the display.

d. Differential Trace (Figure 17).

NOTE

The Differential Trace mode provides the user with a means of displaying the difference between two circuit traces (usually a faulted and a good circuit).

(1) Connect the TDR test leads to the (Red and Black jacks).

(2) Connect the second TDR test lead set to the (Blue and Yellow jacks) of the reference circuit.

(3) Press the Enter key to accept the choice (updated in the Setup step) and start the measurement.

(a). **Result:** The circuit under test is displayed at the top of the display. The reference circuit is displayed at the bottom of the display.

e. Crosstalk (Figure 18).

NOTE

Use the Crosstalk mode to display the amplitude and location of signals that “cross” from one conductor to the other.

(1) Connect the TDR test leads to the (Red and Black jacks).

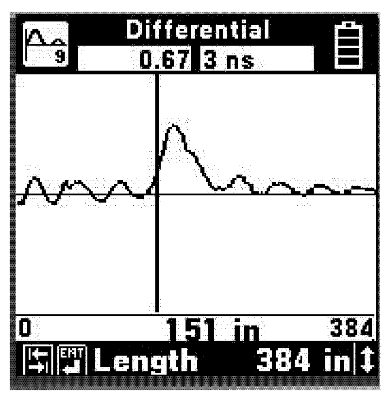


Figure 17. AST900 TDR Differential Trace Selection

(2) Connect the second TDR test lead set to the (Blue and Yellow jacks) of the reference circuit.

(3) Press the Enter key to accept the choice (updated in the Setup step) and start the measurement.

(a). **Result:** The circuit under test is displayed at the top of the display. The reference circuit is displayed at the bottom of the display.

f. Memory (Figure 19).

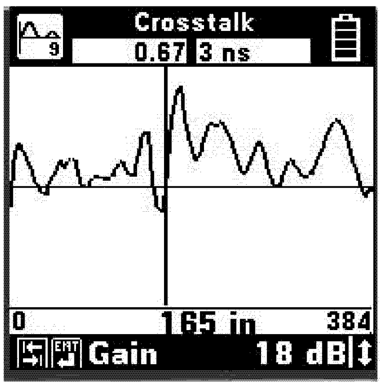


Figure 18. AST900 TDR Crosstalk Selection

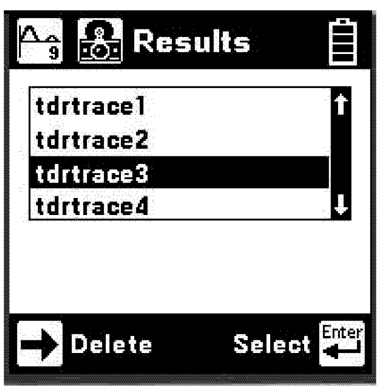


Figure 19. AST900 TDR Memory Selection

NOTE

Memory mode is used to compare a circuit under test to a stored trace in memory.

The first screen in memory mode will show a list of the ID numbers for all stored TDR traces.

Use the and keys to highlight the desired stored result.

(1) Press the Enter key to select the highlighted result and display the stored results list for that ID number by type (TDR), date and time.

(2) To delete individual stored results, press the key.

(3) Use the and keys to highlight the desired stored result.

(4) Press the Enter key to display the stored trace on the bottom of the TDR screen and the “live” trace on the top. The cursor may be moved by using the and keys (refer to step j(7) for additional information).

(5) The control settings for the stored trace can be viewed by pressing the Select key or the Enter keys (but the settings cannot be changed from this location).

NOTE

The TDR Memory function includes a Difference (‘Diff’) control, accessible from the memory screen by pressing the key. The default is Difference Control OFF.

Diff combines the live trace with the stored trace to show the difference in the two readings.

(6) Use the or arrow key to turn on the Difference Control mode.

g. Peak (Figure 20).

NOTE

Use the TDR Peak mode to capture events that may be intermittent.

(1) The 'live' trace is displayed continuously. As a new maximum or minimum trace is detected, it will replace the previous one on the display.

(2) If the circuit being tested is stable (no intermittent faults), then the minimum, maximum and "live" traces should appear as a single trace.

(3) If any of the control values are changed, the peak histories will be erased and new values will begin to display.

h. TDR Controls (Figure 21)

(1) Length allows the user to set the distance (or span) from the left side of the screen to the right side. The left side of the screen is at the end of the test leads, and the right side is the farthest distance that can be displayed with the selected length.

(2) Available controls are Length, Filter, Vp, Pulse, and Gain. For additional information on these controls, refer to the operator's manual.

i. Move Cursor.

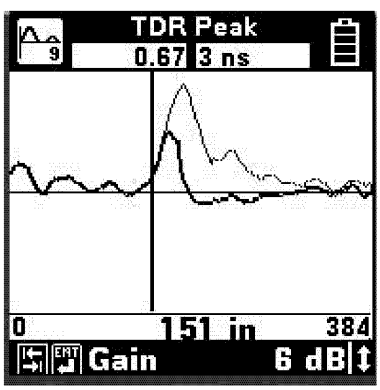


Figure 20. AST900 TDR Peak Selection

Figure 21. AST900 TDR Controls

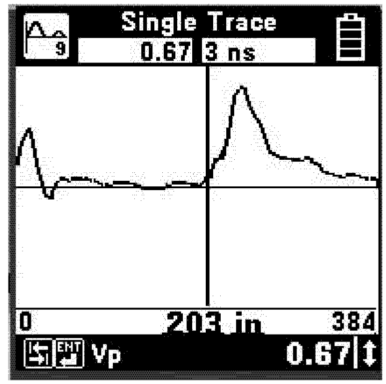


Figure 22. AST900 Target Contact and Open Circuit Display

(1) Always place the cursor to the left side of an event, to mark its location. Use the  and  arrow keys to move the cursor across the screen. The distance from the meter to the cursor is always shown in the center of the distance bar. The TDR function automatically compensates for the length of the special TDR test leads. Zero distance is at the very end of the test lead at the BNC connector. Should the BNC be used, or additional length conductor added, the meter would not compensate for it. The "Start" and "Stop" numbers shown in the distance bar are the distances represented at the left and right side of the screen.

NOTE

The following steps provide details on interpreting TDR displayed information.

j. Event Recognition.

(1) Events are the "dips" and "peaks" seen on the screen caused by faults or changes (such as an open circuit or short) on the conductor or pair.

k. Target Contact. (Figure 22).

(1) The first peak, or dip on the screen is usually the "target contact" which occurs at the point where the meter connects to the circuit under test. Since impedances of the different types of conductors vary significantly, the initial event caused by the 100–ohm TDR launch circuit contacting the target can usually be ignored. As a standard, the distance zero (0") begins at the end of the test leads for the TDR function.

l. Open Circuit (Figure 22).

(1) Any open circuit will show up as a peak on the screen.

(2) A complete open will be the tallest peak displayed.

(3) No events can be seen past a complete open.

m. Short Circuit (Figure 23).

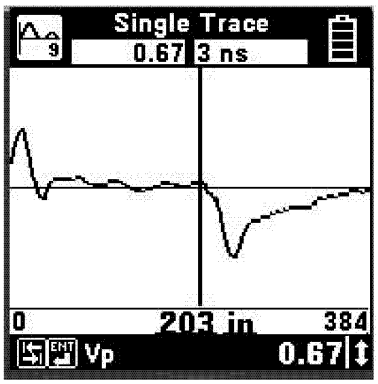


Figure 23. AST900 Short Circuit Display

(1) A short circuit (or zero–Ohm resistance fault) will show up as the lowest dip on the screen.

(2) No events can be seen past a short circuit.

n. Resistance Fault.

(1) A resistance fault will show as a dip on screen. The lower the value of resistance (or the closer to a zero–ohm short), the lower the dip.

o. Branch Circuit.

(1) A branch circuit is a wire that has one or more wires branching off of the main wire. The beginning of the branch circuit will look like a resistance fault and an open (a dip followed by a peak). Use the meter's Resistance function (step: 22) to measure the resistance on the conductors. If there is no resistance, and the display shows a dip followed by a peak, suspect a branch circuit.

p. TDR Trace Save for Wiring Trace Comparison. (Figure 24).

NOTE

Approximately 200 TDR screenshots can be saved.

Only active traces can be saved from the "Single Trace" TDR screen.

(1) Select the TDR control parameters so the screen displays the trace as desired.

(2) Press the  key.

(3) The display shows the Save Results screen (see Figure 24).

(4) Use the blue keys to enter an alphanumeric ID.

(a). The ID may have up to twelve digits.

(b). Whether a number or letter is entered depends on how many times the key is pressed.

(c). For example: if the Ohms key is pressed once, the number "3" will be displayed. If the same key is pressed twice, the letter "d" will be displayed.

(5) Use the  arrow to position the cursor under the first space and enter the first character, and then

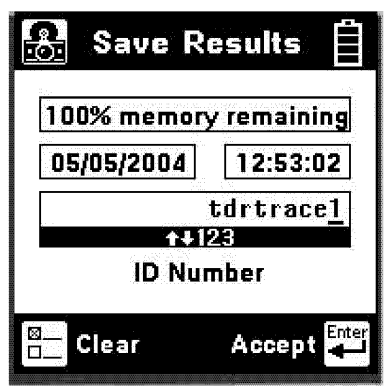


Figure 24. AST900 Save Results Display

use the arrow to move the cursor under the next space.

(6) Insert the next character and use the cursor again to position the cursor to the next position. Continue entering numbers or letters in this manner until all have been entered.

(7) To delete a character, press the key.

(8) Once the ID has been entered, press the key to save the current TDR trace information.

q. Auto TDR Trace Analysis (Figure 25).

NOTE

Use the Auto TDR function to have the meter analyze and interpret a TDR trace.

The Auto TDR function uses the wire configuration selected in the TDR function using the Setup key (refer to step a.)

The current wire configuration is imported directly and is displayed at the bottom of the screen.

To change the wire configuration select the TDR function and press the Setup key.

(1) Use the and keys and the blue numeric keys to enter the length of cable to analyze (Enter a length longer than the cable being tested but as close as possible to the total length of the conductor being tested).

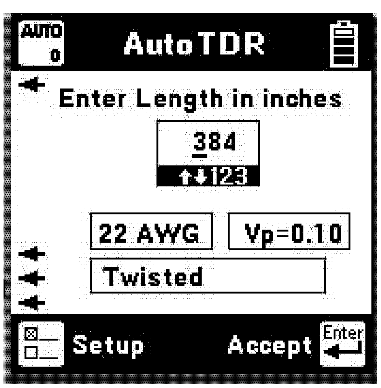


Figure 25. AST900 Auto TDR Display

(2) When the correct information is displayed on the Auto TDR screen, press the Enter key to start the analysis.

(3) The meter performs tests to determine if the conductor or cable is shorted, open circuited, or has a resistance fault.

NOTE

Resistance faults are very difficult to detect using TDR techniques. If a resistance fault is detected, the meter prompts the user to consider using the RFL (Resistance Fault Locate) function as shown in Figure 26.

Figure 26. AST900 Resistance Fault Display

Auto TDR operates from a captured trace. The trace is not ‘live’ as in the standard TDR mode.

r. Auto TDR Trace Analysis.

(1) If the Auto TDR detects an open circuit, the cursor is positioned at the location of the open circuit and OPEN is displayed below the trace. (Figure 27)

(2) If the Auto TDR detects a short circuit or low resistance fault, the cursor is positioned at the location of the short circuit and SHORT is displayed below the trace.

(3) If the most significant event is the target contact, the Auto TDR positions the cursor at the target contact point (zero distance) and displays EVENT below the trace. This usually means that there was no fault found in the selected length.

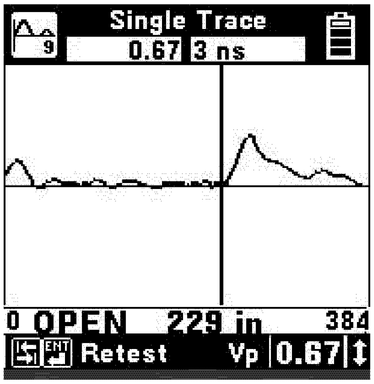


Figure 27. AST900 Open Circuit Fault Display

(4) If further analysis is needed, enter a longer length and retest. If multiple events are detected, the Auto TDR places the cursor at the most significant event and attempts to classify it.

(5) Light cursor marks are placed at less significant event locations. Press the key to move the cursor to the other events detected.

(6) In this case the low impedance anomaly at 24 inches is detected but not yet classified, the Auto TDR displays '????' below the trace. (Figure 28)

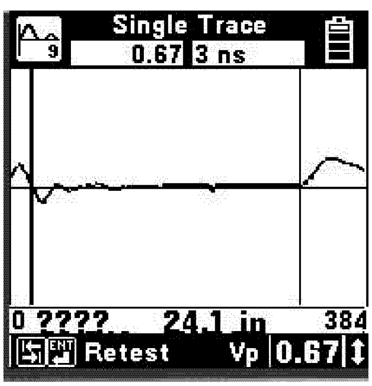


Figure 28. AST900 Unclassified Fault Display

33. 900 AST OTHER TESTS.

a. The 900AST meter is capable of performing additional wire tests. Refer to the Instruction Manual for additional information on the following tests:

(1) DC Load Test (measures the DC current through a load lamp).

(2) Capacitance Test (measures the capacitance of a component or circuit).

(3) Tone Generator (sends an interrupted tone which can be used to locate a circuit fault in a wire bundle).

34. SELF CALIBRATION (VERIFICATION).

NOTE

The self calibration function is used to self−calibrate the 900AST meter anytime that the outside temperature changes by more than 35°F.

Self−calibrate the meter at the temperature at which it will be used.

Perform a self−calibration before the meter is to be employed for the first time.

To validate the operation of the meter, a separate procedure is to be employed (Validation of Operation within Specification). This procedure is available from METCAL and the manufacturer.

a. Press the Toolbox key .

b. Select the Self−Calibrate function and press the Enter key .

c. Connect all the test leads and short them together as shown on the display (see Figure 29).

d. Press the Enter key to initiate test.

e. Result:

(1) If upon completion, the display shows: "Self−Calibration Complete", the meter is now ready for use. (See Figure 30)

(2) If upon completion, the display shows: "Self−Calibration Failed!", Check the test lead connections and perform the test again by pressing the Enter key .

(3) If the meter continues to fail the Self−Calibration, contact the manufacturer for its repair, using the information on the decal on right side of meter.

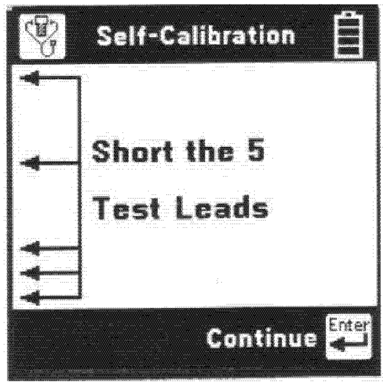


Figure 29. AST900 Self−Calibration Prompt Display

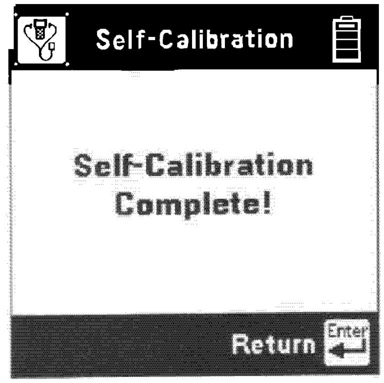


Figure 30. AST900 Self−Calibration Success Display

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BASIC FAULT ISOLATION METHODS

EQUIPMENT AND REPAIR PRACTICES FOR

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Materials Required

None

Support Equipment Required

Nomenclature	Part No./Type Designation
Digital Multimeter (DMM)	FLUKE 77 / Fluke 77 (or equivalent)
Gauge Pin Set	16U42563−1/MS3197
Multi meter (analog)	TS 352B/U

1. **INTRODUCTION.**

2. This section shows two approaches to cable assembly fault isolation. Use the first approach when full documentation of the cable is available. Use the second approach when no documentation is available. Follow these procedures only if the platform−specific manual, or T.O. does not provide instruction in these areas.

3. **First Approach.** This approach should be used for fault isolation when the information in the applicable manual, or technical order (TO) provides the schematic or point−to−point wiring list. Where radio frequency (RF) cables are involved, specific platform manual, or T.O. data for frequencies and wave forms may also be required for fault isolation.

WARNING

Remove all electrical power from the affected connector, or circuit before proceeding with any of the following steps. Failure to do so can result in damage to the equipment and severe injury, or death to personnel.

4. **Visual Inspection.** The importance of a thorough visual inspection of the entire cable assembly can not be over emphasized. Valuable time can be saved when an obvious problem is identified before performing a pin−for−pin test. Items to look for are shown in WP 004 01.

5. **Worn/Loose−Fitting Socket (Pin Retention Check).** A worn socket contact can be identified using its corresponding pin contact and a small weight (Gauge Pin Set is 16U42563−1, or equivalent). Hold connector vertically and hang the small weight from a pin contact. Insert it into each of the same size sockets. If the pin falls out, the socket may be worn. Replace worn socket contacts, as during aircraft vibration or high G−loading, the circuit continuity could be interrupted. Table 1 gives hanging weight values for different contact sizes. For example, a size 10 pin/socket pair should support a minimum of three ounces without separating.

6. **Point−to−Point Continuity.** Following the cable's wire data list or wiring schematic, perform a continuity or resistance check for all connections (see paragraph 16).

a. Check closely for the following:

(1) Open connections.

(2) Shorted connections between:

(a) Adjacent contacts.

(b) Contacts and shield.

Table 1. Contact Separation Forces

Contact Mating Size	Minimum Hanging Weight (Ounce)
4/0	12
2/0	12
1	12
2	8
4	8
6	4
8	4
10	3
12	2.5
16	1.5
20	0.6
22	0.6
23	0.4

(3) Loose connections when moving/flexing the cable; may cause a short, open, or change in resistance value.

7. A multimeter (DMM) test−lead can be easily adapted for cable assembly troubleshooting. Clipping the proper contact pin/socket onto the test−lead simplifies connection to the cable/connector. WP 004 00, table 7, contains conductor resistance values. Use those values as a reference to determine excessive resistance in cables.

8. Refer to WP 014 02, for additional information on the operation of various diagnostic equipment on performing additional tests on wiring and interconnect systems.

9. **Second Approach**. This approach should be used for fault isolation when the applicable manual, or TO does not contain a schematic or point−to−point wiring list.

10. **Visual Inspection.** Perform a complete visual inspection. Look closely for corrosion, broken pins, deep cuts, and smashed connectors. Refer to WP 004 01 for additional inspection items.

11. **Worn/Loose−Fitting Socket.** See Paragraph 5.

12. **Point−to−Point Continuity.** Perform single point continuity check to all other in order to draw a wiring diagram for the assembly. If a known functioning cable is available, make the schematic from that cable. It is important to make a schematic before disassembling the defective cable. See Paragraphs 16 and 17 for more information on continuity checks.

13. **Disassembly.** Disassemble one connector at a time. Remove any cable clamps, backshells, and extensions

necessary to reveal all connections. See this manual and NA 01−1A−505−2 or −3 for specific connector assembly/disassembly and repair techniques.

14. Perform a visual inspection of the wire/contact area.

a. Look carefully for the following:

(1) Loose or broken wires.

(2) Corroded connections and fungus growth.

(3) Broken splices.

(4) Metal filings.

(5) Moisture.

15. If one or two wires are broken, close examination can help identify where the wires were connected by looking for the following:

a. Contact(s) with solder in solder cup.

b. Crimped contact.

c. Number of strands remaining in contact and number of strands missing from wire.

d. General orientation/location of the broken wire.

16. **Continuity Test.**

a. Test all wires and wire groups as fabricated, with terminations attached, for short circuits as well as for continuity between the termination points specified on the applicable schematic.

CAUTION

Do not use lead pencils to count pins in connectors; points can break off and lodge in the connector, leading to arching, shorting, and system malfunction.

Do not use oversize probes in connector sockets during testing; this may result in splayed or damaged sockets.

Do not puncture wire insulation with a probe, or attach clamps to wire insulation while continuity testing or trouble shooting.

b. Use the ohmmeter section of an approved analog multi meter, using the TS 352B/U, or a digital multi meter (DMM) such as a Fluke 77 (or equivalent) to determine circuit continuity. Continuity for short runs, where conductor resistance is not a factor, is defined as “zero” resistance. The procedure for determining continuity, using a multi meter is as follows:

NOTE

Steps 1 thru 3 address steps to be followed using a DMM (such as a FLUKE 77). Steps (4) thru (6) show the use of an analog multi meter (such as a TS 352B/U). Skip steps (1) thru (3) if using an analog multi meter. Either method is suitable for determining conductor continuity.

(1) Refer to the operator’s manual of the DMM used and set meter for a resistance check.

(2) Apply the test leads to the terminations of the wire run

(3) Note reading on the ohms scale. A reading of 0.25 ohms, is considered verification of circuit continuity.

NOTE

Steps (4) thru (6) address steps to be followed when using a typical analog multi meter (such as TS 352B/U).

(4) Set the function control to OHMS, and the range control to RXI. Zero the instrument as directed in the operating manual for the instrument used.

(5) Apply the test leads to the terminations of the wire run.

(6) Note reading on the ohms scale. A reading of 0.25 ohms, +0.25 ohms, is considered verification of circuit continuity.

NOTE

The test lead extremities contacting the terminations under test must provide adequate constant contact, and must not damage the termination.

17. **Test Leads.**

CAUTION

Do not insert an oversized test probe into a connector socket, as this will result in a splayed or damaged contact. Do not hang a test lead from a pin contact as this will result in a bent pin.

18. For ground points and terminal lugs, use test leads with alligator clips. For connector pins and sockets, use a special lead ending in a sleeve−insulated pin or socket of the same size as that being tested.

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SHIELD TERMINATIONS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Bus Bar and Terminal Board 019 00
Soldering 016 00
Wire and Cable Stripping 009 00
Lockwiring and Shearwiring 018 00
Wire Characteristics and Substitutions 004 00
Connectors Electrical (Circular, Miniature, Quick disconnect, environment resisting),
Receptacles, Plugs, General Specification For MIL-C-26482
Connectors Electrical (Circular, Environment Resisting), Receptacles,
Plugs, General Specification For MIL-DTL-83723
Standard General Requirements for Electronic Equipment MIL-HDBK-454
Wiring Aerospace Vehicles AS50881A

Alphabetical Index

Subject — Page No.

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part. No./Type Designation
Fixture, Holding	AD-156
Heat Gun	HT-900B
Heat Gun	HT-920B
Heater, Two Station	IR-1044
Heating Tool, Infrared	IR-500
Heating Tool, Infrared	IR-550

Materials Required

Contact		M39029/73–397
Contact		M39029/73–398
Contact		M39029/73–396
Contact		M39029/74–399
Contact		M39029/74–400
Contact		M39029/74–401
Shield Terminations		SAE–AS83519 Series
Shielding Jumper Wire		M22759/11-22-5
Shielding Termination Ferrule	1	3280XX
Shielding Termination Ferrule	1	5M608-XX
Sleeve, Filling		CTA-0006
Sleeve, Filling		CTA-0042
Sleeve, Protective		RNF-100
Sleeving, Insulation	1	M23053/12-XX-0
Tape, Insulation, Electrical, High Temperature, Polytetrafluoroethylene, Pressure Sensitive		A–A–52080 thru A–A–52084
Wire		MIL-W-22759

Note

1 Size required to be determined by technician.

1 . **INTRODUCTION.**

2 . This work package (WP) covers the types of shield terminations used for shielded/coaxial cables, their selection and the authorized shield termination installation procedures for terminating shields and shielded cable on aircraft.

3 . **SHIELD TERMINATIONS FOR SHIELDED/ COAXIAL CABLE.**

4 . **DESCRIPTION.** Shield terminators are used to terminate shielded single cable, multi–conductor cable and coaxial cable to a wire pair PC board, connector terminals, wire-wrap posts, or match impedance between cable and PC boards.

5 . The types of shield terminations are solder sleeves, paddle card, pinpak, and matched impedance terminations.

6 . **HEATING.** Proper heat is essential to all types of shield terminations to ensure proper solder connection and sealing. These shield terminations are designed to be installed using a heat gun or infrared heating tool.

7 . **SOLDER SLEEVE TERMINATIONS.** A solder sleeve termination consist of heat-shrinkable insulation sleeve with an integral solder preform with flux and thermal indicator, Class I termination only, and two integral rings of sealing material. When specified, these terminations contain a preinstalled ground lead. Environment resistant. heat-shrinkable solder type terminations may be used on data bus, shield, and coaxial cables where temperatures does not exceed 302°F (150°C).

8 . **FUNCTION.** When the solder sleeve is placed over a cable and heated, the solder melts and flows connecting the ground lead to the shield. The outer sleeve shrinks and the thermoplastic insert melts encapsulating the termination. The result is a soldered, strain relieved, and environmentally protected termination.

9 . **VERSATILITY.** Solder sleeve terminations can be utilized at any location along a cable providing excellent protection from electromagnetic interference.

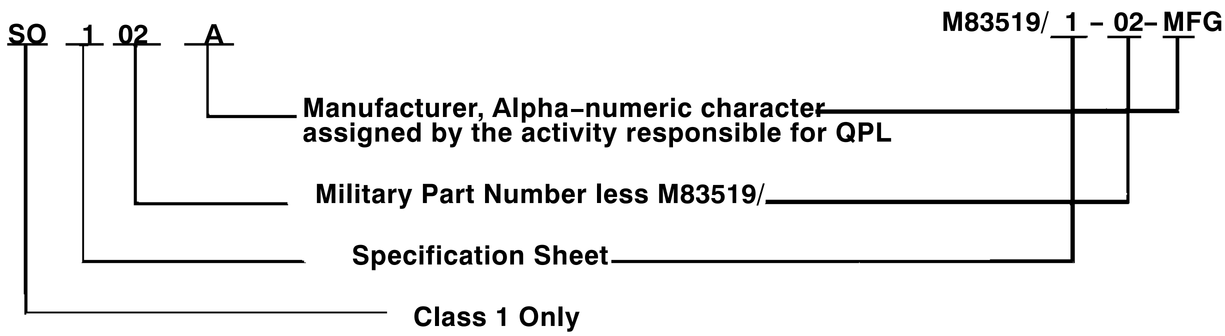
10 . **CLASSIFICATION.** Solder sleeve terminations are divided into two classes, Class I and Class II.

11 . **Class I.** These terminations are intended for use by the military and the only class authorized for use by their activities.

12 . **Class II.** These terminations are authorized for original equipment manufacturers and are not to be used for replacement purposes.

13 . **MARKING CODE.** Class I terminations are permanently marked with six alpha-numeric characters in contrasting ink (Figure 1) Class II terminations are marked with four alpha-numeric characters consisting of specification sheet number, a two digit part number, and an alpha character manufacturer code.

14 . **IMMERSION RESISTANT SOLDER SLEEVES (PREFERRED).** Immersion resistant solder sleeve shield grounding terminations provide a strong, environmentally sealed, soldered connection which is both completely insulated and encapsulated. They are can be procured with a pre-installed ground lead to provide: a single pre-assembled part. The preinstalled ground lead combined with the solder sleeve termination



Example: S0102X – Standard configuration without ground lead – .145 I.D.
S0215X – Standard configuration with preinstalled ground lead – .300 I.D.

Figure 1 . Marking Code

method means part positioning and installation are exceptionally fast, easy, and convenient (Figure 2).

15 . Advantages of immersion resistant solder sleeves are as follows:

a. Higher operating temperatures.

b. Altitude immersion resistant.

c. Meets sealing requirements of AS50881.

16 . **M83519/1 or Series SO1.** These solder sleeves are supplied without a ground lead; and if required, ground lead must be installed. (Figure 3).

17 . **M83519/2 or Series SO2.** These solder sleeves are supplied with a pre-tinned ground lead (Figure 4).

18 . **IMMERSION RESISTANT SOLDER SLEEVE SELECTION.** To provide proper sealing and connection, the solder sleeve must be selected by size and cable dimensions (Figure 5).

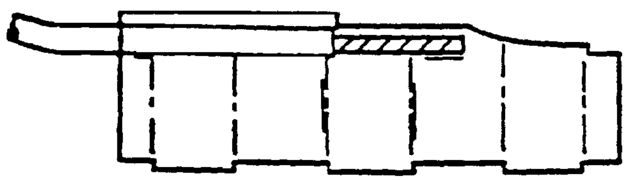


Figure 2 . Immersion Resistant Solder Sleeve

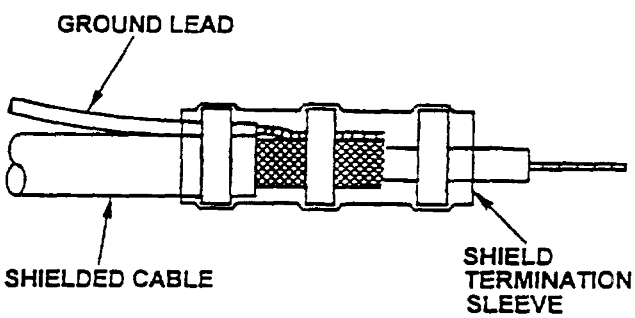


Figure 3 . M83519/1 Termination

NOTE

For center stripped applications on cables rated above 257°F (125°C) only, the cable jacket diameter shall not exceed E maximum.

When using an M83519/2 the E diameter is of the cable only.

The G dimension is the minimum the sleeve will seal. Additional sealing material may be required for certain multi conductor cables.

19 . **STANDARD SOLDER SLEEVES.** Standard solder sleeve shield grounding terminations provide a strong, soldered connection that is completely insulated and encapsulated. They are not normally supplied with a pre-installed ground lead to provide a single pre-assembled part (Figure 6). The pre-installed ground lead combine with the solder sleeve termination method means part positioning and installation are exceptionally fast, easy, and convenient.

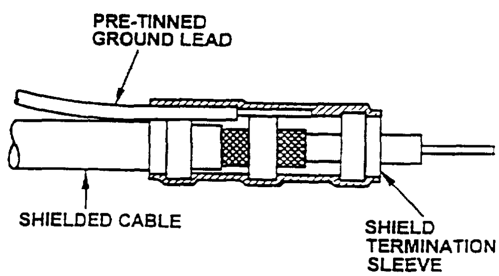
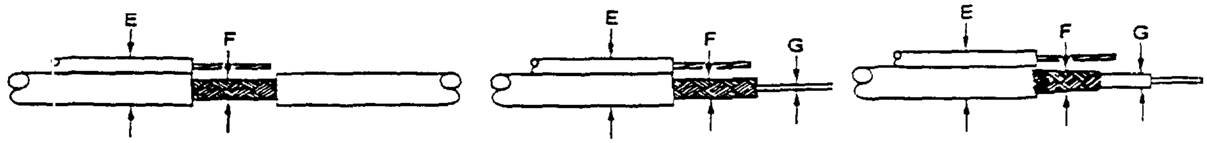


Figure 4 . M83519/2 Termination



CENTER STRIP

END STRIP

END STRIP
BRAID FOLDED BACK

NOTE:
FOR CENTER–STRIPPED APPLICATIONS ON CABLES RATED ABOVE 257° F (125° C) ONLY THE CABLE JACKET DIAMETER SHALL NOT EXCEED E MAX.

WHEN USING A SLEEVE WITH A PRE–INSTALLED LEAD. THE E DIAMETER IS THE DIAMETER OF THE CABLE ONLY.

G DIAMETER IS THE MINIMUM DIAMETER ON WHICH THE SLEEVE WILL SEAL.

USE FOLD BACK METHOD FOR CABLES RATED BELOW 257 F (125° C).

Part Number	Marking Code	Gage of Ground Lead	E Max.	F Min.	G Min.
M83519/1-1	S0101X	—	.105	.035	.020
M83519/1-2	S0102X	—	.145	.055	.030
M83519/1-3	S0103X	—	.200	.085	.050
M83519/1-4	S0104X	—	.255	.130	.070
M83519/1-5	S0105X	—	.300	.170	.100
M83519/2-1	S0201X	20	.105	.035	.020
M83519/2-2	S0202X	20	.145	.055	.030
M83519/2-3	S0203X	20	.200	.085	.050
M83519/2-4	S0204X	20	.255	.130	.070
M83519/2-5	S0205X	20	.300	.170	.100
M83519/2-6	S0206X	22	.105	.035	.020
M83519/2-7	S0207X	22	.145	.055	.030
M83519/2-8	S0208X	22	.200	.085	.050
M83519/2-9	S0209X	22	.255	.130	.070
M83519/2-10	S0210X	22	.300	.170	.100
M83519/2-11	S0211X	24	.105	.035	.020
M83519/2-12	S0212X	24	.145	.055	.030
M83519/2-13	S0213X	24	.200	.085	.050
M83519/2-14	S0214X	24	.255	.130	.070
M83519/2-15	S0215X	24	.300	.170	.100
M83519/2-16	S0216X	26	.105	.035	.020
M83519/2-17	S0217X	26	.145	.055	.030
M83519/2-18	S0218X	26	.200	.085	.050
M83519/2-19	S0219X	26	.255	.130	.070
M83519/2-20	S022OX	26	.300	170	.100
X = The Manufacturer’s Alpha Numeric Character assigned by the Qualifying Activity					

Figure 5 . Immersion Resistant Solder Sleeve Selection

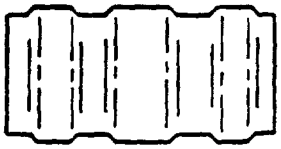


Figure 6 . Standard Solder Sleeve

20 . The heat-shrinkable thermoplastic sleeve contains a fluxed solder preform which provides exactly the amount of solder and flux required to terminate the ground lead to the cable shield. Thermoplastic sealing rings, one at each end of the sleeve, melt when the sleeve, is heated, providing strain relief and forming an environmental seal to protect the termination from dirt and moisture. The termination contains a thermochromic temperature indicator (Class 1 only) to assist in termination and inspection. In addition, a permanent identification number is marked on the sleeve.

21 . **COAXIAL CABLE SOLDER SLEEVE TERMINATIONS.** Coaxial cable solder sleeve terminations (Figure 7) are used to terminate coaxial cables to PC boards, solderless wrap terminals, and crimp solder connections. These solder sleeves consist of two heat-shrinkable thermoplastic sleeves, each containing a ground or signal lead, fluxed solder preform and thermoplastic sealing inserts. The thermoplastic sealing inserts melt when the sleeve is heated to form an environmentally protected termination and eliminates the possibility of a solder bridge between the center conductor and the shield. Two types of coaxial terminators are available for use with low temperature, -67°F (-55°C) to -257°F (+125°C) and high temperature, -67°F (-55°C) to +302°F (+150°C).

22 . **Low Temperature Part Number Breakdown.** Figure 8 provides the part number breakdown for the Series D−131 low temperature coaxial cable solder sleeve terminations.

23 . **Low Temperature Selection.** The dielectric O.D. (Table 1) determines low temperature coaxial cable solder sleeve size.

24 . **High Temperature Part Number Breakdown.** Figure 9 provides the part number breakdown for the Series D-181 high temperature coaxial cable solder sleeve terminations (Table 2).

25 . **COAXIAL CABLE WITH AIR/POLYETHYLENE DIELECTRIC SOLDER SLEEVE TERMINATIONS.** Coaxial cable with air/polyethylene dielectric solder sleeve terminations (Figure 10) is used to terminate cables to a wire pair, PC board, connector terminals, or wire-wrap posts. These solder sleeves consist of two separate assemblies. The center conductor termination consists of a dielectric barrier and a heat-shrinkable sleeve containing a fluxed solder preform, a meltable insert, and a pre-installed ground lead. These solder sleeves are used on low temperature cables with a temperature rating of -67°F (-55°C) to +257°F (+125°C).

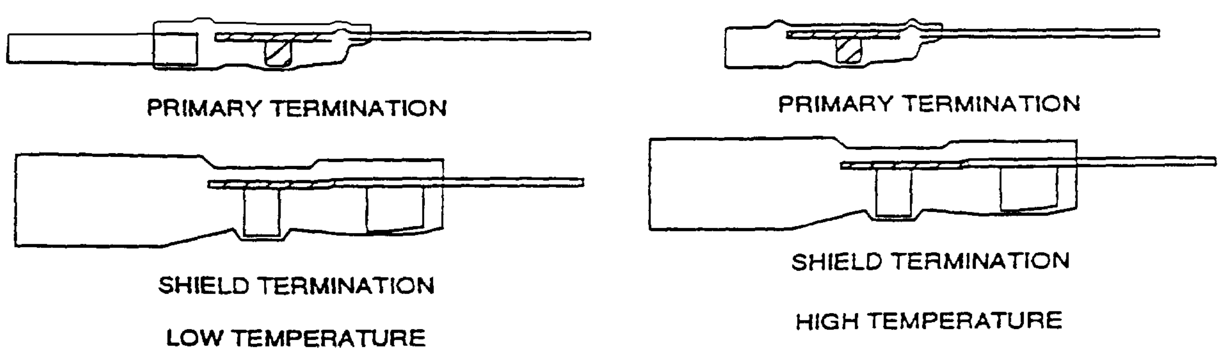


Figure 7 . Coaxial Cable Solder Sleeves

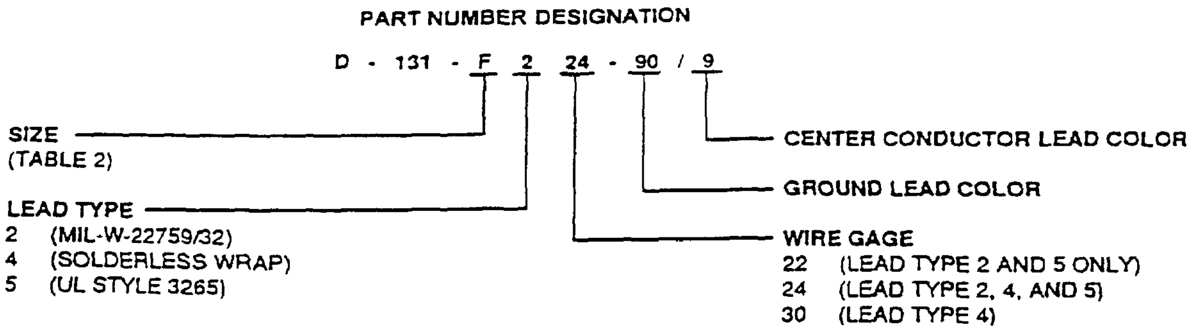


Figure 8 . Low Temperature Coaxial Cable Termination Part Number Breakdown

Table 1 . Low Temperature Coaxial Cable Solder Sleeve Selection

Termination Size	Dielectric O.D (in)	Cable Type	Termination Size	Dielectric O.D (in)	Cable Type
A	.050	—	G	.110	—
B	.060	—	H	.120	—
C	.070	174	J	.130	58
D	.080	—	K	.140	—
E	.090	—	L	.150	—
F	.100	122	M	.160	59, 62, 100

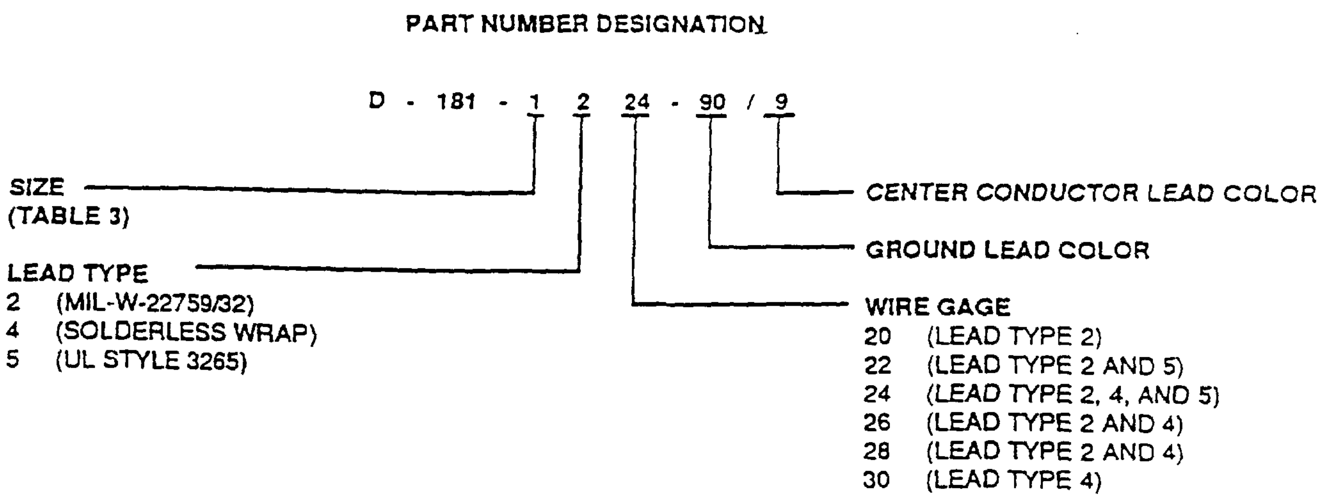


Figure 9 . High Temperature Coaxial Cable Solder Sleeve Selection

Table 2 . High Temperature Coaxial Cable Solder Sleeve Selection

Termination Size	Dielectric O.D. (in)	Shield O.D. (in)	Jacket O.D. (in)	Cable Type
D-181-1XXX	.025-.090	.045-.125	.060-.140	178, 179, 188, 316, 404
D-181-2XXX	.035-.118	.060-.140	.075-.170	180, 279
D-181-3XXX	.055-.153	.085-.180	.100-.205	141, 195, 302, 303, 400

Table 3 . Coaxial Cable with Air/Polyethylene Dielectric Solder Sleeve Termination

Part Number	Primary Lead Color Code	Ground Lead Color Code	Dielectric O.D. (in) max	Jacket O.D. (in)	Lead Wire Gage
D-500-0089	White	Blue	.130	.145-.290	22AWG
D-500-0114	White	Blue	.080	.090-.215	24AWG
D-500-0120	Yellow	White	.130	.145-.290	22AWG
D-500-0121	Yellow	White	.130	.145-.290	24AWG
D-500-0122	Yellow	White	.130	.145-.290	26AWG
D-500-0134	White	White with Black Stripe	.157	.200-.290	22AWG

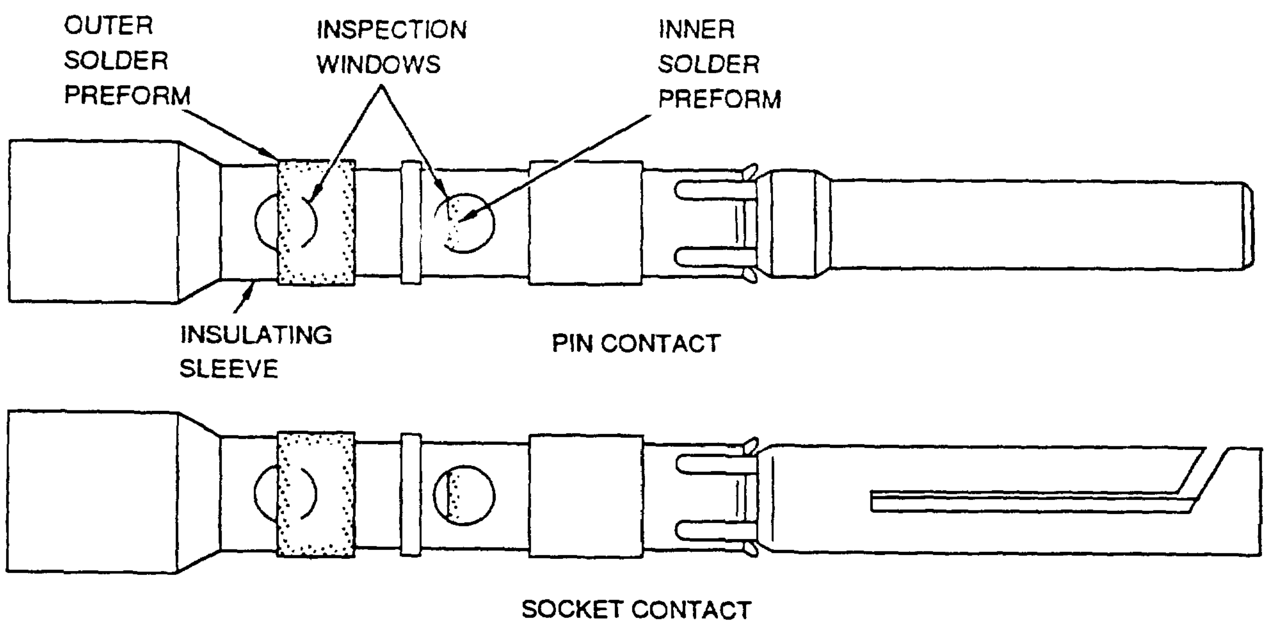


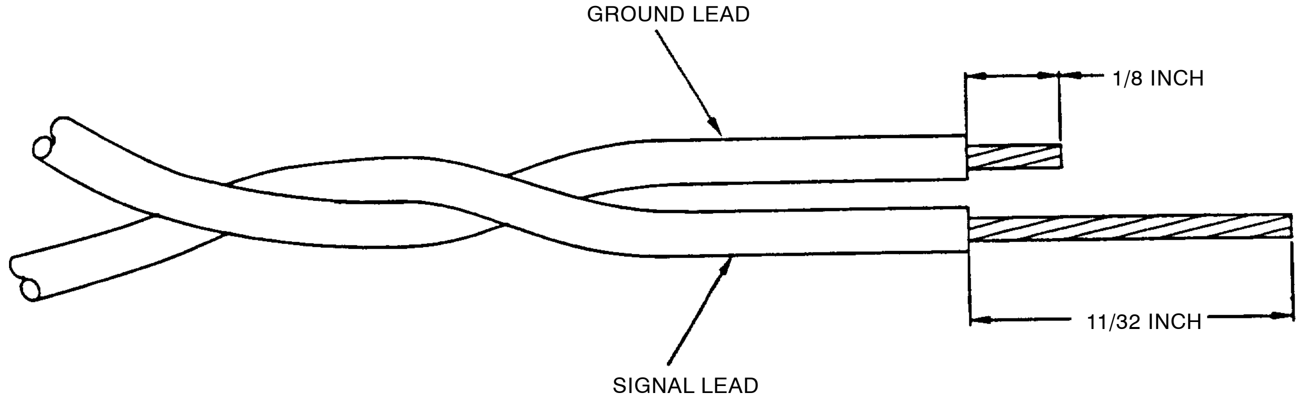
Figure 10 . Typical Coaxial Solder Contact

26 . **COAXIAL CABLE WITH AIR/ POLYETHYLENE DIELECTRIC SOLDER SLEEVE TERMINATION SELECTION.** Selection of these solder sleeves is determined by the O.D. of the dielectric and jacket and the lead wire gage (Table 3).

27 . **PADDLE CARD TERMINATIONS.**

28 . Paddle card terminations (Figure 11) are used to terminate coaxial cables to paddle card or PC boards. These terminations consist of a heat-shrinkable sleeve containing a pre-installed ground bus and a solder preform. When the paddle card termination is installed on a coaxial cable, the ground bus is soldered to the shield and the heat-shrinkable sleeve (Figure 12).

29 . **PADDLE CARD TERMINATION SELECTION.** Selection of paddle card terminations is determined by the O.D. of the cable jacket. For cables with a temperature rating below 257°F (125°C), select the dielectric barrier by dielectric O.D. of the cable and paddle card termination to be installed (Table 4).



FOR CONTACTS NO.
D–602–54, D–602–55, D–602–56
D–602–57, M39029/74–401, MS39029/73–398

Figure 11 . Strip Dimensions for Twisted Pair Solder Contacts

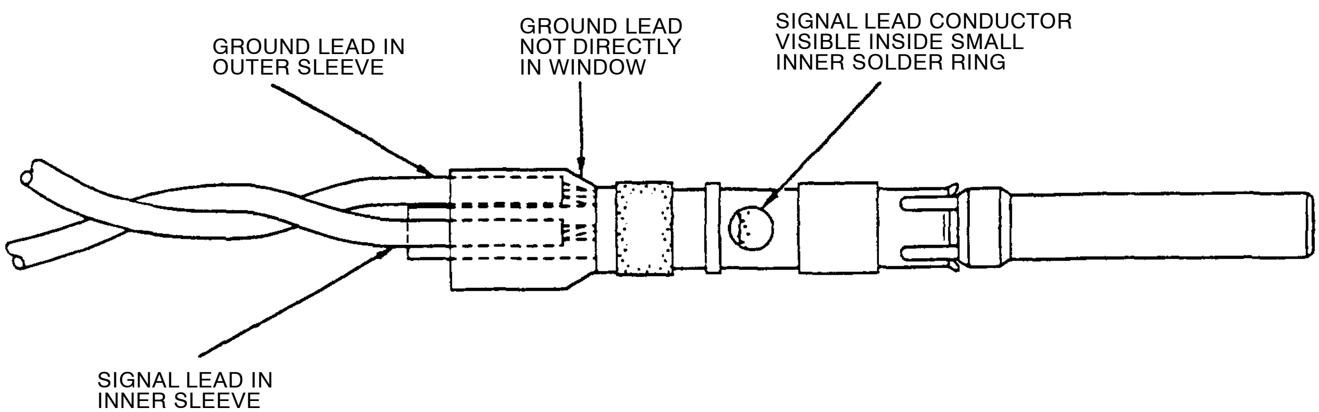


Figure 12 . Inserting Twisted Pair into Solder Contact

Table 4 . Paddle card Termination and Dielectric Barrier Selection

Termination Part Number	Cable Jacket O.D. (in)	Color Code	Barrier Part Number	Cable Dielectric O.D. (in)	Color Code
D-134-03	.070-.130	Black	D-513-03	.020-.030	Yellow
D-134-04	.090-.215	Blue	D-513-04	.030-.040	Blue
			D-513-05	.040-.050	White
			D 513-06	.050-.060	Yellow
			D 513-07	.060-.070	Blue
			D-513-08	.070-.080	White
			D-513-09	.080-.090	Yellow
D-134-05	.130-.240	Yellow	D-513-09	.080-.090	Yellow
			D-513-10	.090-.100	Blue
			D-513-11	.100-.110	White
			D-513-12	.110-.120	Yellow
D-134-06	.145-.270	Red	D-513-10	.090-.100	Blue
			D-513-11	.100-.110	White
			D-513-12	.110-.120	Yellow
			D-513-13	.120-.130	Blue
			D-513-14	.130-.140	White
D-134-07	.165-.315	Green	D-513-12	.110-.120	Yellow
			D-513-13	.120-.130	Blue
			D-513-14	.130-.140	White
			D-513-15	.140-.150	Yellow
			D-513-16	.150-.160	Blue
			D-513-17	.160-.170	White
D-134-08	.190-.365	Violet	D-513-15	.140-.150	Yellow
			D-513-16	.150-.160	Blue
			D-513-17	.160-.170	White
			D-513-18	.170-.180	Yellow
			D-513-19	.180-.190	Blue
			D-513-20	.190-.200	White
			D-513-21	.200-.210	Yellow
			D-513-22	.210-.221	Blue

30 . PINPAK COAXIAL TERMINATIONS.

31 . PinPak coaxial terminations (Figure 13) are used to terminate coaxial cables to PC boards. These terminations consist of a heat-shrinkable sleeve containing a pre-shaped lead member, solder preforms, and meltable insert. The lead member consists of a ground lead portion and a signal lead portion, which are on a fixed spacing to match the holes in the PC board. The other end of the lead member fits the coaxial cable so that the ground lead aligns with the braid and the signal leads aligns with the cable center conductor. When the termination is installed, the shield and the center conductor are simultaneously soldered to the lead member and the sleeve shrinks to form an insulated and strain relieved termination.

32 . **PINPAK COAXIAL TERMINATION SELECTION.** Selection of these terminations is determined by cable O.D., shield type, lead diameter, and row spacing (Table 5).

33 . **MATCHED IMPEDANCE TERMINATIONS.**

34 . Matched impedance terminations (Figure 14) provide a fully shielded, low voltage standing wave ratio (VSWR), matched impedance termination of 50 and 75 ohm coaxial cables to PC boards. These terminations consist of a tin plated copper body, heat-shrinkable sleeve, and a fluxed solder preform. When installed and soldered to the PC board, all conducting and insulating components are securely fixed to maintain consistent impedance.

35 . **MATCHED IMPEDANCE TERMINATION SELECTION.** These terminations are supplied in one size, which fit cables with a jacket diameter of .075 to .110 inch and a dielectric diameter of /034 to .060 inch. Selection is determined by requirement for a straight or right angle matched impedance termination.

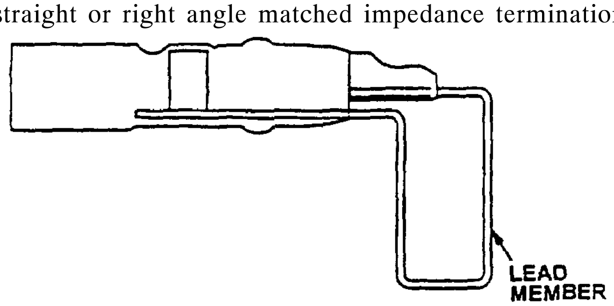


Figure 13 . PinPak Coaxial Termination

The D-607-09 is the straight termination and D-607-10 is the right angle termination.

36 . **SHIELD TERMINATION INSTALLATION.**

NOTE

Thermal indicator is the red color around the solder band and is used as an inspection aid. The final inspection criteria for a proper termination is as called out in MIL-HDBK-454 Requirement 5 and Figure 15 .

37 . **HEATING.** Proper heat is essential to ensure proper solder connection and sealing. The sleeves are designed to be installed using the HT-900B/HT-920B Heat Gun or IR-500/550 infrared heating tool. The sleeve contains a colored thermochromic temperature indicator that changes to clear when the surfaces have reached wetting temperature, which also aids in the inspection of the completed transmission (Figure 15).

38 . The following paragraphs and Figures provide installation procedures for all shield terminations presented in this manual.

39 . **IMMERSION RESISTANT AND STANDARD SOLDER SLEEVE INSTALLATION.** Figures provides installation procedures for the M83519/1, M83519/2, and Series SO immersion resistant solder sleeves.

40 . **COAXIAL CABLE SOLDER SLEEVE TERMINATION INSTALLATION.** Figure 17 and Figure 18 provide installation procedures for low temperature Series D-131 and high temperature Series

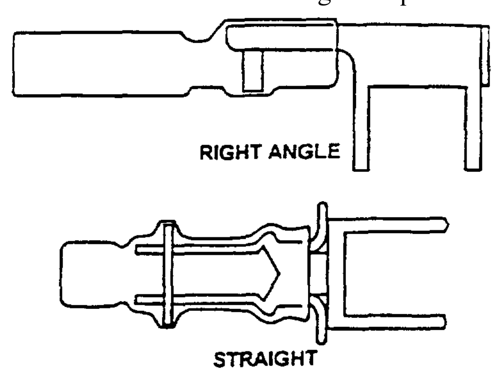


Figure 14 . Matched Impedance Termination

D-181 coaxial cable solder sleeve installation, respectively.

41 . **PADDLE CARD TERMINATION INSTALLATION.** (Figure 19) provides installation procedures for paddle card terminations.

42 . **INFRARED.** Infrared heat may be used when available. Solder sleeves may be affixed with these tools which offer faster shrinking and solder flow and a1so less complication in setup and portability. There are two types of Infrared Heating tools.

43 . **IR-550.** This tool is a self contained portable unit that requires 115 volts AC for operation. The tool consists of a main body with a stand and handle attached (Figure 16).

44 . **IR-500B.** This tool is a self contained portable unit that requires 115 volts AC for operation. The tool differs slightly in that the IR-500 has a screen covered main body with a stand and handle that contains a trigger switch where as the IR-500B has a pressure push switch.

45 . **INFRARED PROCEDURE.** The procedure for shrinking solder sleeves is as follow:

a. Prepare cable as in Figure 17 depending upon the application required.

b. Assemble cable, ground lead when required, and solder sleeve. Ensure no strands protrude to puncture sleeve. Ground lead entry can be either front or rear (Figure 18).

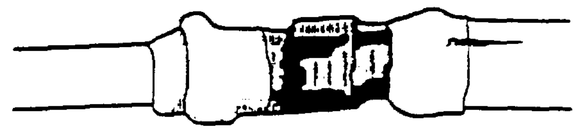
UNACCEPTABLE TERMINATION (INSUFFICIENT HEAT)

DULL RED COLOR (THERMAL INDICATOR) IS CLEARLY VISIBLE.

ORIGINAL SHAPE OF SOLDER PREFORM IS CLEARLY VISIBLE.

MELTABLE SEALING INSERTS HAVE NOT FLOWED.

CONTOUR OF BRAID AND/OR LEAD IS BLOCKED BY SOLDER.



ACCEPTABLE TERMINATION (MINIMUM SOLDER FLOW)

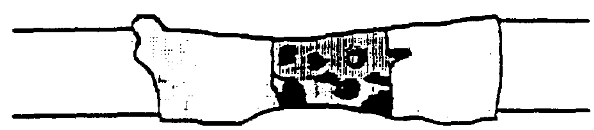
SLIGHT TRACES OF DULL RED COLOR SHALL BE PRESENT.

SOLDER HAS LOST ALL ORIGINAL SHAPE.

SEALANT INSERTS HAVE MELTED AND FLOWED ALONG WIRES.

SHIELD AND LEAD CONTOURS ARE VISIBLE.

A DEFINITE FILLET IS VISIBLE BETWEEN LEAD AND SHIELD.



ACCEPTABLE TERMINATION (MAXIMUM SOLDER FLOW)

DULL RED COLOR HAS DISAPPEARED.

NO TRACES OF DULL RED COLOR REMAIN IN THE SEALANT INSERT AREA. SLIGHT TRACES OF DULL RED COLOR IN SEALANT INSERT AREA ARE ACCEPTABLE.

A DEFINITE FILLET IS CLEARLY VISIBLE BETWEEN LEAD AND SHIELD.

JOINT AREA IS VISIBLE DESPITE BROWNING OF SLEEVE.

UNACCEPTABLE TERMINATION (OVERHEATED)

JOINT AREA IS NOT VISIBLE BECAUSE OF SEVERE DARKENING OF THE OUTER SLEEVE.

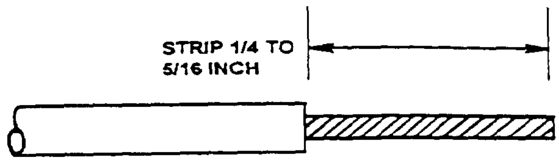
SOLDER FILLET IS NOT VISIBLE ALONG LEAD AND SHIELD INTERFACE.

WIRE INSULATION DAMAGED OUTSIDE OF SLEEVE.

Figure 15 . Termination Inspection

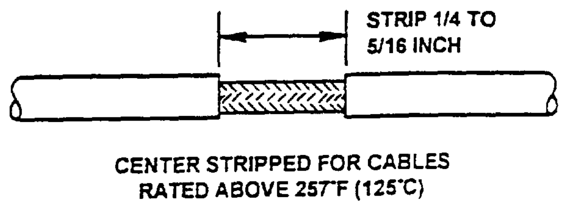
A. GROUND LEAD PREPARATION.

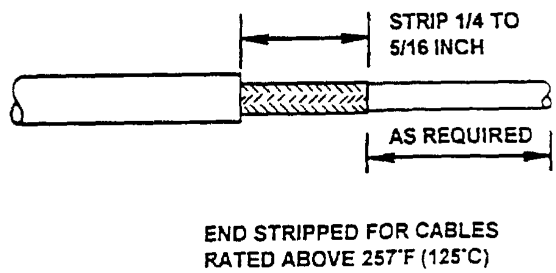
1. IF GROUND WIRE IS NOT PRE–INSTALLED, SELECT WIRE FROM MIL–W–22759



B. SHIELD PREPARATION

1. STRIP 1/4 TO 5/16 INCH OF JACKET FROM CABLE.





2. AFTER STRIPPING, BUILD UP DIAMETER OF SMALL CABLE BY FOLDING BRAID OVER JACKET.

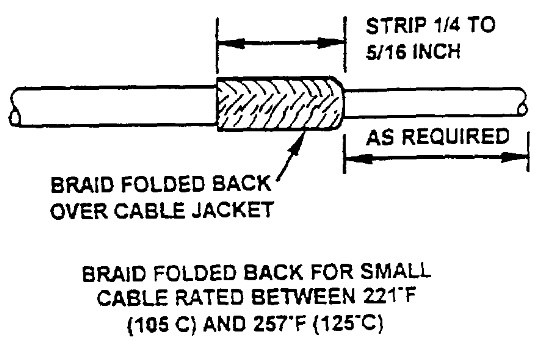
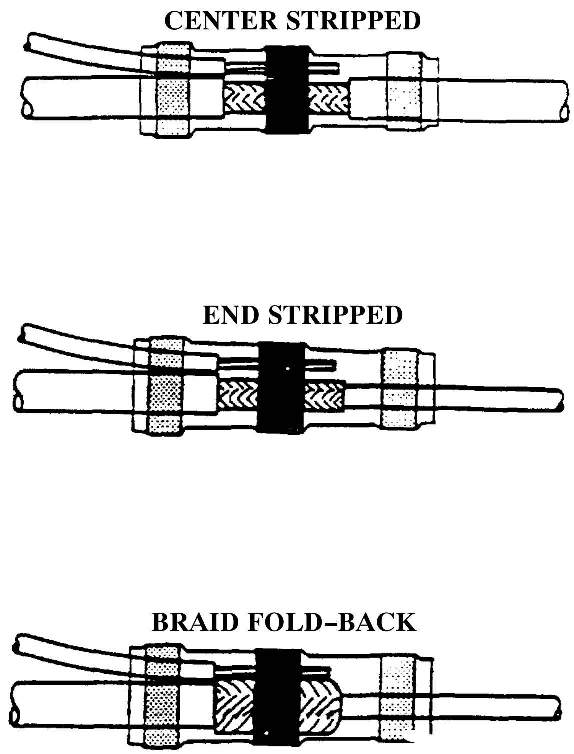


Figure 16 . Immersion Resistant and Standard Solder Sleeve Installation (Sheet 1 of 3)



C. ASSEMBLY.

1. Assemble Cable, Ground Lead, and Solder Sleeve Ensuring No Strands Protrude to Puncture Sleeve. Ground Lead Entry May Be From Front or Rear.

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3.

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

2. Using Heat Gun, Apply Heat Directly to Solder Perform Until Solder Melts, Flows and Wets Shield Braid and Ground Lead.

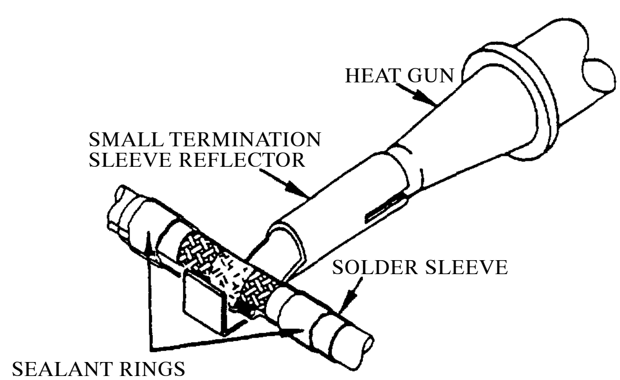


Figure 16. Immersion Resistant and Standard Solder Sleeve Installation (Sheet 2)

NOTE

The Collapse of Solder Preform Does Not Indicate Solder Flow. Continue to Apply Heat Until Solder Flows and Forms Fillet Between Shield and Ground Lead

3. If Necessary, Heat Ends of Sleeve to Complete Shrinkage of Sleeve and Inserts.
4. Inspect Termination for Acceptable Conditions.
5. Reshrink, If Necessary, Until Acceptable Condition Exists.

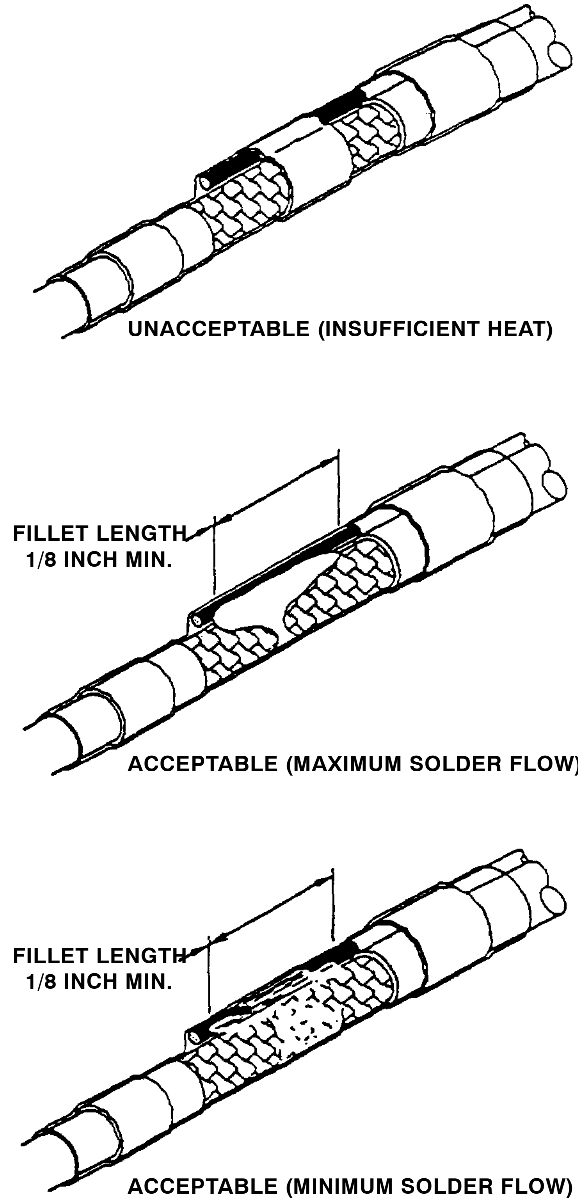
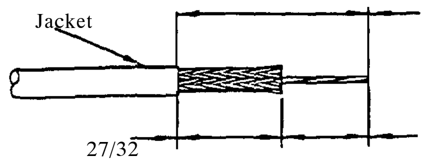


Figure 16. Immersion Resistant and Standard Solder Sleeve Installation (Sheet 3)

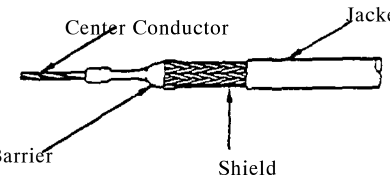
A. CABLE PREPARATION.

1. Strip Cable Jacket Exposing 1 1/8 to 1 15/64 Shield (WP 009 00)
2. Trim Shield from 27/32 to 29/64.
3. Strip Dielectric Exposing 9/32 to 21/64 Center Conductor.



B. ASSEMBLY

1. Slide Primary Termination with Barrier over Center Conductor and Dielectric. Ensure Barrier is Between Dielectric and Shield.



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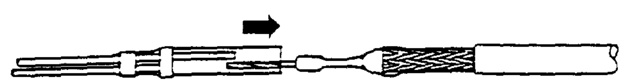
Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information

2. APPLY HEAT TO SOLDER PREFORM UNTIL A FILLET IS FORMED BETWEEN PRE–INSTALLED LEAD AND CENTER CONDUCTOR.

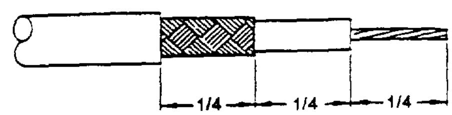


3. POSITION SHIELD TERMINATION SO THAT SOLDER PREFORM IS ALIGNED WITH END OF SHIELD
4. APPLY HEAT TO SOLDER PREFORM UNTIL A FILLET IS FORMED BETWEEN GROUND LEAD AND SHIELD. ENSURE INSERT IS COMPLETELY MELTED.

Figure 17 . Low Temperature Coaxial Cable Solder Sleeve Installation

A. CABLE PREPARATION

1. Strip Cable Jacket Exposing 3/4 Inch of Shield.
2. Trim Shield from 1/2 Inch Dielectric.
3. Strip Dielectric Exposing 1/4 Inch Center Conductor.

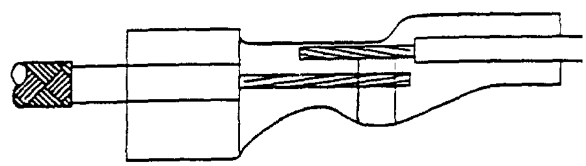


B. ASSEMBLY

NOTE

D–181 Termination May Be Installed Separately or Snap Together.

1. Insert Cable into Primary Sleeve Until Dielectric Stops at Shoulder in Sleeve and Center Conductor Extends Through Solder Preform.



WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3.

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information

Figure 18 . High Temperature Coaxial Cable Solder Sleeve Installation (Sheet 1 of 2)

WARNING

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Only the HT−900B/HT−920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01−1A−35).

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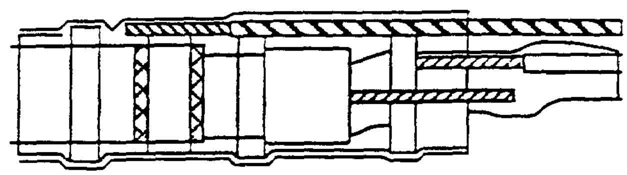
Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.



2. Apply Heat to Solder Preform until a Fillet is Formed Between Pre−Installed Lead and Center Conductor.

3. Position Shield Termination Over Primary Termination so that Solder Preform is Aligned with Shield.

4. Apply Heat to Solder Preform Until a Fillet is Formed between Pre−Installed Lead and Shield. Ensure Insert is Completely Melted.

Figure 18. High Temperature Coaxial Cable Solder Sleeve Installation (Sheet 2)

Table 5 . PinPak Coaxial Termination Selection

Termination Part Number	Cable O.D. (in) max	Shield O.D. (in) min	Shield Description	Lead Diameter (in)	Row Spacing (in)
D-148-0201	.090	.025	Single or double with tin or silver plating	.025	7/64
D-148-0202	.090	.025	Single or double with tin or silver plating	.025	13/64
D-148-0203	.090	.025	Single or double with tin or silver plating	.025	1/4
D-148-0204	.090	.025	Single or double with tin or silver plating	.032	13/64
D-148-0205	.090	.025	Single or double with tin or silver plating	.032	1/4
D-148-0206	.175	.080	Single with tin plating	.025	7/64
D-148-0207	.175	.080	Single with tin plating	.025	13/64
D-148-0208	.175	.080	Single with tin plating	.025	l/4
D-148-0209	.175	.080	Single with tin plating	.032	13/64
D-148-0210	.175	.080	Single with tin plating	.032	1/4
D-148-0211	.175	.080	Double or silver plated	.025	7/64
D-148-0012	.175	.080	Double or silver plated	.025	13/64
D-148-0213	.175	.080	Double or silver plated	.025	1/4
D-148-0214	.175	.080	Double or silver plated	.032	13/64
D-148-0215	.175	.080	Double or silver plated	.032	1/4

46 . **PINPAK COAXIAL TERMINATION INSTALLATION.** The installation procedures for PinPak terminations are the same as paddle card terminations (Figure 19), except the leads must be cut to proper length before attachment to PC board.

47 . **MATCHED IMPEDANCE TERMINATIONS.** Figure 20 provides installation procedures for match impedance terminations.

a. Place assembled cable in fixture of tool.

b. Ensure eye protection is in place.

c. Ensure hands and fingers are clear from work area.

WARNING

Infrared heating tools reach operating temperature extremely fast and can inflict serious painful burns instantaneously. Do not operate without eye shield in place. Refer to manufacturer's operating instructions.

Allow solder sleeve to cool before handling for inspection as serious burns can result.

CAUTION

Do not hold power switch on for extended periods as damage to product and unit will result. Cycle switch, do not hold.

d. Cycle switch, do not hold to shrink sleeve.

e. Allow solder sleeve to cool and inspect termination.

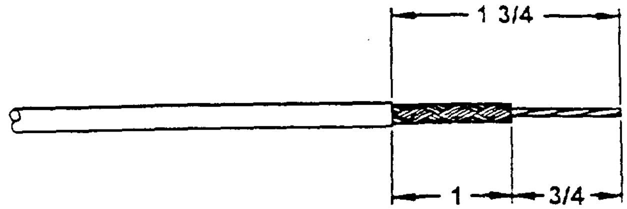
f. Reshrink if necessary until acceptable condition exists.

g. If over heated cut out bad termination and start procedure again.

A. CABLE PREPARATION.

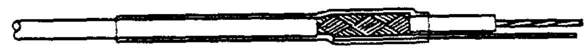
1. STRIP CABLE JACKET EXPOSING 1 3/4 INCH BRAID.

2. TRIM BOTH SHIELD AND DIELECTRIC EXPOSING 3/4 INCH CENTER CONDUCTOR.



B. ASSEMBLY.

1. SLIDE BARRIER UNDER BRAID.
2. SLIDE TERMINATION OVER STRIPPED END OF CABLE UNTIL IT STOPS.



WARNING

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The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3.

Only the HT–900B/HT–920B are authorized for use on aircraft when working environment exceeds Class 4 LEL. i.e. Open fuel cell, open fuel line, fuel venting, LOX venting, (NA 01–1A–35).

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Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information

3. APPLY HEAT UNTIL SOLDER MELTS AND FLOWS.

4. BEND CENTER CONDUCTOR AND GROUND LEAD AND INSERT LEADS THROUGH PC BOARD. CUT LEADS TO APPROPRIATE LENGTH AND SOLDER (WP 017 00)

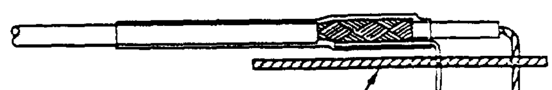


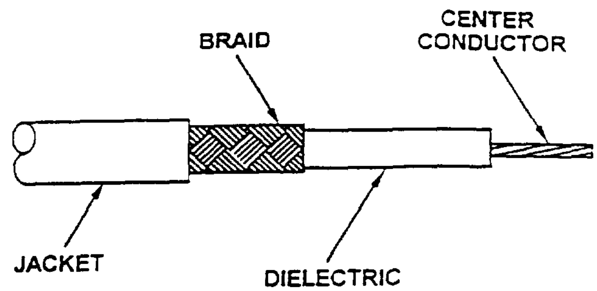
Figure 19 . Paddle Card Termination Installation

A. CABLE PREPARATION.

1. STRIP CABLE JACKET EXPOSING APPROPRIATE LENGTH OF BRAID.

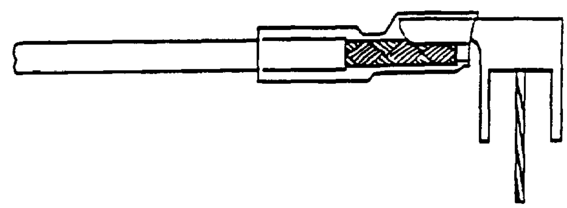
2. TRIM BRAID EXPOSING APPROPRIATE LENGTH OF DIELECTRIC.

3. STRIP DIELCTRIC EXPOSING APPROPRIATE LENGTH OF CENTER CONDUCTOR FOR STRAIGHT OR RIGHT ANGLE TERMINATION.



B. ASSEMBLY

1. PRE–TIN CENTER CONDUCTOR.
2. INSERT STRIPPED END OF CABLE INTO TERMINATION.



WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE).

The HT–900B, HT–920B, HT–71002, MCH–100–A and IR–1759 are the only authorized heat guns to be used when working on aircraft that have not been defueled and purged. The aircraft must be defueled and purged before using any other heat guns listed in this manual.

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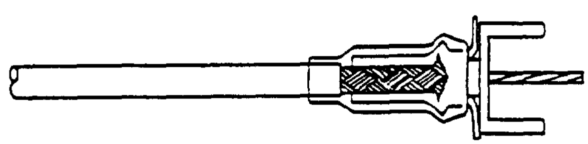

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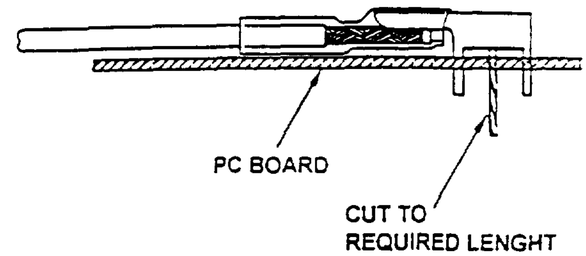
Figure 20 . Matched Impedance Termination Installation (Sheet 1 of 2)



3. APPLY HEAT UNTIL SOLDER PREFORM MELTS AND SOLDERS BRAID TO TERMINATION BODY.

4. INSTALL ON PC BOARD AND SOLDER FOUR LEGS AND CENTER CONDUCTOR

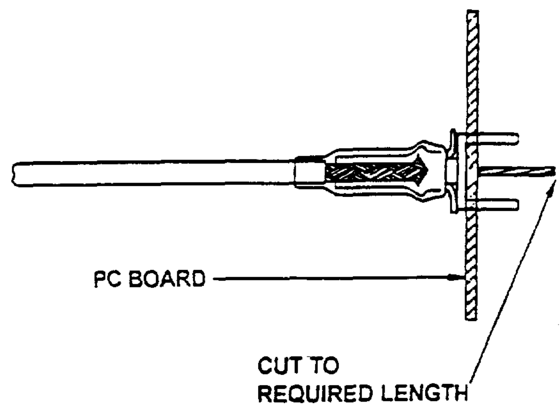


Figure 20. Matched Impedance Termination Installation (Sheet 2)

48 . **SERIES D-106 SOLDER SLEEVE SELECTION.** The selection of the appropriate solder sleeve is determined by the braid diameter.

49 . **SERIES D-153 SOLDER SLEEVES.** The Series D-153 solder sleeves are used for termination of gross shielded harnesses (Figure 21).

50 . **SERIES D-153 SOLDER SLEEVE SELECTION.** The selection of the appropriate solder sleeve is determined by the gross shield diameter, minimum, and the back shell assembly braid, braid straps-and gross shield, maximum.

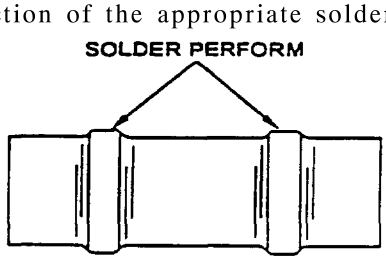


Figure 21 . Series D-153 Solder Sleeve

51 . **TERMINATION OF GROSS-SHIELD HARNESS WITH PRIMARY WIRES ONLY.** To terminate gross-shield harnesses with primary wires only, perform procedure (Figure 22)

52 . **TERMINATION OF GROSS-SHIELD HARNESS.** To termination of gross-shielded harnesses containing shielded and jacketed cables with or without primary wires, perform procedures (Figure 23).

WARNING

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Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information

1. INSTALL PROTECTIVE SLEEVE AND SHRINK WITH HOT AIR.

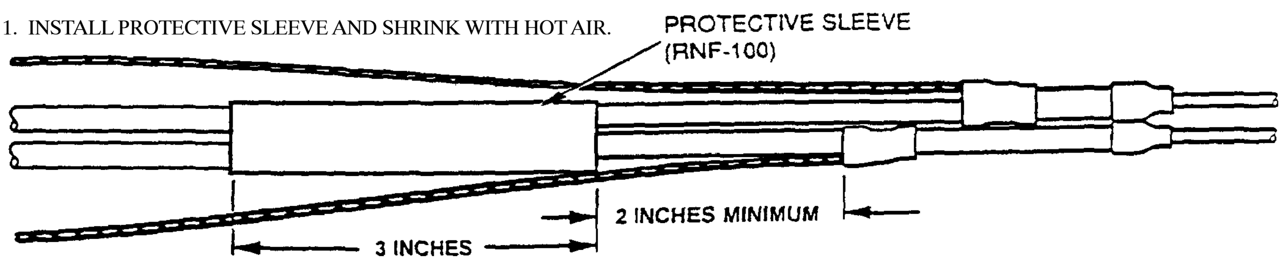
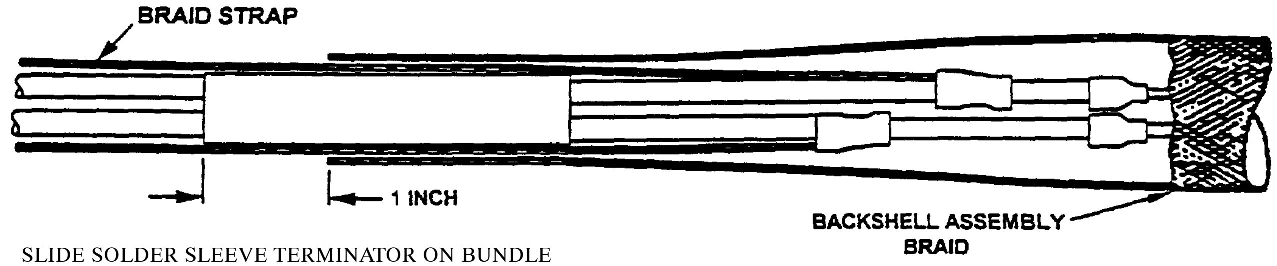


Figure 22 . Termination of Bundled Shielded and Jacketed Cable (Sheet 1 of 2)

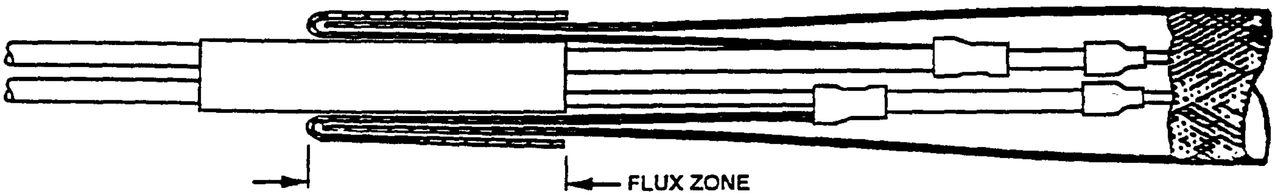


2. SLIDE SOLDER SLEEVE TERMINATOR ON BUNDLE BEYOND PROTECTIVE SLEEVE AND BRAID STRAPS.

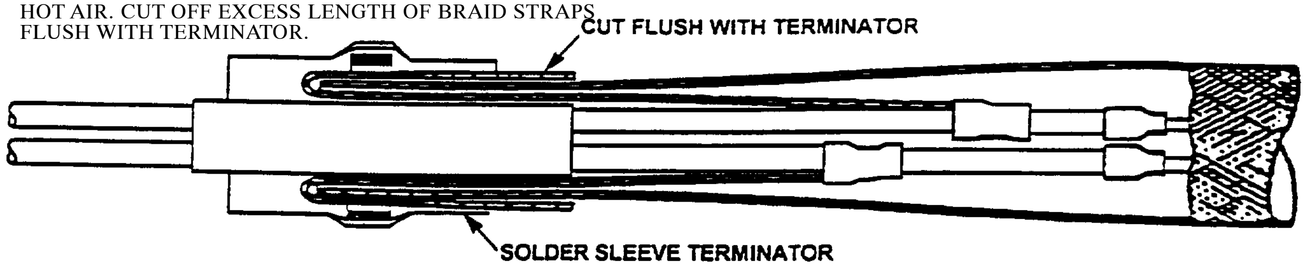
3. POSITION BRAID STRAPS AND BRAID OF BACKSHELL ASSEMBLY OVER PROTECTIVE SLEEVE.

4. FOLD BRAID STRAPS BACK TO FULLY EXTENDED LENGTH ONTO OUTSIDE SURFACE OF BACK SHELL ASSEMBLY BRAID.

5. COAT BRAID IN FLUX ZONE WITH LIQUID FLUX.



6. POSITION SOLDER SLEEVE TERMINATOR AND HEAT WITH HOT AIR. CUT OFF EXCESS LENGTH OF BRAID STRAPS FLUSH WITH TERMINATOR.



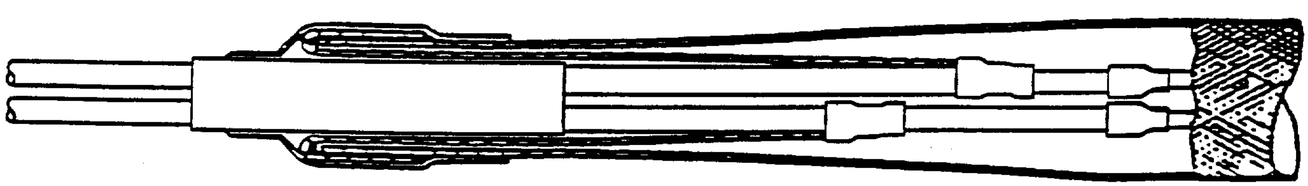


Figure 22. Termination of Bundled Shielded and Jacketed Cable (Sheet 2)

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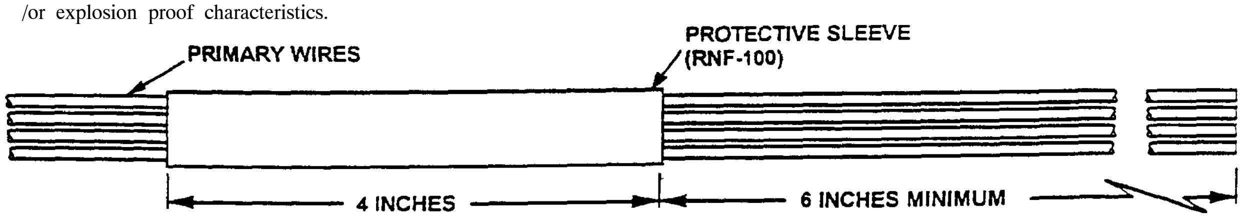


1. INSTALL PROTECTIVE SLEEVE AND SHRINK WITH HOT AIR.

2. INSTALL GROSS SHIELD.

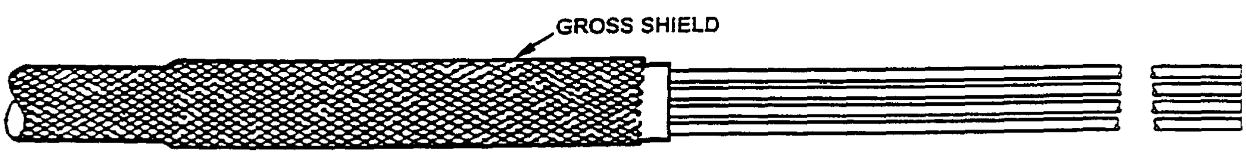
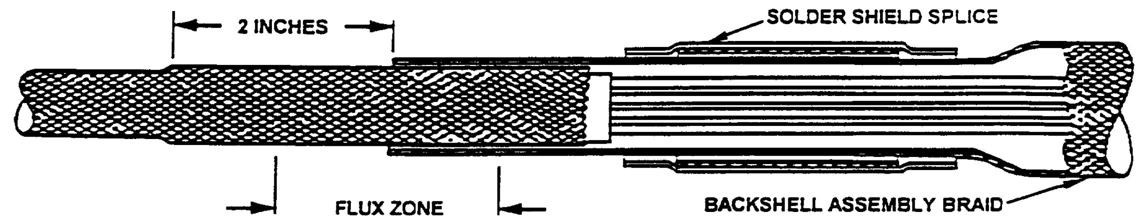


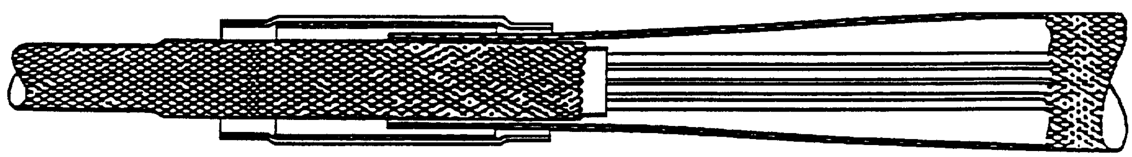
Figure 23 . Termination of Gross-Shielded Harnesses with Primary Wires Only (Sheet 1 of 2)

3. INSTALL SOLDER SHIELD SPLICE ON BACKSHELL ASSEMBLY BRAID AND POSITION BRAID OF BACKSHELL ASSEMBLY OVER GROSS SHIELD.

4. COAT BRAID IN FLUX ZONE WITH LIQUID FLUX.



5. POSITION SOLDER SHIELD SPLICE OVER FLUX ZONE AND HEAT WITH HOT AIR STARTING AT BACKSHELL ASSEMBLY.



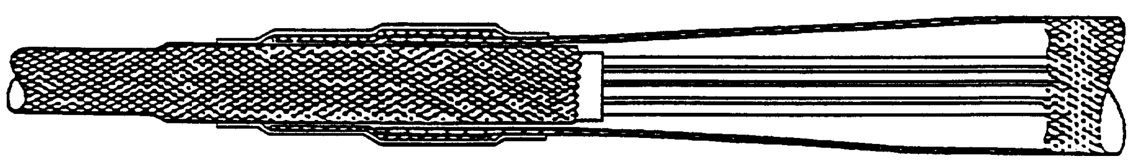


Figure 23. Termination of Gross-Shielded Harnesses with Primary Wires Only (Sheet 2)

WARNING

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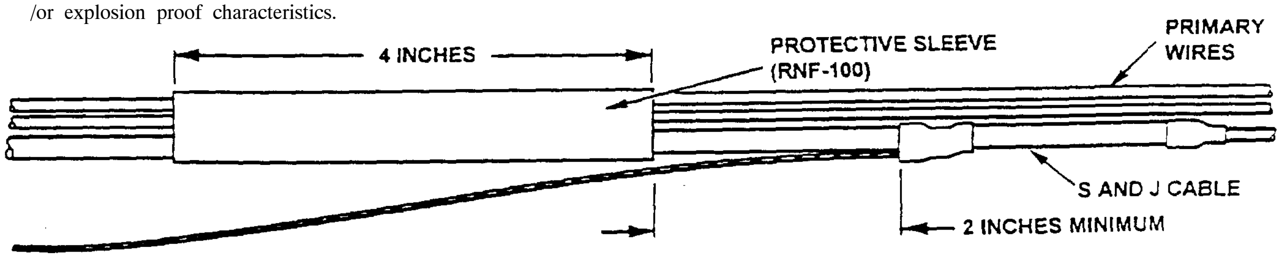
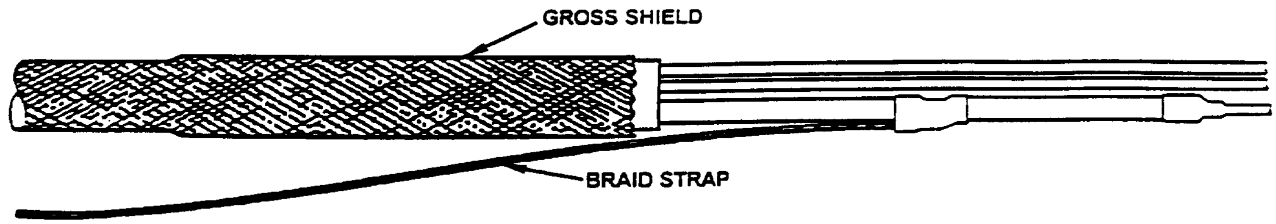


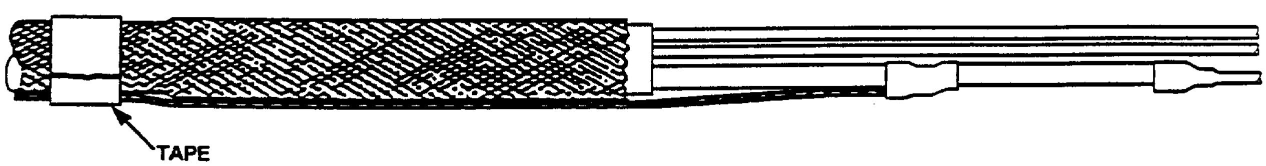
1. INSTALL PROTECTIVE SLEEVE AND SHRINK WITH HOT AIR.

Figure 24 . Termination of Gross-Shielded Harness (Sheet 1 of 3)

2. INSTALL GROSS SHIELD.



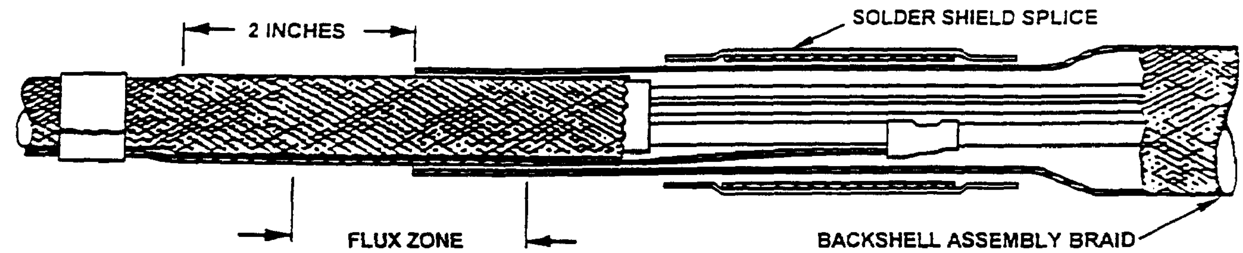
3. POSITION BRAID STRAP OVER GROSS SHIELD AND HOLD WITH TAPE.



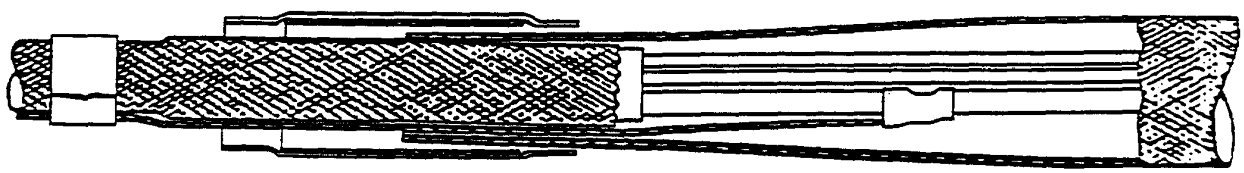
4. INSTALL SOLDER SLEEVE SPLICE ON BACKSHELL ASSEMBLY BRAID AND POSITION BRAID OF BACKSHELL ASSEMBLY OVER GROSS SHIELD.

Figure 24. Termination of Gross-Shielded Harness (Sheet 2)

5. COAT BRAID IN FLUX ZONE WITH LIQUID FLUX.



6. POSITION SOLDER SHIELD SPLICE OVER FLUX ZONE AND HEAT WITH HOT AIR STARTING AT THE BACK- SHELL END.



7. REMOVE TAPE AND TRIM BRAID STRAP FLUSH WITH END OF SOLDER SLEEVE SPLICE.

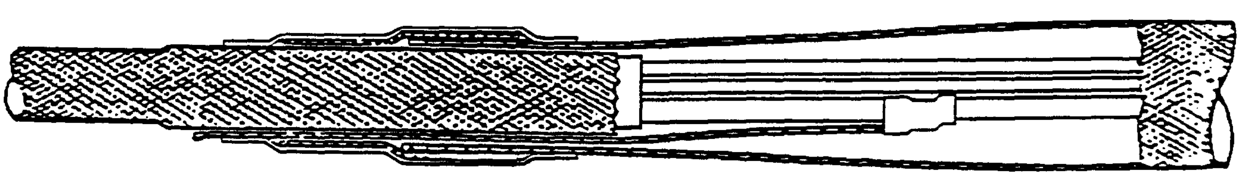


Figure 24. Termination of Gross-Shielded Harness (Sheet 3)

53 . <u>SHIELDING TERMINAL FERRULES.</u>

54 . **PROCEDURE.**

CAUTION

To prevent damage to aircraft wiring or equipment, disconnect both the utility battery and the emergency battery. When electrical power is off, 24vdc battery voltage exists in some wiring. Refer to appropriate aircraft repair manual for correct procedures.

NOTE

Identify applicable cable/wiring assembly then refer to Wire Type List (WP 004 00) for correct wire strippers.

a. Using wire strippers identified in WP 009 00, strip cable and shielding jumper wire as shown below in Figure 25.

b. Determine ferrule and die set required. Refer to Table 6.

c. Install shielding termination ferrule on cable and shielding.

d. Insert shielding jumper wire into shielding termination ferrule so that end of jumper wire is visible through inspection hole of ferrule. See Figure 26..

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e. Shrink insulation sleeving using heat tool. See Figure 25 .

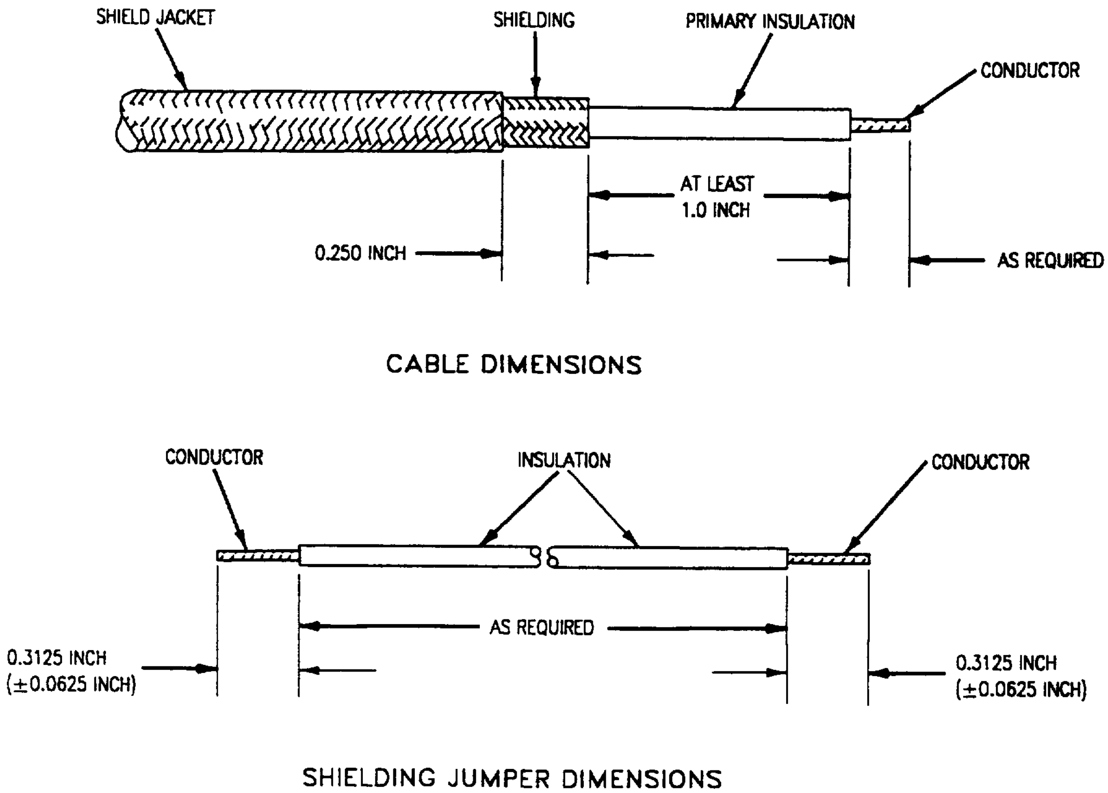


Figure 25 . Strip Cable and Shielding Jumper Wire

Table 6 . Ferrule and Die Set Combinations

Ferrule Part Number	Insulation Diameter (Inch)	Die Set Part Number	Die Set Color Code
5M608-12 or 328051	0.025 thru 0.045	45061-2	White
5M608-13 or 328052	0.045 thru 0.065	45062-2	Violet
5M608-14 or 328053	0.065 thru 0.085	45063-2	Blue
5M608-15 or 328054	0.085 thru 0.105	45064-2	Brown
5M608-16 or 328055	0.105 thru 0.125	45065-2	Orange
5M608-17 or 328056	0.125 thru 0.145	45066-2	Green
5M608-18 or 328057	0.145 thru 0.170	45238-2	Violet
5M608-19 or 328058	0.170 thru 0.195	45239-2	Blue
5M608-20 or 328059	0.195 thru 0.220	45240-2	Brown
5M608-21 or 328060	0.220 thru 0.245	45241-2	Orange
5M608-22 or 328061	0.245 thru 0.270	45158-2	Green

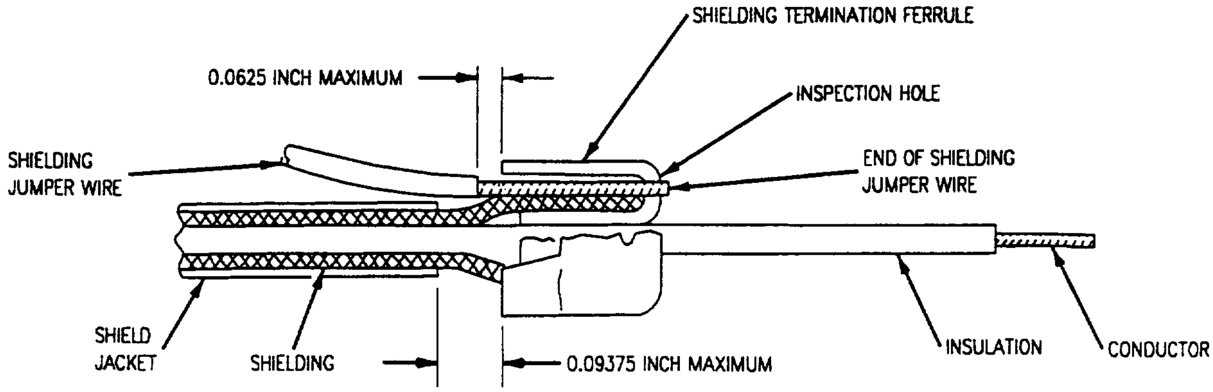


Figure 26 . Installing Shielding Termination Ferrule

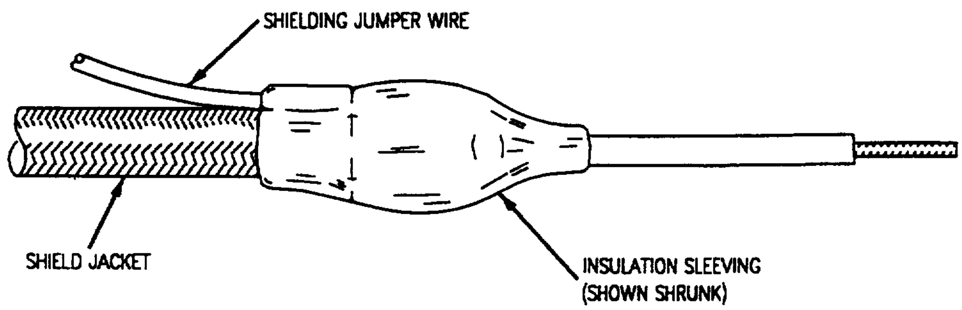


Figure 27 . Shrink Insulation Sleeving

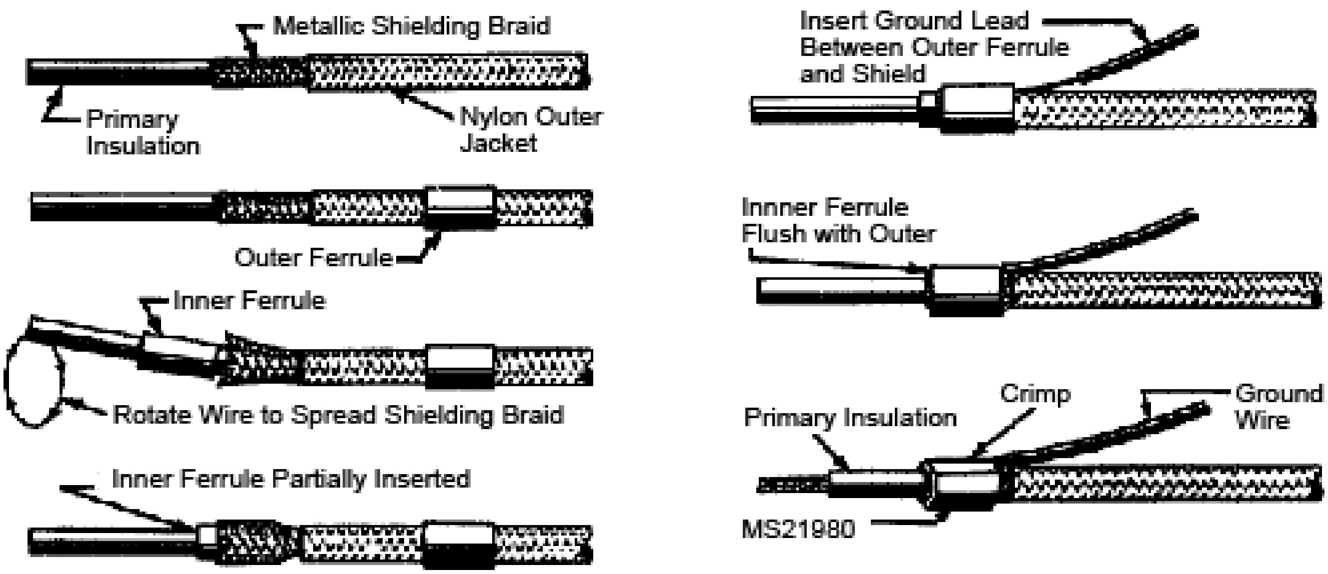


Figure 28 Shield Termination (Two Part Sleeve, Crimped–On)

55 . **TWO–PIECE CRIMPED–ON, SHIELDED CABLE TERMINATION.**

56 . The metallic braid of shielded cable can also be terminated with a two–piece grounding sheath connector, by crimping it, with or without a ground wire as required, between two ferrules (or sleeves) (see Figure 28). Use the standard MS inner and outer ferrules listed in Table 7, 8, 9 and the tools listed in the Tables. The procedure is as follows:

a. Strip off shielding braid (and outer jacket if present) with hand strippers or scissors. Length to be stripped is determined by length of unshielded conductor necessary for making connection.

b. Strip outer jacket (if present) 1/2 to 3/4 inch.

c. Measure OD of insulation directly under shield.

d. Add 0.005 inch minimum to OD obtained in step c, and select inner sleeve having the nearest larger ID from Table 7.

e. Note OD of inner sleeve selected in step d, and add 0.025 inch minimum to it to allow for thickness of shielding braid. Add an extra 0.030 to 0.040 to allow clearance for a No. 20 or No. 18 ground wire if required. From Table 8, or 9 select an uninsulated or insulated outer sleeve as required, with the above dimensions as minimum ID.

f. Slide outer sleeve back over insulation and braid.

g. Rotate cable with circular motion to flare out braid.

h. Slip inner sleeve under braid so that about 1/16 inch of sleeve sticks out beyond braid.

i. If required, insert stripped ground wire under outer sleeve and slide both forward over braid and inner sleeve until only 1/32 to 1/16 inch of inner sleeve and braid protrude (see Figure 28). Ground wire may extend from front or back of outer sleeve as required.

CAUTION

Examine assembly to make sure that shield braid and ground wire come through under the outer sleeve.

j. Crimp with hand tool selected from Table 8 or 9.

Table 7 Shielded Wire Termination; Inner Sleeve

Part No.	Color Code	Insulation OD Under Shield	Inner Sleeve (Nominal) ID	Inner Sleeve (Nominal) OD
MS21981 − 046	Tin	.031 − .041	.046	.070
− 058	Yellow	.043 − .053	.058	.083
− 063	Red	.048 − .058	.063	.088
− 071	Green	.056 − .066	.071	.096
− 080	Blue	.065 − .075	.080	.104
− 090	Orange	.075 − .085	.090	.114
− 096	Purple	.081 − .091	.096	.119
− 101	Yellow	.091 − .096	.101	.124
− 109	Red	.096 − .104	.109	.131
− 115	Tin	.104 − .110	.115	.146
− 124	Green	.110 − .119	.124	.145
− 128	Tin	.110 − .123	.128	.152
− 134	Orange	.123 − .129	.134	.156
− 149	Blue	.129 − .144	.149	.179
− 156	Red	.145 − .151	.156	.192
− 165	Tin	.151 − .160	.165	.194
− 175	Green	.160 − .170	.175	.215
− 187	Yellow	.175 − .182	.187	.227
− 194	Blue	.182 − .189	.194	.225
− 205	Orange	.189 − .200	.205	.245
− 219	Tin	.200 − .214	.219	.248
− 225	Yellow	.214 − .220	.225	.256
− 232	Red	.220 − .227	.232	.263
− 250	Green	.220 − .227	.250	.281
− 261	Blue	.227 − .255	.261	.297
− 266	Tin	.261 − .271	.266	.297
− 275	Orange	.255 − .270	.275	.306
− 281	Yellow	.270 − .276	.281	.331
− 287	Tin	.276 − .282	.287	.327
− 297	Red	.282 − .292	.297	.336
− 312	Purple	.292 − .307	.312	.362
− 375	Blue	.370 − .380	.375	.406

Table 8 Shielded Wire Termination; Uninsulated Outer Sleeve

Part No.	Color Code	Nominal Sleeve ID (Inches)	Installing Tools M22520/5−01 (Basic Tool with the Following Dies)
MS21980−101	Tin	0.101	M22520/5−33 (B)
−128	Blue	0.126	/5−35 (B)
−149	Purple	0.149	/5−37 (B)
−156	Yellow	0.156	/5−39 (B)
−175	Blue	0.175	/5−41 (B)
−187	Orange	0.187	/5−43 (B)
−194	Red	0.194	/5−43 (B)
−199	Tin	0.199	/5−43 (B)
−205	Yellow	0.206	/5−19 (B)
−219	Green	0.219	/5−19 (B)
−225	Purple	0.225	/5−45 (B)
−232	Orange	0.233	/5−45 (A)
−261	Yellow	0.261	/5−19 (A)
−275	Tin	0.275	/5−43 (A)
−281	Purple	0.281	/5−41 (A)
−287	Blue	0.287	/5−41 (A)
−299	Green	0.299	/5−41 (A)
−312	Yellow	0.312	/5−39 (A)
−327	Tin	0.327	/5−37 (A)
−346	Orange	0.346	/5−55
−359	Purple	0.359	/5−33 (A)
−375	Yellow	0.375	/5−47
−405	Red	0.405	/5−23
−415	Blue	0.415	/5−23
−460	Tin	0.46	/5−53
−500	Green	0.5	/5−21

Table 9 Shielded Wire Termination; Insulated Outer Sleeve

Part No.	Color Code	Nominal Sleeve ID (Inches)	Installing Tools M22520/5−01 (Basic Tool with the Following Dies)
M818121−101	Tin	0.101	M2252015−35 (B)
−128	Blue	0.128	/5−37 (B)
−149	Purple	0.149	/5−41 (B)
−156	Yellow	0.156	/5−43 (B)
−175	Blue	0.175	/5−11 (A)
−187	Orange	0.187	/5−45 (A)
−194	Red	0.194	/5−45 (A)
−199	Tin	0.199	/5−45 (A)
−205	Yellow	0.205	/5−19 (A)
−219	Green	0.219	/5−19 (A)
−225	Purple	0.225	/5−19 (A)
−232	Orange	0.232	/5−43 (A)
−261	Yellow	0.261	/5−41 (A)
−275	Tin	0.275	/5−39 (A)
−281	Purple	0.281	/5−35 (A)
−287	Blue	0.287	/5−35 (A)
−297	Green	0.297	/5−35 (A)
−312	Yellow	0.312	/5−47
−327	Tin	0.327	/5−23
−348	Orange	0.348	/5−23
−359	Purple	0.359	/5−23
−375	Yellow	0.375	/5−49
−405	Red	0.405	/5−51
−415	Blue	0.415	/5−51
−460	Tin	0.46	/5−31
−500	Green	0.5	/5−27

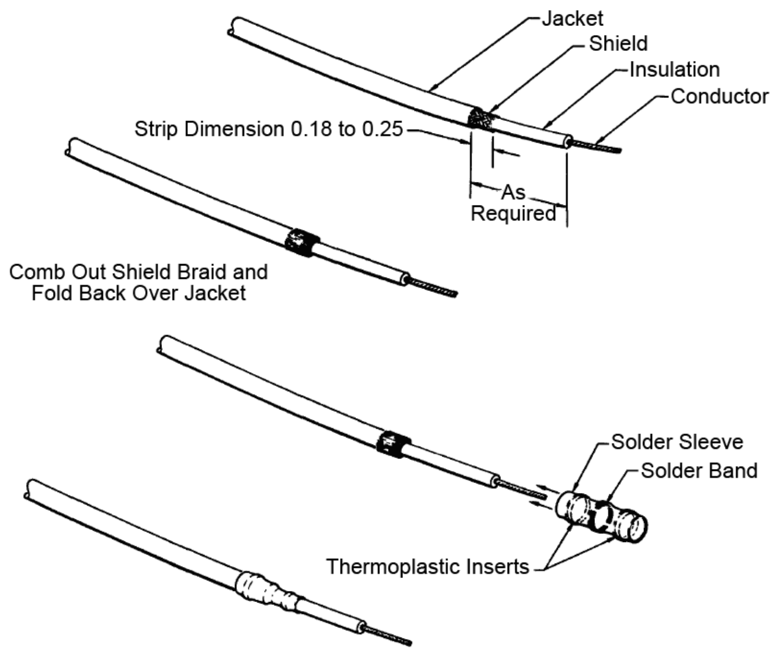


Figure 29. Solder Sleeve Floating Shield Termination

57 . **UNGROUNDED (FLOATING) SHIELD TERMINATION.**

58 . The floating ground shield termination is one which does not have, or require a ground lead, pigtail, or jumper. The shielding is terminated as follows (Figure 29).

a. Strip the shielded wire.

b. Comb out the exposed shielding and fold back over the jacket.

c. Select the size solder sleeve (Table 10).

d. Make sure that the shield strands are flat and smooth.

e. Position the solder sleeve over the assembly so that the solder ring is centered over the folded back shielding.

f. Hold assembly horizontal and position sleeve in heat shield.

Table 10. Shield Termination, Without Ground Lead

Part Nr.	Max. Cable Diameter OD
M83519/1−1	0.075
M83519/1−2	0.105
M83519/1−3	0.17
M83519/1−4	0.235
M83519/1−5	0.275

WARNING

Do not perform hot work without specific authorization of activity Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE). The HT– 900B, HT– 920B, HT–71002 and MCH–100–A heat guns are the only authorized heat guns to be used when working on aircraft that have not been de–fueled and purged.

The aircraft must be defueled and purged before using any other heat guns listed in this manual. Aircraft with open fuel cells or broken or open fuel lines shall be certified gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3.

Only the HT–900B/HT–920B, HT– 71002, MCH–100–A heating tools are authorized for use on any aircraft whenever the presence of aircraft fuel is imposing an immediate danger.

