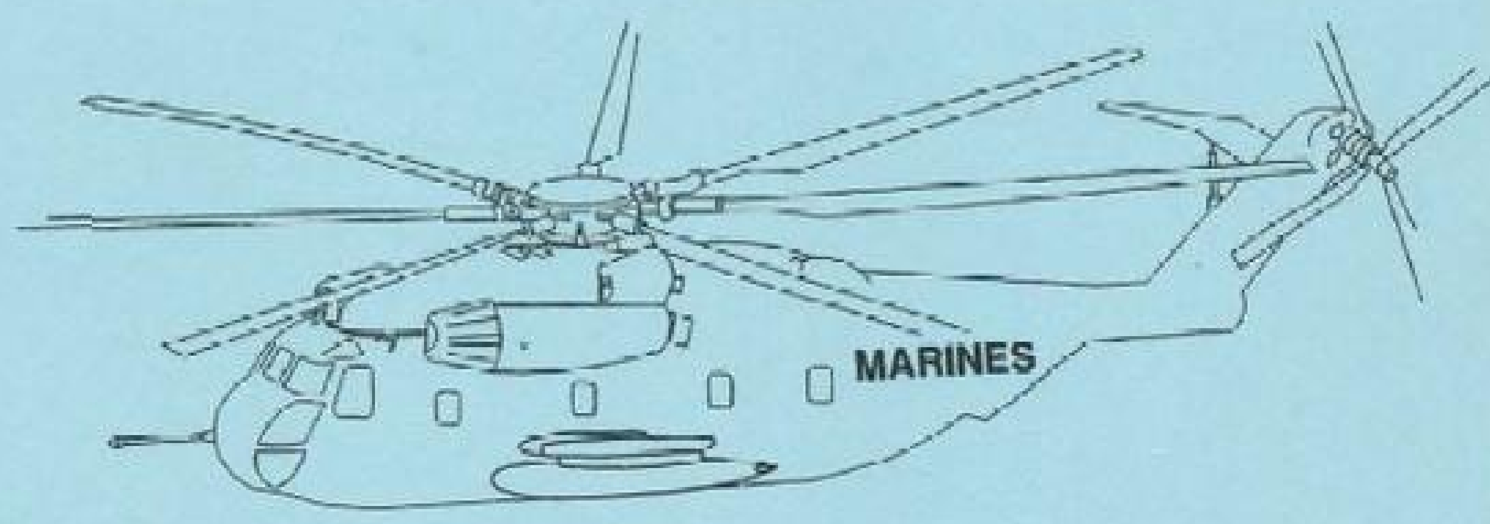
A1-H53BE-NFM-000

NATOPS FLIGHT MANUAL NAVY MODEL CH-53E HELICOPTER

THIS MANUAL SUPERSEDES A1-H53BE-NFM-000 DATED 15 OCTOBER 1994 CHANGED 31 MARCH 2000, WHICH SHOULD BE DESTROYED



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HC0743M

15 APRIL 2001

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

15 April 2001

LETTER OF PROMULGATION

1. The Naval Air Training and Operating Procedures Standardization (NATOPS) Program is a positive approach toward improving combat readiness and achieving a substantial reduction in the aircraft mishap rate. Standardization, based on professional knowledge and experience, provides the basis for development of an efficient and sound operational procedure. The standardization program is not planned to stifle individual initiative, but rather to aid the commanding officer in increasing the unit's combat potential without reducing command prestige or responsibility.

2. This manual standardizes ground and flight procedures but does not include tactical doctrine. Compliance with the stipulated manual requirements and procedures is mandatory except as authorized herein. In order to remain effective, NATOPS must be dynamic and stimulate rather than suppress individual thinking. Since aviation is a continuing, progressive profession, it is both desirable and necessary that new ideas and new techniques be expeditiously evaluated and incorporated if proven to be sound. To this end, commanding officers of aviation units are authorized to modify procedures contained herein, in accordance with the waiver provisions established by OPNAVINST 3710.7, for the purpose of assessing new ideas prior to initiating recommendations for permanent changes. This manual is prepared and kept current by the users in order to achieve maximum readiness and safety in the most efficient and economical manner. Should conflict exist between the training and operating procedures found in this manual and those found in other publications, this manual will govern.

3. Checklists and other pertinent extracts from this publication necessary to normal operations and training should be made and carried for use in naval aircraft.

M.J. McCABE
Rear Admiral, U.S. Navy
Director, Air Warfare

U.S. Navy Distribution
CH-53E NATOPS FLIGHT MANUAL

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RECORD OF CHANGES

Change No. and Date of Change	Date of Entry	Page Count Verified by (Signature)

INTERIM CHANGE SUMMARY

The following Interim Changes have been canceled or previously incorporated in this manual:

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
1 thru 25	Previously Incorporated

The following Interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
26	Parachute Operations Procedure Update (051931Z AUG99)
27	External Transport of Cargo (091735Z MAY00)
28	Bearing Monitor System Procedure Updates (151757Z FEB01)

Interim Changes Outstanding - To be maintained by the custodian of this manual:

INTERIM CHANGE NUMBER(S)	ORIGINATOR/DATE (or DATE/TIME GROUP)	PAGES AFFECTED	REMARKS/PURPOSE

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 299	Incorporation of Centerline Cargo Winch (ECP 2000R1S1)	1 Sep. 82	Winch installed at forward centerline of cargo compartment
AFC 300	Incorporation of Engine Ignition Circuit Breakers (ECP 2015R1)	1 Sep. 82	EMER START and ENG IGN circuit breakers installed in cabin
AFC 303	Incorporation of inward-pull release for cabin and overhead door windows (ECP 2027)	1 Sep. 82	Pull strap inside upper right corner of window
AFC 307	Incorporation of Overtorque Warning (ECP 2014)	15 Dec. 83	ENGINE OVERTORQUE and TAIL ROTOR HIGH STRESS caution light on caution panel
AFC 308	Incorporation of Hydraulic Heat Exchanger System Improvements (ECP 2011R1)	15 Dec. 83	UTILITY OIL HOT caution light on caution panel

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 309	Incorporation of Hydraulic Isolation Valves (ECP 2021)	15 Dec. 83	None
AFC 310	Incorporation of ALE-39 Countermeasures Dispensing Set (ECP 2006R1)	15 Dec. 83	ALE-39 control panel on cockpit console
AFC 334	Incorporation of fuzz burn-off chip detectors in tail rotor and intermediate gear boxes (ECP 2065R1)	15 Jan. 85	None
-	Incorporation of AN/ARC-174 HF RADIO (ECP 2117)	1 Aug. 87	AN/ARC-174 control panel on cockpit console
-	Incorporation of Marker Beacon (ECP 2038R1)	1 Aug. 87	Marker beacon lights on instrument panel
AFC 342	Incorporation of Strobe-Type Anticollision Lights (ECP 2116)	1 Aug. 87	Anticollision light control switches on cockpit overhead console

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 355	Incorporation of Fail Operational Flight Control Desensitizer (ECP 2078R2)	1 Aug. 87	None
AFC 358	Incorporation of Collective Flight Controls Damper (ECP 2146)	1 Aug. 87	Left electronics compartment on copilot's collective torque arm
AFC 369	Deactivation of Electrical Release Circuit from Two-Point Cargo Emergency Release T-Handle	1 Aug. 87	None
-	Incorporation of Crash-attenuating Pilot/Copilot Seats (ECP 2160)	15 Dec. 88	VLEA control dial on seat
-	Incorporation of AN/ARC-182 VHF-UHF Radio (ECP 2115)	1 Aug. 89	AN/ARC-182 control panel on cockpit console
AFC 327	Incorporation of LTN-211 Omega Navigation (ECP 2140 R1)	1 Aug. 89	LTN-211 control panel on cockpit console

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 379	Incorporation of Capacitive Discharge (Fuzz Burn-off) Chip Detectors in MGB, AGB, and NGB (ECP 2128 R1-2)	1 Aug 1989	None
AFC 382	Incorporation of Cabin Emergency Lighting Modification (ECP 2128 R1-5)	1 Aug 1989	Addition of four emergency exit lights
AFC 337	Incorporation of Radar Warning System	1 Aug 1989	Radar signal indicator on instrument panel
AFC 383	Incorporation of Hydraulic Fluid Replenishment In Flight (ECP 2128 R1-6)	1 Aug 1989	Manually operated gear pumps, one gallon tank and manual selector valve on rear left-hand side of cabin (sta 442-482)
AFC 434	Incorporation of Armament Provisions Modification (ECP 2128 R1-7)	1 Aug 1989	Strengthening of aircraft frame at station 222, left-hand side only

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 397	Incorporation of Composite Tail Rotor Blades (ECP 2136R1)	1 May 1990	Composite tail rotor blades
AFC 453	Incorporation of AN/ARN-151 Global Positioning System (ECP 0232 PN -51)	22 Dec 1995	Control Display Navigation on Cockpit Console
AFC 472	Relocation of the AN/ARC-94 HF Radio	22 Dec 1995	Cockpit Console
AFC 471	Incorporation of Helicopter Night Vision System (HNVS)	22 Dec 1995	Cockpit Console
AFC 342 Revision A	Modification of Anticollision Light	22 Dec 1995	Anticollision Light
AFC 490	Electrical Systems, Alternate Voltage Source for Flight-Critical Avionics; Incorporation of (ECP SA-CH-53E-2166R1)	15 Jul 1996	No. 3 primary ac bus circuit breakers on cockpit overhead circuit breaker panel.
AFC 455	Avionics, Installation of AN/ARC-210(V) Radio Set (ECP H53-PN47)	31 Jul 1996	AN/ARC-210(V) Control Panel on Cockpit Console
AFC 479	Electrical, Night Vision Compatible Exterior Lighting, Incorporation of (ECP H53-PN53)	31 May 1997	IR beacon