The MCH–100–A heat gun is the only authorized heat gun which contains an electrical motor. It has been electromagnetic interference (EMI) qualified for flight line and/or flight deck use. All other electric motor type heat guns are not authorized for flight line and/or flight deck use due to lacking EMI and /or explosion proof characteristics.

The MCH–100–A is safe for use by personnel at the organizational maintenance level to repair aircraft wiring, provided the aircraft meets the gas–free environment criteria (NAVAIR 01–1A–35 or AF T.O. 1–1–3). When using this heat gun, recertification may be required as work progresses, as directed by the Aviation Gas Free Engineering Technician (AVGFET).

Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using a heat tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit. Refer to WP 012 00 for additional information.

g. Apply heat using approved heat gun for the application (WP 012 00).

NOTE

The heat gun must have a thermal heat shield and must develop 550°F at the heat shield nozzle.

h. Rotate assembly while heating to achieve proper solder penetration and uniform sleeve shrinkage. About 10-30 seconds are required for complete solder melt and flow.

NOTE

Disappearance of color in the solder band does not indicate an acceptable termination. Continue to apply heat until solder brightens and starts to flow toward thermoplastic inserts at either end of sleeve.

i. As soon as the solder flow is observed, withdraw the heat.

j. When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a joint mechanically weak, and with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts. Inspect per Figure 15.

59. PIGTAIL METHOD OF SHIELD TERMINATION.

60. When grounding sheath connectors and tools are not available, terminate shield for grounding by making a pigtail as follows (Figure 30):

CAUTION

Take extreme care not to damage shielding or insulated conductor while forming pigtail.

a. Determine and mark point at which shielding is to terminate. This depends on the individual installation.

b. Push back shielding to form a bubble at the termination point.

c. Insert an awl or other pointed tool into shielding braid at termination point and work an open circular area in the shield. Be careful not to cut into wire insulation.

d. Bend cable, insert tool between shielding and wire, and pull insulated conductor through hole formed by tool.

e. Pull empty part of shield taut and tin last inch to prevent fraying.

f. On unjacketed shield cable, spot tie (A−A−52083 or A−A−52084) shielding on cable with clove hitch and square knot. This is not necessary if cable has extruded plastic jacket over shield provided jacket is replaced and covers pigtailed shield (see WP 014 00 for heat shrink to repair jacket).

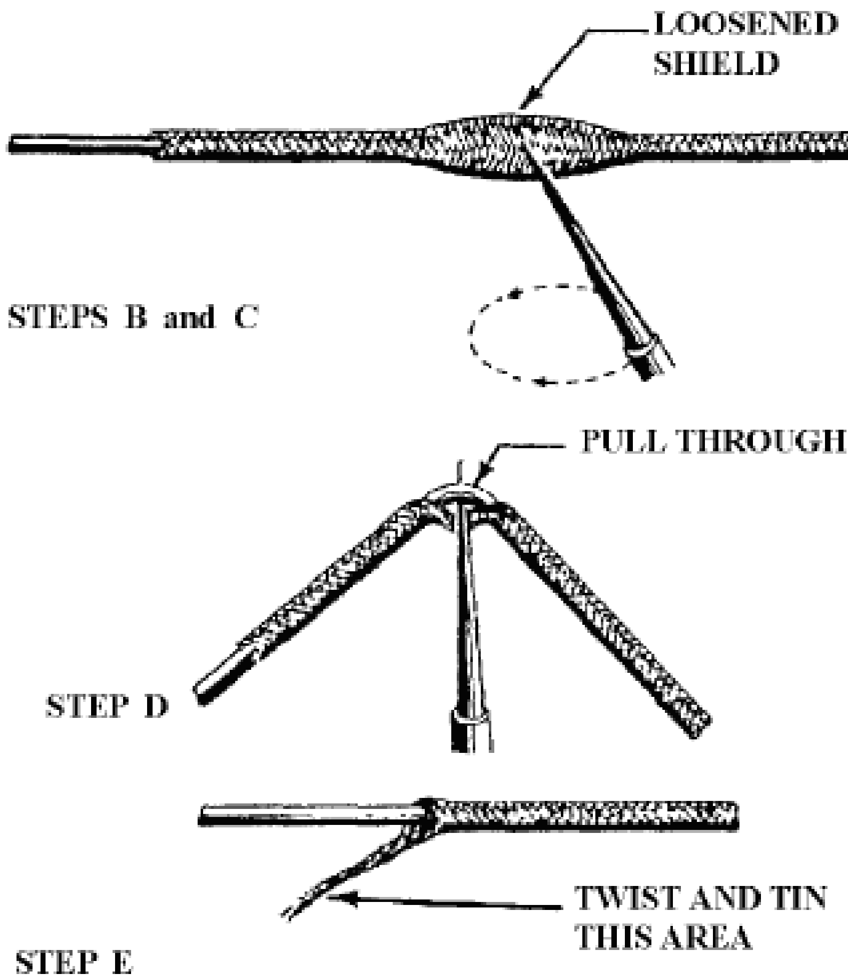


Figure 30. Pigtail Method of Forming Shield Termination

SOLDERING

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Wire and Cable Stripping 009 00
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair . . . NAVAIR 01–1A–23
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair . . . . . . T.O. 00–25–259
Standard Maintenance Practices Miniature/Microminiature (2M) Electronic Assembly Repair . . . . . TM 5895–45/1D

Alphabetical Index

Subject Page No.

Alphabetical Index (Cont)

Support Equipment Required

None

Materials Required

Specification/ Part Number	Nomenclature
Alcohol, Isopropyl (Isopropanol)	TT-I-735
Brush, Acid Swabbing	A-A-289
Flux, Silver Brazing	AMS3410
Flux, Brazing, Silver Alloy, Low Melting Point	O-F-499
Primer, Coating, Alkyd Base, One Component	TT-P-1787

Materials Required (Cont)

Specification/ Part Number	Nomenclature
Requirements for Soldering Fluxes	ANSI J-STD-004
Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications	ANSI J-STD-006
Sheet, Copper Alloy 110, Soft Annealed, .020 in. Thick (Nominal)	Copper Alloy 110
Solder, Hard	QQ-B-654
Solder, Hard	46S657

1. **INTRODUCTION.**

2. This work package (WP) is concerned with solder connections. This WP will describe general terms, materials, equipment and processes used in soldering, as well as the general inspection criteria. For specific soldering requirements refer to NA 01–1A–23, T.O. 00–25–259 or TM 5895–45/1D.

CAUTION

Tin–lead solder should be used for repair processes addressed in this manual.

The use of lead–free solder is prohibited except for repair processes on lead–free assemblies. Do not use tin–lead with lead–free assemblies as it will significantly reduce the reliability of the assembly

NOTE

All soldering operations involving repairable components require certification of personnel performing the soldering task. Navy personnel refer to COMNAVAIRFORINST 4790.2 Series for 2M requirements.

a. Solder repair of lead–free components is not permitted at organization and intermediate level of maintenance. For further guidance on lead–free solder refer to WP 020 00 of NA 01–1A–23, T.O. 00–25–259 or TM 5895–45/1D.

3. **GENERAL.**

4. **SOLDERING.** Soldering is the joining of metal parts with a metal alloy that has a lower melting point than the parts being joined. Soldering offers an economical and reliable method to assemble and repair wires and their terminations. Soldering shall not be used to terminate crimp style contacts.

5. **SOLDER.** Solder is fusible metal alloy used to join two or more metals using heat.

6. **SOLDERABILITY.** Solderability is the property that permits good bonding of a specified solder in the presence of a specified flux at a specified temperature.

7. **SOLDER PREFORM.** A solder preform is a part that has been formed into a specific shape for a specific purpose.

8. **SOLDER TYPES.** There are two types of solder and distinctions are made between, hard solder or brazing and soft solder. Alloys used in hard solder normally reach the melting point at temperatures above 1700 °F (371 °C), while those used in soft solder normally reach the melting point at temperatures below 700°F (371°C).

9. **Hard Solder.** Hard solder often called brazing solder, is a silver alloy which conforms to QQ-B-654 with a melting point 700°F to 1600°F (371°C to 871°C). Hard solder has advantages as well as disadvantages.

a. Used where greater mechanical strength is required.

b. Used where higher temperatures are encountered.

c. Commonly used to solder thermocouple connections.

d. Not to be used on standard contacts, connectors, terminals, or circuit boards.

10. **Soft Solder.** Soft solder is an alloy, consisting mainly of tin and lead along with silver and other additives, which conforms to ANSI J-STD-006 and has

a melting point below 700°F (371°C). Soft solder is more widely used in aircraft wire repair and termination.

11. **SOLDER FORMS.** Solder is available in many styles and forms designed for a specific task.

12. **Pig.** A pig is a large block of solder 20 to 100 pounds used to replenish large solder baths.

13. **Cakes or Ingots.** Cakes or ingots, either rectangular or circular in 3, 5 and 10 pound units, also used to replenish solder baths.

14. **Bars.** Bars weigh 1/2 pound to 2 pounds and are used to replenish solder pots or small baths.

15. **Segment or Drops.** Segments or drops are solder wire or bars precut to the length desired for application as desired.

16. **Foil.** Solder as foil, also in sheets and ribbons, are used mainly in light solder applications.

17. **Cream.** Solder cream is a suspension of solder and flux and is able to be placed where needed. Solder cream was brought about by the ever changing production requirements and electronic advances.

18. **Wire.** Wire solder, available in different diameters and on spools, is one of the most common in use for hand soldering.

19. **Wire Flux Core.** Wire solder with a flux core is the most common in use. Available in different diameters and on spools for use in hand soldering which conform to ANSI J-STD-006.

20. **Preforms.** Solder preforms are parts that have been formed into a specific shape for a specific purpose.

21. **HARD SOLDER USE.** Hard solder used in aircraft wiring and termination using hand soldering techniques is commonly solid wire solder.

WARNING

Silver solder brazing alloy 46S657 per QQ-B-654 contains cadium. The use of this material is preferred because of its low brazing temperature range and satisfactory service performance, however, poisonous fumes are produced upon heating. It will be deleted from QQ-B-654 when substitute brazing alloys have been evaluated for satisfactory service performance. Become familiar with the Materials Safety Datasheets (MSDS) for all materials used and use proper personal protection equipment. (PPE).

22. **SOFT SOLDER USE.** Soft solder used in aircraft wiring and termination using hand soldering techniques, most commonly will be solid wire solder, or flux core solder.

WARNING

Solder contain lead and other hazardous materials. Avoid oral contact with hands during soldering operations and always wash hands immediately after soldering. Become familiar with Material Safety Datasheets (MSDS) for all materials used and use proper personal protection equipment (PPE).

23. **Solid Wire Solder.** When solid wire solder is used, a rosin based flux must also be used. A list of preferred wire type solders follows:

a. Sn60Pb40. This type of solid solder is for use in general electrical and electronic applications.

b. Sn62Pb36Ag02. This type of solid solder is used for silver plated applications.

c. Sn63Pb37. This type of solid solder is used for applications on printed circuit boards and semi-conductor devices.

d. Flux Core Solder. Flux core solder, also referred to as rosin core, requires no external flux. Preferred solders used in flux core solder are the same as the solid solders shown in steps a through c, with the fluxes described in paragraph 26.

24. **FLUX USE.** Flux is used to prepare the surface, as proper soldering requires unrestricted intermetallic contact between the solder and the metal being joined. Any barrier between the two in the form of oxide, grease, or other contaminants will prevent proper union. Flux removes these films without attacking the surfaces to be joined. The additional benefits include:

a. Sealing. Flux seals the surface to be joined.

b. Heating. As the surface is sealed heating time is decreased.

c. Oxidation. Oxidation is halted.

d. Solder Flow. The flux reduces surface tension and allows the solder to flow.

WARNING

Isopropyl alcohol is flammable - do not use near open flames, welding areas, or on hot surfaces. Do not smoke when using it, and do not used where others are smoking. Inhalation of vapors can cause drowsiness, dizziness and headaches. Contact of liquid wit skin may cause dermatitis and irritation. If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air. Consult MSDS.

26. **FLUX TYPE FOR SOFT SOLDER.** The flux used shall conform to ANSI J-STD-004 and are of the organic rosin type. Acid or inorganic flux shall not be used as they are highly corrosive. The residual action of even rosin flux will cause corrosion therefore the work area shall be cleaned with isopropyl alcohol when soldering is complete. Preferred fluxes as liquids and as cored solders follows:

a. ROL0. This This type of flux is rosin based with low activity and no halide content. It is recommended for use on electronic applications and on printed circuit boards and on semiconductor devices.

b. ROM0. This type of flux is rosin based with moderate activity and no halide content. It may be used on electronic applications where greater flux activity is desired, but greater care must be taken to properly clean all residue after soldering.

27. **FLUX TYPE FOR HARD SOLDER.** The flux used for brazing hard solder is not to be used with soft solder. Use flux which meets AMS3140 or equivalent.

28. **HEAT APPLICATION.** There are methods by which heat is applied to the work and these will be covered in detail within this WP. These methods are as follows:

29. **Soldering Iron.** Hand held, electrically heated soldering irons are the most commonly used tools to accomplish solder joining on aircraft or components. Soldering irons are available in different sizes, wattage, shape, angles, and tip selection. It is necessary to use the correct tool and soldering irons must be matched to perform the job correctly. Soldering irons must be selected to do the task assigned as quickly and efficiently as possible. Examples of typical soldering irons are illustrated (Figure 1).

30. **Resistance Soldering.** Resistance soldering is utilized in areas of large volume and when heat is needed only at the point of contact. A low voltage transformer is used and the metal to be soldered is heated by resistance by this low voltage. A carbon pencil is used in another type of resistance soldering as one electrode and is desired for use in congested areas and heat restricted areas (Figure 2).

31. **Torch Soldering.** Torch soldering is used where high heat is required, in soldering with hard solder, as in thermocouple soldering. Soft solder applications may be used providing the area of work is large enough. Torch soldering is not recommended for small parts.

32. **Din Solder.** Dip soldering is accomplished by using a solder pot or solder bath. By this method one or more connections can be accomplished in a single operation and is normally used on printed circuit boards. The dip method can also be used for wire tinning.

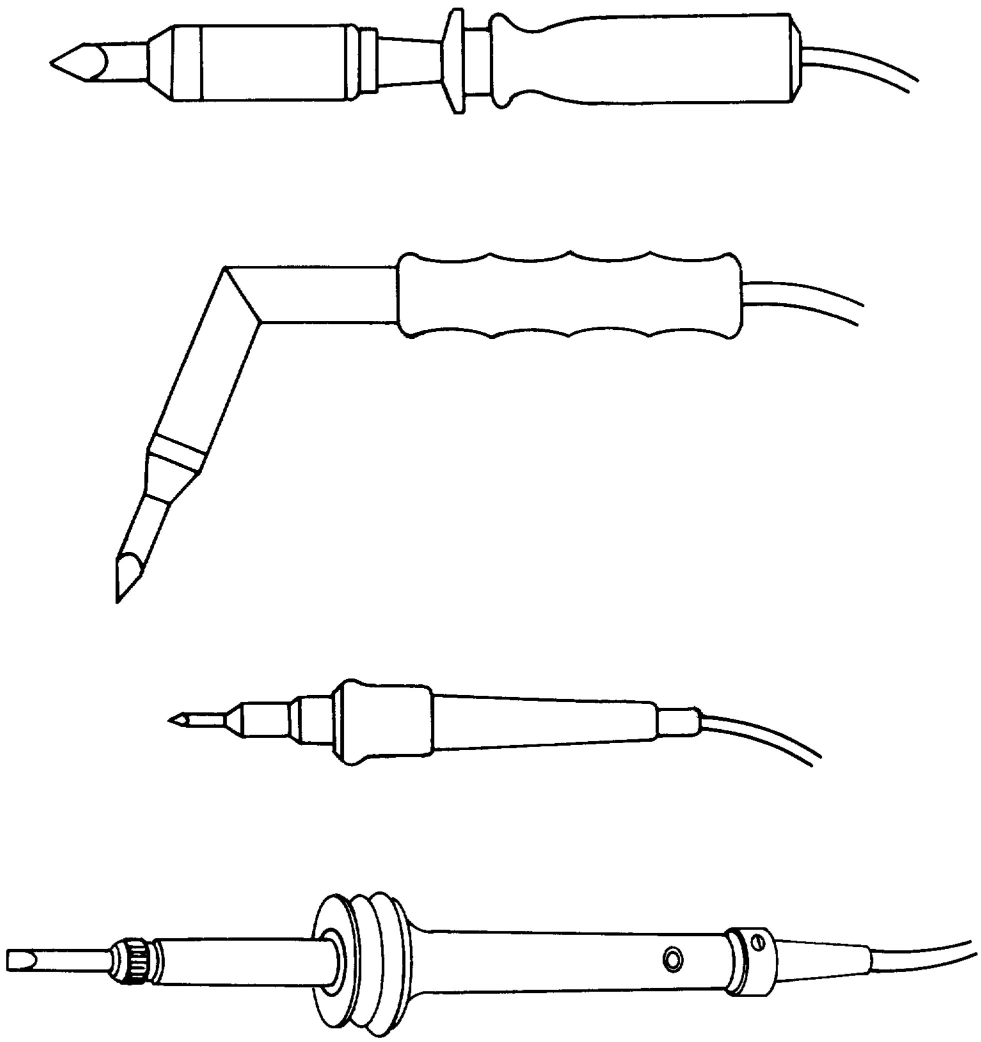


Figure 1. Types of Hand Soldering Irons (Typical)

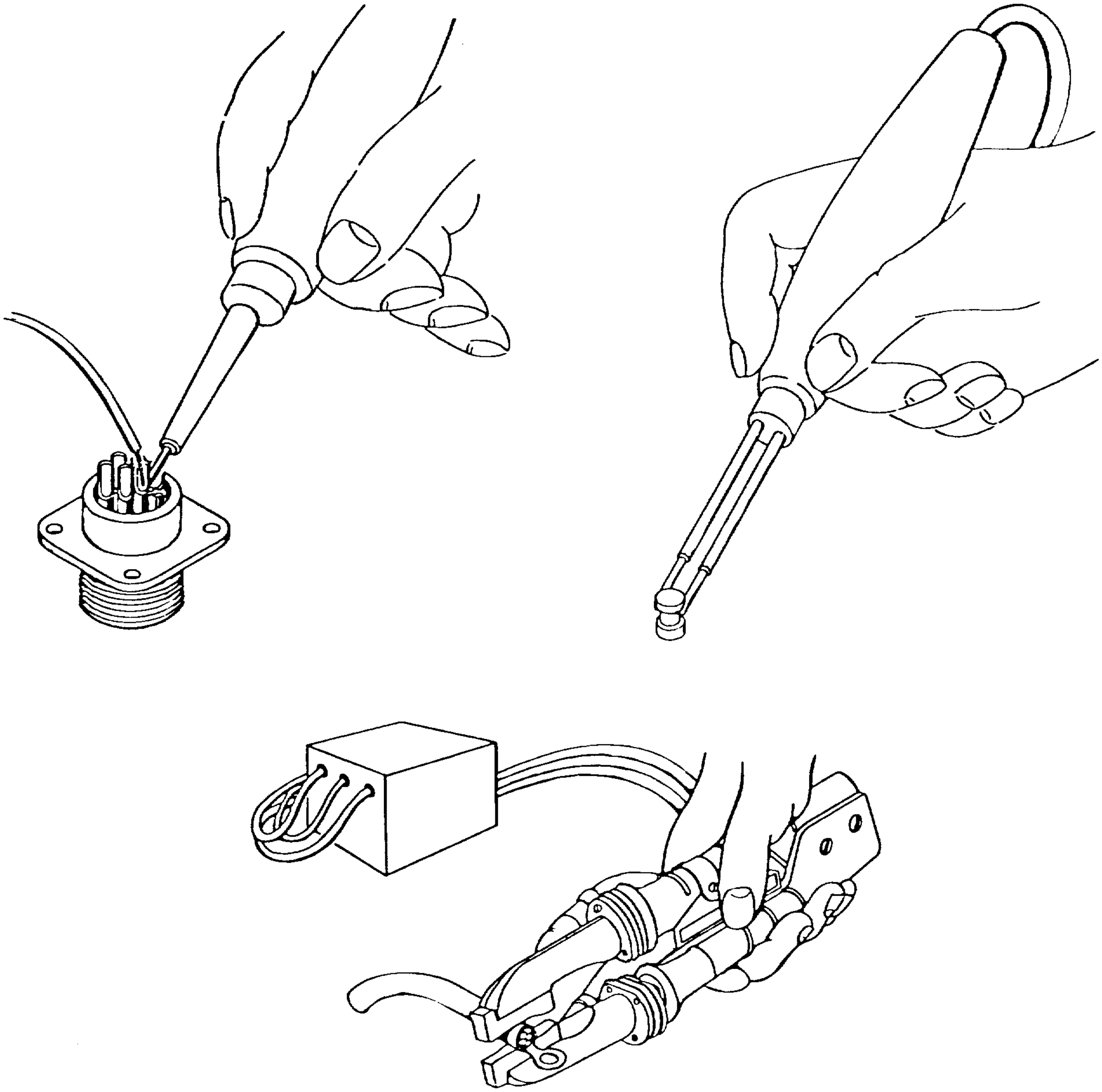


Figure 2. Resistance Soldering

33. SOLDERING IRON PREPARATION AND MAINTENANCE.

34. **PREPARATION.** The soldering iron tip must be tinned to provide a completely metallic surface through which the heat may flow readily from the iron to the metal being soldered. If no tinning is present, the iron will oxidize and the heat cannot flow. Copper has a very high rate of heat conductivity, but copper tips oxidize quickly and must be frequently cleaned and re-tinned. If a tip has become badly burned and pitted as a result of overheating, replace it. Some copper soldering iron tips used in production soldering are coated with pure iron to help prevent oxidation. Follow manufacturer's instructions for cleaning such irons. A clean damp cloth may be used to wipe the iron.

NOTE

Do not file soldering iron tips coated with pure iron. Filing will ruin the protective coating. If the tip is pitted, replace it.

a. With the iron unplugged, file each working surface of the tip with a double-cut mill file until it is smooth and a bright copper color (Figure 3).

b. Remove copper filings from dressed edges with a file card.

c. Plug in the iron.

WARNING

Avoid oral contact with hands during soldering operations and wash hands immediately after soldering operation. The lead contained in solder can be a source of lead oxide. Lead oxide, when absorbed in the body over the years, can cause serious health problems. Touching solder followed by smoking or eating is a potential means of ingesting trace amounts of lead oxide.

CAUTION

Do not allow the iron to come up to full temperature before starting the tinning operation.

d. Apply cored solder just as the dressed copper is turning to a pigeon-blue, bronze, oxide color. This will allow the flux to wet and clean the tip before the solder melts to form an even bright coating (Figure 4).

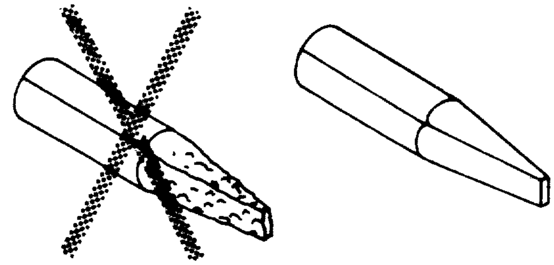


Figure 3. Soldering Iron Tip Before and After Cleaning

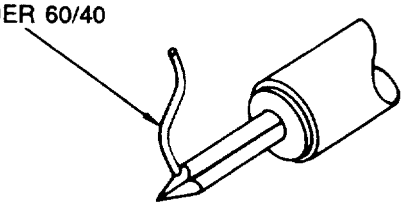


Figure 4. Tinning Soldering Iron Tip

CAUTION

Never shake or whip an iron to get rid of dross or excess solder droplets.

e. Wipe off excess solder with a damp sponge or cloth.

35. **MAINTENANCE.** During use and just before each application, pass the soldering iron tip (with a rotary motion) through the folds of a damp cleaning sponge. This will remove the surface dross and excess solder from the working surface.

36. **DAILY MAINTENANCE.** Once a day, remove the tip and clean the black scale from the inside of iron and from the tip with fine steel wool. When the iron or tip is new, coat the inside of shank with dry flake graphite or anti-seize material to prevent freezing, and ensure maximum heat transfer. When replacing tip, ensure it is inserted the full depth of the casing and seated firmly against the heating element.

37. GENERAL SOLDERING PROCEDURES.

WARNING

Do not perform hot work without specific authorization of activity. For Navy: Aviation Gas Free Engineer (AVGFE) or Gas Free Engineer (GFE). For Air Force: Base Fire Department. Hot work for the purposes of this manual shall be defined as any equipment that produces an open flame or sparking (either internal or external to the equipment). Only authorized equipment (such as hot air gun and infra red heat gun in WP 012 01 or soldering equipment) which does not produce an open flame, or sparking is approved for on aircraft use. The aircraft must be defueled and purged before using any other brazing or hot air equipment in this manual. Aircraft with open fuel cells or open fuel lines shall be certified as gas free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3. Do not perform wire repair while using explosive or flammable solvent/paint products on the aircraft. When using soldering tool, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power source

38. **AREA PREPARATION.** Cleanliness is of the utmost importance in the soldering operation. If possible, soldering should be done in an area that is reasonably clean and free from excessive dust. Drafty areas should be avoided so that the soldering iron will not cool.

WARNING

Isopropyl alcohol is flammable - do not use near open flames, welding areas, or on hot surfaces. Do not smoke when using it, and do not used where others are smoking. Inhalation of vapors can cause drowsiness, dizziness and headaches. Contact of liquid wit skin may cause dermatitis and irritation. If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air. Consult MSDS.

39. **DECONTAMINATION.** Parts contaminated with dirt, oil, grime, grease, etc., cannot be successfully soldered. Make sure all parts are mechanically bright-clean before soldering. Clean the parts with a cloth or brush dipped in isopropylalchol, or other approved solvent. Badly corroded parts may be cleaned carefully by mechanical means, such as fine abrasive paper, a wire brush, or by careful scraping with a knife blade.

40. **WIRE STRIPPING.** Insulated conductors should be stripped a distance longer than required for the solder connection. This allows for easier tinning of the conductor; the excess conductor will be trimmed off prior to soldering. The outer circumference of the end of the insulation shall have a smooth edge. The inner circumference shall have no insulation protrusions around the wire's surface. The insulation shall not show evidence of nicks or cuts. For specific wire stripping procedures, refer to WP 009 00.

WARNING

Avoid oral contact with hands during soldering operations and wash hands immediately after soldering operation. The lead contained in solder can be a source of lead oxide. Lead oxide, when absorbed in the body over the years, can cause serious health problems. Touching solder followed by smoking or eating is a potential means of ingesting trace amounts of lead oxide.

41. PRE-TINNING.

42. Before wires are soldered to connectors, the ends exposed by stripping are tinned to hold the strands solidly together. The tinning operation is considered satisfactory when the ends and sides of the wire strands are fused together with a coat of solder. Wires are usually tinned by dipping into flux and then into a solder bath. Unacceptable tinning may leave stray conductor strands, may have too little or excessive solder, or the insulation may be damaged by overheating. In the field, wires can be tinned with a soldering iron and rosin core solder (Figures 5 and 6).

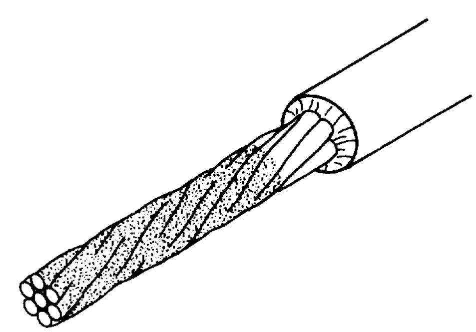


Figure 5. Properly Tinned Wire

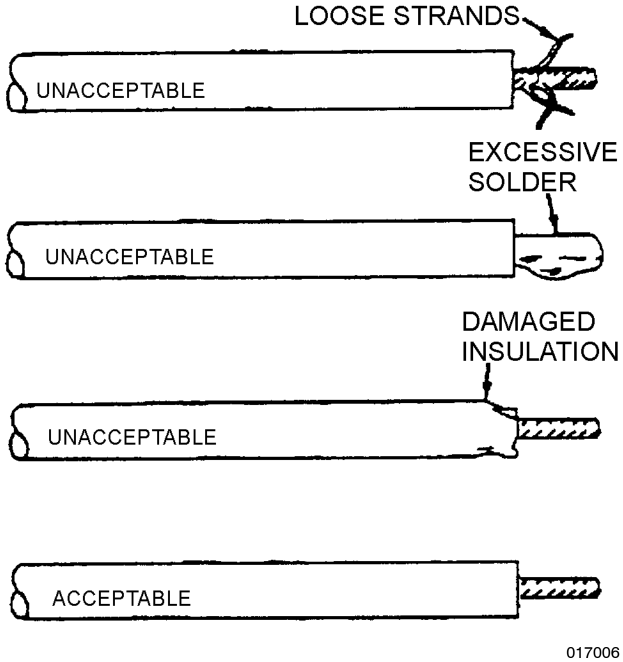


Figure 6. Acceptable and Unacceptable Conditions of Tinned Wire

43. **WIRES TO BE CRIMPED.** Do not tin wires which are to be crimped to Class K (fireproof) connectors, wires which are to be attached to solderless terminals or splices, or wires which are to be crimped to removable crimp-style connector contacts.

44. **SOFT SOLDER AND FLUX PREPARATION.** The flux used to tin wire is a mixture of alcohol and rosin in a non-activated solution. During use, the alcohol will evaporate and should be replaced. Keep container closed when not in use to minimize evaporation. The solder used is a mixture of tin and lead. Maintain temperature of the solder pot between 450°F and 500°F (232°C and 260°C); this will keep solder in a liquid state. Skim surface of solder pot as necessary with a metal spoon or blade to keep solder clean and free from oxides, dirt, etc.

45. **HARD SOLDER AND FLUX PREPARATION.** The flux used for hard solder is water based, and may evaporate over time. Keep container closed when not in use. Dilute with water or warm to proper consistency before use. The temperatures required for hard solder are higher than that of soft solder. Maintain the solder pot in the proper range for the solder composition being used. Silver alloy will flow at approximately 635°C (1175°F).

CAUTION

Do not use extra heat and special fluxes as a substitute for properly cleaned soldering surfaces.

Do not use any other flux or solder for tinning copper wires for use in aircraft electrical systems.

During tinning operation, take care not to melt, scorch, or burn the insulation.

46. **DIP-TINNING.** Dip-Tin wires individually, regardless of size (Figure 7). The procedure for dip-tinning is as follows:

a. Prepare flux and solder as described in paragraphs 44 or 45, as appropriate.

b. Ensure that exposed end of wire is clean and free from oil, grease, and dirt. Strands should be straight and parallel. Dirty wire should be restripped.

c. Grasp wire firmly and dip into dish of prepared flux to a depth of about 1/8 inch.

d. Remove wire and shake off excess flux.

e. Immediately dip into molten solder. Dip only half of stripped conductor length into solder.

NOTE

The thickness of the solder coat depends on the speed with which the wires are handled and shaken, and the temperature of the solder bath.

f. Manipulate wire slowly in solder bath until it is thoroughly tinned. Watch the solder fuse to wire. Do not keep wire in bath longer than necessary.

g. Remove wire and shake off excess solder.

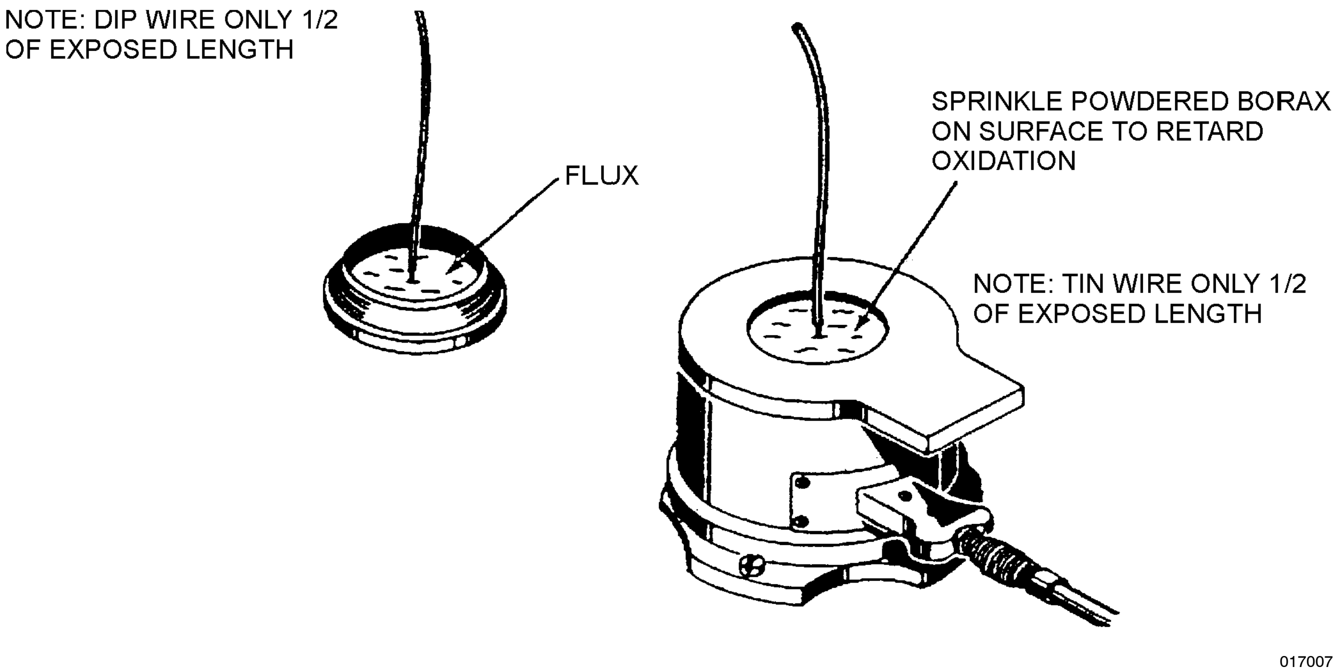


Figure 7. Dip-Tinning in Solder Pot

47. **ALTERNATE DIP TINNING.** If an electrically heated solder pot is not available, a small number of wires may be tinned by means of the following procedure (Figure 8):

a. Cut off beveled section of tip of a discarded soldering iron tip.

b. Drill hole (1/4 to 3/8 inch diameter) in cylindrical part of tip, about two-thirds through.

c. Heat iron and melt rosin-core solder into hole.

d. Tin wires by dipping into molten solder one at a time.

e. Keep adding fresh rosin-core solder as the flux burns away.

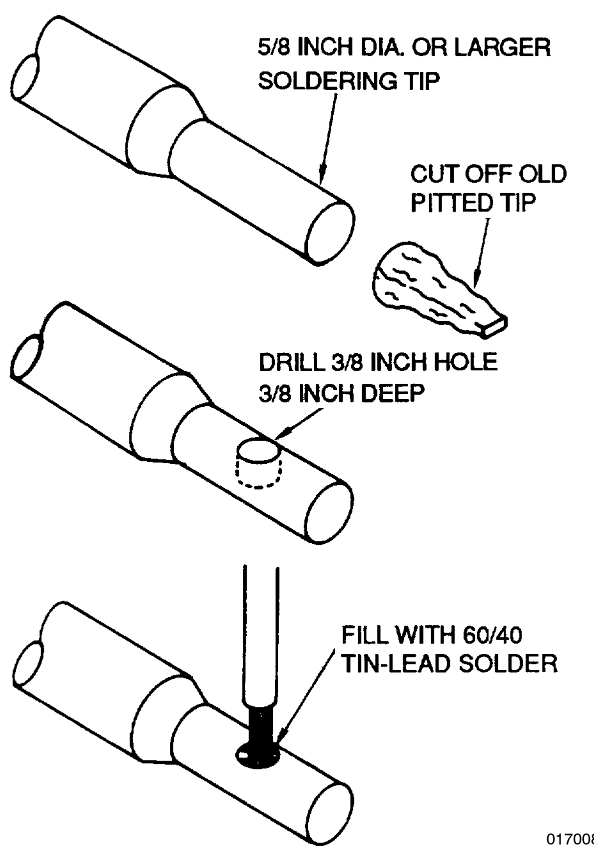


Figure 8. Alternate Dip-Tinning Method

48. **TINNING WITH A SOLDERING IRON.** In the field, wires smaller than size 10 AWG may be tinned with a soldering iron and rosin-core solder as follows (Figure 9):

a. Select a soldering iron having suitable heat capacity for wire size from Table 1. Ensure that iron is clean and well tinned.

b. Prime by holding iron tip and solder together on wire until solder begins to flow.

c. Move soldering iron to opposite side of wire and tin half of the exposed length of conductor.

Table 1. Approximate Soldering Iron Sizes For Tinning

Wire Size (AWG)	Soldering Iron Size (Heat Capacity)
#20 - #16	60 Watts
#14 & #12	100 Watts
#10 & #8	200 Watts

49. **TINNING WITH SILVER (HARD) SOLDER.** Before wires are soldered to terminals or other connections, they are tinned. The inability to obtain a good tinned surface indicates that the wire was not clean. The procedure for tinning wire and terminals is shown in Figure 10.

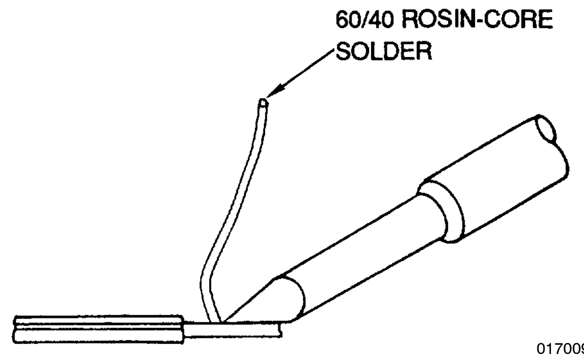
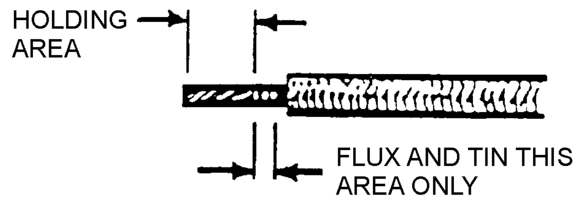


Figure 9. Tinning Wire With a Soldering Iron

A. TINNING

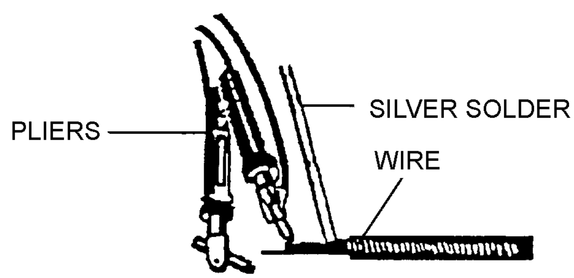
WARNING

SILVER SOLDER BRAZING ALLOY, QQ-B-654 GRADESIV, V, VII, AND VIII, ARE OF THE CADIUM-CONTAINING SILVER ALLOY TYPE. THEIR USE WAS PREVIOUSLY PREFERRED BECAUSE OF THEIR LOW BRAZING TEMPERATURE RANGE AND SATISFACTORY SERVICE PERFORMANCE. HOWEVER, POISONOUS FUMES ARE PRODUCED ON HEATING WHICH MAKES THEIR THEIR USE OBJECTIONAL FOR BRAZING OPERATIONS. THEY WILL BE DELETED FROM QQ-B-645 WHEN SUBSTITUTED BRAZING ALLOYS HAVE BEEN EVALUATED FOR SERVICE USE.



CAUTION

SILVER SOLDER WILL FLOW AND ADHERE TO CONDUCTOR AT APPROXIMATELY 1175°F. (635°C) AVOID HEAT GREATER THEN NECESSARY. EXCESS HEAT WILL DECOMPOSE FLUX AND PREVENT ALLOYING OF SILVER SOLDER TO WIRE.



1. RESISTANCE TINNING.

(A) STRIP 1/2 INCH LONGER THEN AREA WHICH IS TO BE TINNED. REFER TO PARAGRAPH 40.

(B) THE EXTRA LENGTH IS TO BE USED AS A GRIP AREA DURING TINNING AND IS TO BE REMOVED AFTER TINNING IS COMPLETE.

CAUTION

DO NOT OVERHEAT THE WIRE BY ALLOWING THE CURRENT TO REMAIN ON LONGER THAN NECESSARY TO FLOW THE SILVER SOLDER.

(C) WITH BRUSH, APPLY A SMALL AMOUNT OF HARD SOLDER FLUX TO AREA TO BE TINNED.

Figure 10. Tinning with Silver Solder (Sheet 1 of 3)

(D) USING HEAT RESISTANCE PLIERS, APPLY HEAT DIRECTLY TO WIRE AND MELT A THIN COAT OF SILVER ONTO WIRE.

(E) AFTER SOLDER HAS FLOWED BETWEEN STANDS, SHUT OFF CURRENT AND ALLOW WIRE TO COOL.

(F) TRIM OFF HOLDING AREA OF EXPOSED CONDUCTOR SHOULD BE TRIMMED TO POINT OF TINNING.

2. TORCH TINNING.

(A) STRIP WIRE AS NEEDED. REFER TO PARAGRAPH 40.

(B) DIP HALF OF EXPOSED, CLEAN CONDUCTOR INTO HARD FLUX.

(C) PROTECT WIRE INSULATION WITH NOTCHED COPPER SHEET SHIELD, TO PREVENT SCORCHING.

CAUTION

SILVER SOLDER WILL FLOW AND ADHERE TO CONDUCTOR AT APPROXIMATELY 1175°F (635°C). AVOID GREATER HEAT THAN NECESSARY. EXCESS HEAT WILL DECOMPOSE FLUX AND PREVENT ALLOYING OF SILVER TO WIRE.

(D) USING TORCH, APPLY FLAME TO WIRE UNTIL FLUX BUBBLES. THEN FEED SMALL AMOUNT OF SILVER SOLDER IN WIRE TO FLUXED AREA WHILE FLAME IS KEPT THERE. AFTER SOLDER HAS FLOWED, REMOVE FLAME AND ALLOW WIRE TO COOL.

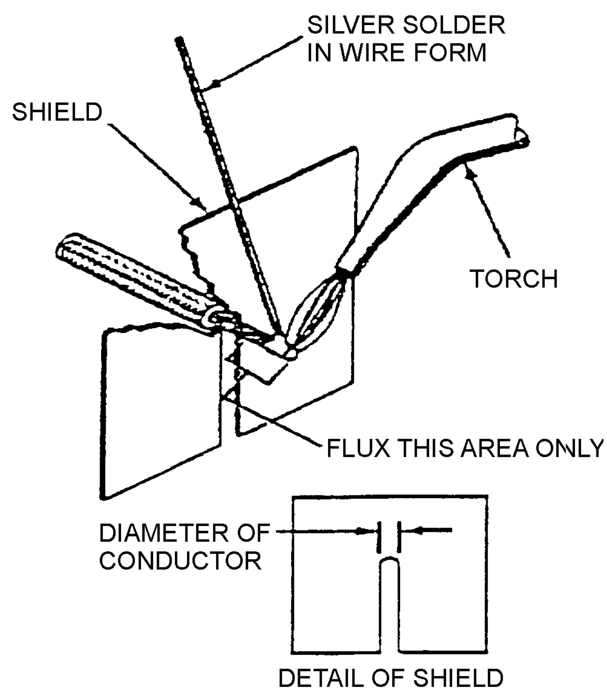


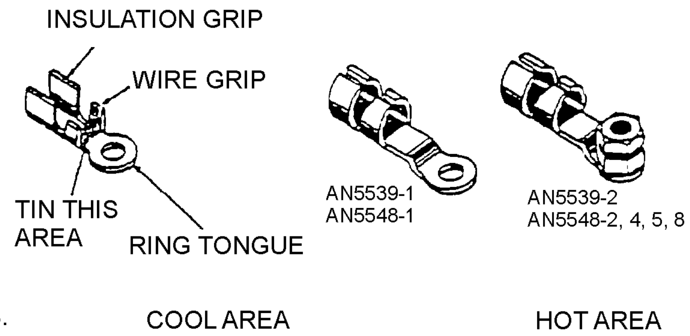
Figure 10. Tinning with Silver Solder (Sheet 2)

B. ATTACHING THERMOCOUPLE WIRE TO TERMINALS.

NOTE

TINNING OF THERMOCOUPLE TERMINALS IS REQUIRED TO THERMOCOUPLE WIRE.

1. TYPES OF THERMOCOUPLE TERMINALS.



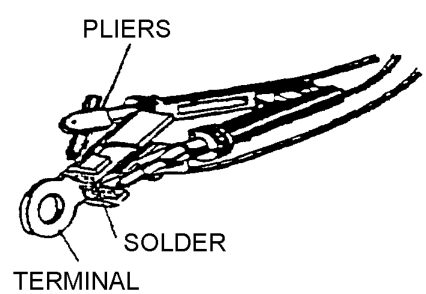
NOTE

TINNING OF THERMOCOUPLE TERMINALS IS REQUIRED TO THERMOCOUPLE WIRE.

2. WITH BRUSH, APPLY A SMALL AMOUNT OF HARD SOLDER FLUX TO AREA TO BE TINNED.

3. TINNING TERMINALS CAN BE ACCOMPLISHED BY USING RESISTANCE OR TORCH METHODS.

(A) RESISTANCE TINNING USE A UNIT WITH 2500 WATTS POWER. APPLY HEAT TO TERMINAL AT WIRE GRIP AND MELT A THIN COAT OF SOLDER ONTO INNER SURFACE.



(B) TORCH TINNING. USING A TORCH, APPLY HEAT TO BACK SIDE OF TERMINAL AT WIRE GRIP AREA AND MELT A COAT OF SOLDER ONTO TERMINAL.

4. ALLOW TERMINAL TO COOL.

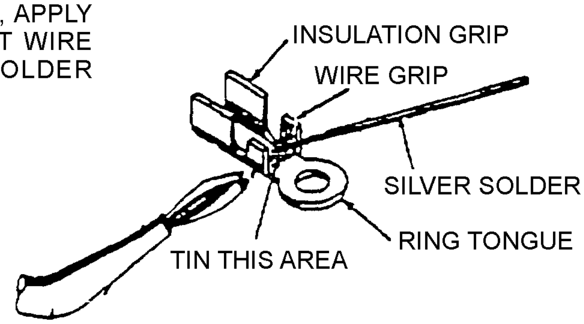


Figure 10. Tinning with Silver Solder (Sheet 3)

50. SOLDERING IRONS.

51. **SOLDERING IRON SELECTION.** Select a soldering iron with a thermal capacity high enough so that the heat transfer is fast and effective. An iron with excessive heat capacity will burn or melt wire insulation; an iron with too little heat capacity will make a cold joint in which the solder does not alloy with the work. A soldering iron should also be suited to the production rate. Do not select a small pencil iron where a high steady heat flow is required.

52. **SELECTION BY WATTAGE.** Soldering irons are available in wattage ranges from 20 to 500 watts. Irons with wattage ratings of 60, 100, and 200 watts are recommended for general use in aircraft electrical wiring. Pencil irons with a rating of 20 to 60 watts are recommended for soldering small parts. The soldering iron recommended for printed circuit soldering is a lightweight 55 watt iron with a 600°F (316°C) Curie point tip control. This iron has a three-wire cord to eliminate leakage currents which could damage the printed circuits.

53. **TIP SELECTION.** Select the tip best suited for the size and shape of the work being soldered. Soldering iron tips are available in sizes from 1/16 inch to 2 inches in diameter. For general use, a tip of 1/4 inch to 3/8 inch diameter is recommended. For printed circuit soldering, use a long shank tip of 1/16, 1/8, 3/32, or 3/16 inch diameter. Screwdriver, chisel, and pyramid shapes are recommended (Figure 11).

WARNING

Avoid oral contact with hands during soldering operations and wash hands immediately after soldering operation. The lead contained in solder can be a source of lead oxide. Lead oxide, when absorbed in the body over the years, can cause serious health problems. Touching solder followed by smoking or eating is a potential means of ingesting trace amounts of lead oxide.

54. **APPLICATION OF HEAT AND SOLDER.** Apply flux-core solder at the exact point between the metal and the soldering iron holding iron directly against the assembly. Melt the solder on the joint, not to the iron. Place the soldering iron firmly against the junction. If heavy rocking pressure is necessary, either the iron does not have sufficient heat capacity for the job, or it has not been properly prepared, or both. Do not apply heat to the work any longer than necessary to melt the solder on all parts of the joint. Do not use any more solder than necessary. Do not pile up solder around the joint; this is wasteful and results in joints difficult to inspect. Care should be exercised with silver coated wire to prevent wicking during solder application (Figure 12).

55. **OVERHEAT PROTECTION.** Do not allow the iron to overheat. Disconnect the iron when it is not in use (between operations), or use a heat dissipating stand which will keep the iron at a constant temperature. When the soldering iron is not in actual use during operations, keep it in a holder. This will protect the operator against burns and the iron against damage (Figure 13).

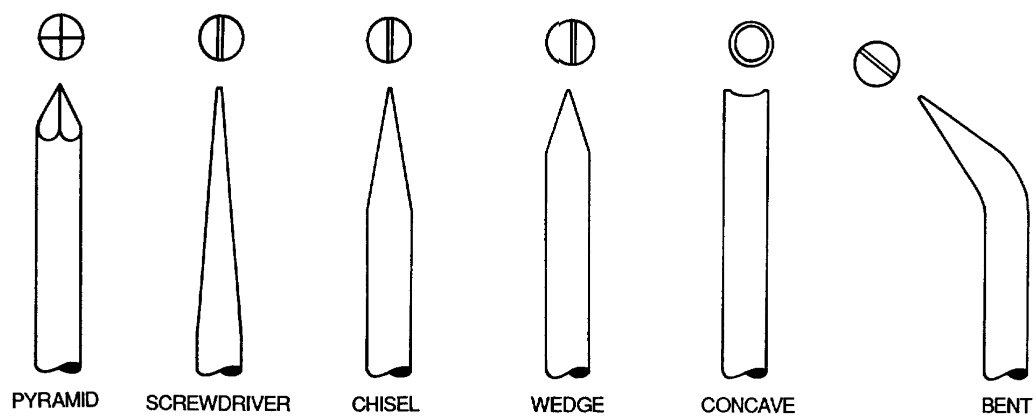


Figure 11. Soldering Iron Tip Shapes (Typical)

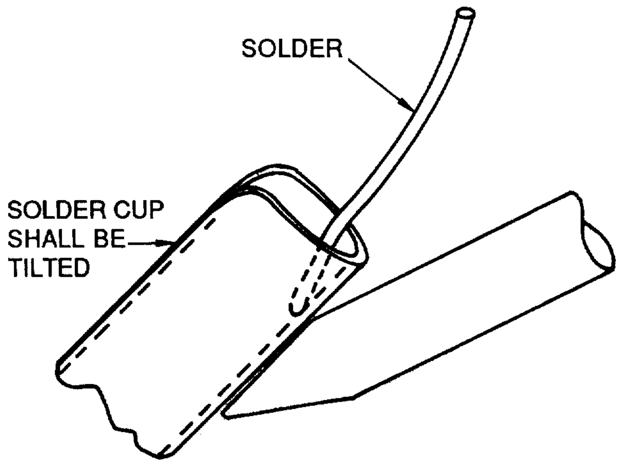


Figure 12. Correct Solder Application

56. **COOLING.** When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a mechanically weak joint with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

WARNING

Isopropyl alcohol is flammable - do not use near open flames, welding areas, or on hot surfaces. Do not smoke when using it, and do not used where others are smoking. Inhalation of vapors can cause drowsiness, dizziness and headaches. Contact of liquid wit skin may cause dermatitis and irritation. If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air. Consult MSDS.

Ensure proper PPE is used. It is especially critical to wear eye protection during the following cleaning steps as the brushing action can cause isopropyl alcohol to be ejected from the brush.

57. **CLEANING.** If the correct amount of solder is used and procedure instructions followed carefully, there should be little or no excess flux remaining on the finished joint. Remove remaining flux by brushing the joint with a stiff brush (an acid brush with the bristles cut in half can be very useful for this purpose) dipped in isopropyl alcohol. Use alcohol sparingly and avoid contact between alcohol and wire insulation. For cleaning printed circuit connections, use a cotton swab−stick for small areas and a lint−free clean cloth for large areas and board edges. Ultraviolet light may be used to detect the flux resin residue. Under the ultraviolet light, traces of flux appear as a fluorescent yellow to light brown residue.

58. SOLDER TERMINATION PROCEDURE.

59. Solder termination procedures shall be followed to ensure good electrical contact, mechanical adhesion, and clean solder joints. Each type of termination must be inspected and cleaned in accordance with the general procedures.

60. **SPADE TERMINALS.** Spade terminals, also called eyelet terminals, shall be terminated in the manner described (Figure 14).

61. **HOOK TERMINALS.** Hook terminals are manufactured in the shape of a hook and are terminated using a hook shape in the wire to be terminated (Figure 15).

62. **TURRET TERMINALS.** Turret terminals are those that stand upright in a post position and are terminated using a hook shape in the wire to be terminated (Figure 16).

63. **BIFURCATED TERMINALS.** Bifurcated terminals are those that stand upright but are divided into two parts and are terminated using three types of terminal fill (Figure 17).

64. **SOLDER CUP.** A solder cup is a hollow cylinder at the tubular end of a terminal or solder contact in which a conductor is inserted and soldered in place (Figure 18).

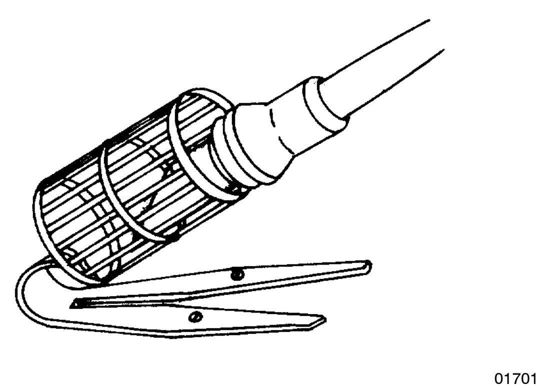
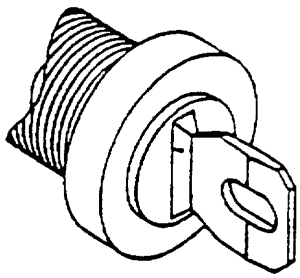


Figure 13. Soldering Iron Holder

A. SPADE TERMINAL TERMINATIONS.

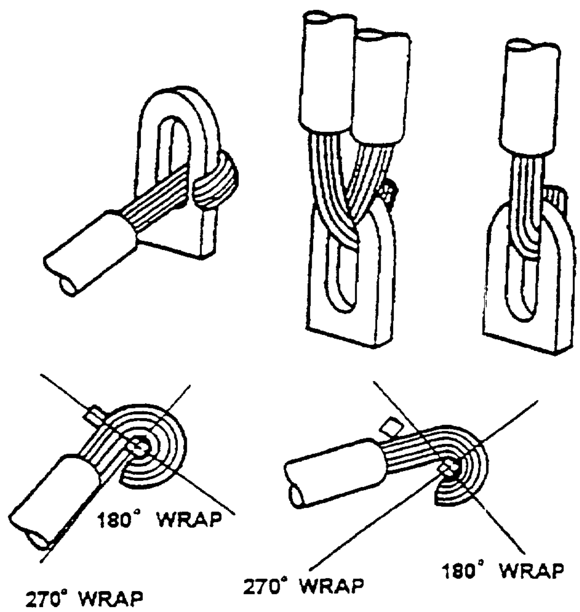


1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. INSERT AND CENTER WIRE ON THE TERMINAL.

4. WRAP THE WIRE EITHER 90° OR 180° FROM THE POINT OF ENTRY AROUND THE TERMINAL.



5. APPLY FLUX, SOLDER, AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

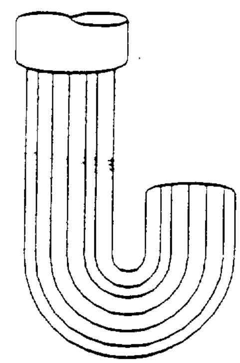
Figure 14. Spade Terminal Terminations

A. HOOK TERMINAL TERMINATIONS.

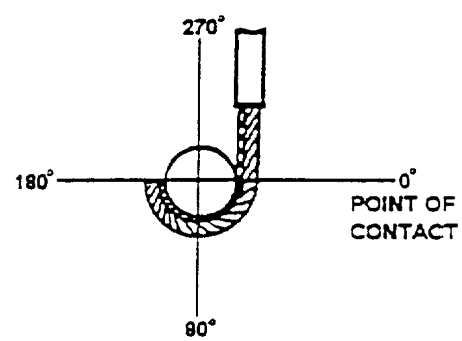
1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. FORM THE WIRE TO BE TERMINATED IN SHAPE OF HOOK 180 .



4. POSITION HOOK ON TERMINAL. ENSURE CONTACT WITH TERMINAL. ENSURE WIRE DOES NOT EXTEND BEYOND HOOK TERMINAL.



5. APPLY FLUX, SOLDER, AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTIONS FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

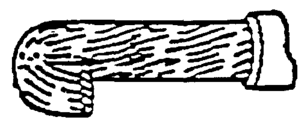
Figure 15. Hook Terminal Terminations

A. TURRET TERMINAL TERMINATIONS.

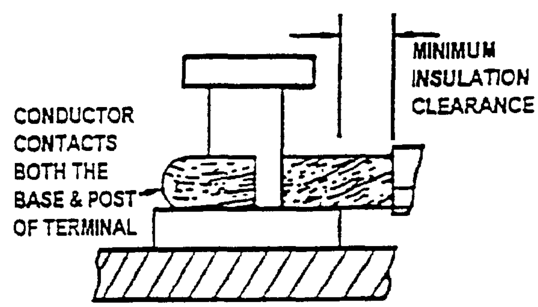
1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. FORM THE WIRE TO BE TERMINATED IN SHAPE OF HOOK 180°.



4. POSITION HOOK ON TERMINAL. ENSURE CONTACT WITH TERMINAL. ENSURE WIRE DOES NOT EXTEND BEYOND HOOK TERMINAL.



5. APPLY FLUX, SOLDER, AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTIONS FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

Figure 16. Hook Terminal Placement

A. TOP-ROUTE WIRES. METHOD OF CONNECTING THE WIRE BY COMING THROUGH THE TOP OF BIFURCATION GAP.

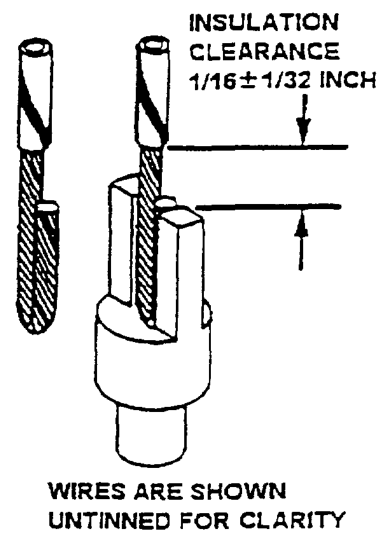
1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. FORM THE WIRE TO BE TERMINATED. DEPENDING ON THE BIFURCATION GAP, IN ONE OF THE FOLLOWING:

(A) A LARGE-DIAMETER WIRE WHICH FILLS THE GAP SHALL BE INSERTED WITH NO BEND AND SHALL REQUIRE ONLY FILLETS FOR RETENTION.

(B) A SMALL-DIAMETER WIRE WHICH DOES NOT FILL THE GAP SHALL BE BENT INTO A U-SHAPE AND INSERTED, PROVIDED THAT THE COMBINED DIAMETER IS SUFFICIENT TO FILL THE GAP.



4. POSITION WIRE IN GAP, ENSURE CONTACT WITH TERMINAL.

5. APPLY FLUX, SOLDER AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

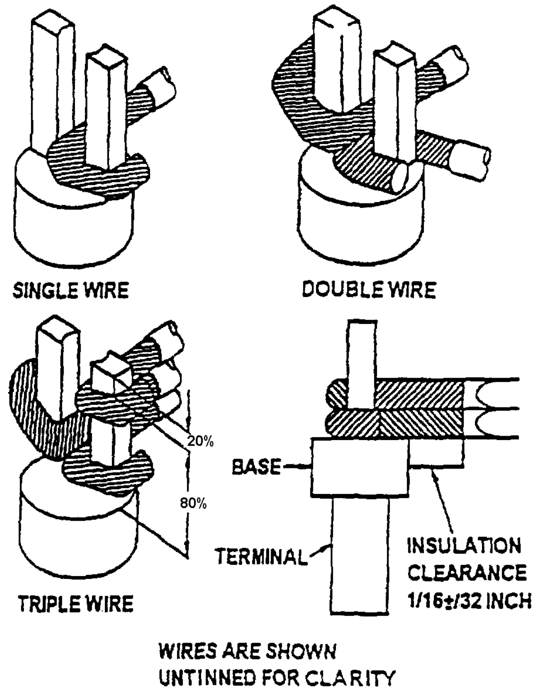
Figure 17. Bifurcated Terminal Terminations (Sheet 1 of 3)

B. SIDE-ROUTE WIRES. METHOD OF CONNECTING THE WIRE BY ENTERING THE MOUNTING SLOT FROM THE SIDE.

1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. FORM THE WIRE TO BE TERMINATED INTO THE SHAPE OF TWO 90° BENDS. WHEN MORE THAN ONE WIRE IS TO BE CONNECTED TO TERMINAL, DIRECTION OF THE 90° BENDS SHALL ALTERNATE. FIRST WIRE SHALL BE ATTACHED TO THE BASE AND THE VERTICAL POST. ADDITIONAL WIRES SHALL BE ATTACHED AS CLOSE AS POSSIBLE TO THE PRECEDING WIRE. A MAXIMUM OF THREE WIRES WILL BE PERMITTED. ALL WIRES SHALL BE CONFINED WITHIN LOWER 80 PERCENT OF THE TERMINAL.



4. POSITION WIRE IN GAP, ENSURE CONTACT WITH TERMINAL.

5. APPLY FLUX, SOLDER AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTIONS FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

Figure 17. Bifurcated Terminal Terminations (Sheet 2)

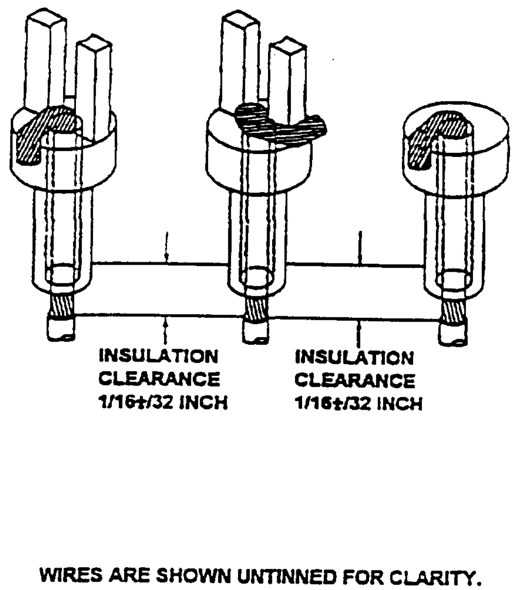
C. BOTTOM-ROUTED WIRES. ALSO KNOWN AS HOLLOW FEED-THROUGH. METHOD OF CONNECTING THE WIRE BY PASSING THROUGH THE FEED THROUGH TERMINAL.

1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. AFTER PASSING THROUGH THE FEED-THROUGH TERMINAL, FORM THE WIRE TO BE TERMINATED WITH A DOUBLE 90° BEND.

4. POSITION WIRE ON THE TERMINAL TOP SURFACE, ENSURE CONTACT WITH TERMINAL.



5. APPLY FLUX, SOLDER AND HEAT IN ACCORDANCE WITH PARAGRAPH 54.

6. INSPECT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

Figure 17. Bifurcated Terminal Terminations (Sheet 3)

A. SOLDER CUP PREPARATION.

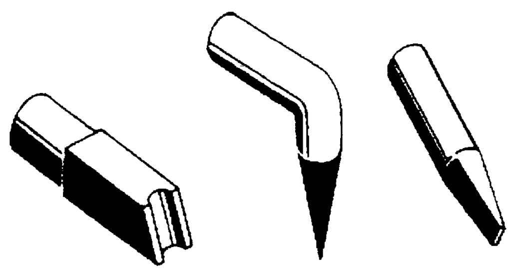
WARNING

ISOPROPYL ALCOHOL IS FLAMMABLE - DO NOT USE NEAR OPEN FLAME, WELDING AREAS, OR ON HOT SURFACES. DO NOT SMOKE WHEN USING IT, AND DO NOT USE IT WHERE OTHERS ARE SMOKING. INHALATION OF VAPORS CAN CAUSE DROWSINESS, DIZZINESS AND HEADACHE. CONTACT OF LIQUID WITH SKIN MAY CAUSE DERMATITIS AND IRRITATION. IF ANY LIQUID CONTACTS SKIN OR EYES, IMMEDIATELY FLUSH AFFECTED AREA WITH WATER. REMOVE SOLVENT-SATURATED CLOTHING. IF VAPORS CAUSE DROWSINESS, GO TO FRESH AIR.

1. CLEAN THE SOLDER CUP PRIOR TO SOLDERING. NEW SOLDER CUPS CAN BE CLEANED WITH ISOPROPYL ALCOHOL AND AN ACID BRUSH. USED SOLDER CUPS THAT ARE TO BE REWORKED CAN BE CLEANED BY TINNING. VERY DIRTY OR OXIDIZED SOLDER CUPS MAY REQUIRE ABRASIVE METHODS TO REMOVE NON-METALLIC OXIDES.

2. IMPROVE TINNING AND SOLDERING OF CONTACTS IS ACHIEVED BY PROPER HEATING OF THE CONTACT. CHOOSE THE SOLDERING IRON TIP SHAPE WILL PROVIDE THE BEST HEATING OF THE CONTACT. LARGE CONTACTS CAN BE REMOVED FROM THE INSERT AND HELD IN A NONMETALLIC BLOCK TO MINIMIZE HEAT LOSS (FIGURE 21).

3. PREFILL THE SOLDER CUP WITH ENOUGH SOLDER TO FILL THE CUP WITHOUT OVERFLOW WHEN THE TINNED CONDUCTOR IS INSERTED. THE AMOUNT OF PREFILLING NEEDED WILL DEPEND UPON THE CONDUCTORS BEING USED. AS A RULE OF THUMB, FILL THE CUP WITH SOLDER TO THE LOWER LIP OF THE CUTOUT SECTION.



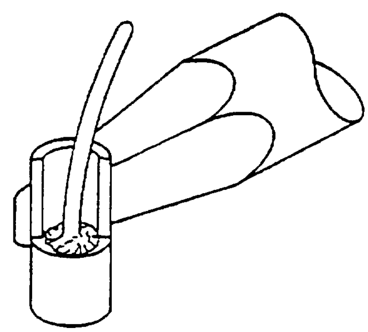


Figure 18. Solder Cup Termination (Sheet 1 of 3)

4. ALL EXCESS SOLDER SHOULD BE REMOVED, LEAVING THE TERMINAL INTERIOR BRIGHT AND SHINY. AVOID SPILLING SOLDER INTO AREAS NOT REQUIRING SOLDER. CLEAN THE SOLDER CUP WITH ISOPROPYL ALCOHOL AND AN ACID BRUSH AFTER THE TINNED SOLDER CUP HAS COOLED.

B. SOLDER CUP TERMINATION.

1. STRIP WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 40.

2. TIN WIRE TO BE TERMINATED IN ACCORDANCE WITH PARAGRAPH 41.

3. CUT A SUFFICIENT LENGTH OF INSULATION SLEEVING/TUBING AND SLIDE INTO WIRE.

4. HEAT THE SOLDER AND INSERT THE CONDUCTOR WHEN WHEN THE SOLDER IS MOLTEN (ALLOW GASES AND FLUXES TO ESCAPE). FULLY BOTTOM THE CONDUCTOR.

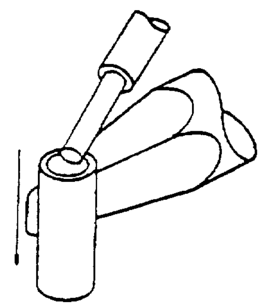
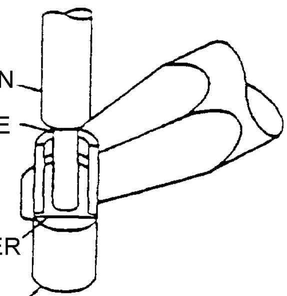


Figure 18. Solder Cup Termination (Sheet 2)

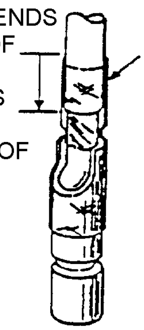
5. THE WIRE SHALL BE CENTERED IN THE CUP AND ENTER PARALLEL TO THE AXIS OF THE SOLDER CUP. THE WIRE SHALL BE BOTTOMED AND IN CONTACT WITH THE REAR OF THE SOLDER CUP.



6. INSULATION CLEARANCE SHALL BE A MINIMUM OF ONE WIRE DIAMETER AND NO GREATER THAN TWO WIRE DIAMETERS (INCLUDING INSULATION) FROM THE TOP EDGE OF THE SOLDER CUP.

7. THE INSULATION SLEEVING/TUBING SHALL EXTEND BEYOND THE WIRE INSULATION A MINIMUM OF TWO WIRE INSULATION DIAMETERS.

8. THE INSULATION SLEEVING/TUBING SHALL FIT SNUGLY AGAINST THE WIRE'S INSULATION. THERE SHALL BE NO EVIDENCE OF OVERHEATING OF THE INSULATION SLEEVING/TUBING.



CAUTION

DO NOT ALLOW SOLDER TO COLLECT OUTSIDE OF THE SOLDER CUP. THIS WILL REDUCE THE EFFECTIVE DISTANCE BETWEEN CONTACTS AND CAN RESULT IN CONNECTOR FAILURE.

9. INSERT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

Figure 18. Solder Cup Termination (Sheet 3)

CAUTION

Use only rosin based non-active flux when soldering to contacts, and clean thoroughly following soldering to minimize potential corrosion.

65. **ELECTRICAL RESISTANCE SOLDERING.** Resistance soldering will yield excellent results for both very large and very small contacts.

a. Large contacts are soldered to wires by the use of resistance soldering pliers (Figure 19). The contact is removed from the insert, held in the jaws of the pliers and current is applied until the solder in the cup has melted. The tinned wire is inserted slowly into the solder cup while the current is being applied. After the wire is fully inserted, continue heating until the solder flows to form a smooth fillet. Allow joint to cool and harden without movement.

b. Small contacts are soldered by the use of a pencil type resistance soldering tool (Figure 20). The two electrodes of the tool are placed in contact with the side of the solder cup so that the heating current will pass through the wall of the cup. When the solder flows, insert the tinned wire. Continue to apply heat to the connection until the solder flows to form a smooth fillet, then the current and allow the joint to cool and harden without movement.

66. **TORCH SOLDERING.** A torch can be used to solder wire into a large contact which has been removed from its insert (Figure 21).

CAUTION

Do not overheat. Excessive heat will destroy the planting and soften the contact.

a. Hold the contact in a nonmetallic block to avoid heat loss. Direct the torch over the solder cup area until the solder melts.

b. When the solder in the cup has melted, insert the wire slowly into the cup and add more solder if necessary. Continue to heat the connection until the solder flows into a smooth fillet, then remove from the flame. Allow the joint to cool and harden without movement.

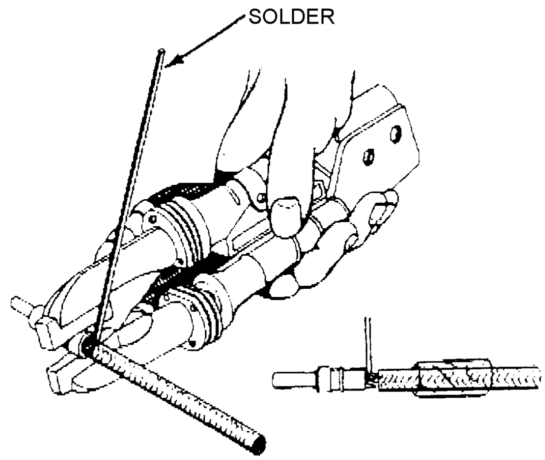


Figure 19. Resistance Soldering to Large Contacts

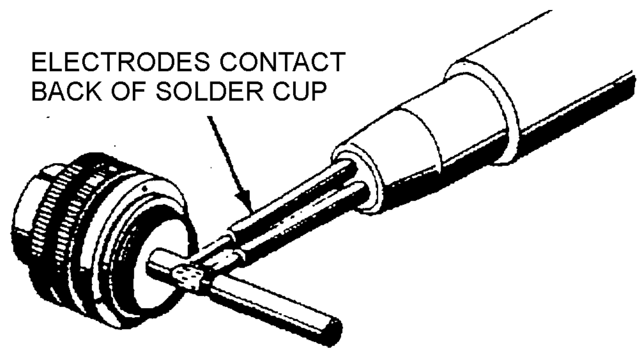


Figure 20. Resistance Soldering to Small Contacts

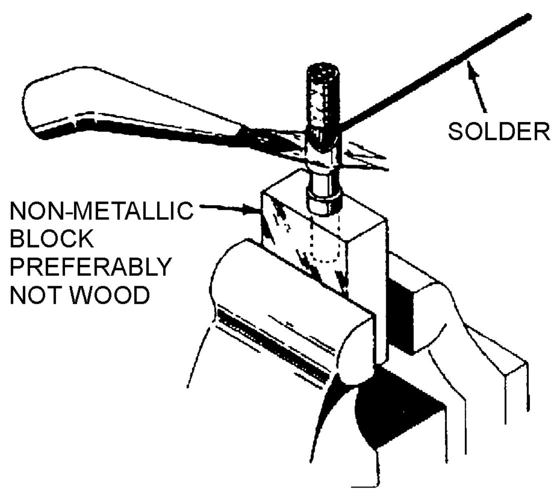


Figure 21. Torch Soldering Large Contact

NOTE

When soldering to connectors with a large number of contacts, a cooling off period should be allowed after each series of twenty contacts in order to prevent heat build-up.

67. **SOLDERING SEQUENCE.** When soldering wires to connector, follow a rigid sequence to help avoid errors in wiring and prevent burning or scorching the insulation of wires already soldered. Two suggested sequences are shown (Figure 22) but are not mandatory. It is important tat a fixed sequence is developed and used.

68. **SOLDERING TERMINALS WITH SILVER (HARD) SOLDER.** Solder high temperature wire to terminals (see Figure 23). For more detailed information on soldering thermocouple wire, see WP 015 00.

69. **SOLDERING CONTACTS WITH SILVER (HARD) SOLDER.** Refer to Figure 24 for procedures to attach conductors to contact pins using silver solder. For more detailed information on soldering thermocouple wire, see WP 015 00.

70. **QUALITY STANDARDS.** Quality is the most important standard. When quality is maintained, good electrical and mechanical joints will follow. Solder joints or connections are either acceptable or unacceptable.

a. Solder Joint. A good solder joint will have a bright silvery appearance, with smooth fillets and feathered, not sharp, edges. The entire joint will be covered with a smooth even coat of solder, and the contour of the joint will be visible. Any of the following indicate a poor solder joint and are cause for rejection:

(1) Dull gray, chalky, or granular appearance (evidence of a cold joint).

(2) Hair cracks or irregular surface (evidence of a disturbed joint).

(3) Grayish, wrinkled appearance (evidence of excessive heat).

(4) Partially exposed joint (evidence of insufficient solder).

(5) Scorched wire insulation or burned connector inserts.

(6) Globules, drips, or tails of solder.

b. Insulation Damage. When a good solder joint is accomplished, the insulation will be properly cut and shall not show any of the following, which will be cause for rejection:

(1) Charred, burned or blistered (evidence of overheating).

(2) Frayed or uneven appearance.

(3) Solder on insulation.

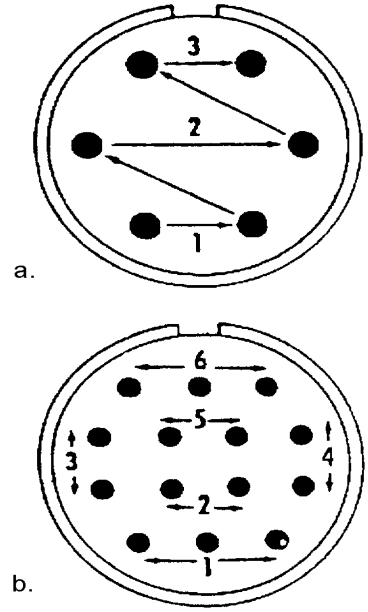


Figure 22. Connector Soldering Sequence

71. **TERMINAL STANDARDS.** Poor workmanship which relates to poor quality as illustrated. This type of workmanship applies to spade, hook, and turret terminals. This work is unacceptable and is cause for rejection (Figure 25).

72. **SOLDER CUP STANDARDS.** Standards illustrated are acceptable and unacceptable work. Unlike terminal standards there is a maximum solder and minimum solder quantity. When these are exceeded the work is unacceptable and is cause for rejection (Figure 26).

73. **REWORK.** If any of the above are present, the joint shall be taken apart, parts cleaned, and the entire soldering operation repeated, using fresh solder and flux.

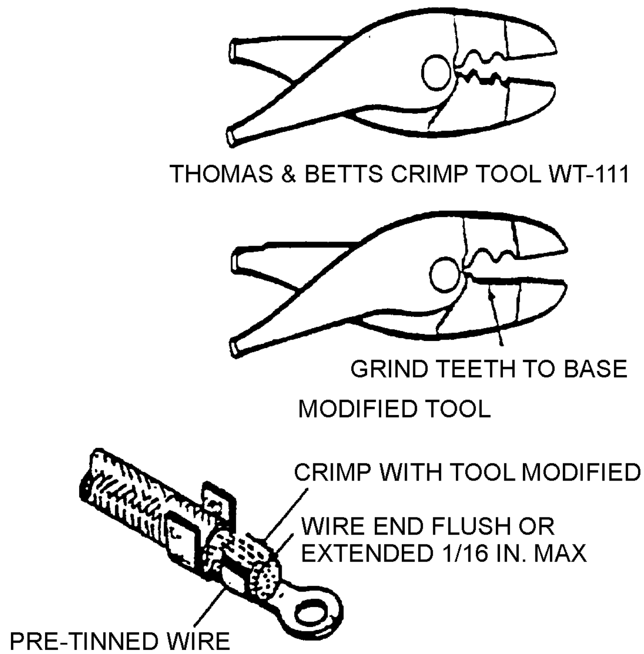
74. **UNSOLDERING.** There are times that it will be necessary to remove a wire from a soldered connection. Solder should be removed from terminals and solder cups either by mechanical means or by wicking.

a. Mechanical Means. The mechanical means is by using a mechanical vacuum device. As the soldering iron heats the solder the mechanical vacuum removes the solder from the work. A solder sucker, which is a hand operated bulb with a tip, may also be used.

b. Wicking. In wicking use a stranded conductor or braided conductor and flux. Place the wire on the solder connection and the tip of the hot iron on the wire, the solder will wick to the wire. When the solder has wicked remove the wire and the iron together.

NOTE
TINNING OF THERMOCOUPLE TERMINALS IS REQUIRED TO THERMOCOUPLE WIRE.

1. SECURE TERMINAL TO THERMO-COUPLE WIRE.



(A) RESISTANCE SOLDERING.

(1) PLACE COPPER SHIELD BETWEEN INSULATION AND AREA TO BE SOLDERED.

(2) HEAT JOINT UNTIL FLUX BUBBLES.

(3) APPLY SILVER SOLDER TO JOINT. WHEN SOLDER HAS FLOWED INTO WIRE GRIP REMOVE PLIERS AND ALLOW JOINT TO COOL.

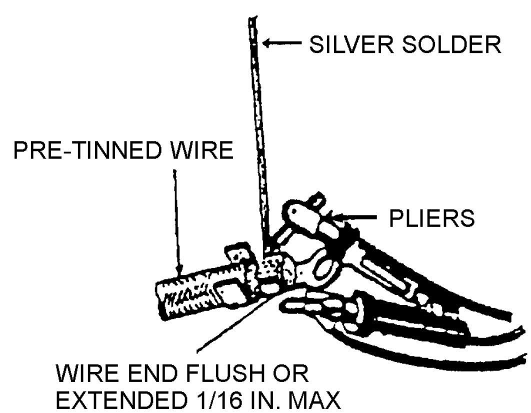


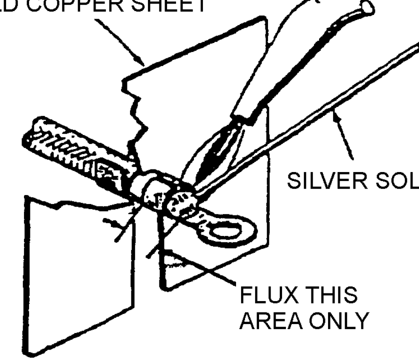
Figure 23. Silver Soldering Terminals (Sheet 1 of 3)

B. TORCH SOLDERING.

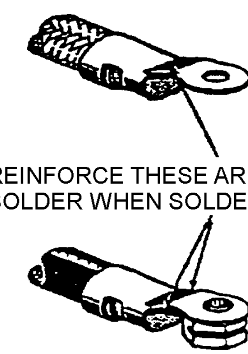
(1) PLACE COPPER SHIELD BETWEEN INSULATION AND AREA TO BE SOLDERED.

(2) HEAT JOINT UNTIL FLUX BUBBLES.

(3) APPLY SILVER SOLDER TO JOINT. WHEN SOLDER HAS FLOWED INTO WIRE GRIP, REMOVE FLAME AND ALLOW JOINT TO COOL.



NOTE
IF AN5539 TERMINALS ARE USED, PLACE ADDITIONAL SOLDER IN AREAS INDICATED.



2. COMPLETING TERMINAL CONNECTION.

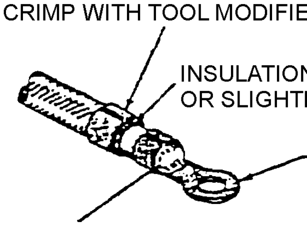
(A) REMOVE FLUX RESIDUES WITH WARM WATER AND A BRISTLE BRUSH. DRY THOROUGHLY.

(B) EXAMINE CONNECTION TO ENSURE SILVER SOLDER HAS ALLOYED TO WIRE AND TERMINAL, AND IS NOT SCORCHED.

Figure 23. Silver Soldering Terminals (Sheet 2)

3. SECURE INSULATION GRIP ON INSULATION USING INSULATION MODIFIED CRIMPING TOOL WT-111. INSULATION GRIP TABS SHALL BE IN FULL CONTACT AND SHOW EVIDENCE OF BITING INTO BUT NOT THROUGH INSULATION.

4. INSPECT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.



WHEN NECESSARY, EARS MAY BE CLIPPED SO THAT ENDS BUTT AFTER CRIMPING

WARNING

ZINC CHROMATE PRIMER IS FLAMMABLE - DO NOT USE NEAR OPEN FLAMES, WELDING AREAS, OR ON HOT SURFACES. DO NOT SMOKE WHEN USING IT, AND DO NOT USE WHERE OTHERS ARE SMOKING. CONTACT WITH LIQUID OR VAPOR CAN CAUSE SKIN OR EYE IRRITATION, DIZZINESS AND HEADACHE. PROLONGED INHALATION CAN RESULT IN KIDNEY AND LIVER DAMAGE. AFTER PROLONGED SKIN SKIN CONTACT, WASH CONTACTED AREA WITH SOAP AND WATER. IF VAPORS CAUSE DIZZINESS, GO GET FRESH AIR. IF IRRITATION PERSISTS, GET MEDICAL ATTENTION.

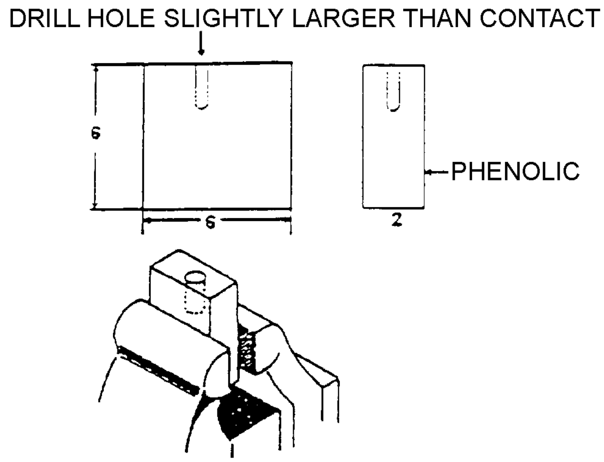
5. COAT WIRE AND INSULATION GRIP AREAS OF TERMINAL WITH ZINC CHROMATE, DO NOT COAT RING TONGUE.

Figure 23. Silver Soldering Terminals (Sheet 3)

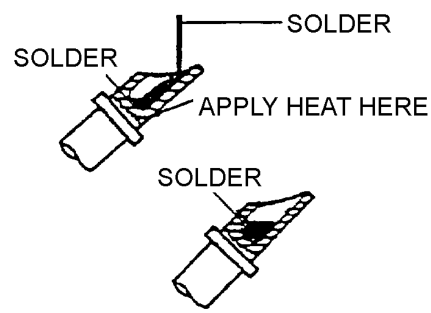
A. SOLDER CONTACT PINS.

1. REMOVE CONTACT FROM CONNECTOR USING APPROPRIATE NAVAIR MANUAL.

2. SECURE CONTACT IN SUITABLE HOLDING FIXTURE.



3. USING HEAT RESISTANCE PLIERS OR FLAME, HEAT CONTACT AND PARTIALLY FILL WITH SOLDER, 46S657, TO FORM CORRECT FILLET.

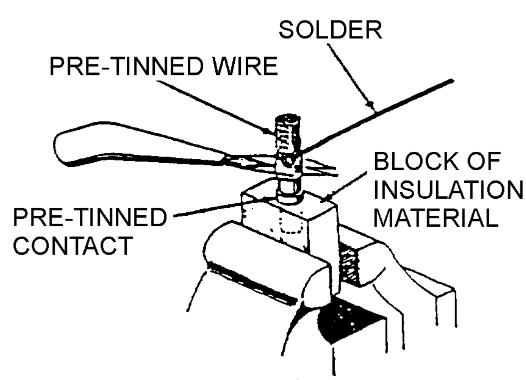


ACCEPTABLE

4. USING PROCEDURES IN FIGURE 23, STRIP AND TIN WIRE AS REQUIRED.

5. INSERT PREPARED WIRE INTO CUP.

6. APPLY HEAT TO CUP WITH HEAT RESISTANCE PLIERS OR FLAME UNTIL FILLER FLOWS ABOUT THE JOINT AND WIRE IS SEATED IN CUP.

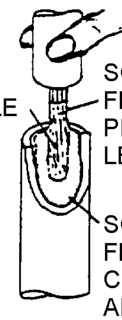


FLAME METHOD

Figure 24. Silver Soldering Contacts (Sheet 1 of 2)

7. REMOVE HEAT AND HOLD WIRE STEADY UNTIL SOLDER SOLIDIFIES,

8. ADDITIONAL FILLER MAY BE USED TO OBTAIN CORRECT FILLET.



9. REMOVE EXCESS FLUX USING WARM WATER AND BRISTLE BRUSH. DRY THOROUGHLY.

10. INSPECT SOLDER CONNECTION FOR QUALITY STANDARDS AS DEFINED IN PARAGRAPH 70.

Figure 24. Silver Soldering Contacts (Sheet 2)

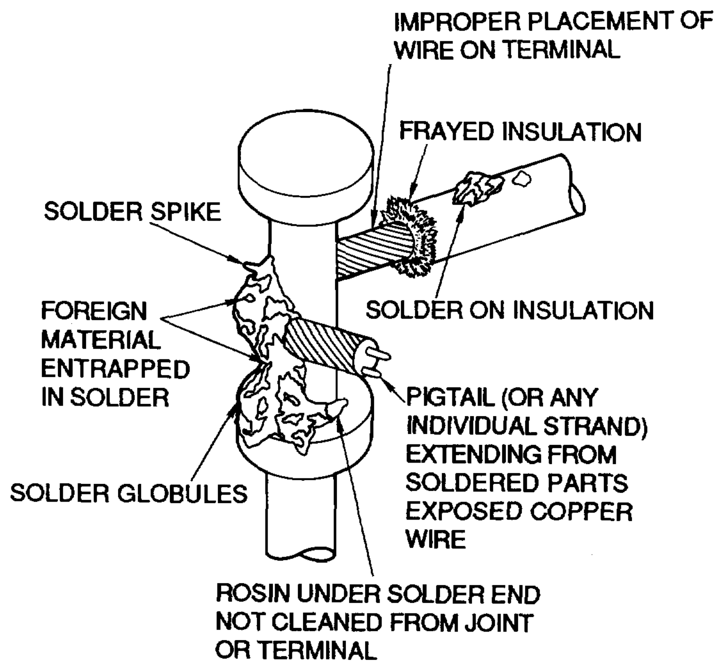


Figure 25. Unacceptable Conditions

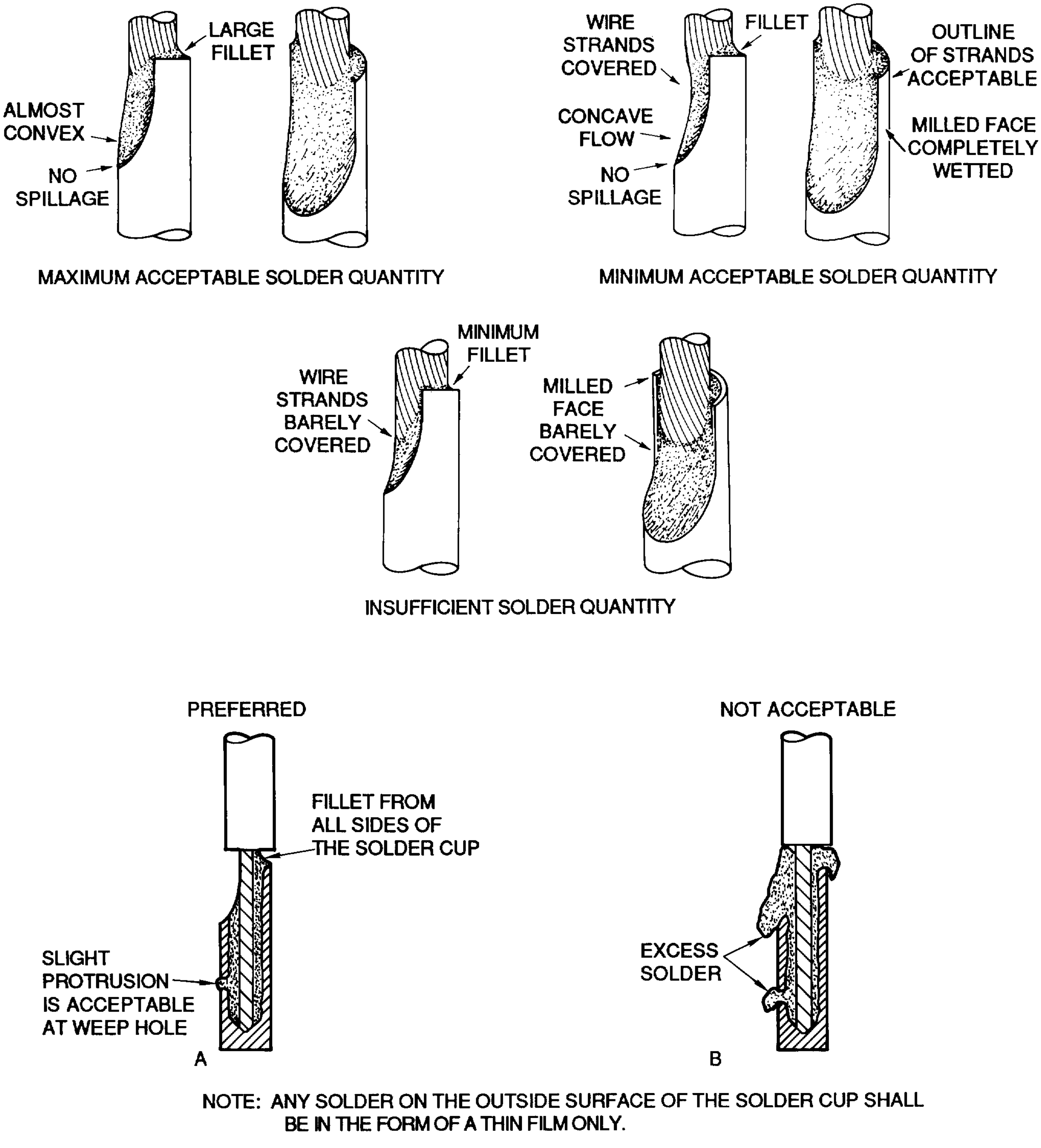


Figure 26. Acceptable and Unacceptable Conditions

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BONDING AND GROUNDING

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatiability and Safety ARP1870
Chemical Conversion Material . . . . . MIL–C–5541 CLASS 3
Connectors and Assemblies, Electrical, Aircraft Grounding:
Type IV Jumper Cable Assembly, Lead, Electrical MIL-C-83413/8
Electromagnetic Environmental Effects Requirements for Systems MIL-STD-464

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directive

None

Support Equipment Required

Nomenclature	Part Number/Type Designation
Low Range Ohmmeter	AN/USM–21A
Ohmmeter	R1L–E or R1L–E–1, 247000, T477W
Crimp Tool	M22520/5
Crimp Tool	M22520/24
Die, Crimp	MS23002
Crimp Tool, Hydraulic	MS25441
Die, Crimp	MS90485

Materials Required

Nomenclature	Part Number/Type Designation
Abrasive Mats	A–A–58054
Chemical Conversion Material	MIL–DTL–81706
Clamp, Bonding	SAE–AS7351
Cloth, Abrasive Coated	ANSI B74.18
Conductor, Copper	ASTM-B172
Lockwasher	NASM35338
Lockwasher	MS35340
Magnesium Alloy. Pretreatment	SAE–AMS–M–3171, Type VI
Methanol	O-M-232
Primer Coating, Epoxy	MIL–PRF–23377
Remover, Paint, Epoxy	TT–R–2918
Sleeving, Insulation, Heat Shrinkable	SAE AMS–DTL–23053/5, Class I
Mineral Spirits, Dry Cleaning	MIL–PRF–680 TYPE II
Splice Set, Quick Disconnect	M6852-3
Terminal Lug, Crimp Copper Insulated	SAE–AS25036 (Series)
Terminal Lug, Crimp Copper Uninsulated	SAE–AS20659 (Series)
Thinner, Dope and Lacquer	TT–R–2918
Washer	NAS1149
Screw	NAS1801
Screw	NAS1802
Lock nut	NASM21042
Lock nut	NASM21043

1 . **INTRODUCTION.**

2 . This work package (WP) describes bonding and grounding procedures, tools and the necessary associated hardware used in the installation and interconnection of electronic and electrical equipment to provide for proper grounding, bonding, and lightning protection.

3 . **USE.** The intended use of bonding requirements is to ensure that the structures of aerospace systems are electrically stable and are made for the following:

a. To protect aircraft and personnel against hazards from lightning discharges.

b. To provide power current paths.

c. To prevent development of EMI potentials.

d. To protect personnel from shock hazard.

e. To provide stability and uniformity of radio transmission and reception.

f. To prevent accumulation of static charges.

g. To provide fault current return paths.

4 . **DEFINITIONS.** For the purpose of this work package the following definitions apply:

a. **Bond.** A bond is a fixed union existing between two objects that results in electrical continuity between them. The bond is formed by either physical contact or from the addition of an electrical connection.

b. **Bonding.** Bonding, or to bond, is the process of obtaining, the electrical continuity which forms the bond.

c. **Bonding Jumpers** . A bonding jumper is a wire, braided wire, or metal strap that provides the necessary continuity to form the bond.

d. **Conducting Surface**. A conducting surface includes all objects having a resistance of less than one megohm per centimeter.

e. **Isolated Surface**. An isolated surface is one that is physically separated by insulation from the structure or other conductors, which are bonded.

f. **Grounding**. The electrical connecting of conducting objects to primary structure for return of current.

5 . **REQUIREMENTS.**

6 . **STANDARD PARTS**. Standard parts shall be used wherever suitable and shall be identified on drawings or documents by their part number. Commercial parts such as screws, bolts, washers, nuts and other hardware may be used providing they do not degrade the equipment or the bond. Standard parts will be preceded by MS, AN, NAS or JAN.

7 . **JUMPERS.** Jumpers used in bonding shall meet the requirements as set forth in MIL-C-83413/8 and as outlined below:

a. Bond or ground parts to the primary aircraft structure where practical.

Table 1 . Bonding Classes

Class	Application
A	Antenna installation
C	Current path return
H	Shock hazard
L	Lightning protection
R	RF potentials
S	Static charge

b. Bond parts individually wherever possible.

c. Make bonding or grounding connections against smooth, clean surfaces.

d. Install bonding or grounding connections so that vibration, expansion or contraction, or relative movement incident to normal service use will not break or loosen the connection.

e. Locate bonding and grounding connections in protected areas whenever possible. Locate connections near hand holes, inspection doors, or other accessible areas to permit easy inspection and replacement whenever possible.

f. No more than four ground wires shall be connected to a common stud (per SAE-AS-50881).

g. Each ground for electric power sources (primary, secondary, conversion, emergency) shall be connected to separate ground points.

h. Equipment that has power supplied from the same source may be connected to a common ground point provided these equipment do not perform duplicate or overlapping functions.

i. Jumpers shall be kept as short and direct as possible.

j. The number of jumpers shall be kept to a minimum by careful design.

k. Jumpers are not to be used in series.

l. Inspect the grounding and bonding straps to make sure that they are free of corrosion which will adversely affect performance, and are not frayed or cut more than 25% of the original strap.

8 . **CLAMPS.** Clamps shall be of the plain type conforming to SAE–AS7351.

9 . **BONDING CLASSES.**

10 . Electrical bonding falls into six classes of application as specified (Table 1). Refer to weapon system/ platform technical manuals for specific applications and associated values. In the absence of specific data, use the information provided in the paragraphs below.

11 . **CLASS A.** Class A bonding relates to the installation of antenna radiating elements exclusive of radar and other similar types. Antennas are installed and provided with a suitable ground plane of adequate dimensions so as not to detract from the desired radiation patterns.

a. Make bonding or grounding connections in such a way as not to weaken any part of the aircraft structure.

12 . **CLASS C.** Class C bonding relates to current path returns and shall be adequate to carry the power current

return. The total impedance shall be such that the voltage drop does not exceed the limits of operation. Magnesium alloy structures shall not be used as a current path return.

13 . **CLASS H.** Class H bonding is to protect against shock hazard. Bonding of 0.1 ohm or less is required for conduits carrying electrical wiring. and may be accomplished through the equipment at which the conduit terminates. Exposed conducting frames or electronic parts and equipment shall be bonded to the structure with a resistance of 0.1 ohm or less.

a. Do not compression-fasten bonding or rounding connections through any nonmetallic material.

14 . **CLASS L.** Class L bonding relates to lightning protection, which shall be provided at all possible points of entry of lightning. Entry points include, but are not limited to the following:

a. Navigation lights.

b. Fuel Filler Caps.

c. Fuel Gage Covers.

d. Refueling Booms.

e. Fuel Vents.

f. Radomes.

g. Canopies.

15 . **CLASS R.** Class R bonding relates to EMI protection. All electrical and electronic units or components, which produce electromagnetic energy, shall be installed to provide a continuous low impedance path (2.5 milliohms or less) from the equipment to the structure per MIL-STD-464. Refer to weapon system/platform technical manual for specific application and associated values. In the absence of specific data, use the information provided in the paragraphs below.

16 . **CLASS S.** Class S bonding relates to static charges. All isolated conducting items except antennas greater than 3 inches, which are external to the vehicle, carrying fluids in motion, are subject to frictional charging and shall be bonded to discharge static or frictional charging. Bonding for static charge shall be 1.0 ohm or less, in accordance with MIL-STD-464.

17 . **FUEL SYSTEM BONDING.**

WARNING

No work shall be performed in open fuel cell unless fuel cell has been defueled, purged and certified gas−free IAW NAVAIR 01−1A−35.

18 . All metallic components in fuel systems can be sources of electrical discharges and are potentially hazardous when they are electrically isolated. Grounding and bonding shall eliminate this component hazard.

19 . **BONDING JUMPER INSTALLATIONS.**

20 . The jumper should not interfere with the operation of movable aircraft elements, such as surface controls, nor should normal movement of these elements result in damage to the bonding jumper.

a. Bonding Connections. To ensure a low−resistance connection, non conducting finishes such as paint and anodizing films should be removed from the attachment surface to be contacted by the bonding terminal. Refer to paragraph 40 for surface preparation procedure

b. Corrosion Protection. One of the more frequent causes of failures in electrical system bonding and grounding is corrosion. Aircraft operating near salt water are particularly vulnerable to this failure mode. Because bonding and grounding connections may involve a variety of materials and finishes, it is important to protect completely against dissimilar metal corrosion. The areas around completed connections should be post−finished in accordance with paragraph 40.

c. Corrosion Prevention. Electrolytic action may rapidly corrode a bonding connection if suitable precautions are not taken. Aluminum alloy jumpers are recommended for most cases; however, copper jumpers should be used to bond together parts made of stainless steel, cadmium plated steel, copper, brass, or bronze.

Where contact between dissimilar metals cannot be avoided, the choice of jumper and hardware should be such that corrosion is minimized, and the part likely to corrode would be the jumper or associated hardware. Figures 3−5 and Figures 7−10 show the proper hardware combinations for making a bond connection.

d. Bonding Jumper Attachment. Tubular members should be bonded by means of clamps to which the jumper is attached. Proper choice of clamp material should minimize the probability of corrosion, Figures 5−7 through 5−9 show the proper clamp material

e. Test the bonding installation in accordance with paragraph 66.

21 . <u>HARDWARE SELECTION.</u>

22 . **SMALL METALLIC COMPONENTS**. Small metallic components within fuel systems such as name tags, coupling shells, brackets and clamps are all potentially hazardous and their use avoided whenever possible. When the use of such components are essential they shall be properly bonded with an electromechanical connection to the structure with one ohm or less resistance.

23 . **EXCEPTION.** When small metallic components cannot be feasibly bonded, as in paragraph 25, the component shall have a bonding connection that measures 10 megohms or less and shall be proven safe by tests performed in a laboratory by the procuring activity.

24 . **FAULT CURRENT.** Fault current is the maximum current delivered when an internal power to ground short occurs. Since bonding itself cannot eliminate all possible sources of ignition, the equipment itself must be so designed to minimize or eliminate all possible sources of ignition. The resistance between the equipment case and the structure shall not exceed those shown (Figure 1).

25 . **PIPE AND HOSE BONDING.** All metallic pipes, tubes, and hoses that carry petroleum products, or other fluids, shall have a mechanically secure bond that measures one ohm or less.

26 . **SELECTION.** The selection of hardware to be used in bonding and grounding shall be selected to meet the requirements established in accordance with MIL-STD-464.

27 . **SELECTION OF BOLTS, NUTS, AND SCREWS.** The selection of bolts, nuts, and screws shall be of the following:

28 . **Cadmium Plated Steel.** Cadmium plates, steel bolts, nuts. and screws shall be selected when weight is not critical and temperatures do not exceed 550°F (288°C).

29 . **Corrosion Resistant Steel.** Corrosion resistant steel shall he selected for use in high temperature applications.

30 . **Titanium.** Titanium shall be selected for use in high temperature applications and a saving of weight is desired. Bolts that carry current shall not be coated with tetrafluoroethylene.

31 . **Aluminum.** Aluminum shall be selected for general applications where temperatures do not exceed 300°F (149°C).

32 . **Prohibited.** Bolts. nuts, and screws that are zinc plated and all self-tapping screws are not to be used in any situation.

33 . **SELECTION OF WASHERS**. The selection of washers shall be of the following:

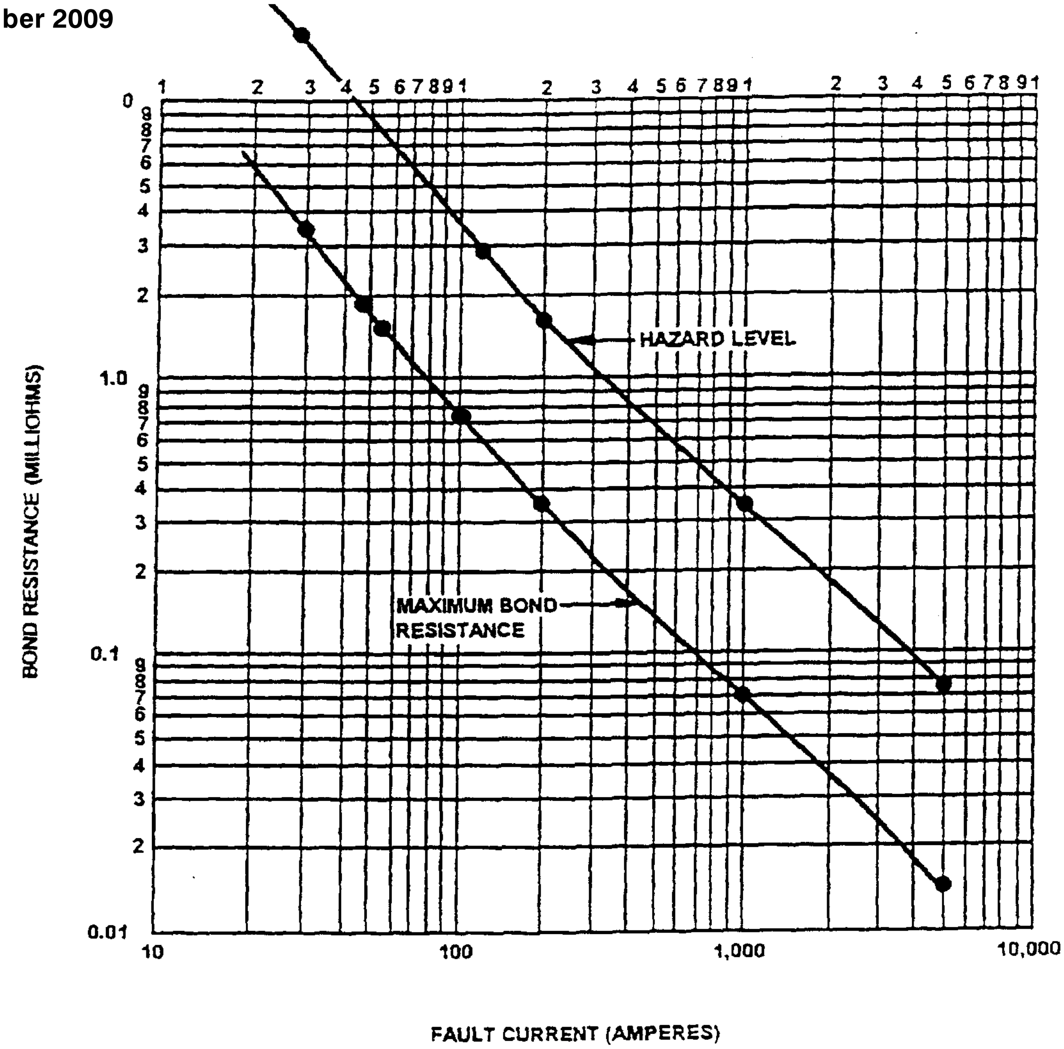
34 . **Plain.** NAS1149 washers are plain washers in various size, composition. and series. They are used in all bonding applications. Refer to applicable diagrams and drawings for selection. Aluminum alloy washers are to be finish code J. Corrosion resistant steel washers are to be finish code R.

35 . **Locking.** Lockwashers shall be one of two types and are used in connection with plain or self locking nuts. Refer to applicable diagrams and drawing for selection.

a. NASM35338. This series is used where temperatures do not exceed 400°F (204°C).

b. MS35340. This series is interchangeable with MS35338 Series.

36 . **Prohibited.** Washers that are anodized, zinc plated, unplated, as well as any star washers are not to be used in any situation.



DATA POINTS

AMPS	HAZARD RESISTANCE (MILLIOHMS)	MAX RESISTANCE (MILLIOHMS)
5000	0.074	0.0148
1000	0.37	0.074
200	1.85	0.37
120	2.83	----
100	3.7	0.74
58	7.7	1.54
49	9.3	1.96
30	18	3.6

Figure 1. Fault Current

37 . **SELECTION OF CLAMPS.** Clamps shall be of the plain type conforming to SAE–AS7351 and used as follows:

38 . **SAE–AS7351 Cadmium Plate.** This series clamp shall he used on corrosion resistant steel where the temperature does not exceed 300°F (149°C).

39 . **SAE–AS7351 Non–plated.** This series is for use on aluminum only.

40 . **SURFACE PREPARATION.**

41 . **ALUMINUM SURFACE CLEANING.**

WARNING

Mineral spirits dry cleaning solvent MIL–PRF–680 TYPE II is flammable. Avoid eye and skin contact or breathing of vapors. Protective equipment consisting of goggles and gloves is required.

CAUTION

Do not use abrasives such as emery cloth, crocus cloth, steel wool, or steel wire brushes, etc. These may leave particles imbedded in the surface or scattered in the area which may cause corrosive action.

a. Remove grease, oil. or other gross contaminants from the surface with mineral spirits dry cleaning solvent (ASTM-D235).

b. Remove paint, lacquer and/or primer from surface with epoxy paint remover (MIL-R-81294).

c. Remove anodic film from surface with aluminum oxide cloth. 320 grit (ANSI B74.18) or aluminum oxide abrasive webbing (A–A–58054) around mounting holes.

d. After cleaning, but before grounding hardware installation, cleaned surfaces shall be protected with a corrosion resistant conductive protective film in accordance with MIL–C–5541 Class III.

e. After hardware assembly, the mating surfaces around the ground hardware shall be restored to the original finish.

42 . **MAGNESIUM ALLOY SURFACE CLEANING.**

WARNING

Solvents, paint remover, methanol and chemical conversion coatings are flammable, do not use near open flames, welding areas or on hot surfaces. Contact with liquid or vapor can cause skin and eye irritation, dermatitis and drowsiness. If there is any prolonged skin contact. wash contacted area with soap and water. Remove solvent-saturated clothing. Ground returns shall not be connected to magnesium.

CAUTION

Do not use abrasives such as emery cloth, crocus cloth, steel wool or steel wire brushes, etc. These may leave particles imbedded in the surface or scattered in the area, which may cause corrosive action.

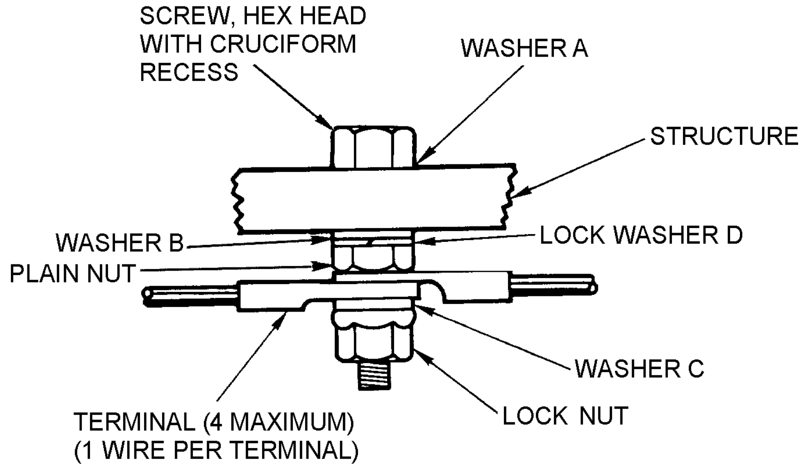
a. Remove grease, oil, or other gross contaminants from the surface with dry cleaning solvent.

b. Remove paint, lacquer and/or primer from surface with epoxy paint remover.

c. Apply chemical conversion coating in accordance with the manufacturer's recommended procedures, diluted one part to nine parts clean, fresh water, to slow down reaction speed normally used for aluminum.

d. After cleaning, but before grounding hardware installation, cleaned surfaces shall be protected with a corrosion resistant conductive protective film (MIL–DTL–81706) in accordance with MIL–C–5541 Class 3.

e. After hardware assembly, the mating surfaces around the ground hardware shall be restored to the original finish.



NOTE: SEE BELOW FOR MATERIALS

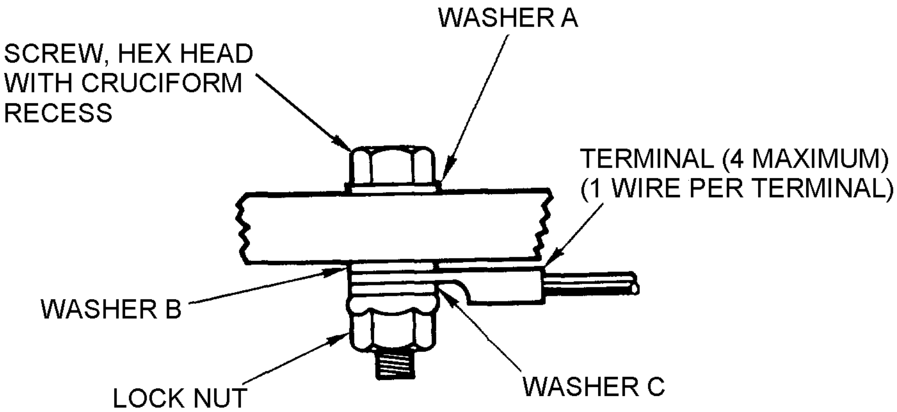
ALUMINUM TERMINAL AND JUMPER

STRUCTURE	SCREW, HEX HEAD	PLAIN NUT[3]	WASHER A	WASHER B	WASHER C	LOCK WASHER D	LOCK NUT [4]
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	TIN PLATED BRASS	ALUMINUM ALLOY[1]	ALUMINUM ALLOY[1]	ALLOY[1]	CAD. PLATED STEEL	NASM21042 CAD. PLATED STEEL
MAGNESIUM ALLOYS	NAS1801 CAD. PLATED STEEL	CAD. PLATED STEEL	MAGNESIUM ALLOY	MAGNESIUM ALLOY	ALLOY[1]	CAD. PLATED STEEL	NASM21042 CAD. PLATED STEEL
STEEL, CAD. PLATED	NAS1801 CAD. PLATED STEEL	CAD. PLATED STEEL	NONE	NONE	ALLOY[1]	CAD. PLATED STEEL	NASM21042 CAD PLATED STEEL
STEEL, COR. RESIST.	NAS1802 COR. RESIST STEEL	CAD. PLATED STEEL	NONE	NONE	ALLOY[1]	COR. RESIST. STEEL	NASM21043 CAD. PLATED STEEL
TINNED COPPER TERMINAL AND JUMPER							
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	CAD. PLATED STEEL	ALUMINUM ALLOY[1]	ALUMINUM ALLOY[1]	COR. RESIST[2]	CAD. PLATED STEEL	NASM21042 CAD. PLATED STEEL
MAGNESIUM ALLOYS	AVOID CONNECTING COPPER TO MAGNESIUM						
STEEL, CAD. PLATED	NAS1801 CAD. PLATED STEEL	CAD. PLATED STEEL	NONE	NONE	COR. RESIST[2]	CAD. PLATED STEEL	NASM21042 CAD. PLATED STEEL
STEEL, COR. RESIST.	NAS1802 COR. RESIST. STEEL	COR. RESIST. STEEL	NONE	NONE	COR. RESIST[2]	COR. RESIST. STEEL	NASM21043 COR. RESIST. STEEL

NOTES:

1. Finish Code J.
2. Finish Code R.
3. For #10 nuts, torque to 40 inch-pounds. For #8 nuts, torque to 20 inch-pounds.
4. For #10 lock nuts, torque to 35 inch-pounds. For #8 lock nuts, torque to 17 inch-pounds.

Figure 2. Hardware for Stud Bonding or Grounding to Flat Surface



ALUMINUM TERMINAL AND JUMPER

STRUCTURE	SCREW, HEX HEAD	WASHER A	WASHER B	WASHER C	LOCK NUT[3]
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	ALLOY[1]	ALUMINUM ALLOY[1]	ALLOY[1]	NASM21042 CAD. PLATED STEEL
MAGNESIUM ALLOYS	NAS1801 CAD. PLATED STEEL	MAGNESIUM ALLOY	MAGNESIUM ALLOY	ALLOY[1]	NASM21042 CAD. PLATED STEEL
STEEL, CAD. PLATED	NAS1801 CAD. PLATED STEEL	NONE	NONE	ALLOY[1]	NASM21042 CAD. PLATED STEEL
TINNED COPPER TERMINAL AND JUMPER					
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	ALUMINUM ALLOY[1]	ALUMINUM ALLOY[1]	COR. RESIST STEEL[2]	NASM21042 CAD. PLATED STEEL
MAGNESIUM ALLOYS	AVOID CONNECTING COPPER TO MAGNESIUM				
STEEL, CAD. PLATED	NAS1801 CAD. PLATED STEEL	NONE	NONE	COR. RESIST STEEL[2]	NASM21042 CAD. PLATED STEEL
STEEL, COR. RESIST.	NAS1802 COR. RESIST. STEEL	NONE	NONE	COR. RESIST STEEL[2]	NASM21043 CAD. PLATED STEEL

NOTES:

1. Finish Code J.
2. Finish Code R.
3. For #10 lock nuts, torque to 33 inch-pounds. For #8 lock nuts, torque to 17 inch-pounds.

Figure 3. Hardware for Bolt and Nut Bonding or Grounding to Flat Surface

43 . **STEEL SURFACE CLEANING.** When the surface is corrosion resisting, or plated steel, clean bonding or grounding surfaces as follows:

WARNING

Solvents, paint remover, methanol and chemical conversion coatings are flammable, do not use near open flames, welding areas or on hot surfaces. Contact with liquid or vapor can cause skin and eye irritation, dermatitis and drowsiness. If there is any prolonged skin contact, wash contacted area with soap and water. Remove solvent-saturated clothing.

CAUTION

Do not remove zinc or cadmium plate from steel surfaces.

a. Remove grease and oil from surface with methanol.

b. Remove paint or lacquer, if present, from surface with lacquer thinner.

44 . <u>BONDING AND GROUNDING METHODS.</u>

45 . **FLAT SURFACE CONNECTION.** Bonding and grounding connections are made to flat surfaces by means of through bolts or screws where installation has easy access. There are three types of bolted connection, as follows:

46 . **Stud Connection.** In this type of connection, a bolt or screw is locked securely to structure, thus becoming, in effect a stud. Grounding or bonding jumpers can be removed or added to the shank or stud without removing stud from structure (Figure 2).

CAUTION

When terminal is under head of screw or bolt, it is preferable not to install more than one terminal. Otherwise, the screw may loosen and cause improper operation of equipment.

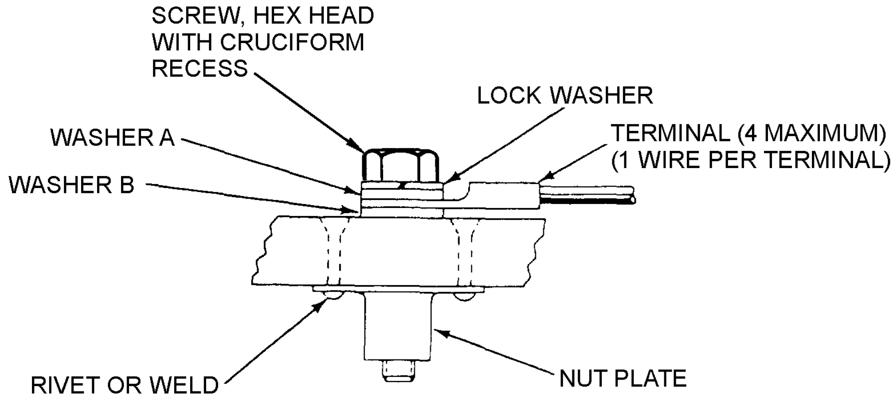
Ground attachment shall not be used as attachment points for any other equipment.

47 . **Nut and Bolt Connection.** In this connection the bolt or screw is not attached permanently to structure. When jumpers are to be added or removed, the entire connection is remade (Figure 3).

48 . **Nut Plate and Bolt Connection.** Nut plates are used where access to the nut for repair may be difficult. Nut plates are riveted or welded to a clean area of the structure (Figure 4).

49 . **RIVETED TAB CONNECTION.** For bonding leads carrying high current size AN-4 or larger, do not make connection directly to the structure. These connections shall be made to a tab of suitable size riveted to the aircraft structure. When a connection is made to a tab, clean the bonding or grounding surface and make the connection exactly as though the connection were being made to flat structure surface. If it is necessary to remove the tab for any reason, replace rivets with one size larger. Make sure surfaces of structure and tab are prepared in accordance with the applicable paragraph (Figure 5).

50 . **CYLINDRICAL SURFACE CONNECTION.** Make bonding or grounding connections to aluminum alloy, magnesium alloy, or corrosion resisting steel tubular structure as shown in Figures 6 and 7. Figure 6 shows the arrangement of hardware for bonding with an aluminum jumper. Because of the ease with which aluminum is deformed, it is necessary to distribute screw and nut pressure by means of plain washers as shown. Figure 7 shows the arrangement of hardware for bonding with a copper jumper. No extra washers are used. If installation conditions require, use AN742 clamp (uncushioned) instead of SAE−AS7351 Do not change any other hardware if this substitution is made.



NOTE: SEE BELOW FOR MATERIALS

ALUMINUM TERMINAL AND JUMPER

STRUCTURE	SCREW, HEX HEAD	RIVET	LOCK WASHER	WASHER A	WASHER B	NUT PLATE
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	ALUMINUM ALLOY[1]	CAD. PLATED STEEL	ALUMINUM ALLOY[1]	NONE	CAD. PLATED STEEL
MAGNESIUM ALLOYS	NAS1801 CAD. PLATED STEEL	ALUMINUM ALLOY[1]	CAD. PLATED STEEL	ALUMINUM ALLOY[1]	NONE OR MAG. ALLOY	CAD. PLATED STEEL
CAD. PLATED STEEL	NAS1801 CAD. PLATED STEEL	COR. RESIST. STEEL	CAD. PLATED STEEL	ALUMINUM ALLOY[1]	NONE	CAD. PLATED STEEL
COR. RESIST. STEEL	NAS1802 COR. RESIST. STEEL	COR. RESIST. STEEL	CAD. PLATED STEEL	ALUMINUM ALLOY[1]	CAD. PLATED STEEL	CAD. PLATED STEEL
TINNED COPPER TERMINAL AND JUMPER						
ALUMINUM ALLOYS	NAS1801 CAD. PLATED STEEL	ALUMINUM ALLOY[1]	CAD. PLATED STEEL	COR. RESIST. STEEL[2]	ALUMINUM ALLOY[1]	CAD. PLATED STEEL
MAGNESIUM ALLOYS	AVOID CONNECTING COPPER TO MAGNESIUM					
CAD. PLATED STEEL	NAS1801 CAD. PLATED STEEL	COR. RESIST. STEEL	CAD. PLATED STEEL	COR. RESIST. STEEL[2]	NONE	CAD. PLATED STEEL
COR. RESIST. STEEL	NAS1802 COR. RESIST. STEEL	COR. RESIST. STEEL	CAD. PLATED STEEL	COR. RESIST. STEEL[2]	NONE	CAD. PLATED STEEL

NOTES:

1. Finish Code J.
2. Finish Code R.

Figure 4. Hardware for Nut Plate Bonding or Grounding to Flat Surface

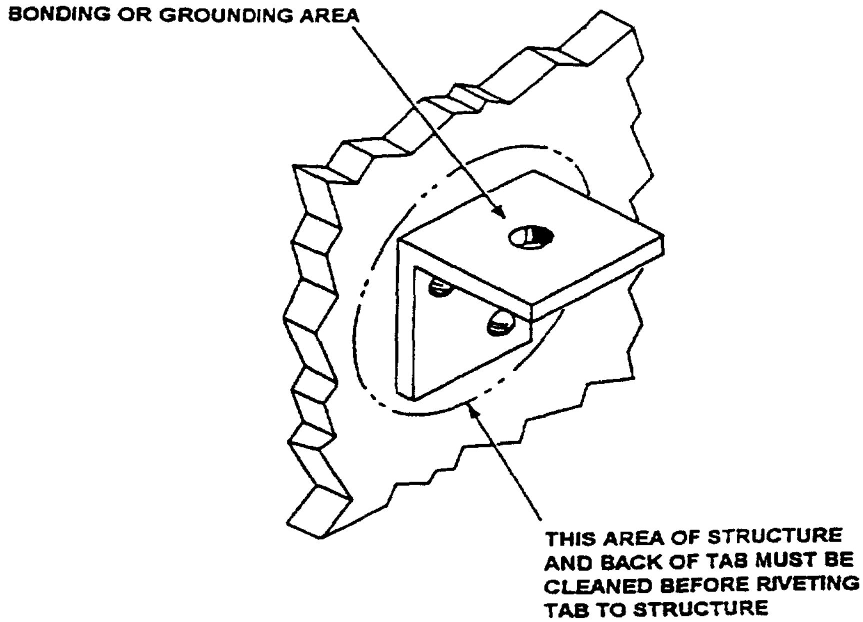


Figure 5. Bonding Tab Riveted to Structure

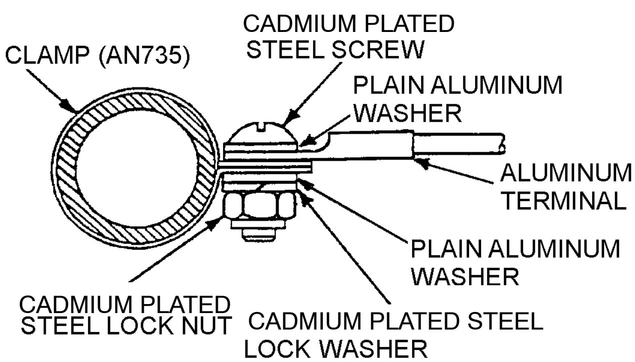


Figure 6. Aluminum Jumper Connector to Tubular Structure

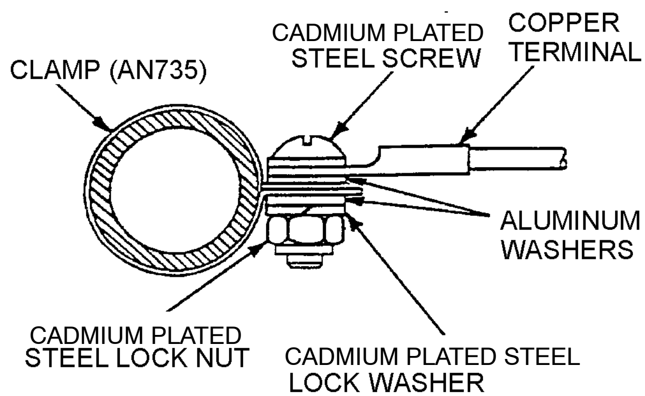


Figure 7. Copper Jumper Connection to Tubular Structure

Table 2 . Bonding Jumper Selection

M83413/8 Jumper Type	Purpose	Material Size (AWG)	Available Lug Size (Table 3)	Method of Attaching Terminals	Marking Band Color
-A	Bonding	Copper 12	A, B, C, D, E,	Crimp	None
-B	Current Return	Copper 8	D,E	Crimp	None
-C	Bonding	Aluminum 10	A, B, C, D, E Aluminum	Brazed	Clear
-D	Quick Discon- nect (QD)	Copper 12	A, B	Crimp	None
-E	Short end QD	Copper 12	A, B	Crimp	None
-F	Long end QD	Cooper 12	A, B	Crimp	None
-G	Bonding	Copper 12	A, B, C, D, E	Crimp	Yellow
-H	Current Return	Copper 8	D, E	Crimp	Yellow

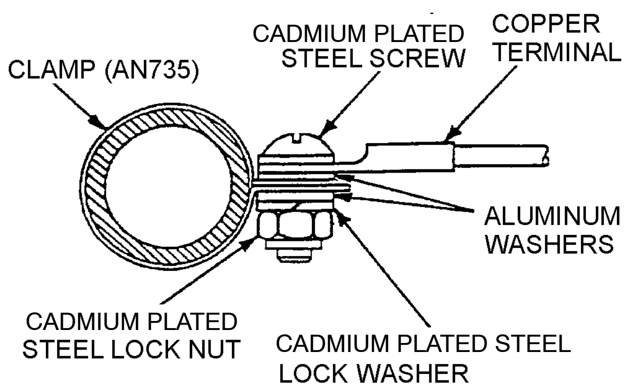


Figure 8. Bonding Conduit to Structure

51 . **BONDING CONDUIT TO STRUCTURE.** Bond aluminum alloy or corrosion resisting steel conduit to structure as shown in Figure 8. If installation conditions require, AN742 clamp (uncushioned) may be used instead of SAE−AS7351 using the same hardware.

NOTE

This application is not recommended for Aerospace use, if required contact CEA for guidance.

52 . **BONDING AND GROUNDING JUMPERS.**

53 . Bonding and grounding, jumpers are used to provide a conductive path where direct electrical contact does not exist. In aircraft, jumpers are used in such applications as between moving parts, between shock-mounted equipment and structure, and between electrically conducting objects and structure. Keep jumpers as short as possible; if practical. under three inches. The use of two or more bonding jumpers in series is not recommended for Aerospace use, if required contact CEA for guidance.

54 . **SELECTION.** Bonding jumpers shall conform to M83413/8. Aluminum and copper jumpers are available through supply channels, but copper jumpers may also be fabricated (Table 2).

55 . **FUEL COMPATIBILITY.** Copper jumpers are not compatible with fuel. Only M83413/8-C aluminum jumpers are to be used in fuel cells and shall not be interchanged with other jumpers, or used external to fuel cells.

56 . **PROCUREMENT.** Jumpers may be obtained through normal supply channels using the part number (Figure 9).

57 . **FABRICATION.** Fabrication of jumpers consisting of copper is accomplished by the maintenance activity. The procedure will vary depending upon the series jumper required. M83413/8-D jumpers are illustratedin Figure 10. M83413/8-A, B. C, G, H are illustrated in Figure 11. Procure braided wire using A−A−59569 see Figure 13.

58 . **M83413/8-A Fabrication.** The M83413/8-A jumper can be fabricated by the maintenance activity. Table 4 shows the terminals and crimp tools to be used in fabrication and the procedure follows:

a. Cut tinned wire to desired length.

b. Crimp terminals to wire with applicable crimp tool (Table 4).

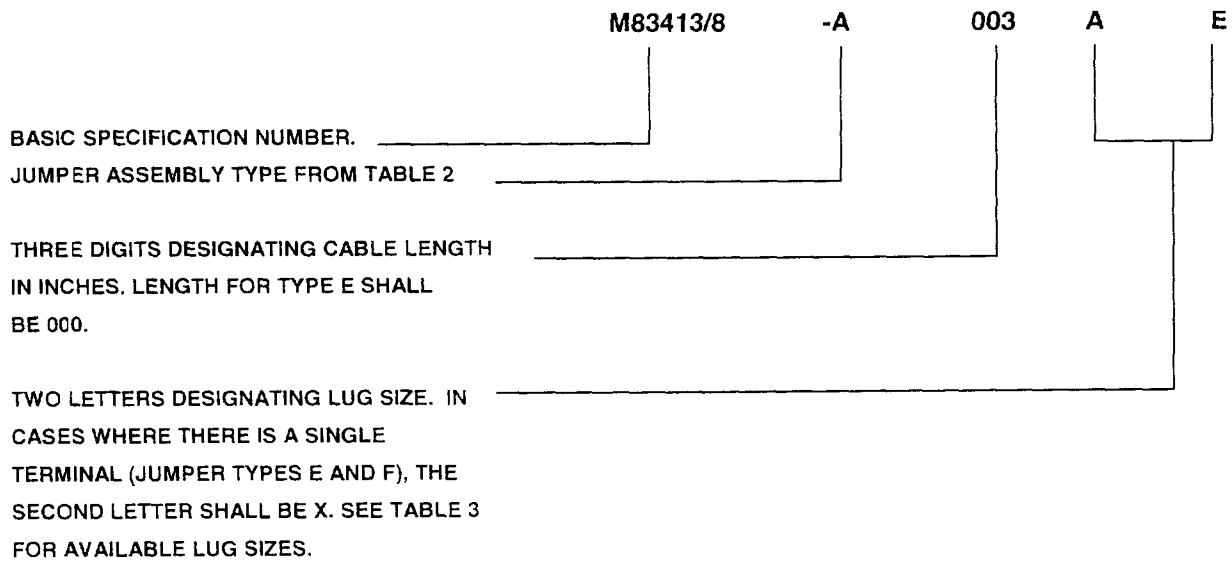


Figure 9. Part Number Breakdown

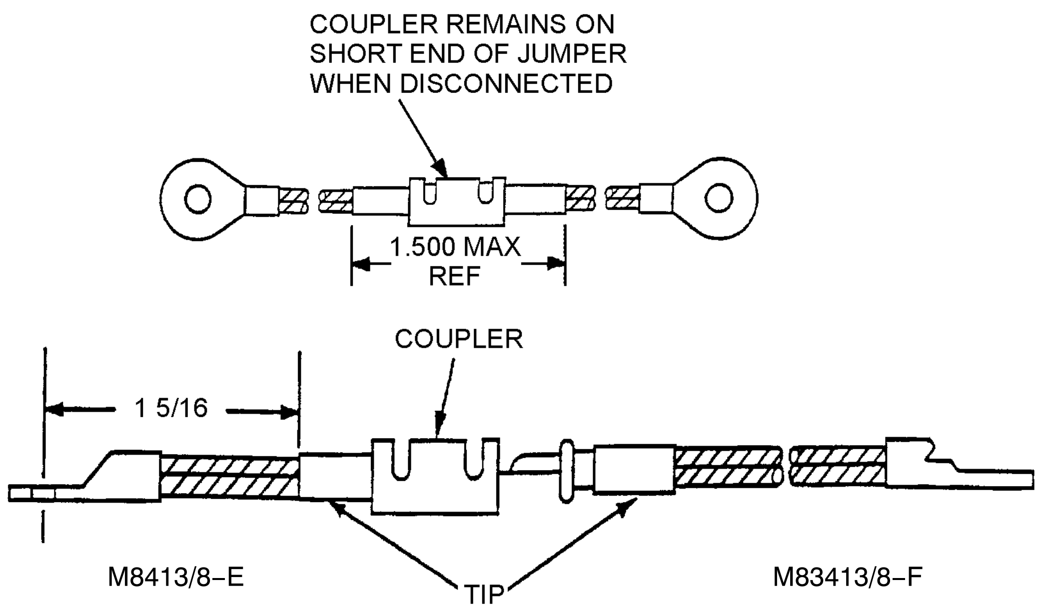


Figure 10. M83413/8-D (Jumper)

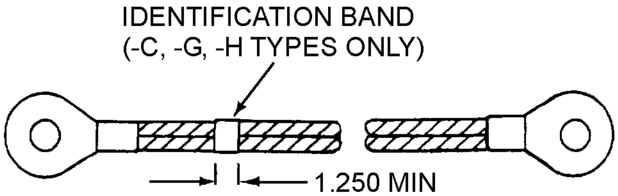


Figure 11. M83413/8-A, B, C, G, H

Table 3 . Available Lug Size

Code Letter Lug Size Designation	For Stud Size (inches)
A	.112 or .134
B	.164 or .190
C	.24
D	.3125
E	.375

59 . **M83413/8-B Fabrication.** The M83413/8-B jumper can be fabricated by the maintenance activity. Table 5 shows the terminals and crimp tools used in the fabrication and the procedure follows:

a. Cut tinned wire to desired length.

b. Crimp terminals to wire with applicable crimp tool (Table 5).

60 . **M83413/8-C Fabrication.** The M83413/8-C is made of aluminum and is not to be fabricated. Order through normal supply channels.

61 . **M83413/8-D Fabrication.** The M83413/8-D is a quick disconnect jumper and can be fabricated by the maintenance activity. Table 6 shows the terminals and crimp toolsused in fabrication, and the procedure follows:

a. Cut tinned wire to desired length.

b. Crimp terminals to wire with applicable crimp tool (Table 6).

c. Select quick disconnect coupler M6852-3measure length of quick disconnect coupler tip, add 15/16 inches.

d. Cut wire the length obtained (step c) measured from center of terminal stud hole.

e. Crimp quick disconnect coupler assembly to ends of jumper, using M22520/24.

f. Coupler shall be attached to the short jumper.

62 . **M83413/8-G Fabrication.** The M83413/8-G can be fabricated by the maintenance activity. Table 4 shows the terminals and crimp tools used in fabrication, and the procedure follows:

a. Cut tined wire to the desired length.

b. Cut 1 1/4 minimum length of heat shrinkable sleeving of Polyolefin Class 2, SAE AMS−DTL-23053/5.

c. Mark sleeving with part number and install on jumper wire with approved heat source.

d. Crimp terminals to wire with applicable crimp tool (Table 4).

Table 4 . Terminals and Tools for M83413/8-A and G Jumpers

Stud Hole Designation	Stud Size	Terminal* SAE−AS25036	Terminal* SAE−AS20659 (Optional)	Crimp Tool*
A	No. 4 or No.6	-111	-165	M22520/5
B	No. 8 or No. 10	-112	-105	
C	0.250	-157	None	
D	0.3125	-113	-106	
E	0.375	-114	-128	
*See WP 01300				

Table 5 . Terminals and Tools for M83413/8-B and H Jumpers

StudHole Designation	Stud Size	Terminal* SAE−AS25036	SAE−AS20659 (Optional)	Crimp Tool	Terminal* SAE−AS25036	SAE−AS20659 (Optional)
D	0.3124	-117	-108	HD51	HD51−133−2 Die	HD51−133−2 Die
E	0.375	-118	-129		HD51−133−2	HD51−133−2
* See WP 013 00						

Table 6 . Terminals and Tools for M83413/8-D Jumpers

Stud Hole Designation	Stud Size	Terminal* MS25036	SAE−AS20659 (Optional)	Crimp Tool
A	No. 4 or No. 6	-111	-165	M22520/5
B	No. 8 or No. 10	-112	-105	
* See WP 013 00				

63 . **M83413/8-H Fabrication.** The M83413/8-H can be fabricated by the maintenance activity. Table 5 shows the terminals and crimp tool used in fabrication. Proceed with fabrication using the steps in paragraph 57 .

64 . **BONDING INSPECTIONS.**

65 . Inspect for the following:

a. If there is evidence of electrical arcing, check for intermittent electrical contact between conducting surfaces, that may become a part of a ground plane or a current path.

b. Bond connections should be secure and free from corrosion.

c. Bonding jumpers should be installed in such a manner as not to interfere in any way with the operation of movable components of the aircraft.

d. Inspect bonding jumper condition. Bonding jumpers shall not be frayed or kinked. Jumper must be replaced if more than one−third of the jumper wires are broken.

e. Self−tapping screws should not be used for bonding purposes. Only standard threaded screws or bolts of appropriate size should be used.

f. Bonds should be attached directly to the basic aircraft structure rather than through other bonded parts.

g. Use appropriate washers when bonding aluminum or copper to dissimilar metallic structures so that any corrosion that may occur will be on the washer.

h. Multiple Grounds. Ground module in accordance with AS81714 may be used for multiple grounds.

(1) No more than four ground wires shall be connected to a common ground stud.

(2) No more than 16 ground wires shall be connected in a ground module.

(3) Each ground for electric power sources (primary, secondary, conversion, emergency) shall be connected to separate ground points.

(4) Grounds for utilization equipment may be connected to a common ground point only when supplied from the same power source provided these equipments do not perform duplicate or overlaping functions.

(5) Ensure proper washer and terminal stack up WP 019 00.

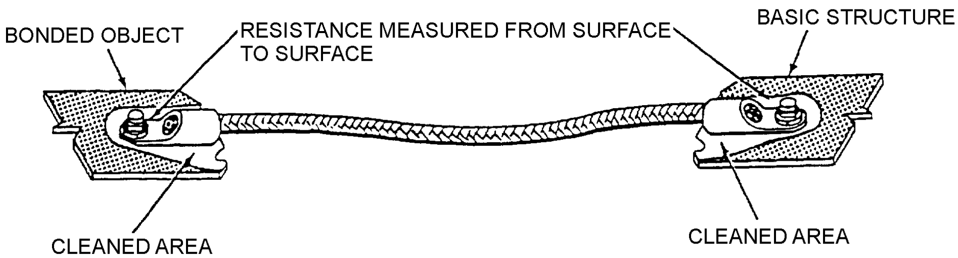


Figure 12. Resistance Testing of Bonds and Grounds

66 . **TESTING BONDS AND GROUNDS.**

67 . The resistance across a bonding or grounding, jumper is required to be 0.1 ohm or less. Test is made after the mechanical connection is completed, and consists of a milliohm-meter reading, of the resistance between the cleaned areas of the object and the structure. Measurements of the specified resistance value are made with a special calibrated low-range ohmmeter such as the R1L−E or R1L−E−1. The Avtron T477W or functional equivalent, meeting UL−913 meeting explosion proof test criteria may be used in enclosed areas where hazards exist, such as explosive vapors from fuel systems. Test IAW ohmmeter instruction manual.

a. If the specified resistance value has been obtained the cleaned areas are now ready for refinishing.

68 . **REFINISHING.**

69 . Within 24 hours after an area has been cleaned and connection made, refinish surfaces IAW 01−1A−509 or TMS structures manual.

70 . **AIRCRAFT GROUNDING RECEPTACLES**. Inspect for reliability. Replace defective item with receptacle M83413/5−1 (Figure 14) for one piece or M83413/6−#−X (Figure 15). Both mate with M83413/4−# (Figure 16). Exception: provided enough reliable receptacles are available for adequate grounding; extremely hard to replace receptacles (requiring removal of wing, fuel cells and the like) maybe disabled by plugging or covering and the maintenance record annotated “For replacement during major overhaul, consult aircraft technical order.”

NOTE

To inspect for the reliability of a grounding/bonding receptacle, perform all of the following steps.

a. Visual Inspection: Inspect for loosely mounted receptacles and evidence of corrosion on washers, lugs, nuts and the aircraft skin.

b. Mechanical and Electrical: Tests are performed using stainless steel plug M83413/4−1. The plug is inserted in the receptacles being tested. Insure that the contact (spring) is seated in the plug detent.

c. Withdrawal Force: The longitudinal force required to remove the plug from the jack is 8 + 2 lbs.Less than 6 lbs. indicates a weak or damaged receptacle contact (spring). More than 10 lbs. indicates the possibility of a corroded receptacle.If pull is greater than 10 lbs. inspect spring for corrosion and clean or replace as necessary. Otherwise, the receptacle is serviceable.

d. Engagement: There shall be no free axial movement of the contact tip in the plug detent due to clearance between the contact (spring) tip and plug detent. Free axial movement indicates the contact is not maintaining connection with plug.

e. Electrical Resistance Tests: Electrical resistance measurements are made using Test Set AN/URM−90 or equivalent. Measurements to aircraft skin shall be at a point where the aircraft skin is clean and unpainted. The DC resistance of cables, or test leads, including plug used for making a specific resistance test, shall be measured and subtracted from the reading for that specific test.

(1) The DC resistance between the plug (see paragraph b.) and the aircraft skin shall be one ohm or less, but not zero. Greater resistance indicates a defective receptacle contact (spring) due to corrosion, loose receptacle mounting, or defective bonding strap if used. Aircraft technical order is applicable when specified MAX is less than 0.1 ohm.

(2) The DC resistance between receptacles (electrical interconnection through aircraft frame or skin) shall be less than 1 ohm. Greater resistance indicates defective or insufficient bonding. Repair of bond requires removal of the receptacle cleaning of the structure and replacement/reinstallation of receptacle (refer to applicable structural repair manual prior to cleaning of aircraft structure).

NOTE

For Navy and Marine activities a local Maintenance Requirement Card (MRC) is required if not published in the aircraft maintenance requirement cards.

f. Inspection shall be performed at a minimum of every 180 days when frequency is not specified in aircraft technical order.

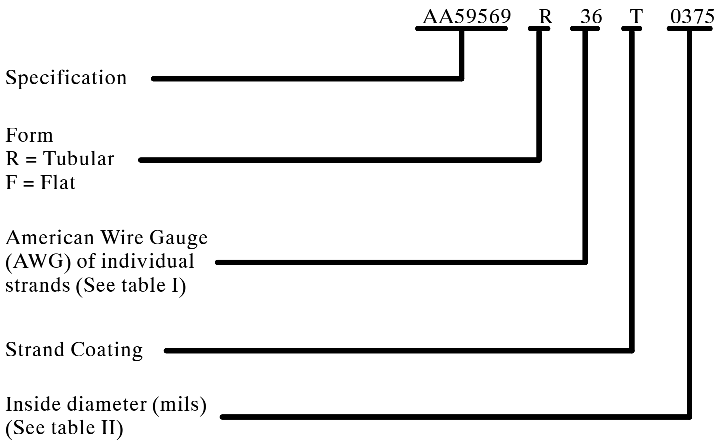


Table II

Dimensions	Tolerance
.000 – .099	.010
.100 – .249	.016
.250 – .499	.031
.500 – .999	.063
Over .999	.094

Table I

PIN 1/	Strand wire size (AWG)	Tubular inside diameter (inches) 2/	Number of carriers	Number of ends	Current rating (amps) 3/	Approx. AWG equiv. 4/	Flat form width x thickness (inches) 5/
AA59569							
*36*0156	36	.156	24	240	40.0	12	.250x.046
*36*0203	36	.203	24	312	46.0	11	.281x.046
*34*0203	34	.203	24	192	46.0	11	–
*32*02037/7	32	.203	24	120	46.0	11	–
*36*0250	36	.250	24	384	53.0	10	–
*30*0281	30	.281	24	120	60.0	9	–
*36*0375	36	.375	48	384	53.0	10	.625x.030
*34*0375	34	.375	48	240	53.0	10	–
*32*0375	32	.375	48	144	46.0	11	–
*30*0375/7	30	.375	24	1686/6	75.0	8	–
*30*0437	30	.437	24	240	90.0	6	.500x.093
*36*0500	36	.500	48	528	62.0	9	.625x.046
*34*0500	34	.500	48	336	62.0	9	–
*32*0500/7	32	.500	48	192	62.0	9	–
*30*0500	30	.500	24	360	120.0	6	.625x.093
*30*0562	30	.562	48	480	145.0	3	–
*30*0656	30	.656	48	768	190.0	1	–
*36*0781	36	.781	48	864	88.0	7	.750x.040
*34*0781	34	.781	48	528	88.0	7	–
*32*0781	32	.781	48	336	88.0	7	–
*30*0875	30	.875	48	336	100.0	5	1.375x.050
*30*1000	30	1.000	48	384	120.0	4	–
*30*1125	30	1.125	48	432	130.0	4	–
*30*1375	30	1.375	48	528	150.0	3	1.500x.060
*30*1500	30	1.500	48	576	165.0	2	–
*30*2000	30	2.000	48	672	180.0	2	–

1/ The complete PIN shall include additional information to indicate the form (first asterisk) and strand coating (second asterisk).
2/ Dimensional tolerances shall be as shown in Table I and II.
3/ Direct current ratings are given for information only and are not requirements. Values shown are for uninsulated braid in free air at 30°C. Values should be derated if the braid is insulated or in close contact with other components.
4/ Approximate AWG equivalents are given for information only and are not requirements.
5/ Flat form width and thickness are given for information only and are not requirements. Tolerances shall be as shown in table I an II.
6/ This P/N supersedes the similar construction using 96 ends.
7/ It may not be possible to produce 90% coverage on these constructions.

Figure 13. Copper Bonding Wire

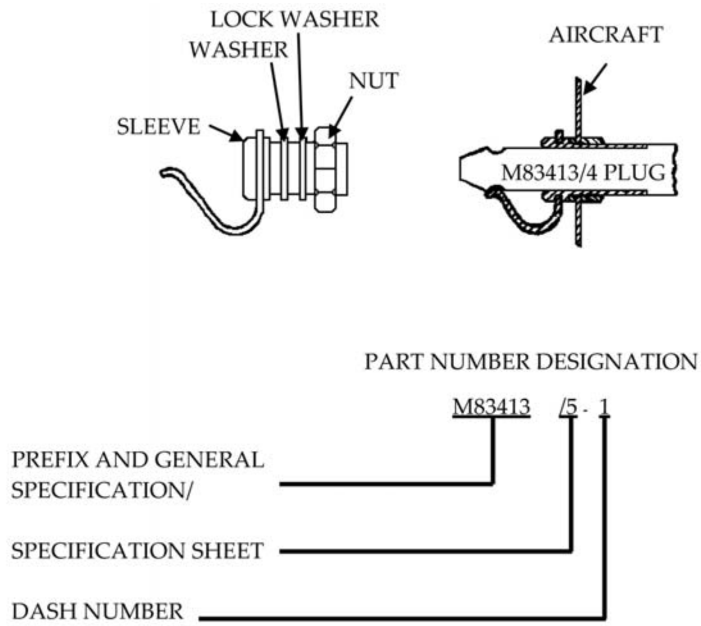


Figure 14. M83413/5 Aircraft Grounding Receptacles, One Piece

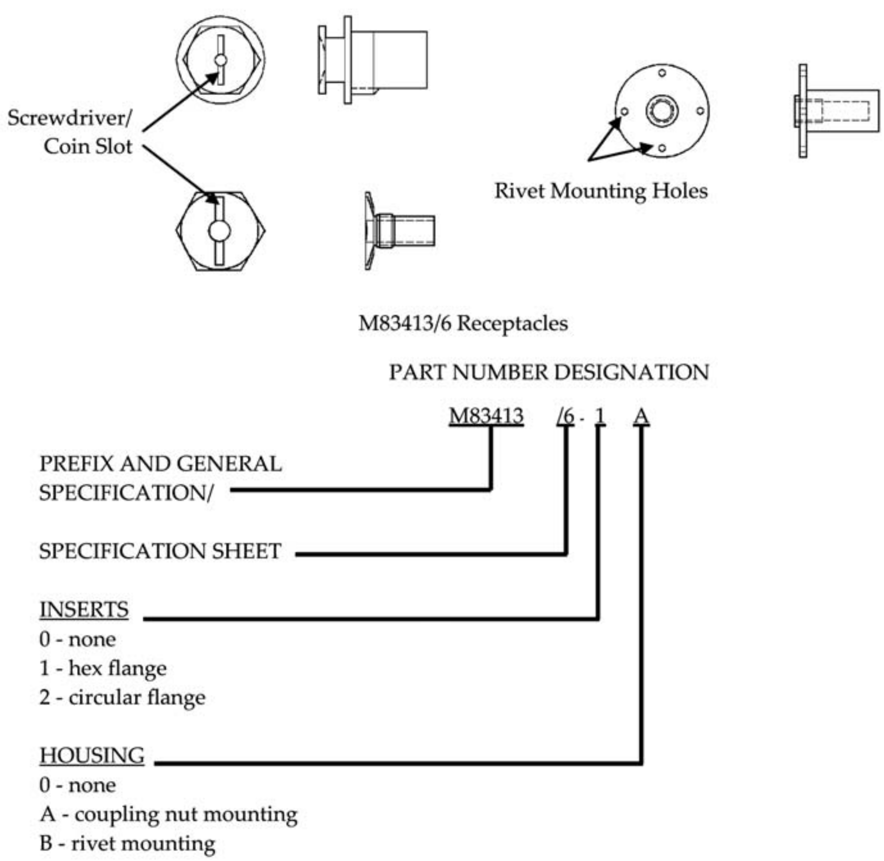
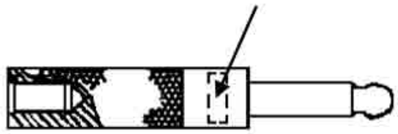


Figure 15. M83413/6 Aircraft Grounding Receptacles, Two Piece, with Inserts and Housings



Part Number	Description	Supersedes
M83413/4-1	M83413/4-3 & M83413/4-2 plug with end cap attached	MS3493-3 MS3493-5 MS25384-2 with MS25384-4
M83413/4-2	7/16 inch end cap	MS3493-2 MS25384-4
M83413/4-3	Knurled cylindrical plug or un-knurled hexagonal plug	MS3493-1 MS3493-4 MS25384-2

Note: Plugs shall be supplied with the end caps screwed in the non-mating end. A nominal 7/16-inch hexagonal shaped plug body may be used in lieu of the cylindrical shape shown in this figure.

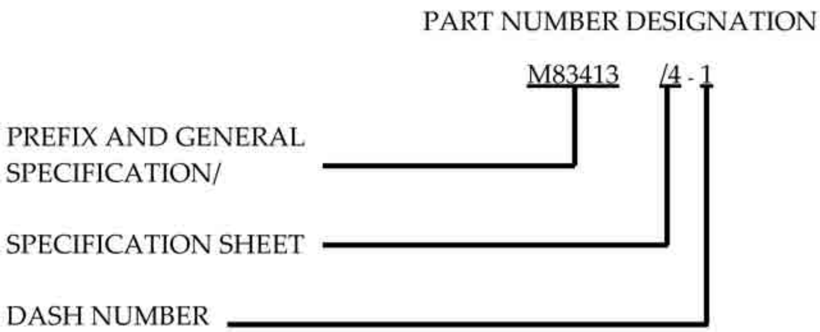


Figure 16. M83413/4 Aircraft Grounding Plugs, for Types I and II Grounding Assemblies

LOCKWIRING, SHEARWIRING AND SAFETY CABLES

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Safety Cable Kit Procurement Specification and Requirements for Use . . . . SAE AS4536

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part Number/Type Designation
Drill Bit	#56 (.046)
Wire Twister Plier with Side Cutter	–

Materials Required

Nomenclature	Part. Number./Type Designation
Cable, Safety, Self-Looping	AS3621 Series
Ferrule, Elongated	AS3619 Series
Kit, Safety Cable	AS3617 Series
Lockwire, Aluminum Alloy, Anodized, Blue, 0.020 Diameter	NASM20995-AB20
Lockwire, Aluminum Alloy, Anodized, Blue, 0.032 Diameter	NASM20995-AB32
Lockwire, Nickel-Chromium-Iron Alloy, 0.032 Diameter	NASM20995-N32
Lockwire, Nickel-Chromium-Iron Alloy, 0.020 Diameter	NASM20995-N20
Lockwire, Nickel-Copper Alloy, 0.020 Diameter	NASM20995-NC20
Lockwire, Nickel-Copper Alloy, 0.032 Diameter	NASM20995-NC32
Shearwire, Copper, Cadmium Plated, Yellow, 0.020 Diameter	NASM20995-CU20

1 . INTRODUCTION.

CAUTION

Under no circumstance shall lockwire and shearwire procedures be mixed or shall the materials be mixed or interchanged.

2 . This work package (WP) describes that lockwiring and shearwiring serve two complete and distinctly different purposes. The use of lockwire is for physical security against loosening due to vibration. The use of shearwire is for emergency device protection against accidental actuation. Lockwire is also referred to as safety wire and pre-twist lock wire is referred to as safety cable. This work package will cover procedures, materials, tools, and standards used in lockwiring and shearwiring.

3 . **GENERAL WARNINGS AND CAUTIONS.**

WARNING

Loss of life may occur when lockwire is used instead of shearwire.

WARNING

When using wire twister pliers and wire extends 3 inches or more beyond jaws of pliers loosely wrap wire around pliers to prevent whipping and personal injury.

Eye protection shall be worn when installing or removing safety wire/cable. Keep fingers away from jaws and cutting edge. Failure to do so may cause serious injury.

CAUTION

When cutting wire ensure all cut pieces are recovered and disposed of to prevent foreign object damage and personal injury.

On connectors and accessories use 0.020 lockwire to avoid breakout or damage to lockwire hole.

4 . GENERAL.

5 . **LOCKWIRE.** Lockwire is uninsulated wire used to secure electrical equipment and connectors in aircraft to prevent accidental loosening caused by vibration. Lockwire is often referred to as safety wire. Lockwiring or safety wiring is the process of application of lockwire to prevent accidental loosening. Safety cable is a lockwire process where the lockwire is pre-twisted prior to installation then crimped to hold the components (paragraph 31).

6 . **SHEARWIRE.** Shearwire is uninsulated copper wire with a low tensile strength or breaking point used to secure emergency devices to prevent accidental actuation. Shearwiring is the process of application to prevent accidental actuation.

7 . **ELECTRICAL CONNECTORS.** Threaded coupled connectors located in engine compartments or other areas of high vibration, and in areas which are normally inaccessible to periodic maintenance, shall have the coupling nut lockwired to prevent loosening of the connector caused by vibration. When lockwire is used on connectors, threaded coupling rings, screws, or rings used in fastening the connector, 0.020 diameter lockwire shall be used to prevent breaking out of the lockwire hole.

WARNING

Loss of life may occur when lockwire is used in place of shearwire.

8. **LOCKWIRE AND SHEARWIRE APPLICATION.** Lockwire and shearwire are not to be interchanged or substituted. Their purpose is distinct. The table below lists the types of lockwire and shearwire, part number, size, material, and identification to be used (Table 1):

9. **LOCKWIRE PROCEDURES.**

10. There are two lockwiring procedures. The double twist method which is used in high vibration areas and inaccessible areas, and the single wire method used in close, hard to reach areas.

WARNING

The strength of a connector lockwire hole is marginal. Cut the wire close to the hole. Never twist the wire off when removing (paragraph 12, step a, Caution).

11. **DOUBLE TWIST METHOD.** The double twist method is used for all equipment in areas of high vibration and in areas that are not accessible for periodic maintenance inspections. The lockwiring procedure is as follows (Figure 1):

a. When cutting lockwire for installation, use the shortest length needed to accomplish the task.

b. Lockwire shall be new upon each application, and shall be free of nicks or kinks.

c. Electrical connectors shall be properly mated and tightened prior to lockwiring.

d. Electrical connector hardware shall not be overtightened or loosened to align the lockwire holes.

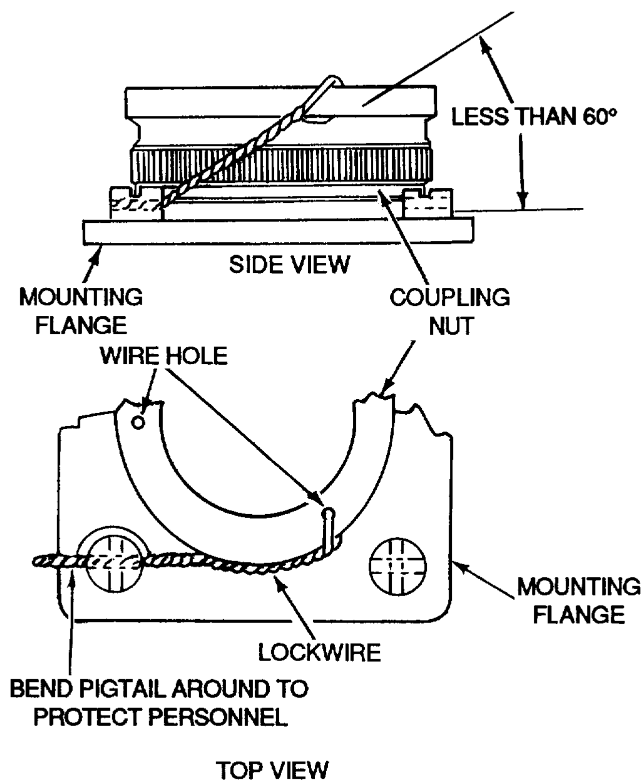


Figure 1. Double Twist Method

Table 1. Lock/Shearwire Types and Applications for Connectors

Wire	Material (Note 1)	Color	Size	Part Number (Note 2)
Lockwire	Monel (Below 700°F)	Natural	0.020	NASM20995-NC20 (0.020)
	Inconel (700 to 1500°F)			NASM20995-N32 (0.032) NASM20995-N20 (0.020)
	Aluminum Alloy (Alclad) Use on (magnesium parts)	Blue	0.020	NASM20995-AB20 (0.020)
Shearwire	Copper (Cadmium Plated)	Yellow (Copper)	0.020	NASM20995-CU20

NOTES:

1. Inconel may be used in all temperature applications.

2. Size 0.032 (NASM20995-NC32 or -N32, as applicable) should be used when the single wire method is required (paragraph 12, step a).

e. Parts shall be lockwired in such a manner that the lockwire shall be put in tension if the part begins to loosen (Figure 2).

f. When lockwiring screw or bolts, the lockwire shall be installed so that the loop around the head stays down and does not tend to come up over the head and leave a slack loop.

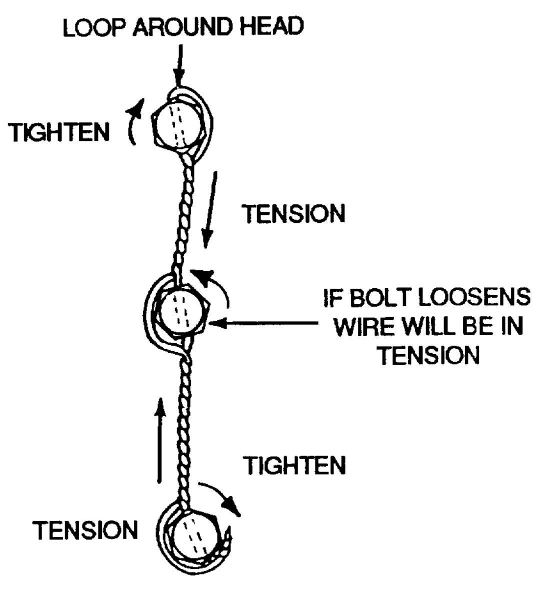


Figure 2. Proper Installation of Double Twisted Lockwire

g. Lockwire shall be twisted in a clockwise direction, with approximately 8 to 10 twists per inch (Figure 3).

h. When twisting wire by hand, the two ends of the wire shall be held straight and taut. Use pliers for the final twist to apply tension and to secure ends of wire. Lockwire must not be nicked, kinked, or mutilated. Never twist the wire ends off with pliers. Always cut the end leaving 4 to 6 complete turns (1/4 to 1/2 inches long), which is then bent under or back to prevent injury to personnel (Figure 5).

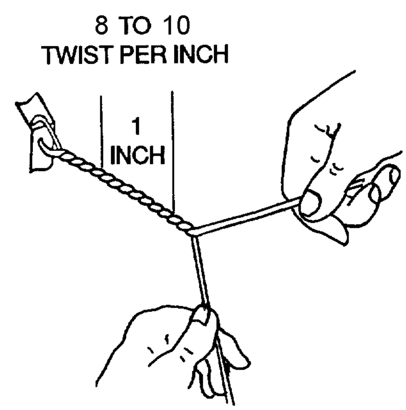


Figure 3. Wire Twisting by Hand

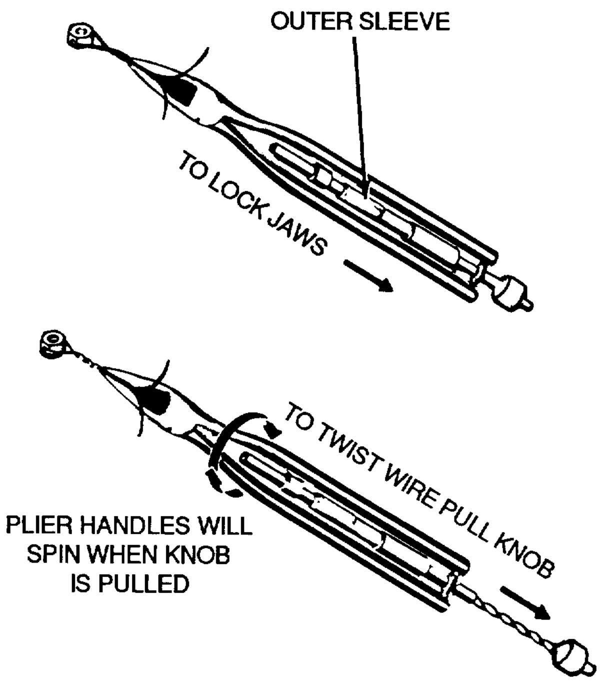


Figure 4. Twisting with Wire Twister Pliers

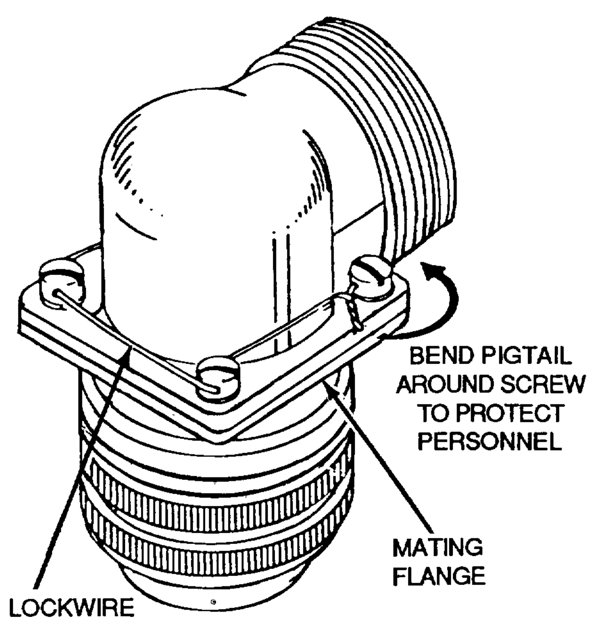


Figure 5. Single Wiring Method (Typical)

WARNING

When wire extends 3 inches beyond the pliers' jaw, loosely wrap the wire ends around the pliers to prevent whipping and possible personnel injury.

i. When using wire twister pliers, secure wire in jaws of pliers by sliding the outer sleeve down to lock handles (Figure 4). To prevent mutilation of the twisted section of the wire, grasp the wire with pliers at the end of the wire and not in the middle.

j. Pull knob to twist wire.

k. Lockwire shall be twisted tight but not overstressed to avoid breakage under strain or vibration.

l. Lockwire shall not be used to secure hardware which is spaced more than 6 inches apart unless tie points are provided on adjacent parts to shorten the span of the lockwire to less than 6 inches.

m. Terminated lockwire shall have a 1/4 to 1/2 inch (3 to 6 twists) pigtail. The cut end shall be bent under the twisted wire (Figure 5) to prevent injury to personnel.

n. It is preferred to lockwire all electrical connectors individually (except jam nut receptacles). Do not lockwire one connector to another unless it is necessary to do so.

12. **SINGLE WIRE METHOD.** This method may be used to lockwire equipment in areas hard to reach or for small screws that are 2 inches or less between centers (Figure 5).

a. When using single wire method use size 0.032 inch wire (Table 1).

CAUTION

When cutting wire ensure all cut pieces are recovered and disposed of to prevent foreign object damage and personal injury.

On connectors and accessories use 0.020 lockwire to avoid breakout or damage to lockwire hole.

b. When cutting lockwire for installation use shortest length needed to accomplish task.

c. Ends of wire shall be pulled taut but not overstressed.

d. Terminated lockwire shall have 1/4 to 1/2 inch (3 to 6 twists) pigtail. The cut end shall be bent to prevent injury.

13 . **CONNECTOR LOCKWIRE APPLICATIONS.**

CAUTION

Most connectors are designed not to require lockwire. Lockwire should only be used when required by the aircraft maintenance manual.

14 . **CONNECTOR PREPARATION.** Threaded coupling connectors shall be lockwired using the double twist method. When holes are not present in the coupling ring lockwire holes must be drilled (Figure 6).

a. Select #56 (0.046 inch) drill bit.

b. Mark three locations 120° apart.

c. Drill diagonally through edge of coupling nut.

d. Upon completion preserve in accordance with NAVAIR 01–1A–540.

15 . **CONNECTORS WITH THREADED COUPLINGS.** Threaded couplings shall be lockwired using the double twist method.

16 . **Flanged Receptacle.** Connectors mated to a flanged receptacle shall be lockwired to one of the thru holes in fillister head mounting screws (Figure 1).

17 . **Jam Nut Receptacle.** Connectors mated to a jam nut receptacle shall be lockwired to one of the thru holes on the jam nut (paragraph 19).

18 . **No Provision.** Connectors mated to a receptacle with no lockwire provision shall be lockwired to a hole. If no provisions are made, contact CFA for guidance. (Figure 7).

19 . **JAM NUT RECEPTACLES.** Jam nut receptacles shall be lockwired using the double twist method using the thru holes in the jam nut to another jam nut. Up to three jam nuts may be lockwired together (Figure 8) When only one jam nut receptacle is used, the nut must

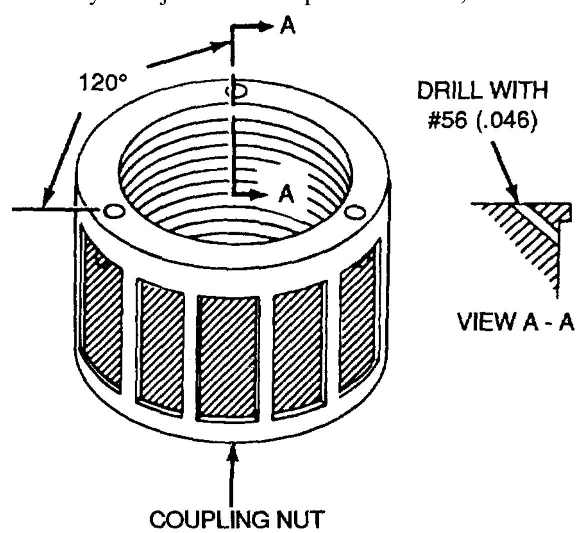


Figure 6. Lockwire Hole Locations

be safety wired to structure (Figure 7). If no provisions are made, refer to paragraph 18.

20 . **BACKSHELLS.** Backshells are held in place by assembly nuts or by a mating flange.

21 . **Mating Flange.** Typical mating flange types are of two pieces held together and in place by four fillister head screws which are lockwired using the single wire method (Figure 5).

22 . **Assembly Nuts.** When assembly nuts are used, lockwire using double twist method from assembly nut through hole to lockwire lug on backshell (Figure 9).

23 . **SPLIT BACKSHELLS.** Split backshells or two-piece backshells are held together by two fillister head screws, which are lockwired using the single wire method (Figure 10).

24 . **FLANGE TYPE RECEPTACLES.** Flange type receptacles are mounted with fillister head screws which are lockwired by the single wire method when mounting screws are less than 2 inches apart. When the mounting screws are greater than 2 inches use the double twist method (Figure 11).

25 . **QUALITY STANDARDS.** Inspect all lockwire applications for the following:

a. Electrical connectors which use threaded couplings, or employ screws or nuts to fasten the individual parts of the connector together have been lockwired using only size 0.020 wire of the applicable material (Table 1).

b. Connectors are lockwired individually, not to one another, if possible.

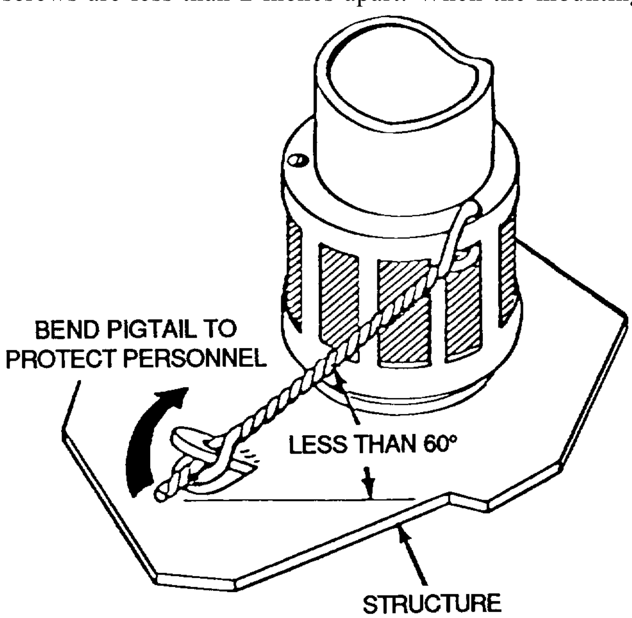


Figure 7. Lockwiring Connector to Structure

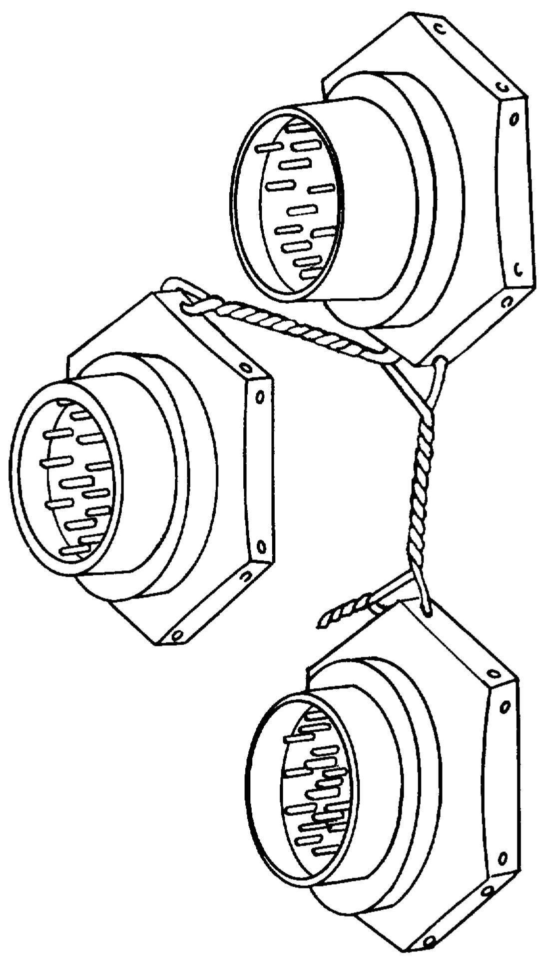


Figure 8. Lockwiring Jam Nut Receptacles

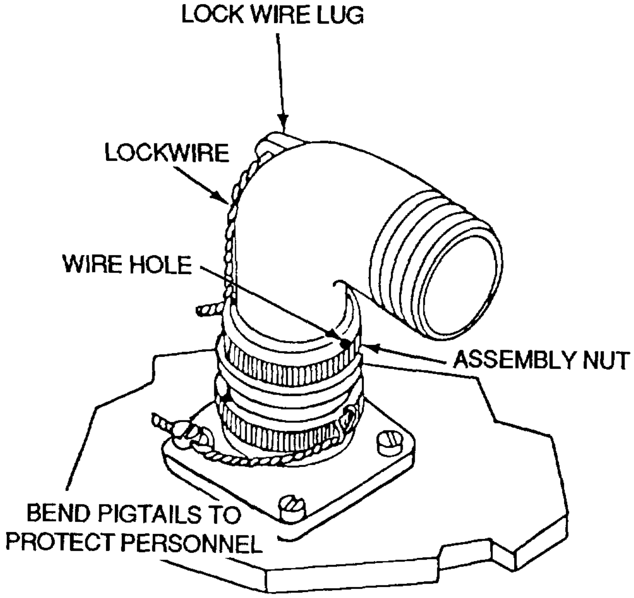


Figure 9. Lockwiring Assembly Nut Type Connectors (Typical)

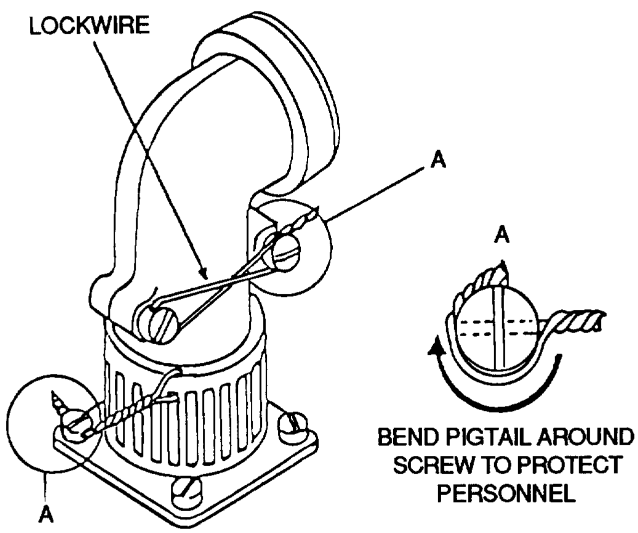


Figure 10. Lockwiring Split Shell Connectors (Typical)

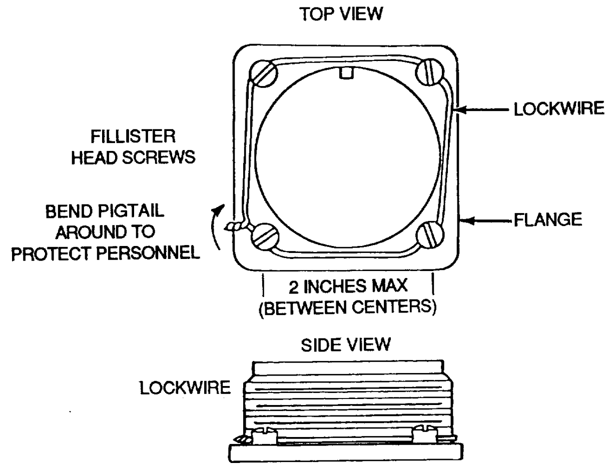


Figure 11. Single Wire Method of Locking Flanged Type Receptacles

c. Lockwire is twisted 8 to 10 twists per inch (Figure 3).

d. Lockwire is not kinked or nicked.

e. Lockwire installed with a wire angle of 60° or less.

f. Pigtails have been bent toward the connector, around the screw, or under the wire to protect personnel.

g. Lockwire is installed so that the wire will be in tension if the part loosens.

26 . SHEARWIRE APPLICATIONS.

WARNING

Loss of life may occur when lockwire is used instead of shearwire.

27 . Shearwiring is used to prevent accidental actuation of emergency devices. Shearwire is installed so that a deliberate effort is required to actuate these emergency devices.

28 . **EMERGENCY DEVICES.** Emergency devices are color coded yellow with black stripes for visual recognition to include switches, switch guards, and handles which operate egress systems; emergency ordnance releases are color coded red. These emergency devices are shearwired with copper wire part number NASM20995-CU20 only.

29 . **SHEARWIRING.** All application of shearwire will use the single wire method. Under no circumstances will the double wire method be used. All applications of shear wire will use copper wire part number NASM20995-CU20 only and shall be wired as illustrated (Figure 12).

30 . **QUALITY STANDARDS.** All shearwire applications shall be inspected to comply with the following:

a. Only copper wire part number NASM20995-CU20 is used.

b. All applications are single wire method.

c. Installed so that shearwire may be easily broken in an emergency.

d. Wire ends are out of the way to protect against injury.

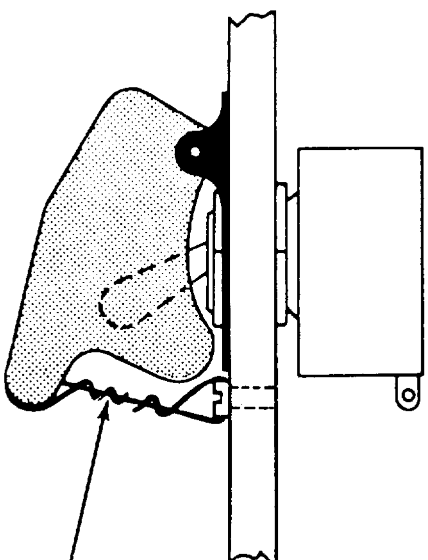


Figure 12. Shearwiring Emergency Devices

31 . SAFETY CABLE PROCEDURE.

32 . The selection of materials shall be in accordance with AS4536 and shall be in accordance with the service limitations outlined herein.

NOTE

Minimize mixing of safety wire and safety cable.

a. AS3617 series Safety Cable Kit (UNS N6600 Nickel Alloy) shall be selected for all standard safety cable applications on electrical connectors and accessories.

b. AS3619 series Ferrule, Elongated (UNS N6600 Nickel Alloy) for low profile and limited access applications is approved for use on electrical connectors and accessories.

c. AS3621 series Safety Cable, Self-Looping (UNS N6600 Nickel Alloy) for application of safety cable where safety device hole is not provided is approved for use on electrical connectors and accessories.

d. Only safety cables and ferrules supplied by a manufacturer that meets all the requirements of AS4536 shall be allowed.

e. Safety cable shall not be used for any shear or breakaway applications.

f. Safety cable shall be installed with a calibrated tool which is supplied by the safety cable manufacturer for the purpose of applying tension to the cable, crimping the ferrule, and cutting the excess cable without allowing tension to be lost.

33 . Safety Cable Diameter. The size of safety cable shall be in accordance with the following requirements:

a. 0.020 inch diameter safety cable is intended for use on parts having a nominal hole diameter of 0.045 inch (1.14 mm) or smaller.

b. 0.032-inch diameter safety cable is intended for use on parts having a nominal hole diameter of 0.075 inch. (1.91 mm) of smaller.

c. 0.040 inch diameter safety cable is intended for use on parts having a nominal hole diameter of 0.095 inch (2.41 mm) or smaller.

d. The specified length of the cable shall be selected to accommodate the span between fasteners/connectors added to the length of cable required to correctly engage the application tool.

34 . **SAFETY CABLE APPLICATIONS.**

CAUTION

Do not loosen or tighten properly tightened components to align safety wire holes.

35 . **GENERAL.** The following examples are typical of acceptable safety cable applications. The examples are typical of the application of safety cable on electrical connectors and accessories. All possible applications are not shown.

36 . **CONNECTORS WITH THREADED COUPLINGS.** Select the appropriate diameter safety cable using the guidelines in this manual, and install safety cable on threaded couplings as shown in Figure 13.

37 . **FLANGED RECEPTACLE.** Select the appropriate diameter safety cable using the guidelines in this manual, and install safety cable on flanged receptacles as shown in Figure 14.

38 . **JAM NUT RECEPTACLE.** Select the appropriate diameter safety cable using the guidelines in this manual. When installing safety cable on adjacent jam nut receptacles use the method shown in Figure 15. When installing safety cable on a single jam nut receptacle, safety cable may be installed from a fastener as shown in Figure 16, or it may require the use of a self looping safety cable as shown Figure 17.

39 . Backshells and Strain Relief. Backshells are held in place by assembly nuts or by a mating flange.

40 . **Mating Flange.** Typical mating flange types are of two pieces, held together and in place by three or four screws. The screws can be secured with safety cable

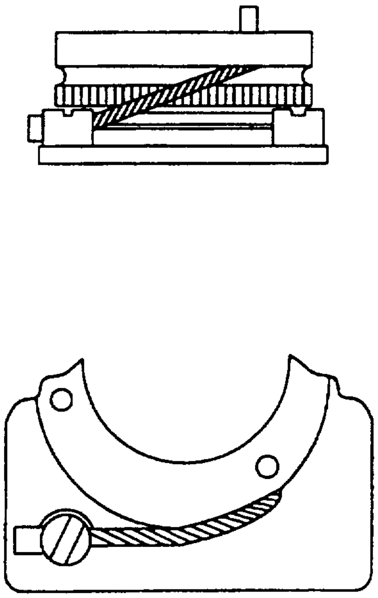


Figure 13. Threaded Coupling and Assembly Nut Safety Cable Installation Detail

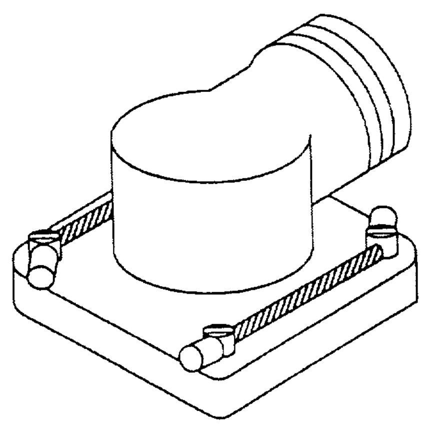


Figure 14. Flanged Receptacle Safety Cable Installation

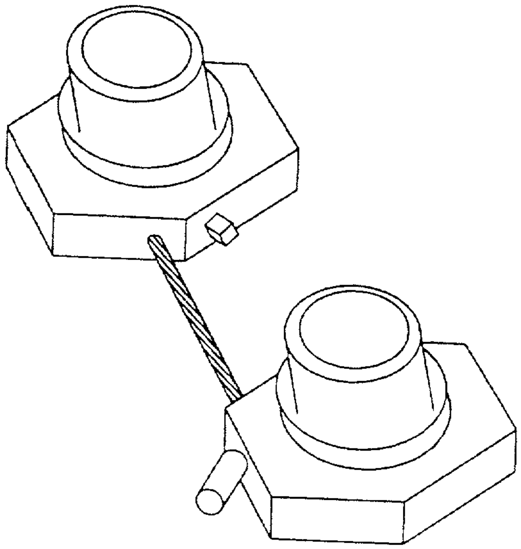


Figure 15. Multiple Jam Nut Receptacle Safety Cable Installation.

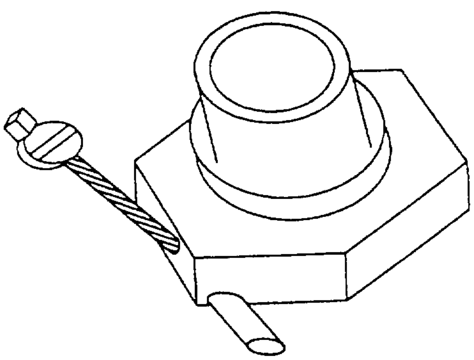


Figure 16. Single Jam Nut Receptacle Safety Cable Installation

by installing safety cable through two or three screws in a positive or neutral direction.

41 . **Assembly Nuts.** When assembly nuts are used, safety cable may be installed between a strain relief screw, or other backshell screw (Figure 18), to a fastener such as the receptacle flange screw (Figure 13), or it may require a self-looping safety cable (Figure 19).

42 . **Strain Relief Components.** The screws, which secure saddle clamps and other strain relief components, shall be secured with safety cable by installing the safety cable between the heads of two screws (Figure 20).

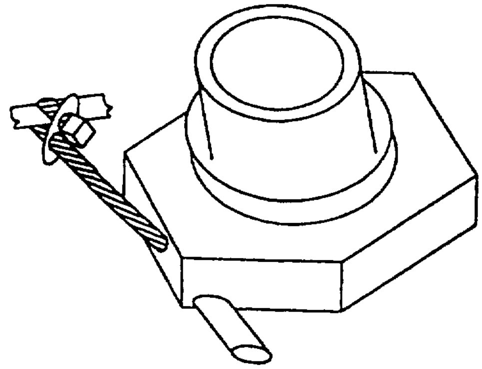


Figure 17. Single Jam Nut Receptacle Self-Looping Safety Cable Installation

NOTE

If safety cable on a strain relief wraps across metal corners as shown in Figure 20, and the application is for high vibration areas, it is a recommended practice to install protective tubing over the safety cable.

43 . **SAFETY CABLE INSTALLATION**

CAUTION

Do not allow safety cable to touch the electrical wires that are installed in the connector.

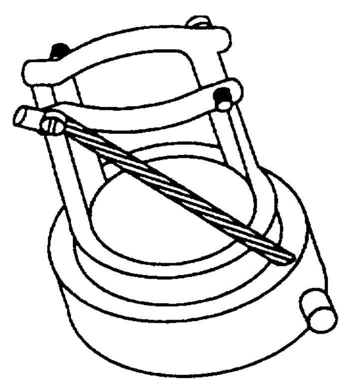


Figure 18. Assembly Nut to a Backshell or Strain Relief Screw Safety Cable Installation.

NOTE

Always refer to the platform/weapon system specific manual governing maintenance practices to ensure that the use of safety cable is not limited or prohibited from use.

44 . Safety cable may be used as a substitute for lockwire on electrical equipment and connectors in aircraft to prevent accidental loosening caused by vibration. Threaded parts, such as connector coupling mechanisms, backshells, strain relief components, relays, other electrical components, and equipment covers/panels. The following rules shall apply when using safety cable.

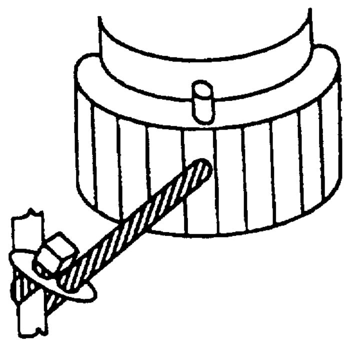


Figure 19. Assembly Nut Self-Looping Safety Cable Installation.

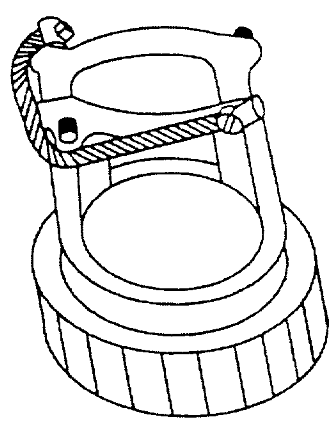


Figure 20. Strain Relief Safety Cable Installation.

NOTE

Routing of safety cable may vary from that of lockwire in order to achieve a proper installation.

a. When safety cable is being substituted for lockwire in an existing installation (maintenance, rework, etc.), equivalent diameter safety cable to that of the lockwire shall be selected for use. Use the selection guidelines defined in paragraph 31 unless otherwise specified.

b. Adjacent Units. Safety cable shall be installed in such a manner that any tendency for a threaded part to loosen will be counteracted by an additional tension on the cable. Safety cable shall be threaded through fasteners in such a way as to produce installed safety cable with either positive or neutral pull.

c. Maximum Span. The maximum span of the safety cable between two termination points shall be six inches (152.4 mm) unless otherwise specified.

d. Installing Defects. Any cable defect (nick, fray, kink, or any other mutilation of the safety cable) found prior to, during, or subsequent to installation is not acceptable.

NOTE

Avoid kinks or sharp bends while handling and threading safety cable.

e. Applications where safety cable is to be installed through a hole having a nominal diameter of greater than 0.095 inch (2.41 mm), but less than 0.200 inch (5.08 mm) shall require a flat washer (same material composition as the safety cable) which is supplied by the safety cable manufacture for this purpose, and shall be used as shown in Figure 21.

f. Safety cable shall be installed with an application tool which has been calibrated to meet the performance requirements of AS4536 (SAE) and this manual.

g. Installing Holes. Safety cable must be installed through the holes intended for this purpose in the part being secured, or through the holes provided in a self-looping device secured to the safety cable by the safety. cable manufacturer (Figure 22). In applications where holes are not provided for safety cable in the component to which it is attached, the self looping safety cable may be used in a manner like, or similar, Figures 22 and 23.

h. Safety Cable/Ferrule Reuse. Safety cable and ferrule shall be new upon each application. Reuse is not allowed.

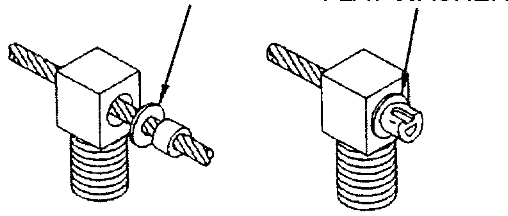


Figure 21. Flat Washer Safety Cable Installation

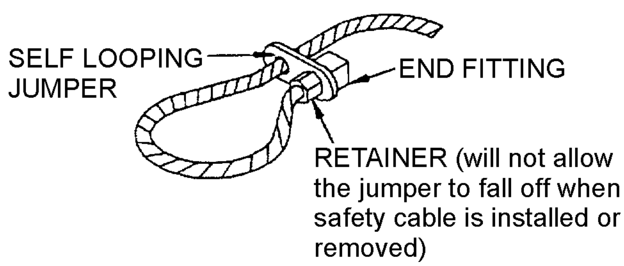


Figure 22. Self Looping Safety Cable

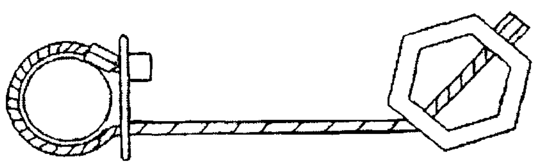


Figure 23. Self-Looping Safety Cable Anchored to a Pin Assembly

Table 2. Safety Cable Minimum Crimp Requirements (Pull-Off Load)

Nominal Cable Diameter inch (mm)	Safety Cable Construction	Minimum Pull-Off Load lb.-ft. (N)
0.020 (0.51)	1 x 7	30 (133.4)
0.032 (0.81)	3 x 7	70 (311.4)
0.040 (1.02)	7 x 7	1 10 (489.3)

i. Excess Cable. After installing safety cable, excess cable from the crimped ferrule shall be cut by the installation tool. The maximum allowable length of cable extending beyond the ferrule shall be 0.031 inch (0.79 mm).

45 . C**RIMPING REQUIREMENTS.** Safety cable shall be installed with the safety cable manufacturer's recommended tool, which has been tested and calibrated in accordance with procedures in paragraph 54 and meets the requirements of Table 2.

WARNING

The maximum bend exit limit of safety cable, when applied to the head of a threaded fastener (such as a screw or bolt) shall be 135 °. This does not apply to electrical connector coupling mechanisms and backshells where the safety cable is constrained by the shape of the component being secured.

a. Hole Alignment. Under torquing or over torquing to obtain proper alignment of the holes is not permitted. Apply recommended torque values to parts to be secured, and alignment of holes shall be evaluated before attempting to proceed with safety cable installation.

WARNING

This method should only be used in applications where the safety cable can not "flip"
over the corner or over the head of the fastener being secured.

b. In applications where safety cable shall be required to exceed the 135° maximum bend on a threaded fastener head, a self looping device which is secured to the safety cable by the safety cable manufacturer may be used to obtain a secured installation as shown (Figure 24).

c. Cable Flex Limits. After installing safety cable, the maximum flex between termination points shall be no greater than specified in Table 3 (Figure 25).

Table 3. Flex Limits for Safety Cable

Flex Limits; Inch (mm)		
A	B	C
0.5 (12.7)	0.125 (3.18)	0.062 (1.59)
1.0 (25.4)	0.250 (6.35)	0.125 (3.18)
2.0 (50.8)	0.375 (9.52)	0.188 (4.76)
3.0 (76.2)	0.375 (9.52)	0.188 (4.76)
4.0 (101.6)	0.500 (12.70)	0.250 (6.35)
5.0 (127.0)	0.500 (12.70)	0.250 (6.35)
6.0 (152.4)	0.625 (15.88)	0.312 (7.94)

NOTE

Light finger pressure of approximately 2 pounds shall be applied at mid-span when inspecting the total flex limit of installed safety cable.

It is important to hold the tool as steady and perpendicular to the fastener as possible during the crimp/cut cycle in order to maintain consistent tensioning of the cable after the tool is removed.

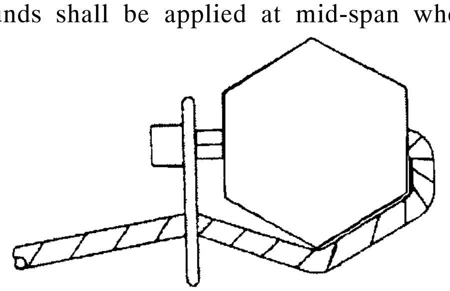


Figure 24. Self-Looping Safety Cable in High Bend Exit Applications.

46 . **ELONGATED FERRULES.** Ferrules of extra length, having a radius at one end and a straight surface at the other end, may be used in applications that restrict the clearance for the installation tool nose to be placed in correct alignment with the fastener (such as low profile fastener heads, recess locations, or obstructions, by structures or installed components); (Figure 26).

NOTE

Always install elongated ferrules with the radius end toward the fastener, and the straight end in the tool crimp cavity. Double

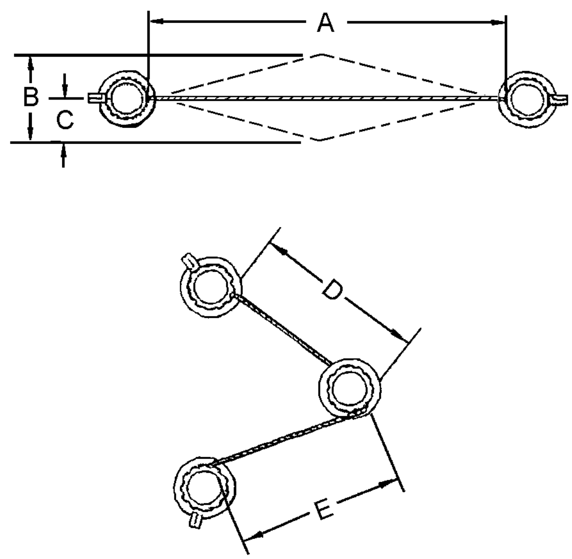


Figure 25. Safety Cable Flex Limits

check cable tension between fasteners after removal of application tool.

Radius required on 0.032inch diameter and larger elongated ferrules. Radius optional on 0.020inch diameter elongated ferrules.

47. **SAFETY CABLE IDENTIFICATION STAMP.** In applications where the user requires a logo or ID code to be a permanent part of the safety cable installation (for warranty or trace-ability), it shall be applied by the safety cable manufacturer to one or more surfaces of the square end fitting of the safety cable. Only impression stamping is permitted, no paint, ink, or labels are acceptable (Figure 27).

48. **SAFETY CABLE JACKETING FOR PROTECTION.** It is recommended to use a tubular jacket over safety cable when it is installed in a location where it is in contact with (or may contact) surfaces which may damage the safety cable or may be damaged by the safety cable. A tubular jacket material shall be capable of meeting the temperature range of the application, and shall be resistant to oil and chemical environments (Figure 28).

49. **SAFETY CABLE APPLICATION TOOLS.** When safety cable is used, the following basics apply for the application tools and calibration equipment.

a. Minimize mixing of safety wire and safety cable.

b. Install the ferrule cartridge into the tool body under the handle grip.

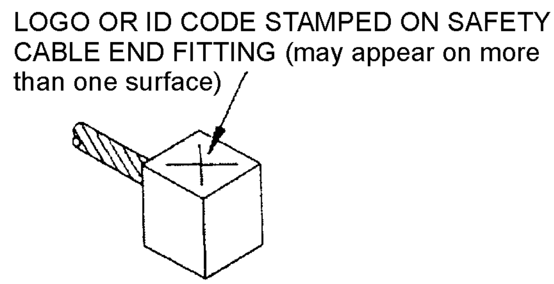


Figure 27. Safety Cable Identification Stamp

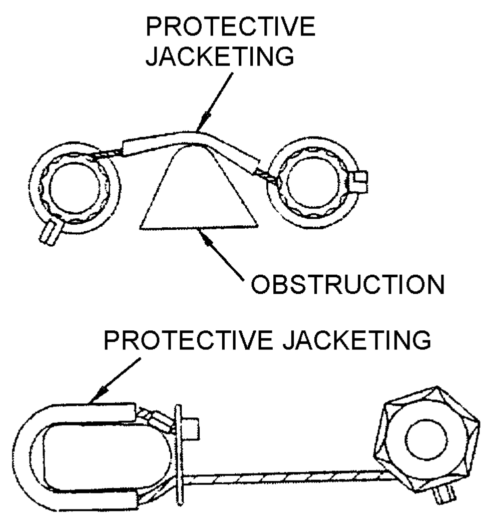


Figure 28. Safety Cable Jacketing for Protection

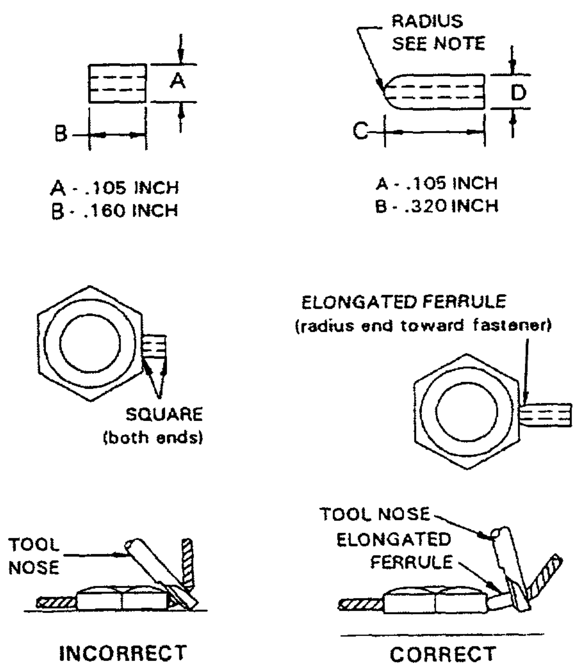


Figure 26. Low Profile Application for .032 and .040 Diameter Safety Cable

NOTE

When loading and using the safety cable application tools, be certain that the correct size safety cable and ferrules are being used with the tools.

c. Install the safety cable through the components to be secured.

d. The nose can rotate to any desired position (Figure 29).

e. Insert the free end of the cable through the ferrule in the cartridge, and remove the ferrule by pulling the cable away from the end of the cartridge (Figure 29).

NOTE

Do not release the free end of the cable until it has been inserted through the tool nose (Figure 29).

f. Insert the free end of the cable through the tool nose and slide the tool along the cable to the component being secured (Figure 30).

50 . TYPES OF SAFETY CABLE TOOLS.

51 . The Pre-Set Tension Tool (Figure 30). Insert the free end of the cable into the cable entrance and continue to push the cable into the cavity. When the free end of the cable appears at the bottom of the tool, grip the cable and pull the slack from the cable by repeatedly closing the tool handle allowing the handle to open fully before closing again. When all slack is removed, from the cable, snug the tool against the fastener by using several short strokes of the handle. Release the handle to the full open position and fully close the handle to crimp securely and cut flush.

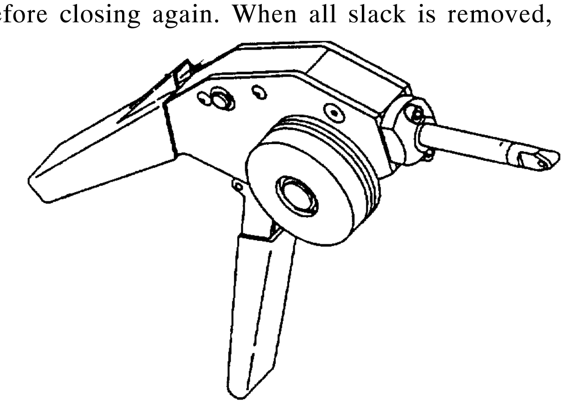


Figure 29. Safety Cable Application Tools

WARNING

Do not overtighten safety cable. It is a good practice to find a tension setting which removes the slack from the cable, (in order to meet the flex limit requirement) without overstressing the safety cable components.

NOTE

It is important on this final stroke to hold the tool as steady and perpendicular to the cable as possible while completing a full stroke. This assures consistent tensioning of the cable (Figure 31).

52 . **ADJUSTABLE TENSION TOOL** (Figure 32). Thread the safety cable through the fastener, ferrule, and tool nose in the same way as with other models. Wrap the cable one full revolution (clockwise) around the tension wheel, and with slight pressure applied by pulling the cable, secure the cable into the slot. Rotate the tension knob until several clicks are heard and felt. If additional tension is required, adjustment can be made

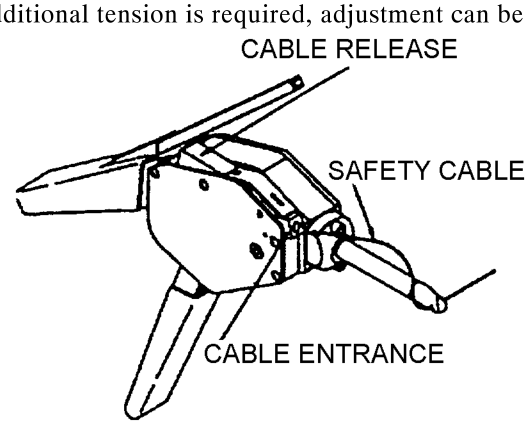


Figure 30. Pre-Set Tension Safety Cable Application Tool

with the tension adjuster on the opposite side of the tool.

a. Completely close the handles to crimp and cut the cable. Hold the tool steady and perpendicular to the cable to maintain constant cable tension (Figure 31). Release the handle and remove the tool from the crimped ferrule. Remove the excess cable segment from the tool prior to the next application.

b. If it is more convenient to use the adjustable tension tool with the tension wheel on the opposite side, you may remove the retaining ring located on the opposite side from the tension wheel, slide the tension wheel assembly out of the tool body, reinsert it from the opposite direction, and replace the retaining ring. The tension wheel is now located on the opposite side of the tool.

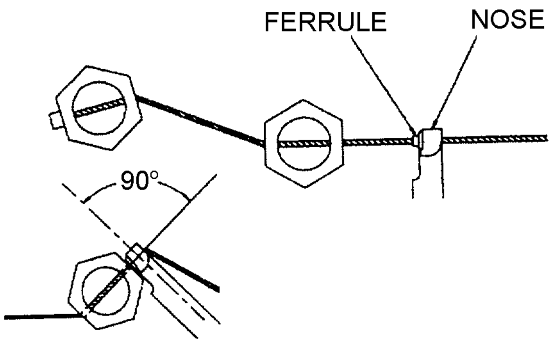


Figure 31. Correct Alignment of Safety Cable Tool Nose

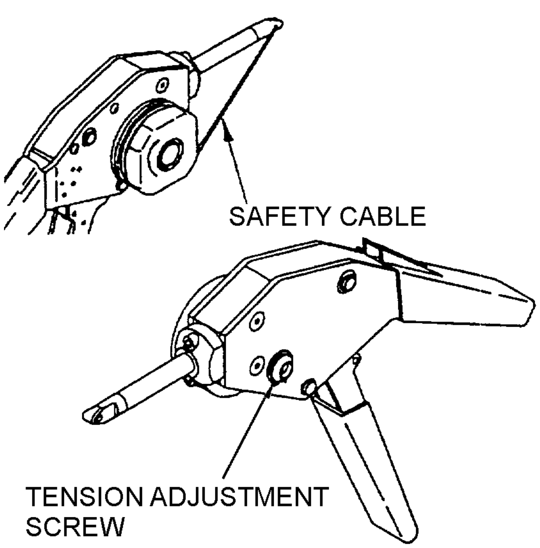


Figure 32. Adjustable Tension Safety Cable Tool.

NOTE

When using a hand tool, the tool handles are to remain fully open during the cable entry process (in both tool models).

53. **PNEUMATIC SAFETY CABLE TOOL** (Figure 33). Confirm that the tool is set-up correctly and calibrated. Connect the pneumatic safety cable application tool to a clean dry air supply of 80 to 100 psi.

a. Install the safety cable through the components that are to be secured.

b. The tool nose can be rotated to any convenient position.

c. Insert the free end of the cable through the ferrule in the cartridge, and remove the ferrule by pulling the cable away from the end of the cartridge. Insert the free end of the cable through the nose of the tool, and slide the tool along the cable to the desired position.

d. Rotate the cable tension wheel clockwise if necessary to move the cable entry slot to an assessable position. Align the nose such that the ferrule is pressed square against the component being secured. Make certain the ferrule is fully seated in the tool nose. Insert the free end of the cable into the cable entry slot of the cable-tensioning wheel. When the end of the cable

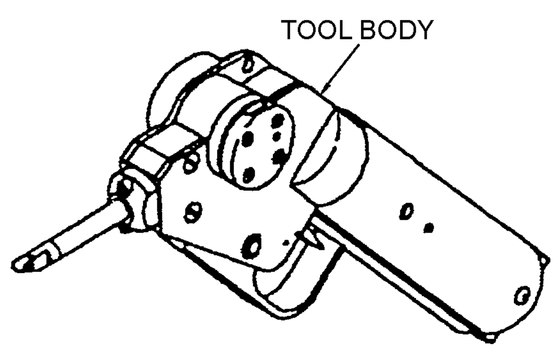


Figure 33. Pneumatic Safety Cable Application Tool

exits the wheel, grip the slack from the cable. Do not leave more than 1 1/2 inch of total slack in the cable.

e. Press the trigger and hold. The tool will apply tension to the cable, crimp and cut. When the trigger is released, the crimp mechanism will retract (after the cycle is completed). The tool nose can then be removed from the ferrule, and the excess cable discarded.

f. The tension is adjustable by inserting the adjustment key (supplied by the manufacturer) into the adjustment port located on the tool handle. Clockwise rotation increases tension, and counter clockwise rotation decreases tension.

54 . **SAFETY CABLE APPLICATION TOOL MAINTENANCE AND CALIBRATION.**

55 . The safety cable tools should be stored in a dry place when not in use. Clean any debris (especially in the crimp cavity in the tool nose) from the tool with a small brush and solvent if necessary. Lubricate the tool nose (into the crimp cavity) with a drop of oil on a regular basis.

56 . **TOOL CALIBRATION.** Verify tool calibration with the torque verification fixture, or the electronic pull tester.

NOTE

Indent calibration must be checked frequently, and must be checked each time the nose assembly has been removed or changed.

57 . **TORQUE FIXTURE.** Use the torque verification fixture and a calibrated torque wrench (0-155 inch-pound scale) to verify the. safety cable tool indenter adjustment. Thread a new piece of safety cable into the torque verification fixture (Figure 34), and crimp a ferrule onto the cable with the safety cable application tool that is being tested. This process is the same for all hand and pneumatic tool models.

58 . **PRETEST AREA.** Apply approximately 2 pounds force to the cable with your finger at the point marked "test area". The cable should not touch the side of bottom wall of the fixture.

59 . **TORQUE WRENCH.** Place a calibrated 3/8 inch drive torque wrench (capable of indicating 30 inch-pounds for .020 cable, 70 inch-pounds for .032 cable, and 110 inch-pounds for .040 cable) into the square drive hole. Orient the verification fixture and the torque wrench on a stable surface, slowly and steadily apply the-force until the required torque is indicated. Do not apply additional pressure after the required force is indicated. Release and remove the torque wrench.

60 . **POST TEST AREA.** Repeat the application of a 2-pound force to the area marked "test area". The safety cable should not touch the wall of the verification fixture. Upon the successful completion of this test, the tool can be used to apply safety cable.

61 . **TOOL DISPOSITION.** If the safety cable does touch the wall of the fixture, the tool should not be returned to service, and must be adjusted or serviced by the manufacturer.

62 . **TOOL CALIBRATION VERIFICATION WITH AN ELECTRONIC TESTER.** It may be required in some applications to use an electronic pull tester to test safety cable to destruction. If this is required, the tester

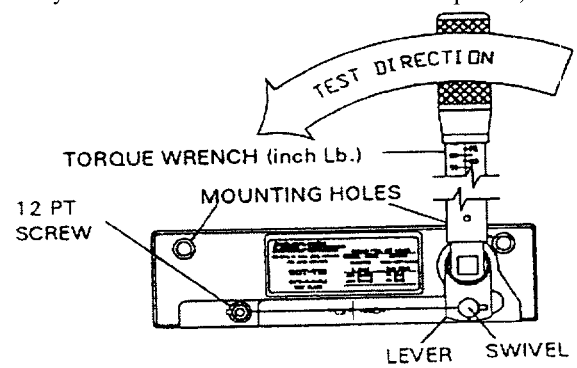


Figure 34. Torque Verification Fixture and Torque Wrench

(Figure 35) should have digital readout capability, and a two (2) inch/minute pull rate.

63. **SAFETY CABLE TOOL INDENTER ADJUSTMENT/CALIBRATION.** Remove the nose assembly by removing the two 8-32 socket head cap screws with a 9/64-inch hex wrench (Figure 36).

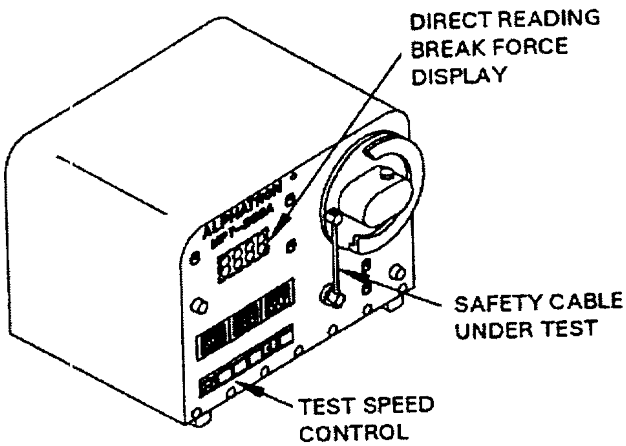


Figure 35. Electronic Safety Cable Pull Tester

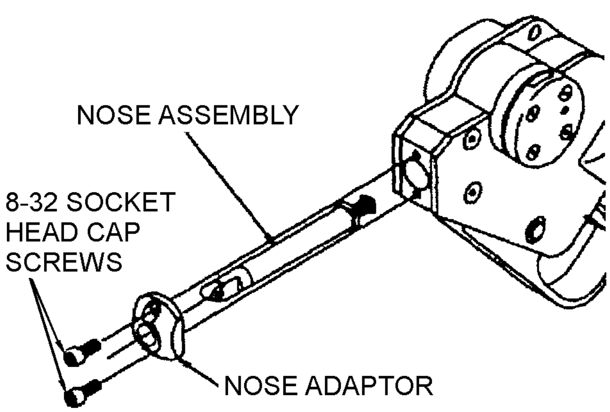


Figure 36. Removal of Safety Cable Tool Nose Assembly.

CAUTION

Do not adjust the pushrod adjustment screw more than one-quarter turn at a time. Radical adjustments may cause damage to the tool.

64. **SCT32080 TOOL.** Unlock the jamnut using the SCT32084 tool (supplied by the manufacturer). Adjust the pushrod adjustment screw using a 1/4-inch straight edge screwdriver (Figure 37). Turn the screw clockwise to loosen the crimp (enlarge the gaging dimension), or counterclockwise to tighten the crimp (reduce the gaging dimension). After each adjustment, securely tighten the jam nut using the SCT32084 tool (while holding the adjustment screw tight with the screwdriver). Reinstall the tool nose being sure to tighten the 8-32 socket cap screws securely.

65. **TOOL CHECK.** Retest the tool using the procedures previously defined. Accept or reject the tool on the basis of the pass/fail criteria stated above, and repeat adjustment process if necessary to achieve passing results.

66. **REPLACING THE TOOL NOSE.** If satisfactory results cannot be achieved by adjusting the tool as defined above, it may be necessary to replace the tool nose with a new assembly. Should this be necessary, obtain the new nose assembly, and follow steps as defined in paragraphs 63 through 65.

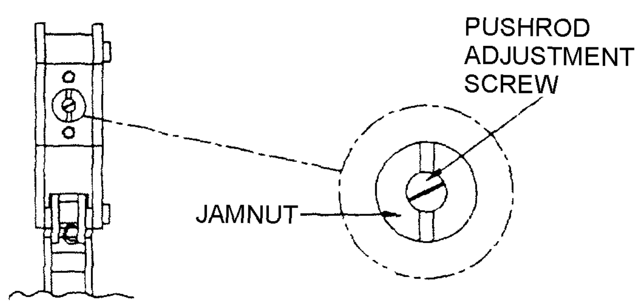


Figure 37. Adjustment of Safety Cable Indenter (Same for Hand and Pneumatic Tool Models)

BUS BAR AND TERMINAL BOARD

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Contacts, Terminals, Splices and Caps 013 00
Bonding and Grounding 018 00
Connector Cleaning and Preservation 027 00
Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured MIL–PRF–8516G
Terminal Board Assembly, Molded-In Stud, Electric SAE–AS27212
Terminal Junction Block . . . . . WP 028 00

Alphabetical Index

Subject Page No.

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part Number/Type Designation
Soft Bristled Brush	—
Spatula	—

Materials Required

Nomenclature	Part Number/Type Designation
Bolt	NASM3 thru 20
Cloth	A–A–59323
Compound, Sealing	MIL–PRF–8516G
Insulator	MS3373
Lockwasher	AN–935
Lockwasher	AN-936B
Lockwasher	MS35388
Methanol	O-M-232
Nut	AN-345
Nut	MS-25682
Nut, Plain	AN-340
Nut, Plate	O–E–925A
Nut, Self locking	NASM21042
Nut, Self locking	NASM21044
Nut, Steel	NASM35649
Nut, Steel	NASM35650
Petrolatum,-Zinc Dust Compound	—
Polyethlene Sheeting	—
Polyurethane Coating	PR-1532
Screw	MS51957
Tape, Pressure Sensitive	—
Terminal Board	MS27212
Terminal Board Cover	MS18029
Terminal Lug, Aluminum	M70991
Terminal Lug, Aluminum	MS25435
Terminal Lug, Copper	M7928
Terminal Lug, Copper	MS20659
Terminal Lug, Copper	MS25036
Tubing or Vinyl Sheet	—
Washer, Plain	AN-960
Washer, Flat Plated	NASM25440
Wrench, Torque	0 – 200 in. lb.

1 . **INTRODUCTION.**

2 . This work package (WP) describes bus bars, protective devices, terminal boards, and terminal junctions, their use, protection, preparation, and the recommended procedures for installation.

3 . **BUS BARS.**

4 . Bus bars are used in aircraft for power distribution. The most commonly used materials for bus bars is bare aluminum, plated aluminum, or plated copper.

5 . **UNPLATED ALUMINUM ALLOY BUS BAR PREPARATION.**

WARNING

Methanol, is highly flammable. Do not use near heat, open flame, or any source of ignition. Avoid prolonged breathing of vapors. Use only with adequate ventilation.

Clean bus bar by immersing in methanol, or by wiping with a clean soft cloth saturated with methanol solvent.

a. Keep enclosed areas well ventilated to prevent concentration of vapors

b. Non−soluble films may be removed by using a fine rotary stainless steel wire brush with pilot (Figure 1). They may also be removed by sanding or polishing with very fine garnet paper (silicon carbide or aluminum oxide, 320 grit or finer) or fiberglass eraser, using caution so as to not remove excessive metal.

NOTE

No emery or iron oxide paper or cloth is permitted. Stainless steel wire brushes should be used on only one type of metal in order to reduce the risk of galvanic reaction due to dissimilar metals

c. Apply a chemical conversion coating (ref. MIL−S−5002 and MIL−C−5541) to the area with clean scotch−brite (abrasive impregnated non−woven nylon), sponge, or equivalent. Keep area wet 3 to 5 minutes or until yellow color develops.

d. Remove most of the compound from bus bar by wiping lightly with a clean, soft cloth.

e. Examine bus bar to make sure that there are no steel brush bristles lodged in the aluminum.

NOTE

Allow the final coat of Petrolatum-Zinc Dust compound to remain on bus bar when installed. Excess will be squeezed out of connections and removed later.

f. Apply a thin coating of chemical conversion compound to contact surfaces.

6 . **PLATED ALUMINUM AND COPPER BUS BAR PREPARATION.**

WARNING

Methanol, is highly flammable. Do not use near heat, open flame, or any source of

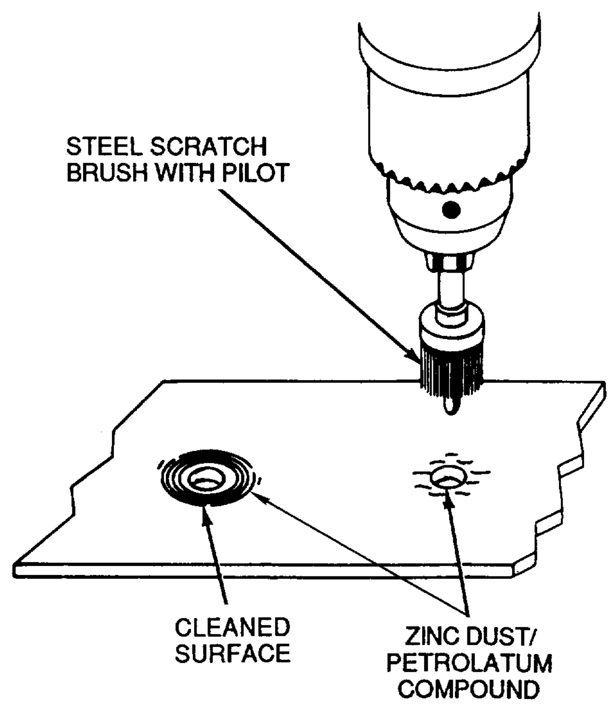


Figure 1. Unplated Aluminum Alloy Bus Bar Preparation

ignition. Avoid prolonged breathing of vapors. Use only with adequate ventilation.

a. Clean bus bar by immersing in methanol or by wiping with a clean, soft cloth saturated with methanol solvent.

b. Wipe dry with a clean, soft cloth.

7 . **PLATING REPAIR.**

CAUTION

Do not attempt to repair plating on aluminum.

8 . Inspect contact surfaces of plated aluminum or copper bus bars for damage to plating. Reject damaged aluminum bus bars and return for rework. Repair slight damage to plated copper bus bars by tinning with a soldering iron or by brush plating. Thoroughly wash and dry brush plated areas.

9 . **BUS BAR INSTALLATION.** Install bus bars inside panels, junction boxes, or in protected areas when possible. If this cannot be done, the bus bar shall be insulated.

10 . **Mounting.** When installing a copper bus bar, always use a plain cadmium plated steel washer between the bus bar and the lockwasher or self-locking nut. When installing on aluminum alloy bus bar, use a plain aluminum alloy washer between the bus bar and the lockwasher or self-locking nut (Figure 2).

11 . **Isolation.** Isolate the bus bar from structure, junction box, or support with a fiberglass, phenolic, or other rigid insulating stand-off. Do not use any moisture-absorbing material. Isolate to prevent fault to ground or phase to phase fault which would disrupt the electrical power system.

12 . **Insulation.** When conditions require, bus bars must be protected against accidental shorting. Bus bars may be insulated by applying a protective coating to the bus bar.

NOTE

Use a protective coating such as MIL–PRF–8516G sealing compound (WP 027 00).

a. Using pressure sensitive tape, mask all areas where connections will be made.

b. Apply a thick coat of compound using a spatula or soft bristled brush.

c. After compound has cured, remove tape with a razor blade by cutting into compound next to tape then peeling tape from masked area.

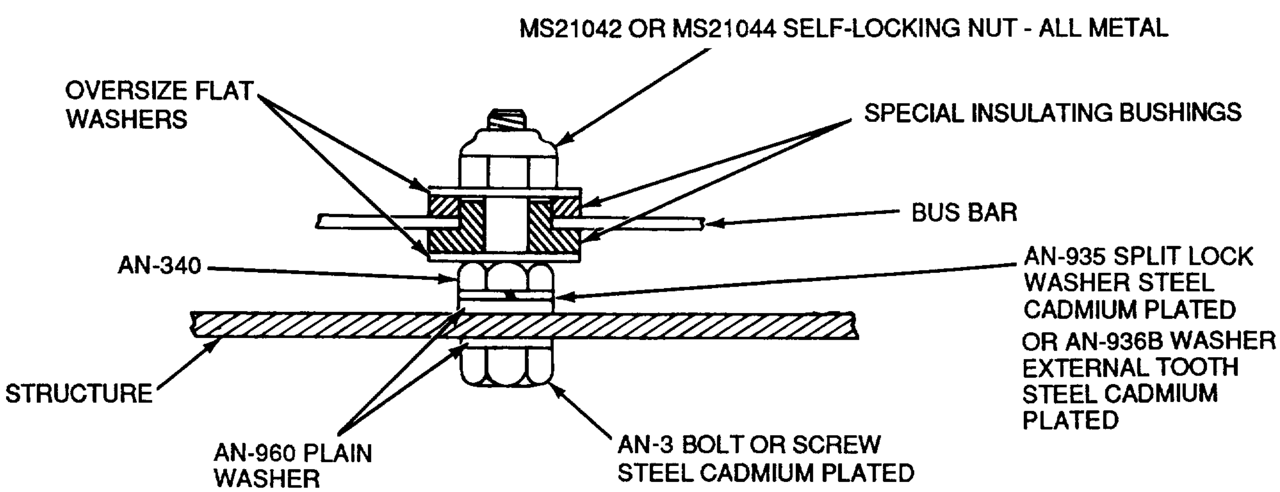


Figure 2. Bus Bar Mounting

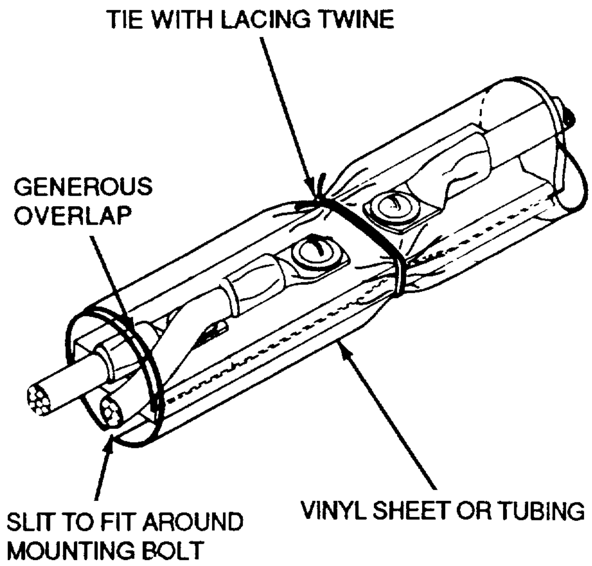


Figure 3. Vinyl Tubing Around Bus Bar

d. In conjunction with the previous steps, bus bars can also be protected by slitting a piece of vinyl tubing or suitable substitute with comparable dielectric characteristics, and wrapping it around the bus bar after all connections are made and coatings applied. Select tubing which has large enough diameter to permit a generous overlap when tying it in place (Figure 3).

13 . <u>CONNECTIONS TO BUS BAR.</u>

14 . HARDWARE FOR CONNECTION TO BUS BARS. Cadmium plated steel hardware (except as noted below) is used to secure terminals to bus bars. Use split lockwashers under hex nuts and under self-locking nuts. Use plated steel plain washer AN-960 between lockwashers and copper terminals. Use plated brass flat washer NASM25440 between lockwashers and aluminum terminals. The head of the screw or bolt can be located on the terminal side or the bus bar side, as required to simplify the installation.

a. Use a cadmium plated steel split lockwasher NASM35338 under the head of every bolt or screw and also under the nut.

b. Use plated brass flat washers NASM25440 in contact with aluminum. The washer diameter must be at least equal to the tongue diameter of the terminals. Do not select a washer so large that it will ride on the barrel of the terminals (WP 013 00).

15 . **CONNECTING TERMINAL LUGS TO BUS BARS.** In order to obtain maximum efficiency in the transfer of power, the terminal lug and the bus bar should be in direct contact with each other so that the current does not have to go through any of the attaching parts, even if these are good-current-carrying materials. As illustrated in Figures 4 through 7 the above applies whether the terminal lugs and bus bar are of the same or of different materials.

NOTE

Terminal lug offset is positioned so that barrel cannot contact bus bars. This allows proper seating of tongue on bus bar.

16 . **PRECAUTIONS WHEN REPLACING EXISTING CONNECTIONS.** When replacing existing terminal lug connections to bus bars, observe the following precautions:

a. Check all flat washers. Replace bent washers. Replace washers which have scratched plating or paint on faying surface.

b. Clean bus bar connection areas.

c. Check plated copper terminal lugs before connecting to an aluminum bus bar. If plating is scratched, replace terminal lug.

17 . **CONNECTING TWO TERMINALS.** Terminal lugs must always be in direct contact with bus bar. As shown in Figure 8, connect one terminal lug to top of bus bar and the other to bottom.

18 . <u>TERMINAL BOARDS.</u>

19 . Terminal boards are used for junctions of wiring requiring infrequent disconnection or for joining two or more wires to a common point. Terminal boards shall be in accordance with MS27212 and shall be installed with MS18029 covers (Figure 9).