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 481	Installation of Infrared Position Lights (RAMEC L-25-91)	31 May 1997	Panel-mounted six-position rotary switch on left side of overhead center console
AFC 485	Range Extension and Left-Hand Utility Receptacles Wiring, Modification of (RAMEC PNCLA-43-90)	31 May 1997	DC receptacle by left cabin circuit breaker panel
AFC 486	Provisions for Installation of HELOSAT Antenna (RAMEC L-04-93)	31 May 1997	HELOSAT Antenna and PSC-3 Mission Kit
AFC 483	Incorporation of No. 2 Engine Dual Thermal Detection System (ECP PNCLA PN-56)	31 Jan 1998	Caution/advisory Panel
AFC 497	Installation of the Improved Troop Seats for the CH/MH-53E Helicopters (ECP H-53-002)	31 Dec 1998	Telescopic legs
AFC 491	Transmission systems, Tail Rotor Drive Shaft Bearings, Duplex Bearing and Swashplate Sensors and Monitor, Incorporation of (ECP SA-CH-53E-2175R4)	15 Jan 1999	Caution/advisory Panel and Bearing Monitor Panel in cabin

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 482	Incorporation of AN/AVS-7 Heads-Up Display (ECP H53-PN55)	31 Jan 2000	Installation of Signal Data Convertor at FS 162
AVC 4831	Incorporates changes to Collective Stick Assembly (ECP TBD)	31 Jan 2000	Installation of HUD (AN/AVS-7) Control Switch
AFC 501 Part 2	Installation of AN/AYQ-23(V) Ground Proximity Warning System (GPWS) (ECP H53-003)	31 Mar 2000	GPWS annunciator lights on advisory panel

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

GLOSSARY

A	APPROACH.
AC	ALTERNATING CURRENT.
ACCEL	ACCELERATION.
ADC	AIR DATA COMPUTER.
AFCS	AUTOMATIC FLIGHT CONTROL SYSTEM.
AHD	LOOK AHEAD (HNVS).
AHRS	ATTITUDE HEADING REFERENCE SYSTEM.
AJ	ANTI JAMMING.
AJ/M	ANTI JAMMING/MASTER.
ALM	ALMANAC.
AMBIENT TEMPERATURE	TEMPERATURE OF THE UNDISTURBED AIR MASS SURROUNDING AN AIRCRAFT.
APP	AUXILIARY POWERPLANT.
APPR	APPROACH.
APPROXIMATE	ENGINEERING TERM FOR A TOLERANCE OF APPROXIMATELY 10 PERCENT.
AT	AUTO TRACK (HNVS).
ATE	AUTO TRACK ENABLE (HNVS).
AUTO	AUTOMATIC.
BAR ALT	BAROMETRIC ALTITUDE.
BASELINE	REFERENCE LINE.
BBC	BACKUP BUS CONTROLLER.
BC	BUS CONTROLLER.
BDHI	BEARING-DISTANCE-HEADING-INDICATOR.
BIT	BUILT IN TEST.
BLIND SPEED (EFFECT)	A PHENOMENON CAUSED WHEN DOPPLER FREQUENCIES OF A RADAR TARGET ARE MULTIPLES OF GCA RADAR'S PULSE-REPETITION FREQUENCIES (PRF), CAUSING THE AIRCRAFT TO NO LONGER INDICATE ON THE RADAR SCREEN.
BRT	BRIGHT.
BTU	BRITISH THERMAL UNIT.
°C	DEGREE CENTIGRADE.
C/A	COURSE ACQUISITION.
CAL	CONFINED AREA LANDING.
CAL	CALIBRATION (HNVS).
CAS	CALIBRATED AIRSPEED (INDICATED AIRSPEED CORRECTED FOR INSTRUMENT ERROR).
CC	CREWCHIEF.
CCA	CARRIER-CONTROLLED APPROACH.
CCR	CLOSED CIRCUIT REFUELING.
CD-17	ARC FREQUENCY COUNTERMEASURES CONTROLLER OR A8 APPLIQUE.
CDI	COURSE DIRECTION INDICATOR.
CDNU	CONTROL DISPLAY NAVIGATION UNIT.
CENTIGRADE	A SCALE OF TEMPERATURE MEASUREMENT WHEREIN THE FREEZING POINT OF WATER IS 0° AND THE BOILING POINT OF WATER IS 100°.
CFIT	CONTROLLED FLIGHT INTO TERRAIN.
CG	CENTER OF GRAVITY.
CHAN	CHANNEL.
CI	COURSE INDICATOR.
CLR	CLEAR.

CO_2 CARBON DIOXIDE.

CP COPILOT.

CPS CYCLES PER SECOND.

CRS COURSE.

CRS COMPUTED MAGNETIC COURSE.

CS COLD START.

CSEP CONSOLIDATED SINGLE CHANNEL RADIO ECCM PACKAGE.

CU CV-4092/A.

CUE ANTI-JAMMING CHANNEL.

DAC DIGITAL ANALOG CONVERTER

DAMA DEMAND ASSIGNED MULTIPLE ACCESS

DC DIRECT CURRENT.

DECAY LOSS OF N_R BEYOND DROOP, RESULTING FROM A POWER REQUIREMENT IN EXCESS OF POWER AVAILABLE.

DENSITY ALTITUDE (DA) THE ALTITUDE IN A STANDARD ATMOSPHERE CORRESPONDING TO A GIVEN DENSITY ACTUALLY ENCOUNTERED. (CALIBRATED PRESSURE ALTITUDE IS PRESSURE ALTITUDE CORRECTED FOR FREE AIR TEMPERATURE.)

DEU DISPLAY ELECTRONICS UNIT.

DFT DRIFT ANGLE.

DIR DIRECTION.

DMA DEFENSE MAPPING AGENCY.

DIST DISTANCE.

DN DOWN.

DOWNING DISCREPANCY A DISCREPANCY THAT LEAVES THE HELICOPTER UNSAFE TO PERFORM ITS DESIGNATED MISSION.

DOM DAY OF MONTH.

DROOP DECREASE IN N_F AND N_R WHICH RESULTS FROM AN INCREASED POWER DEMAND WHEN THE ENGINE IS ALREADY OPERATING AT MAXIMUM N_G SPEED.

DTD DATE TRANSFER DEVICE.

DTK DESIRED COURSE.

DTK DESIRED MAGNETIC COURSE.

DTM DATA TRANSFER MODULE.

EAPS ENGINE AIR PARTICLE SEPARATOR.

ECCM ELECTRONIC COUNTER COUNTERMEASURE.

EHE ESTIMATED HORIZONTAL ERROR.

EMER EMERGENCY

ENDURANCE THE LENGTH OF TIME THAT AN AIRCRAFT CAN FLY UNDER SPECIFIED CONDITIONS WITHOUT REFUELING.

ENG ENGINE.

ENR ENROUTE.

EP ELECTRONIC PROTECTION.

ERF ECCM REMOTE FILL.

°F DEGREE FAHRENHEIT.

FAA FEDERAL AVIATION ADMINISTRATION.

FAHRENHEIT A SCALE OF TEMPERATURE MEASUREMENT WHEREIN THE FREEZING POINT OF WATER IS 32° AND THE BOILING POINT OF WATER IS 212°.

FBC FLIGHT BITE CODE.

FCLP FIELD CARRIER LANDING PRACTICE.

FH FREQUENCY HOPPING.

FIT FAULT ISOLATION TEST.

FLIR FORWARD LOOKING INFRARED.

FLPN FLIGHT PLAN.

FPM FEET PER MINUTE.

FREQ FREQUENCY.

FS FUSELAGE STATION.

FT FEET.

FUEL DENSITY	THE SPECIFIC WEIGHT OF FUEL AT TEMPERATURE VARIATIONS.
FUEL FLOW (W_F)	THE RATE THAT FUEL FLOWS TO THE ENGINE.
FUEL GRADE	FACTOR ASSIGNED TO IDENTIFY FUELS.
FWD	FORWARD.
GCA	GROUND-CONTROLLED APPROACH.
GPS	GLOBAL POSITIONING SYSTEM.
GPWS	GROUND PROXIMITY WARNING SYSTEM.
GRD IDLE	GROUND IDLE.
GROSS WEIGHT	THE ACTUAL WEIGHT OF THE HELICOPTER, WHETHER LOADED OR NOT, CONSISTING OF ITS OWN WEIGHT PLUS THAT OF THE CREW, FUEL, CARGO, PASSENGER, ETC.
GROUND EFFECT	WHEN OPERATING CLOSE TO THE SURFACE OF THE EARTH OR A LARGE FLAT AREA, THE SURFACE RESTRAINT ON THE DOWNWASH FROM THE ROTOR CREATES A REDUCTION IN INDUCED VELOCITY AND THEREFORE A REDUCTION IN POWER REQUIRED TO MAINTAIN FLIGHT.
GROUND IDLE	LOWEST POINT AT WHICH THE ENGINE IS CAPABLE OF SELF-SUSTAINING OPERATION.
GROUND ROLL	THE LANDING OR TAKEOFF RUN OF AN AIRCRAFT ON THE GROUND.
GUIDELINE	A REFERENCE LINE USED AS A GUIDE FOR RELATED TRACTINGS.
GUK	GROUP UNIQUE KEY.
GW	GROSS WEIGHT.
H	HOP SETS.
HAC	HELICOPTER AIRCRAFT COMMANDER.
HEADWIND	A WIND BLOWING FROM SUCH A DIRECTION THAT IT RETARDS THE GROUND SPEED OF AN AIRCRAFT.
HEEDS	HELICOPTER EMERGENCY ESCAPE DEVICE SYSTEM.
HELOSAT ANTENNA	HELICOPTER SATELLITE ANTENNA.
HG	MERCURY.
HIFR	HELICOPTER IN FLIGHT REFUELING.
HIGE	HOVERING IN-GROUND EFFECT.
HNVS	HELICOPTER NIGHT VISION SYSTEM.
HOGE	HOVERING OUT-OF-GROUND EFFECT.
HOVER	TO REMAIN IN A STATIONARY POSITION AT A GIVEN ALTITUDE.
HP	HORSEPOWER.
HQ	HAVE QUICK.
HR(S)	HOUR(S).
HYSTERESIS	A CONDITION EXHIBITED BY SYSTEMS WHOSE STATE RESULTS FROM PREVIOUS HISTORY, SPECIFICALLY ONE WHOSE INSTANTANEOUS VALUES LAG BEHIND PREDICTION. THESE EFFECTS CAN BE CAUSED BY INTERNAL FRICTION IN ELASTIC MATERIAL UNDERGOING CHANGING STRESS (E.G., HEAT).
HZ	HERTZ (CYCLES PER SECOND).
H2P	HELICOPTER SECOND PILOT.
IAF	INITIAL APPROACH FIX.
IAS	INDICATED AIRSPEED.
IBD	IDENTIFIER/BEARING/DISTANCE WAYPOINT.
I-BIT	INITIALIZATION BIT .
ICS	INTERPHONE COMMUNICATION SYSTEM.
IDX	INDEX.
IFR	INSTRUMENT FLIGHT RULES.