20 . **MOUNTING.** Terminal boards shall be installed and mounted so that they are both mechanically and electrically secure. Terminal boards shall not be subject to mechanical strain or used to support insulating materials. The following methods are recommended for mounting and installation of the terminal board:

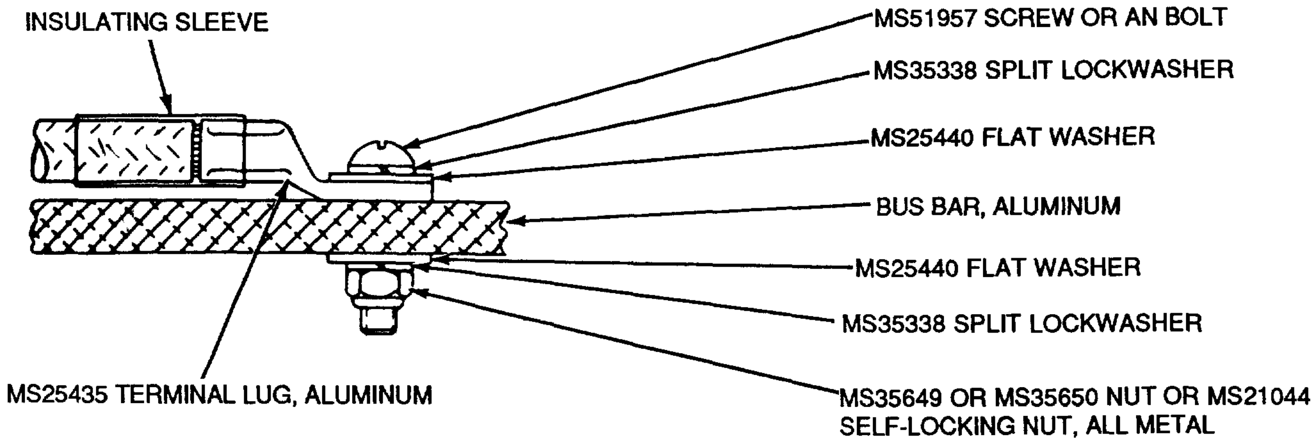


Figure 4. Connecting Aluminum Terminal to Aluminum Bus Bar

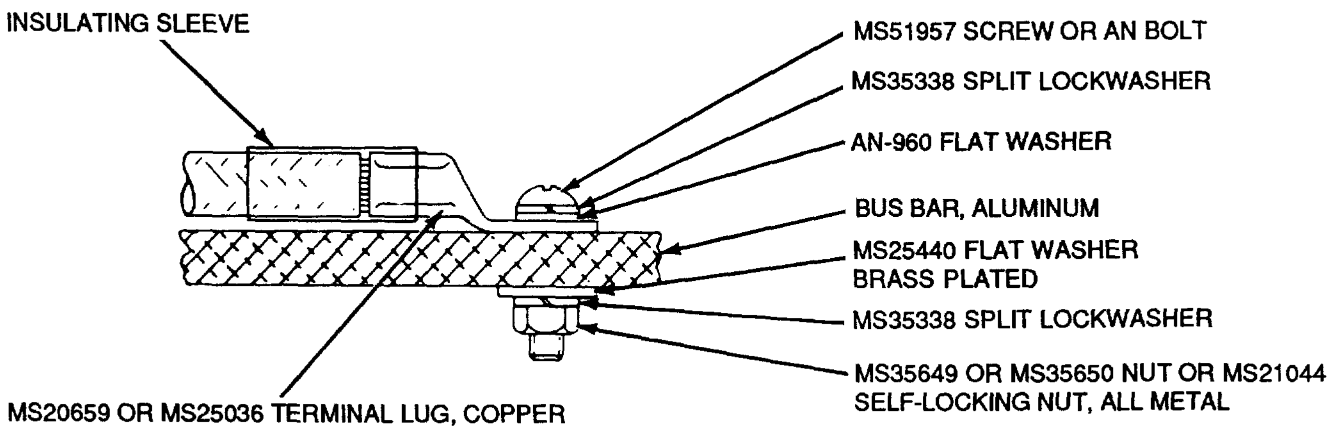


Figure 5. Connecting Copper Terminal to Aluminum Bus Bar

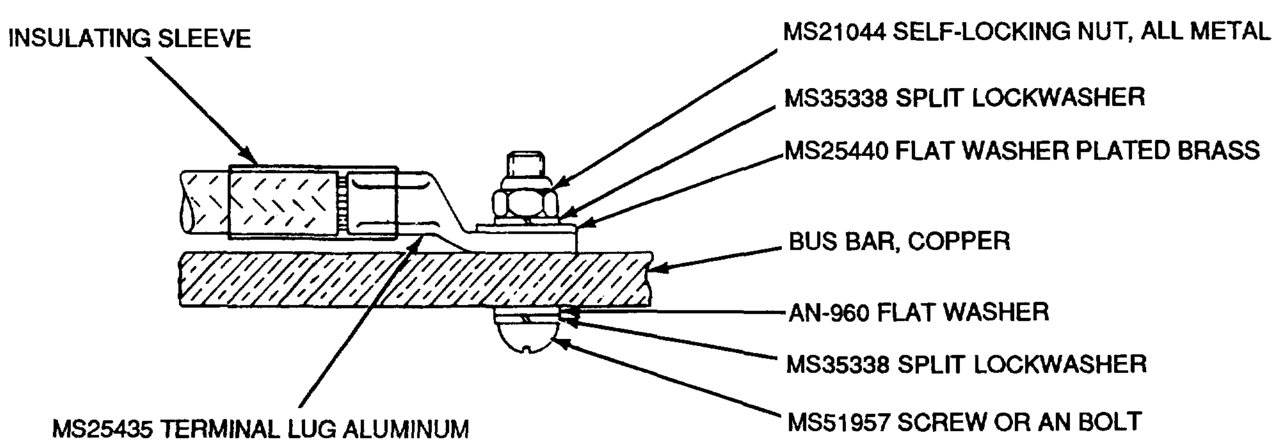


Figure 6. Connecting Aluminum Terminal to Copper Bus Bar

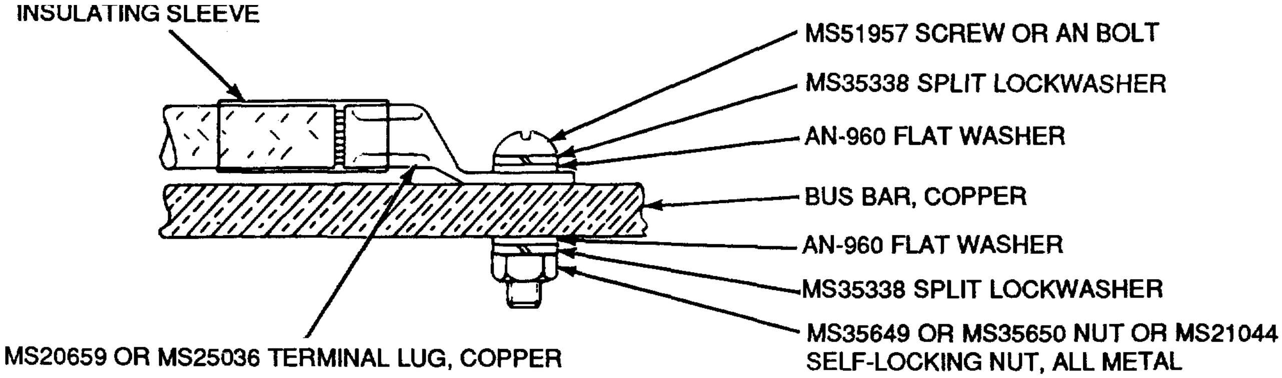


Figure 7. Connecting Copper Terminal to Copper Bus Bar

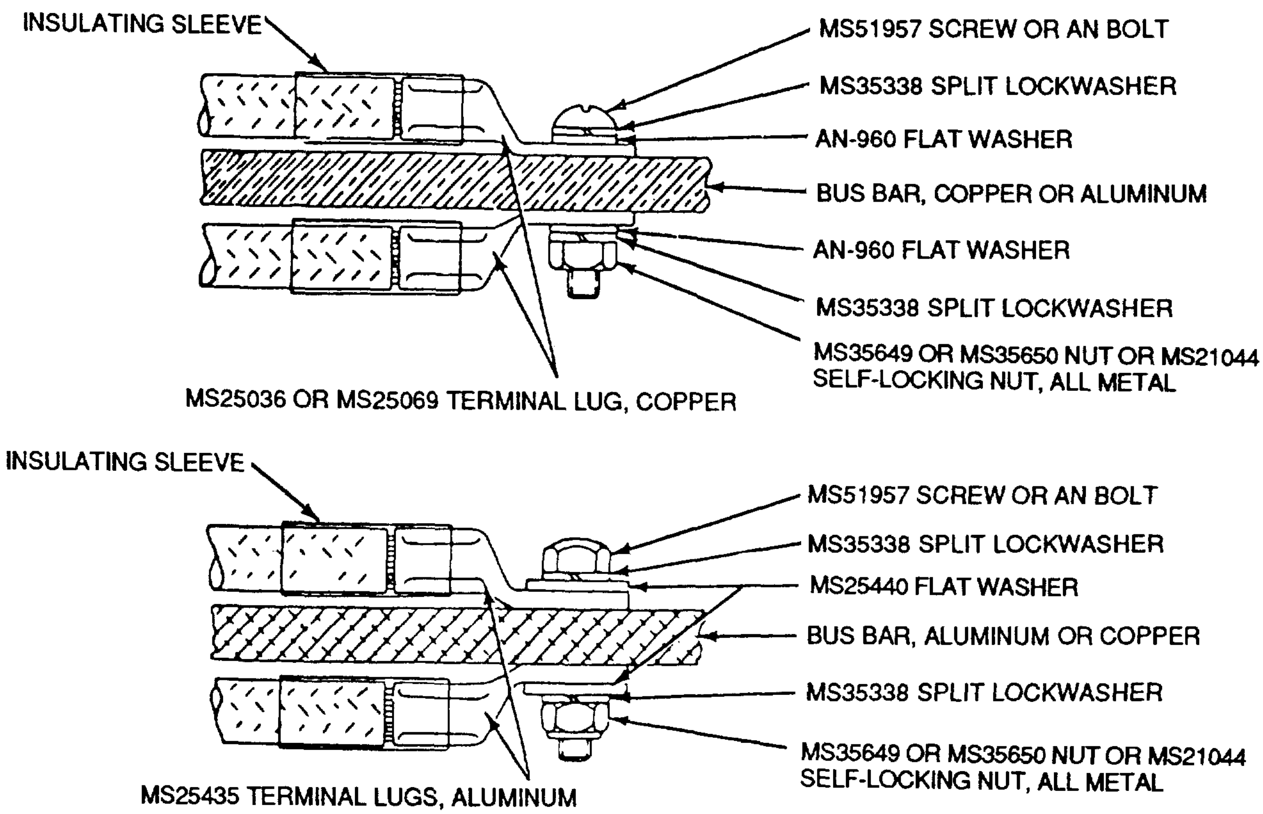


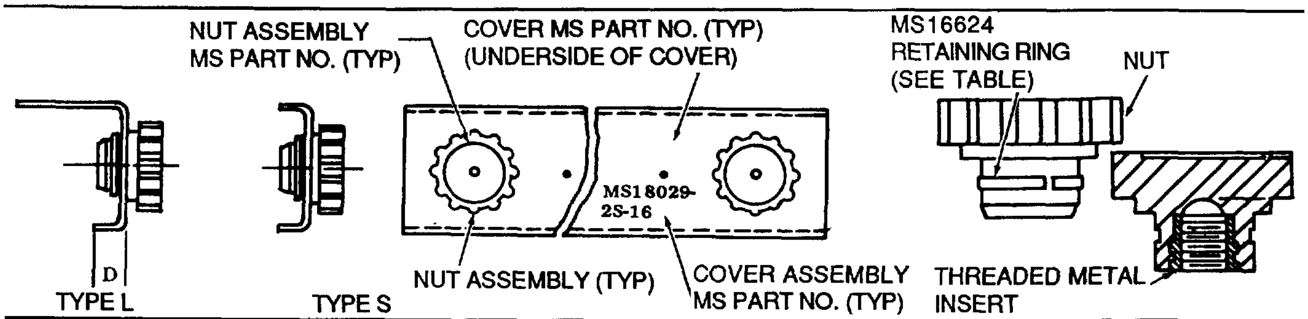
Figure 8. Connecting Two Terminals to Same Point on Bus Bar

Terminal Board MS Part Number	Stud Thread	Number Of Studs	Cover Part Number
MS27212-1-20	6-32UNC-2A	20	MS18029-1(*) - (N)
MS27212-2-16	10-32UNF-2A	16	MS18029-2(*) - (N)
MS27212-3-8	1/4-18UNF-2A	8	MS18029-3(*) - (N)
MS27212-4-8	5/16-24UNF-2A	8	MS18029-4(*) - (N)
MS27212-5-8	3/8-24UNF-2A	8	MS18029-5(*) - (N)
MS27212-6-16	8-32UNF-2A	16	MS18029-6(*) - (N)

NOTE: TERMINAL BOARDS AND COVERS ARE PROCURED IN FULL LENGTHS WITH NUMBER OF STUDS INDICATED. CUT TO SUIT NEEDS AT INSTALLATION.

COVER ASSEMBLY

NUT ASSEMBLY



Cover Assembly Part Number	Cover Part Number Type L Type S	Studs Maximum (N)	Nut Assembly Dash No.	Threaded Metal Insert	Retaining Ring Part Number
MS18029-1(*) - (N)	-11L - (N) -11S - (N)	20	21	0.138-32UNC-2B	MS16624-1040
MS18029-2(*) - (N)	-12S - (N) -12S - (N)	16	22	0.190-32UNF-2B	
MS18029-3(*) - (N) MS18029-4(*) - (N) MS18029-5(*) - (N)	-13L - (N) -13S - (N)	8	23 24 25	0.250-28UNF-2B 0.312-24UNF-2B 0.375-24UNF-2B	MS16624-1062
MS18029-6(*) - (N)	-14L - (N) -14S - (N)	16	26	0.164-32UNC-2B	MS16624-1040

NOTES:

1. (*) USE LETTER L OR S TO INDICATE TYPE COVER DESIRED.
   (N) INDICATES THE NUMBER OF STUDS IN A MS27212 TERMINAL BOARD ASSEMBLY TO BE COVERED.
2. EXAMPLE OF PART NUMBER:
   MS18029-2S-16 INDICATES A COVER ASSEMBLY FOR A MS27212 TERMINAL BOARD ASSEMBLY HAVING 16 STUDS . . . 190-32 UNF
   THIS COVER ASSEMBLY WILL CONSIST OF THE FOLLOWING:
   1 - MS18029-12S-16 TYPE S COVER
   2 - MS18029-22 NUT ASSEMBLIES
   COVER ASSEMBLY MS PART NUMBER SHALL BE MARKED ON TOP OF COVER.
3. THE GOVERNMENT SERVICES SHALL PROCURE AND STOCK ONLY COVERS MS18029-11L-20, -11S-20, -12L-16, -12S-16, -13L-8, -13S-8, -14L-16, -14S-16, AND NUT ASSEMBLIES MS18029-21 THROUGH -26.
4. THE INSTALLING ACTIVITY SHALL FABRICATE COVER ASSEMBLIES FROM PARTS TO BE STOCKED.
5. (N) CODE IS FOR INDUSTRY USE ONLY, FOR THE PROCUREMENT OF COVER ASSEMBLIES OF VARIOUS LENGTHS.
6. COVER ASSEMBLIES ARE NOT TO BE USED IN INSTALLATIONS WHERE THE TEMPERATURE EXCEEDS 475°F (246°C).
7. A MINIMUM OF THREE THREADS MUST BE EXPOSED AFTER TERMINAL STACKING ON THE END STUDS FOR COVER INSTALLATION.

Figure 9. MS27212 Terminal Boards and Covers

a. Install mounting screws so that the screws extend through the bottom of the terminal board (Figure 10).

b. Install washer, lockwasher, and mounting nut.

NOTE

Screws shall not extend more than two threads beyond nut.

c. Pass a steel scale or other flat piece of metal over the top of nut. If it passes over freely, the screw is too short and must be replaced with the next longer length screw.

21 . **ALTERNATE MOUNTING.** When it is not possible to install the mounting screws from the top of the terminal board, install as follows:

a. Install mounting screws, washers, and lockwashers from the bottom of the terminal board.

b. Install mounting nut.

c. Mounting screws shall extend beyond the top of the nut, but not beyond the level of the terminal board mounting surface (Figure 11).

22 . **INSULATION.** An insulating strip shall be installed over each mounting screw. Install strips between the adjacent terminal studs under the securing washers and nuts (Figure 12).

23 . **TERMINAL BOARD COVERS.** Use terminal board cover MS18029 on the MS27212 terminal board. Attach no more than two terminal lugs on the stud which is to be used for mounting the cover to the terminal board.

24 . **IDENTIFICATION.** Each terminal board in the aircraft electrical system is identified by the letters TB, followed by a number which is the number of the individual board. Each stud on the terminal board is identified by a number adjacent to it, with the lowest number in the series at the end nearest the terminal board identification number. The identification may be marked on the aircraft structure to which the terminal board is attached or may be on an identification strip cemented to the structure, under the terminal board. When a terminal board is replaced, do not remove the identification marking unless it has been damaged. In that case, replace the identification marking exactly as in the original, in accordance with the applicable wiring diagram.

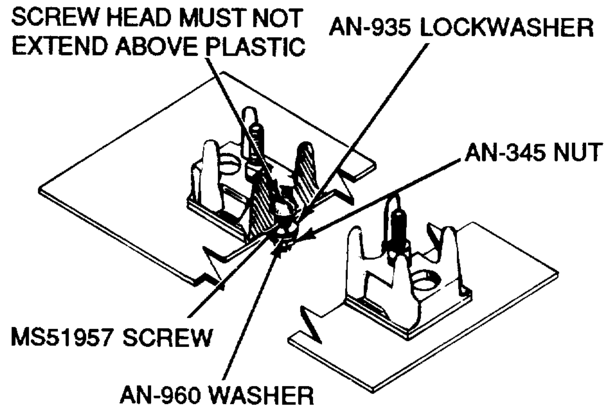


Figure 10. Terminal Board Mounting

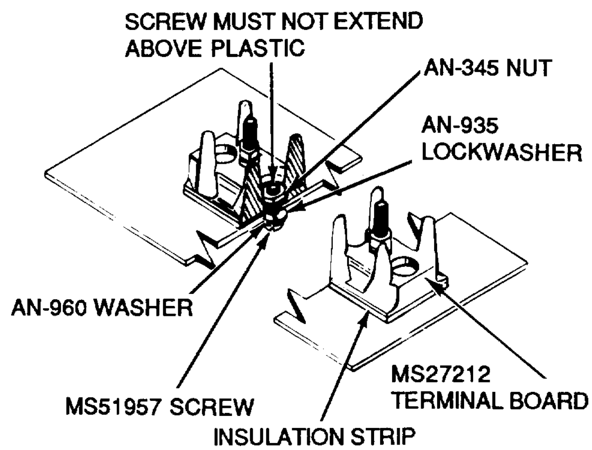


Figure 11. Alternate Method of Mounting Terminal Boards

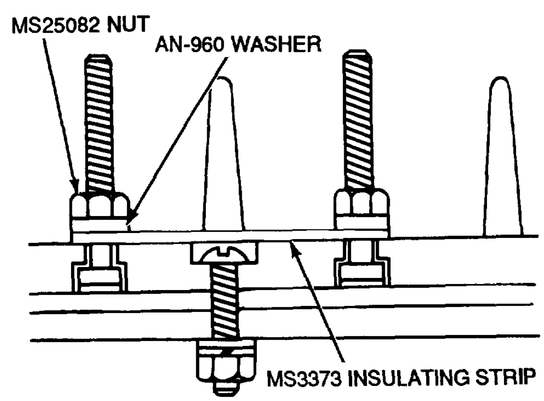


Figure 12. Terminal Board Insulation

25 . **CONNECTING TERMINAL BOARDS.** Terminal lugs are used to terminate wires to terminal boards (WP 013 00). Connections will adhere to the following (Figure 13):

a. No more than four terminal lugs, or three terminal lugs and one bus shall be connected to one terminal stud.

b. Terminal lugs with various diameters shall be stacked with the largest outer diameter on the bottom and the smallest on top.

c. Terminal lugs shall be selected by stud diameter.

d. Tighten but do not over tighten so as to deform either the terminal lug or stud.

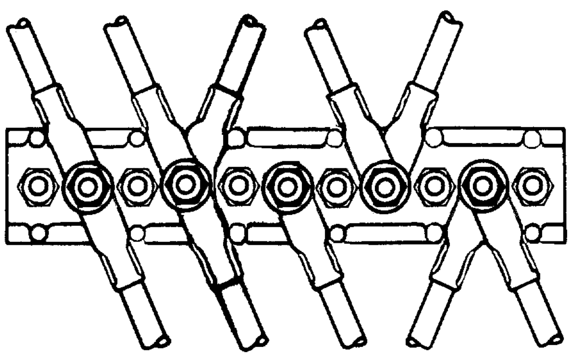


Figure 13. Connecting Terminal Lugs To Terminal Board

e. Position terminal lugs so that bending is not required to remove fastening screw or nut.

f. Position so that movement will tend to tighten the nut.

g. Copper terminal lugs shall not have spacers or washers between the tongues of terminal lugs.

h. Aluminum terminal lugs shall have the tongue or total number of tongues sandwiched between two NASM25440 flat washers. Spacers or washers are not permitted between the tongues.

26 . **HARDWARE FOR WIRING TERMINAL BOARDS.** Terminal boards have lugs molded in and do not require stud securing hardware as did the MS25123 terminal board which has been superseded. Attaching hardware is shown (Table 1).

27 . **INSTALLATION TORQUE.** As the terminal studs are molded into the terminal board the use of a torque wrench is recommended. The torque values are shown in Table 2.

28 . **ATTACHING COPPER TERMINALS.** To attach copper terminals to terminal boards proceed as follows (Figure 14):

a. Select proper hardware (Table 1).

b. Follow procedure as outlined (paragraph 25).

c. Assemble in proper sequence (Figure 13).

d. Torque securing nut (Table 2).

Table 1. Attaching Hardware

Part No. MS27212	Flat Washer	Lockwasher	Nut	
			Plain	Self Locking
-1	AN960-C6	NASM35338-136 or 155	NASM35649-264	NASM21042-06 or NASM21042L06
-2	AN960-C10	NASM35338-138 or 157	NASM35650-304	NASM21042-3 or NASM21042L3
-3	AN960-C416	NASM35338-139 or 158	NASM35650-3254	NASM21042-4 or NASM21042L4
-4	AN960-C516	NASM35338-140 or 159	NASM35650-3314	NASM21042-5 or NASM21042L5
-5	AN960-C616	NASM35338-141 or 160	NASM35650-3384	NASM21042-6 or NASM21042L6
-6	AN960-C8	NASM35338-137 or 156	NASM35649-284	NASM21042-08 or NASM21042L08

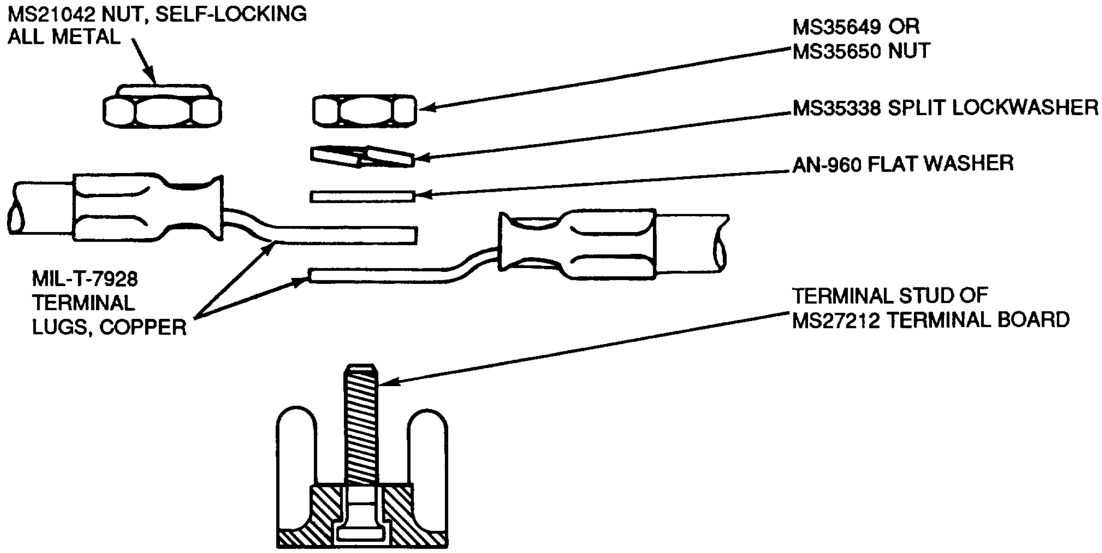


Figure 14. Hardware for Wiring Terminal Boards with Copper Terminals

Table 2. Torque Values

Stud Size	Torque Values
No. 6	22 Inch-Pounds
No. 8	32 Inch-Pounds
No. 10	40 Inch-Pounds
5/16 Inch	170 Inch-Pounds
3/8 Inch	170 Inch-Pounds

Table 3. Washer for Use with Aluminum Terminal Lugs

Part No, MS25440	Terminal Size	Stud Size
-3	8, 6, 4	No. 10
-4	8, 6, 4, 2, 1,1/0	1/4
-5	8, 6, 4, 2, 1, 1/0, 2/0	5/16
-6	8, 6, 4, 2, 1, 1/0, 2/0	3/8
-6A	3/0, 4/0	3/8
-8	2, 1, 1/0, 2/0, 3/0, 4/0	1/2

29. **ATTACHING ALUMINUM TERMINALS.** To attach aluminum terminals to terminal boards special washers are required as shown in Table 3. Proceed as follows (Figure 15):

a. Select proper hardware (Tables 1 and 3).

b. Follow procedure as outlined in paragraph 25.

c. Assemble in proper sequence (Figure 15).

d. Torque securing nut (Table 2).

30. **ATTACHING COMBINATIONS OF TERMINALS.** To attach copper terminals with aluminum terminals on the same terminals stud proceed as follows (Figure 16).

a. Select proper hardware (Tables 1 and 3).

b. Follow procedure as outlined in paragraph 25.

c. Assemble in proper sequence (Figure 16).

d. Torque securing nut (Table 2).

31. **TERMINAL JUNCTION BLOCK.** For connection to Terminal Junction Blocks refer to Volume II WP 028 00.

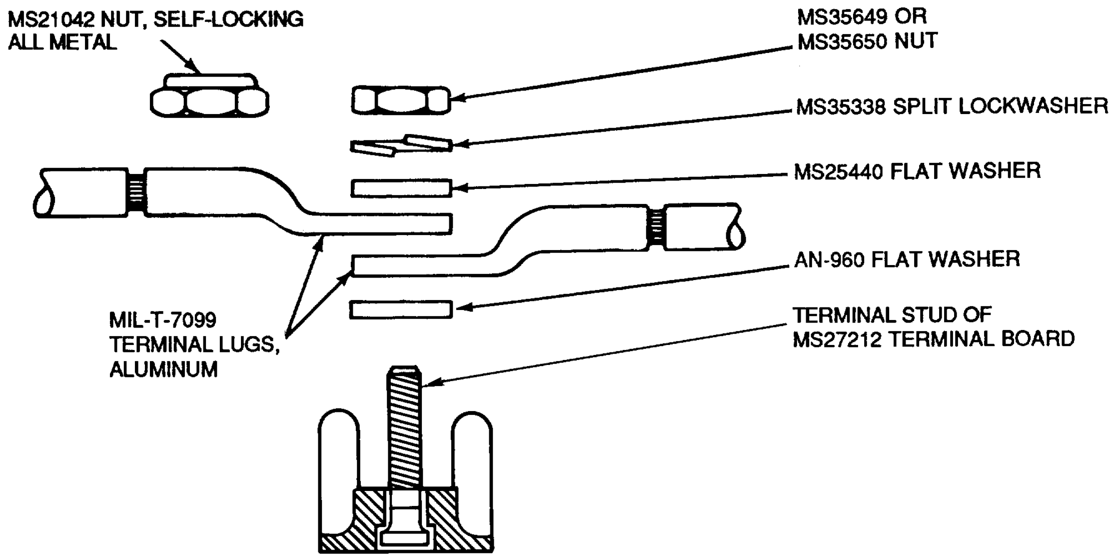


Figure 15. Hardware for Wiring Terminal Boards with Aluminum Terminals

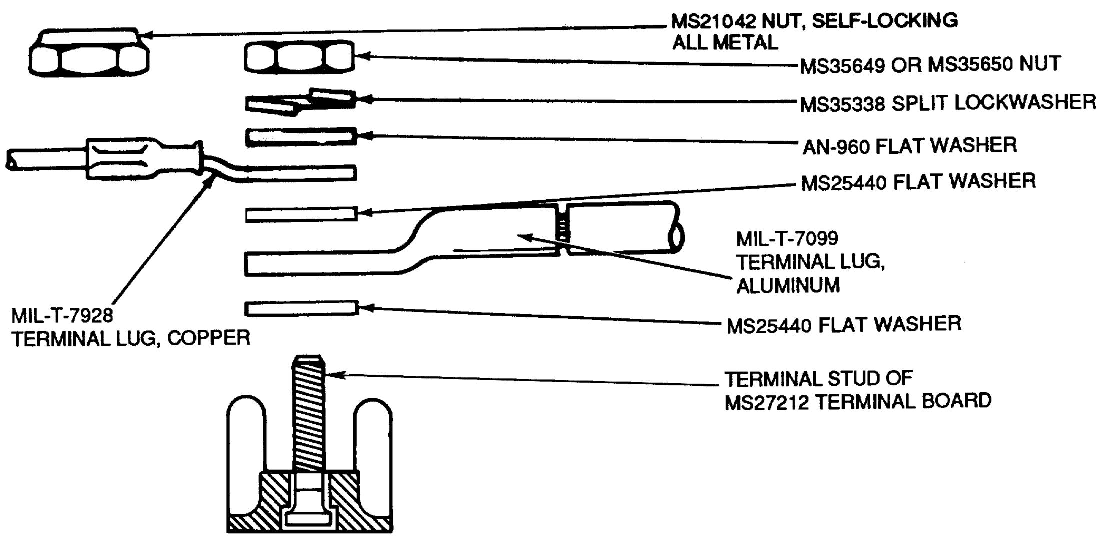


Figure 16. Hardware for Wiring Terminal Boards with Combination of Terminals

MILITARY STANDARD CIRCULAR CONNECTORS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Alphabetical Index (Cont)

Support Equipment Required

Nomenclature	Part. No./Type Designation
Heat Gun	HT-900B
Heat Gun	HT-920B

Materials Required

Nomenclature	Specification/ Part Number
Contact	D-602-16
Contact	D-602-17
Contact	D-602-44
Contact	D-602-45
Contact	D-602-46
Contact	D-602-47
Contact	D-602-54
Contact	D-602-55
Contact	D-602-56
Contact	D-602-57
Contact	D-602-72
Contact	D-602-73
Contact	D-602-94
Contact	D-602-95
Contact	D-602-104
Contact	D-602-105
Contact	D-602-106
Contact	D-602-107
Isopropyl Alcohol	TT-I-735
Sleeve, Filling	CTA-0006
Sleeve, Filling	CTA-0042

1. **INTRODUCTION.**

2. This work package (WP) covers general information for circular connectors commonly used on military aircraft. Specific information on a particular type connector is contained in the appropriate NAVAIR 01-1A-505-2, WP003 00 thru WP012 00.

3. **GENERAL.**

WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. Consult applicable health an environmental regulations regarding it's use, handling and disposition.

4. **CONNECTORS.** Connectors are electromechanical devices that permit circuit elements to be electrically and mechanically separated and reconnected without disturbing other elements. The connector performs no function electrically except to connect and disconnect circuits, and serves to join wires together.

5. **CONNECTOR SYSTEM.** A connector system (Figure 1) consists of two mating assemblies, a plug and z receptacle. The plug usually is on the end of a cable originating in a piece of equipment. The receptacle is usually fastened to a fixed structure or to piece of equipment.

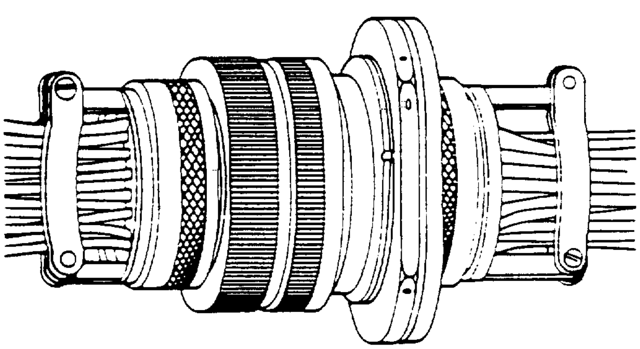


Figure 1. Typical Connector System

6. **RECEPTACLE ASSEMBLY.** The receptacle assembly (Figure 2) is that part of the: connector system that mates with the plug assembly, and is usually fired to a wall, bulkhead, or equipment case. A receptacle consists of an insulator insert, contacts, and a shell. The contacts, whether pin or socket, do not alter the terminology of the receptacle and maybe of any of the following types:

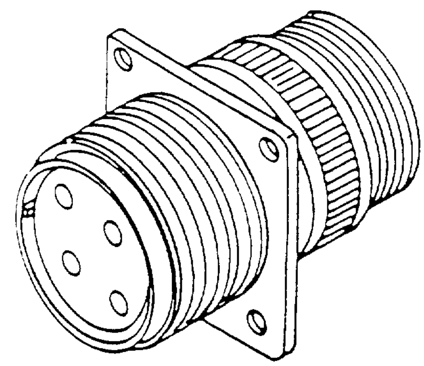


Figure 2. Typical Receptacle

7. **Flanged Receptacle.** Flanged receptacles (Figure 3) are may be box or wall mount. The body of the connector has a rectangular flange with screw mounting holes at each corner. This type requires five holes in the structure, one for the body and four for the mounting screws. Depending on the thickness of the structure, the receptacle can be mounted with the flange either on the front or back.

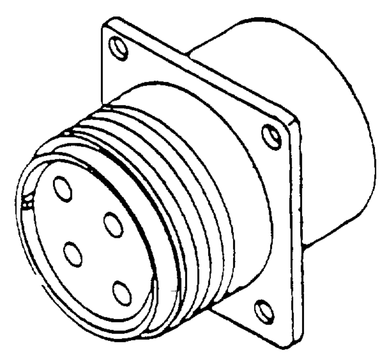


Figure 3. Typical Flanged Receptacle

8. **Jam Nut Receptacle.** Jam nut receptacles (Figure 4) are mounted by means of a large nut, or jam nut, threaded onto the connector body. This method requires one hole in the structure. The connector shell normally has provisions for an O-ring seal.

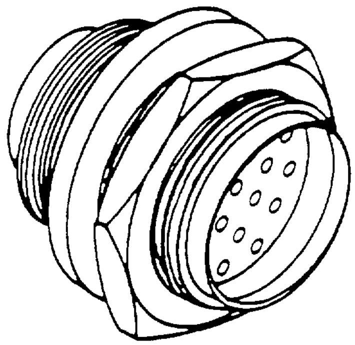


Figure 4. Typical Jam Nut Receptacle

9. **Cable Receptacle.** Cable receptacles (Figure 5) are used when two cables are to be connected together.

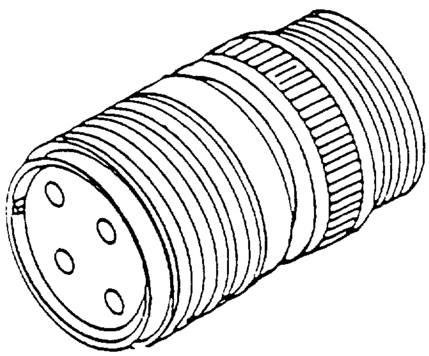


Figure 5. Typical Cable Receptacle

10. **PLUG ASSEMBLY.** The plug assembly (Figure 6) is the removable part of the connector system that mates with the receptacle, and is usually attached to a cable. A plug consists of an insulator insert, contacts,shell, and coupling mechanism. The contacts, whether pin or socket, do not alter the terminology of the plug.

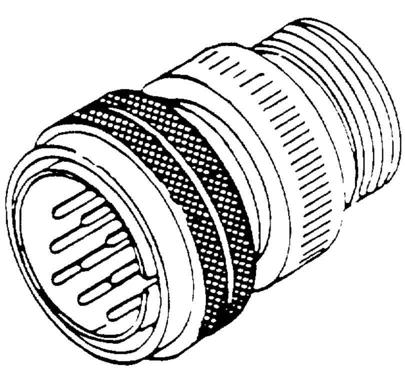


Figure 6. Typical Plug

11. **SHELL.** The shell (Figure 7) is usually fabricated of plated aluminum, steel, or composite, and supports and protects the insulator insert. Some receptacle shells are also used for in mounting. These shells are polarized to prevent mismatching of similar connectors.

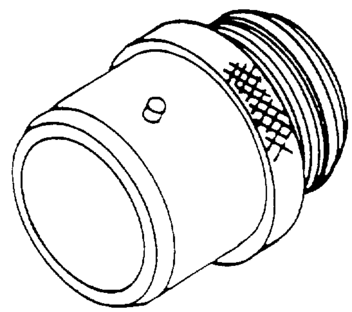


Figure 7. Typical Receptacle Shell

WARNING

Do not grind cadmium plated parts. Breathing airborne cadmium particles is a health hazard.

CAUTION

Only Cadmium plated connectors and accessories are approved for Navy applications.

12. **Plating Types.** The following are typical shell plating and finish types: Cadmium over nickel or suitable underplate, electroless nickel, anodized, passivated, cadmium, and fused tin. Refer to WP024 00, table 1 for additional materials and finishes information.

CAUTION

Nickel plated parts are not for Navy use or new design. They do not pass the aircraft corrosion requirement resulting in premature failure.

NOTE

The use of multiple connector plating types within the same connection shall be avoided to eliminate the issue of galvanic corrosion.

When ordering replacement components, ensure the correct base and plating materials are the same for both mating connections.

13. **POLARIZATION.** Polarization (Figure 8) is accomplished by use of a key and keyway or series of keys and keyways. One method has a slot or keyway cut into the plug shell with a corresponding protrusion or key on the inside of the receptacle shell. The other method is the opposite. The keys, usually one large and four small, are on the outside diameter of the plug and corresponding keyways are recessed into the inside diameter of the receptacle. Further polarization can be achieved by rotation of the smaller keys and keyways relative to the large ones. In some series, the insert itself can be rotated to allow for alternate insert positions.

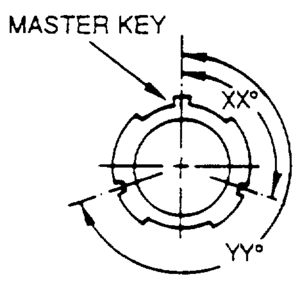


Figure 8. Polarization

14. **CLOCKING.** Clocking is defined as the angle in degrees that the wiring, backshell, boot, or potting are displaced from the connector keyway as read clockwise from the keyway when facing the connector mating surface.

15. **COUPLING.** The most common types of coupling and locking of a plug and receptacle are the threaded, double or triple start; bayonet; breech lock; and push-pull.

16. **Threaded.** The threaded system (Figure 9) employs a captive. Internally threaded coupling ring that mats with the threads on the receptacle. Double start threaded connectors begin coupling within 180 degrees of rotation. Triple start threaded connectors begin coupling within 120 degrees of rotation.

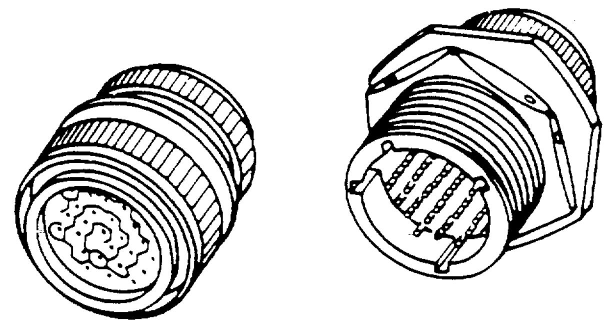


Figure 9. Typical Thread Coupling

17. **Bayonet.** The bayonet system (Figure 10) employs three pins spaced 120 degrees apart on the outside perimeter of the receptacle. The coupling ring of the mating plug contains three corresponding ramped grooves and a spring loaded device that provides a positive lock.

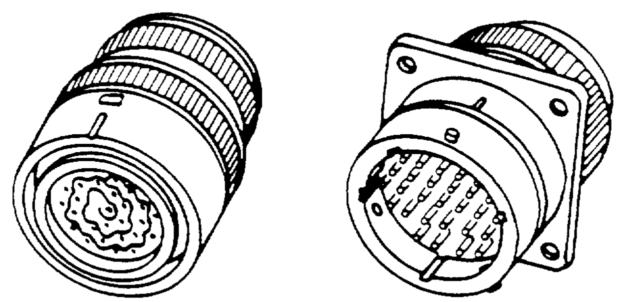


Figure 10. Typical Bayonet Coupling

18. **Breech Lock.** The breech lock system (Figure 11) is similar to the bayonet system except solid lands and grooves are utilized instead of bayonets. Coupling requires a 90 degree clockwise twist to couple.

19. **Push-Pull.** The push-pull coupling system (Figure 12) employs a coupling ring that slides along the axis of the connector.

20. **SERVICE CLASS.** Service class pertains to the environmental parameters in which the connector will operate successfully. These parameters include:

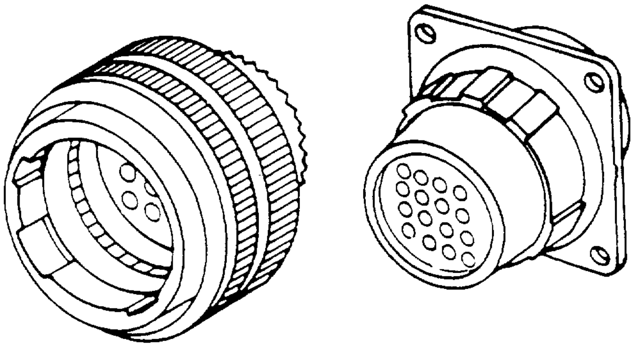


Figure 11. Typical Breech Coupling

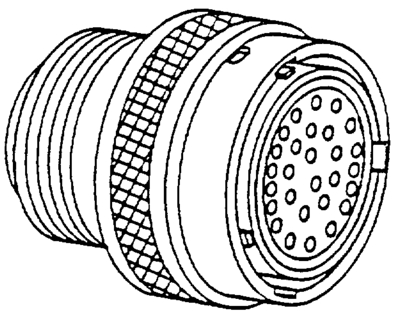


Figure 12. Typical Push-Pull Coupling

a. Environmental sealing

b. Fuel and fluid resistance

c. Vibration and shock

d. Corrosion resistance

e. Operating temperature

f. Special condition

21. **INSERTS.** The entire insert is essentially one integral part designed to provide suitable support around the wires and insulate the contacts from the shell as well as from other contacts. These inserts are usually constructed of a dielectric material such as rubber or plastic compositions, are nonremovable' and are secured to prevent rotation. The design is such that the contacts are able to be inserted and removed to facilitate installation and maintenance, except when using hermetic receptacle in which the contacts are fixed in the insert. A connector contains either a pin insert or socket insert (Figure 13).

22. **Rigid Dielectric.** The rigid dielectric is one molded piece, or more than one piece bonded together. The design is such that the contacts may be inserted and removed to facilitate installation and maintenance, except for hermetic receptacles.

23. **Contact Locking Devices.** The contact locking devices are contained in the rigid dielectric and securely hold the contacts during normal coupling (Figure 14).

24. **Insert Arrangement.** The insert arrangement indicates the service rating, and the quantity, size, and position of the contacts.

25. **Service Rating.** The service rating defines the test voltage that can be applied between adjacent contacts or a contact and the connector shell without evidence of breakdown or flashover.

26. **ENVIRONMENTAL SEALS.** The environmental seal is designed and utilized to prevent moisture from entering the connector and causing shorts. There are several types of seals.

27. **Peripheral Seal.** This is either a flat gasket. O-ring seal, or molded gasket to keep moisture from entering through the shell. As the connectors mate, the seal flattens causing an environmental seal.

28. **Interfacial Seal.** This seal is normally a rubber seal bonded to the pin insert face with a hole pattern corresponding to the insert. The connector, when mated, compresses the interfacial seal forming the environmental seal round each pin.

29. **Grommet Seal.** Typically, connectors have a grommet seal that is placed at the rear of the connector with a hole pattern corresponding, to the insert. Inside the grommet are one or more seals that hold themselves against the wire to prevent moisture entry. Wire outside diameter must he within tolerances defined in the applicable connector specification to meet the sealing requirements. Undersized wire may be built up with heat shrinkable sleeving to the correct size (WP 014 00). For sealing grommets to be effective, damage requires connector replacement or sealing. Connector sealing and preservation (WP 025 00) may offer repair method for connectorsealing using the Dual Connector Wrap Kit. verify connectors which employ a grommet seal are (Figures 14, 15 16):

(1) Not damaged, chip or gouged extending out from the recessed or chamfered area.

(2) The connector grommet shall have no surface gouges that extend to the wire or below the bottom of the chamfer (first sealing gland).

(3) Wire outside diameter must be within tolerances defined in the applicable connector specification to meet the sealing requirements.

30. **Cable Seal.** When using jacketed cable, an adapter and special seal may be used. As the adapter clamp is tightened. the cable seal is compressed forming the environmental seal.

31. **Hermetic Seal.** A glass-like material is used to insulate and seal the contacts, and all pin contacts will have an interfacial seal. The contacts are nonremovable.

32. **GROMMET SEALING PLUGS.** The grommets of environmental resisting connectors are designed to accept sealing plugs in accordance with MS27488. Sealing plugs shall be used, in conjunction with unwired contacts, in all empty connectors cavities to maintain environmental sealing characteristics of the connector. The connector, when ordered as a unit, will have sealing plugs enclosed so as to equal 15% of the number of contacts, but not less than one.

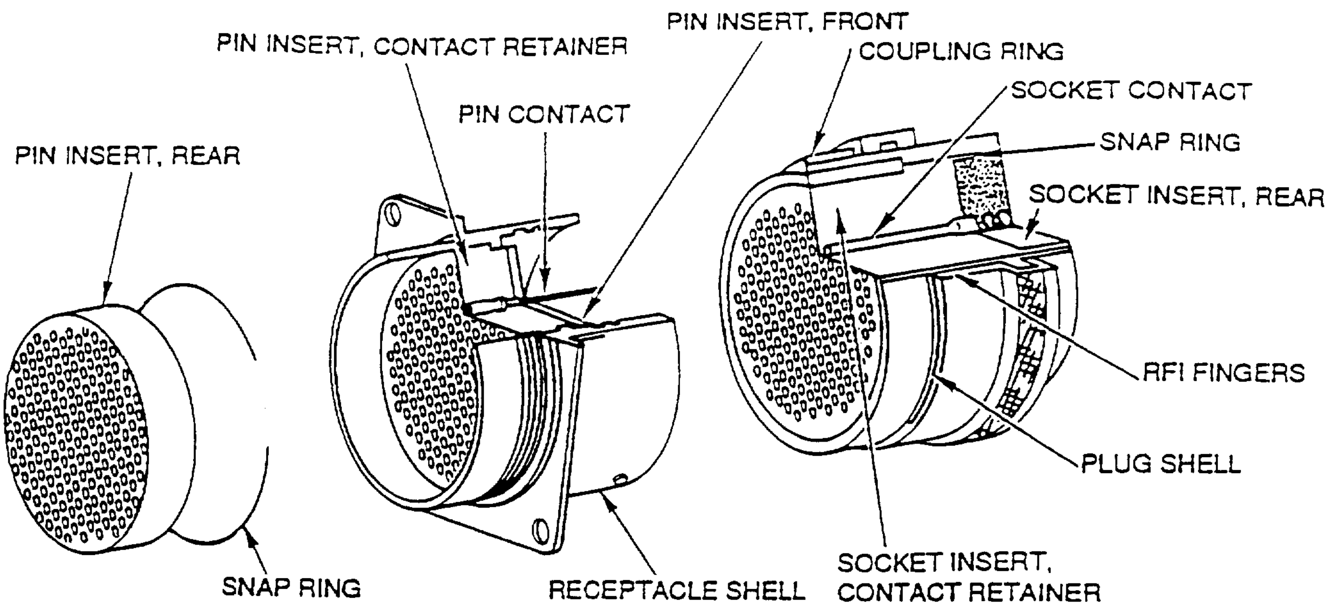


Figure 13. Connector Insert and Design Features

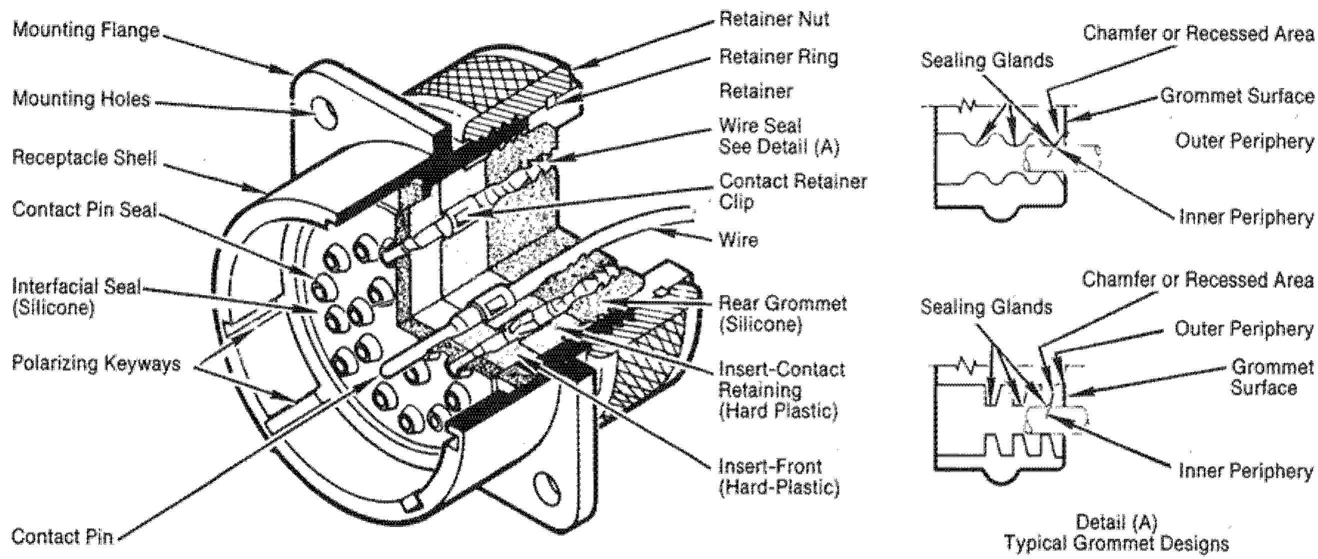
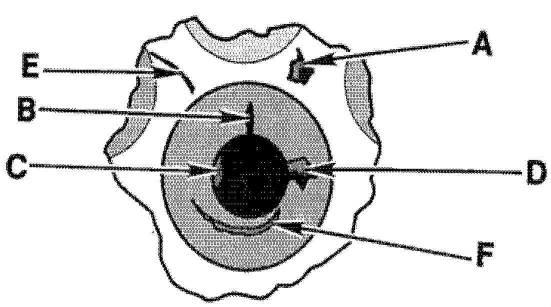


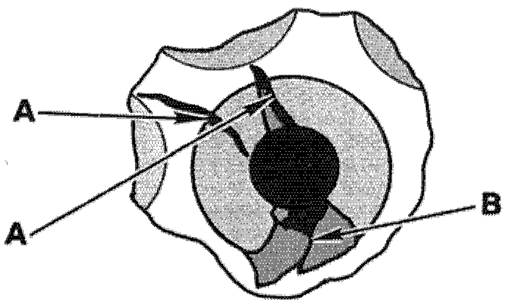
Figure 14. Connector Sealing Grommet Detail



Acceptable Conditions:

- Although gouges appear on the grommet surface (A) and in the chamfer area (B), none extend to the base of the chamfer.
- Any ONE imperfection: (A) Chip, nick or gouge, (B) Split crack through the sealing gland but not extending out of the recessed or chamfered area, (C) Mold Flash, (D) Chip, nick or gouge through the sealing gland but not out of the recessed or chamfered area, (E) Split or crack, (F) Chip , nick or gouge not through the sealing gland.

Figure 15. Acceptable Sealing Grommet Damage



Unacceptable Conditions:
- The large deep gouges (D) extend below bottom of the chamfer, and destroy the sealing capability of the grommet.
- (A) Split or crack extending out of the recessed or chamfered area, (B) Chip, nick or gouge extending out of the recessed or chamfered area.

Figure 16. Unacceptable Sealing Grommet Damage

33. **Sealing Plug Selection.** Sealing plus are sized according to contact size (Table 1).

TABLE 1. SEALING PLUG SELECTION

Contact size	Sealing Plug Part Number	Color
22	MS27488-22	Black
20	MS27488-20	Red
16	MS27488-16	Blue
12	MS27488-12	Yellow
8	MS27488-8	Red
4	MS27488-4	Blue
0	MS27488-0	Yellow

NOTE

All unused cavities in circular and rectangular connectors shall be filled with unwired contacts and appropriate MS27488 scaling plugs (see previous paragraph and table for sealing plug selection). The unwired contacts and sealing plugs are required to preserve the environmental sealing characteristics of the connectors.

34. **Installation of Sealing Plugs.** When installing into cavities with contacts, the sealing plugs shall be installed knob end first and shall bottom on the contact wire barrel.

35. **CONTACTS.** Contacts are the pins or sockets within the insert and may be either fixed or removable, solder or crimp, The contacts terminate the wire within the connector (Figure 13 and Figure 15).

36. **Solder Contacts.** Solder contacts are normally fixed, but some series connectors have removable solder contacts. The wire are terminated to the contact through a solder cup or barrel on the contact, with solder (WP 016 00).

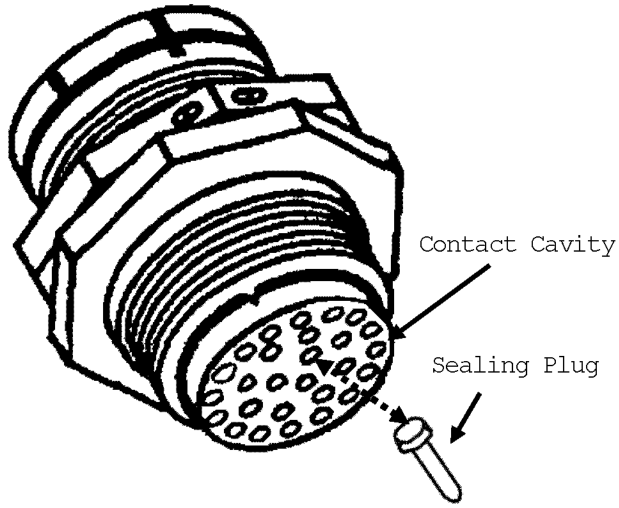


Figure 17. Inserting Sealing Plug into Contact Cavity

37. **Crimp Contacts.** Crimp contacts are removable and utilize special tools to insert and remove the contacts. The contacts are crimped to the wire using standard crimp tools and positioners (WP 013 00).

WARNING

Inspect all connectors for fiber optic termini prior to performing any type of maintenance. If connector contains fiber optics, refer to NA 01-1A-505-4 for required maintenance and cleaning guidance. Failure to do so may damage the terminus or fiber link beyond repair.

38. **Fiber Optic Terminus.** A fiber optic connection component which is removable. These termini are maintained, cleaned and inspected using special tools, refer to the NA 01-1A-505-4.

39. **Contact Availability.** Crimp contacts are supplied with each connector unit package and consist of a full complement plus one spare per size for connectors of 26 contacts or less. Connectors with more than 26 contacts will have two spares of each size used. Contacts may also be ordered in individual quantities when necessary.

40. **CONNECTOR INSTALLATION.**

41. **INSTALLATION GUIDELINES.** Connectors shall be used to join cables to cables, equipment. components, or other wires. The following installation guidelines shall be followed:

a. Adequate space shall be provided for mating and unmating connectors without the use of tools.

b. A minimum of 3/4 inch shall he provided around coupling rings on circular connectors.

c. Circular connectors installed with the axis horizontal shall have the large keyway located at the top.

d. Circular connectors installed with the axis vertical shall have the large keyway located to the front of the aircraft.

e. Locate connectors so as not to provide footrests, handholds, or in areas not to be damaged by cargo or stored materials.

f. Locate both plug and receptacles to be visible for engagements and orientation of polarizing keys.

g. Adequate strain relief shall he provided to prevent pulled wires.

h. Connectors in pressurized structures shall he installed preferably with the flange on the high pressure side.

i. Ground power receptacles shall be installed with the small contacts at the bottom.

j. Test all connector contacts for shorts and continuity following installation.

42. **ADJACENT INSTALLATION.** The use of identical connectors in adjacent locations shall be avoided. In situations where the use of identical connectors is unavoidable, adhere to the following, guidelines:

a. Route and support wiring to prevent improper connections.

b. Where the same configurations are used, connectors shall be selected with different polarizations.

c. Color code plugs with a colored sleeve near the plug, and the receptacle color coded with a band on the structure.

43. **CONNECTOR DRAINAGE.** Receptacles shall be positioned that when unmated for maintenance, fluids and condensation will drain from the receptacles. External connectors, connectors in engine compartments, wheel wells, and other like locations shall be given special attention to protect them from the entry of oil, moisture, and other fluids. Connectors shall not be mounted in fluid collecting areas.

44. CONNECTOR MAINTENANCE.

45. Before proceeding with maintenance, repair or installation, become familiar with the following warnings, cautions and notes, as each of these are pertinent throughout this section.

WARNING

Assure all power is disconnected prior to performing any wiring system repair.

If the connector has a backshell, it must be removed before maintenance procedures can proceed (WP 024 00).

Safety glasses shall be worn during all wire cutting and stripping operations.

WARNING

Isopropyl alcohol is highly flammable. Use only with adequate ventilation. Avoid prolonged breathing of vapors.

Unwired contact cavities must have contact and sealing plugs installed.

Metal tool tips are sharp and can cause injury to personnel and/or damage to the connector.

Use only approved heating tools when performing wire maintenance on or near aircraft that have not been defueled and purged, and certified gas–free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3. Use heating tools approved in WP 012 00.

Nozzle and output air of heating tools get very hot. Use extreme care while operating heat gun to avoid serious burns.

Use of nitrogen with the HT-900B/HT920B heating tool in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from aircraft being repaired. Use electrical power from ground power unit.

CAUTION

Be careful if using, metal M81969 tools. These tools can damage the wire sealing grommet in the connector if not used properly. Plastic tools are preferred when available.

Inspect tool tips for damage or distortion before each use. Damage to the connector wire sealing grommet can occur. Avoid using metal tooling, to remove and install backshells. These tools, can damage the backshell and connector. Non-metallic tools are designed to wear before damaging connector or backshell. (WP 024 00)

CAUTION

Do not remove a contact attached to a broken wire with an unwired contact removal tool. The connector and tool may be damaged.

Withdraw tool any time it cannot be advanced into connector. Inspect tool tip for nick, cracks, mushrooming and other damage that will prevent proper functioning Replace removal tool and repeat procedure if required.

Do not use lead pencils to count connector contacts as points can break off and lodge in the connector leading to arcing, shorts and system malfunction.

Do not use oversize probes in connector sockets during testing as this may result in splayed or damaged sockets.

Do not puncture wire insulation with a probe or attach clamps to wire insulation while continuity testing or troubleshooting.

Do not apply preservatives or solvents (including corrosion prevention compounds (CPC), solvents or lubricants) on multiple termini/contact connectors containing fiber optic termini or on fiber optic single ferrule connectors. Any seepage ingress into the connector housing is considered a contaminate and may degrade the system transmission performance or cause failure.

NOTE

A preapproved, "permanent" solid film lubricant may have been applied to threads by connector manufacturers (with durability of at least 500 mating cycles). Repair or replacement of this coating is not authorized for fiber optic connectors.

46. **DETERMINATION OF PROPER INSTALLING AND REMOVAL TOOLS AND CONTACTS.** If the connector part number is an MS number, the basic connector specification and series can be determined from the connector example of part number in NA 01–1A–505–2.

47. **WIRE DIAMETER BUILD-UP.** In cases where the outside diameter does not fill the grommet sealing holes, environmental resistance will be severely degraded. The wire diameter must be built up to provide proper sealing prior to contact insertion, by performing the following:

a. Select proper heat shrinkable insulation sleeving in accordance with MIL-DTL-23053 (WP 014 00).

b. Cut to length necessary to extend 1/4 inch beyond grommet.

c. Do not apply so as to cover crimp contact area.

d. Using proper reflector, apply heat using HT 900B/HT-920B to shrink sleeving.

e. Repeat above steps until diameter is built up to seal diameter.

48. CONTACT INSTALLATION AND RELEASE. Removable contacts, either solder or crimp, may be either front or rear release. Both systems result in the contact being inserted from the rear of the connector. Rear release connectors are required to have one or more blue color bands that are readily visible when the connectors are installed.

NOTE

Before attempting any insertion or removal of contacts from MIL-C-81511 Series 1 or 2 connectors, ensure that the rear nut assembly is in the unlocked position. A yellow colored stripe will appear when the rear nut assembly is rotated counterclockwise. At this point, the connector is in position for both insertion and removal of contacts. (Refer to NA 01–1A–505–2, WP004 00).

49. FRONT RELEASE CONNECTORS.

CAUTION

Do not attempt to reseat a contact once the insertion tool has been removed. Remove the contact and start over with the contact wire barrel properly seated in the tool. Failure to follow this procedure may cause damage to the connector, contact or tool.

50. INSERTION FRONT RELEASE. For front release connectors, the contact or wired contacts are inserted from the rear of the connector using the specified tool, until the contact seats (Figure 18 for individual contact retention systems, and Figure 19 for gang contact retention systems). An audible click may be heard when the contact is properly seated in an individual contact retention system.

51. REMOVAL FRONT RELEASE. To remove the contact or wired contacts, the tool is inserted into the front (mating face) of the connector to release the retaining clips and push the contact from the rear of the connector (Figure 20 for individual contact retention systems, and Figure 21 for gang retention systems).

52. REAR RELEASE CONNECTORS. Do not attempt to reseat a contact once the insertion tool has been removed. Remove the contact and start over with the contact wire barrel properly seated in the tool. Failure to follow this procedure may cause damage to the connector, contact or tool.

53. INSERTION REAR RELEASE. For rear release connectors, the contacts or wired contacts are inserted, using the specified tool, from the rear of the connector until the contact seats (Figure 22). An audible click may be heard when the contact is properly seated.

54. REMOVAL REAR RELEASE (WIRED). Removal of wired contacts is accomplished by inserting the specified tool into tile rear of the connector to release tile retaining, clip. When released, tile wire and tool are Grasped together and pulled from the connector cavity with the contact intact (Figure 23).

55. REMOVAL REAR RELEASE (UNWIRED). Removal of unwired contacts is accomplished by inserting the specified tool into the rear of the connector until the plunger locates the end of the contact wire barrel. The tool body is then pushed in until the probe (plastic tip) grasps the contact wire barrel and releases the retaining clips. With the plunger retracted, the tool with the contact intact is pulled from the connector (Figure 24).

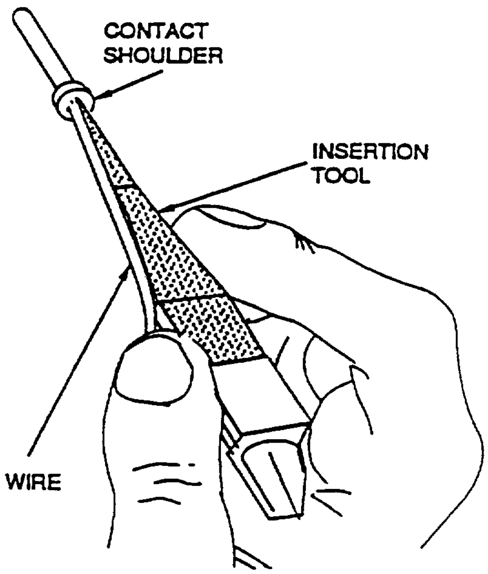
56. BROKEN WIRE CONTACT REMOVAL. An unwired contact removal tool should not be used to remove a contact with a broken wire. Select the appropriate removal tool and follow the procedure outlined in Figure 25.

A. REMOVE SEALING PLUG AND/OR CONTACT FROM CONTACT CAVITY.

B. ENSURE WIRE OR CABLE ON CONTACT IS ROUTED THROUGH BACKSHELL.

C. SELECT CORRECT INSERTION TOOL (PARAGRAPH 46).

D. PLACE WIRE AND CONTACT ASSEMBLY INTO TIP OF INSERTION TOOL. ENSURE TOOL TIP IS OVER CONTACT CONDUCTOR BARREL AND BUTTED AGAINST CONTACT SHOULDER.



E. INSERT TIP CONTACT INTO CAVITY. START CONTACT INSERTION NEAR CONNECTOR CENTER CAVITIES AND WORK OUTWARD.

F. AXIALLY ALIGN CONTACT WITH CONTACT CAVITY.

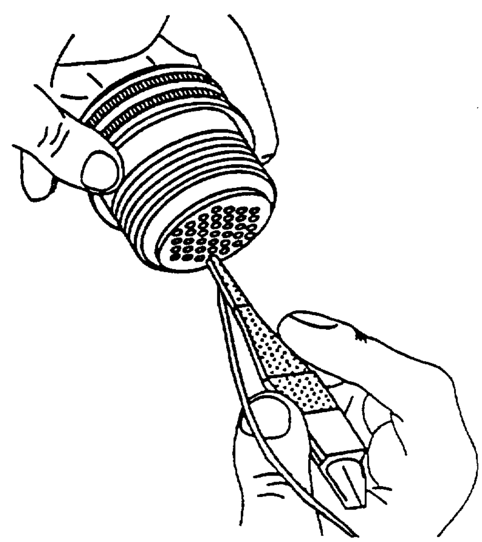
G. WITH FIRM EVEN PRESSURE, PRESS TOOL AGAINST CONTACT SHOULDER AND SEAT CONTACT INTO CAVITY. A SLIGHT CLICK MAY BE HEARD AS RETENTION TINES SNAP INTO PLACE BEHIND CONTACT SHOULDER.

H. PULL TOOL STRAIGHT OUT OF CONTACT CAVITY. REMOVE TOOL FROM WIRE. PULL BACK LIGHTLY ON WIRE TO ENSURE CONTACT IS PROPERLY SEATED.

I. SEAL CONNECTOR AS REQUIRED (WP02500) AND INSTALL BACKSHELL.

J. FILL ALL UNUSED CAVITIES WITH UNCRIMPED CONTACTS.

K. INSERT SEALING PLUG, KNOB END FIRST, UNTIL BOTTOMED IN CONTACT CAVITY. FILL ALL CAVITIES THAT HAVE UNCRIMPED CONTACTS.

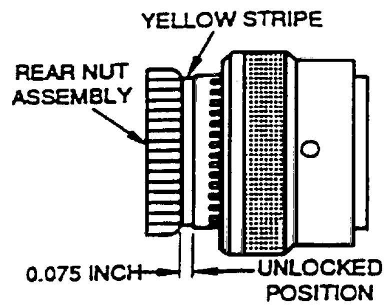


02203601

Figure 18. Contact Insertion, Front (Individual) Release

CONTACT INSERTION

A. IF NOT PREVIOUSLY REMOVED, REMOVE BACKSHELL FROM REAR OF CONNECTOR. TURN REAR NUT ASSEMBLY COUNTERCLOCKWISE UNTIL SLIGHT RESISTANCE IS FELT (2 1/2 TURNS OR 5/64 INCH SPACE, MINIMUM). YELLOW STRIPE WILL BE VISIBLE.



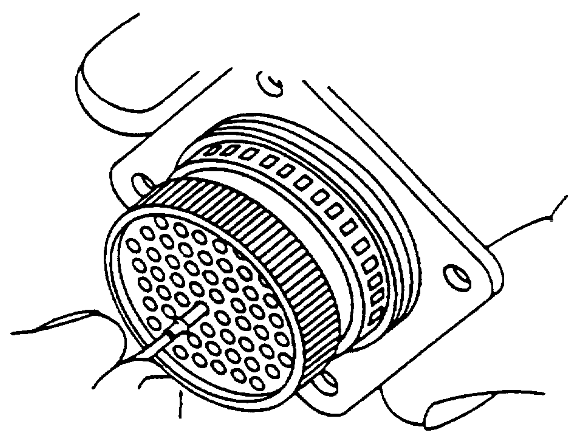
B. REMOVE SEALING PLUG AND/OR CONTACT FROM CONTACT CAVITY.

C. ROUTE WIRE OR CABLE THROUGH BACKSHELL.

NOTE

START CONTACT INSERTION NEAR CENTER CONTACT CAVITIES AND WORK OUTWARD.

D. HAND INSERT CONTACT INTO CORRESPONDING HOLE UNTIL ONLY CRIMP BARREL PORTION OF CONTACT EXTENDS FROM GROMMET.



E. SELECT CORRECT INSERTION TOOL (PARAGRAPH 46).

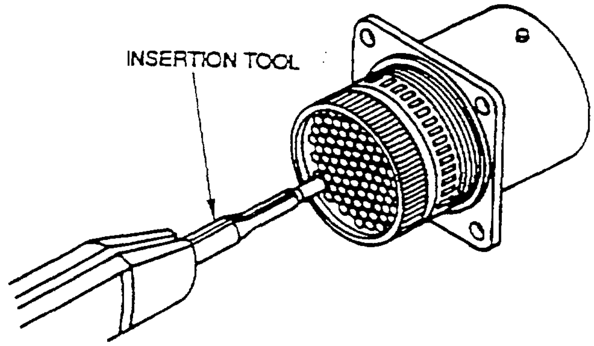
02203701

Figure 19. Contact Insertion, Front (Gang) Release (Sheet 1 of 2)

NOTE

TAKE CARE NOT TO DISTURB OR DISLODGE SEATED CONTACTS BY PUTTING STRAIN ON WIRES OR CABLE WHILE INSERTING OTHER CONTACTS.

F. POSITION INSERTION TOOL AROUND REAR OF CONTACT. CONTACT AND TOOL SHOULD BE ALIGNED WITHIN HOLE AS STRAIGHT AS POSSIBLE TO AVOID DAMAGE TO WIRE SEALING GROMMET. PRESS INSERTION TOOL AGAINST CONTACT SHOULDER FIRMLY TO SEAT CONTACT IN CAVITY.



G. REMOVE INSERTION TOOL BY SLIDING BACK ALONG WIRE INSULATION UNTIL IT CLEARS GROMMET.

H. SEAL CONNECTOR AS REQUIRED (WP 026 00) AND INSTALL BACKSHELL.

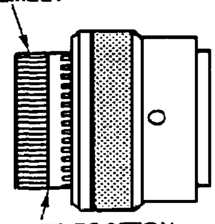
SEALING PLUG INSERTION

A. FILL ALL UNUSED CAVITIES WITH UNCRIMPED CONTACTS.

B. SELECT SEALING PLUG ACCORDING TO SIZE OF CONTACT (TABLE 1).

C. INSERT SEALING PLUG KNOB END FIRST UNTIL BOTTOMED IN CONTACT CAVITY. FILL ALL CAVITIES THAT HAVE UNCRIMPED CONTACTS.

D. AFTER ALL CONTACTS AND SEALING PLUGS ARE INSERTED, ROTATE REAR NUT ASSEMBLY BY HAND UNTIL NUT IS FULLY BOTTOMED AGAINST REAR SHELL.



02203702

Figure 19. Contact Insertion, Front (Gang) Release (Sheet 2)

CRIMP FRONT RELEASE CONTACTS

A. SELECT CORRECT REMOVAL TOOL (PARAGRAPH 46).

B. IF CONTACT IS UNWIRED, REMOVE SEALING PLUG FROM CAVITY OF CONTACT TO BE REMOVED.

C. WORKING FROM THE FRONT (MATING END) OF CONNECTOR, SLIDE HOLLOW END OF REMOVAL TOOL OVER CONTACT.

D. HOLDING REMOVAL TOOL AT RIGHT ANGLE TO FRONT INSERT FACE, PUSH TOOL STRAIGHT TOWARD REAR OF CONNECTOR, FIRMLY PRESSING TOOL TO POSITIVE STOP WHEN TOOL BOTTOMS IN INSERT CAVITY.

E. MAINTAIN PRESSURE ON TOOL HANDLE AND SLIDE COLLAR OF TOOL FORWARD UNTIL IT STOPS. CONTACT WILL BE PARTIALLY EJECTED FROM REAR OF CONNECTOR INSERT.

F. REMOVE TOOL BY PULLING STRAIGHT BACK TO CLEAR CONNECTOR INSERT FACE. REMOVE CONTACT OUT REAR OF CONNECTOR BY PULLING LIGHTLY ON WIRE OR USING A MATING CONTACT TO PUSH OUT RELEASED CONTACT.

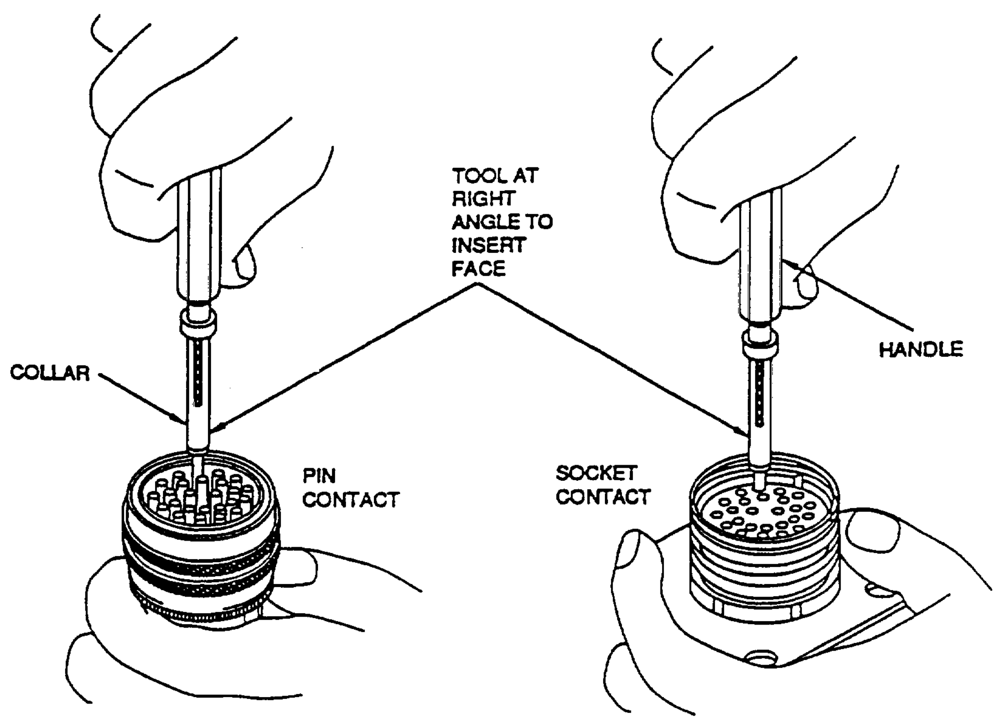


Figure 20. Contact Removal, Front (Individual) Release

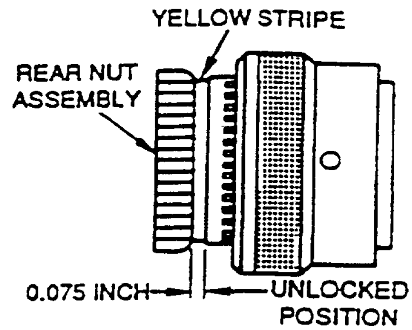
CONTACT REMOVAL

CAUTION

INSPECT TOOL TIPS FOR DAMAGE OR DISTORTION BEFORE USE.

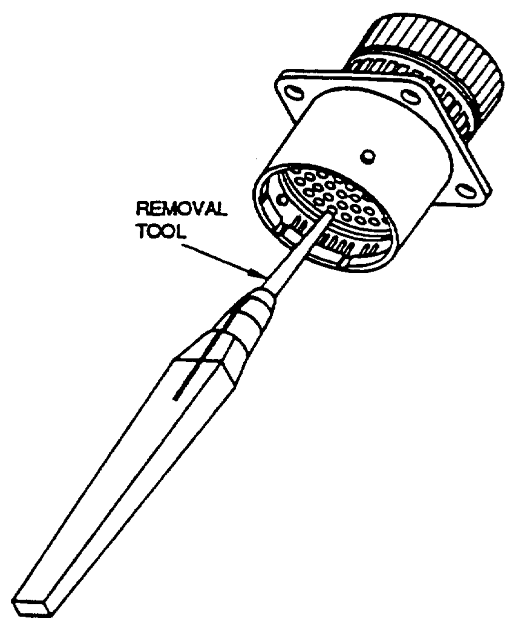
A. IF NOT PREVIOUSLY REMOVED, REMOVE BACKSHELL FROM REAR OF CONNECTOR (WP 025 00). TURN REAR NUT ASSEMBLY COUNTER-CLOCKWISE UNTIL SLIGHT RESISTANCE IS FELT (2 1/2 TURNS OR 5/64 INCH SPACE, MINIMUM). YELLOW STRIPE WILL BE VISIBLE.

B. SELECT REMOVAL TOOL (PARAGRAPH 46).



C. IF REQUIRED, REMOVE SEALING PLUG.

D. TO REMOVE CONTACTS. INSERT TOOL THROUGH INSERT AND INTO SOCKET CONTACT.



022039

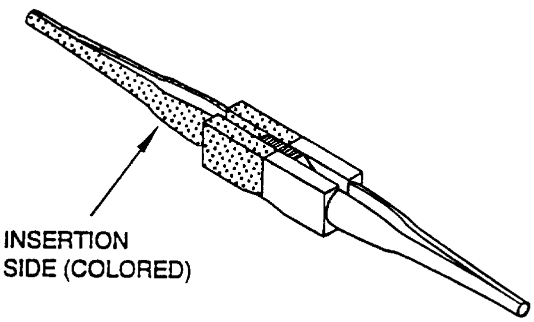
Figure 21. Contact Removal, Front (Gang) Release

CONTACT INSERTION.

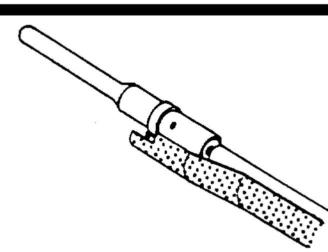
A. REMOVE SEALING PLUG AND/OR CONTACT FROM CONTACT CAVITY.

B. ASSURE WIRE OR CABLE ON CONTACT IS ROUTED THROUGH BACKSHELL.

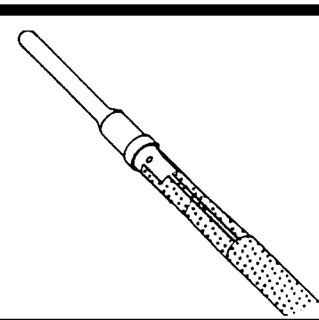
C. SELECT INSERTION TOOL (PARAGRAPH 46).



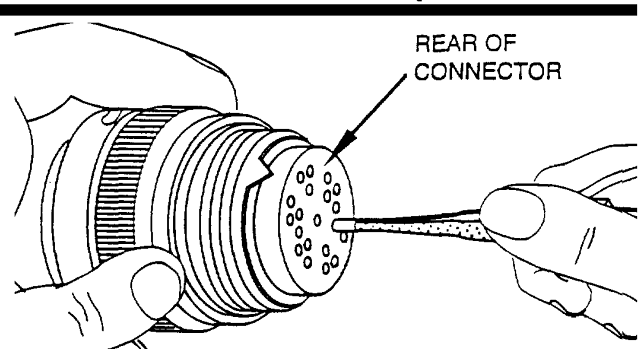
D. HOLD INSERTION HALF OF TOOL BETWEEN THUMB AND FOREFINGER AND LAY WIRE AGAINST SLOT OF TOOL, THEN SNAP WIRE INTO SLOT.



E. AFTER WIRE SNAPS INTO TOOL, SEAT RETENTION SHOULDER AGAINST TIP OF TOOL.



F. HOLDING CONNECTOR WITH REAR GROMMET FACING YOU, SLOWLY PUSH CONTACT STRAIGHT INTO GROMMET CAVITY. DO NOT TWIST TOOL.



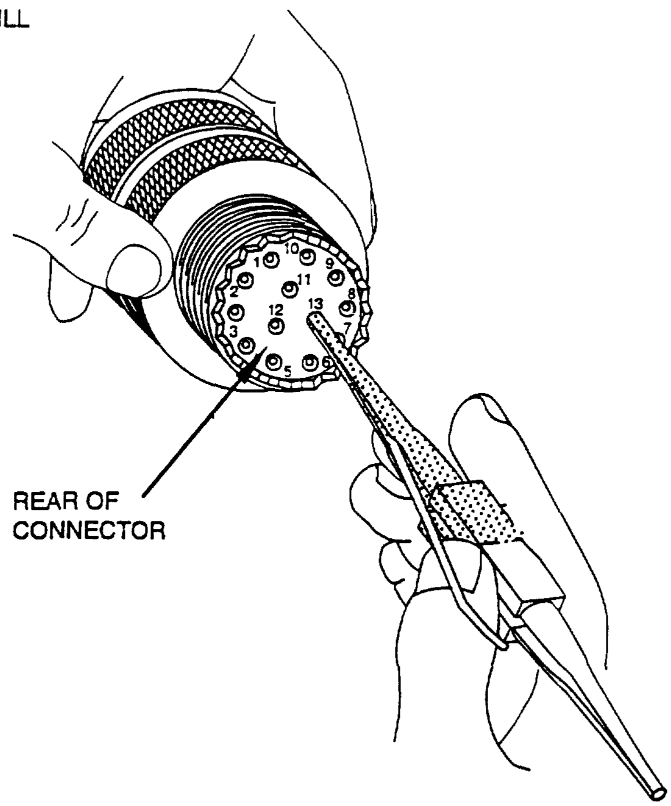
02204001

Figure 22. Contact Insertion, Rear Release (Sheet 1 of 2)

G. KEEP CONTACT AND TOOL CENTERED IN HOLE, APPLY SMOOTH EVEN PUSHING PRESSURE UNTIL CONTACT IS SEATED. A FAINT AUDIBLE SNAP WILL BE HEARD WHEN CONTACT SEATS.

H. WITHDRAW TOOL ONLY AT RIGHT ANGLE TO GROMMET FACE UNTIL COMPLETELY FREE. LIGHTLY PULL ON WIRE TO ENSURE CONTACT IS SECURELY LOCKED IN PLACE.

I. INSERT ALL WIRED CONTACTS FIRST, INSTALL UNWIRED CONTACTS IN REMAINING HOLES.



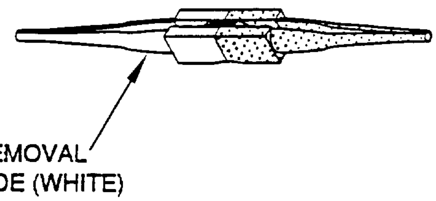
J. INSERT SEALING PLUG BEHIND EACH UNWIRED CONTACT. KNOB END FIRST PUSH SEALING PLUG UNTIL SEATED.

02204002

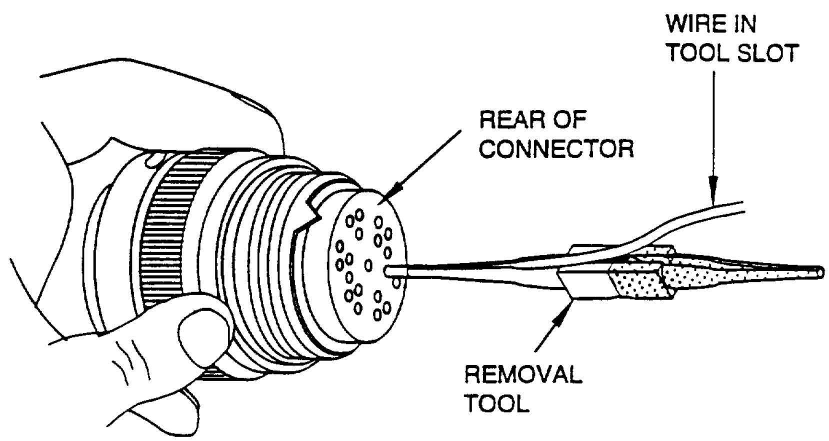
Figure 22. Contact Insertion, Rear Release (Sheet 2)

WIRED CONTACT REMOVAL.

A. SELECT REMOVAL TOOL (PARAGRAPH 46).



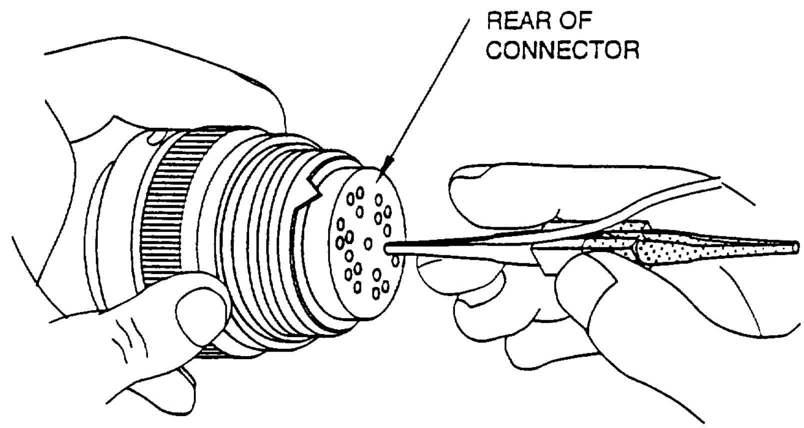
B. WORKING FROM WIRE SIDE OF CONNECTOR, LAY WIRE OF CONTACT ALONG SLOT OF REMOVAL TOOL LEAVING ABOUT 1/2 INCH FROM END OF TOOL TO REAR OF CONNECTOR. SQUEEZE WIRE FIRMLY INTO TOOL BETWEEN THUMB AND FOREFINGER ABOUT 1/2 INCH FROM TIP AND QUICKLY PULL TOOL AWAY FROM CONNECTOR SNAPPING WIRE INTO SLOT.



02204101

Figure 23. Contact Removal, Rear Release (Sheet 1 of 2)

C. SLIDE REMOVAL TOOL DOWN WIRE AND INTO REAR OF CAVITY AND SLOWLY INTO CONNECTOR UNTIL POSITIVE RESISTANCE IS FELT. AT THIS TIME, CONTACT RETAINING MECHANISM IS IN UNLOCKED POSITION.



D. PRESS WIRE OF CONTACT AGAINST SERRATIONS OF PLASTIC TOOL AND PULL BOTH TOOL AND CONTACT/WIRE ASSEMBLY OUT OF CONNECTOR.

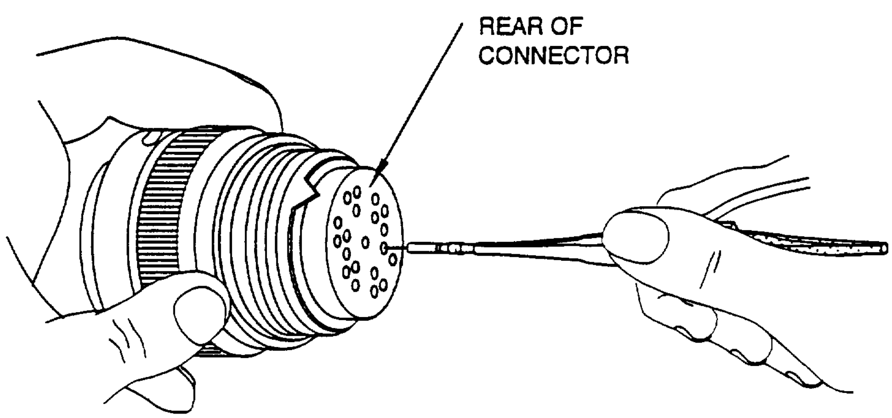
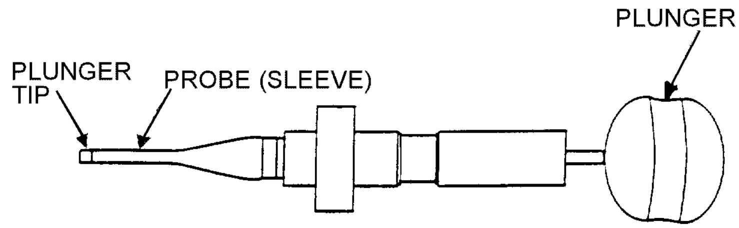


Figure 23. Contact Removal, Rear Release (Sheet 2)

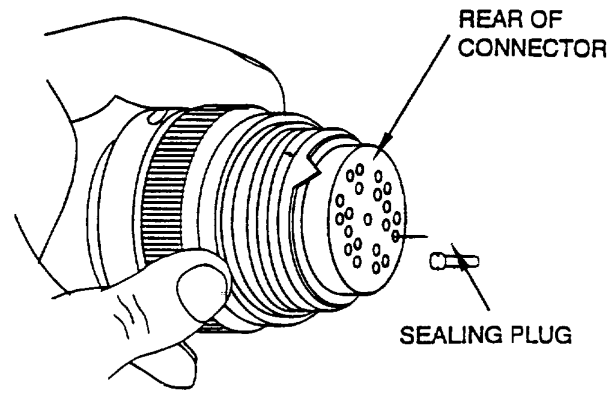
022042

UNWIRED CONTACT REMOVAL

A. SELECT UNWIRED CONTACT REMOVAL TOOL (PARAGRAPH 46).



B. WITH REAR OF CONNECTOR EXPOSED, REMOVE SEALING PLUG FROM INSERT CAVITY OF CONTACT TO BE REMOVED.



C. PRESS AND HOLD TOOL PLUNGER UNTIL TIP OF TOOL IS EXPOSED.

D. AXIALLY ALIGN REMOVAL TOOL WITH CONTACT TO BE REMOVED.

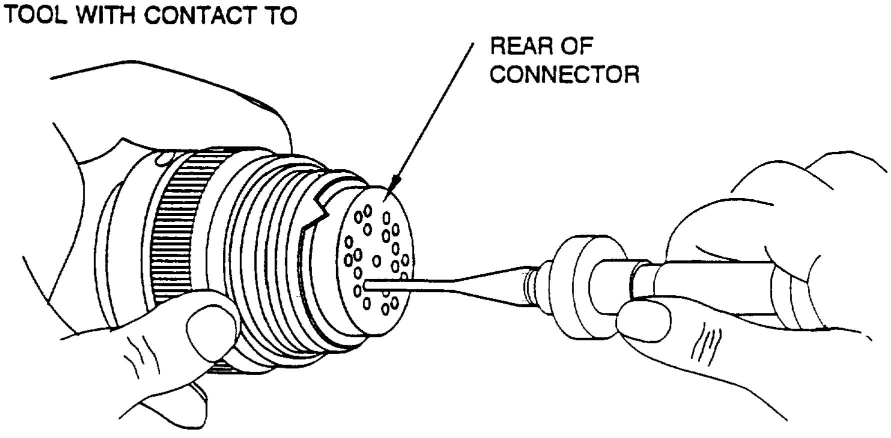
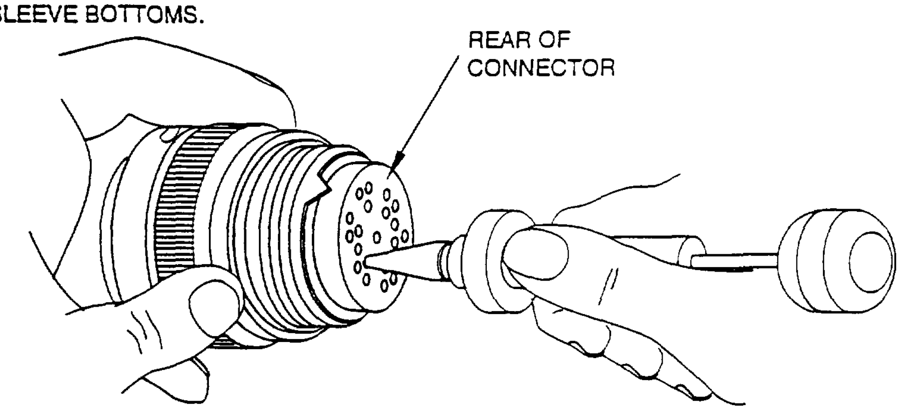


Figure 24. Contact Removal, Unwired Contact, Rear Release (Sheet 1 of 2)

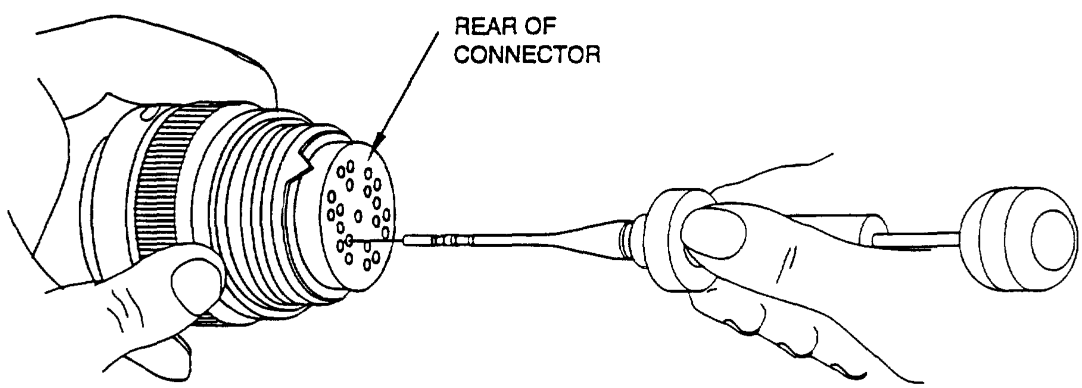
02204201

E. INSERT PLUNGER TIP INTO CONTACT CAVITY TO BUTT CONTACT WIRE BARREL, THEN SLIDE REMOVAL TOOL SLEEVE OVER CONTACT AND EXERT PRESSURE UNTIL SLEEVE BOTTOMS.



F. REMOVE TOOL AND UNLOCKED CONTACT FROM CONNECTOR BY WITHDRAWING TOOL FROM CONNECTOR.

G. REMOVE CONTACT FROM REMOVAL TOOL BY PRESSING PLUNGER.

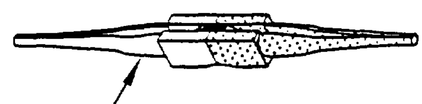


02204202

Figure 24. Contact Removal, Unwired Contact, Rear Release (Sheet 2)

BROKEN WIRE CONTACT REMOVAL.

A. SELECT REMOVAL TOOL (PARAGRAPH 46).



NOTE

DIMENSIONS IN THIS PROCEDURE ARE BASED ON A SIZE 22 CONTACT.

B. INSERT REMOVAL TOOL 1/8 INCH INTO CAVITY FROM REAR OF CONNECTOR. AT RIGHT ANGLE TO GROMMET FACE.

CAUTION

WIRE STRANDS MAY BE ENCOUNTERED AT ANY POINT UP TO 5/16 INCH OF TOOL INSERTION. FORCING TOOL INTO CAVITY IF WIRE STRANDS ARE ENCOUNTERED MAY CAUSE DAMAGE TO REMOVAL TOOL AND/OR CONNECTOR. WITHDRAW REMOVAL TOOL WHENEVER IT CANNOT BE ADVANCED AND INSPECT TOOL TIP FOR NICKS, CRACKS, MUSHROOMING, AND OTHER DAMAGE THAT WILL PREVENT PROPER FUNCTIONING.

C. GENTLY INSERT REMOVAL TOOL INTO CAVITY ABOUT 1/16 INCH UNITS, RELEASING TOOL AFTER EACH UNIT IF RESISTANCE IS FELT.

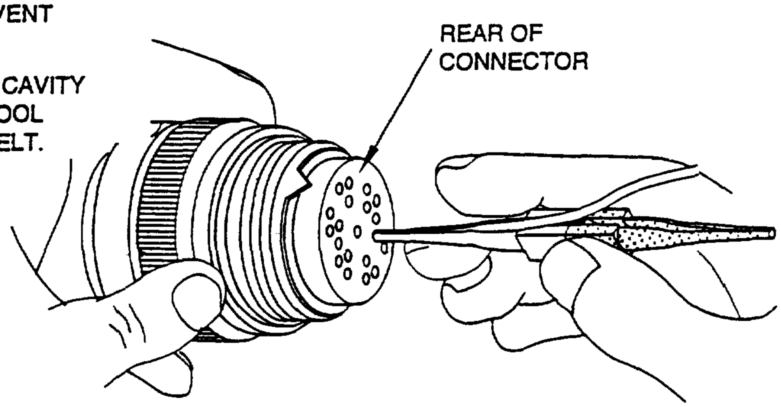
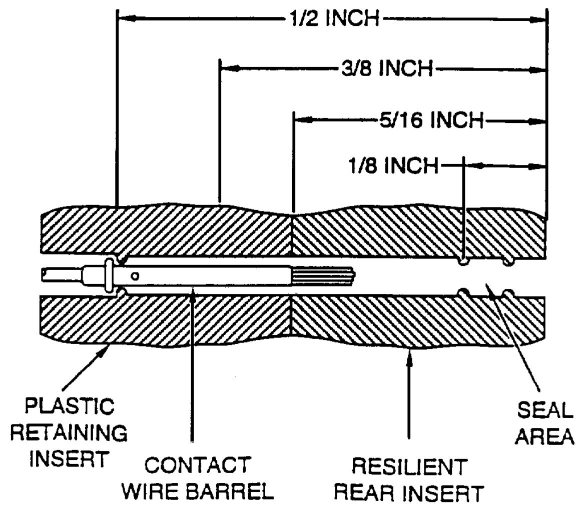


Figure 25. Contact Removal, Broken Wire Contact, Rear Release (Sheet 1 of 2)

NOTE

ROTATING REMOVAL TOOL WORKS SPLAYED WIRE STRANDS INTO SLOT OF TOOL, ALLOWING TOOL TO PASS.

D. IF RESISTANCE IS FELT BEFORE REMOVAL TOOL REACHES BACK OF CONTACT, WITHDRAW TOOL SLIGHTLY, ROTATE 1/6 OF A TURN AND REINSERT TOOL. REPEAT ROTATING AND INSERTION PROCEDURE UNTIL TOOL PASSES WITH MINIMUM ADDITIONAL FORCE TO 5/16 INCH DEPTH (BACK END OF CONTACT).



E. AT REAR OF CONTACT, TOOL MAY BE BLOCKED BY PLASTIC INSERT OR ADDITIONAL STRANDS OF BROKEN WIRES. WIGGLE REMOVAL TOOL GENTLY TO AID INSERTION TOOL INTO CONTACT CAVITY AND OVER CONTACT. ADDITIONAL ROTATION MAY BE REQUIRED IF BROKEN STRANDS ARE ENCOUNTERED.

F. CONTINUE INSERTION OF TOOL UNTIL STOP IS FELT ABOUT 1/2 INCH DEPTH.

G. EXERT AXIAL PRESSURE ON ENGAGING END OF CONTACT USING APPROPRIATE SIZE PIN OR SOCKET CONTACT. IF CONTACT DOES NOT MOVE, SEAT REMOVAL TOOL MORE FIRMLY AND PUSH CONTACT COMPLETELY OUT REAR OF CONNECTOR BEFORE DISENGAGING REMOVAL TOOL.

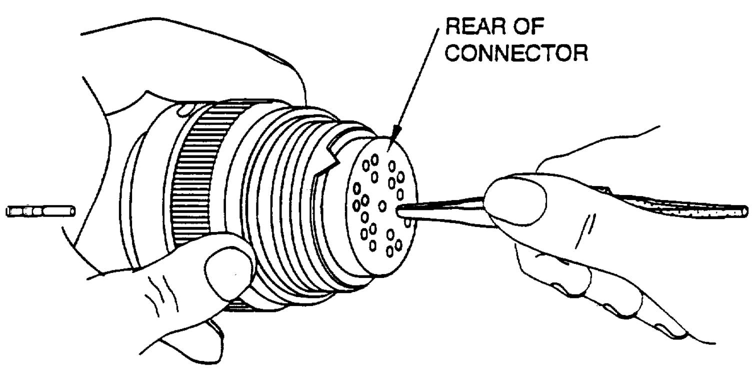


Figure 25. Contact Removal, Broken Wire Contact, Rear Release (Sheet 2)

RADIO FREQUENCY CONNECTORS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This work package (WP) covers coaxial and triaxial connectors commonly utilized for both shielded wire and Radio Frequency (RF) applications. This WP describes these connectors, and their application.

3. GENERAL.

WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. Consult applicable health and environmental regulations regarding its use, handling and disposition.

4. **APPLICATION.** Coaxial connectors are applied, in most cases, to circuits carrying RF current. They are also used in many systems where a shielding function is required for low level signal circuits or for audio circuits.

5. **SHIELDING FUNCTION.** The shielding function is important for protecting the center conductor from external electrical fields or the protection of nearby circuits from the influences of the fields surrounding the center conductor. Refer to EMI and EMV (WP 006 00).

6. **DESIGN.** True RF coaxial connectors are designed with a specific relationship between the outside diameter of the single inner contact and the inside diameter of the outer sleeve. This relationship determines the characteristic impedance of the connector (WP 006 00). These connectors have been proportioned internally so that they will match particular cable impedance values so that the circuit will not see any impedance mismatch (WP 006 00).

7. REQUIREMENTS.

CAUTION

Nickel plated connectors may cause Passive Intermodulation (PIM) problems.

8. Coaxial connectors shall be suitable for the particular application and shall be covered by Military Specifications to include:

a. MIL-C-3607 Pulse Series.

b. MIL-C-3650 LC Series.

c. MIL-C-3655 Twin Series.

d. MIL-C-25516 Environment Resisting Series.

e. MIL-C-26637 LT Series.

f. MIL-PRF-39012 General Specification for:

(1) SMA Series.

(2) SMC Series.

(3) BNC Series.

(4) TNC Series.

(5) N Series.

(6) SMB Series.

(7) C Series.

(8) SC Series.

(9) QSC Series.

(10) QNC Series.

(11) MHV Series.

(12) SHV Series.

(13) EIA Series.

g. MIL-PRF-49142 Triaxial Series.

NOTE

Refer to NAVAIR 01–1A–505–2, WP 012 02 for detailed information on MIL–PRF–39012 connectors and accessories.

9. Only category D and C connectors of MIL-PRF-39012 will be used for all applications using braided coaxial cables, and category E connectors of MIL-PRF-39012 will be used for applications using semi-rigid coaxial cable. When connector parameters beyond the scope of applicable military specifications are required, non-standard commercial type connectors may be utilized providing the general requirements to the specification are met and approved.

10. DESCRIPTION.

11. RF coaxial connectors are available in plug and receptacle types. Plugs may be straight, angle, or flange mount (Figure 1), and receptacles may be straight, angle, flange or jamnut mount (Figure 2).

12. SPECIFICATIONS.

13. **MIL-C-3607 CONNECTORS, COAXIAL, RADIO FREQUENCY, SERIES PULSE, GENERAL SPECIFICATION FOR.** This specification covers the general requirements for weatherproof, high voltage, series pulse RF coaxial connectors.

14. **Description.** These connectors are designed for use with rubber dielectric pulse cables, but may also be used with equivalent size cables of other construction where high voltage is not required. Ceramic or rubber inserts are utilized depending upon voltage requirements. Peak voltage with ceramic inserts is 18,000 volts and 9000 volts with rubber inserts. Connectors are intended for frequencies up to 100 MHz with a maximum operating temperature at 257°(125°C). These connectors are covered by applicable Military Specifications (Table 1). Typical connectors are illustrated (Figure 3).

15. **Selection.** The selection of connectors is determined by the system requirements of voltage, frequency, and cable selected. Consult applicable drawings and diagrams for selection. The connector and its parameters are listed (Table 2).

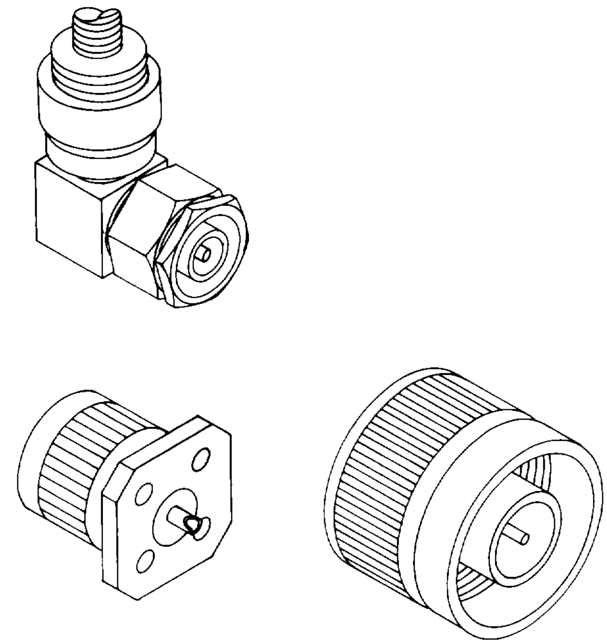


Figure 1. Typical Plug Styles

16. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

17. **MIL-C-3650 CONNECTORS, COAXIAL, RADIO FREQUENCY, SERIES LC.** This specification covers weatherproof, series LC, Radio Frequency coaxial connectors having a nominal impedance of 50 ohms.

18. **Description.** These connectors have threaded couplings for use with large size coaxial cables. They are for use up to 1000 MHz with a maximum operating temperature of 257°F (125°C). These connectors are covered by applicable military standards (Table 3). Typical connectors are illustrated (Figure 4).

19. **Selection.** The selection of connectors is determined by the system requirements of voltage, frequency, and cable selected. Consult applicable drawings and diagrams for selection. The connector and its parameters are shown (Table 4).

20. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

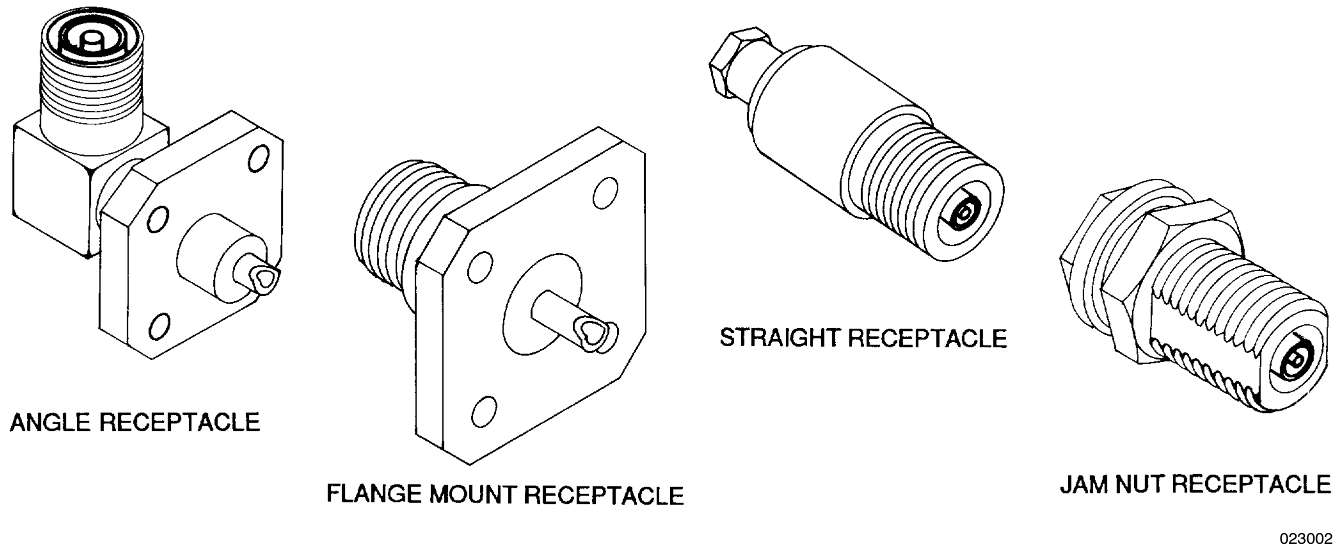


Figure 2. Typical Receptacle Styles

Table 1. Applicable Military Specifications

Specification No. MIL-C-3607/	Part No.	Description
1	UG-34/U	Connector Plug
2	UG-36/U	Connector Plug
3	UG-37/A/U	Connector Receptacle
4	UG-38A/U	Connector Receptacle Pressurized
5	UG-62A/U	Connector Receptacle Pressurized
6	UG-174/U	Connector Plug
7	UG-180A/U	Connector Plug
8	UG-181A/U	Connector Receptacle
9	UG-182A/U	Connector Receptacle
10	UG-222B/U	Connector Adapter
11	UG-264/U	Connector Receptacle
12	UG-336A/U	Connector Adapter
13	UG-350/U	Connector Receptacle
14	UG-1110/U	Connector Adapter
15	UG-1141/U	Connector Receptacle

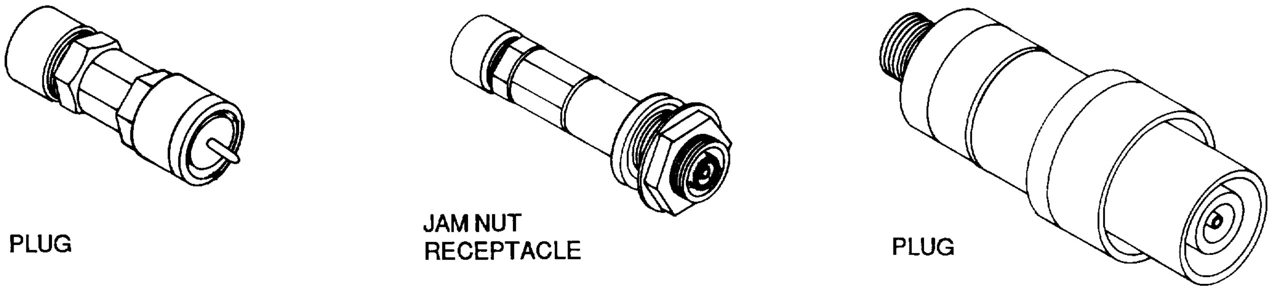


Figure 3. Typical Pulse Series Connectors

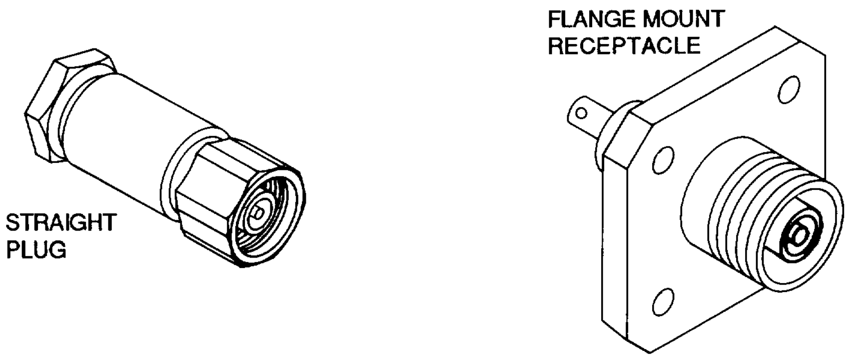


Figure 4. Typical LC Series Connectors

Table 2. MIL-C-3607 Selection

Part No.	Voltage	Connection or Use
UG-34/U	9000V	RF Pulse Cable RG-25/U
UG-36/U	18000V	RF Pulse Cable RG-27/U
UG-37A/U	18000V	RF Pulse Cables
UG-38A/U	9000V	Pressurized Flange Six-Hole Mount RF Pulse Cables
UG-62A/U	9000V	RF Pulse Cables
UG-174/U	18000V	RF Pulse Cable RG28/U
UG-180A/U	9000V	RF Pulse Cables RG-25/U, 26/U, 64/U, 88/U
UG-181A/U	9000V	RF Pulse Cables RG-25/U, 26/U, 64/U, 88/U
UG-182A/U	9000V	RF Pulse Cables
UG-222B/U	18000V	Plug UG-36/U and UG-174/U
UG-264/U	9000V	RF Pulse Cables
UG-336A/U	9000V	Plug UG-180A/U Receptacle UG-181A/U
UG-350/U	9000V	RF Pulse Cables
UG-1110/U	18000V	Plug UG-34/U and UG-174/U
UG-1141/U	18000V	RF Pulse Cables

21. **MIL-C-3655 CONNECTORS, PLUG AND RECEPTACLE, ELECTRICAL, (COAXIAL, SERIES TWIN), AND ASSOCIATED FITTINGS, GENERAL SPECIFICATION FOR.** This specification covers the general requirements for series twin coaxial connectors and associated fittings.

22. **Description.** These connectors are weatherproof with one pin and one socket contact. These connectors are covered by applicable military specifications (Table 5). Typical twin series connectors are illustrated (Figure 5).

23. **Selection.** The selection of connectors is determined by the system requirements of voltage, frequency, and cable selected. Consult applicable drawings and diagrams for selection. The connector and its parameters are shown (Table 6).

24. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

25. **MIL-C-25516 CONNECTORS, ELECTRICAL, MINIATURE, COAXIAL, ENVIRONMENT RESISTANT TYPE, GENERAL SPECIFICATION FOR.** This specification covers a series of miniature, moisture proof connectors suitable for operation with shielded and unshielded cable up to 750 volts rms under severe environmental conditions.

Table 3. Applicable Military Standards

MS No.	Part No.	Nomenclature
MS91596	UG-216B/U	Adapter Connector
MS91604	UG-154A/U	Connector Plug
MS91610	UG-352B/U	Connector Receptacle
MS91614	UG-155B/U	Adapter Connector
MS91616	UG-157B/U	Adapter Connector
MS91617	UG-156A/U	Connector Plug
MS91618	UG-287B/U	Adapter Connector
MS91619	UG-219B/U	Adapter Connector
MS91620	UG-208B/U	Adapter Connector

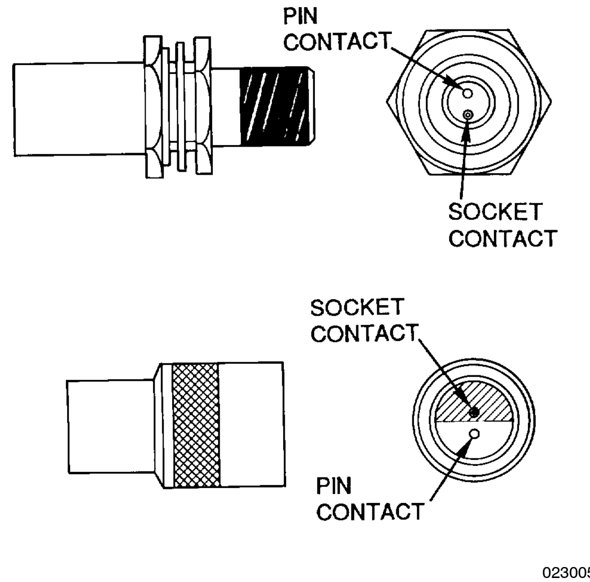


Figure 5. Typical Twin Series Connectors

26. **Description.** These connectors are bayonet coupled miniature coaxial. They are intended primarily for use in capacitance-type fuel quantity measuring systems at lower frequencies. These connectors are not intended for RF applications (Figure 6).

27. **Classification.** The connectors are classified by series, class, and type (Table 7).

a. Series 1. These connectors are plugs and receptacles with cable termination.

b. Series II. These connectors are plugs and receptacles with permanent crimp contacts using a standard MIL-C-22520 tool (WP 013 00).

c. Series III. These are adapters of all types.

d. Series IV. These connectors are plugs and receptacles with solder termination.

e. Class G. These connectors are for general purpose.

f. Class H. These connectors are hermetically sealed with cable termination.

g. Class Y. These are hermetic adapters.

h. Type 1. These connectors have shield termination for a continuous circuit, and grounded.

i. Type 2. These connectors have shield termination for a continuous circuit with isolated ground.

j. Type 3. These connectors have shield termination with interrupted ground.

k. Type 4. These connectors have no shield termination.

l. Type 5. These connectors are Class Y with grounded outer circuit.

m. Type 6. These connectors are Class Y with ungrounded outer circuit.

28. **Polarity.** The mating interface of these connectors are polarized. Where connector configurations are varied, such as mounting features or solder terminations, the first digit may be changed to show the variation (Figure 7).

29. **Cable Size.** These connectors shall be capable of terminating cables by size (Table 8).

30. **Part Number.** The part number consists of the specification sheet, a sequentially assigned dash number to designate polarity, and cable size designation (Figure 8).

31. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

32. **MIL-C-26637 CONNECTORS, COAXIAL, RADIO FREQUENCY, SERIES LT.** This specification covers RF coaxial weatherproof connectors of the LT series having nominal characteristic impedance of 50 ohms.

33. **Description.** These connectors have threaded coupling and appear to be similar to the LC series, but they are not interchangeable. Connectors are used in airborne RF applications from 30 to 5000 MHz, and are designed for large size cables (Figure 9).

34. **Selection.** The selection of connectors is determined by the system requirements. Consult applicable drawings and diagrams to determine the required part. The applicable military specifications show the connector parameters (Table 9).

Table 4. MIL-C-3650 Selection

Part Number	Voltage	Frequency	Connection
UG-216B/U	5000	1000 MHz	Plug UG-154A/U Receptacle UG-352B/U
UG-154A/U	5000 See NOTE	1000 MHz	RF Cable RG-17/U and RG-18/U
UG-352B/U	5000	1000 MHz	Adapter UG-216B/U Pressurized
UG-155B/U	10000	1000 MHz	Plug UG-154A/U Adapter UG-208B/U
UG-157B/U	10000	1000 MHz	Adapter UG-219B/U
UG-156A/U	10000	1000 MHz	RF Cable RG-19/U and RG-20/U
UG-287B/U	5000	1000 MHz	Plug UG-154A/U Adapter UG-216B/U
UG-219 B/U	10000	1000 MHz	Plug UG-156A/U Adapter UG-157B/U
UG-208B/U	10000	1000 MHz	Plug UG-154A/U Adapter UG-155B/U
NOTE: 10,000 V Operation Tool TL-328/U required to counterbore cable.			

Table 5. Applicable Military Specifications

Specification No. MIL-C-3655/	Part No. M3655/	Nomenclature
13A	13-0001	Connector Receptacle
14A	14-0001	Connector Plug
15A	15-0001	Connector Plug
16A	16-0001	Connector Receptacle
17	17-0001	Connector Plug Right Angle
18	18-0001	Connector Plug
19	19-0001	Connector Plug
20	20-0001	Connector Plug
21	21-0001	Connector Plug
22	22-0001	Connector Plug Bulkhead
23	23-0001	Connector Plug Bulkhead

35. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

36. **MIL-PRF-49142 CONNECTORS, TRIAXIAL, RADIO FREQUENCY, GENERAL SPECIFICATION FOR.** This specification covers connectors used with triaxial cable in RF applications and serial digital transfer.

37. **Description.** These connectors are similar to other coaxial connectors except for the provision for mating to a third conductor (Figure 10). The applicable military standards with descriptions are shown (Table 10).

38. **Classification.** These connectors are of the following two classes.

a. Class 1. These connectors are intended to provide superior RF performance at specified frequencies for which RF characteristics are completely defined.

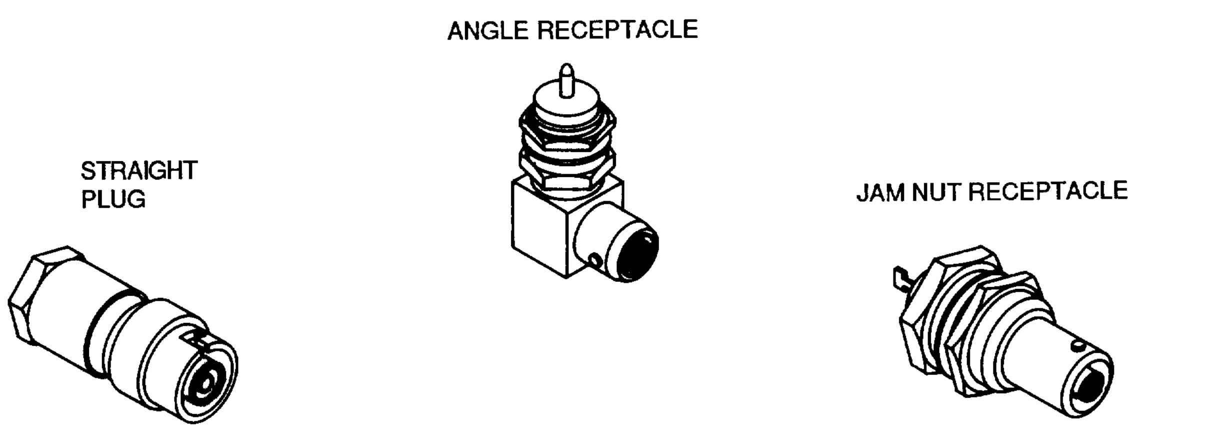
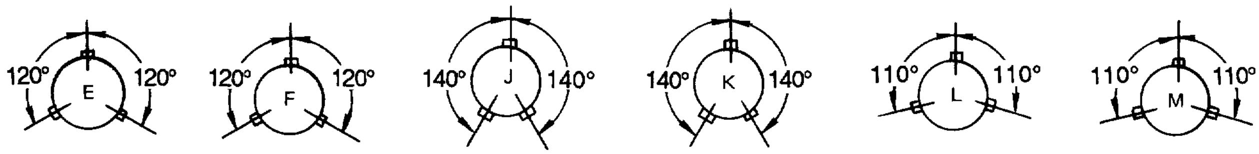


Figure 6. Typical M25516 Series Connectors



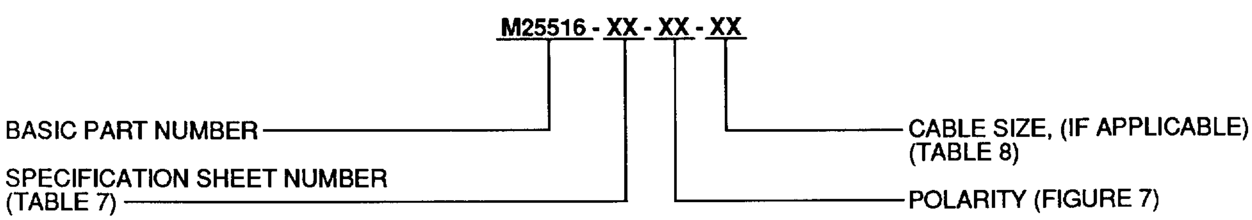
Dash Number	Polarity
03	E
04	F
05	J
06	K
07	L
08	M
13	E
14	F
15	J
16	K
17	L
18	M
23	E
24	F
25	J
26	K
27	L
28	M
33	E
34	F

Dash Number	Polarity
35	J
36	K
37	L
38	M
43	E
44	F
45	J
46	K
47	L
48	M
53	E
54	F
55	J
56	K
57	L
58	M
63	E
64	F
65	J
66	K

Dash Number	Polarity
67	L
68	M
73	E
74	F
75	J
76	K
77	L
78	M
83	E
84	F
85	J
86	K
87	L
88	M
93	E
94	F
95	J
96	K
97	L
98	M

023007

Figure 7. Polarity Coding



023008

Figure 8. M25516 Part Number Breakdown

Table 6. MIL-C-3655 Selection

Part No. M3665/	Impedance	Voltage	Frequency	Connection or Use
13-0001	78 ohms	500V	500 MHz	M3665/14-0001 M17/45-RG-108
14-0001	79 ohms	500V	500 MHz	M3665/13-0001 M17/45-RG-108
15-0001	78 ohms	500V	500 MHz	M3665/16-0001 M17/45-RG-108
16-0001	78 ohms	500V	500 MHz	M3665/15-0001 M17/45-RG-108
17-0001	78 ohms	500V	500 MHz	M3665/16-0001 M17/45-RG-108
18-0001	95 ohms	NOTE 1	500 MHz	M3665/19-0001
19-0001	95 ohms	NOTE 1	500 MHz	M3665/18-0001
20-0001	95 ohms	NOTE 1	500 MHz	M3665/18-0001
21-0001	95 ohms	NOTE 1	500 MHz	M3665/20-0001
22-0001	78 ohms	NOTE 2	500 MHz	M3665/14-0001
23-0001	78 ohms	NOTE 2	500 MHz	M3665/15-0001

NOTES: 1 300V at sea level 75V at 70,000 feet
2 500V at sea level 125V at 70,000 feet

Table 7. Classification

Specification No MIL-C-25516/	Series	Class	Type	Description
16C	IV	G	4	Pressurized Receptacle
17D	IV	H	4	Receptacle
18C	III	Y	5	Panel Adapter
19C	I	G	1	Pressurized Receptacle
20C	I	G	1	Plug
21C	IV	H	2	Receptacle
22C	III	Y	6	Triaxial Adapter
23	NOTE 1	NOTE 1	NOTE 1	Plug
24	NOTE 1	NOTE 1	NOTE 1	Pressurized Receptacle
25A	I	H	1	Receptacle
26A	I	G	3	Triaxial Plug
27A	IV	H	4	Receptacle
28A	I	G	1	Plug (Lanyard Release)
29	IV	G	4	Receptacle

NOTE: 1 Will mate with any jack having the same polarity.

Table 8. Cable Size Code

Specification No. M17/	Cable Designation	Maximum Center Conductor Size (AWG)	Core (Inch) Diameter Min / Max	Shield
84-RG223	01	20	.109 / .119	Yes
93-RG178	02	20	.035 / .045	Yes
	03	19	.065 / .075	Yes
	04	19	.082 / .092	Yes
	05	19	.085 / .095	Yes
	06	20	.075 / .095	No
	07	19	.090 / .100	Yes
	08	20	.044 / .054	Yes
	09	20	.052 / .062	Yes
	10	20	.056 / .060	No
	11	20	.125 / .135	No
	12	19	.090 / .100	No
119-RG174 94-RG179 113-RG316	13	20	.050 / .060	Yes
94-RG179	14	20	.060 / .066	Yes
	15	18	.110 / .120	No
54-RG122	16	20	.105 / .115	Yes
	17	20	.090 / .100	No
95-RG180	18	20	.100 / .110	Yes
28-RG58	19	18	.110 / .121	Yes
111-RG303	20	18	.066 / .070	No

TABLE 8. CABLE SIZE CODE (Cont)

Specification No. M17/	Cable Designation	Maximum Center Conductor Size (AWG)	Core (Inch) Diameter Min / Max	Shield
60-RG142	21	18	.080 / .090	No
	22	19	.068 / .070	Yes
	23	20	.123 / .133	Yes
	24	18	.118 / .128	Yes
95-RG180	25	20	.105 / .115	Yes

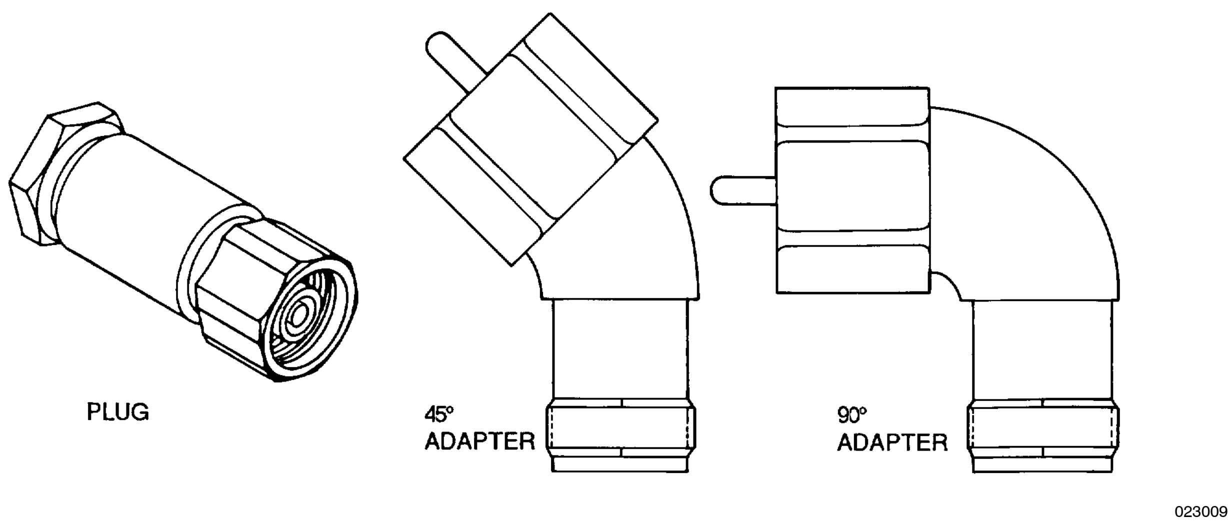


Figure 9. Typical LT Series Connectors

b. Class 2. These connectors are intended to provide mechanical connections within an RF circuit providing specified RF performance.

39. **Selection.** The selection of connectors is determined by the system requirements. Consult applicable drawings and diagrams to determine the required part. The connectors and their parameters are shown (Table 11).

40. **Part Number.** The part number consists of the basic specification sheet number, followed by the detailed specification sheet number, and a four digit dash number. The first digit of the dash number designates the material of the connector shell. The second digit denotes modified bayonet coupling mechanism keying, (when applicable). The third and fourth digits of the dash number are sequentially assigned (Figure 11).

41. **Assembly.** The assembly of this connector is unique to the manufacturer. If assembly instructions are not provided with the connector, see the aircraft maintenance manual or contact the CEA for support.

42. **MIL-PRF-39012 CONNECTORS, COAXIAL, RADIO FREQUENCY, GENERAL SPECIFICATION FOR.** This specification covers RF connectors used with flexible RF cables and certain other types of coaxial transmission lines. Refer to NAVAIR 01–1A–505–2, WP 012 02 for detailed information on MIL–PRF–39012 connectors and accessories.

Table 9. MIL-C-26637 Selection

Specification Number MIL-C-26637/	Frequency	Voltage	Description	Use
1	5 GHz	500V	Plug	RG-211
2	5 GHz	500V	Connector Adapter 90° Male or Female	RG-211
3	5 GHz	500V	Connector Adapter 45° Male or Female	RG-211

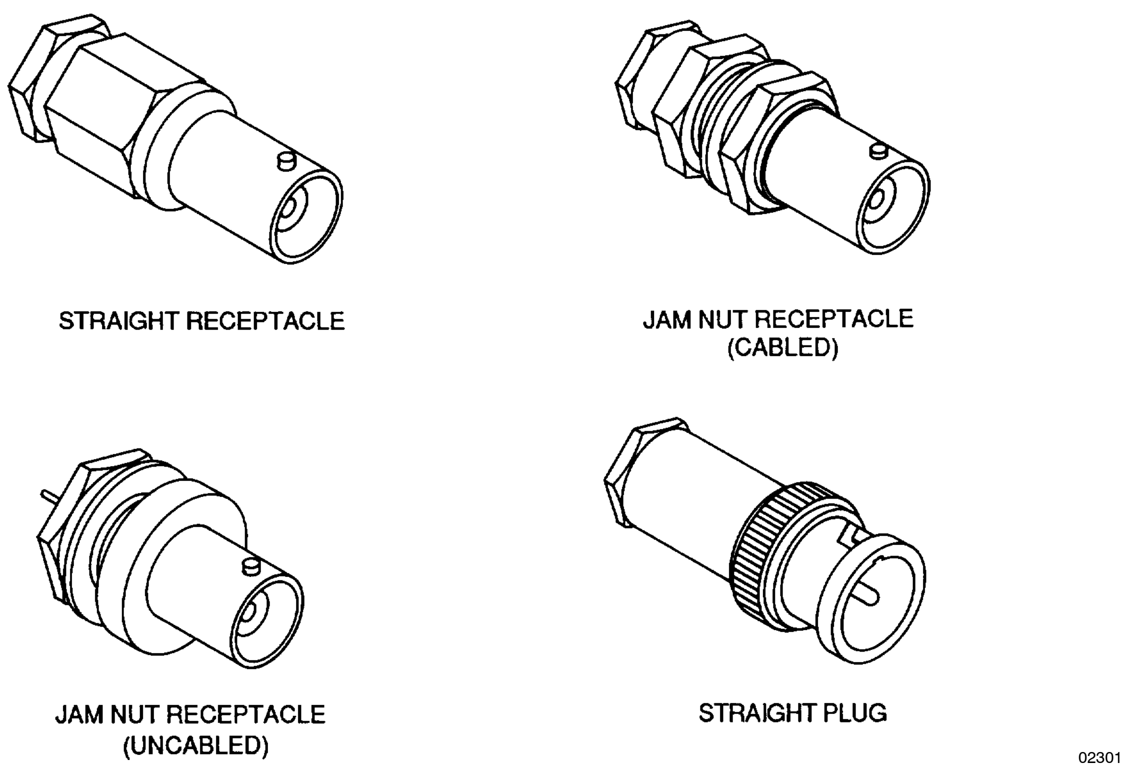


Figure 10. Typical Triax Series Connectors

Table 10. Applicable Military Specifications

Specification No. MIL-PRF-49142	Part No.	Description
8	M49142/08-0001 M49142/08-0002 M49142/08-0005 thru M49142/08-0010	Plugs, Series TRT, Cabled, Pin Contact
9	M49142/09-0001 M49142/09-0002 M49142/09-0006 thru M49142/09-0011	Receptacles, Series TRT, Cabled, Socket Contact, Jam Nut Mounted
10	M49142/10-0001 M49142/10-0002	Receptacles, Series TRT, Uncabled, Socket Contact, Jam Nut Mounted, Hermetic, and Non Hermetic
11	M49142I11-0001 M49142/11-0002 M49142/11-0006 thru M49142/11-0011	Receptacles, Series TRT, Cabled, Socket Contact
12	M49142/12-0001 M49142/12-0002 M49142/12-0005 thru M49142/12-0009	Plugs, Series TRT, Cabled., Pin Contact, Right Angle

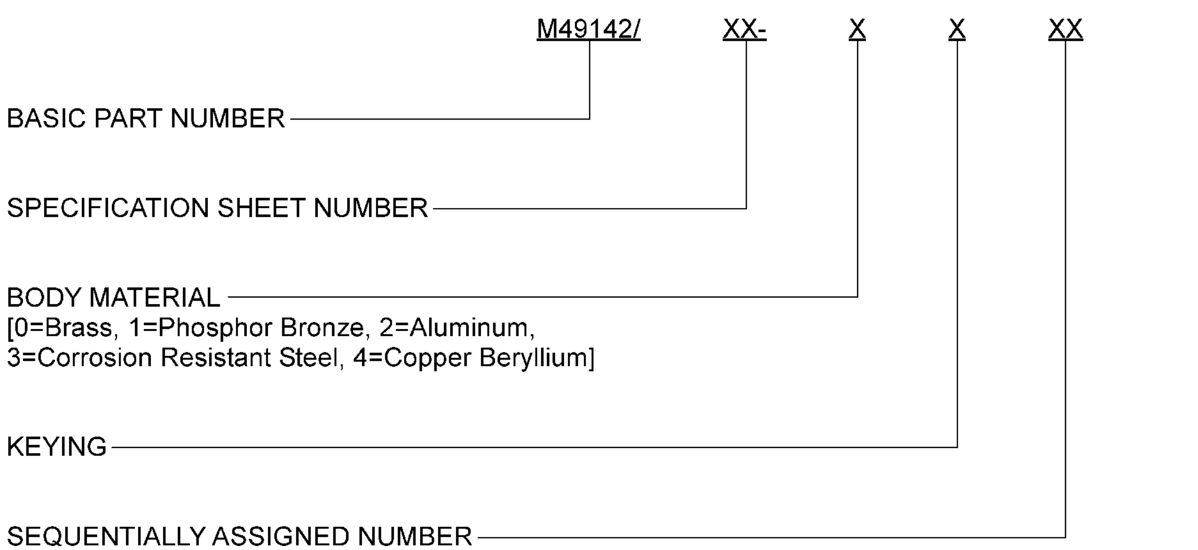


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Figure 11. MIL-C-49142 Part Number Breakdown

Table 11. MIL-PRF-49142 Selection

Part Number M49142	Class	Minimum Frequency Range	Cable
/08-0001	2	0 to 500 MHz	M17/134-00001
/08-0002			M17/134-00002
/08-0005			M17/116-RG307
/08-0006			M17/176-00002
/08-0007			M915/49-28WU-1
/08-0008			M17/177-00001
/08-0009			M17/178-00001
/08-0010			M17/179-00001
/09-0001	2	0 to 500 MHz	M17/134-00001
/09-0002			M17/134-00002
/09-0006			M17/176-00002
/09-0007			M17/116-RG307
/09-0008			M915/49-28WU-1
/09-0009			M17/177-00001
/09-0010			M17/178-00001
/09-0011			M17/179-00001
/10-0001	2	0 to 500 MHz	N/A
/10-0002			N/A
/11-0001	2	0 to 500 MHz	M17/134-00001
/11-0002			M17/134-00002
/11-0006			M17/176-00002
/11-0007			M17/116-RG307
/11-0008			M915/49-28WU-1
/11-0009			M17/177-00001
/11-0010			M17/178-0000l
/11-0011			M17/179-00001
/12-0001	2	0 to 500 MHz	M17/134-00001
/l2-0002			M17/134-00002
/12-0005			M17/116-RG307
/12-0006			M17/176-00002
/12-0007			M17/177-00001
/12-0008			M17/178-00001
/12-0009			M17/179-00001

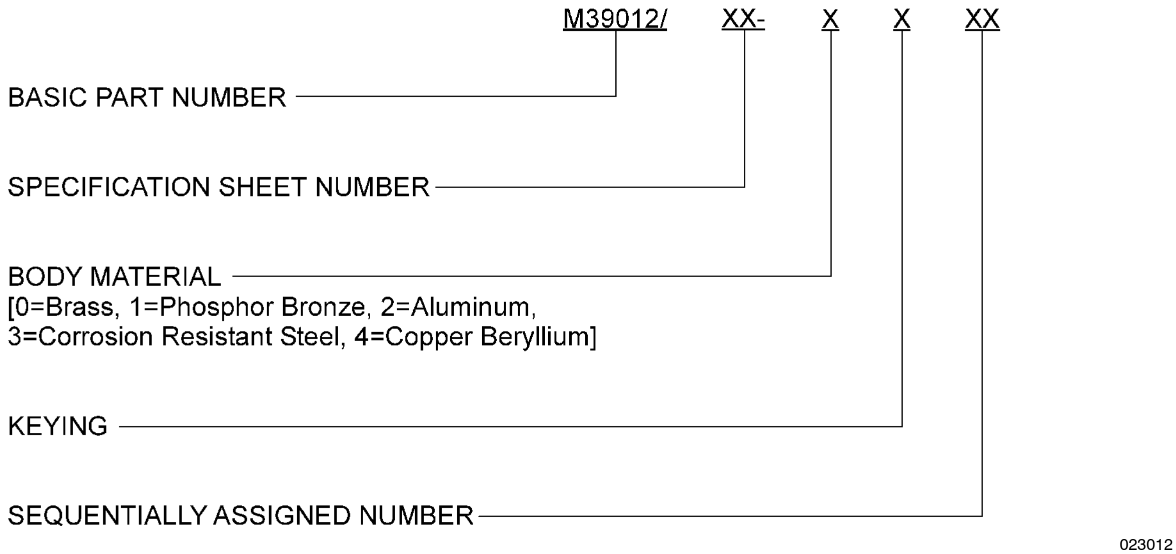


Figure 12. MIL-PRF-39012 Part Number Breakdown

43. **Series N Connectors.** These connectors are midsize, weatherproof, screw type coupling, and a metal to metal cable clamp. These connectors operate with a maximum peak voltage of 1500V and a frequency limit of 10,000 MHz. These connectors have a nominal impedance of 50 or 70 ohms. A 50 ohm connector will not mate with a 70 ohm connector (Figure 13).

44. **Series C Connectors.** These connectors are similar to Series N in that they are designed for medium sized cable. These connectors are midsize, weatherproof, bayonet type coupling, and metal to metal cable clamp. They operate with a maximum peak voltage of 1500 volt and a frequency of 10,000 MHz. The nominal impedance is 50 ohms (Figure 14).

45. **Series BNC Connectors.** These connectors are small, lightweight, weatherproof, bayonet type coupling, and metal to metal cable clamp. They operate with maximum peak voltage of 500 volt and frequency of 10,000 MHz. The nominal impedance is 50 ohms (Figure 15).

46. **Series TNC Connectors.** These connectors are similar to the BNC connector, but have threaded coupling. They operate with a maximum peak voltage of 500 volt and a frequency of 11,000 MHz. The nominal impedance is 50 ohms (Figure 16).

47. **Series SC Connectors.** These connectors are designed for medium sized cable. They are weatherproof with screw type coupling. They operate with a peak maximum voltage of 1500 volt and a frequency of 11,000 MHz. The nominal impedance is 50 ohms (Figure 17).

48. **Series SMA Connectors.** These connectors are subminiature, low voltage connectors with threaded coupling, 50 ohm impedance and an operating frequency to 12,400 MHz (Figure 18).

49. **Series SMB Connectors.** These connectors are subminiature, snap on coupling connectors approximately the same size as SMA series. These connectors operate to 10,000 MHz (Figure 19).

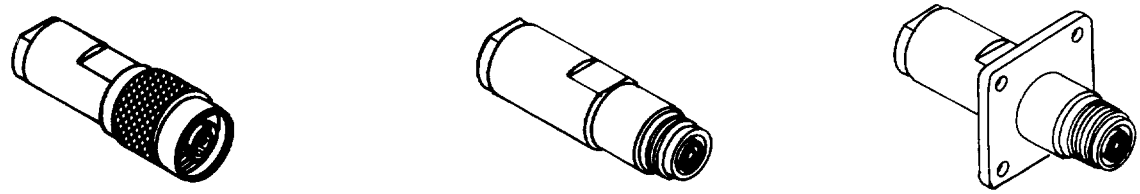
50. **Series SMC Connectors.** These connectors are subminiature, threaded coupling connectors approximately the same size as the SMA series. These connectors operate to 10,000 MHz (Figure 20).

51. **Series QSC Connectors.** These connectors are large, threaded coupling connectors. These connectors operate to 11,000 MHz and to 1500 volt (Figure 21).

52. **Series QNC Connectors.** These connectors are similar to the QSC type both in size and operating characteristics (Figure 22).

53. **Series MHV Connectors.** These connectors are high voltage, flange mount, bayonet coupled connectors (Figure 23).

54. **Series SHV Connectors.** These connectors are high voltage, bayonet coupled connectors (Figure 24).



023013

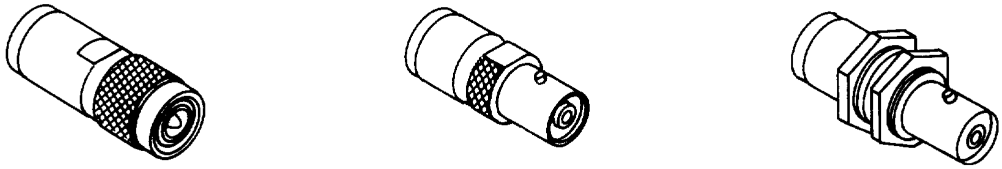
PLUG

STRAIGHT RECEPTACLE

FLANGE MOUNT RECEPTACLE

Figure 13. Typical N Series Connectors

023013



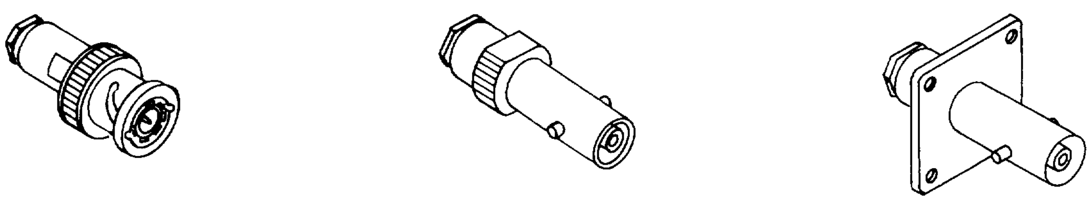
PLUG

STRAIGHT RECEPTACLE

FLANGE MOUNT RECEPTACLE

023014

Figure 14. Typical C Series Connectors



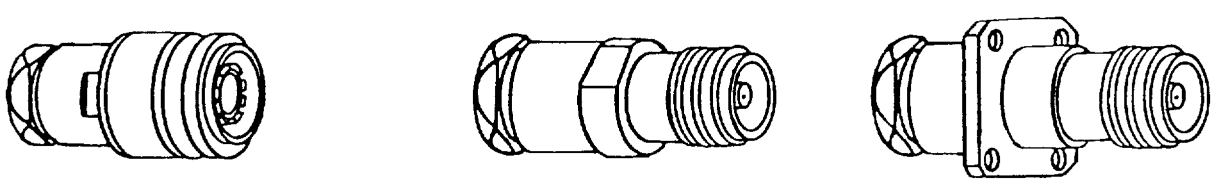
PLUG

STRAIGHT RECEPTACLE

FLANGE MOUNT RECEPTACLE

023015

Figure 15. Typical BNC Series Connectors



PLUG

STRAIGHT RECEPTACLE

FLANGE MOUNT RECEPTACLE

023016

Figure 16. Typical TNC Series Connectors

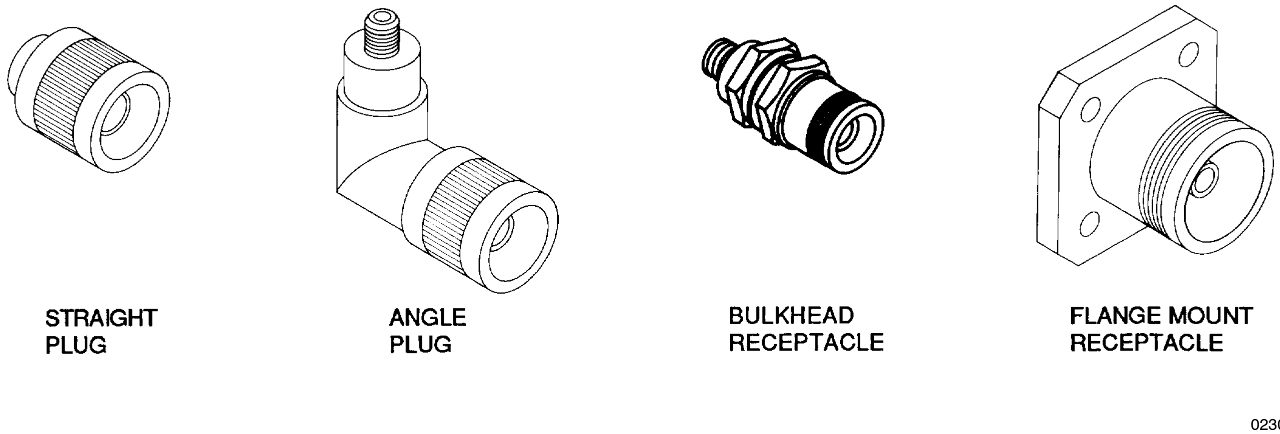


Figure 17. Typical SC Series Connectors

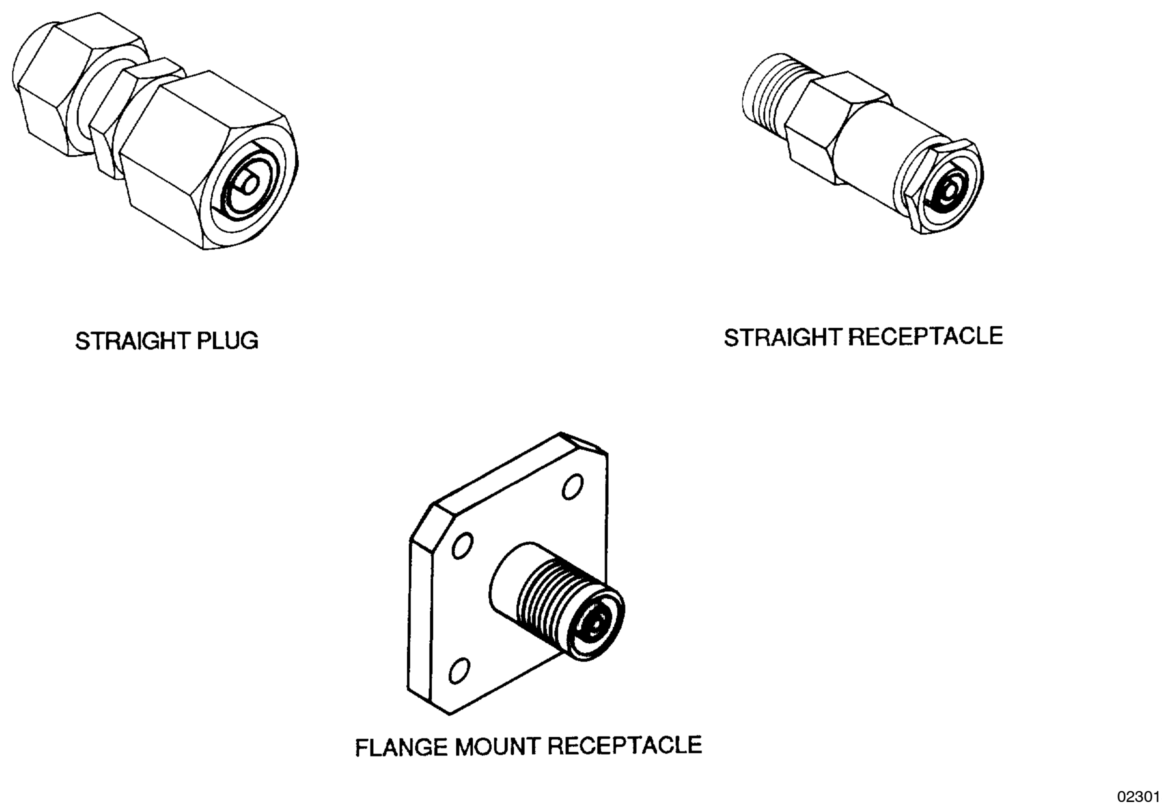


Figure 18. Typical SMA Series Connector

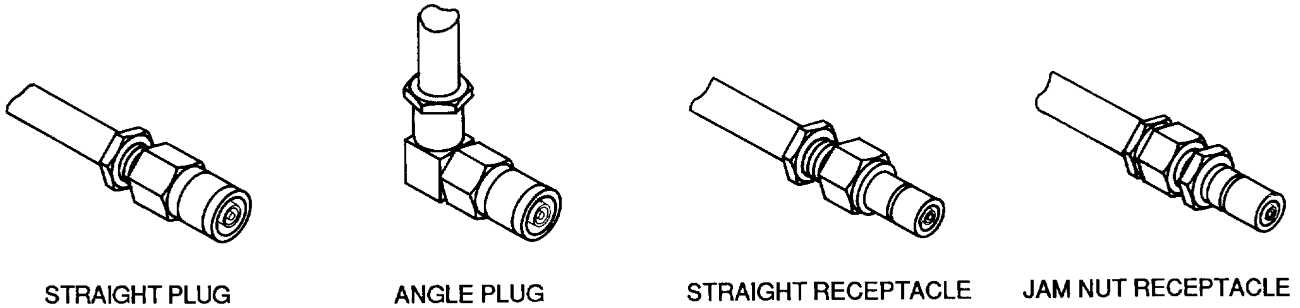


Figure 19. Typical SMB Series Connectors

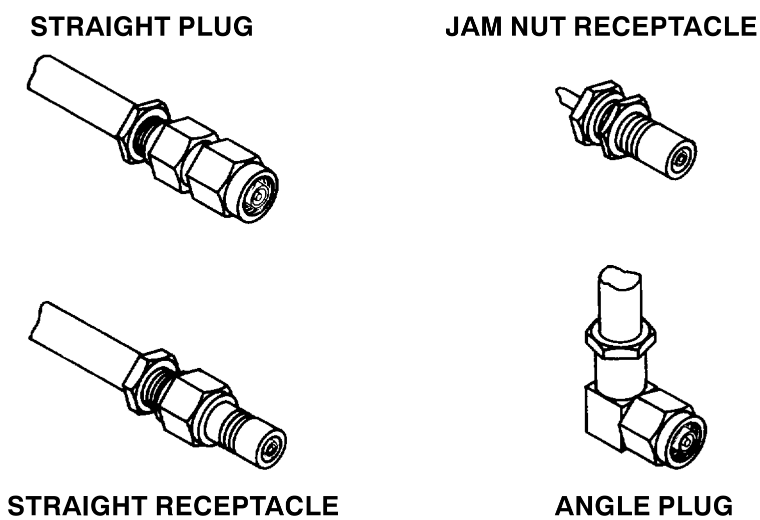


Figure 20. Typical SMC Series Connectors

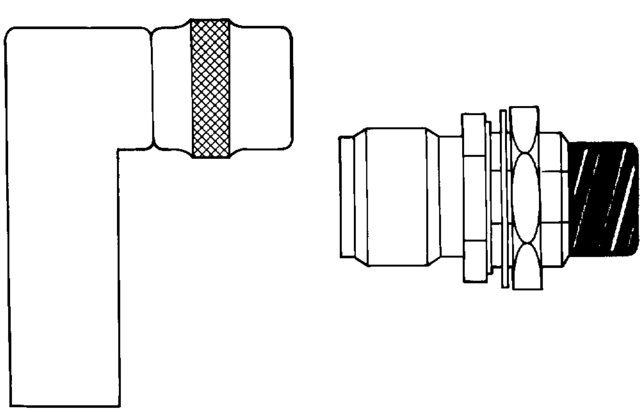
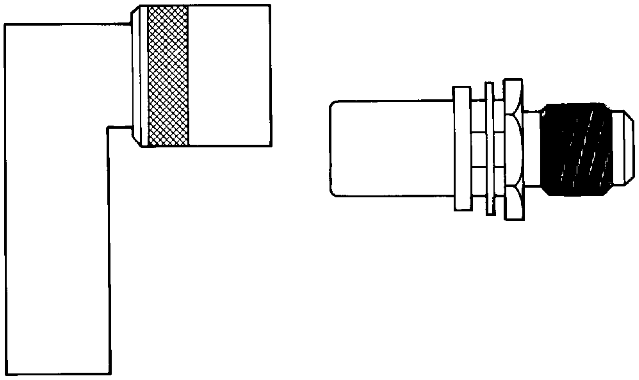


Figure 21. Typical QSC Series Connector

55. **Series EIA Connectors.** These connectors are large, flange mount connectors for use with semi rigid corrugated cables (Figure 25).

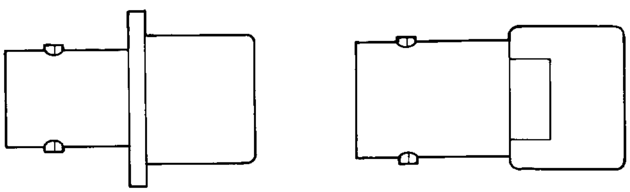
56. **Selection.** The selection of connectors is determined by the system requirements. Consult applicable drawings and diagrams to determine the required part. The applicable military specifications with connector description and frequency applications are shown in Figures 12 and Table 13.

57. **Assembly.** To assemble MIL-PRF-39012 connectors refer to NA 01–1A–505–2, WP 012 00.



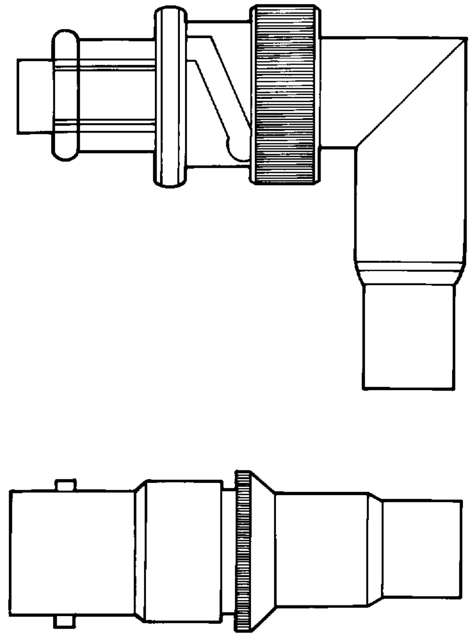
023022

Figure 22. Typical QNC Series Connector



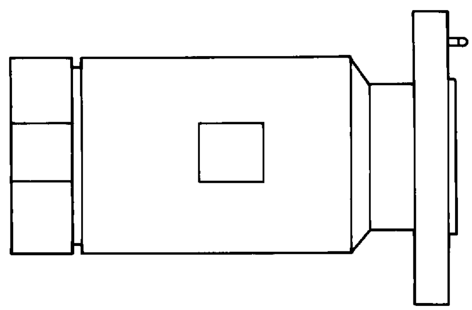
023023

Figure 23. Typical MHV Series Connector



023024

Figure 24. Typical SHV Series Connector



023025

Figure 25. Typical EIA Series Connector

Table 12. Applicable Military Specifications

Specification No. 39012/	Series	Contact	Description
1	N	Pin	Plug
2	N	Socket	Plugs and Receptacles Flange Mount
3	N	Socket	Receptacle Jam Nut Mount
4	N	Socket	Receptacle Jam Nut Mount Flange Mount
5	N	Pin	Plug Right Angle
6	C	Pin	Plug
7	C	Socket	Plug
8	C	Socket	Receptacle Flange Rear Mount
9	C	Socket	Receptacle Jam Nut Front Mount
10	C	Pin	Plug Right Angle
11	C	Socket	Receptacle Jam Nut Rear Mount
12	C	Socket	Receptacle Flange Rear Mount
13	C	Socket	Pressurized Receptacle Jam Nut Front Mount
14	C	Socket	Hermetic Receptacle Jam Nut Mount
15	C	Pin	Plug
16	BNC	Pin	Plug
17	BNC	Socket	Plug
18	BNC	Socket	Receptacle Flange Mount
19	BNC	Socket	Receptacle Jam Nut Mount
20	BNC	Pin	Plug Right Angle
21	BNC	Socket	Receptacle Jam Nut Mount
22	BNC	Socket	Receptacle Flange Mount
23	BNC	Socket	Receptacle Right Angle
24	BNC	Socket	Hermetic Receptacle Jam Nut Mount
26	TNC	Pin	Plug
27	TNC	Socket	Plug
28	TNC	Socket	Receptacle Jam Nut Mount
29	TNC	Socket	Receptacle Flange Mount
30	TNC	Pin	Plug Right Angle
31	TNC	Socket	Receptacle Jam Nut Mount
32	TNC	Socket	Receptacle Flange Mount
33	TNC	Socket	Receptacle Right Angle
34	TNC	Socket	Hermetic Receptacle Jam Nut Mount
35	SC	Pin	Plug
36	SC	Socket	Plug
Specification No. 39012/	Series	Contact	Description

Table 12. Applicable Military Specifications (Cont)

37	SC	Socket	Receptacle Jam Nut Front Mount
38	SC	Socket	Receptacle Flange Rear Mount
39	SC	Pin	Plug Right Angle
40	SC	Socket	Receptacle Jam Nut Rear Mount
41	SC	Socket	Receptacle Flange Rear Mount
42	SC	Socket	Receptacle Jam Nut Front Mount
55	SMA	Pin	Plug
56	SMA	Pin	Plug Right Angle
57	SMA	Socket	Plug
58	SMA	Socket	Receptacle Flange Mount
59	SMA	Socket	Receptacle Jam Nut Mount
60	SMA	Socket	Receptacle Flange Mount
61	SMA	Socket	Receptacle Jam Nut Mount
62	SMA	Socket	Hermetic Receptacle Jam Nut Mount
67	SMB	Socket	Plug
68	SMB	Pin	Plug
69	SMB	Socket	Plug Right Angle
70	SMB	Pin	Receptacle Jam Nut Rear Mount
71	SMB	Pin	Receptacle Jam Nut Mount
73	SMC	Socket	Plug
74	SMC	Pin	Plug
75	SMC	Socket	Plug Right Angle
76	SMC	Pin	Receptacle Jam Nut Rear Mount
77	SMC	Pin	Receptacle Jam Nut Mount
79	SMA	Pin	Plug For Semi-Rigid Cables
80	SMA	Pin	Plug Right Angle For Semi-Rigid Cable
81	SMA	Socket	Plug For Semi-Rigid Cables
82	SMA	Socket	Receptacle Flange Mount For Semi-Rigid Cable
83	SMA	Socket	Receptacle Jam Nut Mount For Semi-Rigid Cable
84	QSC	Pin	Plug Right Angle
85	QSC	Socket	Receptacle Jam Nut Rear Mount
86	QSC	Socket	Receptacle Jam Nut Front Mount
87	QSC	Socket	Hermetic Receptacle Jam Nut Front and Rear Mount
88	QNC	Pin	Plug Right Angle
89	QNC	Socket	Receptacle Jam Nut Mount

Table 12. Applicable Military Specifications (Cont)

Specification No. 39012/	Series	Contact	Description
90	QNC	Socket	Receptacle Jam Nut Front And Rear Mount
91	QNC	Socket	Receptacle Jam Nut Front And Rear Mount
92	SMA	None	Plug For Semi-Rigid Cable
93	SMA	Socket	Receptacle Printed Circuit
94	SMA	Socket	Receptacle Right Angle Printed Circuit
95	SMA	Pin	Receptacle Printed Circuit
96	SMA	Pin	Receptacle Right Angle Printed Circuit
101	MHV	Pin	Plug
102	MHV	Socket	Plug
103	MHV	Socket	Receptacle Flange Mount
104	MHV	Socket	Receptacle Jam Nut Mount
105	SHV	Socket	Plug
106	SHV	Socket	Plug Right Angle
107	SHV	Pin	Receptacle
108	SHV	Pin	Receptacle Flange Mount
109	SHV	Pin	Receptacle Flange Mount
110	SHV	Pin	Receptacle Jam Nut Mount
111	SHV	Pin	Receptacle Jam Nut Mount
112	TNC	Pin	Plug For Semi-Rigid Cable
113	TNC	Socket	Plug For Semi-Rigid Cable
114	TNC	Pin	Plug Right Angle For Semi-Rigid Cable
115	TNC	Socket	Receptacle Jam Nut Mount For Semi-Rigid Cable
116	TNC	Socket	Receptacle Flange Mount For Semi-Rigid Cable
117EC	N	Pin And Socket	Jacks And Plugs For Use With MIL-C-28830/3 Corrugated Semi-Rigid Cable
118EC	N	Socket	
119EC	N	Pin	
120EC	N	Socket	
121EC	N	Socket	
122	EIA	Pin	Flange Receptacle For MIL-C-28830/3 Cable
123	EIA	Pin	Flange Receptacle For MIL-C-28830/4 Cable

Table 12. Applicable Military Specifications (Cont)

Specification No. 39012/	Series	Contact	Description
124	EIA	Pin	Flange Receptacle For MIL-C-28830/5 Cable
128	BNC	Socket	Receptacle Solder Pocket Isolated Jam Nut Mount
129	N	Pin	Plug For Semi-Rigid Cable
130	N	Pin	Plug Right Angle For Semi-Rigid Cable
131	N	Socket	Plug For Semi-Rigid Cable
132	N	Socket	Receptacle Jam Nut Mount For Semi-Rigid Cable

Table 13. General Purpose MIL−PRF−39012 Coaxial Connectors for use with Microwave Frequencies (all 50 Ω)

Connector Type	Description	Frequency Range (*)	SWR (*)	Coupling Type	Interface Type	Size
SMA	Widely used system connector in military applications, popular use with 0.141 semi−rigid cables.	DC − 18 GHz (available to 26.5 GHz)	1.25	1/4 − 36 threads	Teflon, flush	Sub−miniature
SMB	Used for internal dense packaging applications, generally used with flexi−cables.	DC − 4 GHz	1.5	Snap−on	Teflon, overlap	Sub−miniature
SMC	Threaded version of SMB for higher frequency use.	DC − 10 GHz	1.6	10 − 32 threads	Teflon, overlap	Sub−miniature
BNC	Popular, used for small flexible coupling.	DC − 4 GHz (useable to 10 GHz)	1.3	Twist−lock	Teflon, overlap	Miniature
TNC	Durable and reliable for aerospace applications (threaded version of BNC).	DC − 12.4 GHz (version available to 18 GHz)	1.3	7/16 − 28 threads	Teflon, overlap	Miniature
N	Rugged weather proofed connector for use with larger size cables.	DC − 11 GHz (version available to 18 GHz)	1.3	5/8 − 24 threads	Air	Medium
C	Weather proofed, quick disconnect connector for larger size cables.	DC − 10 GHz	1.35	Twist−lock	Teflon, overlap	Medium
SC	Threaded version of type C for aircraft and EW applications.	DC − 11 GHz	1.3	11/16 − 24 threads	Teflon, overlap	Medium

SPECIALTY WIRING TYPES REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Data Network Part 7 Avionics Full Duplex Switched Ethernet (AFDX) Network . . . . ARINC 664P7
ARINC 664 (Ethernet) Wire Repair Installation And Repair Practices Aircraft Electric and Electronic Wiring . . . . WP 022 03
Cable, Electric, Filter Line, Radio Frequency Absorptive SAE–AS–85485
Design and Handling Guide Radio Frequency Absorptive Type Wire and Cables (Filter Line, MIL–C–85485) SAE–AIR–4465
IEEE–1394 (Firewire) Repair Installation And Repair Practices Aircraft Electric and Electronic Wiring . . . . WP 022 02
IEEE–1394b for Military and Aerospace Vehicles Applications Handbook AIR–5654
IEEE–1394b Interface Requirements for Military and Aerospace Vehicle Applications SAE–AS–5643
SAE–AS–85485 (Filter Line) Wire Repair Installation And Repair Practices Aircraft Electric and Electronic Wiring . . . . WP 022 01
Universal Serial Bus (USB) Wire Repair Installation And Repair Practices Aircraft Electric and Electronic Wiring . . . . WP 022 04

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

32. **INTRODUCTION.**

33. This Work Package (WP) covers basic description and procedures for working with specialty type wires and cables. To include filter line (SAE–AS–85485), 1553 databuss, Ethernet (ARINC 664) and fire wire (IEEE–1394). Maintenance procedures are covered in following work packages.

34. **SAE–AS–85485 (Filter Line) Wire**. Today's performance needs for military, avionics, and ordnance systems require increasingly sophisticated electronic equipment and greater use of composite structures. As operational requirements become more critical, the level of electromagnetic interference (EMI) protection for electrical equipment is increasing. Filter line interconnect systems provide a high degree of EMI protection while functioning as conventional electrical wiring systems. In aircraft, most control and monitor signals operate at frequencies substantially below 50 MHz, whereas most interference sources operate in the high VHF, UHF, and SHF bands (e.g., radio, IFF, radar, EW, etc.). By effectively attenuating these sources of interference on susceptible control and monitor wiring, filter line wiring efficiently serves the dual roles of filtering and interconnection. Filter line wiring can also be useful for non–aviation installations where the pass band and stop band characteristics fit the system needs. Filter line interconnect systems consist of high–performance MIL–SPEC wire and cable and termination devices that, when used as specified, suppress conducted and radiated EMI above 100 MHz. It provides a reliable alternative to conventional discrete filters and filter–pin connectors. Filter line cables are flexible, lightweight and can be used with most high–density MIL–SPEC connectors. Filter line wire and cable performance requirements and construction details are specified in SAE–AS–85485. Proven filter line termination devices include back shell adapters, braid splicers, shield terminators, and shield splices. These components provide 360°, low–impedance terminations at connectors; a must for efficient EMI protection. They also permit easy repair of connectors without disconnecting shield terminations. Refer to WP 022 01 for repair.

35. **IEEE–1394 Firewire.** IEEE–1394 was invented by Apple Computer in the 1980's and is also known as Firewire. In 1995 the IEEE adopted it and created a specification to support its use. That specification has been continuously upgraded and improved. In 2002, the IEEE released 1394b, the version SAE has adopted for use in military and aerospace vehicles. IEEE–1394–2008 combines all of the previous versions into a single document released 2008. Prior to its use in the Lockheed Martin F35 Lightning II (Joint Strike Fighter), IEEE–1394b had never been used as a flight critical or mission critical system data bus in any military or aerospace vehicle. The IEEE–1394b specification does not provide necessary functionalities such as guaranteed determinism and information integrity for use in aerospace applications such as the flight control system for aircraft. For that reason, the SAE variant of IEEE–1394b was conceived and implemented. In addition to the F–35 program, the use of IEEE–1394b for safety / mission critical systems is being considered by other major commercial aircraft program, space manned and unmanned vehicles for explorations, and defense systems other than fighters. Refer to WP 022 02.

36. **ARINC 664 Ethernet.** Avionics Full–Duplex Switched Ethernet (AFDX) is a deterministic data network for safety critical applications that utilizes dedicated bandwidth while providing Quality of Service (QoS). AFDX is based on IEEE 802.3 Ethernet technology and utilizes commercial off–the–shelf (COTS) components. It is Part 7 of the ARINC 664 Specification which defines how Commercial Off–the–Shelf networking components will be used for future generation Aircraft Data Networks (ADN). The six primary aspects of AFDX include full duplex, redundancy, deterministic, high speed performance, switched and profiled network. Refer to WP 022 03.

37. **Universal Serial Bus (USB).** Universal Serial Bus (USB) is a serial bus standard to connect devices to a host computer. USB was designed to allow many peripherals to be connected using a single standardized interface socket and to improve plug and play capabilities by allowing hot swapping; that is, by allowing devices to be connected and disconnected without rebooting the computer or turning off the device. Other convenient features include providing power to low–consumption devices, eliminating the need for an external power supply; and allowing many devices to be used without requiring manufacturer–specific device drivers to be installed. Refer to WP 022 04.

SAE−AS−85485 FILTER LINE WIRE REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Cable, Electric, Filter Line, Radio Frequency Absorptive . . . . SAE−AS−85485
Design and Handling Guide Radio Frequency Absorptive
Type Wire and Cables (Filter Line, SAE−AS−85485) . . . . SAE−AIR−4465
Installation and Repair Practices, Volume II, Aircraft
Circular Electrical Connectors and Accessories . . . . NAVAIR 01−1A−505−2

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part. No./Type Designation
Stripper Frame	45−1610
Stripper Blade Set	45−1610−1
Stripper Frame	45−1611
Stripper Blade Set	45−1611−1
Stripper Frame	45−1924
Stripper Blade Set	45−1924−1
Stripper Frame	45−1925
Stripper Blade Set	45−1925−1

Materials Required

Nomenclature	Part. No.
Splice, Center Conductor	SAE−AS−81824/1
Splice, Shield	SAE−AS−81824/4
Splice, Kit	SAE−AS−81824/5

1. **INTRODUCTION.**

2. This Work Package (WP) covers maintenance procedures working with specialty type filter line wire (SAE−AS−85485).

3. **SAE−AS−85485 SELECTION AND PART NUMBER.**

a. Filter line wire can be ordered as component wire (M85485/5, /6, /9 and /10) or as a finished cable (M85485/7, /8, /11 and /12).

(1) Component wire is either Tin−Coated General Purpose Copper (M85485/5 and /9 Figure 1) or Silver−Coated High−Strength Copper Alloy (M85485/6 and /10 Figure 1).

(2) Finished Cable can be ordered as shielded and jacketed (M85485/8 and /12 Figure 2) or unshielded and unjacketed (M85485/8 and /12 Figure 2).

4. **FILTER LINE FINISHED CABLE REPAIR.**

NOTE

Repair to filter line may require disassembly of connector or opening of harness. For disassembly of connector, refer to applicable connector repair work package (NA 01−1A−505−2) for instructions.

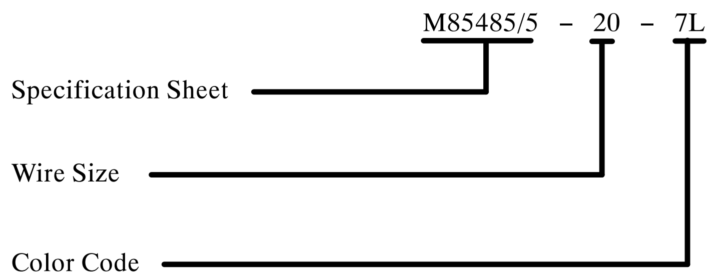
5. **HARNESS REPAIR.** Refer to WP 011 00 for the harness repair procedures (Figure 3).

NOTE

Harness repair consists of removal procedures of Nomex® braid (if installed) and gross shield.

a. Remove Nomex® Braid as necessary to access the Gross Shield (Gross Shielded Harnesses Only) (Figure 3).

b. Remove Gross Shield. Remove Gross Shield as necessary to access wires within harness (Figure 3).



Applicable Slash Sheets

SAE−AS−85485 Slash Sheet Number	Description
/5	Tin Coated Copper Conductor, Component Wire (Used with Finished Cable M85485/7 & /8)
/6	Silver Coated High Strength Copper Conductor, Component Wire (Used with Finished Cable M85485/7 & /8)
/9	Tin Coated Copper Conductor, Component Wire (Used with Finished Cable M85485/11 & /12)
/10	Silver Coated Copper Conductor, Component Wire (Used with Finished Cable M85485/11 & /12)

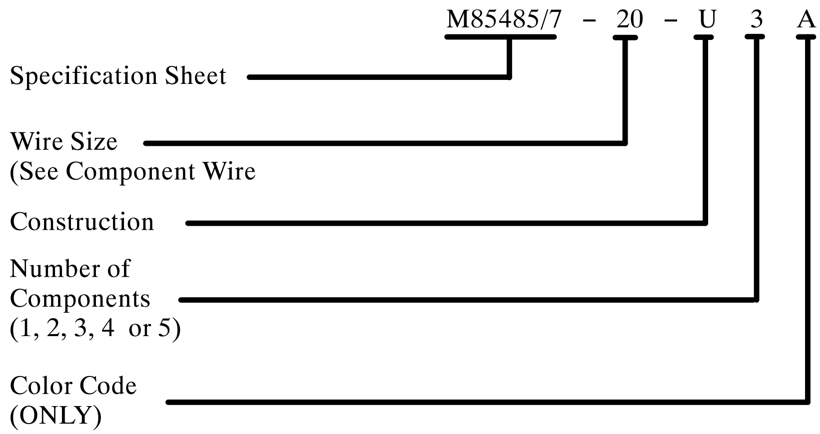
Wire Sizes Available

SAE−AS−85485 Slash Sheet Number	AWG Size
/5	10, 12, 14, 16, 18, 20 & 22
/6	24 Only
/9	10, 12, 14, 16, 18, 20 & 22
/10	24 Only

Color Code

Designator	Color
7L	Light Violet (Purple)
	Only

Figure 1. SAE−AS−85485 Component Wire Part Number Breakdown.



Applicable Slash Sheets

SAE–AS–85485 Slash Sheet Number	Description
/7	Unshielded and unjacketed cable made up of M85485/5 or M85485/6 Component Wire
/8	Shielded and jacketed cable made up of M85485/5 or M85485/6 Component Wire
/11	Unshielded and unjacketed cable made up of M85485/9 or M85485/10 Component Wire
/12	Shielded and jacketed cable made up of M85485/9 or M85485/10 Component Wire

Construction

Construction Code	Center Conductor	Gross Shield
Shielded and Jacketed		
T	Tin–coated copper	Tin–coated copper
S	Silver–coated copper	Silver–coated copper
M	Silver–coated high–strength copper alloy	Silver–coated high–strength copper alloy
U	Silver–coated high–strength copper alloy	Tin–coated copper
V	Silver–coated–high–strength copper alloy	Silver–coated copper
Unshielded and Unjacketed		
T	Tin–coated copper	N/A
S	Silver–coated copper	N/A
M	Silver–coated high–strength copper alloy	N/A

Component Wire Color Breakdown

Number of Components	Outer Insulation Color	Stripe Color
1	Light Violet (Purple)	None
2		Blue
3		Orange
4		Green
5		Red

Figure 2. SAE–AS–85485 Finished Cable Part Number Breakdown.

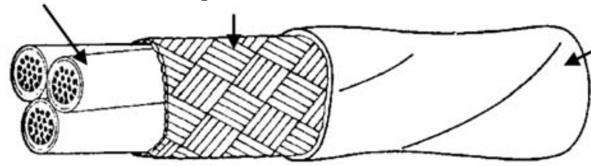


Figure 3. Typical SAE−AS−85485 Finished Cable

6. **FILTER LINE COMPONENT WIRE REPAIR.**

7. Wire Preparation. Wire preparation covers procedures necessary to make wire/cable ready for repairs. These procedures include harness repair and wire stripping.

a. Stripping Filter Line Wire (Except 22 gage).

(1) Using the shear−type cutter part number 45−123 (WP 009 00), cut the filter line to the necessary length. Ensure the end condition of the wire is acceptable (Figure 4.)

(2) Using the strippers identified in Table 1 strip individual wire, refer to WP 009 00 for proper stripping procedures and inspection criteria.

CAUTION

Wire strippers listed in the Table 1 are specially designed for filter line wire. Stripping tools other than those listed shall not be used as damage to cable may occur.

M85485/5 component wire is compatible with all standard connector and contact types, except that the primary jacket diameter of M85485/5−22 component wire exceeds the allowable diameter for MIL−C−38999 size 22D contacts. However, this component wire can be terminated to Size 22D contacts if the primary jacket and filter layer are stripped in the grommet area of the connector, Leaving the primary insulation intact. See Figure 5.

Table 1. Filter Line Wire Strippers

M85485/	Wire AWG	Stripper P/N (Note 1)	Blade Set P/N (Note 2)
/5, /6, /7, /8	16−24	45−1924	45−1924−1
	10−14	45−1925	45−1925−1
/9, /10	16−24	45−1610	45−1610−1
/9, /10, /11, /12	10−14	45−1611	45−1611−1

NOTES: 1. Ideal Custom Stripmaster (Complete Stripper)

2. Blade Set 45−1924−1 has 2 holes

3. Complete Frame Including Gripper (Less Blade Set)

b. Step Stripping (22 Gage Filter Line Only).

(1) Select the proper wire stripper from Table 1.

(2) Using the 22 AWG hole with the “1”, remove the primary jacket and absorptive compound layer of the Filter Line Wire (Figure 6).

(3) Ensure wire is stripped to correct length (Figure 8).

(4) Using the 22 AWG hole with the “2”, remove the primary insulation, exposing the conductor (Figure 7).

(5) Ensure finished cable and component wire are stripped to correct length (Figure 8).

8. Splicing. Splices used on filter line wires shall be immersion–seal crimp type splices, MIL–S–81824. A butt splice is a splice in which wires exit splice from both ends. A stub splice is a splice in which wires exit splice from one end only. Splices consist of a barrel and heat–shrinkable sleeve containing thermoplastic epoxy inserts.

a. Non– Shielded splices.

(1) Butt Splice. Refer to WP 014 00 for butt splice procedures and inspection criteria.

(2) Stub Splice. Refer to WP 014 00 for stub splice procedures and inspection criteria.

b. Shielded Cable Splicing

(1) Using Table 2, select the correct Shielded Cable Splice for the applicable type of Filter Line Wire.

(2) Using Figure 9, assemble the splice kit as shown. Refer to WP 014 00 for inline splice (M81824/1) crimping procedures and assembly. Center the gross shield splice (M81824/4) over the inline splice (M81824/1) and shrink/recover using heat gun as per WP 012 00.

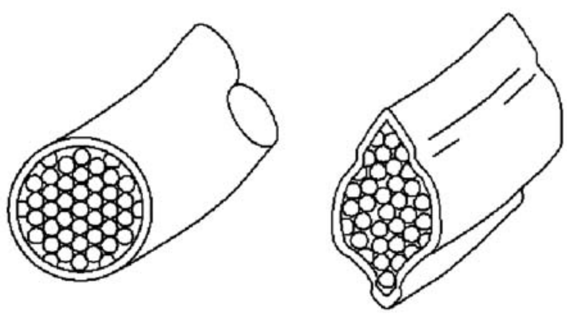


Figure 4. Acceptable/Unacceptable Conditions of Cut Wire Ends

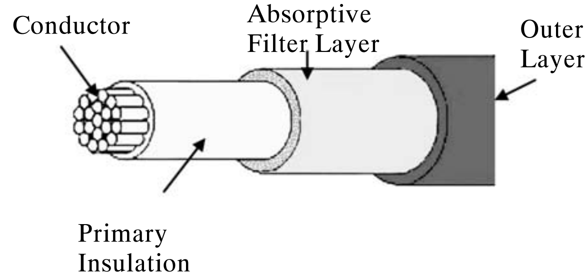


Figure 5. Typical SAE–AS–85485 Component Wire

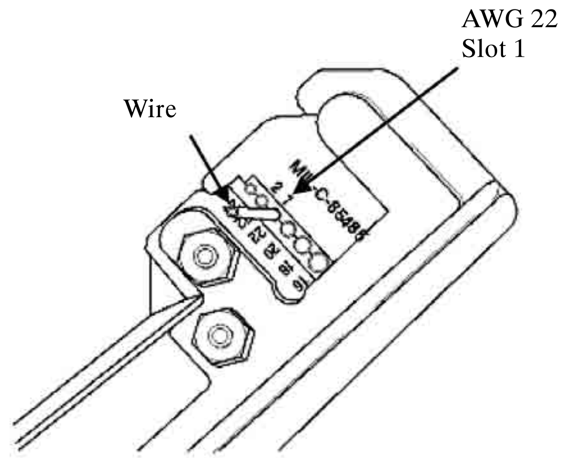


Figure 6. Step Stripping Outer Layer and Absorptive Filter Layer AWG 22

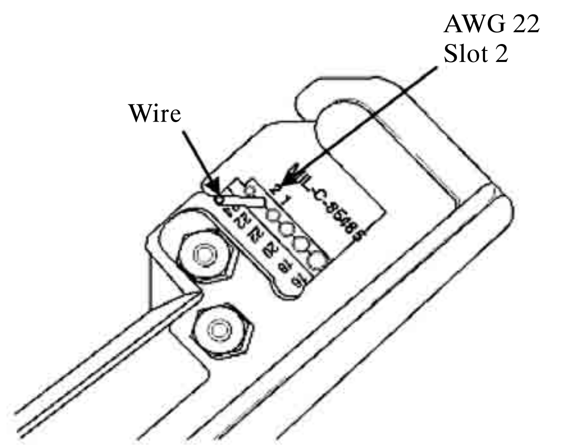


Figure 7. Step Stripping Primary Insulation AWG 22

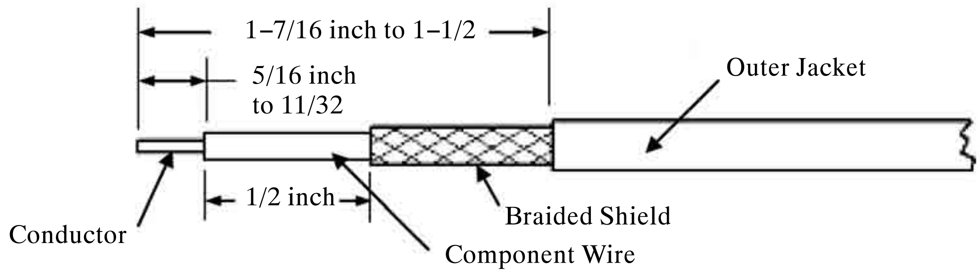


Figure 8. Dimensions for Shielded Cable Splices

Table 2. Shield Repair Selection

PART NUMBER M81824/5	CABLE PARAMETERS		KIT COMPONENTS		
	NUMBER OF CONDUCTORS	CONDUCTOR SIZE RANGE	CONDUCTOR SPLICE PART NO. M81824/1	(QTY)	SHIELD SPLICE PART NO. M81824/4
–1	1	24–22–20	–1	(1)	–1
–2	1	20–18–16	–2	(1)	–2
–3	1	16–14–12	–3	(1)	–3
–4	2	26–24–22–20	–1	(2)	–4
–5	2	18–16	–2	(2)	–5
–6	2	14	–3	(2)	–6
–7	2	12	–3	(2)	–7
–8	3 OR 4	26–24	–1	(4)	–4
–9	3 OR 4	22–20	–1	(4)	–5
–10	3 OR 4	18–16	–2	(4)	–6
–11	3 OR 4	14–12	–3	(4)	–7

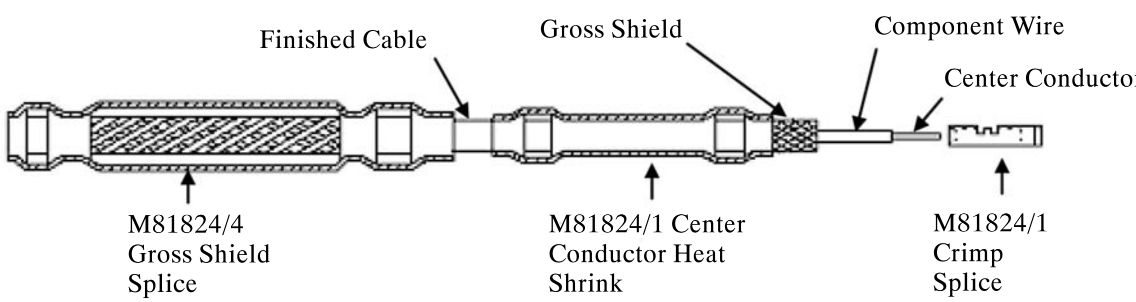


Figure 9. M81824/5 Splice Kit on Finished Cable

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IEEE–1394 (FIREWIRE) REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

IEEE–1394b for Military and Aerospace Vehicles Applications Handbook AIR–5654
IEEE–1394b Interface Requirements for Military and Aerospace Vehicle Applications SAE–AS–5643

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

9.. **INTRODUCTION.**

10.. This Work Package (WP) when developed will cover maintenance procedures for working with specialty type IEEE 1394 Firewire.

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ARINC 664P7 (ETHERNET) REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Data Network Part 7 Avionics Full Duplex Switched Ethernet (AFDX) Network . . . . ARINC 664P7

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

11.. **INTRODUCTION.**

12.. This Work Package (WP) when developed will cover maintenance procedures for working with specialty type ARINC 664P7 Ethernet.

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UNIVERSAL SERIAL BUS (USB) REPAIR

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Aircraft Data Network Part 7 Avionics Full Duplex Switched Ethernet (AFDX) Network .... ARINC 664P7

Alphabetical Index

Record Of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

13.. **INTRODUCTION.**

14.. This Work Package (WP) when developed will cover maintenance procedures for working with specialty type Universal Serial Bus (USB).

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MILITARY STANDARD RECTANGULAR CONNECTORS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Alphabetical Index

Support Equipment Required

None

Materials Required

None

1 . INTRODUCTION.

2 . This work package (WP) contains general information for rectangular connectors commonly used on military aircraft and electric/electronic equipment. Specific information on a particular type rectangular connector is contained in the appropriate NAVAIR 01-1A-505–3.

3 . GENERAL

WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. Consult applicable health an environmental regulations regarding its use, handling and disposition.

NOTE

For the purpose of this WP, the general information pertains to rack and panel connectors.

4 . **CONNECTORS.** Connectors are electromechanical devices that permit circuit elements to be electrically and mechanically separated and reconnected without disturbing other elements. The connector performs no function electrically except to connect and disconnect circuits, and serves to join wires together.

5 . **Rectangular Connectors.** Rectangular connectors are divided into rack and panel connectors and printed circuit connectors.

6 . **Rack and Panel Connectors.** Rack and panel connectors are fixed connectors that provide electrical connections between an electric/electronic unit and its rack mount. An alignment device is usually provided to insure proper mating. Coupling devices are normally not used and the connectors are mated by moving the unit into the rack. Typical rack and panel connectors are shown in Figure 1.

7 . **Printed Circuit Connectors.** There are two basic types of printed circuit connectors: edge connectors and two-piece connectors.

a. Edge connectors contain socket contacts that interconnect with pin contacts etched or printed on a printed circuit board.

b. Two-piece connectors consist of a mating member that is permanently attached to the board and another member connected to the equipment.

8 . **CONNECTOR SYSTEM.** A connector system (Figure 1) consists of two mating assemblies, a plug and a receptacle. The plug usually is on the end of a cable originating in a piece of equipment. The receptacle is usually fastened to a fixed structure or to piece of equipment.

9 . **RECEPTACLE ASSEMBLY.** The receptacle assembly is that part of the connector system that mates with the plug assembly, and is usually fixed to a wall, bulkhead, or equipment case. A receptacle consists of an insulator insert, contacts, and a shell. The contacts, whether pin or socket, do not alter the terminology of the receptacle.

10 . **PLUG ASSEMBLY.** The plug assembly is the removable part of the connector system that mates with the receptacle, and is usually attached to a cable. A plug consists of an insulator insert, contacts, shell, and

coupling mechanism. The contacts, whether pins or sockets, do not alter the terminology of the plug.

11 . **SHELL.** The shell is usually fabricated of plated aluminum, steel, or plastic, and supports and protects the insulator insert. Some receptacle shells are also used for mounting.

WARNING

Do not grind cadmium plated parts. Breathing airborne cadmium particles is a health hazard.

CAUTION

Only Cadmium plated connectors and accessories are approved for Navy applications.

12 . **Plating Types.** The following are typical shell plating and finish types: Cadmium over suitable underplate, electroless nickel, anodized, passivated, cadmium, gold and tin.

CAUTION

Nickel plated parts are not for Navy use or new design. They do not pass the aircraft corrosion requirement resulting in premature failure

13 . **POLARIZATION.** Polarization may be accomplished by a number of methods. See the paragraphs for the appropriate connector type for more details.

14 . **COUPLING.** No special tools are required for coupling rack and panel connectors.

15 . **MOUNTING.** Connectors shall be provided with means to fasten the shell securely to a mounting surface. Rack and panel connector shells are capable of being interchangeably mounted in a fixed or floating position. Fixed mounted connectors will mate properly with float mounted connectors. Shells are provided with either captive clinch nuts for fixed mounting or will be provided with or have provisions to allow installation of spring mounts, bushings, or guide pins. MIL-C-24308 class H and K connectors shall be provided with solder mounting provisions, or for provisions with external mounting hardware.

16 . **DESIGN AND CONSTRUCTION.** Connectors are designed and constructed to withstand normal handling incidental to installation and maintenance.

17 . **SERVICE CLASS.** Service class pertains to the environmental parameters in which the connector will operate successfully. These parameters include:

a. Environmental sealing.

b. Fuel and fluid resistance.

c. Vibration and shock.

d. Corrosion resistance.

e. Operating temperature.

f. Special conditions.

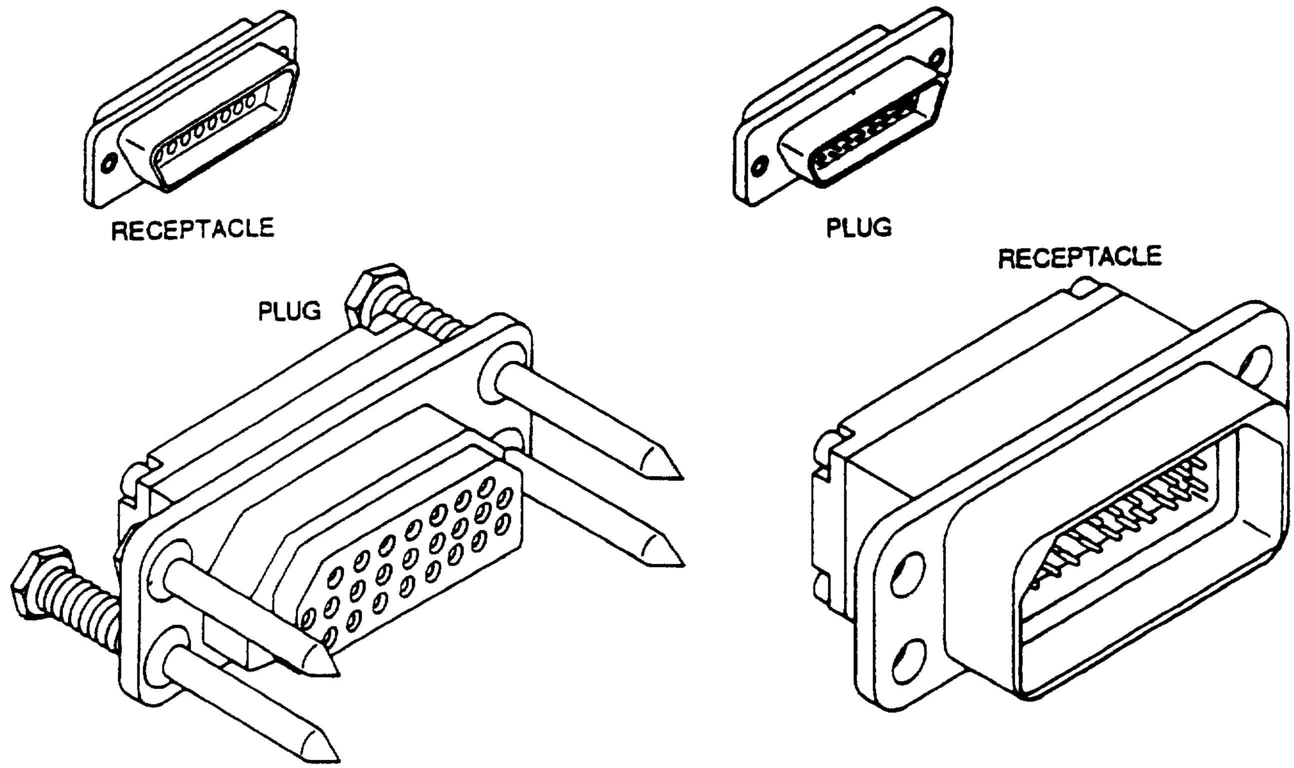


Figure 1. Typical Rack and Panel Connectors (Sheet 1 of 2)

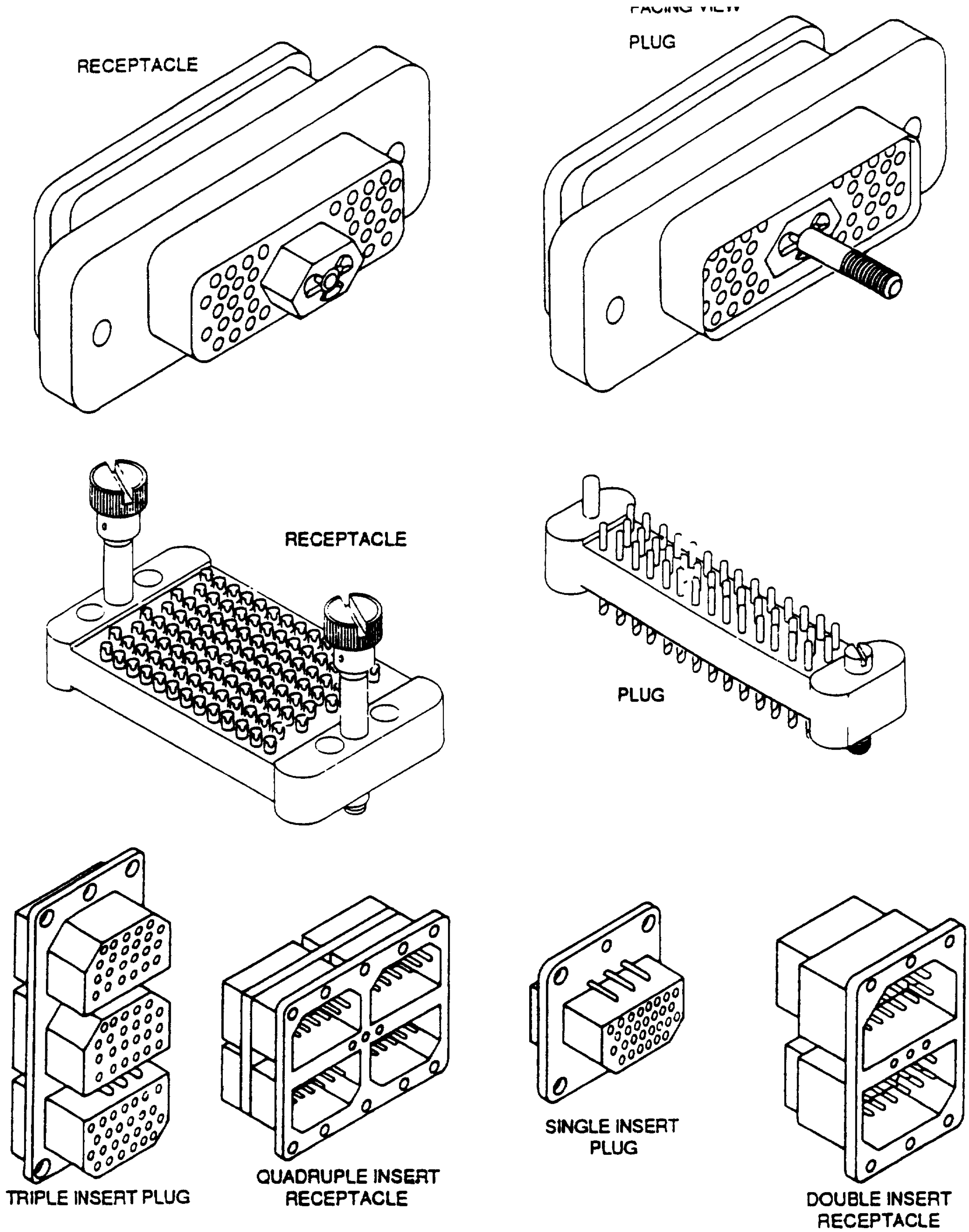


Figure 1. Typical Rack and Panel Connectors (Sheet 2)

18 . **INSERTS.** The entire insert is essentially one integral part, designed to provide suitable support around the wires and insulate the contacts from the shell as well as from other contacts. These inserts are usually constructed of a dielectric material such as rubber or plastic compositions, and are nonremovable. The rigid dielectric is one molded piece, or more than one piece bonded together. The insert design is such that the contacts are able to be inserted and removed to facilitate installation and maintenance, except when using hermetic receptacle in which the contacts are fixed in the insert. A connector contains either a pin insert or socket insert.

19 . **Contact Locking Devices.** In connectors with removable contacts, the contact locking devices are contained in the rigid dielectric and securely hold the contacts during normal coupling.

20 . **Insert Arrangement.** The insert arrangement indicates the service rating, and the quantity, size, and position of the contacts.

21 . **Service Rating.** The service rating defines the test voltage that can be applied between adjacent contacts or a contact and the connector shell without evidence of breakdown or flashover.

22 . **ENVIRONMENTAL SEALS.** The environmental seal is designed and utilized to prevent moisture from entering the connector and causing shorts. There are several types of seals.

23 . **Shell Seal.** This seal is effected when the plug shell pushes against the sealing ring in the receptacle when connectors are mated.

24 . **Peripheral Seal.** This seal is around the edge of the pin insulator, and designed so that when the connectors mate, tension is put on the seal and greatly reduces compression set.

25 . **Interfacial Seal.** This seal is normally a rubber seal bonded to the insert face with a hole pattern corresponding to the insert. The connector, when mated, compresses the interfacial seal forming the environmental seal around each contact.

26 . **Grommet Seal.** Some connectors have a grommet seal that is placed at the rear of the connector with a hole pattern corresponding to the insert. Inside the grommet are one or more seals that hold themselves against the wire to prevent moisture entry. Wire outside diameter must be within tolerances defined in the applicable connector specification to meet the sealing requirements. Undersized wire may be built up with heat shrinkable sleeving to the correct size.

27 . **Cable Seal.** When using jacketed cable. an adapter and special seal may be used. As the adapter clamp is tightened, the cable seal is compressed forming the environmental seal.

28 . **Hermetic Seal.** A glass-like material is used to insulate and seal the contacts, and all pin contacts will have an interfacial seal. The contacts are nonremovable.

29 . **GROMMET SEALING PLUGS.** The grommets of environmental resisting connectors are designed to accept sealing plugs in accordance with MS27488. Sealing plugs shall be used, in conjunction with unwired contacts, in all empty connectors cavities to maintain environmental sealing characteristics of the connector. The connector, when ordered as a unit, will have sealing plugs enclosed so as to equal 15% of the number of contacts, but not less than one.

30 . **Sealing Plug Selection.** Sealing plugs are sized according to contact size (Table 1).

31 . **Installation of Sealing Plugs.** When installing into cavities with contacts, the sealing plugs shall be installed knob end first and shall bottom on the contact wire barrel. Refer to specific connector type for correct installation of sealing plugs in each type of connector.

Table 1. Sealing Plug Selection

Contact size	Sealing Plug Part Number	Color
22	MS27488-22	Black
20	MS27488-20	Red
16	MS27488-16	Blue
12	MS27488-12	Yellow
8	MS27488-8	Red
4	MS27488-4	Blue
0	MS27488-0	Yellow

32 . **CONTACTS.** Contacts are the pins or sockets within the insert and may be either fixed or removable, solder or crimp. The contacts terminate the wire within the connector.

33 . **Fixed Contacts.** Solder contacts are normally fixed, but some connectors may have removable solder contacts. The contacts have either eyelet, solder cup, or solder post terminals. The wires are terminated to the contact through a solder cup or barrel on the contact, with solder (WP 016 00).

34 . **Wrap–post Contacts.** Wrap–post contacts are used for solderless wire wrapping, which is a reliable method for making point to point mechanical and electrical connections between wires and terminals. Wire wrapping may be used in any application where low–cost wiring is used. See Figure 2.

35 . **Crimp Contacts.** Crimp contacts are removable and utilize special tools to insert and remove the contacts. The contacts are crimped to the wire using standard crimp tools and positioners (WP 013 00).

36 . **Pre–wired.** Pre–wired/pre–pinned; maintenance is limited to the installation and connection of the wire or pin (for Printed Circuit Board (PCB) connectors).

37 . **Contact Availability.** Crimp contacts are supplied with each connector unit package and consist of a full complement plus one spare per size for connectors of 26 contacts or less. Connectors with more than 26 contacts will have two spares of each size used. Contacts may also be ordered in individual quantities when necessary.

38 . **INTERCHANGEABILITY.** All connectors having the same military part number are completely interchangeable with respect to installation and performance.

39 . <u>CONNECTOR INSTALLATION.</u>

40 . **INSTALLATION GUIDELINES.** Connectors shall be used to join cables to cables, equipment, components, or other wires. The following installation guidelines shall be followed:

a. Adequate space shall be provided for mating and unmating connectors without the use of tools.

b. Locate connectors so as not to provide footrests, handholds, or in areas not to be damaged by cargo or stored materials.

c. When possible, locate both plug and receptacles to be visible for engagements and orientation of polarizing keys.

d. Adequate strain relief shall be provided to prevent pulled wires.

e. Connectors in pressurized structures shall be installed preferably with the flange on the high pressure side.

f. Ground power receptacles shall be installed with the small contacts at the bottom.

41 . **ADJACENT INSTALLATION.** The use of identical connectors in adjacent locations shall be avoided. In situations where the use of identical connectors is unavoidable, adhere to the following guidelines:

a. Route and support wiring to prevent improper connections.

b. Where the same configurations are used, connectors shall be selected with different polarizations.

c. Color code plugs with a colored sleeve near the plug, and the receptacle color coded with a band on the structure.

42 . **CONNECTOR DRAINAGE.** Receptacles shall be positioned that when unmated for maintenance, fluids and condensation will drain from the receptacles. External connectors, connectors in engine compartments, wheel wells, and other like locations shall be given special attention to protect them from the entry of oil, moisture, and other fluids. Connectors shall not be mounted in fluid collecting areas.

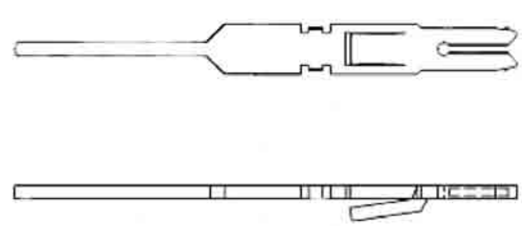


Figure 2. Solderless Wrap Tail Contact

43 . **CONNECTOR MAINTENANCE.**

44 . Before proceeding with maintenance, repair or installation, become familiar with the following warnings, cautions and notes, as each of these are pertinent throughout this section.

WARNING

Assure all power is off/disconnected prior to performing any wiring system repair

If the connector has a backshell, it must be removed before maintenance procedures can proceed (WP 025 00).

Safety glasses shall be worn during all wire cutting and stripping operations.

Isopropyl alcohol is highly flammable. Use only with adequate ventilation. Avoid prolonged breathing of vapors.

Unwired contact cavities must have contact and sealing plugs installed.

Metal tool tips are sharp and can cause injury to personnel and/or damage to the connector.

Use only approved heating tools when performing wire maintenance on or near aircraft that have not been defueled and purged, and certified gas–free in accordance with NAVAIR 01–1A–35 or AF T.O. 1–1–3. Use heating tools approved in WP 012 00.

Nozzle and output air of heating tools get very hot. Use extreme care while operating heating tools to avoid serious burns.

Use of nitrogen with the HT-900B/HT-920B heating tools in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from aircraft being repaired. Use electrical power from ground power unit.

CAUTION

Be careful if using metal M81969 tools. These tools can damage the wire sealing grommet in the connector if not used properly. Plastic tools are preferred when available.

Inspect tool tips for damage or distortion before each use. Damage to the connector wire sealing grommet can occur.

Avoid using metal tooling to remove and install backshells. These tools can damage the backshell and connector. Non-metallic tools are designed to wear before damaging connector or backshell (WP 025 00).

Do not remove a contact attached to a broken wire with an unwired contact removal tool. The connector and tool may be damaged.

Withdraw tool any time it cannot be advanced into connector. Inspect tool tip for nicks, cracks, mushrooming and other damage that will prevent proper functioning. Replace removal tool and repeat procedure if required.

45 . Refer to NAVAIR 01–1A–505–3 for specific connector type maintenance.

CONNECTOR ACCESSORIES

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Heating Tools	012 00
Military Standard Circuliar Connectors Summary of Actions	020 00
Military Standard Rectangular Connectors	023 00
Potting and Sealing Connectors, Electrical Cable Assemblies, and Electrical Components	025 00
Radio Frequency Connectors	022 00
Terminal Junction System	027 00
Aircraft Fuel Cells And Tanks	NAVAIR 01-1A-35
Alternatives to Cadium Plating	AIR5919
Connector Accessories, Electrical, General Specification for	SAE AS85049

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part. No./Type Designation
Adapter Tool	BT–S–389
Diagonal Cutters	—
Screwdriver, Flat	—
Spacer, 3/8 Dowel	—
Strap Wrench	—
T-Handle, 1/4 inch Drive	—
Heat Gun	HT-900B, HT-920B, HT–71002 or MCH–100–A
Wrench, Torque	0–150 in. lbs.

Materials Required

Nomenclature	Specification/Part No.
Glue, Epoxy	—
Tape Electrical Insulation, Self–Adhering, MIL–I–22444c	RL6000SA; NSN 5970–00–841–1172
Tape, Silicone	—

1. **INTRODUCTION.**

2. This work package (WP) describes connector accessories, their function, and availability by connector series as governed by applicable Military Specifications and Standards.

WARNING

When using a heat gun, do not use electrical power from the aircraft being repaired. Use electrical power from a ground power unit.

Use only approved heating tools when performing wire maintenance on or near aircraft that have not been defueled and purged, and certified gas−free in accordance with NAVAIR 01−1A−35 or AF T.O. 1−1−3. Use heating tools approved in WP 012 00.

This document includes cadmium as a plating material. The use of cadmium has been restricted adn/or banned for use in many countries due to environmental and health concerns. Consult applicable health and environmental regulations regarding its use, handling and disposition.

CAUTION

Do not let cable clamp fingers or saddle clamps directly contact the cable or harness. The amount of tape used must be at least one layer plus the amount needed to build up the cable for a secure fit of the clamp to the bundle when a hand is attached, or when screws are tightened to provide metal-to-metal contact.

The white dot on the adapter tool must be in line with the master key of the connector before the tool and connector are mated. Spinning the adapter tool on to the connector until it slips into place causes unnecessary wear on the tools, keys, and keyways.

When cutting heat-shrink sleeving with a sharp tool, do not nick or scrape the wire insulation.

Avoid using metal tooling to remove and install backshells. These tools can damage the backshell and connector. Non-metallic tools are designed to wear before damaging, the connector or backshell.

NOTE

For best results when applying silicone rubber tape, keep hands free of dirt and oil. When the assembly is completed, the leading edge of the tape should protrude 1/8 inch through the clamp.

3. **GENERAL.**

NOTE

Shielding of cable-to-connector termination is a very important and critical aspect of achieving electromagnetic compatibility in electrical wiring and cabling systems. The primary considerations in cable-to-connector EMI/RFI applications are to preserve connector integrity and obtaining optimum connector-to-cable compatibility. Complete electrical continuity, with a minimum voltage drop, between connector and cable or harness shielding can be obtained easily with proper selection of backshells and accessories.

4. **CIRCULAR CONNECTOR ACCESSORIES.** Circular connector accessories are components added to a connector to enhance the wiring system and/or EMC protection. These accessories include the following types:

5. **Backshells.** Backshells are components which are all inclusive of accessories that mount to the rear of the connector (paragraph 19).

6. **Conduit Fittings.** Conduit fittings are used to connect conduit, through which wires are routed to a connector, and may either be a ferrule or a hex nut.

7. **Dummy Receptacles.** Dummy receptacles have no pins or sockets, and shall be used to stow unmated plugs, caps, or protective covers when the related component is not in operational use. The dummy receptacle shall be marked and located to permit easy location and access.

8. **Dust Caps.** Dust caps are protective covers installed on connectors to prevent the intrusion of dirt and moisture.

9. **Gaskets for Flange Mounted Receptacles.** Gaskets are used to mount flanged receptacles to a structure to provide environmental protection or pressure sealing. Gaskets are made from silicone rubber (1) or conductive rubber (2), and the 1 or 2 will be the last dash number in the part number.

10. **Mounting Hardware.** Mounting hardware includes mounting screws, nuts, jam nuts, and mounting plates used to secure receptacles to structures. Mounting flanges are defined in the SAE AS85049 through MIL-C-85049/96 specification sheets.

11. **Rubber Bushings.** MS3420 standard color and material is black neoprene. Primary use is cushion for wires at the connector exit to aid in strain relief.

12. **Sealing Plugs.** Sealing plugs are inserted to fill a cavity in a connector insert. The function of the sealing plug is to seal all cavities occupied by unwired contacts.

13. **DESIGN AND CONSTRUCTION.** Connector accessories may be straight, or angled at 45 or 90 degrees.

NOTE

Spin coupling, self-locking circular connector accessories are preferred for Navy use.

14. **Safety Wire Holes.** When safety wire holes are required, there shall be a minimum of two holes equally spaced for shell size 14 or smaller, and at least three equally spaced holes for sizes 16 and larger. Holes shall be of a diameter sufficient to accommodate .020 inch diameter wire. For non-self-locking accessories, safety wire holes shall not be optional. Self-locking accessories shall not have safety wire holes on the coupling nut.

15. **Spin Coupling.** Spin coupling connector accessories have a coupling ring that is captivated to, and free to rotate on, the follower of the accessory. The spin coupling nut may be either self-locking or non-self-locking.

NOTE

The letter “S” in a M85049 accessory part number may represent the self-locking feature or stainless steel material. Review the part number breakdown for the component in question.

16. **Self-locking.** The self-locking device is a corrosion resistant material that provides either a positive detent or an internal captivated anti-decoupling device that maintains applied torque. Lockwire, set screws and/or locking compounds are not permitted as anti-coupling devices. The self-locking feature is identified in the part number by the letter “S”.

CAUTION

If connectors and accessories are not fully mated, the accessories may vibrate loose in application.

17. **Proper Mating of Connectors and Accessories.** The teeth of the connector and connector accessories need to mate “peak-to-valley” to ensure proper mating. If the teeth are peak to peak, the components may seem properly mated, but the teeth may eventually slide into the “peak-to-valley” position, causing the coupling ring to become loose (Figures 1 and 2). Install the accessory hand tight, then wiggle the accessory to allow the peaks of the teeth to slide past each other. Hand tighten the coupling ring again. Repeat this procedure until the accessory cannot be tighten.

CAUTION

Only Cadmium plated connectors and accessories are approved for Navy applications.

18. **Materials and Finishes.** The materials and finishes used in the construction of SAE AS85049 circular connector accessories are defined in Table 1. Elastomers and nylon are also used for some accessory subcomponents.

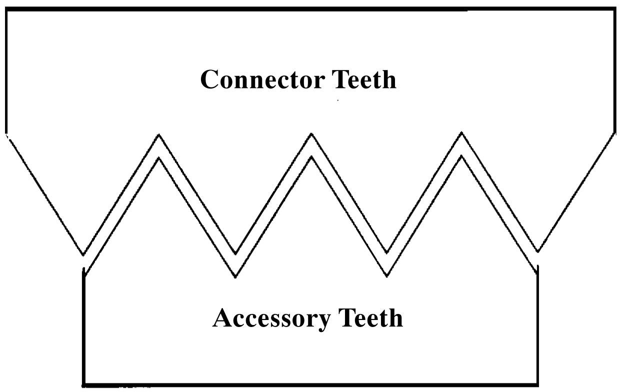


Figure 1. Proper (Peak-to-Valley) Position of Connector and Accessory Teeth in Mated Condition

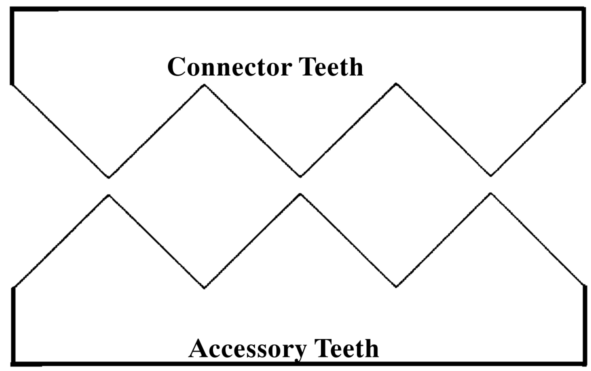


Figure 2. Improper (Peak-to-Peak) Position of Connector and Accessory Teeth in Mated Condition

Table 1. MIL-C-85049 Circular Connector Accessories Materials and Finishes

Component Material	Finish Designator	Finish Description
Aluminum		Black anodize
Aluminum	N	Electroless Nickel (Note 1)
Aluminum	W	Olive drab cadmium over suitable under late (Note 2)
Aluminum	P	Cadmium over electroless nickel (selective plating)
Corrosion resisting steel	B	Black Cadmium
Corrosion resisting steel	S	Passivated
Composite	J	Olive drab cadmium over suitable underplate, electrically conductive
Composite	M	Electrically conductive electroless nickel
Composite	T	Unplated
Composite	L	Cadmium over electroless nickel (selective plating)
NOTES: 1. Not for Navy use. 2. Not for space applications.		

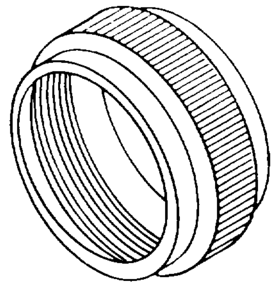


Figure 3. Typical Grommet Nut

CAUTION

Electroless Nickel as a material finish over aluminum alloy is not for Navy or Air Force use because it does not meet corrosion resistance requirements. Electroless Nickel as a finish over composite connectors is acceptable.

19. **BACKSHELLS.** Backshells are connector accessories that provide strain relief, environmental sealing, EMI shielding, and cable entry position. Backshells are divided into the following types:

20. **Grommet and Grommet Nuts.** Grommets are pliable seals placed on the cable side of the connector, with a hole pattern matching the insert configuration. The grommet holes are sized to seal to the wire upon insertion to prevent moisture and dirt contamination. The grommet nut is a threaded ring used to secure the grommet when a strain relief, backshell, shrink adapter, or potting ring is not used (Figure 3).

21. **Cable Clamp/Strain Relief.** A strain relief is a cable support or clamping device which attaches directly to the connector. The strain reliefs attach to the connector and absorb vibration and shock transmitted by the wires or cable to the contact connection. A cable clamp requires an intermediate component for attachment (Figure 4).

22. **Potting Rings and Boots.** Potting boots are plastic molds held in place by a threaded potting ring. They are used together to form a neat potting seal when used with potting or sealing compound (Figure 5).

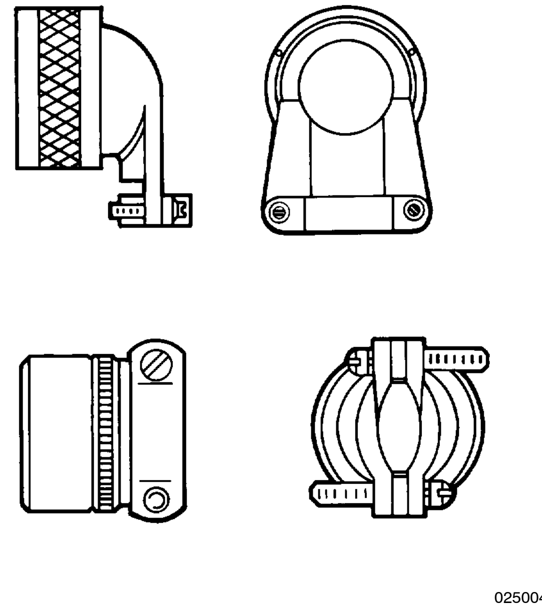


Figure 4. Typical Strain Relief

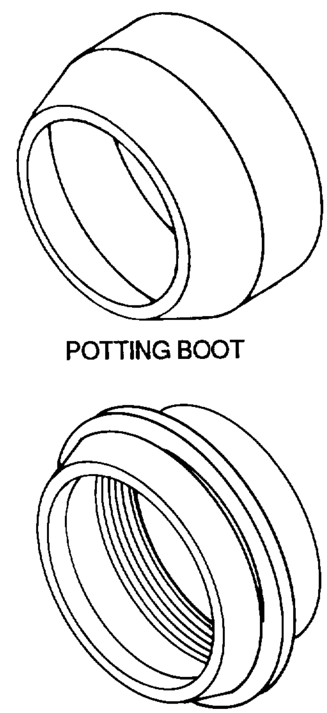


Figure 5. Typical Potting Ring and Boot

23. __Shrink Boot and Adapters.__ Shrink boots are heat shrinkable insulation sleeves used to insulate and seal the connector. Shrink boots are procured by the recovered or shrunk diameter. The adapter is a threaded coupling which attaches to the connector and to which the shrink boot seals (Figure 6).

24. __Non-Environmental Backshell.__ The nonenvironmental backshell is used when moisture entry protection is not required, but the need for additional space is required for maintenance (Figure 7).

25. __Environmental Backshell.__ The environmental backshell is used when moisture entry protection is required. This protection is afforded by the use of O-rings, extra grommets, and other sealing devices (Figure 8).

26. __EMI/RFI Grounding Terminator.__ The grounding terminators are a two piece unit used to ground the shield or shield terminations to a common point using a common lead (Figure 9). Ground terminators reduce electromagnetic radiation and radio frequency interference from other equipment. A physical anti-electrical shield is employed which is terminated at one or both end, to a ground or some other predetermined point with respect to the ground. The EMI/RFI grounding terminators are either bonding rings or ferrule assemblies. These grounding terminators are not to be confused with EMI/RFI backshells. Their function is to place all the shields within the cable at the same potential eliminating EMI/RFI potentials within the cable. Shields can be applied to individual wires, cables, bundle, or harness.

27. __Non-Environmental EMI/RFI Backshell.__ This type of backshell is used when moisture entry protection is not required, but the need for EMI/RFI is required (Figure 10).

28. __Environmental EMI/RFI Backshell.__ This type of backshell is used when moisture entry and EMI/RFI protection is required (Figure 11). Protection is afforded by the use of O-rings, grommets, and other sealing devices.

29. __Quick-Tye Strain Reliefs.__ Quick-Tye strain reliefs are installed with lacing tape instead of saddle clamps to secure the wires. The use of this type eliminates frequent tape wrapping to alter cable diameters for secure clamping (Figure 12).

30. __Banding Adapter.__ Banding adapters (Figure 13) provide 360 degree shield termination for overall shielded cables/harnesses. The 360 degree shield termination is accomplished by use of a shield terminating band that is pulled tightly around the backshell, trapping the shield between the backshell and the band.

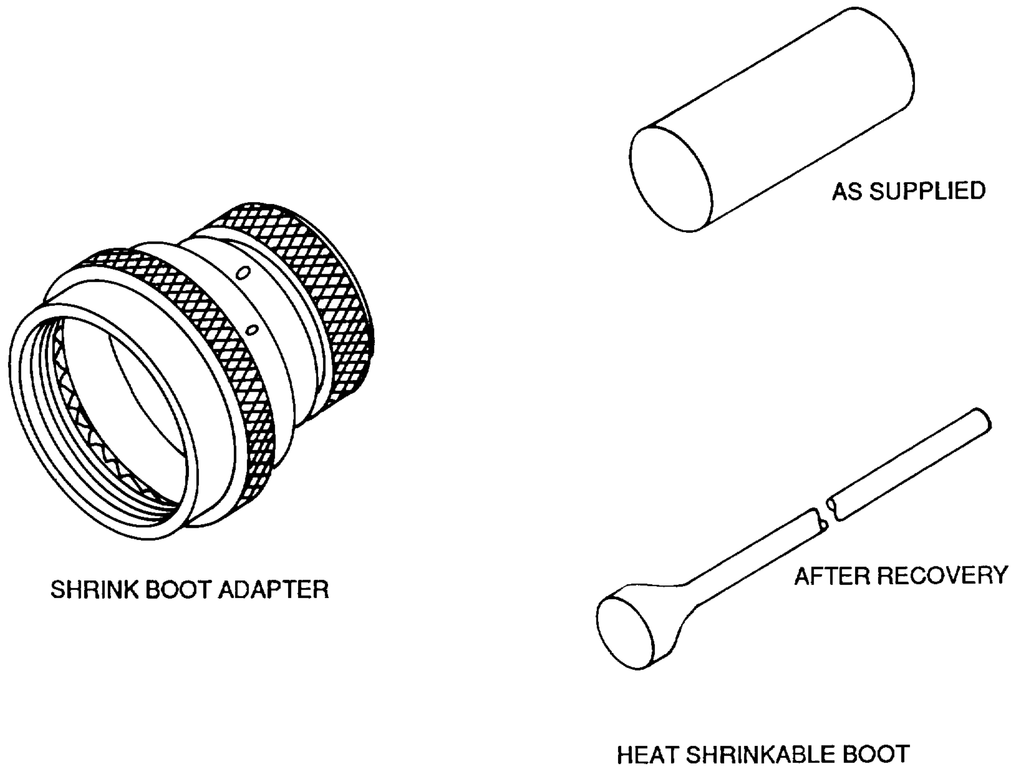


Figure 6. Typical Shrink Boot and Adapter.

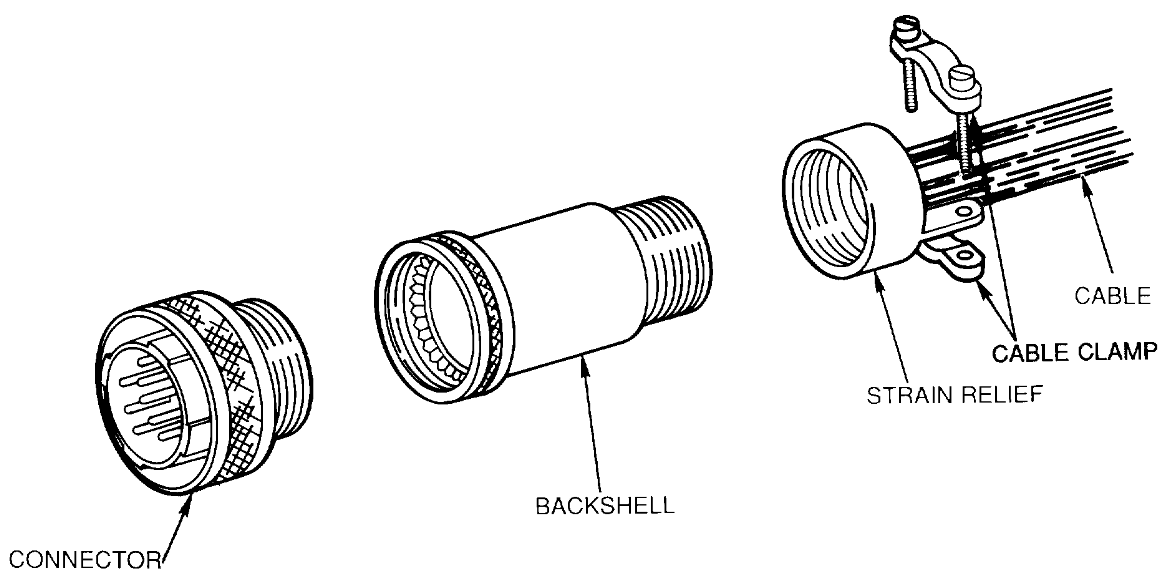


Figure 7. Typical Non−Environmental Backshell.

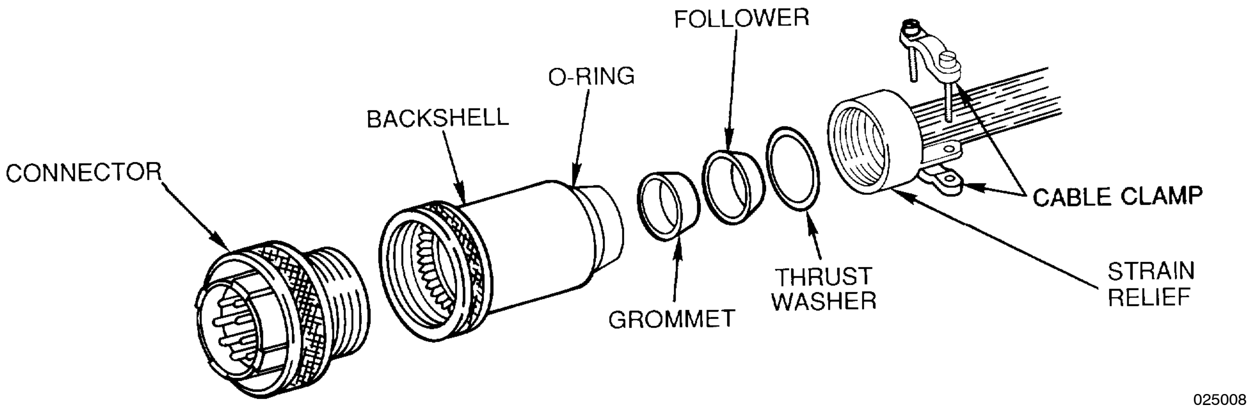


Figure 8. Typical Environmental Backshell.

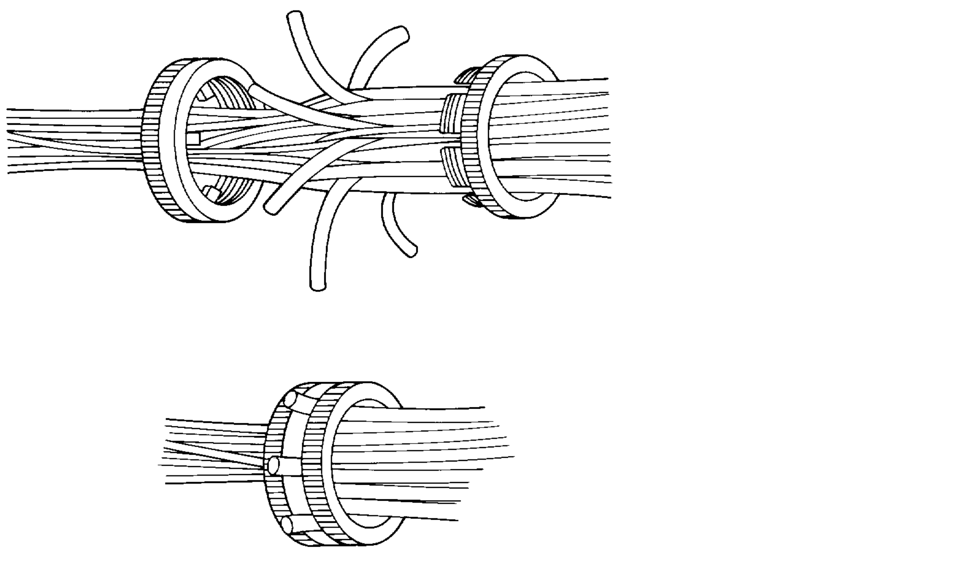


Figure 9. Grounding Terminator.

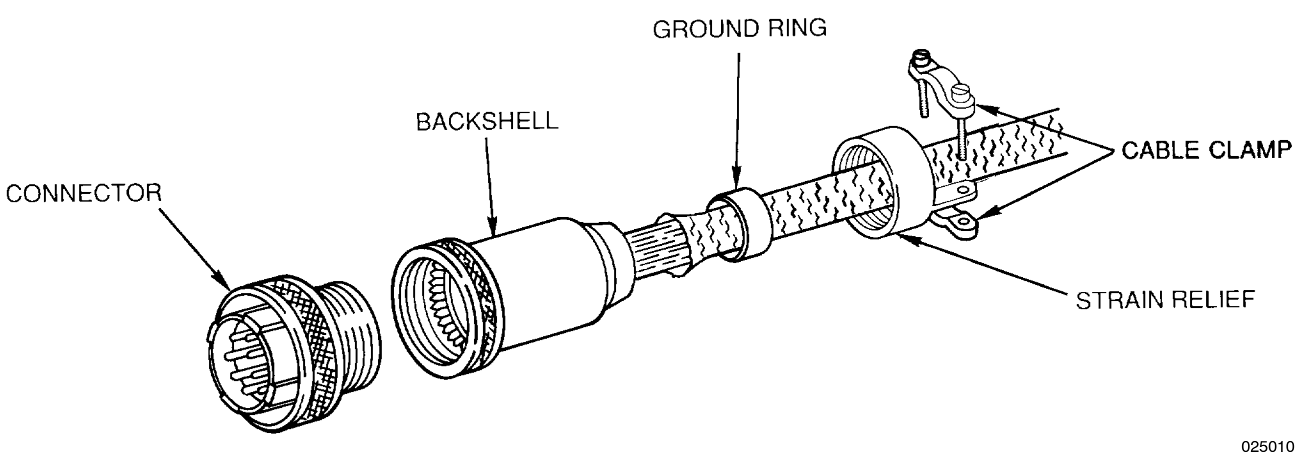


Figure 10. Typical Non–Environmental EMI/RFI Backshell.