IGV INLET GUIDE VANE.

ILS INSTRUMENT LANDING SYSTEM.

IN INCH(ES).

INAV INTEGRATED NAVIGATION.

INBNDCRS INBOUND COURSE.

IND INDICATE.

IN-GROUND EFFECT HOVERING OR FLYING THE ZONE WHERE GROUND EFFECT REDUCES POWER REQUIRED.

INNER LOOP AFCS TERM DENOTING DYNAMIC STABILITY OR RATE DAMPING. THE AFCS CORRECTS WITHOUT FLIGHT CONTROL MOVEMENT.

IRU INTERFACE RECEIVER UNIT.

K METRIC.

KCAS KNOTS CALIBRATED AIRSPEED.

KHZ KILOHERTZ.

KIAS KNOTS INDICATED AIRSPEED.

KT KNOT(S).

KTAS KNOTS TRUE AIRSPEED.

KVA KILOVOLT-AMPERE.

L/S LINE SELECT.

L LINE.

L LOCKOUT SETS.

LAT/LONG LATITUDE/LONGITUDE.

LB POUND(S).

LB/HR POUNDS PER HOUR.

LE LATE ENTRY.

M MAGNETIC.

MAGVAR MAGNETIC VARIATION.

MAN MANUAL.

MAP MISSED APPROACH POINT.

MAP MISSED APPROACH PROCEDURES.

MAX GOV MAXIMUM GOVERNING.

MAXIMUM POWER THE MAXIMUM POWER THE ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR A PERIOD OF 10 MINUTES WITHOUT DAMAGE TO THE ENGINE.

MCS MASTER CONTROL STATION.

MDL MISSION DATA LOADER.

MFCU MULTIFUNCTION CONTROL UNIT.

MGRS MILITARY GRID REFERENCE SYSTEM.

MHZ MEGAHERTZ.

MID MIDDLE.

MILITARY-RATED POWER THE POWER THAT AN ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR A PERIOD OF 30 MINUTES WITHOUT DAMAGE TO THE ENGINE.

MIN MINUTE.

MIN GOV LOWEST POINT AT WHICH THE ENGINE IS CAPABLE OF DEVELOPING FULL SHAFT HORSEPOWER. ALSO, THE LOWEST POINT THAT N_F CAN BE GOVERNED.

MSL MEAN SEA LEVEL.

MWOD MULTIPLE WORD OF DAY.

N ENGLISH..

NATOPS NAVAL AIR TRAINING AND OPERATING PROCEDURES STANDARDIZATION PROGRAM.

NAUTICAL MILE A MEASURE OF DISTANCE EQUAL TO 6,076 FEET (1.15 STATUTE MILE).

NI NORTH ISLAND.

N_F POWER TURBINE SPEED.

N_G GAS GENERATOR SPEED.

NHC NATO (COMPATIBLE) HIGH CAPACITY.

NM NAUTICAL MILE.

NORM NORMAL.

NORMAL-RATED POWER	THE POWER THAT AN ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR CONTINUOUS OPERATION.
N_R	ROTARY WING SPEED.
OAT	OUTSIDE AIR TEMPERATURE.
OFST	OFFSET.
OFT	OPERATIONAL FLIGHT TRAINER.
OFP	OPERATIONAL FLIGHT PROGRAM.
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION.
OUT-OF-GROUND EFFECT	HOVERING OR FLYING AT A HEIGHT FROM A FLAT SURFACE WHEREIN GROUND EFFECT CREATES NO REDUCTION IN POWER REQUIRED.
OUTER LOOP	AFCS TERM DENOTING STATIC STABILITY OR THE ABILITY TO RETURN TO A SELECTED ATTITUDE. WORKS THROUGH THE TRIM SYSTEM; USES FLIGHT CONTROL MOVEMENT TO CORRECT.
P	PILOT.
P	PRECISION.
P	PROGRESS.
PAC	PILOT AT CONTROLS.
P-BIT	PERIODIC BIT.
PCA	POINT OF CLOSEST APPROACH.
PDU	PANEL DISPLAY UNIT.
PMG	PERMANENT MAGNETIC GENERATOR.
PNAC	PILOT NOT AT CONTROLS.
POSITION ERROR	AN ERROR IN THE READING OF AN AIRCRAFT INDICATOR BECAUSE OF A DIFFERENCE IN ACTUAL VALUES AND THE VALUES READ AT THE POSITION OF THE MEASURING DEVICE.
POWER SETTING	THE DESIRED POWER OBTAINED BY POSITION OF ENGINE CONTROLS.
PRESS ALT	PRESSURE ALTITUDE.
PRESSURE ALTITUDE	THE ALTITUDE ABOVE THE STANDARD DATUM PLANE (I.E., ALTITUDE MEASURED FROM STANDARD SEA LEVEL WHEN THE BAROMETRIC ALTIMETER IS SET AT 29.92 INCHES HG).
PRIFLY	PRIMARY FLIGHT CONTROL.
PROG	PROGRESS.
PSI	POUNDS PER SQUARE INCH.
P^3	COMPRESSOR DISCHARGE PRESSURE.
Q	TORQUE.
QD	QUICK DISCONNECT.
RAD (RDR) ALT	RADAR ALTIMETER.
RANGE	THE MAXIMUM DISTANCE FROM THE POINT OF DEPARTURE THAT AN AIRCRAFT CAN FLY UNDER SPECIFIED CONDITIONS WITHOUT REFUELING.
RATE-OF-CLIMB	THE VERTICAL COMPONENT OF THE AIRSPEED OF AN AIRCRAFT WHEN CLIMBING.
RCV	RECEIVE.
RF	RADIO FREQUENCY.
RIGGING	COORDINATING THE CORRECT BLADE ANGLE AT THE MAIN AND TAIL ROTOR WITH CORRESPONDING STICK AND PEDAL POSITION.
ROC	RATE-OF-CLIMB.
ROD	RATE-OF-DESCENT.
RPM	REVOLUTIONS-PER-MINUTE.
RNAV	AREA NAVIGATION.
RNS	RADAR NAVIGATION SET (DOPPLER).
SAFETY-OF-FLIGHT DISCREPANCY	A DISCREPANCY THAT IF LEFT UNCORRECTED COULD RESULT IN LOSS OF LIFE AND EQUIPMENT.
SA/AS	SELECTED AVAILABILITY/ANTI-SPOOFING.