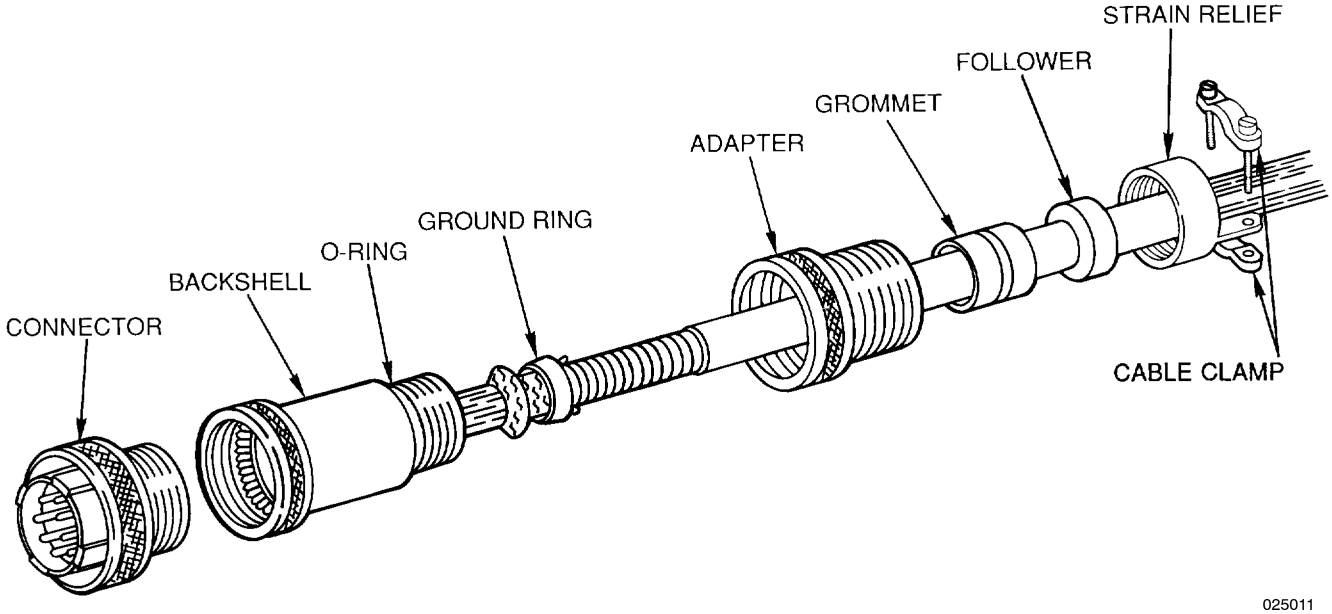


Figure 11. Typical EMI/RFI Environmental Backshells.

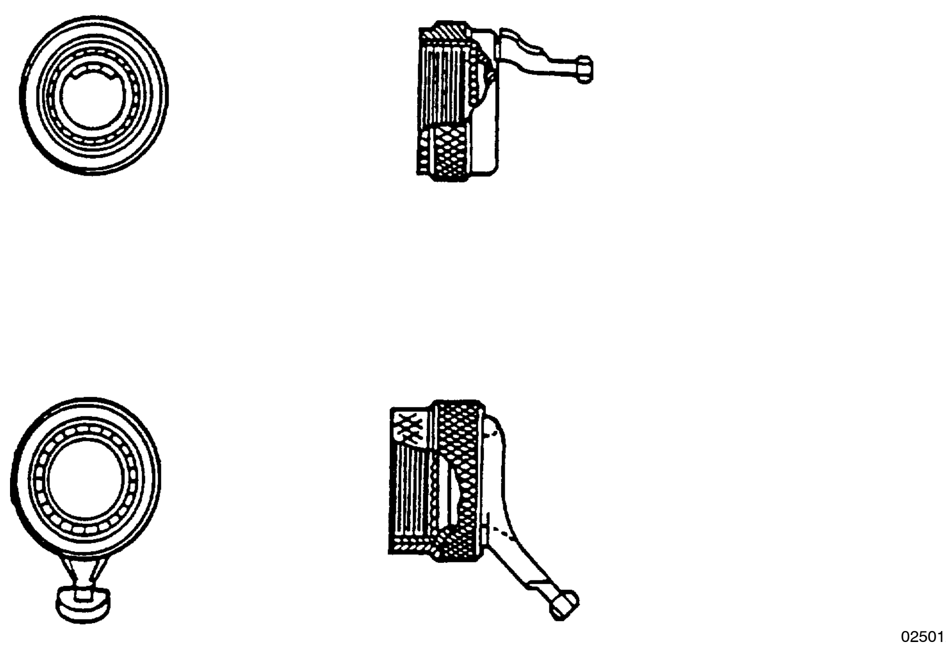


Figure 12. Quick-Tye Strain Reliefs.

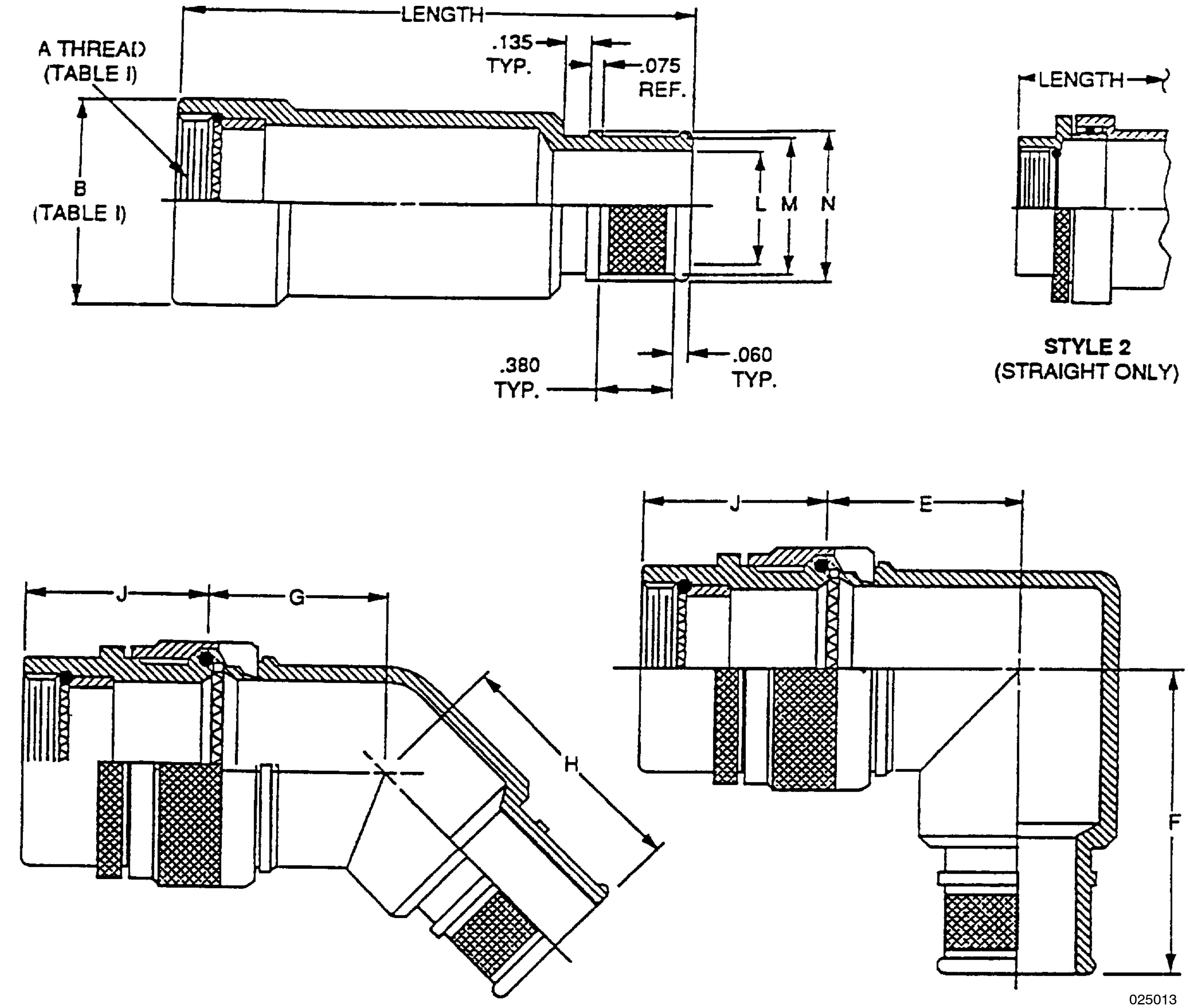


Figure 13. Banding Adapter

31. **MIL-C-29600 Composite Backshells.** MIL-C-29600 backshells (Figure 14) provide backshell to backshell EMI/RFI protection and increased corrosion resistant.

NOTE

MIL-C-29600 connectors are not for Navy use and have been declared not for use in new design. This does not preclude use for maintenance, repair, resupply purposes or in designs where the connectors must interface with Government Furnished Equipment.

32. **MIL-C-85049 CONNECTOR ACCESSORIES, ELECTRICAL, GENERAL SPECIFICATION FOR.** This specification covers accessories for use with electrical connectors under environmental and non-environmental conditions, and for the suppression of radio frequency and electromagnetic interference. The specification is applicable to connectors by type, category, and function in accordance with individual specification sheets.

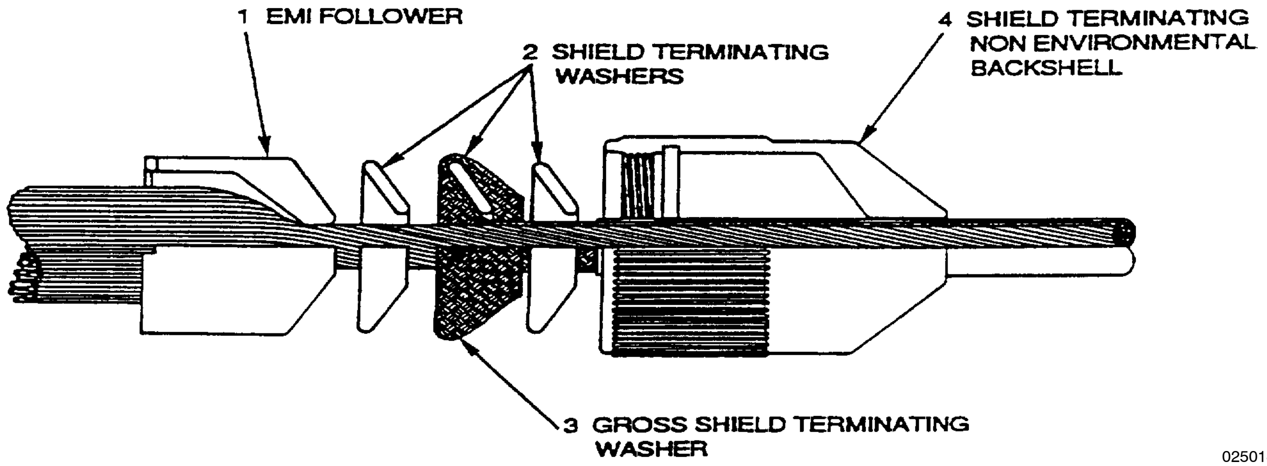


Figure 14. MIL-C-29600 Backshell to Backshell.

33. **Categories.** MIL-C-85049 connector accessories include. but are not limited to, the following categories:

a. 1A - Heavy duty, connector accessory, cable sealing, environmental

b. 1B - Medium duty, connector accessory, cable sealing,, environmental

c. 1C - Light duty, connector accessory, cable sealing, environmental

d. 2A - Heavy duty, connector accessory, environmental

e. 2B - Medium duty, connector accessory, environmental

f. 2C - Light duty, connector accessory, environmental

g. 3C - Heavy duty, connector accessory, nonenvironmental

h. 3B - Medium duty, connector accessory, nonenvironmental

i. 3C - Light duty, connector accessory, nonenvironmental

j. 4A - Heavy duty, connector accessory, strain relief. nonenvironmental

k. 4B - Medium duty, connector accessory, strain relief, nonenvironmental

l. 4C - Light duty, connector accessory, strain relief, nonenvironmental

m. 5 - Connector accessory, adapter, shrink boot and rink potting boot

n. 6 - Boots and sleeves, heat shrinkable (cancelled)

o. 7 - Connector accessory, miscellaneous devices

p. 8A - Connector accessory. adapter. conduit, cable sealing

q. 8B - Connector accessory, adapter. conduit, nonenvironmental

34. **Part Number Breakdown.** See the following part number examples. See the appropriate specification sheet for more details.

a. M85049/2-3C, where M85049 is the military designator
/2 is the specification sheet
-3C is the dash number

b. M85049/3Wl0A1, where M85049 is the military designator
/3 is the specification sheet
W is the finish
10 is the size number
A is the type
1 is the style

c. M85049/7-10W, where M85049 is the military designator

/7 is the specification sheet
-10 is the dash number
W is the finish

d. M85049/14S11W, where M85049 is the military designator
/14 is the specification sheet
S is for self-locking
11 is the shell size
W is the finish

e. M85049/1724W10A, where M85049 is the military designator
/17 is the specification sheet
24 is the shell size
W is the finish
10 is the clamp size
A is the length code

f. M85049/26-3-10W, where M85049 is the military designator
/26 is the specification sheet
-3 is the figure
-10 is the dash number
W is the finish

g. M85049/3724W01L, where M85049 is the military designator
/37 is the specification sheet
24 is the shell size
W is the finish
01 is the clamp size
L is for encapsulating hole
(D is for 3 drain holes)

h. M85049/45W10 where M85049 is the military designator
/45 is the specification sheet
W is the finish
10 is the dash number

i. M85049/47SW10 where M85049 is the military designator
/47 is the specification sheet
S is for self-locking
W is the finish
10 is the dash number

j. M85049/49-2S10S, where M85049 is the military designator
/49 is the specification sheet
-2 is nonsignificant
S is for self-locking
10 is the dash number
S is the finish

k. M85049/60-1W10, where M85049 is the military designator
/60 is the specification sheet
-1 is the figure
W is the finish
10 is the dash number

l. M85049/62-10WD, where M85049 is the military designator
/62 is the specification sheet
-10 is the dash number
W is the finish
D is the drain hole option

m. M85049/74-10-1, where M85049 is the military designator
/74 is the specification sheet
-10 is the shell size
-1 is the geometry (straight)

n. M85049/82-16P02, where M85049 is the military designator
/82 is the specification sheet
-16 is the shell size
P is the finish
02 is the entry size

o. M85049/31-10W, where M85049 is the military designator
/31 is the specification sheet
-10 is the shell size
W is the finish

p. M85049/52-1-12W, where M85049 is the military designator
/52-1 is the specification sheet
-12 is the shell size
W is the finish

q. M85049/51-1-14W, where M85049 is the military designator
/51-1 is the specification sheet
-14 is the shell size
W is the finish

35. **RECTANGULAR CONNECTOR ACCESSORIES.** Rectangular connector accessories are components added to a connector to enhance the wiring system and/or EMC protection. These accessories include the following types of components or variations of them.

36. **Shield Cover.** A shield cover is a variation of a backshell in that it protects the connections at the rear of the connector (Figure 15).

37. **Shield Cover with Clamps.** This accessory is a shield cover with an integral clamp (Figure 16).

38. **Potting Shell.** A potting shell is a form used with potting compound to provide a compound containment area (Figure 17).

39. **Dust Caps.** Dust caps are protective covers installed to prevent the intrusion of dirt and moisture (Figure 18). Also used to protect pins, sockets, and coupling devices.

40. **Strain Relief Clamps.** A strain relief clamp is a support or clamping device that attaches to the connector (Figure 19).

41. **Bushings.** Bushings are used to seal cable access into the shell, cover, or clamp (Figure 20).

42. **Mounting Gaskets.** Mounting gaskets are gaskets used to seal the connector and the mounting structure.

43. **Environmental Seals.** Environmental seals are used to prevent the intrusion of dirt and moisture into mated connectors (Figure 21).

44. **Retaining Plates.** Retaining plates are used for rack and panel mounting the connector. When a retaining plate is used, there is no shield.

45. **Shells.** The shell supports and protects the insulator and is used to mount the connector to the equipment. It is also used for the attachment of coupling and/or fields.

46. **Guidepins.** Guidepins are used to align plug and receptacle connectors during mating.

47. **Jackscrews.** Jackscrews are used to mate some plug and receptacle connectors.

48. **Environmental Backshells.** Environmental backshells are used when moisture entry protection is required. The protection is afforded by the use of gaskets, extra grommets, and other sealing devices.

49. **Non-environmental Backshells.** Non-environmental backshells are used when moisture protection is not required.

50. **Environmental EMI/RFI Backshells.** EMI/RFI backshells are designed to ground or shield a connector to reduce electromagnetic radiation and radio frequency interference from other equipment. This backshell is used when moisture entry and EMI/RFI protection is needed.

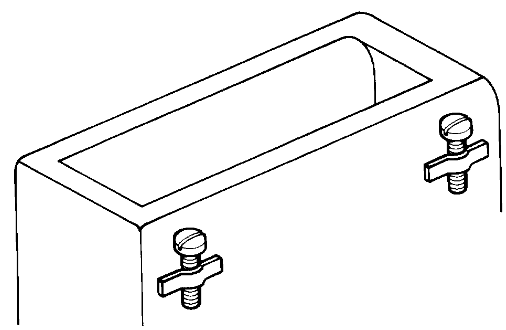


Figure 15. Typical Shield Cover

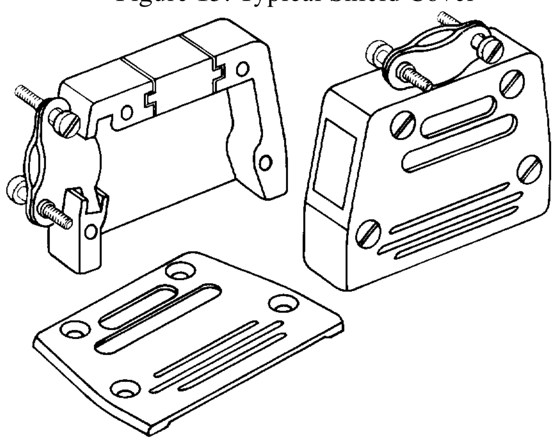


Figure 16. Typical Shield Cover with Clamp

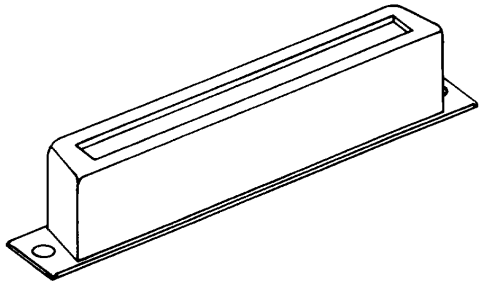
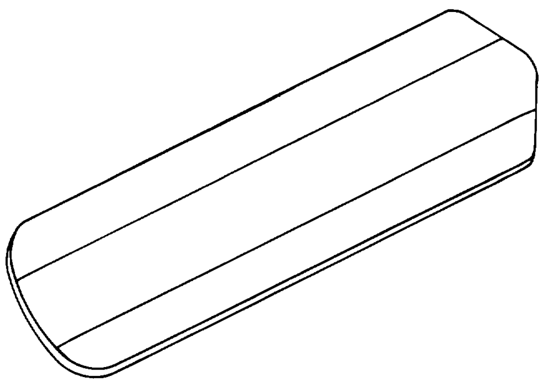
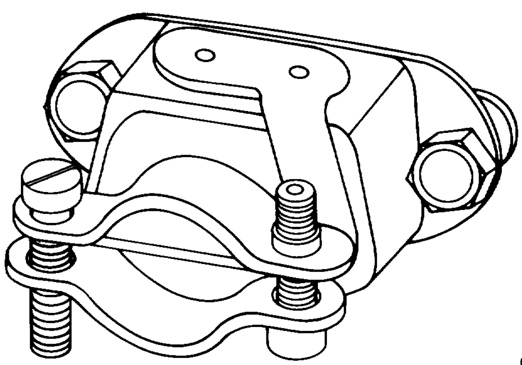


Figure 17. Typical Potting Shell.



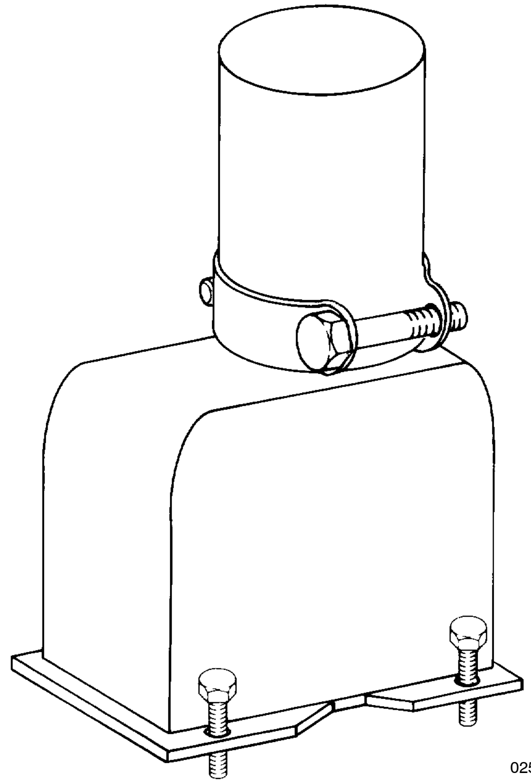
025018

Figure 18. Typical Dust Cap.



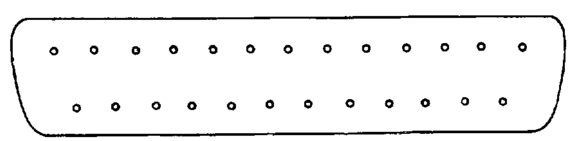
025019

Figure 19. Typical Strain Relief Clamp.



025020

Figure 20. Typical Bushing.



025021

Figure 21. Typical Environment Seal.

51. **MAINTENANCE ON CONNECTOR ACCESSORIES**

52. **CIRCULAR CONNECTOR ACCESSORY MAINTENANCE.**

53. **Special Tools.** Connector backshells come in a wide variety of types, depending on the application. To install backshells or accessories, adapter tools and a strap wrench are needed. Adapter tools are used to hold the connector during backshell installation and removal. The strap wrench is used to tighten or loosen the backshell. Special tools are used so as not to damage the connector shells or accessories.

54. **Adapter Tool Selection.** To select the proper adapter tool, the shell size, series, and type of connector plug or receptacle must be known (See 01–1A–505–2). The adapter tool is illustrated in Figure 22. Select the applicable tool from Tables 2 through 15 using the applicable connector specification.

55. **Adapter Tool Accessory.** To hold the adapter tool and to keep the connector from turning when installing or removing backshells, the use of a 1/4 inch drive T-handle is recommended. A strap wrench (Figure 23) is used on the backshell for installation and removal to apply end pressure without causing damage to accessories.

56. **Backshell Removal.** Backshells are used to protect, shield, and add strength to connectors. When modification or repair to the connector is necessary, the backshell must be removed. Proceed using the following steps:

a. Select the correct adapter tool by connector and series (Tables 2 through 15). For MIL-DTL-38999 Series III receptacles, use two strap wrenches.

b. Mate the adapter tool to the connector. Ensure the white dot on the adapter tool aligns with the master key of the connector. Spinning the tool on the connector will cause damage to the tool and/or the connector. MIL-C-38999 Series III receptacles use a mating plug and a second strap wrench. Mount the strap wrench on the mating plug, opposite to step c, to provide holding.

c. Install the strap wrench around the part to be removed. Draw the strap tightly through the locking link. The backshell will rest on the nose of the wrench (Figure 24).

d. Insert the T-handle into the socket of the adapter tool to provide holding (Figure 24).

e. To loosen the backshell. apply force counterclockwise as viewed from the connector rear (Figure 25).

f. Tape the backshell to the bundle to prevent loss.

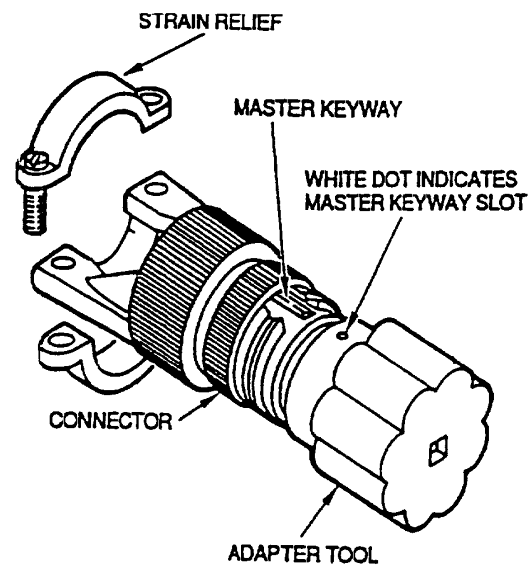


Figure 22. Adapter Tool (BT-S-389)

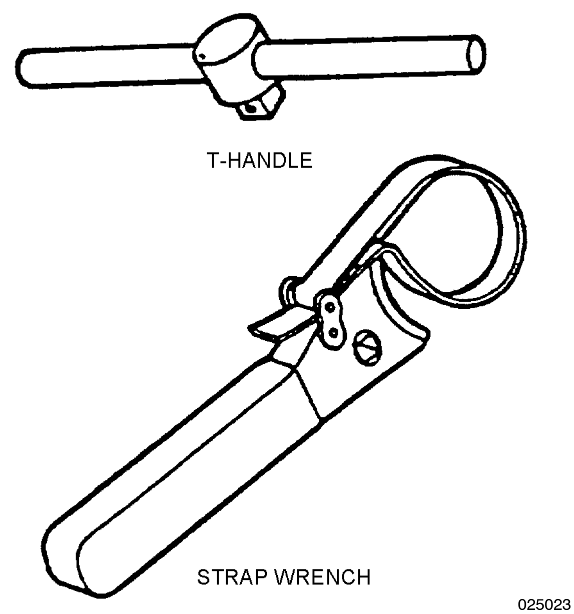


Figure 23. Adapter Tool Accessories

Table 2. MIL-C-38999 Series I Adapter Tool Selection

Individual Tool Part Numbers For Plugs	Shell Size	Keying Positions	Color Coding	Individual Tool Part Numbers For Receptacles	Shell Size	Keying Positions	Color Coding
BT389L-9	9	All	Blue	BT389LR-9	9	All	Blue
BT389L-11	11	All	Blue	BT389LR-11	11	All	Blue
BT389L-13	13	All	Blue	BT389LR-13	13	All	Blue
BT389L-15	15	All	Blue	BT389LR-15	15	All	Blue
BT389L-17	17	All	Blue	BT389LR-17	17	All	Blue
BT389L-19	19	All	Blue	BT389LR-19	19	All	Blue
BT389L-21	21	All	Blue	BT389LR-21	21	All	Blue
BT389L-23	23	All	Blue	BT389LR-23	23	All	Blue
BT389L-25	25	All	Blue	BT389LR-25	25	All	Blue

Table 3. MIL-C-38999 Series II Adapter Tool Selection

Individual Tool Part Numbers For Plugs	Shell Size	Keying Positions	Color Coding	Individual Tool Part Numbers For Receptacles	Shell Size	Keying Positions	Color Coding
BT389S-8	8	All	Gray	BT264R-8	8	All	Orange
BT389S-10	10	All	Gray	BT264R-10	10	All	Orange
BT389S-12	12	All	Gray	BT264R-12	12	All	Orange
BT389S-14	14	All	Gray	BT264R-14	14	All	Orange
BT389S-16	16	All	Gray	BT264R-16	16	All	Orange
BT389S-18	18	All	Gray	BT264R-18	18	All	Orange
BT389S-20	20	All	Gray	BT264R-20	20	All	Orange
BT389S-22	22	All	Gray	BT264R-22	22	All	Orange
BT389S-24	24	All	Gray	BT264R-24	24	All	Orange

Table 4. MIL-DTL-38999 Series III Adapter Tool Selection

Individual Tool Part Numbers	Shell Size	Keying Positions	Color Coding
BT389T-9A	9	N,C,D	Lavender
BT389T-11A	11	N,D,E	Lavender
BT389T-13A	13	N,D,E	Lavender
BT389T-15A	15	N,D,E	Lavender
BT389T-17A	17	N,A,B	Lavender
BT389T-19A	19	N,A,B	Lavender
BT389T-21A	21	N,A,B	Lavender
BT389T-23A	23	N,A,B	Lavender

Table 4. MIL-DTL-38999 Series III Adapter Tool Selection (Cont)

Individual Tool Part Numbers	Shell Size	Keying Positions	Color Coding
BT389T-25A	25	N,A,B	Lavender
BT389T-9B	9	A,B,E	Lavender
BT389T-11B	11	A,B,C	Lavender
BT389T-13B	13	A,B,C	Lavender
BT389T-15B	15	A,B,C	Lavender
BT389T-17B	17	C,D,E	Lavender
BT389T-19B	19	C,D,E	Lavender
BT389T-21B	21	C,D,E	Lavender
BT389T-23B	23	C,D,E	Lavender
BT389T-25B	25	C,D,E	Lavender

Table 5. MIL-DTL-38999 Series IV Adapter Tool Selection

Individual Tool Part Numbers For Plugs	Shell Size	Keying Positions	Color Coding	Individual Tool Part Numbers For Receptacles	Shell Size	Keying Positions	Color Coding
BT389B-11	11	All	Beige	BT389BR-11	11	All	Beige
BT389B-13	13	All	Beige	BT389BR-13	13	All	Beige
BT389B-15	15	All	Beige	BT389BR-15	15	All	Beige
BT389B-17	17	All	Beige	BT389BR-17	17	All	Beige
BT389B-19	19	All	Beige	BT389BR-19	19	All	Beige
BT389B-21	21	All	Beige	BT389BR-21	21	All	Beige
BT389B-23	23	All	Beige	BT389BR-23	23	All	Beige
BT389B-25	25	All	Beige	BT389BR-25	25	All	Beige

Table 6. MIL-C-81511 Series 1 Adapter Tool Selection

Individual Tool Part Numbers for Plugs	Shell Size	Keying Positions	Color Coding
BT815L-8A	8	1,2,3	Yellow
BT815L-10A	10	1,2,6	Yellow
BT815L-14A	14	1,2,6	Yellow
BT815L-16A	16	1,2,3	Yellow
BT815L-18A	18	1,2,3	Yellow
BT815L-20A	20	1,2,3	Yellow
BT815L-22A	22	1,2,3	Yellow
BT815L-24A	24	1,2,3	Yellow
BT815L-8B	8	4,5,6	Yellow
BT815L-10B	10	3,4,5	Yellow
BT815L-14B	14	3,4,5	Yellow
BT815L-16B	16	4,5,6	Yellow
BT815L-18B	18	4,5,6	Yellow
BT815L-20E	20	4,5,6	Yellow
BT815L-22B	22	4,5,6	Yellow
BT815L-24B	24	4,5,6	Yellow
CM815L-8A	8	1,2,3	Yellow
CM815L-10A	10	1,2,6	Yellow
CM815L-14A	14	1,2,6	Yellow
CM815L-16A	16	1,2,3	Yellow
CM815L-18A	18	1,2,3	Yellow
CM815L-20A	20	1,2,3	Yellow
CM815L-22A	22	1,2,3	Yellow
CM815L-24A	24	1,2,3	Yellow
CM815L-8B	8	4,5,6	Yellow
CM815L-10B	10	3,4,5	Yellow
CM815L-14B	14	3,4,5	Yellow
CM815L-16B	16	4,5,6	Yellow
CM815L-18B	18	4,5,6	Yellow
CM815L-20B	20	4,5,6	Yellow
CM815L-22B	22	4,5,6	Yellow
CM815L-24B	24	4,5,6	Yellow

Table 7. MIL-C-81511 Series 2 Adapter Tool Selection

Individual Tool Part Numbers for Plugs	Shell Size	Keying Positions	Color Coding
CM815S-8A	8	All	Red
CM815S-10A	10	1,4,5	Red
CM815S-14A	14	1,4,5	Red
CM815S-16A	16	1,2,4	Red
CM815S-18A	18	1,2,4	Red
CM815S-10B	10	2,3,6	Red
CM815S-14B	14	2,3,6	Red
CM815S-16B	16	3,5,6	Red
CM815S-18B	18	3,5,6	Red
BT815S-8	8	All	Red
BT815S-10A	10	1,4,5	Red
BT815S-14A	14	1,4,5	Red
BT815S-16A	16	1,2,4	Red
BT815S-18A	18	1,2,4	Red
BT815S-10B	10	2,3,6	Red
BT815S-14B	14	2,3,6	Red
BT815S-16B	16	3,5,6	Red
BT815S-18B	18	3,5,6	Red

Table 8. MIL-C-81511 Series 3 Adapter Tool Selection

Individual Tool Part Number for Plugs	Shell Size	Keying Positions	Color Coding
BT815L-8A	8	1,2,3	Yellow
BT815L-10A	10	1,2,6	Yellow
BT815L-14A	14	1,2,6	Yellow
BT815L-16A	16	1,2,3	Yellow
BT815L-18A	18	1,2,3	Yellow
BT815L-20A	20	1,2,3	Yellow
BT815L-22A	22	1,2,3	Yellow
BT815L-24A	24	1,2,3	Yellow
BT815L-8B	8	4,5,6	Yellow
BT815L-10B	10	3,4,5	Yellow
BT815L-14B	14	3,4,5	Yellow
BT815L-16B	16	4,5,6	Yellow
BTS15L-18B	18	4,5,6	Yellow
BT815L-20B	20	4,5,6	Yellow
BT815L-22B	22	4,5,6	Yellow
BT815L-24B	24	4,5,6	Yellow
CM815L-8A	8	1,2,3	Yellow
CM815L-10A	10	1,2,6	Yellow
CM815L-14A	14	1,2,6	Yellow
CM815L-16A	16	1,2,3	Yellow
CM815L-18A	18	1,2,3	Yellow
CM815L-20A	20	1,2,3	Yellow
CM815L-22A	22	1,2,3	Yellow
CM815L-24A	24	1,2,3	Yellow
CM815L-8B	8	4,5,6	Yellow
CM815L-10B	10	3,4,5	Yellow
CM815L-14B	14	3,4,5	Yellow
CM815L-16B	16	4,5,6	Yellow
CM815L-18B	18	4,5,6	Yellow
CM815L-20B	20	4,5,6	Yellow
CM815L-22B	22	4,5,6	Yellow
CM815L-24B	24	4,5,6	Yellow

Table 9. MIL-C-81511 Series 4 Adapter Tools Selection

Individual Tool Part Number For Plugs	Shell Size	Keying Positions	Color Coding
CM815S-8A	8	All	Red
CM815S-10A	10	1,4,5	Red
CM815S-14A	14	1,4,5	Red
CM815S-16A	16	1,2,4	Red
CM815S-18A	18	1,2,4	Red
CM815S-10B	10	2,3,6	Red
CM815S-14B	14	2,3,6	Red
CM815S-16B	16	3,5,6	Red
CM815S-18B	18	3,5,6	Red
BT815S-8A	8	All	Red
BT815S-10A	10	1,4,5	Red
BT815S-14A	14	1,4,5	Red
BT815S-16A	16	1,2,4	Red
BT815S-18A	18	1,2,4	Red
BT815S-10B	10	2,3,6	Red
BT815S-14B	14	2,3,6	Red
BT815S-16B	16	3,5,6	Red
BT815S-18B	18	3,5,6	Red

Table 10. MIL-C-83723 Adapter Tools Selection

Connector Family	Shell Size	Adapter Adapter Set P/N		Adapters In Set
		Plug	Receptacle	
MIL-C 83723 Series I	8 thru 24	CM-S-264	CM-S-264R	9
MIL-C-83723 Series II	8 thru 48	CMS-5015	CM-S-5015R	15
MIL-C-83723 Series III	8 thru 24	CM-S-837	CM-S-837RB	20 9

Table 11. MIL-C-5015 Adapter Tool Selection

Shell Size	Polarization	Adapter Tool Part Number			
		Plug	Color Code	Receptacle	Color Code
8	All	CM5015-8	Chrome	CM5015R-8	Chrome
10	All	CM5015-10	Chrome	CM5015R-10	Chrome
12	All	CM5015-12	Chrome	CM5015R-12	Chrome
14	All	CM5015-14	Chrome	CM5015R-14	Chrome
16	All	QM5015-16	Chrome	CM5015R-16	Chrome
18	All	CM5016-18	Chrome	CM5015R-18	Chrome
20	All	CM5015-20	Chrome	CM501SR-20	Chrome
22	All	CM5015-22	Chrome	CM5015R-22	Chrome
24	All	CM5015-24	Chrome	CM5015R-24	Chrome
26	All	CM5015-26	Chrome	CM5015R-26	Chrome
28	All	CM5015-28	Chrome	CM5015R-28	Chrome
32	All	CM5015-32	Chrome	CM5015R-32	Chrome
36	All	CM5015-36	Chrome	CM5015R-36	Chrome
40	All	CM5015-40	Chrome	CM5015R-40	Chrome
44	All	CM5015-44	Chrome	CM5015R-44	Chrome
48	All	CM5015-48	Chrome	CM5015R-48	Chrome

Table 12. MIL-C-26482 Series 1 and 2 Adapter Tool Selection

Connector Family	Shell Size	Polarization	Part Number			
			Plug	Color Code	Receptacle	Color Code
MIL-C-26482, Series I & II	8	All	BT264-8	Orange	BT264R-8	Orange
MIL-C-26482, Series I & II	10	All	BT264-10	Orange	BT264R-10	Orange
MIL-C-26482, Series I & II	12	All	BT264-12	Orange	BT264R-12	Orange
MIL-C-26482, Series I & II	14	All	BT264-14	Orange	BT264R-14	Orange
MIL-C-26482, Series I & II	16	All	BT264-16	Orange	BT264R-16	Orange
MIL-C-26482, Series I & II	28	All	BT264-18	Orange	BT264R-18	Orange
MIL-C-26482, Series I & II	20	All	BT264-20	Orange	BT264R-20	Orange
MIL-C-26482, Series I & II	22	All	BT264-22	Orange	BT264R-22	Orange
MIL-C-26482, Series I & II	24	All	BT264-24	Orange	BT264R-24	Orange

Table 13. SAE-AS26500 Adapter Tools Selection

Shell Size	Polarization	Part Number Plug	Color Code	Receptacle	Color Code
8	All	BT264-8	Orange	BT264R-8	Orange
10	All	BT264-10	Orange	BT264R-10	Orange
12	All	BT264-12	Orange	BT264R-12	Orange
14	All	BT264-14	Orange	BT264R-14	Orange
16	All	BT264-16	Orange	BT264R-16	Orange
18	All	BT264-18	Orange	BT264R-18	Orange
20	All	BT264-20	Orange	BT264R-20	Orange
22	All	BT264-22	Orange	BT264R-22	Orange
24	All	BT264-24	Orange	BT264R-24	Orange

Table 14. MIL-C-81703 Adapter Tool Selection

Shell Size	Polarization	Part Number Plug	Part Number Color Code	Receptacle	Color Code
8	All	BT265-8	Orange	BT265-8	Orange
10	All	BT264-10	Orange	BT264-10	Orange
12	All	BT264-12	Orange	BT264-12	Orange
14	All	BT264-14	Orange	BT264-14	Orange
16	All	BT264-16	Orange	BT264-16	Orange
18	All	BT264-18	Orange	BT264-18	Orange
20	All	BT264-20	Orange	BT264-20	Orange
22	All	BT264-22	Orange	BT264-22	Orange
24	All	BT264-24	Orange	BT264-24	Orange

Table 15. NAS1599 Adapter Tool Selection

Shell Size	Polarization	Adapter Tool Pin P/N Plug	Color Code	Receptacle	Color Code
8	All	CM264-8	Orange	CM264R-8	Orange
10	All	CM264-10	Orange	CM264R-10	Orange
12	All	CM264-12	Orange	CM264R-12	Orange
14	All	CM264-14	Orange	CM264R-14	Orange
16	All	CM264-16	Orange	CM264R-16	Orange
18	All	CM264-18	Orange	CM264R-18	Orange
20	All	CM264-20	Orange	CM264R-20	Orange
22	All	CM264-22	Orange	CM264R-22	Orange
24	All	CM264-24	Orange	CM264R-24	Orange

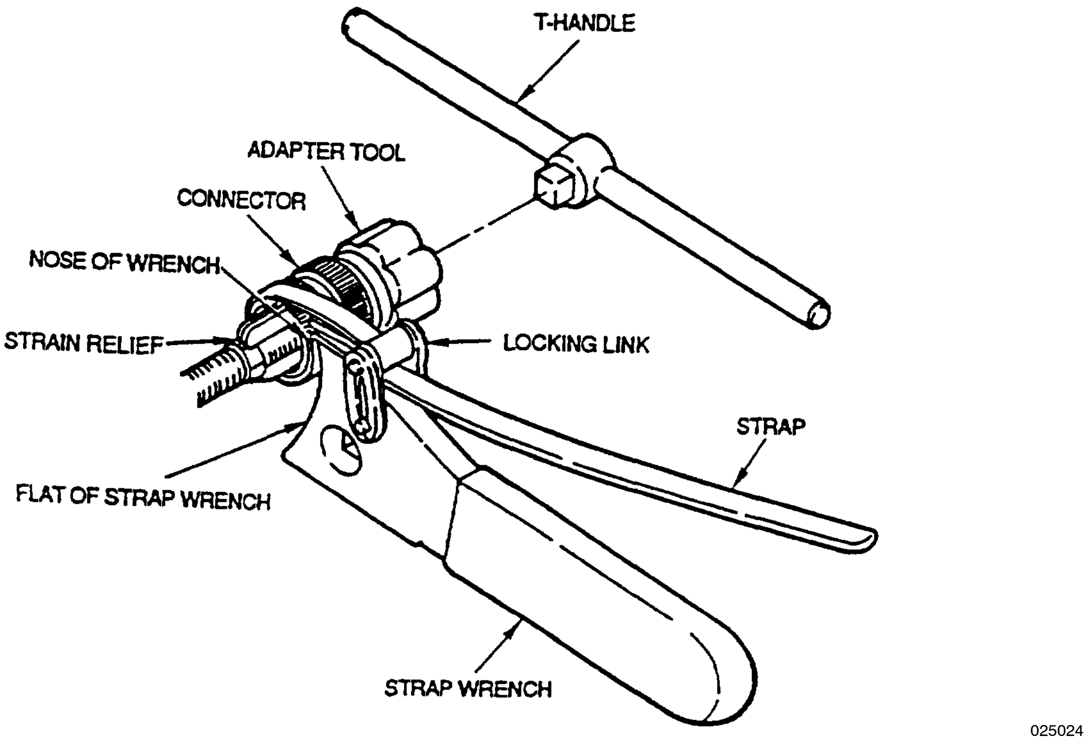


Figure 24. Strap Wrench Set-up and Adjustment

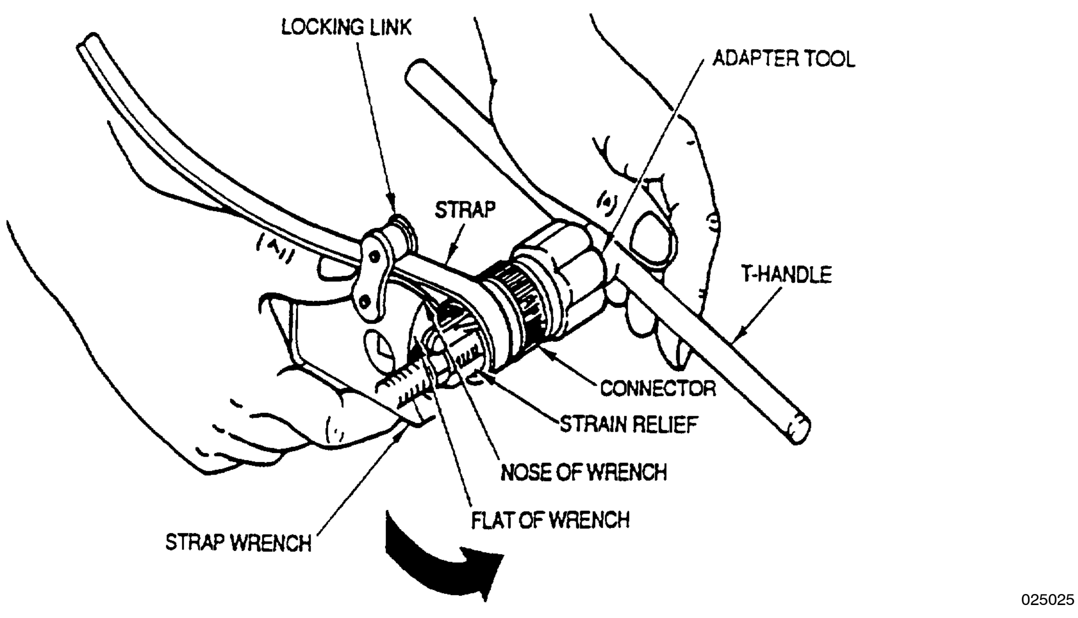


Figure 25. Loosening Position of Wrench

57. **Backshell Installation.** Upon completion of maintenance or modification, the backshell must be replaced. Proceed using the following steps:

a. Untape the backshell from the bundle. Start threading the backshell onto the connector by hand to prevent cross threading.

b. Select the correct adapter tool from the appropriate table, and a T-handle and strap wrench. Select two strap wrenches for MIL-DTL-38999 Series III connectors.

c. Mate the adapter tool to the connector. Ensure the white dot on the adapter tool aligns with the master keyway of the connector. Spinning the tool on the connector will cause damage to the tool and/or the connector (Figure 24). MIL-DTL-38999 Series III receptacles use a mating plug and a second strap wrench. Mount the strap wrench on the mating plug, opposite to step d, to provide holding.

d. Install the strap wrench around the part to be installed. Draw the strap tightly through the locking link. The backshell will rest on the nose of the wrench (Figure 24).

e. Insert the T-handle into the socket of the adapter tool to provide holding (Figure 24).

NOTE

Refer to WP 011 01, Table 1, for torque value information for SAE AS85049 connector accessories and backshells.

f. To tighten the backshell, apply a clockwise force as viewed from the connector rear (Figure 26).

58. **Cable Clamp-Type Strain Relief Removal.** To remove this type of strain relief, use the following procedure (Figure 27):

a. Loosen saddle clamp screws.

b. Unwrap any reinforcing silicone tape.

c. Remove strain relief using tools and tool procedure for backshell removal (paragraph 56).

d. Perform connector repair.

59. **Cable Clamp-Type Strain Relief Installation.** Upon completion of the connector repair, install the strain relief using the following procedure (Figure 27):

a. Wrap cable with reinforcing silicone tape (MIL−L−22444C, 5970−00−841−1172) to build cable diameter where necessary.

b. Install the strain relief using the tools and tool procedure for backshell installation (paragraph 57).

c. Restore the proper dress of wire at the connector. The wire should not elongate the grommet holes, be pulled tightly, or be kinked (Figure 28).

NOTE

A light coating of sealing compound (Vibra−Tite Formula 3, NSN: 8030−00−163−5792 which contains MEK) may be applied to connector clamp attachment screws. Use this sealant until exhausted, then use the following alternate compound: Vibra−Tite Formula 5 (NSN: pending, contains no MEK).

Refer to aircraft technical documentation or Cognizant Engineering Authority (CEA) for specific sealing compound application requirements due to specific hazardous material regulations for each state and operating area.

d. Tighten the screws in the saddle clamp to provide firm gripping and to prevent wire movement without damage or crushing.

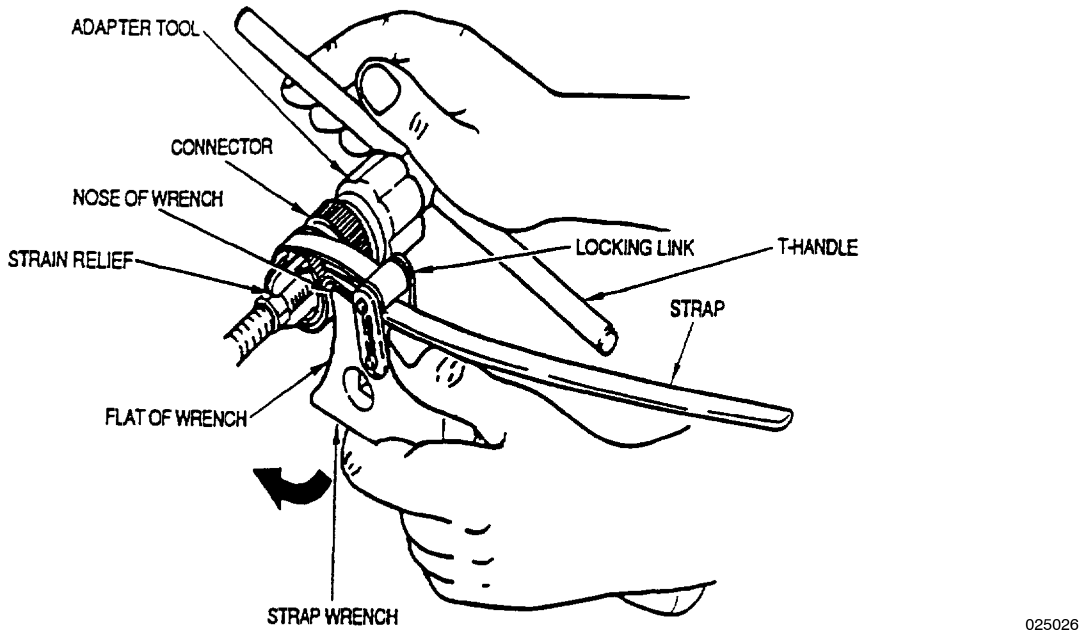


Figure 26. Tightening Position of Wrench

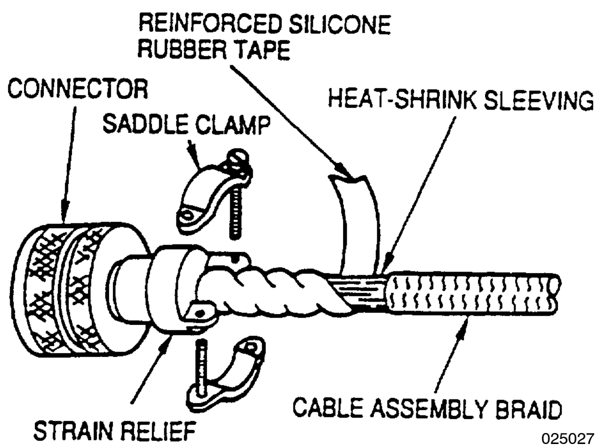


Figure 27. Saddle Clamp Removal/Installation

60. **Quick-Tye Strain Relief Removal.** When connector repair is necessary, remove the Quick Tye strain relief using the following procedure:

a. Cut the lacing tape that secures the cable or wires to the strain relief.

b. Remove the strain relief using the tools and procedure for backshell removal (paragraph 56).

c. Perform the connector repair.

61. **Quick-Tye Strain Relief Installation.** Upon completion of the connector repair, install the Quick-Tye strain relief as follows (Figure 29):

a. Install the Quick-Tye strain relief using the tools and procedures for backshell installation (paragraph 57).

b. Use silicone tape (MIL–L–22444C, 5970–00–841–1172) to wrap a cushion strip around the wire bundle where it contacts the Quick-Tye arm.

c. Use a 3/8 inch dowel or similar spacer aid between the connector and 90 degree Quick-Tye arm.

d. Using lacing tape, wrap the tape around the wires. then around the Quick-Tye arm. Keep wires slack so as to not distort the connector grommet.

e. Tie the lacing tape so as to not damage or crush the wire or insulation, but tighten enough to prevent the wire from shifting.

f. Remove the spacer.

62. **Potting Boot and Ring Removal.** To gain access to the connector for repair, the potting ring and boot must be removed using the following procedure:

a. Using, diagonal cutters, cut the potting boot lengthwise.

b. Peel the boot and sealant from the connector.

c. Remove the potting ring using the tools and procedure for backshell removal (paragraph 56).

d. When the connector plug is removed, slide a new potting boot and ring onto the cable.

e. When the connector is not removed, do not discard the potting boot. Salvage the boot.

f. Perform the connector repair.

63. **Potting Ring and Boot Installation.** Upon completion of the connector repair, install the potting boot and ring using the following procedures:

a. When the connector was not removed for repair:

(1) Install the potting, ring using, tools and procedure in paragraph 57.

(2) Remove the old potting compound from the salvaged boot.

(3) Place the cleaned salvaged boot over the lip of the potting ring and tape into position.

(4) Apply the potting compound in accordance with WP 025 00.

b. When the connector was removed:

(1) Install the potting ring using the tools and procedure in paragraph 57.

(2) Snap the potting boot over the lip of the potting ring.

(3) Apply the potting compound in accordance with WP 025 00.

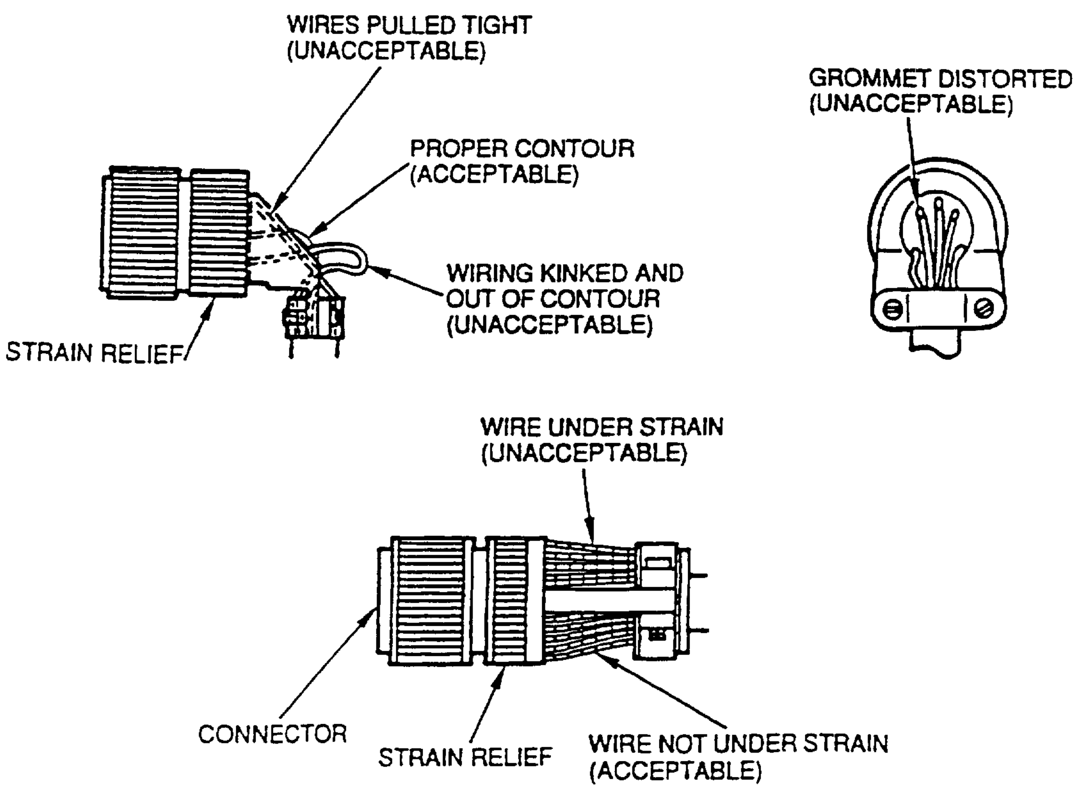


Figure 28. Proper Dress of Wire Into Connector

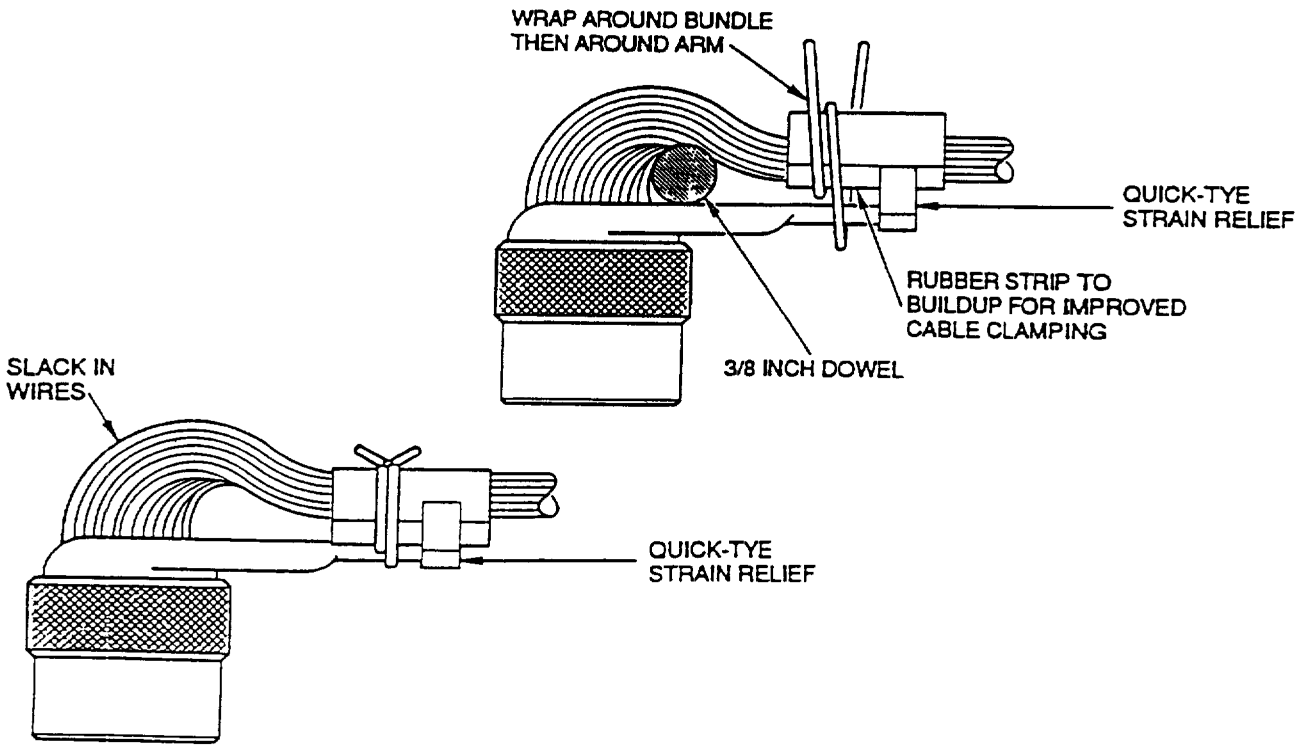


Figure 29. Lacing a Quick-Tye Strain Relief

64. **Shrink Boot and Adapter Removal.** To gain access to the connector rear, the shrink boot and adapter are removed using the following procedures:

a. To salvage the boot, apply heat using a heat gun in accordance with WP 012 00 until the boot is pliable.

b. Using a flat screwdriver, gently pry the boot from the adapter and wires.

c. Remove the adapter using the tools and procedure in paragraph 56.

d. Perform the connector repair.

65. **Shrink Boot and Adapter Installation.** Upon completion of the connector repair, install the shrink boot and adapter using the following procedures:

a. Install the adapter using the tools and tool procedure in paragraph 57.

b. Slide the shrink boot to the connector.

c. Apply a coat of epoxy glue to the adapter lip and inside the shrink hoot.

d. Seat the shrink boot on the adapter lip.

e. Apply heat to the boot to shrink it to the adapter and cable, using a heat gun in accordance with WP 012 00.

66. **EMI/RFI Grounding Terminator Installation.** Follow, the procedure in Figure 30 for installing EMI/RFI grounding terminators.

67. **EMI/RFI Environmental Backshell Assembly.** Follow the procedure in Figure 31 for the assembly of EMI/RFI environmental backshells.

NOTE

For non-EMI/RFI and non-environmental backshells, the assembly procedure is similar to that for EMI/RFI environmental backshell, except not all subcomponents are applicable.

For detailed banding tool operation, adjustment, and calibration, refer to WP 011 02.

68. **Banding Adapter Installation.** Follow the procedure in Figure 32 for installation of banding adapters.

69. **SAE AS29600 Connector Accessory Removal.** The MIL-C-29600 connector accessory shall be removed using the following procedure:

a. Unscrew and slide the backshell coupling nut from the follower, braid, and washers.

b. Slide the third washer (farthest from the connector) back over the outer braid.

c. Carefully unwrap the outer braid from the center washer and slide the washer toward the coupling nut.

d. Carefully unwrap the individual shields from the washer closest to the connector and slide back toward the coupling nut.

e. Slide the follower back from the connector toward the coupling nut to expose wires in the wire bundle.

70. **SAE AS29600 Connector Accessory Installation.** Follow the procedure in Figure 33 for installation (buildup) of MIL-C-29600 accessories. The MIL-C-29600 accessory torque values shall be in accordance with Table 16.

71. **RECTANGULAR CONNECTOR ACCESSORY MAINTENANCE.** No special instructions are typically needed for maintenance on rectangular connector accessories.

72. **CONNECTOR MAINTENANCE.** For procedures regarding installation and removal of wired and unwired contacts from connectors, see 01–1A–505–2 and 01–1A–505–3 (See applicable WP for the specific connector type. Vol. 2 identifies circular connectors and Vol. 3 identifies rectangular connectors.)

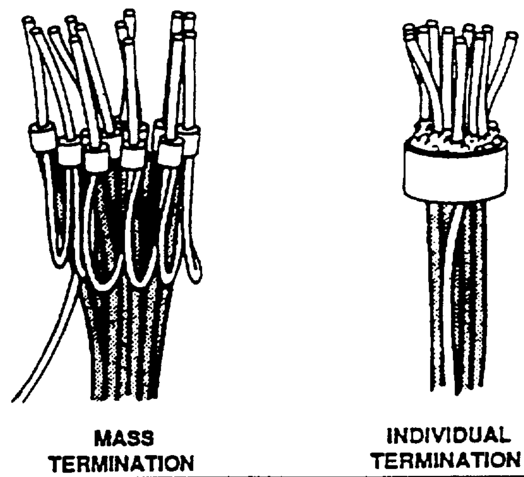
73. **Connector Accessory Availability.** The availability and all pertinent information regarding selection, procurement, installation, and special tools is found in the appropriate 01–1A–505–2 and 01–1A–505–3 (See applicable WP for the specific type of connector. Vol. 2 identifies circular connectors and Vol. 3 identifies rectangular connectors.)

Table 16. SAE AS29600 Backshell Torque Values

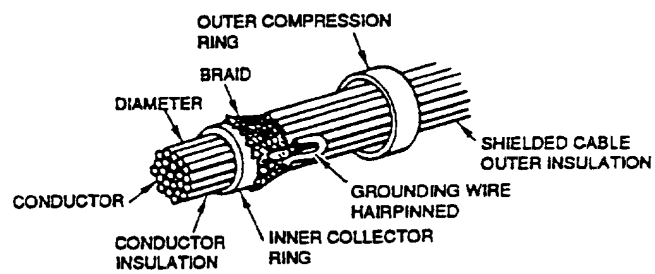
Shell Size	Torque in/lbs Min.	Torque in/lbs Max.
08 thru 16	20	30
18 thru 24	20	50

MASS OR MULTIPLE TERMINATION
MS3161 OUTER FERRULE

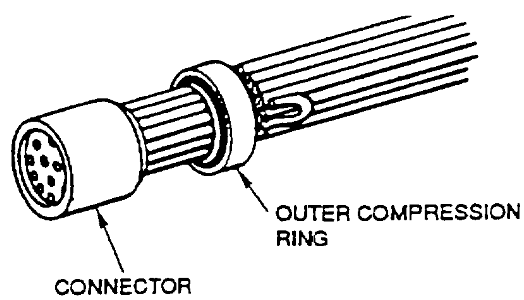
1. AFTER SHIELDING IS EXTRACTED ATTACH GROUND WIRE(S) TO CONNECTOR PIN.



2. PLACE GROUND WIRE(S) BETWEEN COLLECTOR AND COMPRESSION RING.



3. SLIDE COMPRESSION RING OVER COLLECTOR SHIELD AND GROUND WIRE.



FORWARD FOLD METHOD

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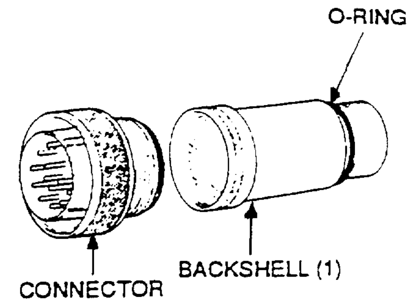
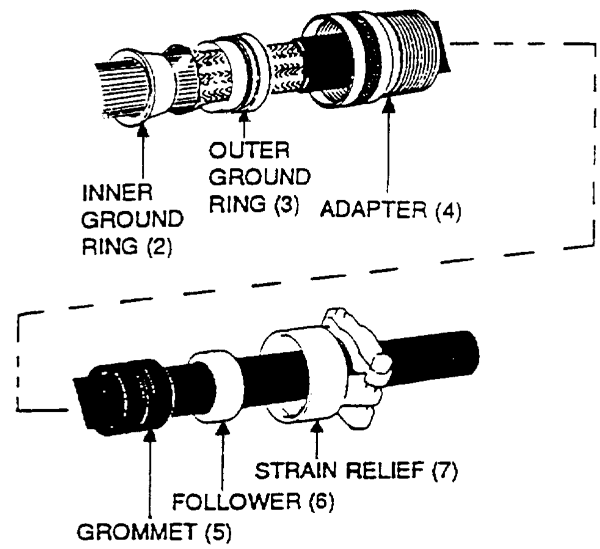
Figure 30 EMFI/RFI Environmental Termination Assembly

A. TEMPORARILY ASSEMBLE BACKSHELL (1) TO CONNECTOR.



B. REMOVE SADDLES FROM STRAIN RELIEF (7).

C. PLACE REMAINING BACKSHELL ASSEMBLY COMPONENTS (2 THRU 7) ON CABLE IN SEQUENCE SHOWN. KEEP THOSE COMPONENTS AT A CONVENIENT DISTANCE FROM END OF CABLE, SO THEY WILL NOT INTERFERE WITH SUBSEQUENT ASSEMBLY STEPS.



D. INSERT CABLE BACKSHELL (1) AND BOTTOM AGAINST CONNECTOR. HOLD CABLE IN POSITION AND MARK AT REAR OF BACKSHELL.

CAUTION

IF CABLE CONDUCTORS ARE TO HAVE SERVICE LOOPS, OR IF CONDUCTORS WILL HAVE CROSSOVERS, ETC., ALLOW SUFFICIENT ADDED LENGTH TO CABLE TO COMPENSATE FOR THESE FACTORS.

E. REMOVE BACKSHELL (1) FROM CONNECTOR AND PLACE ON CABLE WITH COMPONENTS IN STEP (C) ABOVE.

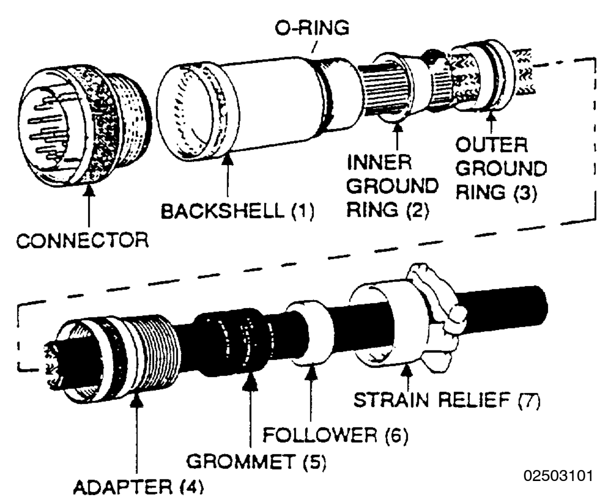


Figure 31. EMFI/RFI Environmental Backshell (Type A Shield Termination) Assembly (Sheet 1 of 2)

F. TRIM CABLE JACKET AND SHIELD AT MARK MADE IN STEP (D) ABOVE (ALLOWING FOR SERVICE LOOPS AND CROSS-OVERS).

G. STRIP JACKET 3/4-INCH BACK FROM TRIM POINT IN STEP (F) TO EXPOSE SHIELD.

H. PREPARE AND TERMINATE CABLE CONDUCTORS.

I. ASSEMBLE BACKSHELL (1) TO CONNECTOR AND TIGHTEN SECURELY. SLIDE INNER GROUND RING (2) INTO BACKSHELL (1).

J. FLARE SHIELD OVER TAPERED END OF INNER GROUND RING (2) AND GENTLY FORCE CABLE TOWARD CONNECTOR UNTIL SHIELD COVERS TAPER OF RING (2).

K. INSERT OUTER GROUND RING (3) INTO BACKSHELL (1) OVER SHIELD.

L. ENGAGE ADAPTER (4) ON BACKSHELL (1) AND TIGHTEN SECURELY.

M. INSERT GROMMET (5) AND FOLLOWER (6) INTO ADAPTER (4).

N. ENGAGE STRAIN RELIEF (7) AND TIGHTEN SECURELY. TIGHTEN STRAIN RELIEF SADDLES ON CABLE JACKET.

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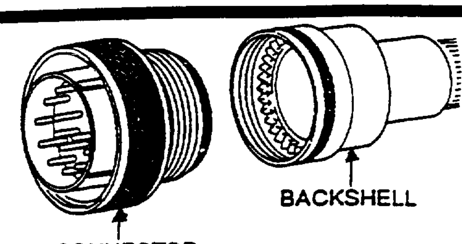
Figure 31. EMFI/RFI Environmental Backshell (Type A Shield Termination) Assembly (Sheet 2)

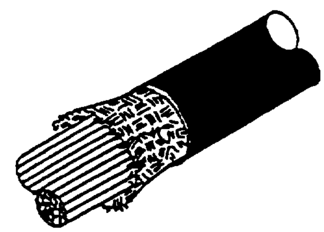
A. TEMPORARILY ASSEMBLE BACKSHELL TO CONNECTOR.

B. INSERT CABLE INTO BACKSHELL UNTIL IT BOTTOMS AGAINST CONNECTOR. HOLD IN POSITION AND MARK CABLE AT REAR END OF BACKSHELL.



C. REMOVE BACKSHELL FROM CONNECTOR AND SLIDE BACK ON CABLE SO IT WILL NOT INTERFERE WITH SUBSEQUENT ASSEMBLY STEPS.

D. STRIP JACKET FROM CABLE AT MARK IN STEP (D) ABOVE.



E. PREPARE AND TERMINATE CONDUCTORS TO CONNECTOR.

F. ASSEMBLE BACKSHELL TO CONNECTOR AND TIGHTEN.

G. INSTALL EMI BAND AS PER WP 011 02, THIS MANUAL.

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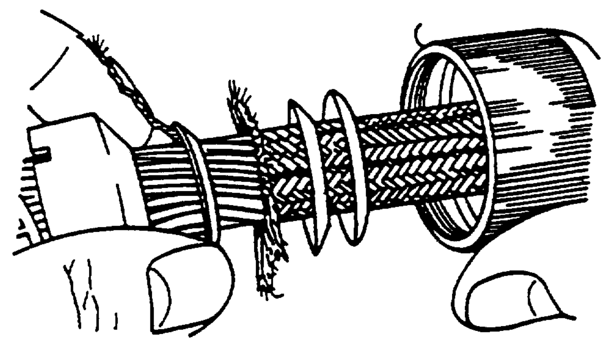
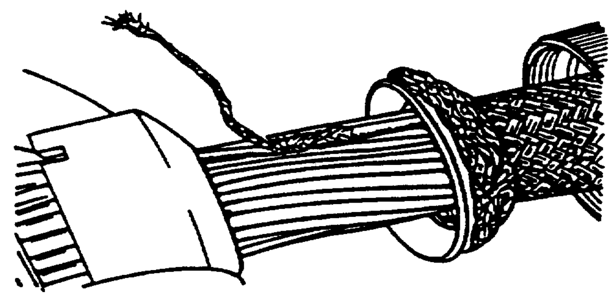
Figure 32. Banding Adapter Assembly

A. PULL INNER FOLLOWER OVER WIRE BUNDLE UNTIL SEATED AGAINST BACK OF CONNECTOR.



B. FLARE END OF OUTER (GROSS SHIELD) BRAID AND FOLD OVER CENTER WASHER.



C. WRAP BRAID FROM ANY SHIELD WIRES WITHIN THE WIRE BUNDLE AROUND WASHER NEAREST TO CONNECTOR.

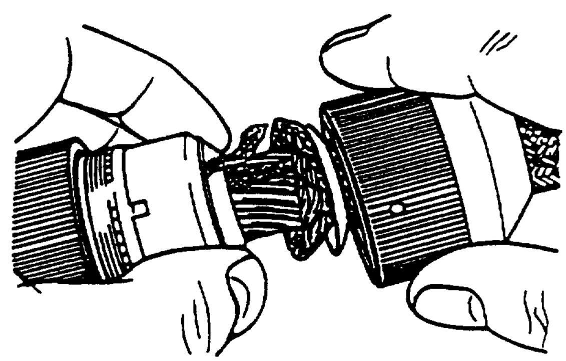


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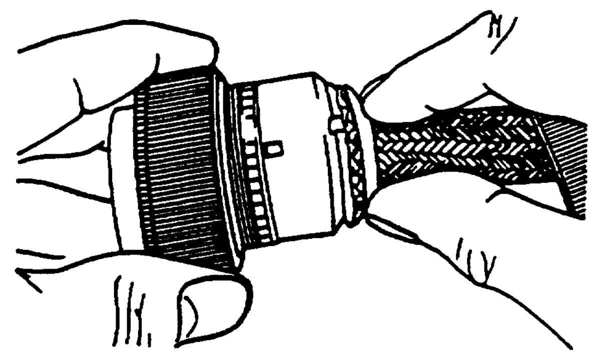
Figure 33. SAE AS29600 Backshell Buildup (Sheet 1 of 2)

D. PUSH THIRD WASHER (FARTHEST FROM CONNECTOR) AGAINST BRAID-WRAPPED WASHER.



E. SLIDE BACKSHELL OUTER COUPLING NUT OVER WASHERS, BRAID, AND INNER FOLLOWER AND HAND-TIGHTEN UNTIL FIRMLY SECURED AGAINST CONNECTOR BACK.

F. TORQUE BACKSHELL COUPLING NUT IN ACCORDANCE WITH TABLE 16.

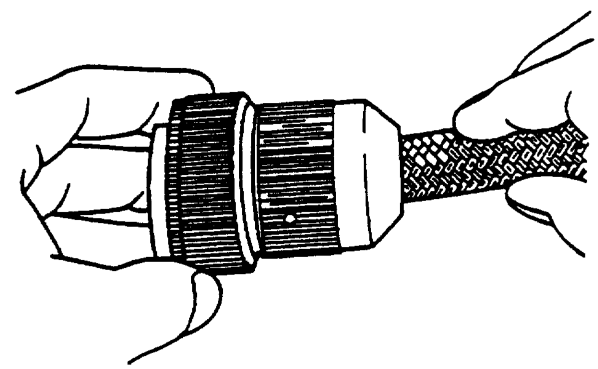


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Figure 33. SAE AS29600 Backshell Buildup (Sheet 2)

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POTTING AND SEALING CONNECTORS, ELECTRICAL CABLE ASSEMBLIES, AND ELECTRICAL COMPONENTS

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

General use of Cements, Sealants and Coatings . . . . NAVAIR 01−1A−507
Corrosion Program and Corrosion Theory . . . . NAVAIR 01−1A−509−1
Avionic Cleaning and Corrosion Prevention/Control . . . . NAVAIR 01−1A−509−3
Consumable Materials and Equipment for Aircraft and Avionics . . . . NAVAIR 01−1A−509−4
Consumable Materials and Equipment for Avionics . . . . NAVAIR 01−1A−509−5
Sealing Compound, Polysulfide . . . . AMS 3276 Class B−1/4
Sealing Compound, Polysulfide Rubber, Electric Connectors
and Electric Systems, Chemically Cured . . . . MIL−PRF−8516
Surface Clearing and Preparating . . . . SAE AIR 4069

Alphabetical Index

Alphabetical Index (Cont.)

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part No./Type Designation
Heat Gun	HT-900B

Materials Required

Brush, Acid Swabbing	—
Carbon Dioxide, Solid	—
Casting Compound, Epoxy (Stycast 2651)	MIL-I-16923
Cleaning Cloth	CCC-C-46, Class 4
Cleaning Compound	MIL-PRF-29608, Type I, Class C
Dichloromethane (Methylene Chloride)	ASTM D4701 or other approved solvent
Dual Connector Wrap Kit	AD28500–36–36–8 (8030–01–501–5351)
Isopropyl Alcohol (Isopropanol)	TT-I-735
Lacing Tape	A–A–52083/4
Polyethylene Bags	—
Polyethylene Wax	—
Primer for Specific Sealing Compound	Primer
Primer for Silicone Substrates	MIL–P–47215
Push-On End Caps	—
Sealant Dispenser	UG981108–01 (5120–01–494–7678)
Sealing Compound, Polysulfide	MIL-PRF-8516
Sealing Compound, Polysulfide	AMS 3276
Sealing Compound, Polyurethane	MIL-M-24041
Sealing Compound, Silicone	MIL-PRF-23586
Sealing Compound, Silicone (DC3140, DC3145)	MIL-A-46146
Sealing Compound, Silicone, Oil Resistant (Dow Corning)	RTV 735
Self Leveling Green Flame Retardant	HT3326–5FR–50 (8030–01–575–5396)
Thixoflex FR	TG2010FR–50 (8030–01–577–8134)

1. INTRODUCTION.

2. **GENERAL.** This work package covers the processes related to the potting of electrical connectors with sealants to protect against moisture, vibration, metallic particles, and various aircraft fluids.

a. The work package covers procedures for surface preparation, mixing, applying, curing and storing sealing compounds, and depotting old sealants.

b. The contents of this work package are specific to the types of sealants covered but are not inclusive of all products available. Refer to NAVAIR 01−1A−509 series and NAVAIR 01−1A−507 for more information on potting compounds and sealants. Each specific TMS manual must also be consulted to ensure current material and processes are used.

3. SURFACE CLEANING AND PREPARATION.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

4. **Primer Application.** Primers must be used for best adhesion and moisture resistance. Apply Primers in accordance with the recommendations of the sealant manufacturer. Each sealant type will have different primer guidelines. Refer to Table 1 for general guidelines on the primer to use for a given substrate and sealant. Always apply the primer to a properly cleaned and dry surface.

Table 1. General Guidelines For Primers To Be Used On Various Substrates After Cleaning

Substrate	Polysulfide MIL-PRF-8516	Silicone MIL-PRF-23586	Silicone MIL-A-46146	Polyurethane MIL-M-24041	Epoxy (e.g. Stycast)
Metal	Primer such as PR-148	Primer such as DC-1200 or SS4004	Primer such as DC-1204	Primer such as PR-420	Abrade/Clean No Primer
Fluorocarbon (PTFE, ETFE, etc.)	Tetra-etch, No Primer	Tetra-etch, Primer such as DC-1200 or SS4004	Tetra-etch, Primer such as DC-1205	Tetra-etch	Tetra-etch No Primer
Polychloroprene (Neoprene)	CS9922 H-1 (Primer may not be needed)	Primer such as DC-1200 or SS4004	Primer such as DC-1205	Primer such as PR-1523M	Abrade/Clean No Primer
Polyvinyl Chloride (PVC)	Primer such as ASTM D740 (Tough to bond)	Primer such as DC-1200 or SS4004	Primer such as DC-1205 or ASTM D740	Primer such as PR-1543 or ASTM D740	Abrade/Clean No Primer
Epoxy	Abrade/Clean surface, No Primer	Do not use this sealant on Amine cured epoxy	Primer such as DC-1205	Abrade/Clean	Abrade/Clean No Primer
Polyurethane	Abrade/Clean surface, No primer	Do not use this sealant	Primer such as DC-1205	Abrade/Clean, No Solvents to clean, No Primer	Abrade/Clean No Solvents, No Primer
Polysulfide	PR-182 if fuel soaked	Do not use this sealant	Primer such as DC-1205	Abrade/Clean	Abrade/Clean No Primer
Silicone	Primer such as MIL−P−47215	Do not use with organometallic (i.e. dbt) cured silicone.	Abrade/Clean No Primer		Abrade/Clean No Primer
NOTE: Material incompatibilities exist when using certain sealants with certain substrates.					

NOTE

Silicone based release agent will contaminate areas beyond where used, and will degrade the bonds of adhesives and sealants.

5. **Molds.** If removable molds are used during the application of sealants, apply a non-silicone based mold release agent to all surfaces of the mold exposed to the sealant prior to use.

WARNING

Sealants contain toxic compounds. Always become familiar with Material Safety Data Sheets (MSDS) prior to working with materials. Consult MSDS for proper Personal Protection Equipment (PPE) to use when working with materials. Always wear gloves and eye protection and avoid skin contact. If sealant or any sealant compound contacts skin, clean thoroughly.

6. **SEALANT PREPARATION, APPLICATION, AND STORAGE.**

7. **CONNECTOR DUAL WRAP KIT AD28500-36-36-8. (POLYURETHANE SEALANT, SELF LEVELING GREEN-FLAME RETARDANT).**

a. Harness bundles and components that will come in contact with the Dual Wrap Kit (AD28500-36-36-8) shall be free of dirt, oil, grease, and other contamination prior to installation. Residue of previously applied adhesives or sealants shall be removed. Clean harness and components. Refer to WP 026 00 in this manual and NA 01-1A-509-3 (Volume 3) under treatment of specific areas (multi-pin connector cleaning and preservation) for additional guidance.

CAUTION

Use only the Self Leveling Green Flame Retardant (SLG-FR) part number HT3326-5FR-50 for on aircraft applications due to its flame retardant characteristics. The conventional Self Leveling Green (HT3326-5-50) is flammable.

NOTE

The dual wrap kit contains two rolls of tape (stretch seal and Silicone type) employed below.

The sealing compound called out is the Self Leveling Green Flame Retardant (SLG-FR) which is intended for connector applications not exceeding 135°C.

NOTE

If possible, un-mate the connector and orient the connector face in a downward position.

b. Remove Self-Leveling Green (HT3326-5FR-50, NSN:8030-01-575-5396) cartridge from package and load cartridge into Application Device (UG981108-08) following package instructions for priming and dispensing Polyurethane potting compound. (One 50cc cartridge will seal 5 small connectors or 1 large connector.)

c. Begin wrapping the StretchSeal tape (AD89503-01-36) around the connector to be protected, behind the coupling ring (nut). Stretch the tape 25 to 50% to ensure good compression around the connector body and rear accessories. Continue to apply the StretchSeal tape with a 50% overlap. Refer to Figure 1.

d. Stop wrapping the StretchSeal and hold in place. Inject Self-Leveling Green into the wire bundle immediately behind the connector rear accessory or through any openings in the rear accessory. Refer to Figure 2.

e. Alternate wrapping StretchSeal and injecting potting compound and at least one complete wrap of StretchSeal has been installed on the harness bundle.

f. Inject potting between wires over entire wrap. Cut the StretchSeal tape and stop wrap approximately 2 inches past end of back shell. Follow instructions provided with potting compound for disposal. Refer to Figure 3.

g. Remove Self-Fusing Silicone Tape (AD59163-01-36) from the package. Pull back a small amount of the release film, making sure that the tape remains free of dirt and other contaminants.

h. Begin to wrap the connector behind the coupling ring (nut) with one complete revolution on itself. Refer to Figure 4.

i. After the first full wrap is complete, continue wrapping with a 50% overlap over the top of the StretchSeal tape. Use the line in the middle of the Self-Fusing Silicone Tape as a guide and remove the release film as required.

j. Stretch the tape 50 to 300% during application to ensure a tight fit when complete. Stretching the tape will aid in the fusing process.

k. Clean any excess potting compound that may have been forced out of the StretchSeal tape from the wire bundle.

l. Continue to wrap the Self−Fusing Silicone Tape until at least one complete wrap past the end of the StretchSeal tape. Make one complete wrap over the top of the last wrap. The first and last wrap must always be a complete wrap directly over the top of the previous wrap. Refer to Figure 5.

m. Cut off any excess Self−Fusing Silicone tape.

n. Secure end of connector wrap with lacing tape A−A−52081 (or equivalent). Refer to Figure 6.

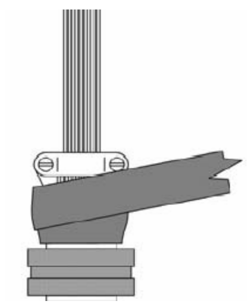

Figure 1. Self Leveling Green; StretchSeal Tape Application

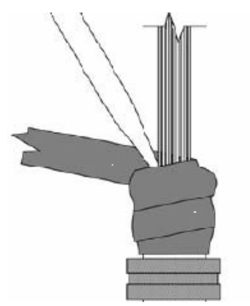

Figure 2. Self Leveling Green; Sealant Application

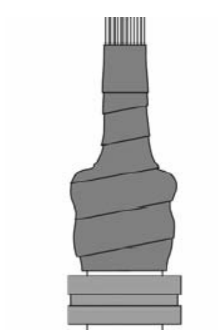

Figure 3. Self Leveling Green; StretchSeal Tape Application – Complete

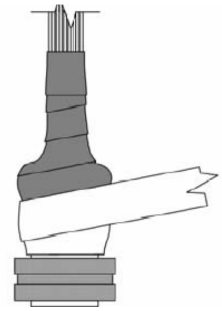

Figure 4. Self Leveling Green; Self−Fusing Silicone Tape Application

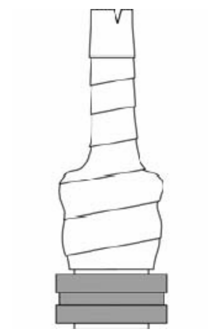

Figure 5. Self Leveling Green; Self−Fusing Silicone Tape Application−Complete

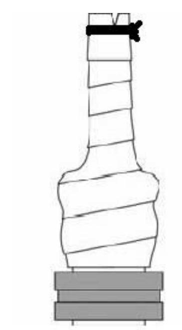

Figure 6. Self Leveling Green; Tie String and Completed Installation

8. **POLYURETHANE REMOVABLE SEALANT (THIXOFLEX–FR, TG2010FR–50).** This sealing and potting compound is intended for electrical components sealing applications in SWAMP areas not exceeding 135°C. Applications including, but not limited to: relays, contactors, terminal board. This sealant is removed cleanly and easily when compared to MIL–A–46146, or MIL–PRF–8516, as such it is best suited for areas requiring rework.

a. Components that will come in contact with the Thixoflex–FR (TG2010FR–50) shall be free of dirt, oil, grease, and other contamination prior to installation. Residue of previously applied adhesives or sealants shall be removed. Clean surface to be sealed on the applicable wiring components. Refer to WP 026 00 in this manual for additional guidance.

CAUTION

Use only the Thixoflex–FR (TG2010FR–50) for on aircraft applications due to its flame retardant characteristics. The conventional Thixoflex (TG2010–50) is flammable.

b. Remove Thixoflex–FR (TG2010FR–50) cartridge from package and load cartridge into Application
Device (UG981108–08) following package instructions for priming and dispensing Polyurethane potting compound.

NOTE

One 50cc cartridge will seal several small components or one large one. If the syringe mixing tip is left on the cartridge, it will act as a cap. In the event multiple small applications need to be sealed and the sealant has cured in the tip, replace with new syringe mixing tip and continue until all sealant is used.

c. Install syringe mixing tip, trim off tip.

d. Inject Thixoflex–FR onto the component area immediately (Figure 7). Ensure that there is a uniform layer over the component to be sealed with a minimum continuous thickness of 1/16”.

e. Follow instructions provided with potting compound for disposal.

f. Clean any excess potting compound from affected area before cured.

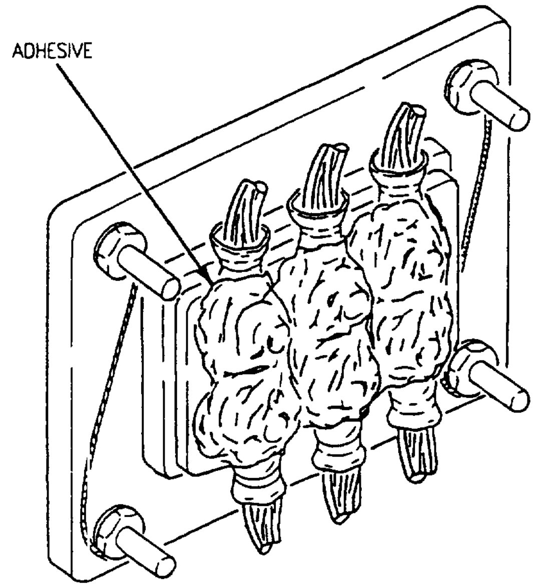

Figure 7. Sealing Electrical Components

9. **POLYSULFIDE SEALANT MIL-PRF-8516.**

a. Frozen Pre-Mixed Compound Preparation.

NOTE

Never use heat to raise sealant temperature.

After removal from deep freeze, sealant work life reduces significantly. Use compound as soon as possible.

(1) Bring frozen compound to room temperature by warming outside of container with compressed air.

(2) Pour compound into dispenser.

(3) Frozen material, especially sealant which has been refrozen, shall be considered suitable for use if it is still pourable and has sufficient pot life remaining for application purposes.

b. Unmixed Compound Preparation. For best results, observe the following general guidelines when mixing MIL-PRF-8516 sealant:

(1) Follow the manufacturer’s instructions carefully when mixing base compound and accelerator. Substitution, partial mixing, or using incorrect portions of base and accelerator may cause sealant to have inferior properties.

(2) Make sure entire amount of accelerator is mixed into entire amount of base. Any change in catalyst ratio will affect the electrical properties of the sealant and may also affect the pot life, reversion resistance, and hardness of the cured compound. Do not mix base compounds and accelerators of different batch numbers because substandard electrical properties may result.

(3) Sealants may contain small quantities of flammable solvents or release flammable by-products when curing. Observe adequate ventilation and fire precautions during curing, mixing, and storage.

(4) Sealants having an application time of one hour or less shall be hand mixed on the job. Do not freeze such material.

c. Mixing Procedure.

(1) Using a clean spatula, wooden tongue depressor, or putty knife, stir accelerator slowly into a smooth, creamy paste. Do not beat or whip; too much air could be trapped in compound. Continuously scrape sides, corners, and bottom of container to mix completely.

(2) Using clean spatula, wooden tongue depressor, or putty knife, stir base until it has a smooth texture. Do not beat or whip. Scrape sides, corners, and bottom of container.

(3) If base and accelerator are supplied in bulk, weigh out needed amounts of base and accelerator in separate containers.

(4) Combine accelerator and base. Thoroughly mix until no streaks or traces of unmixed material are visible. Mixing normally requires 5 to 8 minutes (Figure 8).

(5) When large quantities of sealant are to be mixed, mechanical mixing can be used to improve efficiency. Use an air motor with a T-shape, flat blade or similar mixing paddle attached to a steel rod (Figure 9). Limit speed of the paddle to 80 rpm since higher speeds will generate internal heat, reduce application life, and whip air into the sealant.

(6) Determine if mixing is complete by spreading a drop of sealant very thinly on a piece of white paper. Close examination should not reveal any specks or streaks. Do not mix sealant beyond point where tests show thorough mixing.

(7) If mixed compound is not used immediately, store (paragraph 22).

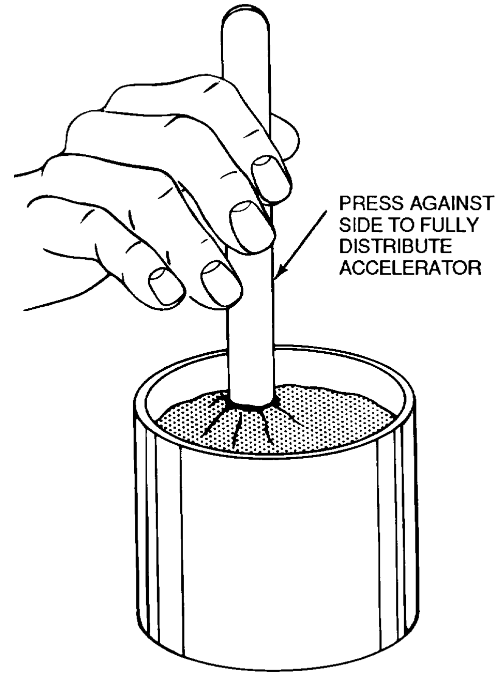

Figure 8. Hand Mixing Potting Compound

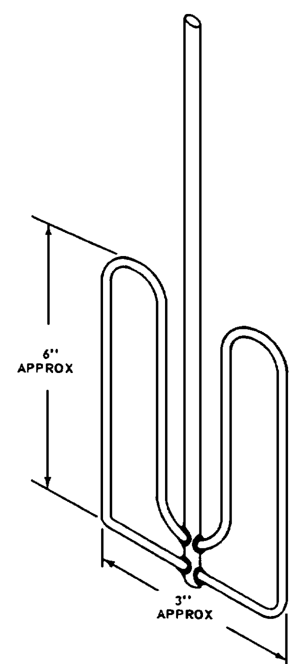

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Figure 9. Mixing Paddle for Potting Compound

NOTE

The base absorbs moisture from the air. Do not open containers until ready to use.

d. Two-Part Sealant Cartridges. (Semkits).

WARNING

Failure to wear safety glasses or face shield may result in eye damage or personnel injury.

e. Wear safety glasses.

f. Hold cartridge, grasp dasher rod and pull back approximately one inch.

NOTE

Use even pressure, do not use force, tap, pound or jolt ramrod if piston does not break loose readily.

g. Insert ramrod into hollow of dasher rod, break piston loose and inject about 1/3 of contents into cartridge.

h. Repeat steps (2) and (3) until all of contents of rod are emptied into cartridge then remove ramrod.

CAUTION

After mixing base and accelerator, use quickly to minimize reduction in application life.

i. Mix material for required number of strokes for hand mix or for required time for machine mix, as indicated on instructions provided with kit.

j. After mixing, remove bottom cap.

k. Pull dasher rod back to neck of cartridge, grasp cartridge firmly at neck, unscrew dasher rod and remove.

l. Screw nozzle into cartridge, insert into extrusion gun and use as required. For hand extrusion, press used dasher rod against plunger to force material from cartridge.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

10. **POLYURETHANE SEALANT MIL-M-24041.**

a. Frozen Pre-mixed Compound Preparation.

CAUTION

Thawing time and temperature must be controlled closely to obtain the maximum application life in the shortest thawing period. Application life will be reduced by an increase in either the thawing time or temperature. An incomplete thaw will result if thawing time or temperature is reduced.

(1) Remove cartridge from storage and place upright in an oven, heating block, or in a dry metal sleeve in a water bath. Heat cartridge at 110°F (43°C) for 20 minutes.

(2) Remove cartridge from heat and work the pliable cartridge with hands to distribute heat.

(3) Heat cartridge an additional 5 minutes at 110°F (43°C).

(4) Remove cartridge from heat and bleed any entrapped air from under the plunger.

(5) Insert cartridge into sealant gun.

(6) Attach nozzle to sealant gun; compound is ready for application.

(7) Frozen material, especially sealant which has been refrozen, shall be suitable for use if it is still pourable and has sufficient pot life remaining for application purposes.

b. Two-Component Kit Preparation.

NOTE

The base absorbs moisture from the air. Do not open containers until ready to use.

(1) Prolonged storage of base below 65°F (18°C) will cause thickening. Base may be liquified by warming to 180°F (82°C) for about 2 to 3 hours and stirring thoroughly.

(2) Accelerator thickens at ambient temperatures. Warm accelerator 200°F (93°C) to 210°F (99°C). Stir occasionally until thoroughly mixed.

CAUTION

After mixing base and accelerator, use quickly to minimize reduction in application life.

(3) Cool base and accelerator 70°F (21°C) to 80°F (27°C). Combine components and mix thoroughly.

(4) Place mixture in a container about two times the volume of the compound. Vacuum degas if possible to release entrapped air and gas in the mixture. Allow foaming to subside. Compound is ready to use.

c. Mixing Procedure.

(1) Using a clean spatula, wooden tongue depressor, or putty knife, stir accelerator slowly into a smooth, creamy paste. Do not beat or whip; too much air could be trapped in compound. Continuously scrape sides, corners, and bottom of container to mix completely.

(2) Using clean spatula, wooden tongue depressor, or putty knife, stir base until it has a smooth texture. Do not beat or whip. Scrape sides, corners, and bottom of container.

(3) If base and accelerator are supplied in bulk, mix 1 part (by weight) of accelerator with 10 parts (by weight) of base compound.

(4) Combine accelerator and base. Thoroughly mix until no streaks or traces of unmixed material are visible. Mixing normally requires 5 to 8 minutes (Figures 8 and 9).

d. Two-Part Sealant Cartridges. (Semkits).

WARNING

Failure to wear safety glasses or face shield may result in eye damage or personnel injury.

NOTE

The base absorbs moisture from the air. Do not open containers until ready to use.

(1) Wear safety glasses.

(2) Hold cartridge, grasp dasher rod and pull back approximately one inch.

NOTE

Use even pressure, do not use force, tap, pound or jolt ramrod if piston does not break loose readily.

(3) Insert ramrod into hollow of dasher rod, break piston loose and inject about 1/3 of contents into cartridge.

(4) Repeat steps (b) and (c) until all of contents of rod are emptied into cartridge then remove ramrod.

CAUTION

After mixing base and accelerator, use quickly to minimize reduction in application life.

(5) Mix material for required number of strokes for hand mix or for required time for machine mix, as indicated on instructions provided with kit.

(6) After mixing, remove bottom cap.

(7) Pull dasher rod back to neck of cartridge, grasp cartridge firmly at neck, unscrew dasher rod and remove.

(8) Screw nozzle into cartridge, insert into extrusion gun and use as required. For hand extrusion, press used dasher rod against plunger to force material from cartridge.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

11. **SILICONE SEALANT, TWO-PART MIL-PRF-23586.**

a. Frozen Pre-Mixed Compound Preparation.

NOTE

Never use heat to raise sealant temperature.

After removal from deep freeze, sealant work life reduces significantly. Use compound as soon as possible.

(1) Bring frozen compound to room temperature by warming outside of container with compressed air.

(2) Pour compound into dispenser.

(3) Frozen material, especially sealant which has been refrozen, shall be considered suitable for use if it is still pourable and has sufficient pot life remaining for application purposes.

b. Unmixed Compound Preparation. For best results, observe the following general guidelines when mixing MIL-PRF-23586 sealant:

(1) Follow the manufacturer's instructions carefully when mixing base compound and accelerator (catalyst). Substitution, partial mixing, or using incorrect portions of base and accelerator may cause sealant to have inferior properties.

(2) Make sure entire amount of accelerator is mixed into entire amount of base. Any change in catalyst ratio will affect the electrical properties of the sealant and may also affect the pot life, reversion resistance, and hardness of the cured compound. Do not mix base compounds and accelerators of different batch numbers because substandard electrical properties may result.

(3) Sealants may contain small quantities of flammable solvents or release flammable by-products when curing. Observe adequate ventilation and fire precautions during curing, mixing, and storage.

(4) Sealants having an application time of one hour or less shall be hand mixed on the job. Do not freeze such material.

c. Mixing Procedure.

(1) Using a clean spatula, wooden tongue depressor, or putty knife, stir accelerator slowly into a smooth, creamy paste. Do not beat or whip; too much air could be trapped in compound. Continuously scrape sides, corners, and bottom of container to mix completely.

(2) Using clean spatula, wooden tongue depressor, or putty knife, stir base until it has a smooth texture. Do not beat or whip. Scrape sides, corners, and bottom of container.

(3) If base and accelerator are supplied in bulk, weigh out needed amounts of base and accelerator in separate containers.

(4) Combine accelerator and base. Thoroughly mix until no streaks or traces of unmixed material are visible. Mixing normally requires 5 to 8 minutes (Figure 8).

(5) Determine if mixing is complete by spreading a drop of sealant very thinly on a piece of white paper. Close examination should not reveal any specks or streaks. Do not mix sealant beyond point where tests show thorough mixing.

(6) If mixed compound is not used immediately, store (paragraph 24).

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

CAUTION

Do not use silicone RTV sealant that releases acetic acid. The liberated acetic acid vapors will cause corrosion and damage metals and electronic equipment.

12. **SILICONE SEALANT, ONE PART ROOM TEMPERATURE VULCANIZING (RTV) NON-CORROSIVE MIL-A-46146 (e.g. DC 3140, DC-3145, RTV 735).**

NOTE

Sealant can be placed in a small syringe for ease of use.

a. The one part RTV silicone sealants are supplied in tubes, cartridges, or cans and do not need mixing or preparation. They are ready to apply.

(1) Sealant shall be considered suitable for use if it has not cured in the tube and retains sufficient pot life for application purposes.

(2) If material is not used immediately, store (paragraph 25).

13. **EPOXY CASTING RESIN, TWO-PART MIL-I-16923 (e.g. Stycast 2651 with Catalyst 9 or Catalyst 11).**

NOTE

Pre-mixed and frozen materials are the recommended form of epoxy to use as needed.

a. Frozen Pre-Mixed Compound Preparation.

NOTE

Do not place in hot water. Material will cure before center of cartridge or syringe can thaw.

After removal from deep freeze, the pot life of the mixed compound reduces significantly. Use compound as soon as possible.

Do not allow water to contaminate epoxy materials.

(1) Bring frozen mixed compound to room temperature by allowing to stand at room temperature. Generally 1-cc to 10-cc syringes will thaw in about 4 to 8 minutes, whereas larger syringes and cartridges will require approximately 12-20 minutes depending on the room temperature. Material may be thawed by placing syringe or cartridge in a water bath. Water should be just warm to bare hands, lukewarm.

(2) Compound is considered suitable for use if the viscosity is acceptable, and it has sufficient pot life remaining for application purposes.

b. Two Component Epoxy Preparation.

(1) The base resin, catalyst, and any support equipment should be held at room temperature (70-75°F (21-24°C)) a minimum of six hours until equilibrated. Cool materials will be difficult to mix thoroughly, and warm materials will shorten the pot life.

(2) Mix the catalyst thoroughly in its original container, and mix the base resin thoroughly in its original container until uniform in consistency. During storage, fillers may separate and either float to the top or sink to the bottom of the container, and they must be fully redispersed for proper results.

(3) Weigh the proper amount of base resin and then add the appropriate amount of catalyst according to the manufacturer’s instructions. Each catalyst and resin combination will have its own mix ratio: Stycast 2651 is mixed with Catalyst 9 at 100 parts resin to 6.5 parts catalyst. Stycast 2651 is mixed with Catalyst 11 at 100 parts resin to 8 parts catalyst.

(4) Blend the mixture thoroughly by hand. Fold in the catalyst using extreme care to prevent entrapment

of air into the mixture. Do not use mixing equipment, as this will generate internal heat, reduce application life, and whip air into the sealant.

(5) Pot life, the time available before the mixed compound cures to become unusable, is different for each base/resin combination. The pot life of mixed Stycast 2651/Catalyst 9 is approximately 30 minutes, while the pot life of Stycast 2651/Catalyst 11 is about 4 hours at room temperature.

(6) If mixed compound is not used immediately, store (paragraph 26).

NOTE

Do not use Two-Part Silicone RTV (MIL-PRF-23586 Grade A) for sections >1/2 inch thick or in confined or partially confined areas as the material will not cure properly.

Do not use Two-Part Silicone RTV (MIL-PRF-23586) for anything other than repairing itself. It must not be used to repair Grade A or B1 material.

Certain types of materials will inhibit the cure of Two-Part Silicone RTV (MIL-PRF-23586). Do not use this material with materials containing sulfur (polysulfide sealant), amines (polyurethane or amine-cured epoxy), or organometallics (dbt-cured silicone, rosin flux residues).

Do not use silicone RTV sealant that releases acetic acid. The liberated acetic acid vapors will cause corrosion and damage metals and electronic equipment.

14. **APPLICATION OF SEALANTS.** The following procedures cover the application of all types of sealants in this document.

15. **Potting Boots and Potting Boot Rings.** Potting boots are forms placed around the wire terminations of the connectors to contain liquid potting compound while hardening. Potting boot rings are threaded rings used as intermediate devices between the connector and the potting boot. A lip, on the opposite end of the threads, provides a means for the boot to grip the ring (Figure 10).

a. Removal.

(1) Using diagonal edge cutting pliers, snip potting boot lengthwise. Peel boot and old sealant away from connector.

(2) Remove potting boot ring.

(3) Slide new potting boot on cable or harness.

(4) Perform connector repair.

b. Installation.

(1) Install potting boot ring.

(2) Snap potting boot over lip of potting boot ring.

(3) Apply sealant.

16. **Applying Sealants to Connectors.**

a. Locate connector in suitable open mold and remove any ties within 6 inches of the connector.

b. Secure spare wires to wire bundle with masking tape, a minimum of 6 inches from crimped connection.

c. Fill dispenser with prepared sealant.

d. Insert nozzle between wires as close as possible to connector insert without touching it. Inject sealant slowly, moving nozzle back from connector as compound fills mold. Ensure no bubbles are trapped during injection (Figure 11).

e. When level of sealant is above nozzle, slowly withdraw nozzle keeping end below level of sealant until mold is filled. Allow to settle for 5 to 10 minutes; refill if necessary. To release trapped air, connector may be tapped or gently vibrated and wires may be slightly flexed.

NOTE

Do not end sealant abruptly to keep stress at joint to a minimum.

f. When mold is filled, taper sealant 1/2 to 1 inch up along wires.

g. Suspend connector by cable clamp attached to bracket so sealant stays level. Air cure for 1-1/2 hours at 75°F (24°C) without moving (Figure 12).

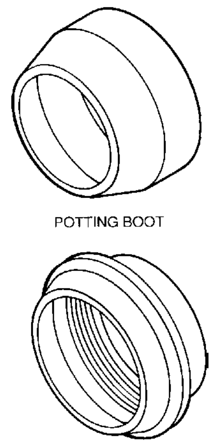


Figure 10. Potting Boot and Potting Boot Ring

NOTE

Each sealant requires specific curing time and temperature. Refer to paragraph 20 for the cure schedule of the sealant being used.

h. Place suspended connector in the oven for the recommended curing time and temperature of the sealant used.

17. **Connector Sealing.** The following procedure is for applying sealant to the connector wire sealing grommet (Figures 13 and 14).

a. Remove backshell and slide back over cable or wire bundle. Spread out wiring to access wiring sealing grommet.

NOTE

Do not remove bulkhead mounted connectors from bulkhead. Remove tape up to first clamp.

Inspect previously sealed connectors for separation and repair as required.

b. Remove any debris from wire sealing grommet area.

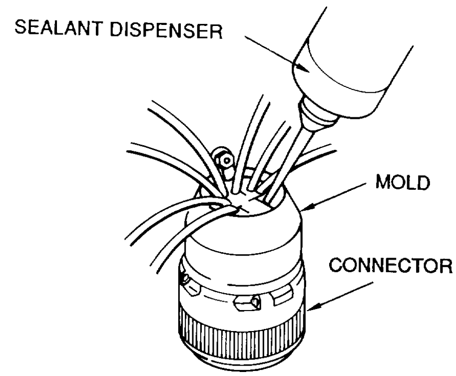


Figure 11. Injecting Sealant

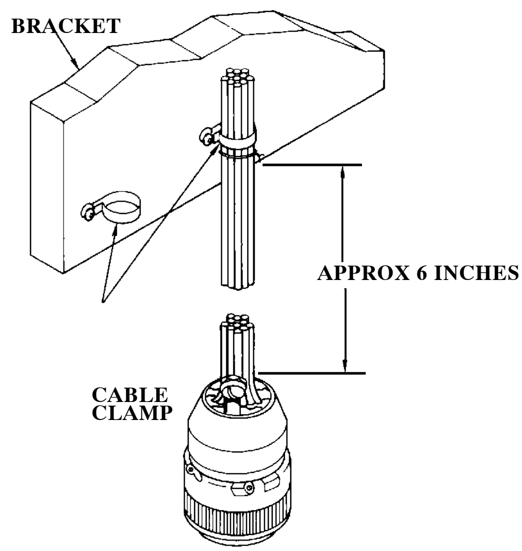


Figure 12. Curing Sealed Connector

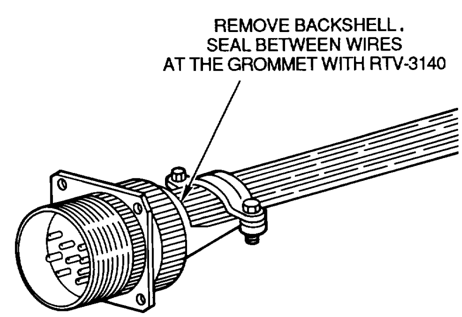
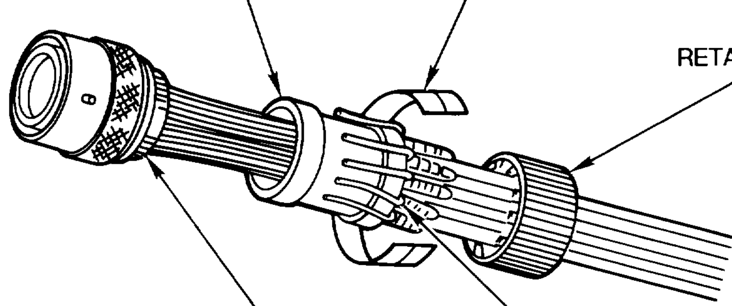
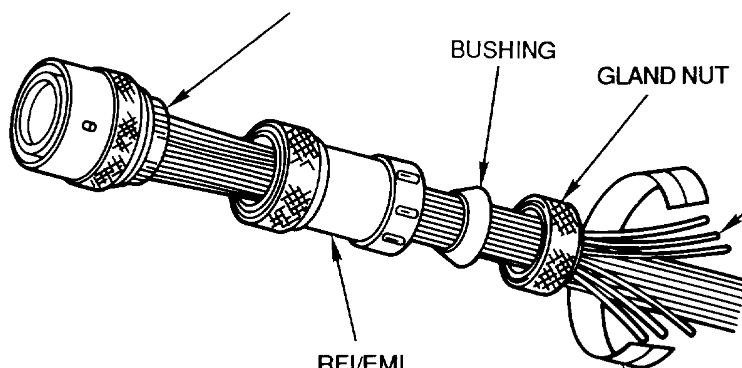


Figure 13. Connectors with Strain Relief



PROCEDURE:
1. REMOVE RETAINER RING.
2. REMOVE MYLAR TAPE
3. PEEL BACK SHIELDED PIGTAILS
4. REMOVE BACKSHELL TO EXPOSE WIRES.
5. SEAL BETWEEN WIRES.

CONNECTORS WITH SHIELDED BACKSHELL
AND 90° SHIELDED BACKSHELL



PROCEDURE:
1. SLIDE BACK GLAND NUT AND BUSHING.
2. REMOVE MYLAR TAPE.
3. PEEL BACK SHIELDED PIGTAILS.
4. REMOVE RFI/EMI BACKSHELL TO EXPOSE WIRES.
5. SEAL BETWEEN WIRES.

CONNECTORS WITH RFI/EMI BACKSHELL
AND 90° RFI/EMI BACKSHELL

Figure 14. Connectors with Shielded and EMI/RFI Backshells

WARNING

Cleaning compound for avionics components, MIL-PRF-29608, is toxic. Protection: chemical splash proof goggles and good ventilation. Keep cleaning compound off skin, eyes, and clothes; do not breathe vapors. Wear gloves. Do not immerse connector or wiring in cleaning compound.

c. Remove oil and/or grease contamination from wire sealing grommet, internal backshell area, and adjacent wires by applying cleaning compound to connector. Loosen and remove contaminants using acid swabbing brush. Clean quickly, draining compound from connector. Wipe residue with cleaning cloth. Allow to dry (Figure 15). Refer to WP 026 00 in this manual and NA 01–1A–509–3 under treatment of specific areas (multi–pin connector cleaning and preservation) for additional guidance.

NOTE

All unused cavities in circular and rectangular connectors shall be filled with unwired contacts and appropriate MS27488 scaling plugs (see WP 020 00, para 33 Sealing plug selection). The unwired contacts and sealing plugs are required to preserve the environmental sealing characteristics of the connectors.

d. Ensure contacts and sealing plugs are installed in any unused contact cavities.

NOTE

Sealant RTV-3140 is supplied in a collapsible aluminum squeeze tube with a plastic applicator nozzle. Sealant may be transferred to a small hypodermic syringe as an alternative (Figure 16).

e. Restore proper dress of wire leading into connector. Wire should not be elongating rubber environmental seal.

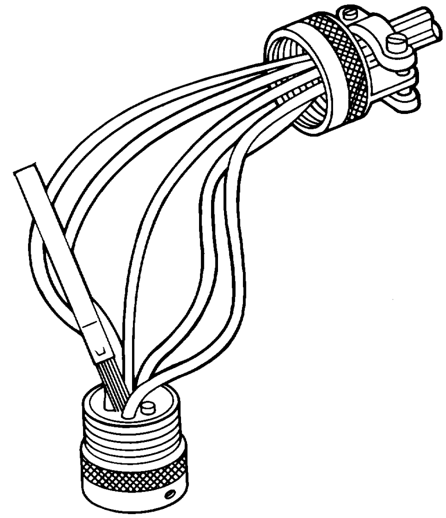


Figure 15. Connector Cleaning

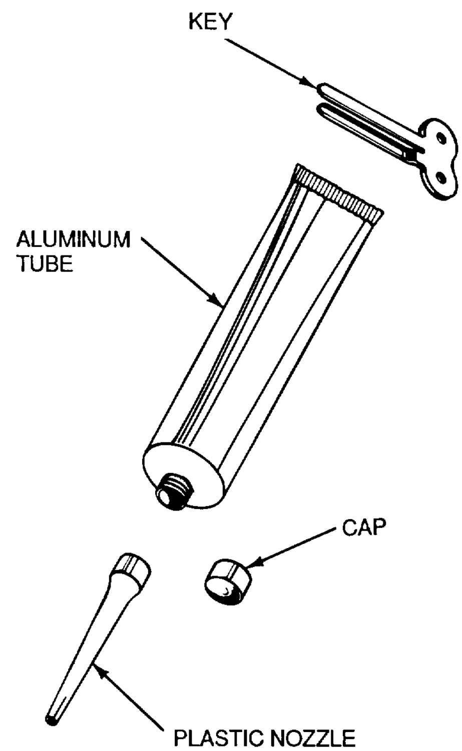


Figure 16. Typical Tube Dispenser

f. Insert nozzle into wire bundle close to connector and squeeze tube while pulling nozzle backward. Repeat application two or three times in different locations. Sealant will level itself in about 15 minutes. Recommended thickness is 1/16 ± 1/32 inch across entire wire sealing grommet (Figure 17).

g. If after 15 minutes from first application there is insufficient coverage, additional sealant may be added. Thickness shall not exceed 1/8 inch; otherwise sealant will no longer be transparent, longer curing time will be required, and connector repairs will be more difficult.

NOTE

Cure time is related to 77°F (25°C) and 50% relative humidity. High temperatures and low humidity will decrease cure times; low temperatures and high humidity will increase cure time.

h. After applying sealant, rig harness so that connector face is parallel to floor. This is necessary for sealant flow to cover wire sealing grommet with uniform thickness. After 30 minutes, harness and connectors may be placed in any orientation. Total cure time, for practical purposes, is 24 hours.

i. Contact may be removed for rework using standard tools and procedures. After replacing contact, add small amount of sealant around replaced wire at wire sealing grommet. Allow connector face to remain parallel to floor for 30 minutes before mating.

j. Install backshell.

18. **Sealing Electrical Cable Assemblies.** The following procedure is for sealing around the bulkhead and EMI cables while installing electrical cable assemblies.

WARNING

Solvent, wipe should be used with care. Gloves must be worn to prevent injury.

a. Clean surfaces to be sealed using solvent, wipe. Apply solvent, wipe with clean, moistened cloth to applicable surfaces. Wipe dry before cleaning solvent evaporates. Refer to WP 026 00 in this manual and NA 01−1A−509−3 under treatment of specific areas (multi−pin connector cleaning and preservation) for additional guidance.

b. Mixing of sealers should be done using the instructions provided with the sealing compound.

c. Mask areas to be protected from sealants.

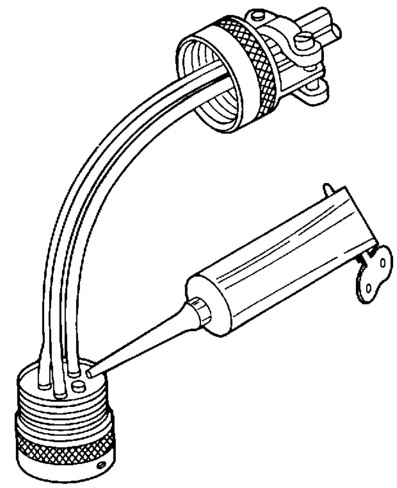


Figure 17. Sealant Application

d. Remove cable ties (plastic tie-down straps) within 6 inches of the area to be sealed.

e. Where cable clamps restrict the flow of sealants in and around cable assemblies or wires, loosen clamps so that sealant must flow under clamps.

f. Inject sealant in and around cable assemblies, and under cable clamps (Figure 18, Detail A).

g. Tighten cable clamps.

CAUTION

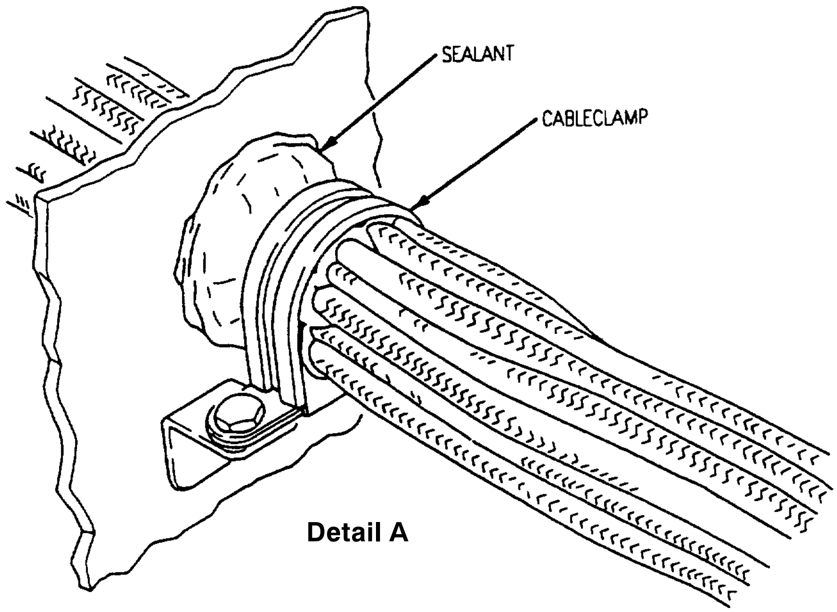
When ground cork is used, apply a heavy coat of AMS 3276 Class A−4 sealing compound over fillet to prevent the ground cork from absorbing fuel or moisture.

NOTE

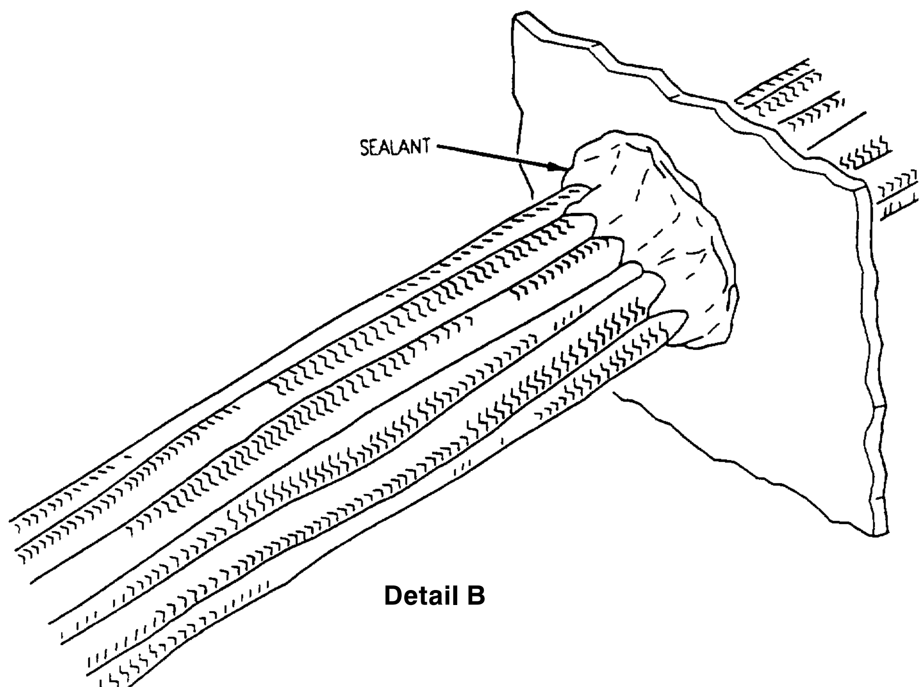
AMS 3276 Class B−1/4 sealing compound may be combined in a ratio of 1 part sealing compound to 1.5 parts ground cork to fill voids exceeding 1/2 inch. Voids to be filled with this mixture must exist between cable assemblies and conduit or cable assemblies and bulkheads.

h. Apply a fillet of sealant around the cable assembly on both sides of the bulkhead when accessible (Figure 18, Details A and B).

i. Remove masking tape from protected areas and smooth sealant around clamps with a wooden tongue depressor.



Detail A



Detail B

Figure 18. Sealing Cable Assemblies

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

19. **EMI Sealing Procedures.**

a. Refer to paragraph 17a for cleaning procedure.

b. Follow special instructions in WP 011 00 when assembling EMI shielding and boots.

c. Mask areas to be protected from sealants.

d. Inject sealant into wire mesh buildup at EMI boot areas.

e. Fashion sealant to a smooth surface using wooden tongue depressor (Figure 19).

f. Remove masking tape and clean excess or unwanted sealant from area by use of a clean dry wiper.

20. **Sealing Electrical Components.** The following procedure is for sealing electrical components against foreign object damage and corrosion. Use only Silicone Sealant to MIL-A-46146 Group 3 (such as DC-3145).

a. Check all connections for correct attachment.

WARNING

Cleaning compound is flammable and toxic to eyes, skin, and respiratory tract. Skin/eye protection required. Avoid repeated/continued contact. Use only in well ventilated areas. Keep away from open flames or other sources of ignition.

b. Clean all surface areas to be sealed with cleaning compound.Refer to WP 026 00 in this manual and NA 01−1A−509−3 under treatment of specific areas (multi−pin connector cleaning and preservation) for additional guidance.

c. Apply a thin coat (1/8-inch thick) of adhesive over the terminations. See Figure 7.

CAUTION

To prevent corrosion because of condensation, do not leave voids and air entrapments.

d. When filling cavities avoid air entrapment by using a fine pointed nozzle and start filling from the bottom up.

e. Curing of the adhesive requires 72 hours.

f. Handling of the assemblies can be done within 2 to 4 hours after which the surface area of the adhesive should be tack free.

WARNING

Camie A1000 is a flammable liquid and vapor. May cause allergic skin reaction, eye, skin and respiratory irritation. Keep away from heat, sparks, and flame. Use only with adequate ventilation. Avoid breathing dust (vapor, mist, gas). Keep container closed. Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.

g. When adhesive contacts a cover which is removable, apply a release agent (Camie A1000).

21. **CURING SEALANTS.** Cure sealants according to the manufacturers' recommendations. The following are general guidelines only. Each manufacturer's material will have specific cure schedules that should be followed. Thickness of the sealant, temperature and humidity are factors which determine the time for a sealant to reach full cure and develop the intended properties.

CAUTION

Unless recommended by the sealant manufacturer, do not exceed 110°F (43°C) or the sealant will begin to degrade.

a. Sealants may be cured at room temperature. Refer to NAVAIR 01−1A−509−4 and NAVAIR 01−1A−507 for specific cure times and acceleration methods.

b. Self Leveling Green HT3326−5FR−50 and Thixoflex−FR (TG2010FR−50) starts to gel in as little as 5 minutes. At approximately 40 minutes it is set up, and is fully cured in 2 hours. (This is at ambient air temperature of 70°F). The ambient air temperature must be at least 50 degrees for it to cure.

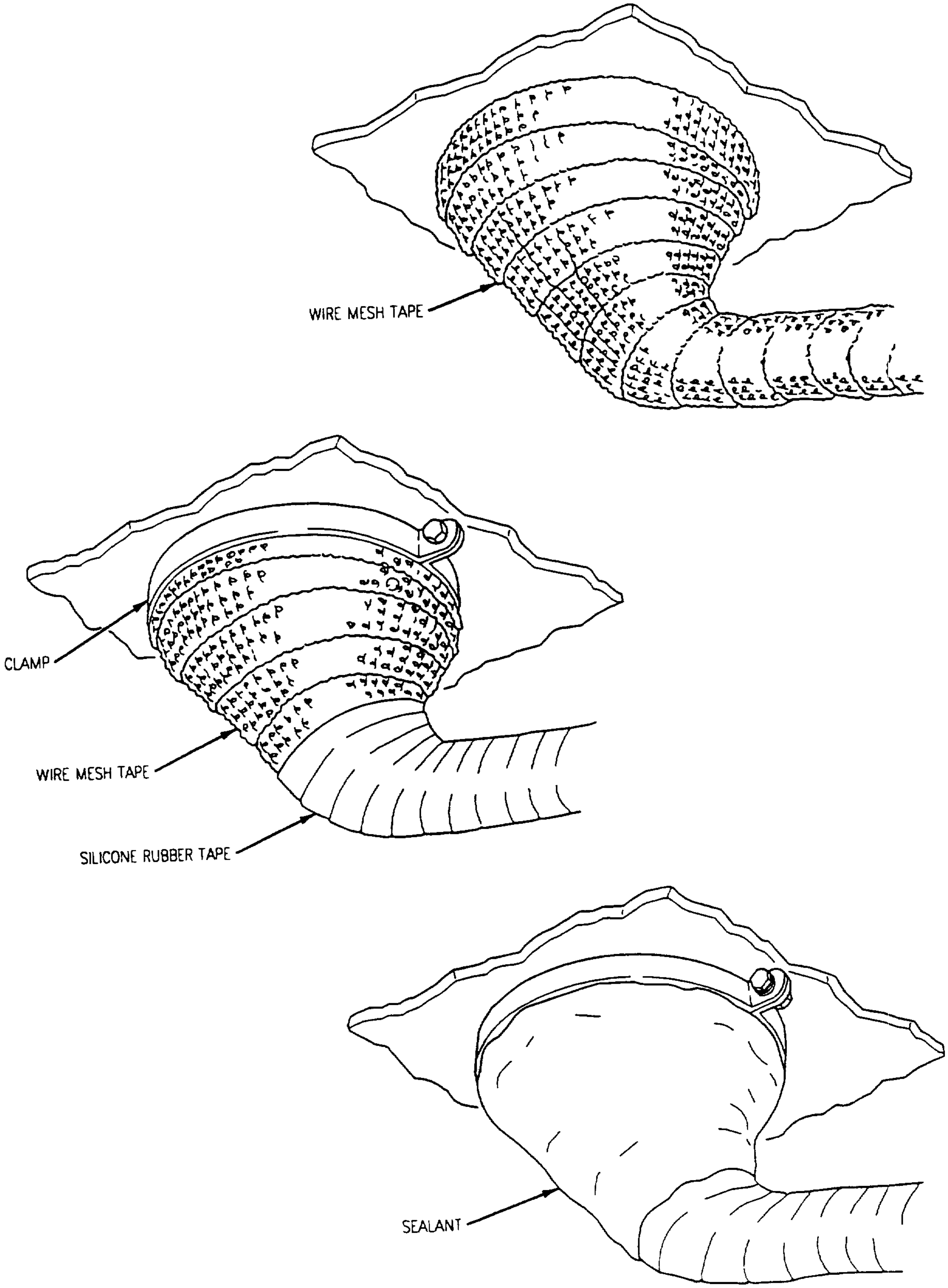


Figure 19. Sealing EMI Cable Assemblies

22. **CONNECTOR DUAL WRAP KIT AND THIXOFLEX−FR STORAGE. (POLYURETHANE SEALANT, SELF−LEVELING GREEN−FR and THIXOFLEX−FR).**

a. AD28500−36−36−8 only needs to be kept out of direct sunlight.

NOTE

If (HT3326−5FR−50) and Thixoflex−FR (TG2010FR−50) have past expiration date and no more is available, test material by injecting a small amount into a cup or bag and check in 1 hour to see if material has cured.

b. (HT3326−5FR−50) and Thixoflex−FR (TG2010FR−50) need to be kept warm, do not refrigerate. There is a 6 month shelf life on this product from date of mfg marked on the outside of the black Nitrogen filled bag. Once the bag has been opened the material must be used within 24 hours. If more than one connector will be wrapped within the 24 hours leave the current mixing straw on the cartridge until ready to use again. At that time replace the mixing straw with another included with the cartridge and re−prime the mixture.

23. **POLYSULFIDE SEALANT (MIL-PRF-8516) STORAGE**.

a. Unmixed Sealant Storage. Store base and accelerator in a cool place, refrigerate if possible. Shelf life is about 6 months when stored below 75°F (24°C), and about one year when stored at 45°F (7°C) or below.

b. Mixed Sealant Storage. Mixed MIL-PRF-8516 compound can be stored in cartridge tubes for periods of 30 to 60 days provided the filled tubes are quick frozen immediately after mixing and are stored at 40°F (-40°C) (paragraph 27). In general, extended storage of mixed, frozen compound shortens pot life and cure time after thawing. Sealant which has a working life of less than one hour should not be refrozen.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

24. **POLYURETHANE SEALANT (MIL-M-24041) STORAGE.**

a. Two-Component Kit Storage. Store components in a cool place. Shelf life is about 6 months when stored below 75°F (24°C), and about one year when stored at 45°F (7°C) or below.

b. Frozen Pre-mixed Compound Storage. When stored at -20°F (-29°C), storage life is at least 7 days. When stored at -90°F (-68°C), minimum storage life is 28 days.

c. Mixed Sealant Storage. Mixed Polyurethane Sealant can be stored in cartridge tubes for periods of 7 to 30 days provided the filled tubes are quick-frozen immediately after mixing and degassing and stored at -40°F (-40°C) (paragraph 27). In general, extended storage of mixed, frozen compound shortens pot life and cure time after thawing. Sealant which has a working life of less than one hour should not be refrozen.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

25. **SILICONE SEALANT, TWO-PART RTV (MIL-PRF-23586) STORAGE.**

a. Unmixed Sealant Storage. Store base and accelerator in a cool place, refrigerate if possible. Shelf life is about 6 months when stored below 75°F (24°C), and about one year when stored at 45°F (7°C) or below.

b. Mixed Sealant Storage. The storage life of quick-frozen MIL-PRF-23586 compounds is usually less then three weeks provided the filled tubes are quick-frozen immediately after mixing and are stored at -40°F (-40°C) (paragraph 27). In general, extended storage of mixed, frozen compound shortens pot life and cure time after thawing. Sealant which has a working life of less than one hour should not be refrozen.

26. **SILICONE SEALANT, ONE-PART RTV STORAGE.**

a. Store below 90°F (32°C). Refrigerated storage is not essential but will extend useful shelf life. Shelf life shall not exceed twelve months without evaluation as to condition prior to use. Since this material cures upon exposure to humidity in the air, keep container sealed when not in use. A plug of cured material may form in tip of tube during storage. This is easily removed and does not affect remaining contents.

27. **EPOXY RESIN (MIL-I-16923) STORAGE.**

a. Unmixed Sealant Storage. Resin and catalyst, unmixed in original unopened containers, should be stored between 40°F (4°C) and -55°F (-48°C) for maximum shelf life. At these temperatures, shelf life of material is greater than 6 months.

b. Mixed Sealant Storage. In general, extended storage of mixed, frozen compound shortens pot life and cure time after thawing.

(1) Stycast 2651/Catalyst 9 mixture maybe stored in small syringes for up to 7 days when quick-frozen (paragraph 27) immediately after mixing and stored at -40°F (-40°C). Sealant which has a working life of less than one hour should not be refrozen.

(2) Stycast 2651/Catalyst 11 mixture may be stored in small syringes for up to 30 days when quick-frozen immediately after mixing and stored at -40°F (-40°C) (paragraph 27).

28. **QUICK-FREEZE PROCEDURE FOR SEALANTS.**

WARNING

Isopropanol and the vapors are extremely flammable. Consult MSDS for proper personal protection equipment.

Do not allow solid carbon dioxide to contact the skin due to danger of frostbite.

a. Quick freezing of filled tubes of mixed compound is done by immersing in a mixture of Isopropanol and solid carbon dioxide for five minutes. This will cool the tubes to below -50°F (-46°C). Store properly once frozen. Freezing by slow cooling in air may significantly reduce the storage life of the mixed compound.

29. **DEPOTTING SEALANTS.**

WARNING

Solvents are hazardous materials. Always become familiar with the Material Safety Data Sheets (MSDS) prior to use of the chemical. Consult MSDS for the proper personal protection equipment (PPE) to use when working with the material. PPE must be worn when working with solvents, including safety goggles, rubber gloves, and aprons when necessary. Personnel should not be exposed to solvent vapors for extended periods of time. Work with solvents in a properly ventilated area. In confined locations, use portable ventilation equipment.

30. **CONNECTOR DUAL WRAP KIT AND THIXOFLEX–FR REMOVAL. (POLYURETHANE SEALANT, SELF–LEVELING GREEN–FR and THIXOFLEX–FR).**

NOTE

For Thixoflex–FR removaal, omit steps a through c.

a. Cut the Self–Fusing Silicone Tape with a sharp blade or similar tool, taking care not to cut the harness beneath.

b. Peel the tape away from the harness bundle.

c. Peel the StretchSeal Tape away from the connector and rear accessory.

d. Remove the polyurethane sealant by pulling with fingers or other blunt instrument, so as to not damage the wires.

WARNING

Isopropanol and the vapors are extremely flammable. Consult MSDS for proper personal protection equipment.

e. Use isopropyl alcohol or other approved cleaning solvent to remove any remaining residue.

NOTE

Dual Wrap Kit and Self−Leveling Thixoflex−FR (TG2010FR−50) Green are non−hazardous and can normally be disposed of in a regular trash receptacle. However check with local regulations before disposal.

WARNING

When using silicone compounds, wash hands thoroughly before eating, drinking, or smoking. Silicone based sealants/adhesives must be used in a well ventilated area.

31. REMOVAL OF POLYURETHANE, POLYACRYLATE, AND EPOXY SEALING COMPOUNDS.

a. Prior to cleaning operation, rope off area involved and provide suitable signs indicating unauthorized personnel will stay clear of area.

CAUTION

Dichiloromethane ASTM D4701 (Methylene Chloride) will damage most paint films.

b. Prepare the area below all items subject to solvent for solvent spillage.

(1) Lay down a sheet of polyethylene covered with absorbent material.

(2) Should any solvent be spilled on the absorbent materials, this material should be removed and disposed of or laundered.

c. Prepare aircraft taking all outlined safety precautions.

d. Remove plastic mold from potting on connector or relay (if installed), using soldering iron or cutting pliers (paragraph 24) to cut plastic.

CAUTION

Use extreme care to prevent damage to wire insulation or to the component body.

NOTE

Soldering iron tip should be modified to resemble a small spoon with no sharp or blunt edges. New tips may be fabricated from brass welding rod.

e. Trim excess potting from component using soldering iron with modified tip. or cutting pliers.

f. Fill the polyethylene bag with enough dichloromethane to completely immerse the potting compound, and check the bag for leakage. If the bag is leaking, transfer the solvent to a. new bag and discard the leaky bag. Label the starting time on the bag with a marking pen to keep an accurate count of the soaking time.

CAUTION

Be sure polyethylene bags are tightly sealed. The alternate procedure must be accomplished in a ventilated booth area approved by the resident Bio-environmental Engineer.

NOTE

An alternate method is to place the connector in a large can or bucket, filling the container with enough dichloromethane to completely immerse the potting compound. Then add about one inch of water to it. The water will stay on top of the dichloromethane keeping the vapors from getting into the air. This will also prevent evaporation of the solvent.

The use of ZIP-LOCK polyethylene bags in lieu of the tie type bags is permitted.

g. Insert the connector or relay in the polyethylene bag. Tie the top of the bag in place with a nylon cord or a wire to prevent evaporation of the solvent.

h. While the compound is soaking, inspect the bags for leaks every 10 to 20 minutes. Leaking bags found during this period shall have a second bag tied around them. This soak period shall be restricted to a maximum of one hour. Connectors which have the potting compound swelled or dissolved in less than one hour should be removed as soon as possible from the solvent to minimize soak time.

i. After the old potting compound has been dissolved, swelled, or one hour soaking time has been obtained, remove the bag of solvent. Contaminated solvent must be disposed of in an environmentally safe manner. Contact the Bioenvironmental Engineer to establish an approved procedure.

j. Using tweezers, needle nose pliers, or picks, remove swollen potting compound.

CAUTION

Never allow the soaking time to be extended over two hours. Prolonged immersion can swell and damage neoprene inserts in connectors.

k. Repeat swelling and picking operation until all potting compound is removed.

l. Brush the connector briskly to remove all residues; rinse while brushing with small quantities of dichloromethane. Allow the solvent to run over the connector and collect in a container or polyethylene bag below the connector.

m. Allow the component to dry for thirty minutes minimum, then apply heat with Raychem HT900 or an explosion proof heat gun starting 6 to 8 inches above the component and work down. Five minutes heating time is sufficient. The applied temperature should not exceed 250°F.

n. Let stand for twenty-four hours. Inspect for cleanliness and check all wires for insulation damage.

32. REMOVAL OF SILICONE AND POLYSULFIDE SEALING COMPOUNDS.

CAUTION

Use extreme care not to damage adjacent connector contacts or wire.

a. Using a soldering iron with a modified tip as shown in Figure 20 cut away the potting to gain access to the desired contact(s).

b. Using a dull knife, scrape away the remaining potting in the contact area.

WARNING

Dichiloromethane ASTM D4701 (Methylene Chloride) is highly toxic to skin, eyes, and respiratory tract; avoid all exposure. Skin, eye, and respiratory protection is required.

c. Final traces of polysulfide may be removed manually or with Dichiloromethane ASTM D4701 (Methylene. Final traces of silicone may be removed using a soldering iron and a dull knife, pick or tool.

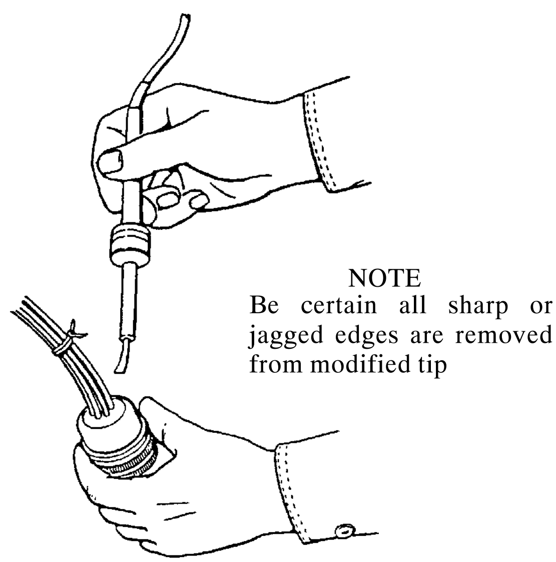


Figure 20. Potting Removal

33. **SEALING OF NON–ENVIRONMENTAL SPLICES AND COMPONENTS.**

Although not authorized in DOD aircraft now, past manufactures and maintenance allowed non–environmental splices. If installed and in acceptable condition seal in accordance with the following:

a. Self–leveling green sealing. Follow procedures in paragraph 7.

b. Silicon Tape Sealing (Figure 21).

(1) Wrap splice or terminal with silicon tape A–A–59163.

(2) Using lacing and tying A–A–52083 or A–A–52084, tie both beginning and end of tape wrap.

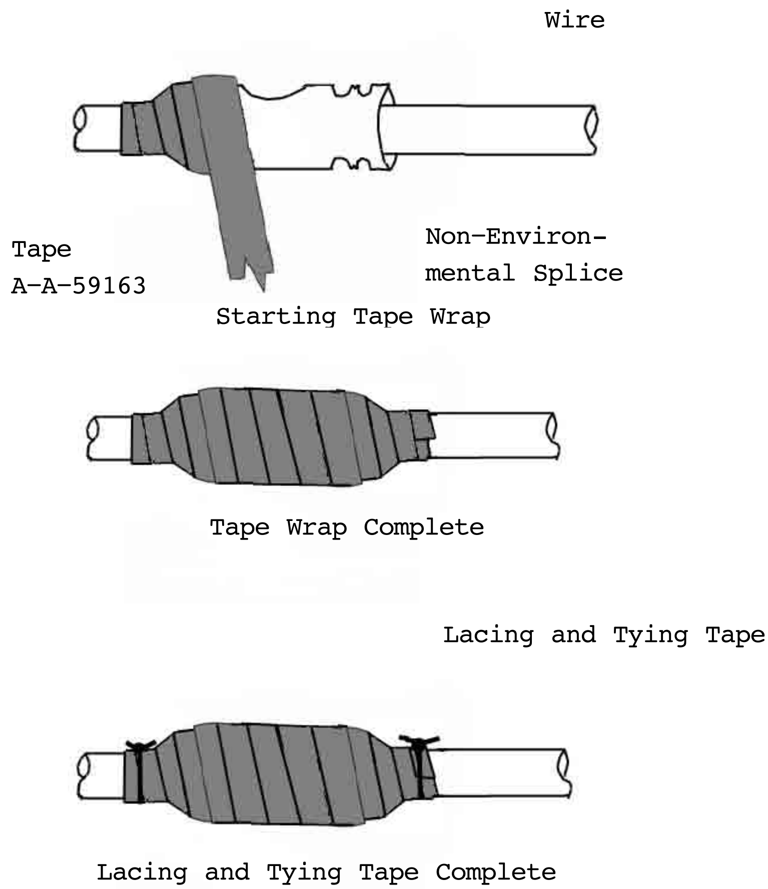


Figure 21. Taping Non–Enviormental Splice

CONNECTOR CLEANING AND PRESERVATION

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Potting and Sealing Connectors, Electrical Cable Assemblies, and Electrical Components 025 00
Toxicity, Flash Point, and Flammability of Chemicals . . . . NAVAIR 07-1-505
Corrosion Program and Corrosion Theory . . . . NAVAIR 01–1A–509–1
Avionic Cleaning and Corrosion Prevention/Control . . . . NAVAIR 01–1A–509–3
Consolidated Hazardous Item List . . . . NAVSUP Publication 4500
Navy Occupational Safety and Health (NAVOSH) . . . . OPNAVINST 5100.23
Navy Hazardous Material Program . . . . NAVSUPINST 5100.27
Hazardous Materials Information System (HMIS) . . . . DOD 6050.5
Individual HAZMAT . . . . Applicable Material Safety Data Sheet (MSDS)

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

Nomenclature	Specification/ Part Number
Abrasive Mat	MIL-A-9962, Type I, Grade A
Brush	H-B-681
Brush, Acid Swabbing	H-B-643
Cleaning Cloth	CCC-C-46, Class 4
Cleaning Solvent	MIL–PRF–29608A Type 1, Class C
Pipe Cleaner	840507
Isopropyl Alcohol	TT–I–735
Toothbrush	H-T-560
Corrosion Preventive Compound	MIL-PRF-81309, Type II and Type III
Water-Displacing Corrosion Preventive Compound	MIL-DTL-85054, Type I

1. **INTRODUCTION.**

2. This work package (WP) describes the cleaning, preservation and corrosion prevention/control procedures for connectors, wire, and EWIS components. Where discrepancies exist between this manual and the NAVAIR 01–1A–509 series, the NAVAIR 01–1A–509 shall take precedence.

3. **SAFETY.**

4. The following warnings shall be observed.

WARNING

Some of the materials identified in this manual can create hazardous conditions or damage equipment unless used strictly in the applications and manner described.

Sealants and solvents may contain toxic compounds. Always become familiar with Material Safety Data Sheets (MSDS) prior to working with materials. Consult MSDS for proper Personal Protection Equipment (PPE) to use when working with materials. Always wear gloves and eye protection and avoid skin contact. If solvents or protective compounds contact the skin, clean thoroughly.

Do not use synthetic fiber wiping cloths with Isopropyl Alcohol, TT–I–735, due to the low flash point of the solvent. Dry fiber wiping cloths will cause a static charge build–up and can result in fire.

WARNING

Solvents are flammable and solvent vapors are toxic. Keep solvents away from open flames and use only in a well-ventilated area. Avoid solvent contact with skin.

Do not use Water-Displacing Corrosion Preventive Compound, MIL-PRF-81309, Water-Displacing Corrosion Preventive Compound, MIL-DTL-85054, Corrosion Preventive Compound, MIL-PRF-16173, or Lubricating Oil, General Purpose Preservative, MIL-PRF-32033 around oxygen, or oxygen fittings, since fire or explosion may result.

Chemical film materials are strongly oxidizing and are a fire hazard in contact with organic materials such as paint thinners. Do not store or mix surface treatment materials in containers previously containing flammable products. Rags contaminated with chemical film material should be burned as soon as practicable.

Experimentation with cleaning and corrosion removal equipment is not an authorized practice. Damage to circuit components may result from reactions to the chemical solutions used in the cleaning and corrosion removal support equipment.

5. **RECOGNIZING CORROSION.**

6. Recognizing corrosion in metals is an important part of Corrosion Cleaning and Prevention Program (Refer to NAVAIR 01–1A–509–1 and NAVAIR 01–1A–509–3). Modern avionics systems make use of many metals not normally considered for airframe structures. In addition to recognizing corrosion in metals, the inspection process must include the recognition of corrosion caused by solder fluxes and the deterioration of metals and non-metals caused by microbial, insects, and animal attack.

7. **COMMON TYPES OF CORROSION.** There are many forms of corrosion that may occur depending upon the types of metal, configuration of the metal, and environment in which the components are placed. The following types of corrosion are common to avionics equipment on military aircraft:

a. Uniform Surface Attack

b. Galvanic (dissimilar metals)

c. Pitting

d. Crevice (concentration cell)

e. Inter-granular

f. Stress

g. Erosion

8. Left untreated, corrosion on electrical connectors will continue to spread to adjacent surfaces and to mating connectors.

9. External corrosion on cable connectors will, if left untreated, continue to corrode into the electrical contacts causing system degradation and eventual failure.

10. The characteristics of corrosion on metals used in avionics systems are explained in NAVAIR 01–1A–509–1, Chapter 3, Corrosion Theory and in Table 1.

WARNING

Ensure that all electrical power is disconnected from the aircraft and all systems in the aircraft are de-activated. Disconnect all batteries.

11. **CLEANING AND PRESERVATION OF CONNECTORS AND BACKSHELLS.**

Connectors require special attention when installed in areas exposed to salt water, such as speed brake, wingfold, and landing gear areas. The following procedures will assist in the prevention of corrosion of multi–contact and coaxial connectors:

a. Whenever possible, mount the connectors horizontally. This will prevent water from running along the wire bundle and into the connector.

b. When system configuration requires the connector to be mounted vertically, place a drip loop in the attached wire bundle which will cause water to run off prior to reaching the connector.

c. If connector boots are installed and water intrusion cannot be prevented, a small drain hole may be cut in the low point of the connector boot to allow the water to escape.

d. Protect open connectors with metal caps. Refer to WP 007 00 (Connector Capping and Stowing).

e. (For multi–contact connectors only) The repeated removal and replacement of contacts, or omission of the sealing plugs, may cause the water tight seals within the connector to lose their effectiveness. The use of additional sealing may be required to prevent water intrusion in extreme cases where the connector cannot be replaced. Refer to WP 025 00.

f. For detailed instructions on connector cleaning proceed to next paragraphs.

12. **CONNECTOR OR COMPONENT (OTHER THEN WIRE OR CABLE) CLEANING.**

a. Dry Contamination.

WARNING

Compressed air used for drying can create airborne particles that may enter the eyes. Pressure shall not exceed 10 psi. Eye protection is required. Use of nitrogen in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

b. For components contaminated with dust or dirt, this shall be removed with a small brush and low−pressure air or nitrogen, with pressure not exceeding 10 psi. This process does not include the removal of corrosion from electrical components. Should corrosion be present refer to paragraph 13.

c. Fluid Contamination.

WARNING

Ensure that all electrical power is disconnected from the aircraft and all systems in the aircraft are de−activated. Disconnect all batteries. Serious injury to personnel and damage to aircraft may occur.

CAUTION

Cleaning compounds and solvents identified in this work package may react with some encapsulants or plastics used to form wire harness tubing, wire coatings, gaskets, and seals. Test a small area for softening or other adverse reactions prior to general application. If swelling persists for over 24 hours, replace affected component.

Do not apply preservatives or cleaning solvents (including corrosion prevention compounds (CPC), solvents or lubricants) on multiple termini/contact connectors containing fiber optic termini or on fiber optic single ferrule connectors. Any seepage onto the fiber optic end face may degrade the system transmission performance or cause failure resulting in potentially lengthy cleaning process, maintenance action or repair to correct.

(1) Wipe off all excess fluid contaminant and debris using a lint free cloth.

WARNING

Isopropyl Alcohol, TT−I−735 is highly flammable and toxic. Do NOT use synthetic wipe cloths due to possible electrostatic discharge and ignition. Use in a well ventilated area. Keep away from open flames. Avoid prolonged or repeated breathing of vapor or contact with skin. Avoid any contact with eyes. Safety glasses and protective gloves are recommended. Wash hands after use.

Cleaning Solvent used is dispensed using an aerosol can and under pressure. Solvent stream used for cleaning can create airborne particles and over−spray which may enter the eyes. Adequate eye protection and gloves are required.

NOTE

If connectors are attached to flexible, accessible harnesses, tip connector downward to allow solvent to flush out loosened debris and contaminants.

(2) For connectors, module blocks, etc, (components having elastomeric parts such as grommets and seals) the contamination should be removed with a small brush, or lint free cloth (CCC−C−46, Class 7), using Isopropyl Alcohol (TT−I−735), or Cleaning Solvent meeting Mil−Prf−29608A, Type 1, Class: C (NSN: 6850−01−418−1704, or 6850−01−412−5579).

CAUTION

Do not use MIL–PRF–29608A, Type 1, Class: ”L”, as it contains silicone and will leave a residue. This traps debris which acts as an abrasive. The only authorized cleaning solvent version is Class: C; no substitutes. Failure to use it will induce wiring system failure.

(3) For applications when higher environmental protection requirements exist, such as those in the European Union, use Lotoxane Cleaning Fluid (NSN: 6850–99–179–9802), or the Lotoxane wipes (NSN: 7930–99–598–5789).

WARNING

Compressed air used for drying can create airborne particles that may enter the eyes. Pressure shall not exceed 10 psi. Eye protection is required.

Use of nitrogen in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

NOTE

Cleaning compounds and solvents identified in this work package may react with some encapsulants or plastics used to form wire harness tubing, wire coatings, gaskets, and seals. Test a small area for softening or other adverse reactions prior to general application.

Certain fluids can cause swelling of the elastomeric materials used within electrical components, after cleaning the swelling should subside. If the swelling does not subside within 24 hours of cleaning, the component should be replaced.

(4) Only use enough cleaning fluid to remove the contamination. At no time shall the component be immersed in the cleaning fluid. After the contamination has been removed, any residual solvent on the component may be dried using low–pressure air or nitrogen, with pressure not exceeding 10 psi.

(5) For additional cleaning information applications refer to NAVAIR 01–1A–509–3, Chapter 6.

(6) Preserve connector or component after cleaning by following procedure in paragraph 14.

13. **CORROSION REMOVAL AND CLEANING.** Corrosion removal and cleaning procedures are not the same for metallic and non–metallic (composite) connectors. Since composite connectors and accessories depend solely on plating for shell conductivity, it is extremely important not to damage the plating during cleaning. The following process is for corrosion removal and cleaning of metallic and non–metallic connectors and backshells:

WARNING

Avoid oral contact with hands during cleaning operations and wash hands immediately when completed. Cadmium plating on connectors (usually OD green in color when new) corrodes leaving a white powder residue. The white powder can be a source of cadmium oxide. When absorbed in the body over the years, can cause serious health problems. Handling, or inhaling the powder, such as when followed by smoking or eating is a potential means of ingesting trace amounts of cadmium oxide. Consult applicable health and environmental regulations regarding its use, handling and disposition.

a. Inspect connectors, backshells and wiring components for corrosion damage. If corrosion is severe, applicable component, connector and/or backshell shall be replaced. If corrosion is found at the contact to wire connection, inspect wire harness or cable (paragraph 16). Refer to NAVAIR 01–1A–509–3, Chapter 6 for additional information.

b. Clean surface corrosion using stiff brush. Only remove surface corrosion and do not remove the protective plating on connectors and components. Replace component if severe corrosion can not be removed, or if plating was removed / corroded off. Refer to NAVAIR 01–1A–509–3, Chapter 6 for additional information.

CAUTION

For connectors containing fiber optics, do not disconnect connectors. Refer to NA 01–1A–505–4, as damage to components may be induced. Follow connector cleaning procedures therein.

c. Disconnect connector. Inspect and clean using brush to remove surface corrosion. Use approved solvent in paragraph 12 above to assist with removing surface corrosion. Replace component if excessive corrosion can not be removed, or if plating was removed / corroded off. For additional corrosion cleaning information applications refer to NAVAIR 01–1A–509–3, Chapter 6.

d. Preserve connector or component after cleaning. Refer to paragraph 14.

14. **WATER DISPLACEMENT AND PRESERVATION OF MULTI-CONTACT CONNECTORS.** This section applies to both metallic and non-metallic (composite) connectors. Any time connectors are separated for maintenance, preserve using the following procedure:

WARNING

Do not apply Corrosion Preventive Compound, MIL–PRF–81309, Type III, to internal sections of connectors and receptacles. Serious damage to equipment, possibly resulting in system failure, fire and personnel injury may occur.

Avoid breathing vapors or spray mist from Water Displacing Corrosion Preventive Compounds. Comply with all MSDS Personnel Protactive Equipment.

CAUTION

Do not apply preservatives or cleaning solvents (including corrosion prevention compounds (CPC), solvents or lubricants) on multiple termini/contact connectors containing fiber optic termini or on fiber optic single ferrule connectors. Any seepage onto the fiber optic end face may degrade the system transmission performance or cause failure resulting in potentially lengthy cleaning process, maintenance action or repair to correct.

NOTE

A pre–approved, “permanent” solid film lubricant may have been applied to threads by connector manufacturers (with durability of at least 500 mating cycles). Repair or replacement of this coating is not authorized for fiber optic connectors.

a. Apply a light film of Water-Displacing Corrosion Preventive Compound, MIL-PRF-81309, Type III, to the external sections of plugs and receptacles.

b. Tilt plug or receptacle down to drain excess, when possible. Wipe off extra preservative with cleaning cloth.

c. Lubricate threaded areas of connectors and backshells with Water-Displacing Corrosion Preventive Compound, MIL-PRF-81309, Type III prior to assembly.

d. Preserve outer shell of connectors with a thin coating of Water-Displacing Corrosion Preventive compound, MIL-DTL-85054, Type III.

15. **WATER-DISPLACEMENT AND PRESERVATION OF COAXIAL CONNECTORS.**

WARNING

Do not apply Water-Displacing Corrosion Preventive Compound (MIL-PRF-81309, Type II or III), or Water-Displacing Corrosion Preventive Compound (MIL-DTL-85054, Type III), to internal areas of coaxial connectors. Application of preservatives to internal sections of coaxial connectors may cause erroneous indications in system performance.

Avoid breathing vapors or spray mist from Water-Displacing Corrosion Preventive Compounds. Wear goggles or face shield. Avoid prolonged skin contact.

a. Mate connectors together.

b. Preserve external areas of connectors with thin coating of water displacing corrosion preventive compound (MIL-DTL-85054, Type III). Avoid excessive application of preservative.

16. CLEANING AND PRESERVATION OF WIRE HARNESSES AND CABLES.

17. When corrosion is found at the pin-to-wire interface on electrical connectors, the wire harnesses and cables should be inspected for corrosion attack and cracking of the wire insulation.

NOTE

Coaxial cable shielding is particularly susceptible to corrosion.

a. Do not apply any CPC to insulation of any wire or cable type. For maximum effectiveness, wires and cables shall be clean and dry. Contamination with fluids and debris, degrades the wire insulation and wiring system operation.

b. Repair, or replace affected damaged wires, or connectors.

WARNING

Ensure wires are completely dry after cleaning, particularly if wiring exhibits cracks in the insulation. Inspect affected wiring prior to applying power. Failure to remove all solvents or contaminants may result in equipment damage and injury to personnel.

c. Inspect cleaned wires during the next application of power to ensure no arching events occur.

18. When wire harnesses are extremely soiled or contaminated refer to NAVAIR 01−1A−509−3, Chapter 10, Wire Harnesses and Cables.

a. Repair, or replace affected damaged wires, or connectors.

WARNING

Ensure wires are completely dry after cleaning, particularly if wiring exhibits cracks in the insulation. Inspect affected wiring prior to applying power. Failure to remove all solvents or contaminants may result in equipment damage and injury to personnel.

b. Inspected cleaned wires during the next application of power to ensure no arcing events occur.

Table 1. Corrosion of Metals - Nature and Appearance of Corrosion Products

Alloy	Type of Attack to Which Alloy Is Susceptible	Appearance of Corrosion Product
Titanium	Extended or repeated contact with chlorinated solvents may result in embrittlement. Cadmium plated tools can cause embrittle of titanium.	White powdery deposit.
Magnesium alloy	Highly susceptible to pitting.	White powder snow-like mounds, and white spots on surface.
Carbon and low alloy steel (1000-800 series)	Surface oxidation and pitting, surface and intergranular.	Reddish-brown oxide (rust).
Stainless steel (300-400 series)	Intergranular corrosion. Some tendency to pitting in marine environment (300 series more corrosion resistant than 400 series).	Corrosion evidenced by rough surface; sometimes by red, brown or black stain.
Nickel-Base alloy (Inconel)	Generally has good corrosion-resistant qualities. Sometimes susceptible to pitting.	Green powdery deposit.
Cadmium (used as protective plating for steel)	Good corrosion resistance. Will cause embrittlement if not properly applied.	White to brown to black mottling of the surface.
Chromium (used as a wear-resistant plating for steels)	Subject to pitting in chloride environments.	Chromium being cathodic to steel, does not corrode itself, but promotes rusting of steel where pits occur in the coating.
Silver	Will tarnish in presence of sulfur.	Brown to black film.
Gold	Highly corrosion resistant.	Deposits cause darkening of reflective surfaces.
Tin	Subject to whisker growth.	Whisker-like deposits.

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TERMINAL JUNCTION SYSTEM

Reference Material

Alphabetical Index

Support Equipment Required

Nomenclature	Part. No./Type Designation
3/8 Inch Socket	—
TJS Block Removal Tool	M81714/39-01
TJS Block Removal Tool	M81714/69-02

Materials Required

Nomenclature	Specification/ Part Number
Component Rack Assembly	M81714/67
Component Rack Assembly	M81714/67
Pin Contact	MIL-C-39029

1. **INTRODUCTION.**

2. The Terminal Junction System (TJS) consists of bussing blocks, racks, brackets, wire-in-line junctions, grounding terminals, grounding blocks, electronics blocks and electronic in-line junctions that are used for innerconnecting electrical components and equipment in an electrical or electronic system. These environment resistant components have in common the use of crimp type external pin contacts in accordance with MIL-C-39029/1 for series I or crimp type external socket contacts in accordance with MIL-C-39029/22 for series II## This family of TJS components is designed to operate continuously over a temperature range of -85°F to +392°F (-65°C to +200°C) (Figure 1).

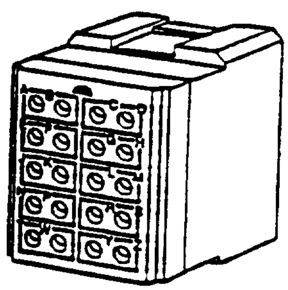

Figure 1. TJS Block

3. **INTENDED USE.** TJS components are intended for electrical distribution use. They are suitable for use in Integrated Wire Termination Systems (IWTS), and environment resistant wiring, in accordance with AS50881.

4. **FUNCTIONAL MARKING.** Top marking of cavities and circuit identification are as specified. Functional marking on bussed components is white and on electronic components is yellow. SKT is marked on the face of the grommet to indicate series II TJS block components required.

5. **SERIES I CLASSES.** Series I terminal junction components described herein are Class D, Classes A, B and C components are inactive for new design. Class D components may be used to substitute for class A, B or C components.

6. **SUPERSEDED PART NUMBERS.** The superseding Series I class D part number is developed by replacing the A, B or C class letter with D in the superseded part number (Figure 4). Examples of such supersessions are as follows:

7. **Bussing Blocks.** Part numbers M81714/7-AA1, -BA1 and -CA1 are superseded by M81714/7-DA1.

8. **Electronic Blocks.** Part numbers M81714/18-A-001, -B-001 and C-001 are superseded by M81714/18-D-001.

9. **Wire In-Line Junctions (splices).** Part Numbers M81714/12-20A-l, -20B-1 and -20C-1 are superseded by M81714/12-20D-1.

10. **Electronic In-Line Junctions.** Part numbers M81714/21-1A-001, -1-B-001 and -1C-001 are superseded by M81714/21-1D-001.

11. **CLASSIFICATION.** Terminal junction components are classed and color coded as follows:

a. Series I, Class A 302°F (150°C) maximum environmental type, limited fluid resistance, green housing, green grommet.

b. Series I. Class B 347°F (175°C) maximum environmental type, extended fluid resistance, red housing, white grommet.

c. Series I, Class C 392°F (200°C) maximum environmental type, limited fluid resistance, black housing, red grommet.

d. Series I, Class D 392°F (200°C) maximum environmental type, extended fluid, resistance, black housing, blue grommet.

e. Series II, 392 °F (200 °C) maximum environmental type, extended fluid resistance, black housing, and reddish brown grommet.

12. **GENERAL.**

13. **BUSSING.** Bussed means interconnected electrically within the component housing. Bussing arrangements and their circuit designators are shown in the boxed areas on top of the grommet (Figure 1). Each common bussed area is called a module.

14. **BLOCK.** A block is one-connector receptacle with one or more modules. The internal structure of atypical block is shown in Figures 2 and 3.

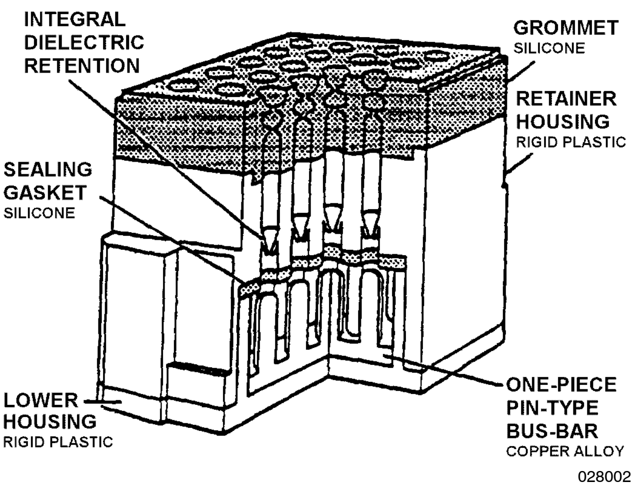

Figure 2. TJS Block

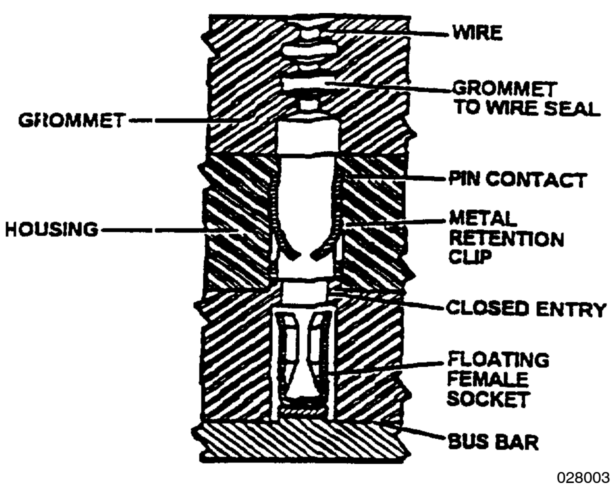

Figure 3. Internal Contact

15. **INTERNAL CONTACT.** Internal contact is the non-removable contact contained in the TJS components (Figure 3).

16. **PACKAGE CONTENTS.** The number of contacts supplied with blocks and in-line junctions should be a minimum of one more for feedback and two more for feedthrough blocks than the number of cavities specified. For feedback blocks two end seal plugs and for feedthrough blocks four end seal plugs are provided.

17. **MILITARY IDENTIFICATION.** The components are identified by a military part number, as shown by the applicable MIL-T-81714 military specification sheet. Components are identified as in the examples (Figure 4).

18. **TYPES OF TERMINAL JUNCTIONS.**

19. **TERMINAL JUNCTION FEEDBACK BUSSING BLOCKS.** A terminal junction feedback bussing block is a receptacle having multiple internal contacts interconnected in parallel to form one or more circuits. A feedback bussing block (Figure 5) has one face containing contact cavities and is used for general purpose interconnection and bussing. Blocks are normally contained and retained in a rack or mounting bracket (Figures 7 and 8).

20. **FEEDTHROUGH BUSSING BLOCKS.** A feedthrough bussing block (Figure 6) has two faces containing contact cavities. The faces are diametrically opposite each other. A contact on one face of a block is electrically and mechanically common with a contact having the same identification letter but exiting from the other face of the block. Feedthrough bussing blocks are used for general purpose interconnection and bussing in applications where circuit wiring must be connected to two sides of the panel, bulkhead or patch board.

21. **RACKS (TRACKS OR RAILS).** A rack (Figure 7) is used to contain and retain a number of blocks. Two types are available, one for feedback blocks and one for feedthrough blocks. The Series I racks have provisions for side or bottom mounting. Blocks are secured to the track by a sliding stop (Series I) or by a latch release system (Series II). The latch system requires a special tool (Figure 14).

22. **MOUNTING BRACKET.** A mounting bracket is used for a single feedback bussing block or electronic block which requires mounting by itself or in a confined space (Figure 8).

23. **WIRE IN-LINE JUNCTION, SINGLE AND DOUBLE (SPLICE).** A wire-in-line junction is essentially a feedthrough environment resistant disconnect component for joining wires. It consists of a body with internal contacts that accommodate removable external contacts. The inline junction splice (Figure 9) is particularly suitable for incorporation into harness wiring, terminating equipment pigtails or single wire repairs that do not affect the overall diameter.

24. **GROUNDING TERMINALS.** The grounding terminal is a feedback receptacle having multiple internal contacts interconnected to form one circuit that in turn is connected to an external mounting stud. Grounding terminals (Figure 10) are used where grounding or a power connection of equipment is necessary.

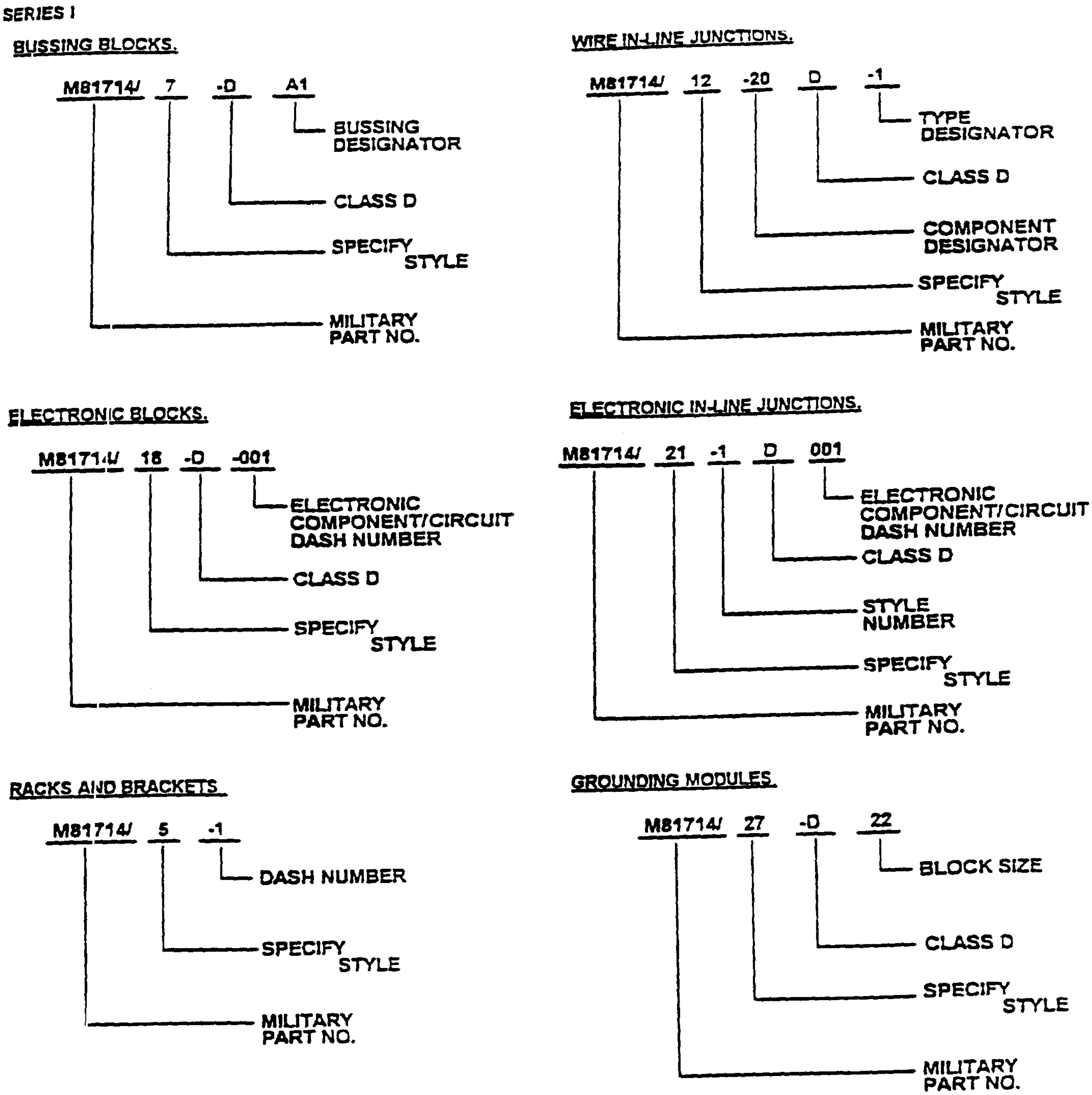

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Figure 4. Identification Examples (Sheet 1 of 3)

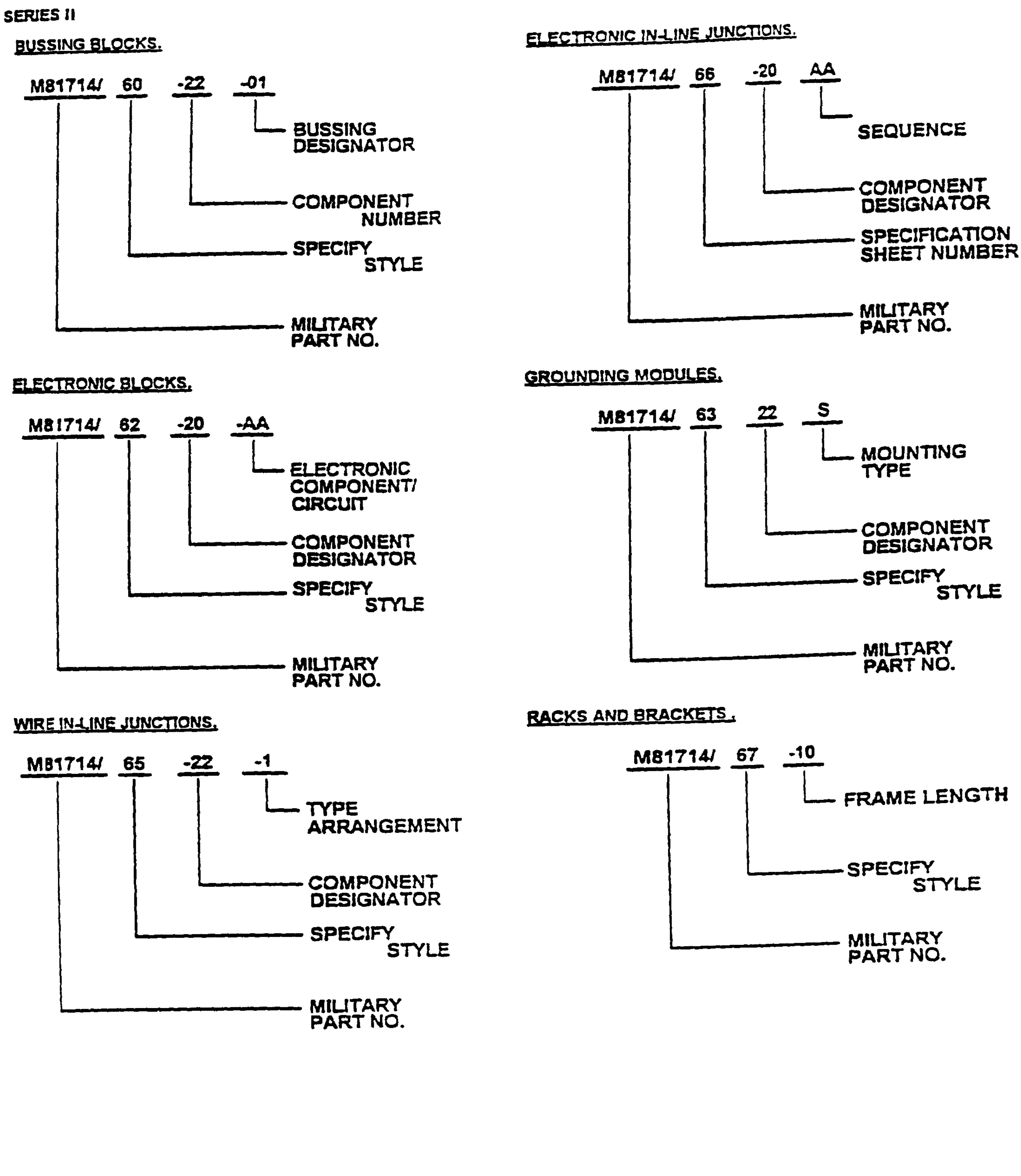

Figure 4. Identification Examples (Sheet 2)

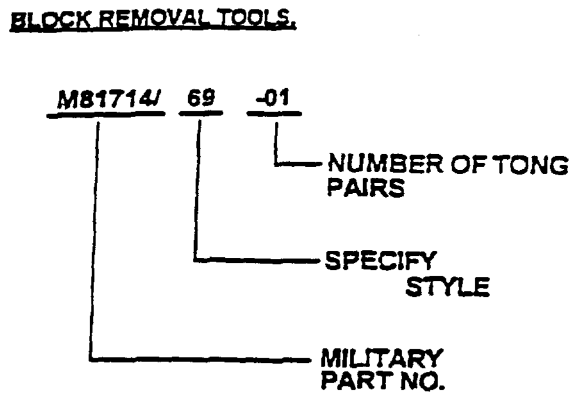

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Figure 4. Identification Examples (Sheet 3)

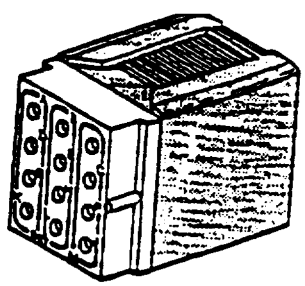

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Figure 5. Feedback TJS Block

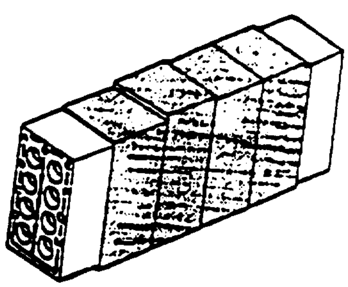

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Figure 6. Feedthrough TJS Block

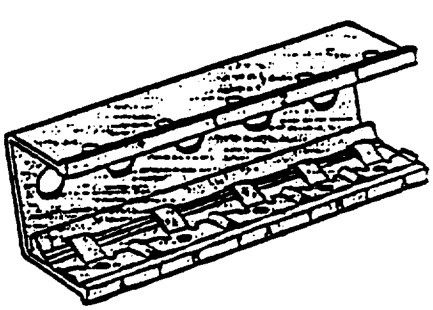

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Figure 7. Series II TJS Rack

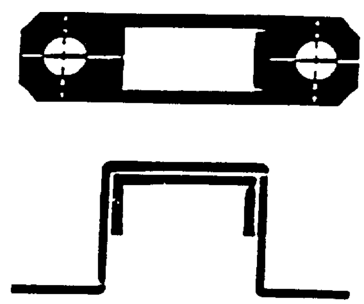

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Figure 8. Series I Mounting Bracket

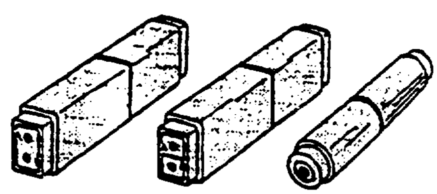

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Figure 9. Wire In-Line Junctions

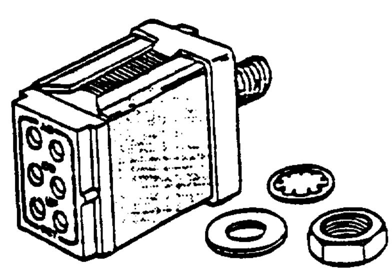

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Figure 10. Grounding Terminals

25. GROUNDING BLOCKS (GROUNDING MODULES). The grounding blocks (Figure 11) are feedback receptacles having multiple internal contacts interconnected to form one circuit that in turn is connected to a grounding plate. These components can also be used for power distribution connections at a buss.

26. **ELECTRONICS BLOCKS (ELECTRONIC MODULES).** Like the feedback bussing blocks, electronic blocks (Figure 12) have one face containing contact cavities. The contact cavities are internally connected by passive electronic components in various combinations. Blocks are normally contained and retained in a rack or mounting bracket.

27. **ELECTRONIC IN-LINE JUNCTION (SPLICE).** Electronic in line junctions (Figure 13) serve the same function as the standard wire in-line junction except these components have resistor, diode or fuse type components incorporated.

28. **SERIES II TJS BLOCK REMOVAL TOOLS.** These tools are intended only for the removal of series II TJS blocks. The M81714/69-01 tool (Figure 14) is designed to remove M81714/60 size 22, 20, or 16 blocks and M81714/61 size 16 or 20 blocks from the M81714/67 component rack assembly. The M81714/69-02 tool (Figure 14) is designed to remove M81714/60 size 12 blocks, M81714/61 size 12 or 16 blocks and M81714/62 blocks from M81714/67 component rack assemblies.

29. **EXTERNAL CONTACT** (Figure 15). Series I blocks require a MIL-C-39029 pin contact and Series II requires a socket contact crimped to the wire. Table 1 specifies the contact types and related conductor size ranges for each series. Table 2 specifies crimp, installing, and removal tools for each series.

30. **END SEAL PLUGS (SEALING PLUGS).** End seal plugs (Figure 16) are the plastic devices used to seal unused cavities in the grommet of a TJS component. Use Table 3 for the correct end seal plug; to fill cavities left in the grommet. End seal plugs should be installed in all unused contact holes in the grommet to prevent the entrance of moisture, dust or other contaminants. When installed, sealing plugs shall have the knob end protruding out of the grommet wire hole and be seated against the grommet top. Sealing plug knobs always protrude out for module blocks regardless whether unused cavities have unwired contacts or no contacts. Other connector types may require the sealing plug knob to be inserted in the contact cavity.

31. **CONTACT PREPARATION AND INSTALLATION IN BLOCK.** Prepare the wire, crimp the contact and insert the contact in the block as follows:

a. Strip the wire in accordance with WP 009 00.

b. Crimp the appropriate Series I pin or Series II socket contact, in accordance with WP 013 00, on the appropriate sized conductor specified in Table 1. Use the required crimp tool and positioner specified in Table 2.

c. Insert the contact in the block in accordance with WP 022 00 using the insertion-tool specified in Table 2. For most applications the contact should be inserted after the block is mounted in the track.

d. When required, insert the un-wired spare contacts in the unused contact cavities.

e. Insert the appropriate sealing plug from Table 3 in all unwired cavities in accordance with Figure 16.

f. Removal of contacts is accomplished by reversing steps c through a of above procedure using the contact removal tool specified in Table 2.

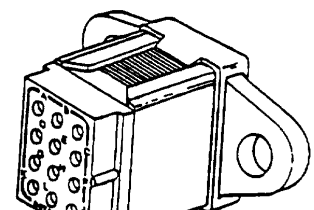

Figure 11. Grounding Block

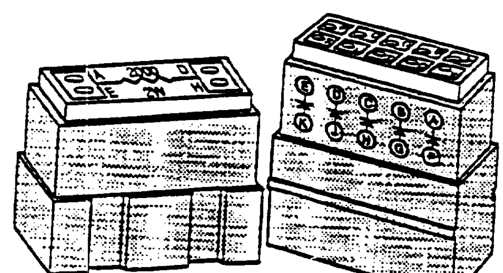

Figure 12. Series I Electronic TJS Blocks

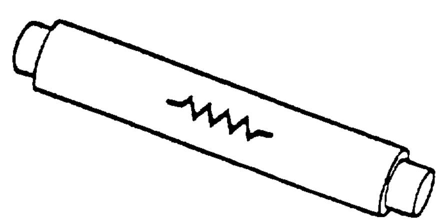

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Figure 13. Electronic In-Line Junctions

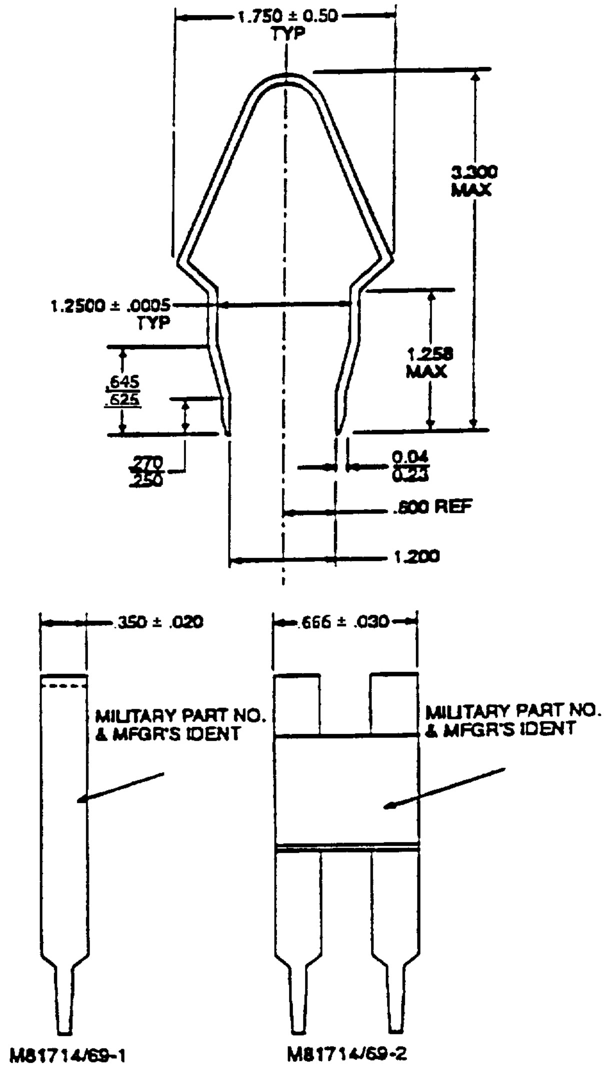

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Figure 14. Series II TJS Block Removal Tools

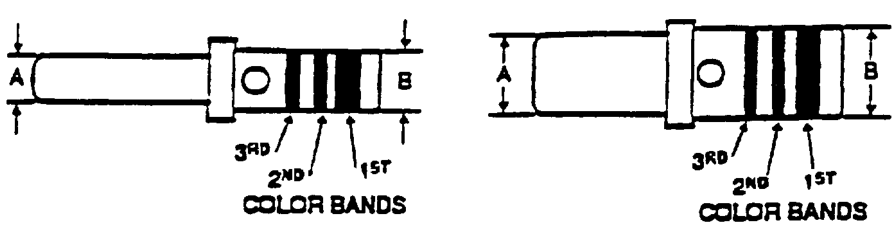

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Figure 15. External Contact

Table 1. Contact Data

M39029/1 Contacts (Series I blocks)							
Part No. M39029	Pin Size Mating	Conductor Size (Wire Barrel)	Color Band 1st	2nd	3rd	Diameter (Figures 15) A(max)	B(max)
/1-100	16	26, 24, 22	Brown	Black	Black	.063	.051
/1-101	16	24, 22, 20	Brown	Black	Brown	.063	.078
/1-102	14	20, 18, 16	Brown	Black	Red	.078	.105
/1-103	12	14, 12	Brown	Black	Orange	.095	.153
/1-507	20	28, 26, 24, 22	Green	Black	Violet	.041	.048
M39029/22 Contacts (Series II blocks)							
Part No. M39029	Socket Size Mating	Conductor Size (Wire Barrel)	Color Band 1st	2nd	3rd	Diameter A(max)	B(max)
/22-191	22	26, 24, 22	Brown	White	Brown	.060	.048
/22-192	20	24, 22, 20	Brown	White	Red	.076	.070
/22-193	16	20, 18, 16	Brown	White	Orange	.108	.103
/22-605	12	14, 12	Blue	Black	Green	.168	.152

Table 2. Contacts Tooling

M39029/1 Contacts				
Pin M3902/1	Basic Crimping Tool	Positioner	Installing Tool	Wire Contact Removal Tool
-100	M22520/2-01	M22520/2-11	M81969/14-11	M81969/14-11
-101	M22520/2-01	M22520/2-11	M81969/14-11	M81969/14-11
	M22520/1-01	M22520/1-02	M81969/8-205	M81969/8-206
-102	M22520/1-01	M22520/1-02	M81969/14-03	M81969/14-03
			M81969/8-207	M81969/8-208
-103	M22520/1-01	M22520/1-02	M81969/14-04	M81969/14-04
			M81969/8-209	M81969/8-210
-507	M22520/2-01	M22520/2-32	M81969/14-01	M8I969/14-01
			M81969/8-01	M81969/8-02
M39029/22 Contacts				
Socket M39029/22-	Basic Crimping Tool	Positioner	Installing Tool	Wire Contact Removal Tool
-191	M22520/7-01	M22520/7-11	M81969/16-04	M81969/16-04
-192	M22520/7-01	M22520/7-12	M81969114-11	M81969/14-11
			M81969/8-205	M8196918-206
-193	M22520/7-01	M22520/7-13	M81969/14-03	M81969/14-03
			M81969/8-207	M81969/8-208
-605	M22520/1-01	DMC#TH343	M819691/16-03	M81969/16-03

Table 3. End Seal Plugs

Contact Part Number	Sealing Plug Part Number	Color Code
M39029/1-507	MS27488-22	Black
M39029/1-100	MS27488-20	Red
M39029/1-101	MS27488-20	Red
M39029/1-102	MS27488-16	Blue
M39029/1-103	MS27488-12	Yellow
M39029/22-191	MS27488-22	Black
M39029/22-192	MS27488-20	Red
M39029/22-193	MS27488-16	Blue
M39029/22-605	MS27488-12	Yellow

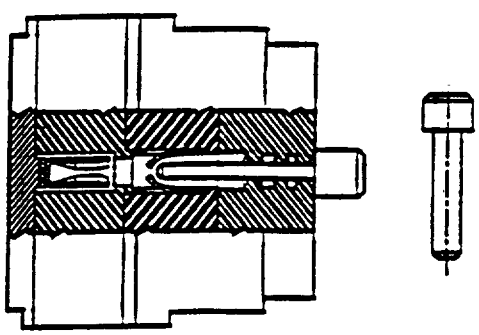


Figure 16. End Seal Plugs

32. **SERIES I BLOCK RAIL/BRACKET INSTALLATION AND REMOVAL.** Install the blocks in the specified MIL-T-81714 track or bracket as follows (Figures 17 through 21):

a. Loosen screw in locking clamp and slide clamp to end of rail opposite the stop (Figures 17 and 20).

b. Insert block into rail next to locking clamp with block index indicator on grommet on same side as the rail indexing indicators. A block can only be installed one way in the rail (Figures 17 and 20).

c. Slide block against the permanent stop at the opposite end of the rail (Figures 18 and 21).

d. Install additional blocks as required, sliding each block against the last previously installed block (Figures 19 and 21).

e. Slide locking clamp against last block and tighten screw securely (Figures 19 and 21).

f. Rails are secured to equipment on aircraft as specified in the aircraft maintenance manuals. Brackets are mounted on top or side of the block then secured to equipment on aircraft.

g. Removal of blocks is accomplished by reversing the procedure given above.

33. **SERIES II BLOCK RAIL/BRACKET INSTALLATION AND REMOVAL.** Install the blocks in the specified MIL-T-81714 track or bracket as follows (Figures 22 through 25):

a. Blocks are pressed into the rail as shown in Figure 22. Press the block by hand into the rail until a definite stop is felt. An audible click may be heard.

b. Visually inspect for block clip retention through the inspection windows on the rail (Figure 23).

34. Removal of the blocks requires the tool shown in Figure 14.

a. Slide the double-sided tool down the indents of the block to the maximum depth to unlock the retaining clips (Figure 24).

b. While holding the tool tightly, remove both the tool and block from the rail (Figure 25).

35. Rails are secured to the equipment or aircraft as specified in the aircraft maintenance manual. Brackets are mounted on the top or side of the block then secured to the equipment or aircraft.

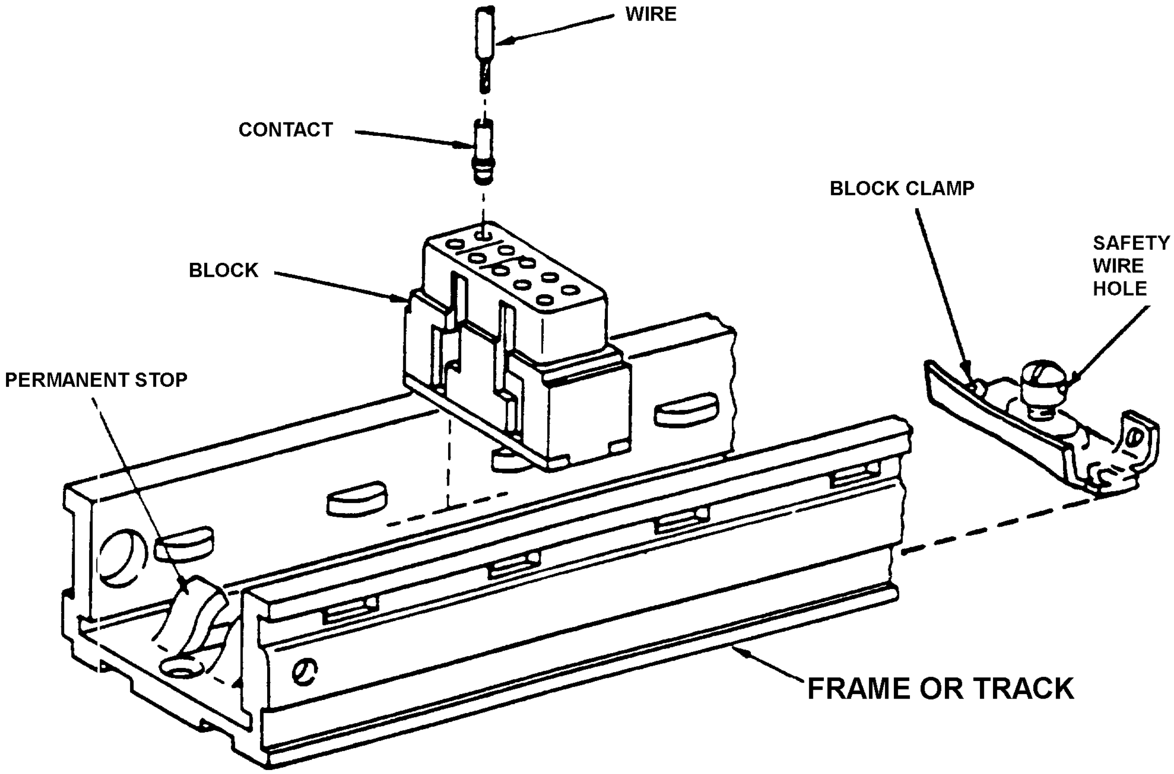


Figure 17. Feedback Terminal Junction Assembly

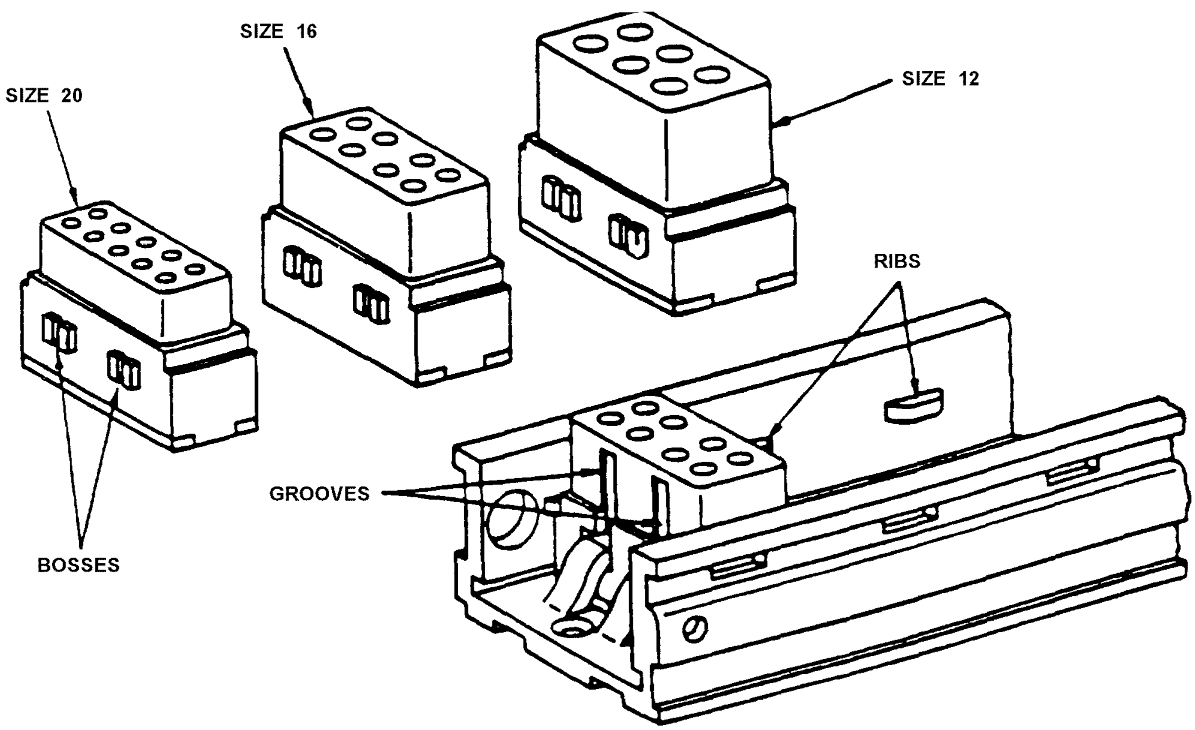


Figure 18. Feedback Terminal Junction Assembly

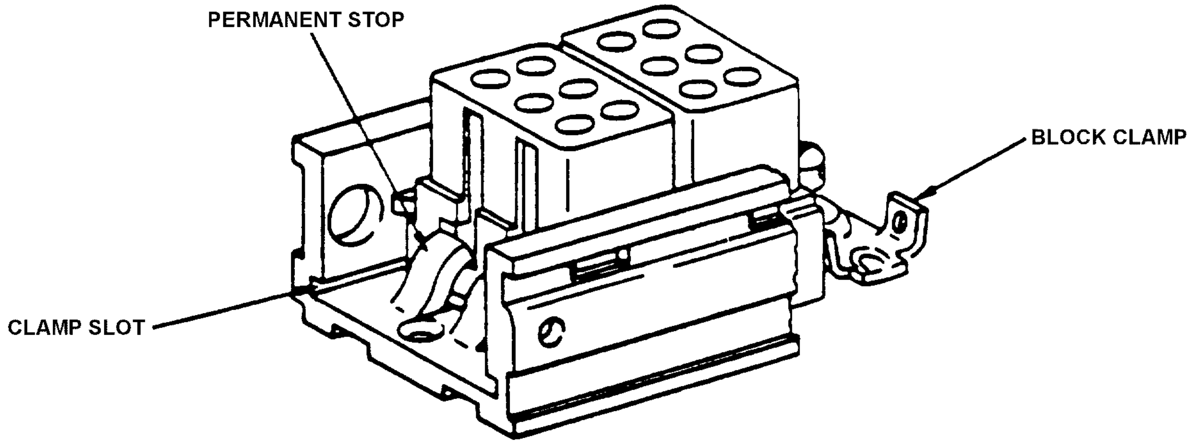


Figure 19. Feedback Terminal Junction Assembly

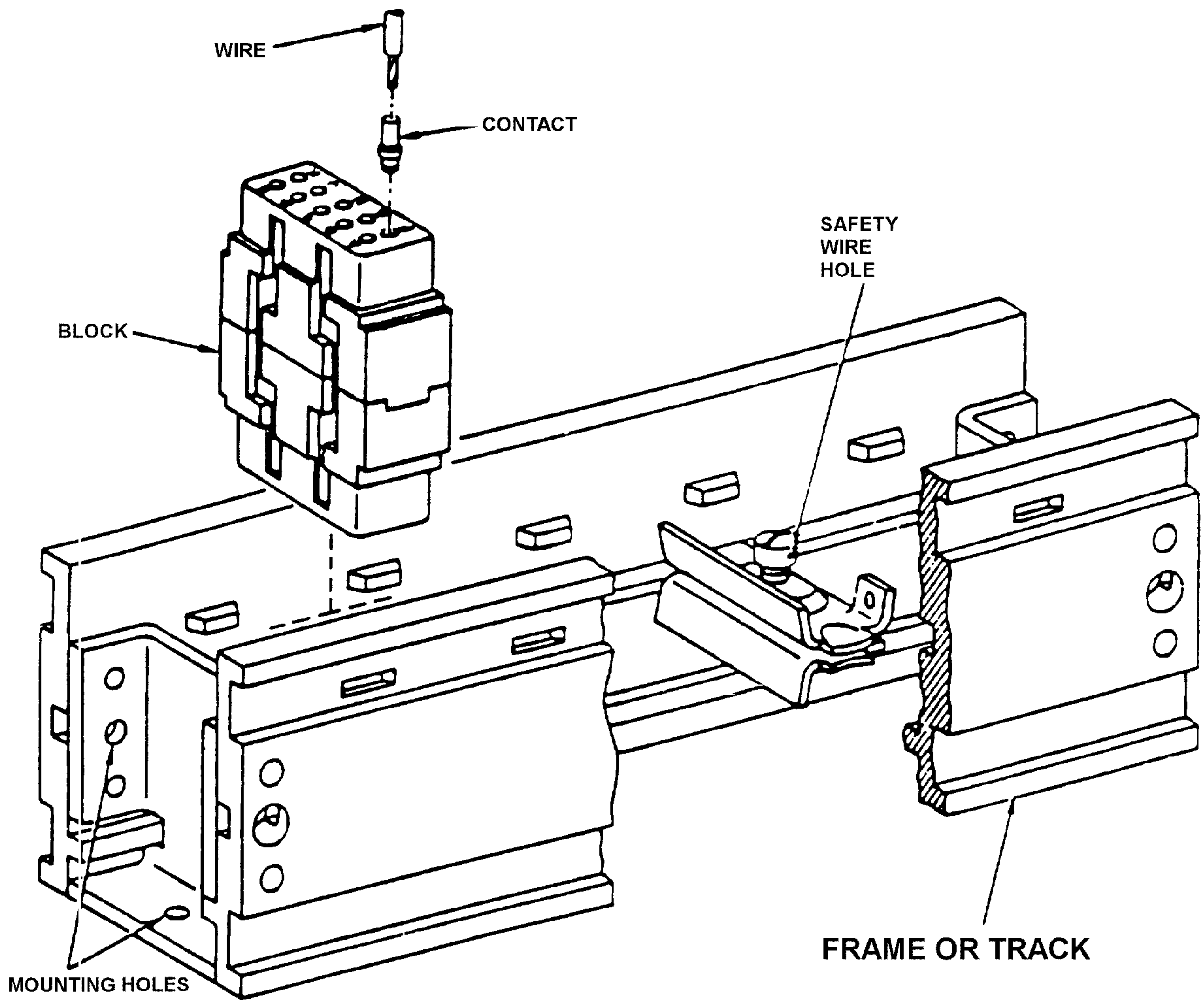


Figure 20. Feedthrough Terminal Assembly (exploded view)

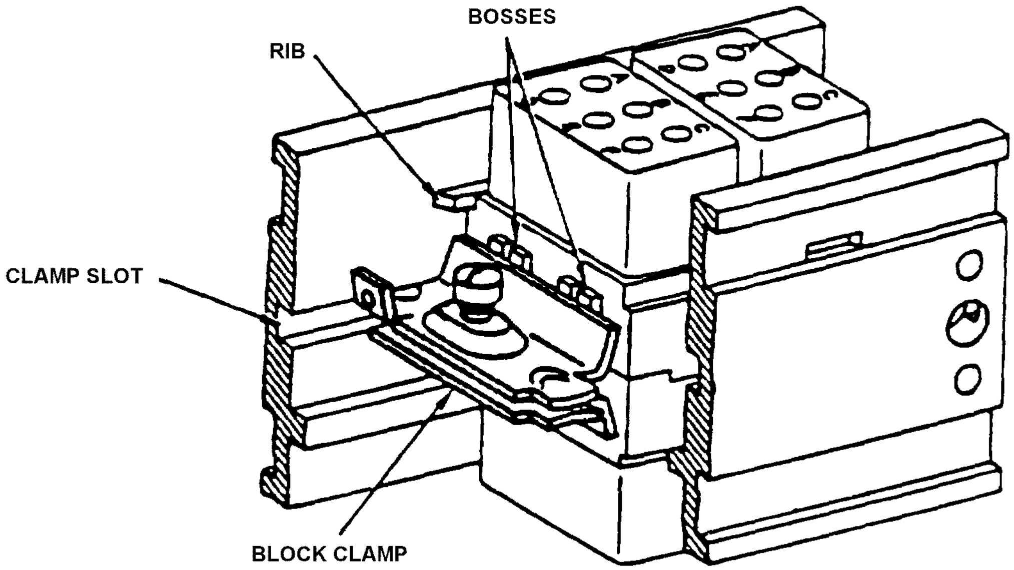


Figure 21. Feedthrough Terminal Assembly

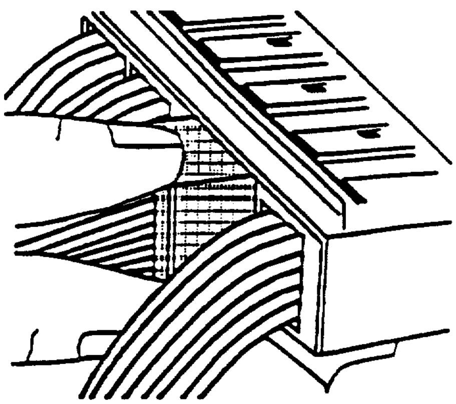


Figure 22. Series II Assembly

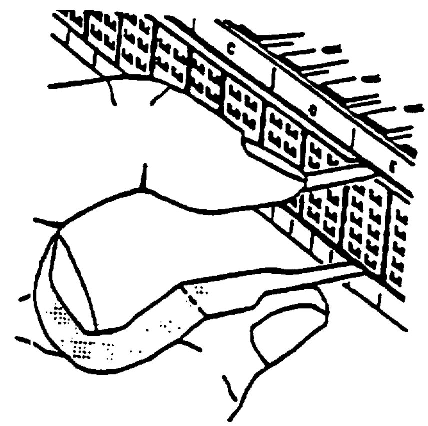


Figure 24. Series II Rail Tool Insertion

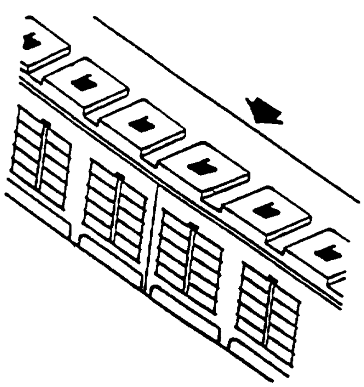


Figure 23. Series II Rail Inspection Holes

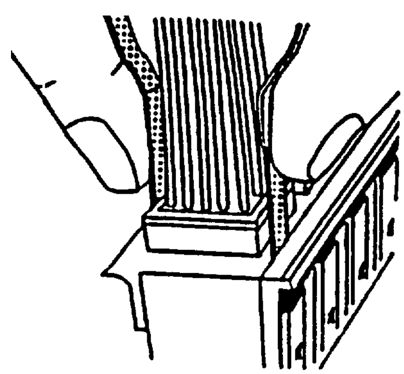


Figure 25. Series II Block Removal

36. **GROUNDING STUD INSTALLATIONS.** Grounding studs (Figures 26 and 27) are mounted into threaded screw holes on equipment or aircraft grounding surfaces. The studs are mounted as follows:

a. Screw the grounding stud in the threaded grounding hole using the hex wrench specified in Table 4. The Series I and II grounding studs are not interchangeable. Be sure the Series II stud has the flat washer on the stud shaft (Figure 27).

b. Firmly tighten the stud to the grounding surface with the wrench. Apply the wrench to the Series I terminal stud nut (Figure 26) or the Series II housing (Figure 27). Do not tighten the stud beyond 25 inch pounds.

c. Reverse the above procedure for removal of the grounding stud.

37. **GROUNDING BLOCK INSTALLATION.** Grounding blocks (Figures 28 and 29) are mounted into through holes on equipment or aircraft grounding surfaces. The blocks are mounted as follows:

NOTE

The Series I and Series II grounding blocks are not interchangeable.

a. Insert the grounding block into the hole then mount the flat washer followed by the lock washer then the hex nut to the stud.

b. Hand tighten the nut then using a 3/8 inch socket tighten the nut to 25 inch pounds. A 3/8 wrench may be used in confined locations, but caution must be taken not to over torque the nut.

Table 4. Hex Wrench Sizes

Series I Studs	Hex Wrench Size (inches)
M81714/15-22	5/16
-20	5/16
-16	3/8
-12	3/8
Series II Studs	Hex Wrench Size (inches)
M81714/64-22	3/16
-20	3/16
-16	1/4
-12	5/16

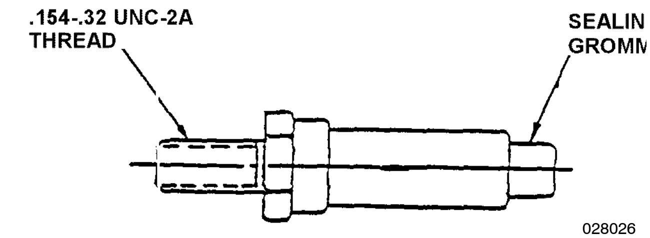


Figure 26. Series I Grounding Stud

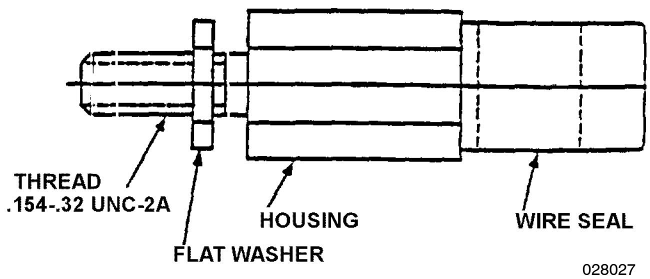


Figure 27. Series II Grounding Stud

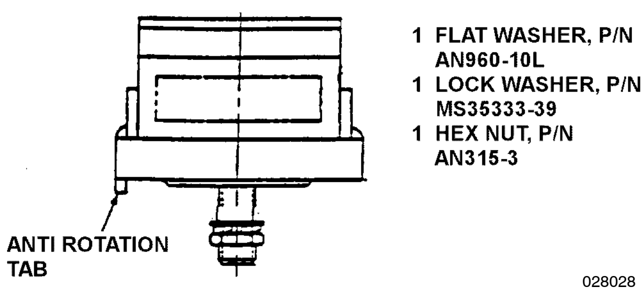


Figure 28. Series I Grounding Block

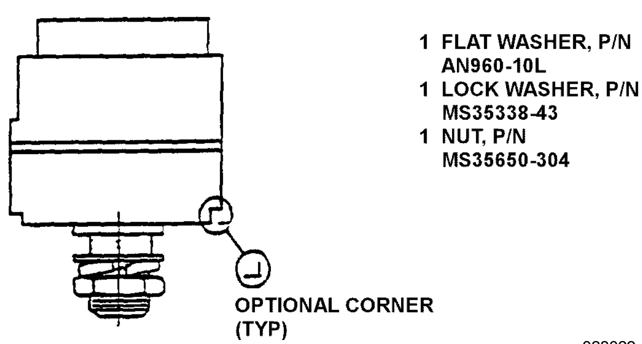


Figure 29. Series II Grounding Block

PROTECTIVE DEVICES

INSTALLATION AND REPAIR PRACTICES

AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

Reference Material

Wire and Cable Stripping 009 00
Circuit Breaker, Aircraft, Trip Free, Push–Pull, 1/2–20 Amp, Type 1, –55 to +121 Deg. C. AS33201
Fuse, Limiter Type, Enclosed Link, 5–60 Amp, Aircraft MS28937
Fuse, Current Limiter Type, Aircraft MIL–F–5372
Fuse, Instrument Type MIL–F–23419
Fuseholders, Block Type, Aircraft MIL–F–5373
Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating MIL–F–19207
Fuses; Instrument, Power and Telephone MIL–F–15160
ARC Fault Circuit Breaker (AFCB), Aircraft, Trip–Free Single Phase 115 VAC,
.400 HZ – Constant Frequency SAE–AS–5692
Circuit Breaker ARP ARP1199

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

Nomenclature	Part No./Type Designation
Collar, Circuiut Breaker Deactivation (White)	12E2081–9
Kit, Safety Lock Circuit Breaker	296050020–1
O–Ring, Safety Lock Circuit Breaker	MS9068–111
Safety Lockout Ring, Circuit Breaker (Red)	S4933959–531
Safety Lock, 3/8" Circuit Breaker	296050002
Safety Lock, 7/16" Circuit Breaker	296050008
Safety Lock Sleeve, Circuit Breaker	296050009
Safety Lock Clip	296050018

Materials Required

None

1. **INTRODUCTION**.

2. This work package (WP) describes the circuit breaker, fuses and limiters for use in the circuitry of aerospace vehicles.

3. **PROTECTIVE DEVICES.** Protective devices are items of electrical equipment such as circuit breakers, fuses, etc., installed in aircraft to protect the electrical system against overloads caused by short circuits or other faults. Protective devices for wired-in equipment shall be connected to the load side of the equipment power switch (main circuit power disconnect). The protective device may be on the line side or the load side of the equipment on-off switch. If possible, mount protective devices in junction boxes or protected areas. If this is not possible, and the devices are to be installed in locations where they may be subject to damage or where the terminals may be dangerous to the personnel, provide a cover to go over the protective device.

4. **AIRCRAFT CIRCUIT BREAKER PROTECTION.**

5. A circuit breaker is used to help provide automatic protection that will limit an electrical fault to a single circuit. It minimizes the danger of smoke and fire to components. Its primary function, however, is to minimize the danger of smoke and fire to the conductors (or cables) leading to and from components. It isolates the fault from the power source so that the non-faulted circuits can be kept functioning in a normal manner. This may not always be achieved by a single circuit breaker, but by a combination of devices, wire size, and routing.

6. **PRACTICAL OVERCURRENT CONCEPTS**. There are two basic principles in use for the protection of electrical and electronic equipment from failures caused by current overloads:

7. **Current Sensing.** The current sensing principle is found in devices such as magnetic or fully ambient compensated circuit breakers. In some applications, practical considerations make it necessary for the circuit breaker and wire to be in entirely different ambient temperatures. In this case it may be necessary to use an ambient insensitive circuit breaker and apply it on the basis of maximum temperature rise expected at any point in the circuit. Increases in the ambient temperature around the circuit breaker will reduce its current trip level.

8. **Combined Current and Temperature Sensing.** Some thermal circuit breakers not only anticipate thermal failures due to overcurrent, but also compensate for variations in the ambient temperature. This compensation helps the circuit breaker follow the changes in wire current carrying capacity due to ambient temperature. These circuit breakers may be located in the same ambient temperature as the wire. They are selected to match the thermal characteristics of the wire being protected.

9. **Arc Fault Sensing.** Thermal circuit breakers are designed to react to the heating effect of current carried by wire; and to protect the wire insulation from thermal damage. These protective devices are not designed to detect or react to the short duration of arcing faults

that typically occur outside (before approaching) the defined trip region, or Time versus Current curve, of the thermal circuit breakers. Arc impedance can reduce low voltage fault current magnitudes appreciably. AFCBs combine active arc fault detection with thermal overload protection into one package. The AFCB provides an equivalent level of thermal protection of existing thermal circuit breakers (typically qualified under AS58091), with the added ability to detect and react to arc fault conditions, thereby mitigating damage that will occur to the wiring system by protracted arcing events. The primary purpose of the AFCB is to mitigate damage to the aircraft wiring from the circuit breaker to the first serial load element (examples: LRU, transformer, ballast, rectifier, or connected equipment, etc.). In doing so, the potential of igniting surrounding materials is reduced, but not eliminated. Use of AFCBs for hazard mitigation/prevention beyond its intended function of mitigating damage to the aircraft wiring should be carefully analyzed and evaluated (SAE AS 5692).

10. **EXTENT OF CIRCUIT PROTECTION**. Equipment and component protection should receive separate consideration. Any protection provided by the circuit breaker is incidental and must not compromise the prime intention of protecting the wiring.

11. **DESCRIPTION**.

12. **INTRODUCTION**. In its simplest form, the circuit breaker is a device to open and close an electrical circuit by non-automatic means, and to open the current automatically on a predetermined overload of current, without injury to itself, when properly applied within its rating. Two most common types of circuit breakers are magnetic and thermal. A protective device is chosen with the lowest rating that will not open inadvertently. It must interrupt the fault or overload current disconnecting the faulted line from the power distribution system before the wire insulation is destroyed. Circuit breakers will be applied within the electrical rating, environmental conditions, and other parameters as described in the applicable Military Specification.

13. **CLASSIFICATION OF CIRCUIT BREAKERS**.

14. **THERMAL**. Thermal circuit breakers generally operate dependent on the heating and subsequent deflection of a bimetallic thermostatic element due to the fault current (resistance heating). Some devices operate with the thermal expansion of a strand wire. Some devices may compensate for ambient temperatures. Thermal circuit breakers are generally not as affected by the start up surges and brief transients as many other devices. Figure 1 shows a typical circuit breaker.

15. **THERMAL-MAGNETIC ASSIST**. Thermal circuit breakers may also include a magnetic assist mechanism used only on high current overloads. However, due to their operating principles, thermal circuit breakers inherently produce less magnetic field interference than magnetic circuit breakers.

16. **MAGNETIC**. Magnetic circuit breakers generally operate using the solenoid principle, where a moveable piece held with a spring may be moved by the magnetic field of a coil energized by the fault current. Some devices may compensate for ambient temperatures. Magnetic circuit breakers often have an instantaneous trip feature that functions during high current overloads. Normally, magnetic circuit breakers are used on the type of current for which they are calibrated.

17. **REMOTE CONTROL CIRCUIT BREAKERS. (RCCB).** These circuit breakers combine the features of a relay (contactor) and circuit breaker. This permits location near the load or power source and control from a remote location such as a cockpit. Control wiring may therefore be of light gauge.

18. **ELECTROMAGNETIC POWER CONTROLLER (EMPC)**. This type of circuit breaker is considered to be electronically controlled, incorporating circuit protection, relay and switch features in a single device. An EMPC is a device that utilizes a solid state sensing mechanism for overcurrent protection. The EMPC may also use solid state switches in combination with discrete contacts to switch the load.

19. **ARC FAULT CIRCUIT BREAKERS.** Arc Fault Circuit Breakers (AFCB) incorporate the functionality of conventional thermal circuit breakers with that of arc sensing capability. AFCBs can trip/open for either thermal or arc events. The AFCB identifies the fault mode by the use of a separate sleeve incorporated in the circuit breaker push button. With a circuit breaker tripped, if thee yellow sleeve is exposed then an arc event was sensed. If the conventional white sleeve is exposed, then a thermal event occurred (Figures 2, 3, and 4).

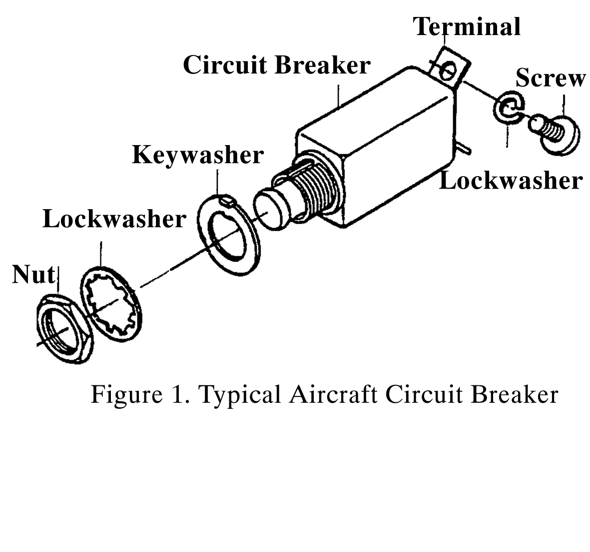


Figure 1. Typical Aircraft Circuit Breaker

20. **SOLID STATE POWER CONTROLLER (SSPC)**. An SSPC is generally considered to be electronically controlled, incorporating circuit protection, relay and switch features in a single device. A SSPC is a device that uses a solid state sensing mechanism for overcurrent protection, and a solid state switching mechanism, employing electromechanical parts.

21. **SPECIAL FEATURES**. Certain features may be incorporated into several classifications of circuit breakers, depending on the particular specification.

22. **Multipole.** A multi-phase circuit breaker has two or more poles controlled by a single-actuating member. It may be used on a multi-phase circuit such that an overload on an individual phase will cause the circuit breaker to open all phases of the circuit. Usually, operating limits and performances are different than single phase circuit breakers. Figure 5 shows a typical multi-phase circuit breaker.

23. **High Vibration.** Circuit breakers identified with a V suffix on the MS specification and ID markings have been designed to operate in a high sine vibration environment. Those additionally identified with a C through K suffix on the MS specification and ID markings have been designed to operate in a random vibration environment.

CAUTION

Some care should be taken to reduce the possibility of extreme side forces on the buttons.

24. **Long Pushbuttons.** Some circuit breakers may have longer push buttons than others. These may be identified with an L suffix on the specification and ID markings.

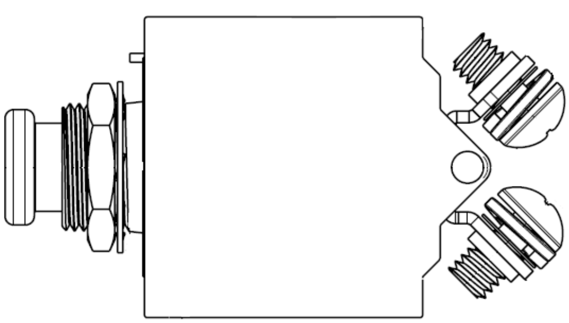


Figure 2. Circuit Breaker Closed / Not Tripped

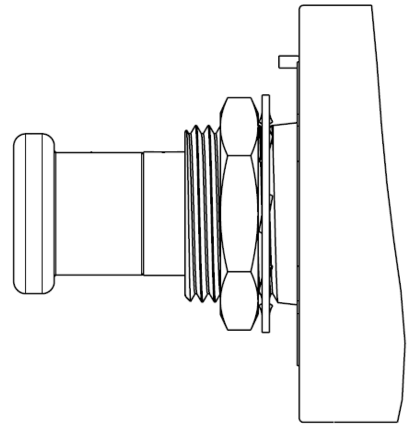


Figure 3. Circuit Breaker Open / Tripped, Thermal Condition Detected

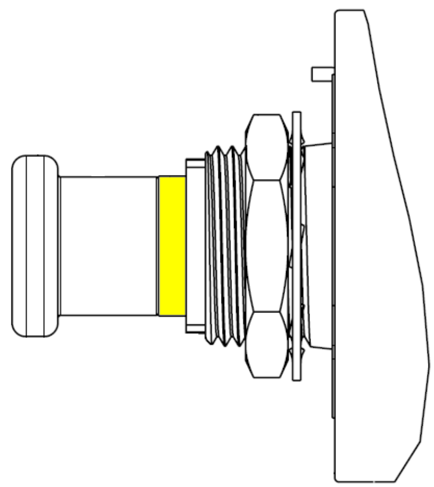


Figure 4. Circuit Breaker Open / Tripped, Arc Fault Condition Detected (Note Yellow Band)

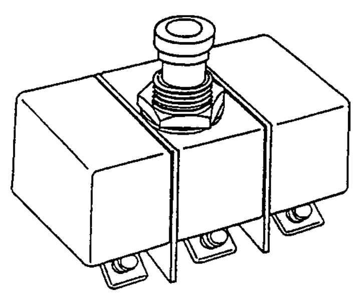


Figure 5. Typical 3 Phase Circuit Breaker

25. **Sealed.** Sealed circuit breakers may be of any type. They are usually sealed against adverse environments and are generally restricted to use on lower power circuits. Non-sealed circuit breakers provide for higher power requirements, but are more restricted as to environment. It is important to handle them carefully so as not to damage the seal.

26. **P Bracket.** Circuit breakers with a special P cover plate mounting bracket are identified with a P suffix on the specification and ID markings. They require different mounting hardware from non-P marked circuit breakers of the same type.

27. **AMPERE RATING**.

28. **DEFINITION**. The nameplate current rating of most circuit breakers is a nominal rating for device identification. The actual usable rating for a particular application may be considerably different from the nameplate rating. The time-current characteristics of the circuit breaker are compared to the time current characteristics (including starting or overload surges) of the equipment, component, and wire. Refer to Safety Factors paragraph 28.

29. **ORIENTATION**. The nominal ampere rating of the circuit breaker is generally marked on the actuator (push button) of the circuit breaker. The ampere rating number is oriented to maximize readability by the user.

30. **SAFETY FACTOR** Safety factor is the value above the steady state application current that helps to ensure that the circuit breaker will handle the application without nuisance trips. Typically a circuit breaker is specified to operate continuously at no more than approximately 80 percent of its nominal rating. This provides a safety factor of 20 percent. Different factors may apply at different ambient temperatures and altitudes.

31. **IDENTIFICATION MARKINGS.** All circuit breakers are permanently and legibly marked. These markings will be resistant to most aircraft fluids. Markings generally include a part number, ampere rating and manufacturers date code.

32. **PART NUMBERS SCHEME FOR THERMAL CIRCUIT BREAKERS.** The following part numbering example for circuit breakers will typically apply:

MS 3320-D 5 A V L

Where:

MS 3320 is the military designation.
D is the random vibration capability.
5 is the ampere rating.
A is for auxiliary terminals.
V is the high sine vibration capability.
L is the pushbutton type.

33. **TERMINALS**

34. **Line** The line side terminal of a circuit breaker is connected to the power source, or to the power source of the electrical system. This terminal may be connected to any bus bar feed system where the system is used.

35. **Load** The load side terminal of the circuit breaker is connected to the load, or to the load side of the electrical system.

36. **SOLID CONNECTIONS.** A solid electrical and mechanical connection of the wire to the circuit breaker is critical for the operation of the breaker. A loose or minimal wire connection can cause increased circuit resistance and create heat. Wire heating near the circuit breaker terminals can cause premature tripping or failure of the breaker. It is equally important to use correct specified size and type of termination, that it be free of corrosion and properly attached.

37. **Markings.** Terminals may be marked LINE or LOAD, 1 or 2, etc., as called out in the circuit breaker specification. It is important that the terminals are wired correctly according to their markings. Circuit breakers with unmarked terminals may or may not have a preferred line or load wiring. Multiphase circuit breakers may have sets of terminals for individual phases or circuits marked A, B, C, etc.

38. **Hardware.** Most terminals are threaded for a specified screw or bolt. It is important to use the specified hardware. Terminal screws that are too short may not hold the terminations properly. Screws that are too long may interfere with or damage the breaker case. Incorrect hardware may also produce excessive, damaging torque.

39. **Captive Nuts.** When available, captive nuts will be solidly attached to the terminals.

CAUTION

The mounting tab should not be used as an anti-rotation tab, as it is not designed to resist the torque that may be transmitted due to rotation of the mounting nut, terminals, or circuit breaker body.

40. **Mounting Tabs.** Mounting Tabs are found on most circuit breakers, and are also called mounting keys. They orient the circuit breaker about the Z-axis through the panel hole.

41. **TRIP BARS.** Trip bars may be used to externally connect the buttons of several circuit breakers, so that they operate together.

42. **OPERATION**

43. The following paragraphs contact information on how circuit breakers may be used, not used, and possible concerns during their lifetime.

44. **AS A SWITCH.** Normally, a circuit breaker should not be used as a switch. Most circuit breakers have a life expectancy of 1/10 or less of the life of a switch. They are not usually snap-action devices and should not be considered as substitutes for switches, unless defined as such in the particular specification. Refer to paragraph 45.

CAUTION

Excessive force, often by using tools to pull the button, can cause hidden damage to the mechanism.

45. **OPENING**. Only reasonable force should be used to open the contacts of a circuit breaker, normally much less than 25 pounds.

46. **RESETTING**. Only reasonable force should be used to reset a circuit breaker, generally less than 25 pounds. They should not be reset by impact. Excessive force can cause hidden damage to the mechanism. Resetting a breaker once may not be a problem, but it should not be held in the set position or repeatedly reset in an effort to get a system to work. Circuit breakers are designed to open if there is an overcurrent. condition. Repeated resetting into an overload condition may allow too much current through the wire, connectors, and the breaker itself. Circuit breakers should not be allowed to develop a history of tripping. A tripped circuit breaker may be faulty, or may be in a faulty or overloaded circuit. A tripped curcuit requires post–flight fault isolation and repair. If a circuit breaker opens (pops) while maintenance is being performed on the aircraft, the opened circuit breaker shall not be reset until the cause is determined. An unexpected popped CB may result from an overloaded or ground fault. A popped fuel system CB should not be reset without following specific guidance in aircraft systems manuals/TOs. General Curcuit Breaker Reset Procedure.

a. Do not push in/close a circuit breaker that is found open until the cause of the open breaker is corrected.

NOTE

For both thermal or arc fault circuit breaker trip events, refer to the applicable troubleshooting/fault isolation procedure for the affected system, or component in the platform–specific maintenance manual.

b. If the open circuit breaker is a part of a 3–phase circuit, open the other two circuit breakers.

WARNING

Failure to ensure that the system is serviceable and without wiring faults prior to closing any circuit breaker may lead to system damage, fire, loss of aircraft and/or personnel injury or death.

c. Close/push in the circuit breakers only after the fault is corrected.

CAUTION

Teasing should be avoided to reduce contact pitting, wear and arcing and to increase the life of the circuit breaker.

47. **TEASING**. Teasing is the slow action of opening or closing a circuit breaker actuator (push-button, toggle, etc.), such that the contacts come in close proximity to each other without engaging the latching mechanism. This action will cause an arc to be drawn across the gap between the contacts, without physically mating or touching each other.

48. **CHANGE IN CHARACTERISTICS.** The operating characteristics of a circuit breaker may change over the life of the device. Heavy fault currents may degrade the current overload sensor. Excessive manual operation may cause dynamic wear of the latching mechanism. Even a circuit breaker that has been dormant for a long period of time may change due to internal spring forces and static wear. This may be reduced by periodic manual operation of the breaker. A suspect breaker should always be replaced.

49. AIRCRAFT COMPONENTS

50. The following paragraphs contain information on aircraft parts and components that may have an effect on circuit breakers or their installation.

51. **MOUNTING PANELS**. The spacing of mounting holes for circuit breakers are to be properly spaced to allow sufficient space between successive circuit breakers, in both vertical and horizontal directions. This is important for thermal, dielectric and mechanical reasons.