SATCOM	SATELLITE COMMUNICATION SYSTEM.
SAR	SEARCH AND RESCUE.
SDC	SIGNAL DATA CONVERTER.
SEA LEVEL	THE STANDARD DATUM PLANE FROM WHICH ALTITUDE ARE COMPUTED BY MEANS OF DIFFERENCE IN ATMOSPHERIC PRESSURES.
SFC	SPECIFIC FUEL CONSUMPTION.
SHAFT HORSEPOWER	OUTPUT POWER DELIVERED BY AN ENGINE.
SHP	SHAFT HORSEPOWER.
SINCGARS	SINGLE-CHANNEL GROUND AND AIRBORNE RADIO SYSTEM.
SND	SEND.
SPEED	RATE OF MOTION RELATIVE TO A STATED OR IMPLIED REFERENCE.
STANDARD ATMOSPHERE	A FICTITIOUS ATMOSPHERE OF ASSUMED COMPOSITION USED FOR COMPARISON OF AIRCRAFT PERFORMANCE AND CALIBRATING PRESSURE INSTRUMENTS. STANDARD ATMOSPHERE IS ASSUMED TO BE DRY, HAVE A PRESSURE OF 29.92 INCHES HG, AND A TEMPERATURE OF 15°C.
T	TERMINAL.
T	TRUE.
T/R	TRANSMIT/RECEIVE.
T/R&G	TRANSMIT/RECEIVE AND GUARD.
TAS	TRUE AIRSPEED.
TBFDS	TACTICAL BULK FUEL DELIVERY SYSTEM.
TEMPERATURE	A MEASURE OF THE AMOUNT OF HEAT PRESENT IN AN OBJECT AS MEASURED AGAINST A DEFINITE SCALE.
TERF	TERRAIN FOLLOWING.
TFU	TURRET FLIR UNIT.
TKE	TRACK ANGLE ERROR.
TOD	TIME OF DAY.
TOPPING	A PROCEDURE FOR ADJUSTING ENGINE FUEL CONTROL TO ACHIEVE ENGINE PERFORMANCE AT MAXIMUM OPERATING LIMITS.
TORQ	TORQUE.
TORQUE	THE AMOUNT OF POWER DELIVERED BY THE ENGINES TO THE GEARBOX.
TRACK	ALL BLADES ROTATING IN THE SAME HORIZONTAL PLANE, ASSUMING PERFECT BLADES.
TRANSEC/ COMSEC	TRANSMISSION SECURITY/COMMUNICATION SECURITY.
TRM	TERMINAL.
TRUE AIRSPEED	ACTUAL OR EXACT AIRSPEED. CALIBRATED AIRSPEED CORRECTED FOR TEMPERATURE, PRESSURE, AND COMPRESSIBILITY EFFECT.
TTI	TIME TO INTERCEPT.
T_2	COMPRESSOR INLET TEMPERATURE OR AMBIENT TEMPERATURE.
T_5	POWER TURBINE INLET TEMPERATURE.
UTC	UNIVERSAL COORDINATED TIME.
VFR	VISUAL FLIGHT RULES.
VGI	VERTICAL GYRO INDICATOR.
W_F.	FUEL FLOW.
WOD	WORD OF DAY.
WPTS	WAYPOINTS.
WRA	WEAPONS REPLACEABLE ASSEMBLY.
XMFR RECT	TRANSFORMER-RECTIFIER.
XTR	CROSS TRACK DEVIATION.
ZRO	ZEROIZE.
1553	MIL-STD-1553B.

PREFACE

SCOPE

The NATOPS Flight Manual is issued by the authority of the Chief of Naval Operations and under the direction of Commander, Naval Air Systems Command in conjunction with the Naval Air Training and Operating Procedures Standardization (NATOPS) Program. This manual contains information on all aircraft systems, performance data, and operating procedures required for safe and effective operations. However, it is not a substitute for sound judgement. Compound emergencies, available facilities, adverse weather or terrain, or considerations affecting the lives and property of others may require modification of the procedures contained herein. Read this manual from cover to cover. It's your responsibility to have a complete knowledge of its contents.

APPLICABLE PUBLICATIONS

The following applicable publications complement this manual:

A1-H53BE-CLG-000 Cargo Loading Manual

A1-H53BE-NFM-500 Pilot's Pocket Checklist

A1-H53BE-NFM-700 Functional Checkflight Checklist

A1-H53BE-NFM-900 Aircrew Pocket Checklist

OH 5-3A Helicopter External Cargo Loading

OPNAVINST 3710.7 NATOPS General Flight and Operating Inst.

NAEC-ENG-7576 Shipboard Aviation Facilities Resume

NAVAIR 00-80T-106 LHA/LPH/LHD NATOPS Manual

NAVAIR 00-80T-110 NATOPS Air Refueling Manual

NAVAIR 00-80T-112 NATOPS Instrument Flight Manual

NAVAIR 01-1ASH-1T Tactical Manual Pocket Guide

NAVAIR 01-230HM-75-17 Conventional Weapons Checklist CH-53 Crew Served Guns

NAVAIR 13-1-6.7 Aircrew Personal Protective Equipment

NWP 42 Shipboard Helicopter Operating Procedures

NWP 55-9-ASH Assault Support Helo Tactical Manual

FMFRP 5-31, Vol I, II, and III, Basic Operation/ Equipment and Single- /Dual-Point Hook procedures

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UPDATING THE MANUAL

To ensure that the manual contains the latest procedures and information, NATOPS review conferences are held in accordance with OPNAVINST 3710.7.

CHANGE RECOMMENDATIONS

Recommended changes to this manual or other NATOPS publications may be submitted by anyone in accordance with OPNAVINST 3710.7.

Routine change recommendations are submitted directly to the Model Manager on OPNAV Form 3710/6 (4-90) shown herein. The address of the model manager of this aircraft is:

Commanding Officer
ATTN: MODEL MANAGER
HMT-302 MCAS New River
PSC Box 21008
Jacksonville, N.C. 28545-1008

Telephone:
Commercial (910)451-6261
DSN 484-6261

Change recommendations of an URGENT nature (safety of flight, etc.) should be submitted directly to the NATOPS advisory group member in the chain of command by priority message.

YOUR RESPONSIBILITY

NATOPS flight manuals are kept current through an active manual change program. Any corrections, additions, or constructive suggestions for improvements of its content should be submitted by routine or urgent change recommendation, as appropriate, at once.

NATOPS FLIGHT MANUAL INTERIM CHANGES

Flight manual interim changes are changes or corrections to the NATOPS flight manuals promulgated by CNO or NAVAIRSYSCOM. Interim changes are issued either as printed pages or as a naval message. The interim change summary page is provided as a record of all interim changes. Upon receipt of a change or revision, the custodian of the manual should check the updated interim change summary to ascertain that all outstanding interim changes have been either incorporated or canceled; those not incorporated shall be recorded as outstanding in the section provided.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change might be material added or information restated. A change symbol in the margin by the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to "WARNINGS", "CAUTIONS", and "Notes" found throughout the manual.

WARNING

An operating procedure, practice, or condition, etc., that may result in injury or death if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition, etc., that may result in damage to equipment if not carefully observed or followed.

Note

An operating procedure, practice, or condition, etc., that is essential to emphasize.

WORDING

The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is optional.

"Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

NATOPS/TACTICAL CHANGE RECOMMENDATION
OPNAV 3710 / 6 (4-90) S / N 0107-LF-009-7900

DATE ____________

TO BE FILLED IN BY ORIGINATOR AND FORWARDED TO MODEL MANAGER

FROM (originator)	Unit
TO (Model Manager)	Unit

Complete Name of Manual / Checklist	Revision Date	Change Date	Section / Chapter	Page	Paragraph

Recommendation (be specific)

☐ CHECK IF CONTINUED ON BACK

Justification

Signature	Rank	Title

Address of Unit or Command

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TO

REFERENCE

(a) Your Change Recommendation Dated ____________

☐ Your change recommendation dated ____________ is acknowledged. It will be held for action of the review conference planned for ____________ to be held at ____________

☐ Your recommendation is reclassified URGENT and forwarded for approval to ____________ ____________ by my DTG ____________

/ S / ____________ MODEL MANAGER | ____________ AIRCRAFT

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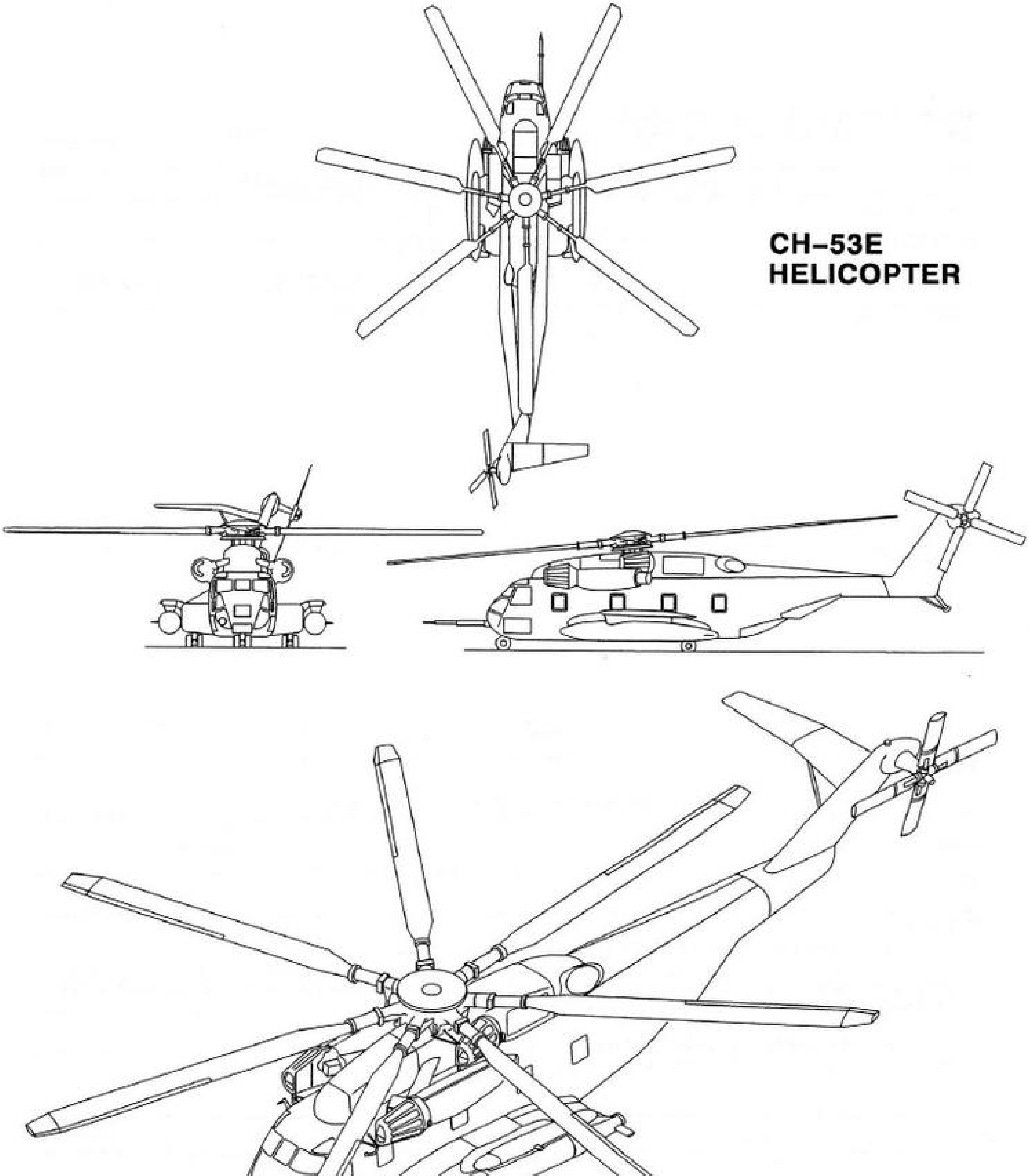


CH–53E HELICOPTER

PART I

THE AIRCRAFT

CHAPTER 1
General Description

1.1 THE HELICOPTER

The CH-53E assault transport helicopter is manufactured by Sikorsky Aircraft, 6900 Main St., P. O. Box 9729, Stratford, CT 06615-9129. The helicopter is a Class 2 aircraft equipped with a seven-blade main rotor and a four-blade canted tail rotor, designed for land- and ship-based operation, and with an emergency water operating capability. The tail rotor is canted 20° to the left. This provides 2% additional lift, improves hover capability, and permits the CG to be moved further aft. The main gear box is tilted 5° forward, which provides a level fuselage at cruising speeds. Power is furnished by three T64-GE-416 or T64-GE-416A engines, manufactured by General Electric Company, Aircraft Group, Lynn, Massachusetts. The engine is capable of producing 4380 shp at a power turbine output speed of 14,280 rpm. Automatic flight control and engine anti-icing systems give the helicopter an all-weather flight capability. An auxiliary powerplant (APP) gives the helicopter a self-starting capability. The helicopter is equipped with a fuel jettisoning system and utility hoist. It normally seats 37 passengers and, with centerline seats installed, 55 passengers. In addition, the helicopter is equipped with a rear ramp loading system, cargo winch, roller conveyors, and cargo tiedown facilities. Provisions are made for external auxiliary fuel tanks, internal range extension tanks, air-to-air and helicopter in-flight refueling (HIFR) capabilities, 24 litters, and structural provisions for two flexible guns. The helicopter's primary mission is movement of cargo and equipment. External cargo may be suspended from hooks using either single- or two-point suspension systems. When so equipped, the helicopter may be used for vertical delivery of cargo and equipment, and airborne mine countermeasures (AMCM). The design gross weight is 46,500 pounds and is the weight at which the maximum G load may be sustained. The maximum weight on wheels is 69,750 pounds. Maximum allowable gross weight is 73,500 pounds. The weight empty is about 33,226 pounds (Figure 6-1). Refer to the foldout pages at the end of the manual for illustrations of the instrument panel and upper and lower consoles.

1.2 PERFORMANCE

The helicopter is designed to carry 32,000 pounds of cargo externally at a cruise speed of at least 100 KIAS to a range of 50 nautical miles on a sea level tropical (32°C) day. At destination, the helicopter can hover for 5 minutes, release its cargo, return 50 nautical miles without payload at speed for best range, and have 20 minutes of fuel in reserve. The helicopter is also designed to be capable of retrieving another CH-53E at a range of 20 nautical miles. With the external auxiliary fuel tank pylons and auxiliary fuel tanks installed, range can be extended, but with reductions in the cargo carrying capability. Refer to Part XI, Performance Data, for specific capabilities. The range of the helicopter can be further extended by installing internal range extension tanks in the cabin, but the internal cargo and troop carrying capability will be reduced.

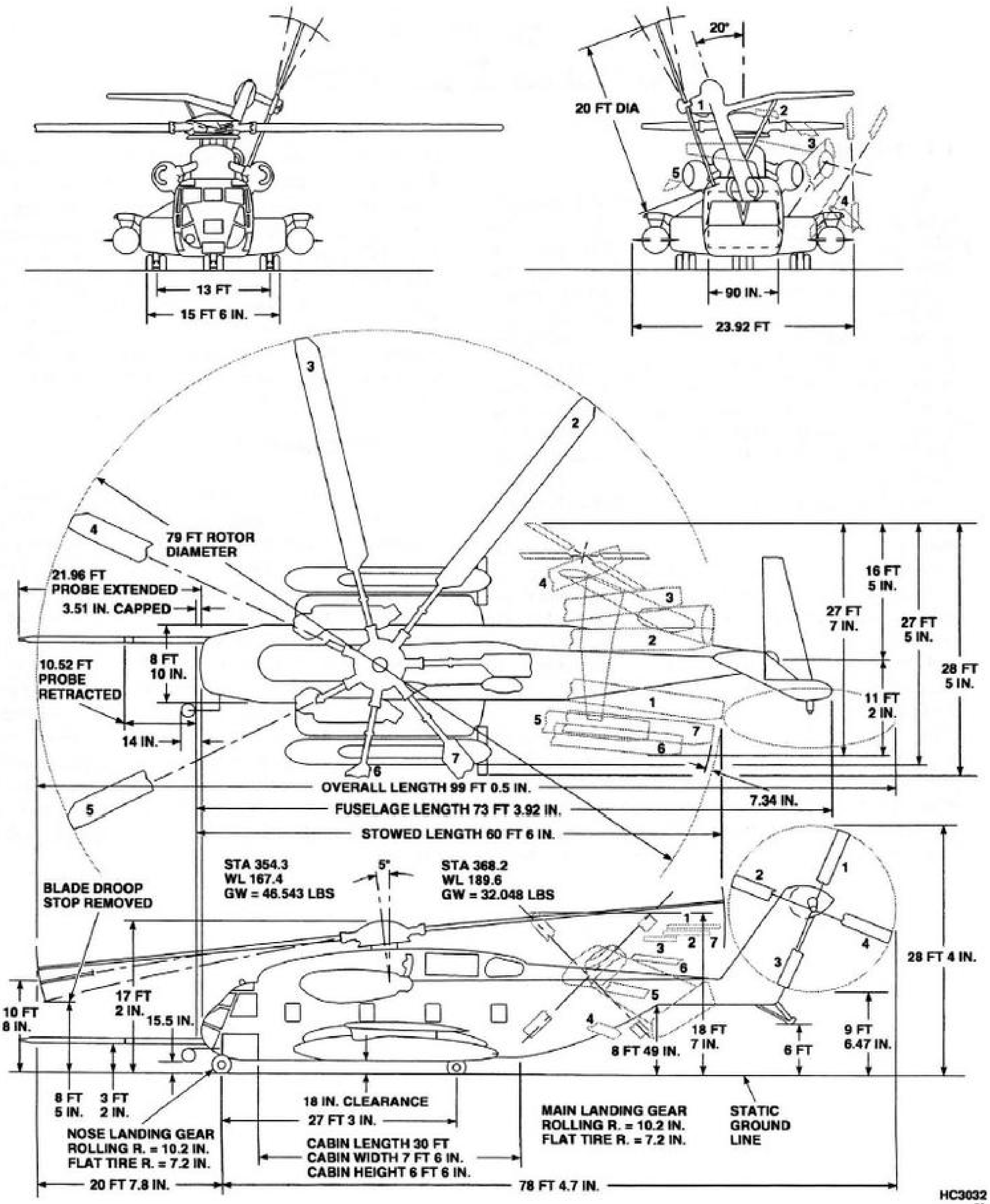
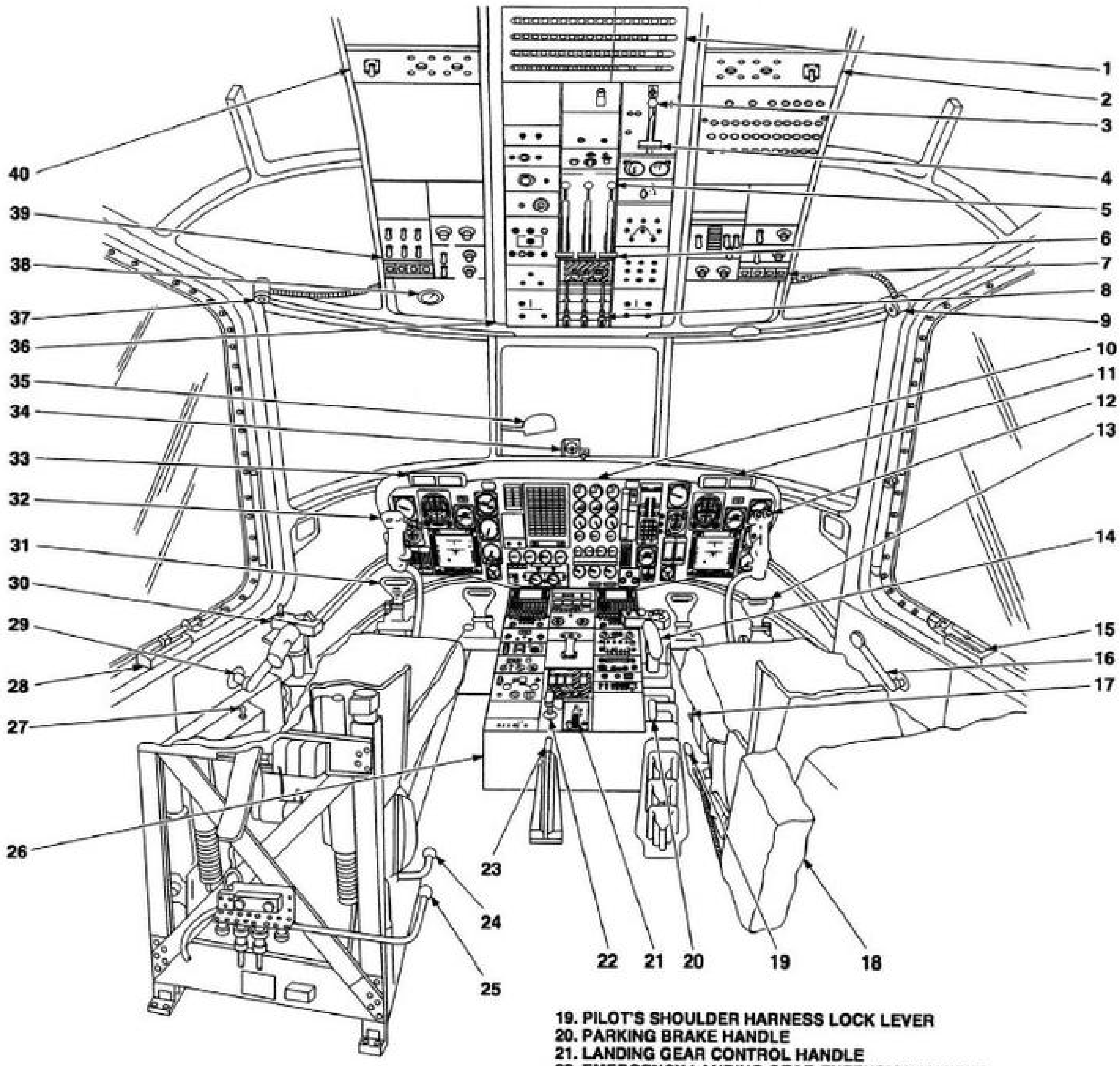