52. **BOOTS**. Boots may be part of the mounting nut, separate from the nut, or integral to the push-button. Boots protect the circuit breaker and/or seal the panel from environmental conditions.

53. **WIRES**. The aircraft wires form an inherent part of thermally activated circuit breakers. Wires and connection both transfer and produce heat that may affect the calibration of the circuit breaker. Wires are kept as far as possible from the body of the circuit breaker behind the panel.

CAUTION

Mechanical force of bending on the terminals should also be considered when routing larger wires.

54. **WIRE GAUGE**. Wires must be of the correct specified size for the particular circuit breaker. Failure to size the wire properly may adversely affect the operating characteristics of the circuit breaker.

55. **INSULATION**. Wire insulation should be of the proper, specified type for the application. Insulation should not be allowed to touch the case of the circuit breaker. Insulation should be visually examined for cracks, burn marks and other defects.

56. **CRIMPING**. Wires should be stripped and crimped using procedures in WP 009 00.

57. REPAIR.

58. **CIRCUIT BREAKER REPAIR**. Most circuit breakers are consumable items and source coded PAOZZ. Only replacements are authorized in the fleet/field.

59. **EVALUATION**. In some cases a circuit breaker may have to be removed for evaluation. If possible, records of the events leading up to the removal of the circuit breaker should be included. If evaluation of operational characteristics is to be performed, it is most important that the circuit breaker not be operated and the case not be opened before returning it for evaluation.

60. REMOVAL AND INSTALLATION.

61. Refer to the build up in Figure 6 for the installation and removal of circuit breakers in aircraft panels.

WARNING

Verify that installed circuit breakers are in the OFF position and aircraft external electrical power and battery or batteries are disconnected before proceeding with any of the following instructions or routine maintenance. Failure to do so can result in damage to the equipment and severe injury or death to personnel.

62. **REMOVAL**.

WARNING

To prevent electrical shock, ensure electrical power is off before commencing work.

To prevent fire and damage to electrical equipment, do not replace a circuit breaker with one of a higher amperage rating.

a. Verify all electrical power is off and batteries are disconnected.

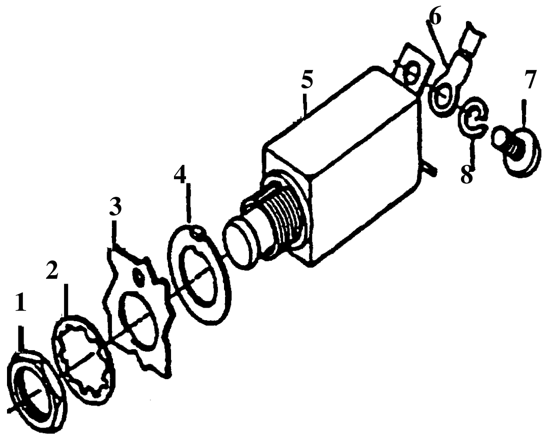
b. After opening the affected circuit breaker panel, but before the start of the maintenance or inspection task, develop and implement a means of covering or protecting the opened panel during the maintenance and inspection process.

c. If a boot is present, carefully remove without damaging. If the boot cannot be removed, carefully pass the boot through the panel-mounting hole. Care should be taken not to puncture or otherwise damage the boot.

d. Refer to Figure 6 to remove nut (1), and lockwasher (2) securing circuit breaker (5) to panel (3). Remove circuit breaker and key washer (4).

e. Remove screws (7). lockwashers (8), and terminals (6) from circuit breaker.

f. Tag and cover terminals with silicone tape.



1. Nut	**5. Circuit Breaker**
2. Lockwasher	**6. Terminal**
3. Panel	**7. Screw**
4. Keywasher	**8. Lockwasher**

Figure 6. Circuit Breaker Installation

63. **INSPECTION**. The following inspections can be used to reveal if the breaker is unserviceable (Refer to Figure 6).

WARNING

Verify that installed circuit breakers are in the OFF position and aircraft external electrical power and battery or batteries are disconnected before proceeding with any of the following instructions or routine maintenance. Failure to do so can result in damage to the equipment and severe injury or death to personnel.

Replacement circuit breakers must have the same electrical characteristics as the circuit breaker being replaced. Failure to maintain characteristics can result in damage to the equipment and severe injury or death to personnel.

NOTE

Refer to WP 004 01 for additional circuit breaker inspection instructions as applicable.

64. **INSTALLATION**.

WARNING

Replacement circuit breakers must have the same electrical characteristics as the circuit breaker being replaced. Failure to maintain characteristics can result in damage to the equipment and severe injury or death to personnel.

a. Replace circuit breakers only with breakers of the same type and current rating as specified by the engineering authority or platform−specific manual/Technical Order.

b. Verify all electrical power is off and batteries are disconnected.

c. Remove silicone tape from terminals.

WARNING

Ensure correct line and load connection. Failure could result in injury to personnel and/or damage to equipment and aircraft.

d. Refer to Figure 6 and install terminals (6), on circuit breaker (5) and secure with lockwashers (8) and screws (7). Remove tags.

e. Place keywasher (4) on circuit breaker and insert through rear of panel (3). Secure with lockwasher (2) and nut (1). The circuit breaker must be held to prevent rotation while tightening the nuts to prevent strain on the mounting key.

f. If required, perform electrical check in accordance with the applicable platform−specific manual or Technical Order.

g. After maintenance on a circuit breaker panel, a thorough inspection should be performed to ensure that no loose foreign objects such as safety wire, nuts, screws, washers, etc., remain in the area that could cause arcing or short circuits if not removed.

h. Remove the applicable cover or circuit breaker protection means installed at the beginning of the task.

Figure 7. Circuit Breaker Lockout Ring

Figure 8. Circuit Breaker Collar

WARNING

Use only red or white teflon devices for deactivating circuit breakers. Do not use black for this purpose. Locking ring must stay securely in place on circuit breaker and prevent circuit breaker from being reset. Failure could cause injury to personnel and/or damage to equipment and aircraft.

65. CIRCUIT BREAKER LOCKOUT/DEACTIVATION.

WARNING

Do not use black colored locking or deactivating devices for circuit breakers. Locking / Deactivation device must stay securely in place on circuit breaker and prevent circuit breaker from being reset. Failure could cause injury to personnel and/or damage to equipment and aircraft.

a. Flight Operations.

1. When positive lockout/deactivation of an electrical circuit breaker is required during flight operations, use lockout ring (Figure 7) part number: S−4933959 or lockout collar (Figure 8) part number: 12E2081−9 or 2S308 (NSN: 6110−00−492−9392).

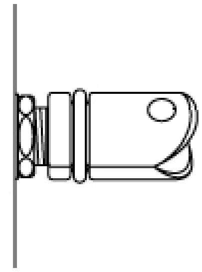


Figure 9. Circuit Breaker Safety Lockout Installed

2. Verify that circuit breakers that require lockout/deactivation are in the OFF (pulled) position.

CAUTION

Do not use any tools to install or remove lockout ring or collar as damage may occur to the circuit breaker.

3. Using slight pressure, snap the lockout ring or collar onto the circuit breaker shaft.

b. Ground Operation Only.

1. When positive lockout/deactivation of an electrical circuit breaker is required during ground operations ONLY, use the lockout ring or collar or the safety lock (Figure 9). For typical circuit breakers (3/8” head size) use part number: 296050002. For larger circuit breaker (7/16” head size) use part number: 296050008.

2. Verify that circuit breakers that require lockout/deactivation are in the OFF (pulled) position.

CAUTION

Do not use any tools to install or remove lockout ring or collar as damage may occur to the circuit breaker.

3. When using the lockout ring or collar apply a slight pressure to snap the lockout device onto the circuit breaker shaft. If using the safety lock, pinch the ends of the safety lockout together and slide over the circuit breaker and release (Figure 10). Safety lock remains secure to circuit breaker (Figure 9).

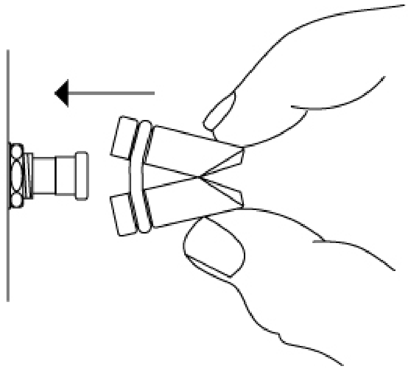


Figure 10. Circuit Breaker Safety Lockout Installation

4. An optional sleeve part number: 296050009 may be used on the safety lock to prevent accidental removal (Figure 11). The sleeve is applied by sliding it over the previously installed safety lock making sure the holes are in alignment. Secure the sleeve to the safety lock with string/lacing tape (A−A−52083 or A−A−52084) through the hole.

NOTE

If the optional safety lock clip and condition tag are used then the string/lacing tape is not required.

5. A condition tag (optional) may be attached to any of the locking devices by drilling a small hole (if not provided). Secure the tag with string/lacing tape (Figure 12) or safety lock retaining clip part number: 296050018 (Figure 13).

6. Safety lock kit (for ground use only) contains safety lock, sleeve, condition tags and clips for typical applications (part number: 296050020−1). The replacement safety lock o−ring is part number MS9068−111(NSN: 5331−00−965−0719).

66. **CIRCUIT BREAKER PERMANENT REMOVAL.** When a circuit breaker is removed permanently, a blanking plug shall be installed in the mounting hole. Use blanking plugs suitable for this purpose: Metal Plug, PN NAS451−43 or Rubber Plug, PN G34. Ensure that the applicable CB identification is removed.

67. **CIRCUIT BREAKER IDENTIFICATION.** Ensure that each protective device is identified by a plate or decal, permanently attached to adjacent aircraft structure and completely visible.

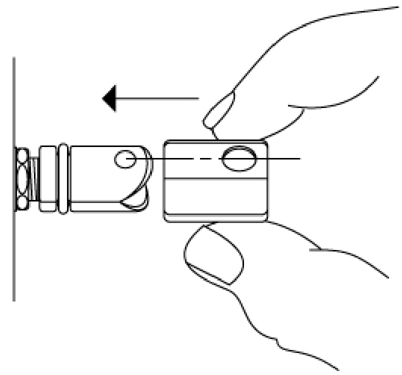


Figure 11. Circuit Breaker Safety Lockout Sleeve Installed

Figure 12. Circuit Breaker Safety Lock Installed with Warning Tag using String/Lacing Tape

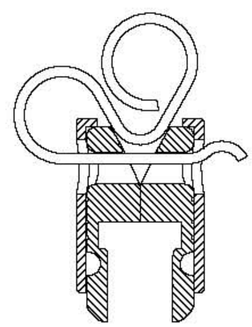


Figure 13. Circuit Breaker Safety Lock Retaining Clip

68. **AIRCRAFT FUSE PROTECTION.**

69. **GENERAL** A fuse is a device that protects a circuit by the melting of its current responsive element when an overcurrent passes through it. Fuses are available in a variety of characteristics to meet the requirements of the circuit designer.

70. **CLASSIFICATION OF FUSES.**

71. **NORMAL**. This type of fuse is often referred to as a “normal opening” fuse and may or may not be current limiting. Normal fuses contain single elements and possess a time-current characteristic curve that is essentially a smooth curve with no discontinuities. Figure 14 shows a typical aircraft fuse.

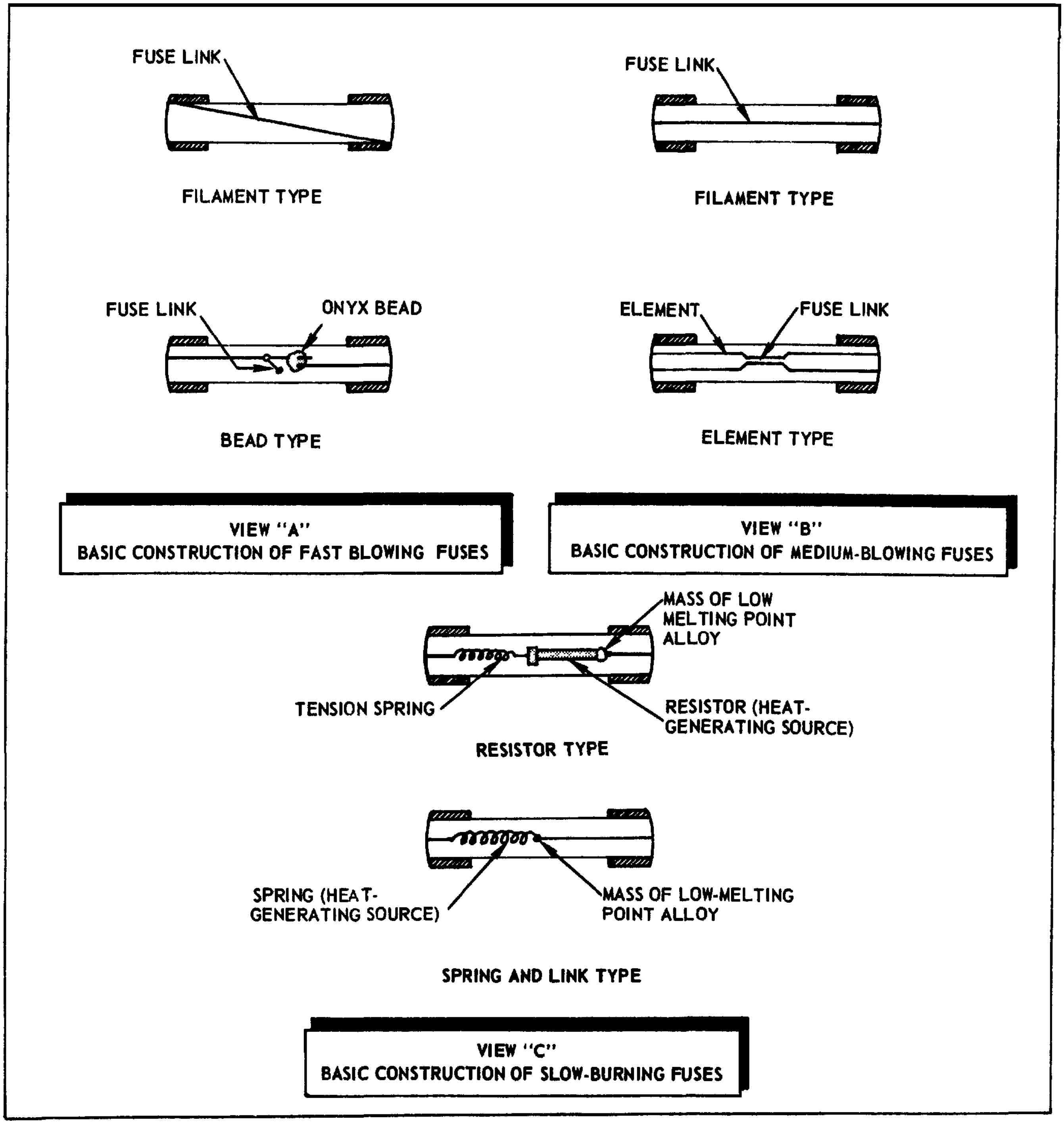


Figure 14. Basic Construction, Views A, B, and C

72. **TIME−DELAY**. Time-delay fuses also may or may not be current limiting. The fuses are often referred to as “dual-element” fuses in that they possess two elements thermal cutout with very high time-lag characteristics which handles harmless transient overloads and blows on continuous light overloads, plus a short-circuit element which blows on heavy overloads and short circuits. The thermal cutout is designed to pass momentary surges such as motor starting transients and switching transients. The time-current characteristics of the time delay fuse show a non-uniform curve with considerable time lag.

73. **VERY FAST ACTING**. These fuses do not possess time-delay features as they are designed to be extremely fast under short-circuit conditions. Very fast-acting fuses are designed to protect semiconductor rectifiers because of their speed of response to overcurrent. These fuses also may or may not be current limiting.

74. **CURRENT LIMITING**. The ability of a fuse to fit into this category depends upon its short-circuit performance. Current limitation is defined as the degree of current-limiting ability a fuse possesses under short-circuit conditions. To be current-limiting, the fuse, under specific short-circuit conditions, must limit the instantaneous peak current to a value less than that which would flow if the fuse were not in the circuit, and it must clear the fault within one-half cycle.

75. **PART NUMBERING SCHEME**. The following part numbering example for fuses will typically apply:

FM08A125V1/2A*

Where:

FM08 is the fuse style.
A OR B is the characteristic.
125V is the voltage rating.
1/2A is the current rating.
* indicates an optional finish.

76. **DEFINITIONS AND DESCRIPTIONS.**

a. Fuse Types and Styles. Fuse types and styles refer to the construction (physical makeup and material) and dimensions of fuses. For example, cartridge fuse mountings may be either knife blade or ferrule type, and the fuse link may be bead, bridge, or some other type of construction. The body of the fuse can be made of glass, ceramic, fiber, or other non−conducting material. To distinguish one type or style from another, the manufacturer usually stamps each fuse with a specific type or style designation. Some common commercial fuse−type designations are MKB, ACX, 3AG, and 3AB; and a few typical military fuse−style designations are F02, F03, and FM09. Each fuse type or fuse style designation denotes a given construction and dimension.

b. Dimensions. Dimensions refer to the length and width (or diameter) of a fuse. The fuse selected for replacement purposes should be one that properly fits into the fuse holder. However, selection of a fuse should not be limited to physical size because it may differ in current, voltage, or blow time characteristics.

c. Current Rating. The current rating is the most commonly used fuse rating. Current ratings are always designated in terms of amperes and may range from 0.002 ampere for sensitive instruments to 600 amperes for high power applications. The current rating indicates the highest value of current that the fuse can carry indefinitely without blowing. Because fuses are the “Safety−Valves of electrical circuits”, it is important to replace a blown fuse with a fuse that has identical fuse current ratings or those required by the design of the equipment.

d. Blow time Characteristics (General). Time and current are the important factors in the operation of a fuse. There is a time and current relationship at which a fuse will operate satisfactorily and will not blow, and still another time and current relationship at which the fuse will blow. The length of time that a fuse carries a quantity of current above its rated value before blowing is known as the blow time characteristic. Some fuses are designed to blow rapidly at certain percent−ages of overloads; other fuses are designed to carry slight overloads for hours without blowing. Still others are designed to handle large surges of current for short periods of time without blowing, and yet protect equipment against excessive current resulting from short circuits or continued overloads. The blow time characteristics are extremely important. Slow blow fuses will not be substituted for fast blow fuses. Temporary substitution of fast blow fuses for slow blow fuses is allowed.

(1) Blow time Characteristics (Commercial). Most commercial fuses fall into one of the following basic types of blow time characteristics: fast blowing, medium blowing, or slow blowing. Other commercial trade names are as follows:

Fast−Blowing	Medium−Blowing	Slow−Blowing
Quick−Blowing	Medium−Acting	Slow−Acting
Instant−Blowing	Medium−Lag	Time−Delay
Fast−Acting		

NOTE

Basic Construction (see Figure 14, Views A, B, and C).

(2) Blow time Characteristics (Military). The blow time characteristics of military fuses are classified on the basis of the amount of current (above that of the actual current rating) that they can safely interrupt, and on their ability to withstand momentary surges of current. All military fuses (fuses manufactured under Military Specification) fall into one of the blow time characteristics in Table 1. Notice that in addition to blow time characteristics, Table 1 lists the characteristic symbols that are stamped on military fuses and the distinguishing properties.

e. Voltage Rating. The fuse voltage rating is the highest voltage at which the fuse can safely interrupt its maxi−mum short circuit current. Since the fuse voltage rating is a design characteristic and is independent of the steady−state, in−circuit voltage, a higher voltage rated fuse may be substituted for a lower voltage rated fuse.

NOTE

It is not permissible to substitute a lower voltage rated fuse for a higher voltage rated fuse. The current rating of the fuse shall not exceed the maximum current rating of the circuit.

77. <u>FUSES</u>

78. Fuses used in aircraft are of two types: the cartridge type, installed in the electrical system in an extractor post style fuseholder or in fuse clips; and the enclosed link type (current limiter) installed in a block type fuseholder (see Table 2). Fuses commonly used in aircraft electrical systems are listed in Table 2 by detailed Military Specifications and Military Standard Drawings and in Table 3, which lists cross reference from old military designation to new military designation with superseded commercial equivalent.

Table 1. Military Fuse Blow time Characteristics

Fuse Blow Time Characteristics	Characteristics Symbols	Current−Interrupting Capacity	Distinguishing Properties
Fast Blowing	A	Normal	1. Used in circuits capable of delivering low values of current. Blow instantly at low values of short−circuit current. 2. Intended for general circuit protection.
Time−Lag	B	(Slow−Blow Fuse)	1. These fuses have a built−in delay period. 2. Used in circuits where allowances must be made for momentary surges of current.
Normal−Blowing	C	Very High	1. Used in circuits capable of delivering high values of current. Blow instantly at extremely high values of short−circuit current. 2. Intended for general circuit protection.

Table 2. Fuses Used In Aircraft Electrical Systems

Cartridge Type No.	Style*	Characteristic	Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
MIL–F–15160/1	FO1	A	250	1/500	90077–1	
		A		1/200	90077–2	
		A		1/100	90077–3	
		A		1/32	90077–4	
		A		1/16	90077–5	
		A		1/10		
		A		1/8	90077–6	
		A		3/16		
		A		2/10		
		A		1/4	90077–7	
		A		3/8	90077–8	
		A		4/10		
		A		1/2	90077–9	
		A	125	6/10		
		A		3/4	90077–10	
		A		8/10		
		A		1	90077–11	
		A		1– 1/4		
		A		1– 1/2	90077–12	
		A		1– 6/10		
		A		2	90077–13	
		A		2– 1/2		
		A		3		
		A		3– 2/10		
		A		4		
		A		5		
		A	32	6		
		A		7		
		A		8		
		A		10		
		A		15		
		A		20		
		A		25		
		A		30		
MIL–F–15160/2	FO2	A, B	250	1/100	90078 – 1–1	90078 – 16–1
		A, B		1/32	– 2–1	– 17–1
		A, B		1/16	– 3–1	– 18–1
		A, B		1/8	– 4–1	– 19–1
		A, B		1/4	– 5–1	– 20–1
		A, B		3/8	– 6–1	– 21–1
		A, B		1/2	– 7–1	– 22–1
		A, B		3/4	– 8–1	– 23–1
		A, B		1	– 10–1	–24–1
		A, B		1 1/2	– 11–1	–
		A, B		2	– 12–1	–
		A		3	– 13–1	–
		A		4	– 14–1	–
		A		5	– 15–1	–
		A		6	–	–

Table 2. Fuses Used In Aircraft Electrical Systems – Continued

Cartridge Type No.	Style*Characteristic		Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
		B	125	5	–	–
		A		10	–	–
		A, B	32	10	–	–
		A, B		15	–	–
		A, B		20	–	–
		B	32	8	–	–
MIL–F–15160/3	FO3	A, B	250	1	90079 – 1–1	90079 – 20–1
		A, B		3	– 2–1	–
		A		5	– 3–1	–
		A		8	– 4–1	–
		A		10	– 5–1	–
		A		12	– 6–1	–
		A		15	– 7–1	–
		B	250	1/100	–	90079– 10–1
		B		1/32	–	– 11–1
		B		1/16	–	– 12–1
		B		1/8	–	– 13–1
		B		15/100	–	– 14–1
		B		3/16	–	– 15–1
		B		1/4	–	– 16–1
		B		3/8	–	– 17–1
		B		1/2	–	– 18–1
		B		3/4	–	– 19–1
		B		2 1/2	–	–
		A	125	20	90079 – 8–1	
		A		30	– 9–1	
		B		5		
		B		8		
		B		10		
		B		12		
		B	125	15		
		B		20		
		B		30		
MIL–F–15160/6	FO6	A	250	1	90082 – 1	
		A		2	– 2	
		A		3	– 3	
		A		5	– 4	
		A		10	– 5	
		A		15	– 6	

Table 2. Fuses Used In Aircraft Electrical Systems – Continued

Cartridge Type No.	Style*Characteristic		Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
MIL–F–15160/7	FO7	A	250	1		
		A		2		
		A		3		
		B	125	1		
		B		2		
		B		3		
		A, B	32	5	90083 –1	90083 –10
		A, B		10	–2	–11
		A, B		15	–3	–12
		A, B		20	–4	–13
		A, B		30	–5	–14
MIL–F–15160/9	FO9	B	250	1/10		90085–36
		B		15/100		90085–37
		B		2/10		90085–38
		B		3/10		90085–39
		B		4/10		90085–40
		B		1/2		90085–41
		B		6/10		90085–42
		B		8/10		90085–43
		A, B		1	90085–9	90085–44
		B		1– 1/8		90085–45
		B		1– 1/4		90085–46
		B		1– 4/10		90085–47
		B		1– 6/10		90085–48
		B		1– 8/10		90085–49
		A, B		2	90085–15	90085–50
		B		2– 1/4		90085–51
		B		2– 1/2		90085–52
		B		2– 8/10		90085–53
		A		3	90085–19	
		B		3– 2/10		90085–55
		A, B		3– 1/2	90085–21	90085–56
		A, B		4	90085–22	90085–57
		B		4– 1/2		90085–58
		A, B		5	90085–24	90085–59
		B		5 6/10		90085–60
		A		5	90085–26	
		A, B		6– 1/4	90085–27	90085–62
		A, B		7	90085–28	90085–63
		A, B		8	90085–29	90085–64
		B		9		90085–65
		A, B		10	90085–31	90085–66
		A		15	90085–32	
		A		20	90085–33	
		A		25	90085–34	
		A		30	90085–35	
		B	125	12		
		B		15		90085–67
		B	32	20		90085–68

Table 2. Fuses Used In Aircraft Electrical Systems – Continued

Cartridge Type No.	Style*Characteristic	Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
	B		25		90085–69
	B		30		90085–70
MIL–F–15160/10	F10 B	250	1/10		
	B		15/100		
	B		2/10		
	B		3/10		
	B		4/10		
	B		1/2		
	B		6/10		
	B		8/10		
	A, B		1	15453–1	
MIL–F–15160/10	F10 B	250	1– 1/4		
	A, B		2	15453–2	
	B		2– 1/2		
	A, B		3	15453–3	
	B		3– 2/10		
	A, B		4	15453–4	
	A, B		5	15453–5	
	B		5– 6/10		
	A		6	15453–6	
	B		8 1/4		
	A		10	15453–7	
	A	125	12	15453–8	
	A		15	15453–9	
	A		2	15453–10	
	A, B		2– 1/2		
	B		3	15453–3	
	A, B		3– 2/10		
	B		4	15453–4	
	A, B		5	15453–5	
	A, B		5– 6/10		
	B		6	15453–6	
	A		6– 1/4		
	A		8	15453–7	
	A		10	15453–8	
	A		12	15453–9	
	A		15	15453–10	
	B	125	7		
	B		8		
	B		10		
	A		20	15453–11	
	A		25		
	A		30		
MIL–F–23419/9	FM09 A, B	250	1/100		
	A, B		1/32		
	B		1/16		
	A, B		1/10		
	B		1/8		
	B		15/100		
	A, B		3/16		
	B		1/4		
	A, B		3/10		
	A, B		3/8		
	B		1/2		
	A, B		6/10		
	A, B		3/4		
	B		8/10		
	A, B		1		
	A, B		1– 1/4		
	A, B		1– 1/2		

Table 2. Fuses Used In Aircraft Electrical Systems – Continued

Cartridge Type No.	Style*Characteristic		Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
		B		1– 6/10		
		A, B		2		
		B		2– 1/2		
		B		2– 8/10		
		A, B		3		
		B		3– 2/10		
		A		4		
		A		5		
		A		6		
		A		8		
		A		10		
		A		12		
		A		15		
MIL–F–23419/9	FMO9	B	125	4		
		B		8		
		B		10		
		B		12		
		A, B		15		
		A, B		20		
		A, B		25		
				30		

*A Normal (normal interrupting capacity); for general circuit protection
*B Time Lag; for circuits containing motors, and circuits where provision must be made for momentary surges.

2. Enclosed Link Type

MS Part No.		Voltage Rating		Current Rating		
MS28937	–5	115/200 VAC,	28 VDC	5 Amps	24124–5,	24125–5
	–10			10 Amps	–10	–10
	–20			20 Amps	–20	–20
	–30			30 Amps	–30	–30
	–40			40 Amps	–40	–40
	–50			50 Amps	–50	–50
	–60			60 Amps	–60	–60

Table 3. Cross Reference of Military and Commercial Fuse Designations

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED					
(Military New)	81349	96906	71400	71400	75915	75915	75915	98997
F01A250V1/500A [1]	FO1GR002	M590077–	AGX1/500	8AG1/500	361.002		364.002	
F01A250V1/200A	A [1] F01GR005	1 [2] M590077–	AGX1/200	8AG1/200	361.005		364.005	
F01A250V1/100A	A F01GR010	2 M590077–	AGX1/100	8AG1/100	361.010		364.010	
F01A250V1/32A	A F01GR031	3 M590077–	AGX1/32	8AG1/32	361.031		364.031	
F01A250V1/16A	A F01GR062	4 M590077–	AGX1/16	8AG1/16	361.062		364.062	8AG1/16
F01A250V1/10A	A F01GR100	5	AGX1/10	8AG1/10	361.100		364.100	8AG1/10
F01A250V1/8A	A F01GR125	M590077–	AGX1/8	8AG1/8	361.125	362.125	364.125	8AG1/8
F01A250V3/16A	A	6	AGX3/16	8AG3/16	361.187		364.187	8AG3/16
F01A250V2/10A			AGX2/10	8AG2/10	361.200		364.200	8AG2/10
F01A250V1/4A	F01GR250	M590077–	AGX1/4	8AG1/4	361.250	362.250	364.250	8AG1/4
F01A250V3/8A	A F01GR375	7 M590077–	AGX3/8	8AG3/8	361.375	362.375	364.375	8AG3/8
F01A250V4/10A	A	8	AGX4/10	8AG4/10	361.400		364.400	8AG4/0
F01A250V1/2A	F01GR500	M590077–	AGX1/2	8AG1/2	361.500	362.500	364.500	8AG1/2
F01Al25V6/10A	A	9	AGX6/10	8AG6/10				8AG6/10
F01Al25V3/4A	F01GR750	M590077–	AGX3/4 [3]	8AG3/4 [3]	361.750 [3]	362.750 [3]	364.750 [3]	8AG3/4 [3]
F01Al25V8/10A	A [3]	10 [3]	AGX8/10	8AG8/10 [3]				8AG8/10 [3]
F01Al25V1A	F01G1R00	M590077–	[3] AGX1 [3]	8AG1 [3]	361.001 [3]	362001 [3]	364001 [3]	8AG1 [3]
F01Al25V11/4A	A [3]	11 [3]		8AG11/4 [3]				8AG11/4 [3]
F01Al25V11/2	F01G1R50	M590077–	AGX11/2 [3]	8AG11/2 [3]	36101.5 [3]	36201.5 [3]	36401.5 [3]	8AG11/2 [3]
F01Al25V16/10A	A [3]	12 [3]		8AG16/10 3				8AG16/10 [3]
F01Al25V2A	F01G2R00	M590077–	AGX2 [3]	8AG2 [3]	361002 [3]	362002 [3]	364002 [3]	8AG2 [3]
F01Al25V21/2A	A [3]	13 [3]	AGX2 1/2					
F01Al25V3A			AGX3		361003	362003 [3]		
F01Al25V31/2A			AGX3 1/2					
F01Al25V4A			AGX4		361004			
F01Al25V5A			AGX5		361005	362005		
F01A32V6A			AGX6			362006		
F01A32V7A			AGX7					
F01A32V8A			AGX8			362008		
F01A32V10A			AGX10			362010		
F01A32V15A			AGX15			362015		
F01A32V20A			AGX20			362020		
F01A32V25A			AGX25			362025		
F01A32V30A			AGX30			362030		

See Footnotes at the end of the Table

Table 3. Cross Reference of Military and Commercial Fuse Designations (Continued)

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED						
(Military New)	81349	81349	96906	71400	71400	75915	75915	75915	98997
F02A250V1/100A1	F02GR010A1	F02CR0101	MS90078–12	AGC1/100		311.010	312.010	392.010	3AG1/100
F02A250V1/32A	F02GR031A	F02CR031	M590078–2	AGC1/32		311.031	312.031	392.031	3AG1/32
F02A250V1/16A	F02GR062A	F02CR062	M590078–3	AGC1/16	MGB1/16	311.062	312.062	392.062	3AG1/16
F02A250V1/8A	F02GR125A	F02CR125	MS90078–4	AGC1/8	MGB1/8	311.125	312.125	392.125	3AG1/8
F02A250V15/100A				AGC15/100		311.150	312.150	392.150	3AG15/100
F02A250V175/1000A				AGC175/1000		311.175	312.175	392.175	3AG175/1000
F02A250V3/16A				AGC3/16		311.187	312.187	392.187	3AG3/16
F02A250V2/10A				AGC2/10		311.200	312.200	392.200	3AG2/10
F02A250V1/4A	F02GR250A	F02CR250	M590078–5	AGC1/4		311.250	312.250	392.250	3AG1/4
F02A250V3/10A				AGC3/10		311.300	312.300	392.300	3AG3/10
F02A250V3/8A	F02GR375A	F02CR375	M590078–6	AGC3/8		311.375	312.375	392.375	3AG3/8
F02A250V1/2A	F02GR500A	F02CR500	M590078–7	AGC1/2		311.500	312.500	392.500	3AG1/2
F02A250V6/10A				AGC6/10		311.600	312.600	392.600	3AG6/10
F02A250V3/4A	F02GR750A	F02CR750	M590078–8	AGC3/4		311.750	312.750	392.750	3AG3/4
F02A250V1A	F02G1R00A	F02C1R00	M590078–9	AGC1		311001	312001	392001	3AG1
F02A250V0/ 1/4A				AGC1 1/4		3111.25	3121.25	3921.25	3AG1 1/4
F02A250V1/ 1/2A	F02G1R50A	F02C1R50	M590078–10	AGC1 1/2		3111.50	3121.50	3921.50	3AG1 1/2
F02A250V16/10A				AGC16/10		3111.60	3121.60	3921.60	3AG16/10
F02A250V2A	F02G2R00A	F02C2R00	M590078–11	AGC2		311002	312002	392002	3AG2
F02A250V2 1/2A				AGC2 1/2		31102.5	31202.5	39202.5	3AG2 1/2
F02A250V3A	F02G3R00A	F02C3R00	M590078–12	AGC3		311003	312003	392003	3AG3
F02A250V4A	F02G4R00A	F02C4R00	M590078–13	AGC4	MTH4	311004	312004	392004	3AG4
F02A250V5A	F02G5R00A	F02C5R00	M590078–14	AGC5	MTH5	311005	312005	392005	3AG5
F02A250V6A	F02G6R00A	F02C6R00	M590078–15	AGC6	MTH6	311006	312006	392006	3AG6
F02Al25V8A	F02A32V8A	F02D8R00		AGC8	GLH8				
F02Al25V10A	F02A32V10A	F02D10R0		AGC10	GLH10				
F02A32V15A		F02A15R0		AGC15					
F02A32V20A		F02A20R0		AGC20					
F02A32V25A		F02A25R0		AGC25					
F02A32V30A		F02A30R0		AGC30					

See Footnotes at the end of Table

Table 3. Cross Reference of Military and Commercial Fuse Designations (Continued)

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED			
(Military New)	81349	81349	71400	75915	75915	98997
F02B250V 1/100A [1]	F02GR010B [1]	MS90078−16 [2]	MDL 1/100	393.010	313.010	3AGTL 1/100 A−250V
F02B250V 1/32 A	F02GR031B	M590078−17	MDL 1/32	393.031	313.031	3AGTL 1/32 A−250V
F02B250V 1/16 A	F02GR062B	M590078−18	MDL 1/16	393.062	313.062	3AGTL 1/16 A−250V
F02B250V 1/10 A			MDL 1/10		313.100	3AGTL 1/10 A−250V
F02B250V 1/8 A	F02GR125B	M590078−19	MDL 1/8	393.125	313.125	3AGTL 1/8 A−250V
F02B250V 15/100A			MDL 15/100		313.150	3AGTL 15/100A−250V
F02B250V 3/16 A			MDL 3/16		313.187	3AGTL 3/16 A−250V
F02B250V 2/10 A			MDL 2/10		313.200	3AGTL 2/10 A−250V
F02B250V 1/4 A	F02GR250B	M590078−20	MDL 1/4	393.250	313.250	3AGTL 1/4 A−250V
F02B250V 3/10A			MDL 3/10		313.300	3AGTL 3/10 A−250V
F02B250V 3/8 A	F02GR375B	M590078−21	MDL 3/8	393.375	313.375	3AGTL 3/8 A−250V
F02B250V 4/10 A			MDL 4/10		313.400	3AGTL 4/10 A−250V
F02B250V 1/2 A	F02GR500B	M590078−22	MDL 1/2	393.500	313.500	3AGTL 1/2 A−250V
F02B250V 6/10 A			MDL 6/10		313.600	3AGTL 6/10 A−250V
F02B250V 7/10 A			MDL 7/10		313.700	3AGTL 7/10 A−250V
F02B250V 3/4 A	F02GR750B	M590078−23	MDL 3/4	393.750	313.750	3AGTL 3/4 A−250V
F02B250V 8/10 A			MDL 8/10		313.800	3AGTL 8/10 A−250V
F02B250V 1 A	F02G1R00B	M590078−24	MDL 1	393.001	313001	3AGTL 1 A−250V
F02B250V 1 1/4 A			MDL 1 1/4		3131.25	3AGTL 1 1/4 A−250V
F02B250V 1 1/2 A	F02D1R50B	M590078−25	MDL 1 1/2		31301.5	3AGTL 1 1/2 A−250V
F02B250V 1 6/10A			MDL 1 6/10		31301.6	3AGTL 1 6/10A−250V
F02B250V 2 A	F02D2R00B	N590078−26	MDL 2		313002	3AGTL 2 A−250V
F02B250V 2 1/2 A			MDL 2 1/2		31302.5	3AGTL 2 1/2 A−250V
F02B250V 2 8/10A			MDL 2 8/10		31302.8	3AGTL 2 8/10A−250V
F02B250V 3 A	F02D3R00B	M590078−27	MDL 3		313003	3AGTL 3 A−250V
F02B250V 3 2/10A			MDL 3 2/10		31303.2	3AGTL 3 2/10A−250V
F02B125V 4 A			MDX 4		313004 [3]	3AGTL 4 A−250V [3]
F02B125V 5 A			MDX 5		313005 [3]	3AGTL 5 A−250V [3]
F02B125V 6 1/4 A			MDX 6 1/4		3136.25	
F02B25V 7 A			MDX 7		313007	
F02B32V 8 A			MDL 8		313008	3AGTL 8 A32V
F02B32V 10 A			MDL 10		313010	3AGTL 10 A32V
F02B32V 12 A			MDL 12		313012	3AGTL 12 A32V
F02B32V 15 A			MDL 15		313015	
F02B32V 20 A			MDL 20		313020	3AGTL 20 A32V
F02B32V 25 A			MDL 25		313025	
F02B32V 30 A			MDL 30		313030	

See Footnotes at the end of the Table

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED					
(Military New)	81349	96906	71400	71400	75915	75915	75915	98997
F03A250V1–4A [1]			ABC1/4	MB01/4	394.250	314.250	3AB 1/4	3AB 1/4
F03A250V1–2A			ABC1/2	MB01/2	394.500	314.500	3AB1/2	3AB 1/2
F03A250V1A			ABC1	MB01	394001	314001	3AB1	3AB1
F03A250V1–1/4A	F03G1R00A [1]	MS90079–1 [2]	ABC11/4	MB011/4	3941.25	3141.25	3AB11/4	3AB11/4
F03A250V1–1/2A			ABC11/2	MB011/2	39401.5	31401.5	3AB1 1/2	3AB11/2
F03A250V2A			ABC2	MB02	394002	314002	3AB2	3AB2
F03A250V3A	F03G3R00A	MS90079–2	ABC3	MB03	394003	314003	3AB3	3AB3
F03A250V4A			ABC4	MB04	394004	314004	3AB4	3AB4
F03A250V5A	F03G5R00A	MS90079–3	ABC5	MB05	394005	314005	3AB5	3AB5
F03A250V6A			ABC6	MB06	394006	314006	3AB6	3AB6
F03A250V8A	F03G8R00A	MS90079–4	ABC8	MB08	394008	314008	3AB8	3AB8
F03A250V10A	F03G10R0A	MS90079–5	ABC10	MB010	394010	314010	3AB10	3AB10
F03A250V12A	F03G12R0A	MS90079–6	ABC12	MB012	394012	314012	3AB12	3AB12
F03A250V15A	F03G15R0A	MS90079–7	ABC15	MB015	394015	314015	3AB15	3AB15
F03Al25V20A	F03D20R0A	MS90079–8	ABC20	MB020	394020	314020	3AB20	3AB20
F03Al25V25A			ABC25	MB025	394025	314025	3AB25	3AB25
F03Al25V30A	F03D30R0A	MS90079–9	ABC30	MB030	394030	314030	3AB30	3AB30
F03B250V1/100A	F03GR010B	MS90079–10	MDA1/100	MDF1/100	390.010	323.010		3ABTL1/100
F03B250V1/32A	F03GR031B	MS90079–11	MDA1/32	MDF1/32	390.031	323.031		3ABTL1/32
F03B250V1/16A	F03GR062B	MS90079–12	MDA1/16	MDF1/16	390.062	323.062		3ABTL1/16
F03B250V1/8A	F03GR125B	MS90079–13	MDA1/8	MDF1/8	390.125	323.125		3ABTL1/8
F03B250V15/100A	F03GR150B	MS90079–14	MDA15/100	MDF15/100	390.150	323.150		3ABTL15/100
F03B250V3/16A	F03GR187B	MS90079–15	MDA3/16	MDF3/16	390.187	323.187		3ABTL3/16
F03B250V1/4A	F03GR250B	MS90079–16	MDA1/4	MDF1/4	390.250	323.250		3ABTL1/4
F03B250V3/10A			MDA3/10	MDF3/10	390.300	323.300		3ABTL3/10
F03B250V3/8A	F03GR375B	MS90079–17	MDA3/8	MDF3/8	390.375	323.375		3ABTL3/8
F03B250V1/2A	F03GR500B	MS90079–18	MDA1/2	MDF1/2	390.500	323.500		3ABTL1/2
F03B250V6/10A			MDA6/10	MDF6/10	390.600	323.600		3ABTL6/10
F03B250V3/4A	F03GR750B	MS90079–19	MDA3/4	MDF3/4	390.750	323.750		3ABTL3/4
F03B250V8/10A			MDA8/10	MDF8/10	390.800	323.800		3ABTL8/10
F03B250V1A	F03G1R00B	MS90079–20	MDA1	MDF1	390001	323001		3ABTL1
F03B250V1 1/4A			MDA11/4	MDF11/4	390.250	3231.25		3ABTL11/4

See Footnotes at the end of the Table

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED					
(Military New)	81349	96906	71400	71400	75915	75915	75915	98997
F03B250V1 1/2A			MDA11/2	MDF11/2	390.500	32301.5		3ASTL11/2
F03B250V1 6/10A			MDA16/10	MDF16/10	390.600	32301.6		3ABTL16/10
F03B250V2A	F03B125V2A		MDA2	MDF2	390002	323002		3ABTL2
F03B250V2 1/2A	F03B125V21/2 A		MDA21/2	MDF21/2	39002.5	32302.5		3ABTL21/2
F03B250V2 8/10A	F03B125V28/10 A		MDA28/10	MDF28/1 0	39002.8	32302.8		3ABTL28/10
F03B250V3A [1]	F03GR00B [1]	MS90079–21 [2]	MDA3	MDF3	390003	323003		3ABTL3
	F03B125V3A							
F03B250V3–2/10 A	F03B125V32/10 A		MDA32/10	MDF32/1 0	39003.2	32303.2		3ABTL32/10
F03B125V4A			MDA4 [3]	MDF4 [3]	390004	323004		3ABTL4
F03B125V5A	F03G5R00B [3]	MS90079–22 [3]	MIDA5 [3]	MDF5 [3]	390005	323005		3ABTL5
	F03D5R00B							
	F03B32V5A							
F03B125V61/4 A 1	F03B32V6–1/4 A1		MDF6 1/4	MDA6 1/4	3906.25	3236.25		3ABTL6 1/4
F03B125V7A	F03B32V7A		MDF7	MDA7	390007	323007		3ABTL7
F03B125V8A	F03G8R00B [3]	MS90079–23 [2]	MDF8	MDA8	390008	323008		3ABTL8
	F03B32V8A							
F03B125V10A	F03G10R0B [3]	MS90079–24	MDF10 [3]	MDA10 [3]	390010	323010		3ABTL10
	F03B32V10A							
F03B125V12A	F03G12R0B [3]	M590079–25	MDF12 [3]	MDAl2 [3]	390012	323012		3ABTL12
	F03B32V12A							
F03B125V15A	F03G15R0B [3]	M590079–26	MDF15 [3]	MDA15 [3]	390015	323015		3ABTL15
	F03B32V15A							
F03B125V20A	F03D20R0B	M590079–27	MDF20 [3]	MDA20 [3]	390020	323020		3ABTL20
	F03B32V20A							
F03B125V25A	F03D25R0B		MDF25	MDA25	390025	323025		3ABTL25
	F03B32V25A							
F03B125V30A	F03D30R0B	M590079–28	MDF30	MDA30	390030	323030		3ABTL30
	F03B32V30A							

Footnotes

[1] A letter S following the part number signifies silver plating.

[2] A second dash number (–1) signifies silver plating.

[3] Replacement of these commercial superseded fuses and military superseded fuses with the superseding number fuses are in exception to general practices stated herein (see paragraph 18.4 step e). In any other case, application personnel should contact the system manager first before substituting a higher voltage rated fuse with a lower voltage rated fuse.

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

MILITARY SUPERSEDED	SUPERSEDING NO. (Military New)	COMMERCIAL SUPERSEDED	
*F04A5R0A	*F02A 250V 5A	MTH or AGC 5	312 3AG 5A 250V
F04A10R0A	F02A 32V 10A	AGC 10	311 3AG 10A 32V
F04A15R0A	F02A 32V 15A	AGC115	311 3AG 15A 32V
F04A20R0A	F02A 32V 20A	AGC 20	311 3AG 20A 32V
F04A5R00B	F02B 32V 5A	MDL 5	
F04A10R0B	F02B 32V 10A	MDL 10	313 3AG 10A 32V
F04A15R0B	F02B 32V 15A	MDL 15	313 3AG 15A 32V
F04A20R0B	F02B 32V 20A	MDL 20	313 3AG 20A 32V
F05A10R0A	F05A 32V 10A	AGS 10	411 4AG 10A 32V
F05A15R0A	F05A 32V 15A	AGS 15	411 4AG 15A 32V
F05A20R0A	F05A 32V 20A	AGS 20	411 4AG 20A 32V
F05A25R0A	F05A 32V 25A	AGS 25	411 4AG 25A 32V
F05A30R0A	F05A 32V 30A	AGS 30	411 4AG 30A 32V
F05A35R0A	NONE	AGS 35	411 4AG 35A 32V
F05A40R0A	NONE	AGS 40	411 4AG 40A 32V
F05A10R0B	F05B 32V 10A	MDM 10	413 4AG 10A 32V
F05A15R0B	F05B 32V 15A	MDM 15	413 4AG 15A 32V
F05A20R0B	F05B 32V 20A	MDM 20	413 4AG 20A 32V
F05A25R0B	F05B 32V 25A	MDM 25	413 4AG 25A 32V
F05A30R0B	F05B 32V 30A	MDM 30	413 4AG 30A 32V
F05A35R0B	NONE	MDM 35	
F05A40R0B	NONE	MDM 40	

* Indicates voltage change from military superseded fuse to superseding number fuse.
military superseded fuse to superseding number fuse.

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

Superseding No.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED			
(Military New)	81349	96906	71400	75915	75915	98997
F06A250V1A [1]	F06G1R00A [1]	MS90082−1 [2]	ABS1	494001	414001	4AB1
F06A250V2A	F06G2R00A	MS90082−2	ABS2	494002	414002	4AB2
F06A250V3A	F06G3R00A	MS90082−3	ABS3	494003	414003	4AB3
F06A250V5A	F06G5R00A	MS90082−4	ABS5	494005	414005	4AB5
F06A250V10A	F06G10R00A	MS90082−5	ABS10	494010	414010	4AB10
F06A250V15A	F06G15R00A	MS90082−6	ABS15	494015	414015	4AB15

Footnotes
[1] A letter S following the part number signifies silver plating.
[2] A second dash number (−1) signifies silver plating.

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

Superseding No. (Military New)	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED		
	81349	96906	71400	75915	75915
F07A250V1A [1]	F07G1R00A [1]		AGU1	590001	512001
F07A250V2A	F07G2R00A		AGU2	590002	512002
F07A250V3A	F07G3R00A		AGU3	590003	512003
F07A32V5A	F07A5R00A	MS90083–1 [2]	AGU5	590005	512005
F07A32V10A	F07A10R0A	MS90083–2	AGU10	590010	512010
F07A32V15A	F07A15R0A	MS90083–3	AGU15	590015	512015
F07A32V20A	F07A20R0A	MS90083–4	AGU20	590020	512020
F07A32V30A	F07A30R0A	MS90083–5	AGU30	590030	512030
F07B125V1A			MDR1		
F07B125V2A			MDR2		
F07B125V3A			MDR3		
F07B32V5A		MS90083–10	MDR5		
F07B32V10A		MS90083–11	MDR10		
F07B32V15A		MS90083–12	MDR15		
F07B32V20A		MS90083–13	MDR20		
F07B32V30A		MS90083–14	MDR30		

Footnotes

[1] A letter S following the part number signifies silver plating.

[2] A second dash number (–1) signifies silver plating.

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

Military Superseded	Superseded No. (Military New)	Commerical Superseded	Commerical Superseded
F08G1R00A	F07A 250V 1A	AGU 1	512 5AG 1A 250V
F08G2R00A	F07A 250V 2A	AGU 2	512 5AG 2A 250V
F08G3R00A	F07A 250V 3A	AGU 3	512 5AG 3A 250V
*F08D5R00A	*F09A 250V 5A	BAN or **AGU 5	513 5AG 1A 250V
*F08D10R0A	*F09A 250V 10A	BAN or **AGU 10	513 5AG 2A 250V
*F08D15R0A	*F09A 250V 15A	BAN or **AGU 15	513 5AG 3A 250V [3]
*F08D20R0A	*F09A 250V 20A	BAN or **AGU 20	
*F08D25R0A	*F09A 250V 25A	BAN or **AGU 25	
*F08D30R0A	*F09A 250V 30A	BAN or **AGU 30	
F08G1R00B	F09B 250V 1A	FNM or **MDR 1	
F08G2R00B	F09B 250V 2A	FNM or **MDR 2	

Footnotes

* Indicates voltage change from old to new military replacement.

**Indicates that the commercial fuse is of a lower voltage rating than one or both military fuse replacement.

[3] Replacement of these commercial superseded fuses and military superseded fuses with the superseding number fuses are in exception to general practices stated herein (see paragraph 18.4 step e). In any other case, application personnel should contact the system manager first before substituting a higher voltage rated fuse with a lower voltage rated fuse.

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

Military Superseded	Superseded No. (Military New)	Commerical Superseded
*F08G3R00B	*F07B 125V 3A	**MDR 3
F08G5R00B	F09B 250V 5A	FNM or **MDR 5
*F08D10R0B	*F09B 250V 10A	FNM or **MDR 10
F08D15R0B	F09B 125V 15A	FNM or **MDR 15
*F08D20R0B	*F09B 32V 20A	**FNM or **MDR 20
*F08D25R0B	*F09B 32V 25A	**FNM or **MDR 25
*F08D30R0B	*F09B 32V 30A	**FNM or **MDR 30

Footnotes
*Indicates voltage change from old to new military replacement.
**Indicates that the commercial fuse is of a lower voltage rating than one or both military fuse replacement.
[3] Replacement of these commercial superseded fuses and military superseded fuses with the superseding number fuses are in exception to general practices stated herein (see paragraph 18.4 step e). In any other case, application personnel should contact the system manager first before substituting a higher voltage rated fuse with a lower voltage rated fuse.

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED				
(Military New)	81349	96906	96906	71400	72076	75915	71424
F09A250V 1A [1]	F09G1R00A [1]	MS90085–9 [2]	MS90084–1 [1]	BAN 1	M0L 1	525001	
F09A250V 2A	F09G2R00A	MS90085–15	MS90084–2	BAN 2	M0L 2	525002	
F09A250V 3A	F09G3R00A	MS90085–19	MS90084–3	BAN 3	M0L 3	525003	
F09A250V 3 1/2A	F09G3R50A	MS90085–21		BAN 3 1/2	M0L 3 1/2	52503.5	
F09A250V 4A	F09G4R00A	MS90085–22		BAN 4	M0L 4	525004	
F09A250V 5A	F09G5R00A	MS90085–24	MS90084–4	BAN 5	M0L 5	525005	
F09A250V 6A	F09G6R00A	MS90085–26		BAN 6	M0L 6	525006	
F09A250V 6 1/4A	F09G6R25A	MS90085–27		BAN 6 1/4	M0L 6 1/4	5256.25	
F09A250V 7A	F09G7R00A	MS90085–28		BAN 7	M0L 7	525007	
F09A250V 8A	F09G8R00A	MS90085–29		BAN 8	M0L 8	525008	
F09A250V 10A	F09G10R0A	MS90085–31	MS90084–5	BAN 10	M0L 10	525010	
F09A250V 15A	F09G15R0A	MS90085–32	MS90084–6	BAN 15	M0L 15	525015	
F09A250V 20A	F09G20R0A	MS90085–33	MS90084–7	BAN 20	M0L 20	525020	
F09A250V 25A	F09G25R0A	MS90085–34	MS90084–8	BAN 25	M0L 25	525025	
F09A250V 30A	F09G30R0A	MS90085–35	MS90084–9	BAN 30	M0L 30	525030	
F09B250V 1/10A	F09GR100B	MS90085–36		FNM 1/10			
F09B250V 15/100A	F09GR150B	MS90085–37		FNM 15/100			
F09B250V 2/10A	F09GR200B	MS90085–38		FNM 2/10			
F09B250V 3/10A	F09GR300B	MS90085–39		FNM 3/10			
F09B250V 4/10A	F09GR400B	MS90085–40		FNM 4/10			
F09B250V 1/2A	F09GR500B	MS90085–41		FNM 1/2			
F09B250V 6/10A	F09GR600B	MS90085–42		FNM 6/10			
F09B250V 8/10A	F09GR800B	MS90085–43		FNM 8/10			
F09B250V 1A	F09G1R00B	MS90085–44	MS90084–10	FNM 1	MEN 1		
F09B250V 11/8A	F09G1R12B	MS90085–45		FNM 11/8	MEN 11/8		
F09B250V 1 1/4A	F09G1R25B	MS90085–46		FNM 1	MEN 1		
F09B250V 14/10A	F09G1R40B	MS90085–47		FNM 14/10	MEN 14/10		
F09B250V 16/10A	F09G1R60B	MS90085–48		FNM 16/10	MEN 16/10		
F09B250V 18/10A	F09G1R80B	MS90085–49		FNM 18/10	MEN 18/10		
F09B250V 2A	F09G2R00B	MS90085–50	MS90084–11	FNM 2	MEN 2		
F09B250V2 1/4A	F09G2R25B	MS90085–51		FNM 2 1/4	MEN 2 1/4		

Footnotes
[1] A letter S following the part number signifies silver plating.
[2] A second dash number (–1) signifies silver plating.

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

Superseding No.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED				
(Military New)	81349	96906	96906	71400	72076	75915	71424
F09B250V 2 1/2A	F09G2R50B	MS90085–52		FNM 2 1/2	MEN 2 1/2		
F09B250V 28/10A	F09G2R80B	MS90085–53		FNM 28/10	MEN 28/10		
F09B250V 32/10A	F09G3R20B	MS90085–55		FNM 31/10	MEN 31/10		
F09B250V 3 1/2A	F09G3R50B	MS90085–56		FNM 3 1/2	MEN 3 1/2		
F09B250V 4A	F09G4R00B	MS90085–57		FNM 4	MEN 4		
F09B250V 4 1/2A	F09G4R50B	MS90085–58		FNM 4.5	MEN 4 1/2		
F09B250V 5A	F09G5R00B	MS90085–59		FNM 5	MEN 5		
F09B250V 56/10A	F09G5R60B	MS90085–60		FNM 56/10	MEN 56/10		
F09B250V 6 1/4A	F09G6R25B	MS90085–62		FNM 6 1/4	MEN 6 1/4		
F09B250V 7A	F09G7R00B	MS90085–63		FNM 7	MEN 7		
F09B250V 8A	F09G8R00B	MS90085–64		FNM 8	MEN 8		
F09B250V 9A	F09G9R00B	MS90085–65		FNM 9	MEN 9		
F09B250V 10A [1]	F09D10R0B [1]	MS90085–66 [2]	MS90084–14 [1]	FNM 10	MEN 10		
F09B125V 12A	F09D12R0B	– – –	– – –	FNM 12	– – –		
F09B125V 15A	F09D15R0B	MS90085–67	MS90084–15	FNM 15	MEN 15		TRM 15
F09B32V 20A	F09D20R0B	MS90085–68	MS90084–16	FNM 20	MEN 20		TRM 20
F09B32V 25A	F09D25R0B	MS90085–69	MS90084–17	FNM 25	MEN 25		TRM 25
F09B32V 30A	F09D30R0B	MS90085–70	MS90084–18	FNM 30	MEN 30		TRM 30

Footnotes
[1] A letter S following the part number signifies silver plating.
[2] A second dash number (–1) signifies silver plating.

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED
(Military New)	81349	96906	71400
F10A250V 1A [1]	F10G1R00A [1]	MS15453−1 [2]	MIN 1
F10A250V 2A	F10G2R00A	MS15453−2	MIN 2
F10A250V 3A	F10G3R00A	MS15453−3	MIN 3
F10A250V 4A	F10G4R00A	MS15453−4	MIN 4
F10A250V 5A	F10G5R00A	MS15453−5	MIN 5
F10A250V 6A	F10G6R00A	MS15453−6	MIN 6
F10A250V 8A	F10G8R00A	MS15453−7	MIN 8
F10A250V 10A	F10G10R0A	MS15453−8	MIN 10
F10A250V 12A	F10G12R0A	MS15453−9	MIN 12
F10A250V 15A	F10D15R0A	MS15453−10	MIN 15
F10A125V 20A	F10D20R0A	MS15453−11	MIN 20
F10A125V 25A	F10D25R0A		MIN 25
F10A125V 30A	F10D30R0A		MIN 30
F10B250V 1/10A			FNJ 1/10
F10B250V 15/100A			FNJ 15/100
F10B250V 2/10A			FNJ 2/10
F10B250V 3/10A			FNJ 3/10
F10B250V 4/10A			FNJ 4/10
F10B250V 1/2A			FNJ 1/2
F10B250V 6/10A			FNJ 6/10
F10B250V 8/10A			FNJ 8/10
F10B250V 1A			FNJ 1
F10B250V 1 1/4A			FNJ 1 1/4
F10B250V 2A			FNJ 2
F10B250V 2 1/2A			FNJ 2 1/2
F10B250V 3A			FNJ 3
F10B250V 3 2/10A			FNJ 3 2/10
F10B250V 4A			FNJ 4

Footnotes
[1] A letter S following the part number signifies silver plating.
[2] A second dash number (−1) signifies silver plating.

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

SUPERSEDING NO.	MILITARY SUPERSEDED		COMMERCIAL SUPERSEDED
(Military New)	81349	96906	71400
F10B250V 5A			FNJ 5
F10B250V 5 6/10A			FNJ 5 6/10
F10B250V 6 1/4A			FNJ 6 1/4
F10B250V 7A	F10G7R00B		FNJ 7
F10B250V 8A	F10G8R00B		FNJ 8
F10B250V 10A	F10G10A08		FNJ 10

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

SUPERSEDING PART NO.	SUPERSEDED PART NO.				
FM02A125V1/500A	FM02−125V−1/500A	FM02−1/500A	FM02125V1/500A	FM021/500A	M23419/2−001
FM02A125V1/200A	FM02−125V−1/200A	FM02−1/200A	FM02125V1/200A	FM021/200A	M23419/2−002
FM02A125V1/100A	FM02−125V−1/100A	FM02−1/100A	FM02125V1/100A	FM021/100A	M23419/2−003
FM02A125V1/64A	FM02−125V−1/64A	FM02−1/64A	FM02125V1/64A	FM021/64A	M23419/2−004
FM02A125V1/32A	FM02−125V−1/32A	FM02−1/32A	FM02125V1/32A	FM021/32A	M23419/2−005
FM02A125V1/16A	FM02−125V−1/16A	FM02−1/16A	FM02125V1/16A	FM021/16A	M23419/2−006
FM02A125V1/10A	FM02−125V−1/10A	FM02−1/10A	FM02125V1/10A	FM021/10A	M23419/2−007
FM02A125V1/8A	FM02−125V−1/8A	FM02−1/8A	FM02125V1/8A	FM021/8A	M23419/2−008
FM02A125V2/10A	FM02−125V−2/10A	FM02−2/10A	FM02125V2/10A	FM022/10A	M23419/2−009
FM02A125V1/4A	FM02−125V−1/4A	FM02−1/4A	FM02125V1/4A	FM021/4A	M23419/2−010
FM02A125V3/10A	FM02−125V−3/10A	FM02−3/10A	FM02125V3/10A	FM023/10A	M23419/2−011
FM02A125V4/10A	FM02−125V−4/10A	FM02−4/10A	FM02125V4/10A	FM024/10A	M23419/2−012
FNI2A125V1/2A	FM02−125V−5/10A	FN02−5/10A	FM02125V5/10A	FM025/10A	M23419/2−013
FM02A125V6/10A	FM02−125V−6/10A	FM02−6/10A	FM02125V6/10A	FM026/10A	M23419/2−014
FM02A125V3/4A	FM02−125V−3/4A	FM02−3/4A	FM02125V3/4A	FM023/4A	M23419/2−015
FM02A125V1A	FM02−125V−1A	FM02−1A	FM02125V1A	FM021A	M23419/2−016
FM02A125V1−1/2A	FM02−125V−1−1/2A	FM02−1−1/2A	FM02125V1−1/2A	FM021−1/2A	M23419/2−017
FNI2A125V2A	FM02−125V−2A	FM02−2A	FM02125V2A	FM022A	M23419/2−018
FM02A125V3A	FM02−125V−3A	FM02−3A	FM02125V3A	FM023A	M23419/2−019
FM02A125V4A	FM02−125V−4A	FM02−4A	FM02125V4A	FM024A	M23419/2−020
FM02A125V5A	FM02−125V−5A	FM02−5A	FM02125V5A	FM025A	M23419/2−021

Table 3. Cross Reference of Military and Commercial Fuse Designations − Continued

MILITARY SUPERSEDED	SUPERSEDING NO. (Military New)	SUPERSEDED COMMERCIAL
FM03A 250V 1/100A	FM09A 250V 1/100A	ABC 1/100A
FM03A 250V 1/32A	FM09A 250V 1/32A	ABC 1/32A
FM03A 250V 1/16A	FM09A 250V 1/16A	ABC 1/16A
FM03A 250V 1/8A	FM09A 250V 1/8A	ABC 1/8A
FM03A 250V 1/4A	FM09A 250V 1/4A	ABC 1/4A
FM03A 250V 3/8A	FM09A 250V 3/8A	ABC 3/8A
FM03A 250V 1/2A	FM09A 250V 1/2A	ABC 1/2A
FM03A 250V 3/4	FM09A 250V 3/4A	ABC 3/4A
FM03A 250V 1A	FM09A 250V 1A	ABC 1A
FM03A 250V 1−1/2A	FM09A 250V 1−1/2A	ABC 1−1/2A
FM03A 250V 2A	FM09A 250V 2A	ABC 2A
FM03A 250V 3A	FM09A 250V 3A	ABC 3A
FM03A 250V 4A	FM09A 250V 4A	ABC 4A
FM03A 250V 5A	FM09A 250V 5A	ABC 5A
FM03A 250V 6A	FM09A 250V 6A	ABC 6A
FM03A 250V 8A	FM09A 250V 8A	ABC 8A
FM03A 250V 10A	FM09A 250V 10A	ABC 10A
FM03A 250V 12A	FM09A 250V 12A	ABC 12A
FM03A 250V 15A	FM09A 250V 15A	ABC 15A
FM03A 250V 20A	FM09A 250V 20A	ABC 20A

Table 3. Cross Reference of Military and Commercial Fuse Designations – Continued

MILITARY SUPERSEDED	SUPERSEDING NO. (Military New)	SUPERSEDED COMMERCIAL
FM03A 250V 25A	FM09A 250V 25A	ABC 25A
FM03A 250V 30A	FM09A 250V 30A	ABC 30A
FM06 250V 1/100A	FM09B 250V 1/100A	MDA 1/100A
FM06 250V 1/32A	FM09B 250V 1/32A	MDA 1/32A
FM06 250V 1/16A	FM09B 250V 1/16A	MDA 1/16A
FM06 250V 1/10A	FM09B 250V 1/10A	MDA 1/10A
FM06 250V 1/8A	FM09B 250V 1/8A	MDA 1/8A
FM06 250V 15/100A	FM09B 250V 15/100A	MDA 15/100A
FM06 250V 3/16A	FM09B 250V 3/16A	MDA 3/16A
FM06 250V 2/10A	FM09B 250V 2/10A	MDA 2/10A
FM06 250V 1/4A	FM09B 250V 1/4A	MDA 1/4A
FM06 250V 3/10A	FM09B 250V 3/10A	MDA 3/10A
FM06 250V 3/8A	FM09B 250V 3/8A	MDA 3/8A
FM06 250V 4/10A	FM09B 250V 4/10A	MDA 4/10A
FM06 250V 1/2A	FM09B 250V 1/2A	MDA 1/2A
FM06 250V 6/10A	FM09B 250V 6/10A	MDA 6/10A
FM06 250V 7/10A	FM09B 260V 7/10A	MDA 7/10A
FM06 250V 3/4A	FM09B 250V 3/4A	MDA 3/4A
FM06 250V 1A	FM09B 250V 1A	MDA 1A
FM06 250V 1–1/4A	FM09B 250V 1–1/4A	MDA 1–1/4A
FM06 250V 1–1/2A	FM09B 250V 1–1/2A	MDA 1–1/2A
FM06 250V 1–6/10A	FM09B 250V 1–6/10A	MDA 1–6/10A
FM06 250V 2A	FM09B 250V 2A	MDA 2A
FM06 125V 2–1/2A	FM09B 250V 2–1/24	MDA 2–1/2A
FM06 125V 2–8/10A	FM09B 250V 2–8/10A	MDA 2–8/10A
FM06 125V 3A	FM09B 250V 3A	MDA 3A
FM06 125V 3–2/10A	FM09B 250V 3–2/10A	MDA 3–2/10A
FM06 125V 4A	FM09B 125V 4A	MDA 4A [3]
FM06 125V 5A	FM09B 125V 5A	MDA 5A [3]
FM06 125V 6–1/4A	FM09B 125V 6–1/4A	MDA 6–1/4A [3]
FM06 125V 7A	FM09B 125V 7A	MDA 7A [3]
FM06 125V 8A	FM09B 125V 8A	MDA 8A [3]
FM06 125V 10A	FM09B 125V 10A	MDA 10A [3]
FM06 125V 12A	FM09B 125V 12A	MDA 12A [3]
FM06 125V 15A	FM09B 125V 15A	MDA 15A [3]
FM06 125V 20A	FM09B 125V 20A	MDA 20A [3]
FM06 125V 25A	FM09B 125V 25A	MDA 25A
FM06 125V 30A	FM09B 125V 30A	MDA 30A

Footnotes

[3] Replacement of these commercial superseded fuses and military superseded fuses with the superseding number fuses are in exception to general practices stated herein (see paragraph 18.4 step e). In any other case, application personnel should contact the system manager first before substituting a higher voltage rated fuse with a lower voltage rated fuse.

79. FUSEHOLDERS.

80. Extractor post fuseholders in accordance with Military Specification MIL–F–19207 are used in conjunction with cartridge type fuses. Block type fuseholders in accordance with Military Specification MIL–F–5373 are used with enclosed link fuses (see Figures 15 and 16).

81. AIRCRAFT CURRENT LIMITERS.

82. **GENERAL**. A limiter is a device that responds only to high values of overcurrent and is applied with this criterion in mind. A limiter is designed specifically with a high temperature melting point to provide protection for electric power distribution systems against short-circuit currents.

83. **CLASSIFICATION OF CURRENT LIMITERS**. There are two basic types of aircraft limiters that are used in aircraft electrical power systems. The most widely used limiter is of the knife blade style and Gives visual indication of a blown limiter by a spring activated pin that extends from the limiter body. The other type of limiter is the bolt-on type with an insulating window covering the link for visual inspection.

84. **APPLICATIONS OF CURRENT LIMITERS**. Limiters are usually applied in aircraft as back-up protection for circuit breakers and in multiple cable circuits for isolating faulted cable.

85. **PART NUMBERING SCHEME**. The following part numbering example for current limiters will typically apply:

MS 28937-10

Where:

MS 28937=the military part number
10=amperage rating of the current limiter

86. **GENERAL SIZING**. Aircraft limners are usually sized according to their tine-current characteristics.

87. **CIRCUIT BREAKER BACK-UP PROTECTION**. Where the available short circuit currents exceed the interrupting rating of a circuit breaker, an aircraft limiter may be used to limit the short-circuit current to within the breaker's capability.

88. **SHORT CIRCUIT PROTECTION**. Where multiple cable runs have been designed into the system, and single cable fault isolation is required, aircraft limiters will be installed at each end of each cable.

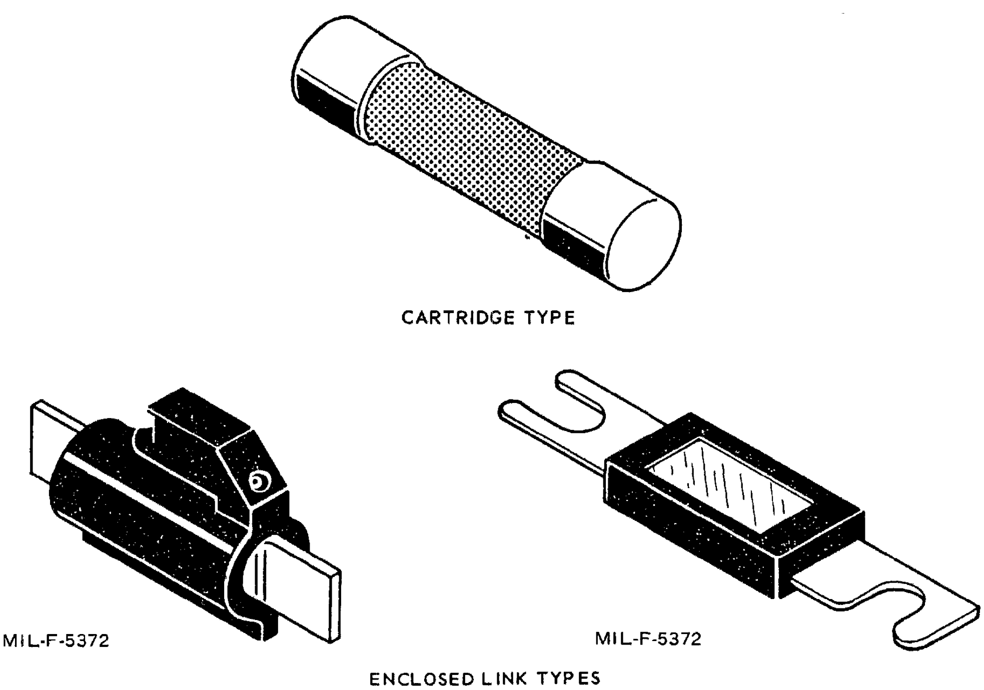
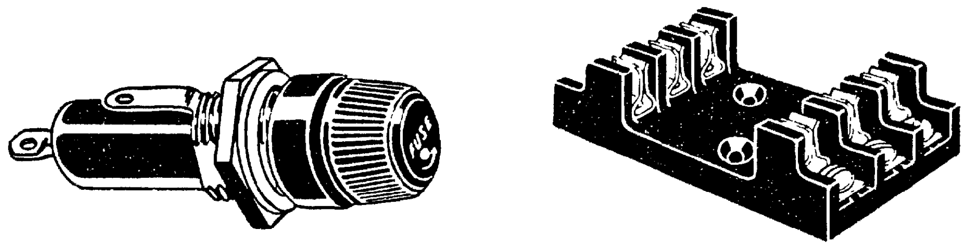


Figure 15. Typical Aircraft Fuses



EXTRACTOR POST TYPE
MIL-F-19207

BLOCK TYPE
MIL-F-5373

Figure 16. Typical Fuse Holders

WARNING

To prevent electrical shock, ensure electrical power is off before commencing work.

To prevent fire and damage to electrical equipment, do not replace a current limiter with one of a higher amperage rating.

89. **MAINTENANCE**. Periodic inspection of the limiter holding device is recommended to insure adequate pressure on the contact making members. Limiter characteristics do not change with age hence, no maintenance is required for those limiters in storage.

90. **IDENTIFICATION.**

a. Military Fuse Designations. Military fuse designations differ from commercial fuse designations and are divided into four parts as follows: (1) style, (2) blowtime characteristics, (3) voltage rating, and (4) current rating. To decode old and new military fuse designations (see Table 4 and 5).

b. Commercial Fuse Designations. Designations of various commercial fuses differ according to the manufacturer. However, when decoded, most of these designations provide the same general information, such as fuse type, current rating, voltage rating, and catalog number (see Table 4 and 5).

91. **GENERAL PRECAUTIONS.**

92. When replacing fuses in aircraft electrical systems, observe the following precautions:

a. Do not use tools except for fuse pullers to remove or insert fuses.

b. Make sure that the new fuse has the same electrical features as the fuse being replaced. The blow time characteristics are extremely important. Slow blow fuses will not be substituted for fast blow fuses. Temporary substitution of fast blow fuses for slow blow fuses is allowed.

c. Make sure that the plating on all metal parts is clean and intact.

d. Make sure that the wire inside the replacement fuse exhibits continuity.

e. Make sure that the replacement fuse has no cracks or breaks.

f. Do not force a fuse into a holder that does not readily accept it; check that a fuse of the correct size is being used.

CAUTION

Cartridge fuses marked F02 and F03 are 1–1/4 inches long and 1/4 inch diameter; fuses marked F05 and F06 are 1–1/4 inches long and 9/32 inch diameter. Do not interchange the two sizes.

g. Inspect fuse holder cap to ensure the rubber grommet is properly installed.

WARNING

Death or injury to personnel and damage to equipment may occur if these instructions are not followed.

h. Panel mounted fuseholder caps of the extractor–post type will be turned by finger pressure only. Use of tools to lock or unlock caps may damage them. The fuseholder cap must retain the fuse when either inserting or removing a fuse. Fuseholder caps which do not securely retain fuses must be discarded and a new fuseholder cap installed.

(1) When installing or removing fuses which are retained in extractor post type fuse holder caps, ensure the fuse remains in the extractor cap.

(2) If the fuse remains in the fuse holder body, the equipment must be disconnected from the power source while attempting to extract the fuse.

Table 4. Voltage Code (Previous)

Voltage Code Letter	Voltage (Volts)
A	32
B	52
C	90
D	125
G	250
H	500
J	1,000
K	2,500
N	5,000
P	10,000

Table 5. Current Code (Previous)

Current Code		Current (Amperes)
R002	.002	= 1/500
R005	.005	= 1/200
R010	.010	= 1/100
R031	.031	= 1/32
R750	.750	= 3/4
1R50	1.50	= 1 1/2

COMPONENT PART NUMBER INDEX

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
1244	Tape, Marking		008	00
2194	Tubing, Wire Braid		014	00
5585	Syringe 33cc, 23 Gauge Needle		022	01
74003	Wrench, Hex, 1/16 inch		011	02
74005	Wrench, Hex, 3/32 inch		011	02
979648	Tip, Boot and Tubing Gun, Sealing		011	01
296050002	Safety Lock, 3/8” Circuit Breaker		028	00
296050008	Safety Lock, 7/16” Circuit Breaker		028	00
296050009	Safety Lock Sleeve, Circuit Breaker		028	00
296050018	Safety Lock Clip		028	00
#56 (.046)	Drill Bit		017	00
0–200 in. lb.	Wrench, Torque		019	00
03–0109	Permanent Marker (black, fine tip)		008	00
04–0245	4 Light LED Headlamp		004	01
05–0140	LED Headlamp (NVG Capability)		004	01
070–7168–04	Metallic Time Delay Reflectometer, Tektronix 1502c (MTDR)		014	02
101A052	Connector End Cap		007	00
101A062	Connector End Cap		007	00
101A073	Connector End Cap		007	00
101A083	Connector End Cap		007	00
101A094	Connector End Cap		007	00
1245, NSN 7510–01–171–2852	Tape, Adhesive Copper Foil		014	00
12E2081–9	Collar, Circuiut Breaker Deactivation (White)		028	00
16U42563–1	Contact Gauge Pin Set		014	03
200D200 Series	Boot, Low Profile		011	01
2010–1000–0152 (or SM–B–450436–3, Rev B) – NSN:5999–00–005–3272	Wire Mesh, Nickel Plated Copper		011	01
202A100 Series	Boot, Bulbous		011	01
202C600 Series	Uni–Boot		011	01
202D100 Series	Boot, Bulbous		011	01
296050020–1	Kit, Safety Lock Circuit Breaker		028	00
299–947–110, Type III, Class I	Tape, Teflon		010	00
3280XX	Shielding Termination Ferrule		015	00
35–053	Cable Shear, Hand		009	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
4–1380	Bands, EMI Shield Termination, 1/4 Inch Steel		011	02
45–100	V–Notch Stripper		009	00
45–101	V–Notch Stripper		009	00
45–123	T–Cutter		009	00
45–128	Cable Stripper		009	00
45–129	Cable Stripper		009	00
45–1610	Wire Strippers		022	01
45–1610–1	Stripper Blade Set		022	01
45–1611	Ideal 45–123 Cutters, Wire		022	01
45–1611–1	Stripper Blade Set		022	01
45–162	(Coaxial) Cable Stripper		009	00
			014	00
45–163	(Coaxial) Cable Stripper		009	00
			014	00
45–164	(Coaxial) Cable Stripper		009	00
			014	00
45–165	(Coaxial) Cable Stripper		009	00
			014	00
45–1924	Stripper Frame		022	01
45–1924–1	Stripper Blade Set		022	01
45–1925	Stripper Frame		022	01
45–1925–1	Stripper Blade Set		022	01
45–350	Lite–Strip Optical Fiber Stripper		009	00
45–4987	Wire Strippers		022	01
4DBS–BR1	Band Removal Tool		011	02
5M608–XX	Shielding Termination Ferrule		015	00
6625–00–376–5105	Insulation Tester (Megger), MEGGER		014	02
69335–0	AMP Crimp Tool		011	00
7510–01–127–0648	Sleeve, Marking		008	00
7510–01–504–8938	Sleeve, Marking		008	00
77/BN	Multimeter, Digital		014	03
80–6113–1157–4/900 AST	Tester, 900 AST (Advanced Systems Tester)		014	02
840507	Pipe Cleaner		026	00
900AST	Wiring Diagnostic Tester, Advanced System Tester		014	02
901–2500	Crimping Tool		013	00
980–0005–548	Stripper No–Nik (.010)		009	00
980–0005–549	Stripper No–Nik (.016)		009	00
980–0006–755	Diamond Scribe		022	01
980–0006–757	Jewel Tweezers		022	01

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
980−9500−000	Kevlar Shears		022	01
980−ESP−00256	Wiring Diagnostic Tester, ESP+ Reflectometer		014	02
A–A–3077	Brush		026	00
AA−400	Heat Gun		011	01
A–A–51145	Flux, or Equivalent		016	00
A–A–52080 thru A–A–52084	Tape, Lacing and Tying (Aramid and Glass)		007	00
			010	00
			011	00
			014	00
			015	00
			025	00
AA52081−C−2 (0.099−0.121 width)	Tape, Finish C, Polyester Tying, Size 2		008	00
AA52081−C−3 (0.077−0.094 width)	Tape, Finish C, Polyester Tying, Size 3		008	00
AA52083−C−2 (0.099−0.121 width)	Tape, Finish C, Glass Tying, Size 2		010	00
AA52083−C−3 (0.077−0.094 width)	Tape, Finish C, Glass Tying, Size 3		004	01
A–A–58054	Abrasive Mats		017	00
A–A–59142	Rosin		016	00
A−A−59163 TYPE 11, 5970−00−955−9976	Tape, Red Non−Adhesive Self−Bonding		010	00
A−A−59163 TYPE 11, 5970−00−955−9976			011	00
A–A–59163 TYPE II, NSN 5970−00−949−4846	Tape, Non−Adhesive, Self−Bonding, Red		011	00
A–A–59163 TYPE II, NSN 5970−00−949−4846	Tape, Red Non−Adhesive Self−Bonding		011	00
A–A–59163 Type II, NSN 5970−00−955−9976	Tape, Black Non−Adhesive Self−Bonding		010	00
A–A–59163 Type II, NSN 5970−00−955−9976			011	00
A–A–59163 TYPE II, NSN 5970−00−955−9976	Tape, Non−Adhesive, Self−Bonding, Black		011	00
A–A–59163, TYPE II	Tape, Self–Bonding Silicone		011	00
A−A−59323	Cloth		019	00
A–A–59474	Tape, Self–Bonding Silicone Rubber (High− Temperature Pressure− Sensitive)		010	00
			011	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
A–A–59474 Type I, Class 4, NSN 5970–01–012–4280	Tape, Teflon		011	00
A–A–59569	Braid, Metallic		017	00
AD–1319	Fixture, Holding		002	00
			013	00
AD–1377	Crimping Tool		013	00
			014	00
AD–1378	Gage, Inspection		013	00
AD–1386	Gage, Inspection		011	02
AD–156	Fixture, Holding		015	00
AD28500–36–36–8 (8030–01–501–5351)	Dual Connector Wrap Kit		025	00
AD89503–01–18	Tape, Stretch Seal		007	00
AD89503–01–24	Tape, Stretch Seal		007	00
AD89503–01–36	Tape, Stretch Seal		007	00
ADEL560	Clamp Assembly Tool		010	00
AMP 49935	Crimping Tool		011	00
			014	00
AMS 3276 Class B–1/4	Sealing Compound, Polysulfide		025	00
AMS3411–S	Flux, Silver Brazing		016	00
AN 5537	Connector, Thermocouple		014	00
AN/USM–21A	Ohmmeter (Low Range)		017	00
AN–340	Nut, Plain		019	00
AN–345	Nut		019	00
AN735	Clamp, Bonding		010	00
AN–935	Lockwasher		019	00
AN–936B	Lockwasher		019	00
AN–960	Washer, Plain		019	00
ANSI B74.18	Cloth, Abrasive Coated		017	00
AS21919	Clamp, Cushioned Metal		007	00
			010	00
AS25281	Clamp, Plastic		010	00
AS33671	Strap, Self–Clinching		010	00
AS3617 Series	Kit, Safety Cable		018	00
AS3619 Series	Ferrule, Elongated		018	00
AS3621 Series	Cable, Safety, Self–Looping		018	00
AS5768/1–T1 thru T–24	Tool, Stripper, Manually Actuated, Electrical Insulation, Round Wire, Size 10 to 30		009	00
AS5768/2–T1 thru T–13	Tool, Stripper, Manually Actuated, Small Grip, Electrical Insulation, Round Wire, Size 16 to 30		009	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
ASTM D4701 or other approved solvent	Dichloromethane (Methylene Chloride)		025	00
ASTM D740	Methyl Ethyl Ketone (MEK)		013	00
ASTM−B172	Conductor, Copper		017	00
AT−1319−11	Adapter, Fixture		013	00
AT−1319−14	Adapter, Fixture		013	00
AT−1319−17	Adapter, Fixture		013	00
AT−1319−18	Adapter, Fixture		013	00
AT−1319−19	Adapter, Fixture		013	00
AT508K	Pliers, Padded Conduit		010	00
B632 (7510−01−167−2606)	Tape, Identification		008	00
BMXC−Plus	Brady Marker SC Plus Printer		008	00
Brady PMW−PK−8	Tape wire markers		014	01
BT–BS–609 or BT–BS–610	Wrench, Strap		010	00
BT−S−389	Adapter Tool		024	00
CCC−C−46, Class 4	Cleaning Cloth		025	00
			026	00
CHR, M−60	Tape, Cellophane		010	00
Copper Alloy 110	Sheet, Cooper Alloy 110, Soft Annealed, .020 in. Thick (Nominal)		016	00
CRN−T	Sleeving, Heat Shrink		011	00
			014	00
CTA−0006	Sleeve, Filling		013	00
			015	00
			020	00
CTA−0042	Sleeve, Filling		013	00
			015	00
			020	00
CV−5000	Tool, Thermogun Heating		012	00
			012	02
CV−5300	Heat Gun, Mini Hot Air		012	00
			012	02
CV−5302	Tool, Mini−Gun Hot Air		012	00
			012	02
CV−5700	Heat Gun, Air		011	01
			014	00
D−150−02	Coaxial Cable Splice Kit		014	00
D−150−12	Coaxial Cable Splice Kit		014	00
D−150−15	Coaxial Cable Splice Kit		014	00
D−150−16	Coaxial Cable Splice Kit		014	00
D−150−28	Coaxial Cable Splice Kit		014	00
D−150−29	Coaxial Cable Splice Kit		014	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
D−436−0184	Sealing End Cap		007	00
D−436−0185	Sealing End Cap		007	00
D−436−0186	Sealing End Cap		007	00
D−602−104	Contact		020	00
D−602−105	Contact		020	00
D−602−106	Contact		020	00
D−602−107	Contact		020	00
D−602−16	Contact		013	00
			020	00
D−602−17	Contact		013	00
			020	00
D−602−44	Contact		013	00
			020	00
D−602−45	Contact		013	00
			020	00
D−602−46	Contact		013	00
			020	00
D−602−47	Contact		013	00
			020	00
D−602−54	Contact		013	00
			020	00
D−602−55	Contact		013	00
			020	00
D−602−56	Contact		013	00
			020	00
D−602−57	Contact		013	00
			020	00
D−602−72	Contact		013	00
			020	00
D−602−73	Contact		013	00
			020	00
D−602−94	Contact		020	00
D−602−95	Contact		020	00
DBS−1100	Tool, Banding		001	00
			011	02
DBS−1102−32	Wrench, Adjustment		011	02
DBS−CG2	Fixture, Calibration, Inspection		011	02
DBS−CG2	Bolt		011	02
DBS−RO3	Rollover Tool		011	02
FLUKE 77	Digital Multimeter (DMM)		014	02
G125	Inspection Gage		013	00
G682	Inspection Gage		013	00
G683	Inspection Gage		013	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
G684	Inspection Gage		013	00
G726	Inspection Gage		013	00
G744	Inspection Gage		013	00
G745	Inspection Gage		013	00
G746	Inspection Gage		013	00
G747	Inspection Gage		013	00
G801	Inspection Gage		013	00
G854	Inspection Gage		013	00
G854	Inspection Gage		013	00
GE21E1	Loop, Strap Fastener		010	00
GE21E1	Loop, Strap Fastener		010	00
GGG−W−3408	Wire Twister Plier with Side Cutter		018	00
H−B−643	Brush, Acid Swabbing		026	00
H−B−681	Brush		026	00
HD51	Crimp Tool Frame, Large Gage Wire		013	00
			014	00
HD51−105−1	Die (Crimping)		013	00
HD51−106−1	Die (Crimping)		013	00
HD51−107−1	Die (Crimping)		013	00
HD51−113−1	Die (Crimping)		013	00
HD51−128	Die Set		013	00
HD51−129	Die Set		013	00
HD51−130−1	Die (Crimping)		013	00
			014	00
HD51−131−2	Die (Crimping)		013	00
			014	00
HD51−132−2	Die (Crimping)		013	00
			014	00
HD51−133−2	Die (Crimping)		013	00
HD51−134−2	Die (Crimping)		013	00
HD51−154	Die Set		013	00
HH80C	Crimp Tool Frame		013	00
HT3326−5FR−50 (8030−01−575−5396)	Self Leveling Green Flame Retardant		025	00
H−T−560	Toothbrush		026	00
HT−71002	Heat Gun, Hot Air		011	00
			024	00
			012	01
HT−900B	Heat Gun, Hot Air (Pneumatic)		007	00
			011	00
			012	00
			012	01

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
			012	02
			013	00
			014	00
			015	00
			020	00
			023	00
			024	00
			025	00
HT–920B	Heat Gun, Hot Air (Pneumatic)		011	00
			012	00
			012	01
			012	02
			013	00
			014	00
			015	00
			020	00
			023	00
			024	00
HT–TMS–WM9	Marker, Harness I.D.		008	00
IR–1044	Two–Station Solder Tacts Heater		015	00
IR–1079	Heating Tool, Infrared		015	00
IR–1759	Heating Tool, Infrared		012	01
IR–500	Heating Tool, Infrared		012	00
			012	02
			015	00
IR–550	Heating Tool, Infrared		011	01
			012	00
			012	02
			015	00
J–STD–004, J–STD–005 and J–STD–006	Flux, Liquid		016	00
J–STD–004, J–STD–005, AND J–STD–006	Solder, Soft		016	00
LS2000	Brady Label Marker		008	00
M22520/10–01	Crimping Tool		007	00
			013	00
M22520/10–05	Die Set		013	00
M22520/10–06	Die Set		013	00
M22520/1–01	Crimp Tool Frame		013	00
			027	00
M22520/10–100	Die, Crimp Tool		007	00
			013	00
M22520/10–101	Die, Crimp Tool		007	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
			013	00
M22520/10–103	Die Set		013	00
M22520/10–104	Die Set		013	00
M22520/1–12	Turret, Positioner Crimping		013	00
M22520/1–13	Turret, Positioner Crimping		013	00
M22520/1–14	Turret, Positioner Crimping		013	00
M22520/1–15	Positioner		013	00
M22520/19–01	Crimp Tool Frame		013	00
M22520/19–02	Positioner		013	00
M22520/19–04	Positioner		013	00
M22520/20–01	Crimp Tool Frame		013	00
M22520/20–02	Positioner		013	00
M22520/20–03	Positioner		013	00
M22520/2–01	Crimp Tool Frame		013	00
M22520/21–01	Crimp Tool Frame		013	00
M22520/21–02	Positioner		013	00
M22520/21–04	Positioner		013	00
M22520/2–24	Turret, Positioner Crimping		013	00
M22520/2–28	Turret, Positioner Crimping		013	00
M22520/2–29	Turret, Positioner Crimping		013	00
M22520/2–30	Turret, Positioner Crimping		013	00
M22520/23–01	Pneumatic Crimper		013	00
M22520/23–02	Die (Crimping)		013	00
M22520/23–03	Die (Crimping)		013	00
M22520/23–04	Die (Crimping)		013	00
M22520/23–05	Die (Crimping)		013	00
M22520/23–06	Die (Crimping)		013	00
M22520/23–07	Die (Crimping)		013	00
M22520/23–09	Locator (Crimping)		013	00
M22520/23–10	Locator (Crimping)		013	00
M22520/23–11	Locator (Crimping)		013	00
M22520/23–12	Locator (Crimping)		013	00
M22520/23–13	Locator (Crimping)		013	00
M22520/23–14	Locator (Crimping)		013	00
M22520/23–15	Locator (Crimping)		013	00
M22520/23–16	Locator (Crimping)		013	00
M22520/2–33	Turret, Positioner Crimping		013	00
M22520/24	Crimp Tool		017	00
M22520/28–01	Pneumatic Crimper		013	00
M22520/28–02	Air Supply Hose		013	00
M22520/29–01	Pneumatic Crimper		013	00
M22520/30–01	Bench Mount		013	00
M22520/30–02	Foot Valve		013	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
M22520/3−10	Inspection Gage		007	00
			011	00
			013	00
M22520/3−12	Inspection Gage		013	00
M22520/3−13	Inspection Gage		013	00
M22520/3−14	Inspection Gage		013	00
M22520/36−01	Crimp Tool Frame		013	00
M22520/36−02	Positioner		013	00
M22520/36−03	Positioner		013	00
M22520/36−04	Locator (Crimping)		013	00
M22520/36−05	Locator (Crimping)		013	00
M22520/36−15	Locator (Crimping)		013	00
M22520/36−16	Positioner		013	00
M22520/36−17	Positioner		013	00
M22520/36−18	Locator		013	00
M22520/37−01	Crimping Tool		011	00
			013	00
			014	00
M22520/38−01	Crimp Tool		013	00
M22520/3−9	Inspection Gage		007	00
			011	00
			013	00
M22520/39−01	Inspection Gage		011	00
			013	00
			014	00
M22520/5	Crimp Tool		013	00
			014	01
			017	00
M22520/5−01	Crimp Tool		007	00
			011	00
			013	00
			014	00
M22520/5−03	Crimp Tool Frame		013	00
M22520/5−05	Die (Crimping)		013	00
M22520/5−07	Die (Crimping)		013	00
M22520/5−08	Die Set		013	00
M22520/5−09	Die (Crimping)		013	00
M22520/5−10	Die Set		013	00
M22520/5−100	Die Set (Die, Crimp Tool)		007	00
			011	00
			013	00
			014	00
M22520/5−102	Die Set		013	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
M22520/5–103	Die Set		013	00
M22520/5–11	Die (Crimping)		013	00
M22520/5–13	Die (Crimping)		013	00
M22520/5–19	Die (Crimping)		013	00
M22520/5–25	Die (Crimping)		013	00
M22520/5–33	Die (Crimping)		013	00
M22520/5–35	Die (Crimping)		013	00
M22520/5–41	Die (Crimping)		013	00
M22520/5–55	Die (Crimping)		013	00
M22520/5–57	Die (Crimping)		013	00
M22520/5–59	Die (Crimping)		013	00
M22520/5–61	Die (Crimping)		013	00
M22520/7–01	Crimp Tool Frame		013	00
M22759/41, /42	Wire		004	00
M22795/11–22–5	Shielding Jumper Wire		015	00
M23053/12–XX–0	Sleeving, Insulation		015	00
M39029/73–396	Contact		013	00
			015	00
M39029/73–397	Contact		013	00
			015	00
M39029/73–398	Contact		013	00
			015	00
M39029/74–399	Contact		013	00
			015	00
M39029/74–400	Contact		013	00
			015	00
M39029/74–401	Contact		013	00
			015	00
M6852–3	Splice Set, Quick Disconnect		017	00
M81714/39–01	TJS Block Removal Tool		027	00
M81714/67	Component Rack Assembly		027	00
M81714/69–02	TJS Block Removal Tool		027	00
M818121–XXX	Sleeve, Outer Insulated Shield Termination		015	00
M81824/1–1	Crimp Splice, Red		011	00
			014	00
M81824/1–2	Crimp Splice, Blue		011	00
			014	00
M81824/1–3	Crimp Splice, Yellow		011	00
			014	00
M85485/9, /10	Wire, Filterline		022	01
MCH–100–A	Heat Gun (Battery Operated)		011	00
MCH–100–A	Tool, Heating		011	01

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
			012	01
			024	00
MEGGER/Mark 3	Insulation Tester (Megger)		014	02
MFE–100	Shears, Full Bypass		010	00
MG–2	Reflector		011	01
			012	00
			012	02
MIL–I–224444c, Part No: RL6000SA	Tape Electrical Insulation, Self–Adhering		024	00
MIL–A–46146	Sealing Compound, Silicone (DC3140, DC3145 Dow Corning), RTV		025	00
MIL–A–9962, Type I, Grade A	Abrasive Mat		026	00
MIL–C–16173, Grade 4	Corrosion Preventive Compound (CPC)		014	00
MIL–C–39029	Pin Contact		013	00
			027	00
MIL–C–5541, Class 3	Chemical Conversion Material		019	00
MIL–C–81309, Type II and Type III	Corrosion Preventive Compound		026	00
MIL–C–81706, Class 3	Alodine		014	01
MIL–C–85043	Cloth		019	00
MIL–DTL–81706	Chemical Conversion Material		017	00
MIL–DTL–85054, Type 1A	Water–Displacing Corrosion Preventive Compound		026	00
MIL–I–16923	Casting Compound, Epoxy (Stycast 2651 B Emerson and		025	00
MIL–I–16923	Cuming)			
MIL–M–24041	Sealing Compound, Polyurethane		003	00
			014	01
			025	00
MIL–P–47215	Primer for Silicone Substrates		025	00
MIL–PRF–23377	Primer, Coating, Epoxy		017	00
MIL–PRF–23586	Sealing Compound, Silicone		025	00
MIL–PRF–29608, Type I, Class C	Cleaning Compound		025	00
			026	00
MIL–PRF–680, Type II	(Stoddard's) Solvent, Dry Cleaning		011	00
			014	00
MIL–PRF–680, Type II	(Mineral Spirits)		017	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
MIL−PRF−8516	Compound, Sealing (Polysulfide)		019	00
			025	00
MIL−PRF−8516	Sealing Compound, Polysulfide		003	00
			019	00
			025	00
MIL−S−46163 Type 2, Grade: N/ASTM D 5363−AN0321	Compound, Thread Coating		024	00
MIL−W−22759	Wire, Heavy Wall		004	00
			005	00
			009	00
			011	00
			014	00
Model 11−6147−1	Pliers, Connector		011	01
Model 2A	Knife, Thermal		011	01
MS18029	Terminal Board Cover		019	00
MS20659	Terminal Lug, Copper		013	00
			019	00
MS20659 (Series)	Terminal Lug, Crimp Copper Uninsulated		013	00
			017	00
			019	00
MS20995−AB20	Lockwire, Aluminum Alloy, Anodized, Blue, 0.020 Diameter		018	00
MS20995−AB32	Lockwire, Aluminum Alloy, Anodized, Blue, 0.032 Diameter		018	00
MS20995−CU20	Shearwire, Copper, Cadmium Plated, Yellow, 0.020 Diameter		018	00
MS20995−N20	Lockwire, Nickel−Chromium−Iron Alloy, 0.020 Diameter		018	00
MS20995−N32	Lockwire, Nickel−Chromium−Iron Alloy, 0.032 Diameter		018	00
MS20995−NC20	Lockwire, Nickel−Copper Alloy, 0.020 Diameter		018	00
MS20995−NC32	Lockwire, Nickel−Copper Alloy, 0.032 Diameter		018	00
MS21042	Locknut		017	00
MS−21042	Nut, Self locking		019	00
MS21043	Locknut		017	00
MS−21044	Nut, Self locking		019	00
MS21980−XXX	Sleeve, Outer Uninsulated Shield Termination		015	00
MS21981−XXX	Sleeve, Inner Shield Termination		015	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
MS23002	Die (Crimping)		013	00
			017	00
MS23002–01	Die Set		013	00
MS23002–02	Die Set		013	00
MS23002–03	Die Set		013	00
MS23002–04	Die Set		013	00
MS23002–1	Die Set		013	00
MS23002–2	Die Set		013	00
MS23002–3	Die Set		013	00
MS23002–4	Die Set		013	00
MS23002–6	Die Set		013	00
MS23002–8	Die Set		013	00
MS23003–01	Inspection Gage		013	00
MS23003–02	Inspection Gage		013	00
MS23003–03	Inspection Gage		013	00
MS23003–04	Inspection Gage		013	00
MS23003–1	Inspection Gage		013	00
MS23003–2	Inspection Gage		013	00
MS23003–3	Inspection Gage		013	00
MS23003–4	Inspection Gage		013	00
MS23003–6	Inspection Gage		013	00
MS23003–8	Inspection Gage		013	00
MS25036 (Series)	Terminal Lug, Crimp Copper Insulated		013	00
			017	00
			019	00
MS25274–1	Cap, End		007	00
			011	00
			014	00
MS25274–2	Cap, End		007	00
			011	00
			014	00
MS25274–3	Cap, End		007	00
			011	00
			014	00
MS25274–4	Cap, End		007	00
			011	00
			014	00
MS25435	Terminal Lug, Aluminum		013	00
			019	00
MS25440	Washer, Flat Plated		013	00
			019	00
MS25441	Crimp Tool, Hydraulic		013	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence (If applicable)	Work Package	Section
			017	00
MS25441−1	Crimp Tool (Large Wire)		013	00
MS25441−3	Hydraulic Hose		013	00
MS25441−5	Hydraulic Pedal Pump		013	00
MS25442−01A	Die Set		013	00
MS25442−02A	Die Set		013	00
MS25442−03A	Die Set		013	00
MS25442−04A	Die Set		013	00
MS25442−1A	Die Set		013	00
MS25442−2A	Die Set		013	00
MS25442−4A	Die Set		013	00
MS25442−6A	Die Set		013	00
MS25442−8A	Die Set		013	00
MS−25682	Nut		019	00
MS27212	Terminal Board		019	00
MS3373	Insulator		019	00
MS35338	Lockwasher		017	00
MS35338			019	00
MS35340	Lockwasher		017	00
MS−35388	Lockwasher		017	00
MS35489	Grommet, Donut		010	00
MS−35649	Nut, Steel		019	00
MS−35650	Nut, Steel		019	00
MS36036	Terminal Lug, Copper		013	00
MS51957	Screw		010	00
			019	00
MS90376	Shipping Cap, Plastic		010	00
MS90387	Hand Tool, Strap Installation		010	00
MS90485	Die (Crimping)		013	00
			017	00
MS90485−01	Die Set		013	00
MS90485−02	Die Set		013	00
MS90485−03	Die Set		013	00
MS90485−04	Die Set		013	00
MS90485−1	Die Set		013	00
MS90485−2	Die Set		013	00
MS90485−4	Die Set		013	00
MS90485−6	Die Set		013	00
MS90485−8	Die Set		013	00
MS90486−01	Inspection Gage		013	00
MS90486−02	Inspection Gage		013	00
MS90486−03	Inspection Gage		013	00
MS90486−04	Inspection Gage		013	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
MS90486–1	Inspection Gage		013	00
MS90486–2	Inspection Gage		013	00
MS90486–4	Inspection Gage		013	00
MS90486–6	Inspection Gage		013	00
MS90486–8	Inspection Gage		013	00
MS9068–111	O–Ring, Safety Lock Circuit Breaker		028	00
NAS1149	Washer		017	00
NAS1801	Screw		017	00
NAS1802	Screw		017	00
NASM22529/2 /3	Grommet, Caterpillar		010	00
NASM3 thru 20	Bolt		019	00
O–F–499	Flux, Brazing, Silver Alloy, Low Melting Point		014	00
			016	00
O–M–232	Methanol		017	00
			019	00
O–M–232	Alcohol, Denatured		014	00
			017	00
			019	00
OMNI SPECTRA T–200	Crimping Tool, Coaxial Connector		013	00
P5100C04 (9330–01–110–8972)	Sheet, Teflon		010	00
PR–1532	Polyurethane Coating		019	00
PS–0231–094W	Portable Printing Sleeves		008	00
PS–0231–094Y	Portable Printing Sleeves		008	00
PS–0231–1000W	Portable Printing Sleeves		008	00
PS–0231–1000Y	Portable Printing Sleeves		008	00
PS–0231–125W	Portable Printing Sleeves		008	00
PS–0231–125Y	Portable Printing Sleeves		008	00
PS–0231–187W	Portable Printing Sleeves		008	00
PS–0231–187Y	Portable Printing Sleeves		008	00
PS–0231–250W	Portable Printing Sleeves		008	00
PS–0231–250Y	Portable Printing Sleeves		008	00
PS–0231–375W	Portable Printing Sleeves		008	00
PS–0231–375Y	Portable Printing Sleeves		008	00
PS–0231–500W	Portable Printing Sleeves		008	00
PS–0231–500Y	Portable Printing Sleeves		008	00
PSBXP–111–125	Portable Printing Sleeves		008	00
PSBXP–111–187	Portable Printing Sleeves		008	00
PSBXP–114–125	Portable Printing Sleeves		008	00
PSBXP–114–187	Portable Printing Sleeves		008	00
PSBXP–211–250	Portable Printing Sleeves		008	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
PSBXP−214−250	Portable Printing Sleeves		008	00
PSBXP−311−375	Portable Printing Sleeves		008	00
PSBXP−314−375	Portable Printing Sleeves		008	00
PSBXP−411−500	Portable Printing Sleeves		008	00
PSBXP−414−500	Portable Printing Sleeves		008	00
QQ−B−654, 46S657	Solder, Hard		016	00
R1L−E/R1L−E−1, 247000, T477W	Milli−Ohmmeter		017	00
RNF−100	Protective Sleeve		015	00
RNF−100	Sleeve, Protective		015	00
RP−4800	Tubing		011	01
RTV 735	Sealing Compound, Silicone, Oil Resistant (Dow Corning)		025	00
RTV−108	Adhesive (Mil−A−46146)		011	01
S−1009	Adhesive		011	01
S−1030	Adhesive		011	01
S−1125	Adhesive		011	01
S4933959−531	Safety Lockout Ring, Circuit Breaker (Red)		028	00
SAE AMS–DTL–23053	Sleeving, Heat Shrink (Heat Shrinkable Tubing)		007	00
			011	00
			013	00
			017	00
SAE AMS–DTL–23053	Tubing, Heat Shrink		007	00
			011	00
			013	00
SAE AMS–DTL–23053/5, Class I	Sleeving, Insulation, Heat Shrinkable		017	00
SAE AMS–M–3171 TYPE VI	Magnesium Alloy, Pretreatment		017	00
SAE AS70991	Terminal Lug, Aluminum		004	00
			013	00
			019	00
SAE AS7928	Terminal Lug, Copper		004	00
			013	00
			019	00
SAE AS81765/1	End caps, Heat shrinkable (also known as SSC end caps)		010	00
SAE AS83519	Solder Sleeve Shield Termination		011	00
			015	00
SAE AS83519 Series	Shield Terminations		015	00
SAE−AMS−T−22085, Type II	Tape, Pressure Sensitive		007	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
SAE−AS7351	Clamp, Bonding		017	00
SAE−AS−81824/1	Splice, Center Conductor		022	01
SAE−AS−81824/4	Splice, Shield		022	01
SAE−AS−81824/5	Splice, Kit		022	01
SBS−111−322	Sleeve, Marking		008	00
SBS−117−322	Sleeve, Marking		008	00
Sn60WRMAP3	Solder		016	00
T12T (9330−01−201−0658)	Tubing, Plastic Spiral Wrap		010	00
T25T (9330−01−169−5995)	Tubing, Plastic Spiral Wrap		010	00
T50T (9330−01−179−0242)	Tubing, Plastic Spiral Wrap		010	00
Tetra Etch	Fluorocarbon Etchant (WL Gore, etc.) (or Equivalent Such as Bondaid or S16943)		025	00
TG−12	Reflector, Heatgun		011	01
			012	00
			012	02
TG−13	Reflector, Heatgun		011	01
			012	00
			012	02
TG−13A	Reflector, Heatgun		011	01
			012	00
			012	02
TG2010FR−50 (8030−01−577−8134)	Thixoflex FR		025	00
TG−21	Reflector, Heatgun		011	01
TG−22	Reflector, Heatgun		011	01
TG−23	Reflector, Heatgun		011	01
			012	00
			012	02
TG−24	Reflector, Heatgun		011	01
			012	00
			012	02
TS 352B/U	Multi meter (analog)		014	03
TT−P−1787	Primer, Coating, Alkyd Base, One Component		016	00
TT−I−735	Alcohol, Isopropyl (Isopropanol)		011	00
			011	01
			012	00
			012	01

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
			012	02
			014	00
			014	01
			016	00
			020	00
			025	00
TT–I–735 Grade A	Alcohol, Isopropyl, Grade A, Technical		HMWS	02
TT–R–2918	Remover, Paint, Epoxy		017	00
TT–R–2918	Thinner, Dope and Lacquer		017	00
UG981108–01 (5120–01–494–7678)	Sealant Dispenser		025	00
VPB–RT	Tubing		011	01
WA22	Pneumatic Crimper		013	00
WA27F	Pneumatic Crimper		013	00
WML–0607–292–1	Label, Wire Marking		008	00
WML–0607–292–75	Label, Wire Marking		008	00
WML–0615–292–1	Label, Wire Marking		008	00
WML–0807–292	Label, Wire Marking		008	00
WML–0807–502	Label, Wire Marking		008	00
WML–0811–292	Label, Wire Marking		008	00
WML–0815–292	Label, Wire Marking		008	00
WML–0823–292	Label, Wire Marking		008	00
WML–1207–502	Label, Wire Marking		008	00
WML–1215–292	Label, Wire Marking		008	00
WML–1215–292–25	Label, Wire Marking		008	00
WML–1215–502	Label, Wire Marking		008	00
WML–1223–292	Label, Wire Marking		008	00
WML–1231–292–22	Label, Wire Marking		008	00
WML–1231–292–30	Label, Wire Marking		008	00
WML–1607–502	Label, Wire Marking		008	00
WML–1615–502	Label, Wire Marking		008	00
WML–2007–502	Label, Wire Marking		008	00
WML–2015–502	Label, Wire Marking		008	00
WML–205–292–1	Label, Wire Marking		008	00
WML–205–292–75	Label, Wire Marking		008	00
WML–211–292–1	Label, Wire Marking		008	00
WML–211–292–75	Label, Wire Marking		008	00
WML–2411–502	Label, Wire Marking		008	00
WML–2431–292–60	Label, Wire Marking		008	00
WML–2431–292–75	Label, Wire Marking		008	00
WML–305–502	Label, Wire Marking		008	00
WML–305–502	Label, Wire Marking		008	00

COMPONENT PART NUMBER INDEX (Continued)

Part Number	Nomenclature	Obsolescence *(If applicable)*	Work Package	Section
WML−305−632	Label, Wire Marking		008	00
WML−311−292	Label, Wire Marking		008	00
WML−317−292	Label, Wire Marking		008	00
WML−350−292	Label, Wire Marking		008	00
WML−505−632	Label, Wire Marking		008	00
WML−511−292	Label, Wire Marking		008	00
WML−511−502	Label, Wire Marking		008	00
WML−511−632	Label, Wire Marking		008	00
WML−517−502	Label, Wire Marking		008	00
WML−705−502	Label, Wire Marking		008	00
WML−705−632	Label, Wire Marking		008	00
WML−711−292	Label, Wire Marking		008	00
WML−711−502	Label, Wire Marking		008	00
WML−711−632	Label, Wire Marking		008	00
WML−717−292	Label, Wire Marking		008	00
WML−905−502	Label, Wire Marking		008	00
WML−905−632	Label, Wire Marking		008	00
WML−911−502	Label, Wire Marking		008	00
WML−911−632	Label, Wire Marking		008	00
WML−917−502	Label, Wire Marking		008	00
WMS−111−322	Sleeve, Marking		008	00
WMS−117−322	Sleeve, Marking		008	00
WMS−211−322	Sleeve, Marking		008	00
WMS−217−322	Sleeve, Marking		008	00
WMS−411−322	Sleeve, Marking		008	00
WMS−417−322	Sleeve, Marking		008	00
WMS−611−322	Sleeve, Marking		008	00
WMS−617−322	Sleeve, Marking		008	00
ZT03−04−010−01/03/05/07/09/11 and ZT03−04−010−13/15/17/19/21/23/25/27	Standard Application Wrap Around Environmentally Sealed Heat Shrink		014	00
ZT98−04−016−#1 through ZT98−04−016−#14	Standard Application Wrap Around Heat Shrink		014	00

By Order of the Secretary of the Army:

GEORGE W. CASEY, JR.
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army
1016104

Distribution:

To be distributed as Electronic Media Only

These are the instructions for sending an electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

From: “Whomever” whomever@wherever.army.mil
To: 2028@redstone.army.mil

Subject: DA Form 2028

1 ***From: Joe Smith***
2 *Unit: home*
3 ***Address: 4300 Park***
4 ***City***: Hometown
5 ***St: MO***
6 ***Zip: 77777***
7 ***Date Sent***: 19--OCT--93
8 ***Pub no***: 55--2840--229--23
9 ***Pub Title: TM***
10 ***Publication Date***: 04--JUL--85
11 *Change Number*: 7
12 *Submitter Rank*: MSG
13 ***Submitter FName***: Joe
14 *Submitter MName*: T
15 ***Submitter LName***: Smith
16 ***Submitter Phone***: 123--123--1234
17 ***Problem: 1***
18 *Page: 2*
19 *Paragraph: 3*
20 *Line: 4*
21 *NSN: 5*
22 *Reference: 6*
23 *Figure: 7*
24 *Table: 8*
25 *Item: 9*
26 *Total: 123*

27 ***Text***:
This is the text for the problem below line 27.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25--30; the proponent agency is ODISC4.	Use Part II (*reverse*) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE 8/30/02

TO: (*Forward to proponent of publication or form*)(*Include ZIP Code*)	FROM: (*Activity and location*)(*Include ZIP Code*)
Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM--MMA--NP Redstone Arsenal, AL 35898	MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565

PART 1 - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
TM 9-1005-433-24	16 Sep 2002	Organizational, Direct Support, And General Support Maintenance Manual for Machine Gun, .50 Caliber M3P and M3P Machine Gun Electrical Test Set Used On Avenger Air Defense Weapon System

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON
1	WP0005 PG 3		2			Test or Corrective Action column should identify a different WP number.

EXAMPLE

* *Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788-1234	

TO: (Forward direct to addressee listed in publication)
Commander, U.S. Army Aviation and Missile Command
ATTN: AMSAM-MMA-NP
Redstone Arsenal, AL 35898

FROM: (Activity and location) (Include ZIP Code)
MSG, Jane Q. Doe
1234 Any Street
Nowhere Town, AL 34565

DATE
8/30/02

PART II - REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER

DATE

TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III - REMARKS (*Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.*)

EXAMPLE

TYPED NAME, GRADE OR TITLE
MSG, Jane Q. Doe, SFC

TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION
788-1234

SIGNATURE

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25--30; the proponent agency is ODISC4.	Use PartII(*reverse*) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE
TO*: (Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMA-NP Redstone Arsenal, AL 35898	FROM*: (Activity and location)(Include ZIP Code)*	

PART 1 --ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

* *Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE

TO: *(Forward direct to addressee listed in publication)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMA-NP Redstone Arsenal, AL 35898	**FROM:** *(Activity and location) (Include ZIP Code)*	**DATE**

PART II --REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III --REMARKS *(Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. Ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. Inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. Inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

PIN: 081991-000