Figure 1-1. Dimension Diagram



1. EMERGENCY AC AND DC BUS CIRCUIT BREAKER PANEL
2. PILOT'S DOME LIGHT PANEL
3. APP CONTROL LEVER
4. APP FIRE EXTINGUISHER T HANDLE
5. FUEL SELECTOR LEVERS
6. ENGINE EMERGENCY T HANDLE
7. PILOT'S OVERHEAD CONTROL PANEL
8. ENGINE SPEED CONTROL LEVERS
9. PILOT'S UTILITY LIGHT
10. INSTRUMENT PANEL
11. MASTER CAUTION AND FIRE WARNING LIGHTS
12. PILOT'S CYCLIC
13. PILOT'S RUDDER AND BRAKE PEDALS
14. PILOT'S COLLECTIVE
15. PILOT'S WINDOW RELEASE HANDLE
16. PILOT'S WINDOW EMERGENCY RELEASE HANDLE
17. PILOT'S SEAT BLOWER SWITCH
18. JUMP SEAT
19. PILOT'S SHOULDER HARNESS LOCK LEVER
20. PARKING BRAKE HANDLE
21. LANDING GEAR CONTROL HANDLE
22. EMERGENCY LANDING GEAR EXTENSION HANDLE
23. CARGO HOOK EMERGENCY RELEASE HANDLE (INOPERATIVE WITH SINGLE POINT SUSPENSION)
24. COPILOT'S FORWARD AND AFT SEAT ADJUSTMENT LEVER
25. COPILOT'S SEAT HEIGHT ADJUSTMENT LEVER
26. CONSOLE
27. COPILOT'S RUDDER PEDAL ADJUSTMENT SWITCH
28. COPILOT'S WINDOW RELEASE HANDLE
29. COPILOT'S WINDOW EMERGENCY RELEASE HANDLE
30. COPILOT'S COLLECTIVE
31. COPILOT'S RUDDER AND BRAKE PEDALS
32. COPILOT'S CYCLIC
33. MASTER CAUTION AND FIRE WARNING LIGHT
34. STANDBY COMPASS
35. MIRROR
36. OVERHEAD CONTROL PANEL
37. COPILOT'S UTILITY LIGHT
38. FREE-AIR TEMPERATURE GAGE
39. COPILOT'S OVERHEAD CONTROL PANEL
40. COPILOT'S DOME LIGHT PANEL.

HC3404
6A

Figure 1-2. The Cockpit

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FOLDOUTS

RECORD OF CHANGES

Change No. and Date of Change	Date of Entry	Page Count Verified by (Signature)

INTERIM CHANGE SUMMARY

The following Interim Changes have been canceled or previously incorporated in this manual:

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
1 thru 25	Previously Incorporated

The following Interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
26	Parachute Operations Procedure Update (051931Z AUG99)
27	External Transport of Cargo (091735Z MAY00)
28	Bearing Monitor System Procedure Updates (151757Z FEB01)

Interim Changes Outstanding - To be maintained by the custodian of this manual:

INTERIM CHANGE NUMBER(S)	ORIGINATOR/DATE (or DATE/TIME GROUP)	PAGES AFFECTED	REMARKS/PURPOSE

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 299	Incorporation of Centerline Cargo Winch (ECP 2000R1S1)	1 Sep. 82	Winch installed at forward centerline of cargo compartment
AFC 300	Incorporation of Engine Ignition Circuit Breakers (ECP 2015R1)	1 Sep. 82	EMER START and ENG IGN circuit breakers installed in cabin
AFC 303	Incorporation of inward-pull release for cabin and overhead door windows (ECP 2027)	1 Sep. 82	Pull strap inside upper right corner of window
AFC 307	Incorporation of Overtorque Warning (ECP 2014)	15 Dec. 83	ENGINE OVERTORQUE and TAIL ROTOR HIGH STRESS caution light on caution panel
AFC 308	Incorporation of Hydraulic Heat Exchanger System Improvements (ECP 2011R1)	15 Dec. 83	UTILITY OIL HOT caution light on caution panel

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 309	Incorporation of Hydraulic Isolation Valves (ECP 2021)	15 Dec. 83	None
AFC 310	Incorporation of ALE-39 Countermeasures Dispensing Set (ECP 2006R1)	15 Dec. 83	ALE-39 control panel on cockpit console
AFC 334	Incorporation of fuzz burn-off chip detectors in tail rotor and intermediate gear boxes (ECP 2065R1)	15 Jan. 85	None
-	Incorporation of AN/ARC-174 HF RADIO (ECP 2117)	1 Aug. 87	AN/ARC-174 control panel on cockpit console
-	Incorporation of Marker Beacon (ECP 2038R1)	1 Aug. 87	Marker beacon lights on instrument panel
AFC 342	Incorporation of Strobe-Type Anticollision Lights (ECP 2116)	1 Aug. 87	Anticollision light control switches on cockpit overhead console

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 355	Incorporation of Fail Operational Flight Control Desensitizer (ECP 2078R2)	1 Aug. 87	None
AFC 358	Incorporation of Collective Flight Controls Damper (ECP 2146)	1 Aug. 87	Left electronics compartment on copilot's collective torque arm
AFC 369	Deactivation of Electrical Release Circuit from Two-Point Cargo Emergency Release T-Handle	1 Aug. 87	None
-	Incorporation of Crash-attenuating Pilot/Copilot Seats (ECP 2160)	15 Dec. 88	VLEA control dial on seat
-	Incorporation of AN/ARC-182 VHF-UHF Radio (ECP 2115)	1 Aug. 89	AN/ARC-182 control panel on cockpit console
AFC 327	Incorporation of LTN-211 Omega Navigation (ECP 2140 R1)	1 Aug. 89	LTN-211 control panel on cockpit console

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 379	Incorporation of Capacitive Discharge (Fuzz Burn-off) Chip Detectors in MGB, AGB, and NGB (ECP 2128 R1-2)	1 Aug 1989	None
AFC 382	Incorporation of Cabin Emergency Lighting Modification (ECP 2128 R1-5)	1 Aug 1989	Addition of four emergency exit lights
AFC 337	Incorporation of Radar Warning System	1 Aug 1989	Radar signal indicator on instrument panel
AFC 383	Incorporation of Hydraulic Fluid Replenishment In Flight (ECP 2128 R1-6)	1 Aug 1989	Manually operated gear pumps, one gallon tank and manual selector valve on rear left-hand side of cabin (sta 442-482)
AFC 434	Incorporation of Armament Provisions Modification (ECP 2128 R1-7)	1 Aug 1989	Strengthening of aircraft frame at station 222, left-hand side only

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 397	Incorporation of Composite Tail Rotor Blades (ECP 2136R1)	1 May 1990	Composite tail rotor blades
AFC 453	Incorporation of AN/ARN-151 Global Positioning System (ECP 0232 PN -51)	22 Dec 1995	Control Display Navigation on Cockpit Console
AFC 472	Relocation of the AN/ARC-94 HF Radio	22 Dec 1995	Cockpit Console
AFC 471	Incorporation of Helicopter Night Vision System (HNVS)	22 Dec 1995	Cockpit Console
AFC 342 Revision A	Modification of Anticollision Light	22 Dec 1995	Anticollision Light
AFC 490	Electrical Systems, Alternate Voltage Source for Flight-Critical Avionics; Incorporation of (ECP SA-CH-53E-2166R1)	15 Jul 1996	No. 3 primary ac bus circuit breakers on cockpit overhead circuit breaker panel.
AFC 455	Avionics, Installation of AN/ARC-210(V) Radio Set (ECP H53-PN47)	31 Jul 1996	AN/ARC-210(V) Control Panel on Cockpit Console
AFC 479	Electrical, Night Vision Compatible Exterior Lighting, Incorporation of (ECP H53-PN53)	31 May 1997	IR beacon

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 481	Installation of Infrared Position Lights (RAMEC L-25-91)	31 May 1997	Panel-mounted six-position rotary switch on left side of overhead center console
AFC 485	Range Extension and Left-Hand Utility Receptacles Wiring, Modification of (RAMEC PNCLA-43-90)	31 May 1997	DC receptacle by left cabin circuit breaker panel
AFC 486	Provisions for Installation of HELOSAT Antenna (RAMEC L-04-93)	31 May 1997	HELOSAT Antenna and PSC-3 Mission Kit
AFC 483	Incorporation of No. 2 Engine Dual Thermal Detection System (ECP PNCLA PN-56)	31 Jan 1998	Caution/advisory Panel
AFC 497	Installation of the Improved Troop Seats for the CH/MH-53E Helicopters (ECP H-53-002)	31 Dec 1998	Telescopic legs
AFC 491	Transmission systems, Tail Rotor Drive Shaft Bearings, Duplex Bearing and Swashplate Sensors and Monitor, Incorporation of (ECP SA-CH-53E-2175R4)	15 Jan 1999	Caution/advisory Panel and Bearing Monitor Panel in cabin

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following applicable technical directives has been incorporated in this manual.

CHANGE NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 482	Incorporation of AN/AVS-7 Heads-Up Display (ECP H53-PN55)	31 Jan 2000	Installation of Signal Data Convertor at FS 162
AVC 4831	Incorporates changes to Collective Stick Assembly (ECP TBD)	31 Jan 2000	Installation of HUD (AN/AVS-7) Control Switch
AFC 501 Part 2	Installation of AN/AYQ-23(V) Ground Proximity Warning System (GPWS) (ECP H53-003)	31 Mar 2000	GPWS annunciator lights on advisory panel

Information relating to the following applicable technical directives will be incorporated in a future change.

CHANGE NUMBER	DESCRIPTION	VISUAL IDENTIFICATION

GLOSSARY

A	APPROACH.
AC	ALTERNATING CURRENT.
ACCEL	ACCELERATION.
ADC	AIR DATA COMPUTER.
AFCS	AUTOMATIC FLIGHT CONTROL SYSTEM.
AHD	LOOK AHEAD (HNVS).
AHRS	ATTITUDE HEADING REFERENCE SYSTEM.
AJ	ANTI JAMMING.
AJ/M	ANTI JAMMING/MASTER.
ALM	ALMANAC.
AMBIENT TEMPERA-TURE	TEMPERATURE OF THE UNDIS-TURBED AIR MASS SURROUNDING AN AIRCRAFT.
APP	AUXILIARY POWERPLANT.
APPR	APPROACH.
APPROXI-MATE	ENGINEERING TERM FOR A TOL-ERANCE OF APPROXIMATELY 10 PERCENT.
AT	AUTO TRACK (HNVS).
ATE	AUTO TRACK ENABLE (HNVS).
AUTO	AUTOMATIC.
BAR ALT	BAROMETRIC ALTITUDE.
BASELINE	REFERENCE LINE.
BBC	BACKUP BUS CONTROLLER.
BC	BUS CONTROLLER.
BDHI	BEARING-DISTANCE-HEADING-INDICATOR.
BIT	BUILT IN TEST.
BLIND SPEED (EFFECT)	A PHENOMENON CAUSED WHEN DOPPLER FREQUENCIES OF A RA-DAR TARGET ARE MULTIPLES OF GCA RADAR'S PULSE-REPETITION FREQUENCIES (PRF), CAUSING THE AIRCRAFT TO NO LONGER INDICATE ON THE RADAR SCREEN.
BRT	BRIGHT.
BTU	BRITISH THERMAL UNIT.
°C	DEGREE CENTIGRADE.
C/A	COURSE ACQUISITION.
CAL	CONFINED AREA LANDING.
CAL	CALIBRATION (HNVS).
CAS	CALIBRATED AIRSPEED (INDICATED AIRSPEED CORRECTED FOR IN-STRUMENT ERROR).
CC	CREWCHIEF.
CCA	CARRIER-CONTROLLED AP-PROACH.
CCR	CLOSED CIRCUIT REFUELING.
CD-17	ARC FREQUENCY COUNTERMEA-SURES CONTROLLER OR A8 APPLI-QUE.
CDI	COURSE DIRECTION INDICATOR.
CDNU	CONTROL DISPLAY NAVIGATION UNIT.
CENTIGRADE	A SCALE OF TEMPERATURE MEA-SUREMENT WHEREIN THE FREEZ-ING POINT OF WATER IS 0° AND THE BOILING POINT OF WATER IS 100°.
CFIT	CONTROLLED FLIGHT INTO TER-RAIN.
CG	CENTER OF GRAVITY.
CHAN	CHANNEL.
CI	COURSE INDICATOR.
CLR	CLEAR.

CO_2	CARBON DIOXIDE.
CP	COPILOT.
CPS	CYCLES PER SECOND.
CRS	COURSE.
CRS	COMPUTED MAGNETIC COURSE.
CS	COLD START.
CSEP	CONSOLIDATED SINGLE CHANNEL RADIO ECCM PACKAGE.
CU	CV-4092/A.
CUE	ANTI-JAMMING CHANNEL.
DAC	DIGITAL ANALOG CONVERTER
DAMA	DEMAND ASSIGNED MULTIPLE ACCESS
DC	DIRECT CURRENT.
DECAY	LOSS OF N_R BEYOND DROOP, RESULTING FROM A POWER REQUIREMENT IN EXCESS OF POWER AVAILABLE.
DENSITY ALTITUDE (DA)	THE ALTITUDE IN A STANDARD ATMOSPHERE CORRESPONDING TO A GIVEN DENSITY ACTUALLY ENCOUNTERED. (CALIBRATED PRESSURE ALTITUDE IS PRESSURE ALTITUDE CORRECTED FOR FREE AIR TEMPERATURE.)
DEU	DISPLAY ELECTRONICS UNIT.
DFT	DRIFT ANGLE.
DIR	DIRECTION.
DMA	DEFENSE MAPPING AGENCY.
DIST	DISTANCE.
DN	DOWN.
DOWNING DISCREPANCY	A DISCREPANCY THAT LEAVES THE HELICOPTER UNSAFE TO PERFORM ITS DESIGNATED MISSION.
DOM	DAY OF MONTH.
DROOP	DECREASE IN N_F AND N_R WHICH RESULTS FROM AN INCREASED POWER DEMAND WHEN THE ENGINE IS ALREADY OPERATING AT MAXIMUM N_G SPEED.
DTD	DATE TRANSFER DEVICE.
DTK	DESIRED COURSE.
DTK	DESIRED MAGNETIC COURSE.
DTM	DATA TRANSFER MODULE.
EAPS	ENGINE AIR PARTICLE SEPARATOR.
ECCM	ELECTRONIC COUNTER COUNTERMEASURE.
EHE	ESTIMATED HORIZONTAL ERROR.
EMER	EMERGENCY
ENDURANCE	THE LENGTH OF TIME THAT AN AIRCRAFT CAN FLY UNDER SPECIFIED CONDITIONS WITHOUT REFUELING.
ENG	ENGINE.
ENR	ENROUTE.
EP	ELECTRONIC PROTECTION.
ERF	ECCM REMOTE FILL.
°F	DEGREE FAHRENHEIT.
FAA	FEDERAL AVIATION ADMINISTRATION.
FAHRENHEIT	A SCALE OF TEMPERATURE MEASUREMENT WHEREIN THE FREEZING POINT OF WATER IS 32° AND THE BOILING POINT OF WATER IS 212°.
FBC	FLIGHT BITE CODE.
FCLP	FIELD CARRIER LANDING PRACTICE.
FH	FREQUENCY HOPPING.
FIT	FAULT ISOLATION TEST.
FLIR	FORWARD LOOKING INFRARED.
FLPN	FLIGHT PLAN.
FPM	FEET PER MINUTE.
FREQ	FREQUENCY.
FS	FUSELAGE STATION.
FT	FEET.

FUEL DENSITY	THE SPECIFIC WEIGHT OF FUEL AT TEMPERATURE VARIATIONS.
FUEL FLOW (W_F)	THE RATE THAT FUEL FLOWS TO THE ENGINE.
FUEL GRADE	FACTOR ASSIGNED TO IDENTIFY FUELS.
FWD	FORWARD.
GCA	GROUND-CONTROLLED APPROACH.
GPS	GLOBAL POSITIONING SYSTEM.
GPWS	GROUND PROXIMITY WARNING SYSTEM.
GRD IDLE	GROUND IDLE.
GROSS WEIGHT	THE ACTUAL WEIGHT OF THE HELICOPTER, WHETHER LOADED OR NOT, CONSISTING OF ITS OWN WEIGHT PLUS THAT OF THE CREW, FUEL, CARGO, PASSENGER, ETC.
GROUND EFFECT	WHEN OPERATING CLOSE TO THE SURFACE OF THE EARTH OR A LARGE FLAT AREA, THE SURFACE RESTRAINT ON THE DOWNWASH FROM THE ROTOR CREATES A REDUCTION IN INDUCED VELOCITY AND THEREFORE A REDUCTION IN POWER REQUIRED TO MAINTAIN FLIGHT.
GROUND IDLE	LOWEST POINT AT WHICH THE ENGINE IS CAPABLE OF SELF-SUSTAINING OPERATION.
GROUND ROLL	THE LANDING OR TAKEOFF RUN OF AN AIRCRAFT ON THE GROUND.
GUIDELINE	A REFERENCE LINE USED AS A GUIDE FOR RELATED TRACTINGS.
GUK	GROUP UNIQUE KEY.
GW	GROSS WEIGHT.
H	HOP SETS.
HAC	HELICOPTER AIRCRAFT COMMANDER.
HEADWIND	A WIND BLOWING FROM SUCH A DIRECTION THAT IT RETARDS THE GROUND SPEED OF AN AIRCRAFT.
HEEDS	HELICOPTER EMERGENCY ESCAPE DEVICE SYSTEM.
HELOSAT ANTENNA	HELICOPTER SATELLITE ANTENNA.
HG	MERCURY.
HIFR	HELICOPTER IN FLIGHT REFUELING.
HIGE	HOVERING IN-GROUND EFFECT.
HNVS	HELICOPTER NIGHT VISION SYSTEM.
HOGE	HOVERING OUT-OF-GROUND EFFECT.
HOVER	TO REMAIN IN A STATIONARY POSITION AT A GIVEN ALTITUDE.
HP	HORSEPOWER.
HQ	HAVE QUICK.
HR(S)	HOUR(S).
HYSTERESIS	A CONDITION EXHIBITED BY SYSTEMS WHOSE STATE RESULTS FROM PREVIOUS HISTORY, SPECIFICALLY ONE WHOSE INSTANTANEOUS VALUES LAG BEHIND PREDICTION. THESE EFFECTS CAN BE CAUSED BY INTERNAL FRICTION IN ELASTIC MATERIAL UNDERGOING CHANGING STRESS (E.G., HEAT).
HZ	HERTZ (CYCLES PER SECOND).
H2P	HELICOPTER SECOND PILOT.
IAF	INITIAL APPROACH FIX.
IAS	INDICATED AIRSPEED.
IBD	IDENTIFIER/BEARING/DISTANCE WAYPOINT.
I-BIT	INITIALIZATION BIT .
ICS	INTERPHONE COMMUNICATION SYSTEM.
IDX	INDEX.
IFR	INSTRUMENT FLIGHT RULES.

IGV	INLET GUIDE VANE.
ILS	INSTRUMENT LANDING SYSTEM.
IN	INCH(ES).
INAV	INTEGRATED NAVIGATION.
INBNDCRS	INBOUND COURSE.
IND	INDICATE.
IN-GROUND EFFECT	HOVERING OR FLYING THE ZONE WHERE GROUND EFFECT REDUCES POWER REQUIRED.
INNER LOOP	AFCS TERM DENOTING DYNAMIC STABILITY OR RATE DAMPING. THE AFCS CORRECTS WITHOUT FLIGHT CONTROL MOVEMENT.
IRU	INTERFACE RECEIVER UNIT.
K	METRIC.
KCAS	KNOTS CALIBRATED AIRSPEED.
KHZ	KILOHERTZ.
KIAS	KNOTS INDICATED AIRSPEED.
KT	KNOT(S).
KTAS	KNOTS TRUE AIRSPEED.
KVA	KILOVOLT-AMPERE.
L/S	LINE SELECT.
L	LINE.
L	LOCKOUT SETS.
LAT/LONG	LATITUDE/LONGITUDE.
LB	POUND(S).
LB/HR	POUNDS PER HOUR.
LE	LATE ENTRY.
M	MAGNETIC.
MAGVAR	MAGNETIC VARIATION.
MAN	MANUAL.
MAP	MISSED APPROACH POINT.
MAP	MISSED APPROACH PROCEDURES.
MAX GOV	MAXIMUM GOVERNING.
MAXIMUM POWER	THE MAXIMUM POWER THE ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR A PERIOD OF 10 MINUTES WITHOUT DAMAGE TO THE ENGINE.
MCS	MASTER CONTROL STATION.
MDL	MISSION DATA LOADER.
MFCU	MULTIFUNCTION CONTROL UNIT.
MGRS	MILITARY GRID REFERENCE SYSTEM.
MHZ	MEGAHERTZ.
MID	MIDDLE.
MILITARY-RATED POWER	THE POWER THAT AN ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR A PERIOD OF 30 MINUTES WITHOUT DAMAGE TO THE ENGINE.
MIN	MINUTE.
MIN GOV	LOWEST POINT AT WHICH THE ENGINE IS CAPABLE OF DEVELOPING FULL SHAFT HORSEPOWER. ALSO, THE LOWEST POINT THAT N_F CAN BE GOVERNED.
MSL	MEAN SEA LEVEL.
MWOD	MULTIPLE WORD OF DAY.
N	ENGLISH..
NATOPS	NAVAL AIR TRAINING AND OPERATING PROCEDURES STANDARDIZATION PROGRAM.
NAUTICAL MILE	A MEASURE OF DISTANCE EQUAL TO 6,076 FEET (1.15 STATUTE MILE).
NI	NORTH ISLAND.
N_F	POWER TURBINE SPEED.
N_G	GAS GENERATOR SPEED.
NHC	NATO (COMPATIBLE) HIGH CAPACITY.
NM	NAUTICAL MILE.
NORM	NORMAL.

NORMAL-RATED POWER THE POWER THAT AN ENGINE CAN DELIVER UNDER SPECIFIED CONDITIONS FOR CONTINUOUS OPERATION.

N_R ROTARY WING SPEED.

OAT OUTSIDE AIR TEMPERATURE.

OFST OFFSET.

OFT OPERATIONAL FLIGHT TRAINER.

OFP OPERATIONAL FLIGHT PROGRAM.

OSHA OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION.

OUT-OF-GROUND EFFECT HOVERING OR FLYING AT A HEIGHT FROM A FLAT SURFACE WHEREIN GROUND EFFECT CREATES NO REDUCTION IN POWER REQUIRED.

OUTER LOOP AFCS TERM DENOTING STATIC STABILITY OR THE ABILITY TO RETURN TO A SELECTED ATTITUDE. WORKS THROUGH THE TRIM SYSTEM; USES FLIGHT CONTROL MOVEMENT TO CORRECT.

P PILOT.

P PRECISION.

P PROGRESS.

PAC PILOT AT CONTROLS.

P-BIT PERIODIC BIT.

PCA POINT OF CLOSEST APPROACH.

PDU PANEL DISPLAY UNIT.

PMG PERMANENT MAGNETIC GENERATOR.

PNAC PILOT NOT AT CONTROLS.

POSITION ERROR AN ERROR IN THE READING OF AN AIRCRAFT INDICATOR BECAUSE OF A DIFFERENCE IN ACTUAL VALUES AND THE VALUES READ AT THE POSITION OF THE MEASURING DEVICE.

POWER SETTING THE DESIRED POWER OBTAINED BY POSITION OF ENGINE CONTROLS.

PRESS ALT PRESSURE ALTITUDE.

PRESSURE ALTITUDE THE ALTITUDE ABOVE THE STANDARD DATUM PLANE (I.E., ALTITUDE MEASURED FROM STANDARD SEA LEVEL WHEN THE BAROMETRIC ALTIMETER IS SET AT 29.92 INCHES HG).

PRIFLY PRIMARY FLIGHT CONTROL.

PROG PROGRESS.

PSI POUNDS PER SQUARE INCH.

P^3 COMPRESSOR DISCHARGE PRESSURE.

Q TORQUE.

QD QUICK DISCONNECT.

RAD (RDR) ALT RADAR ALTIMETER.

RANGE THE MAXIMUM DISTANCE FROM THE POINT OF DEPARTURE THAT AN AIRCRAFT CAN FLY UNDER SPECIFIED CONDITIONS WITHOUT REFUELING.

RATE-OF-CLIMB THE VERTICAL COMPONENT OF THE AIRSPEED OF AN AIRCRAFT WHEN CLIMBING.

RCV RECEIVE.

RF RADIO FREQUENCY.

RIGGING COORDINATING THE CORRECT BLADE ANGLE AT THE MAIN AND TAIL ROTOR WITH CORRESPONDING STICK AND PEDAL POSITION.

ROC RATE-OF-CLIMB.

ROD RATE-OF-DESCENT.

RPM REVOLUTIONS-PER-MINUTE.

RNAV AREA NAVIGATION.

RNS RADAR NAVIGATION SET (DOPPLER).

SAFETY-OF-FLIGHT DISCREPANCY A DISCREPANCY THAT IF LEFT UNCORRECTED COULD RESULT IN LOSS OF LIFE AND EQUIPMENT.

SA/AS SELECTED AVAILABILITY/ANTI-SPOOFING.

SATCOM	SATELLITE COMMUNICATION SYSTEM.
SAR	SEARCH AND RESCUE.
SDC	SIGNAL DATA CONVERTER.
SEA LEVEL	THE STANDARD DATUM PLANE FROM WHICH ALTITUDE ARE COMPUTED BY MEANS OF DIFFERENCE IN ATMOSPHERIC PRESSURES.
SFC	SPECIFIC FUEL CONSUMPTION.
SHAFT HORSEPOWER	OUTPUT POWER DELIVERED BY AN ENGINE.
SHP	SHAFT HORSEPOWER.
SINCGARS	SINGLE-CHANNEL GROUND AND AIRBORNE RADIO SYSTEM.
SND	SEND.
SPEED	RATE OF MOTION RELATIVE TO A STATED OR IMPLIED REFERENCE.
STANDARD ATMOSPHERE	A FICTITIOUS ATMOSPHERE OF ASSUMED COMPOSITION USED FOR COMPARISON OF AIRCRAFT PERFORMANCE AND CALIBRATING PRESSURE INSTRUMENTS. STANDARD ATMOSPHERE IS ASSUMED TO BE DRY, HAVE A PRESSURE OF 29.92 INCHES HG, AND A TEMPERATURE OF 15°C.
T	TERMINAL.
T	TRUE.
T/R	TRANSMIT/RECEIVE.
T/R&G	TRANSMIT/RECEIVE AND GUARD.
TAS	TRUE AIRSPEED.
TBFDS	TACTICAL BULK FUEL DELIVERY SYSTEM.
TEMPERATURE	A MEASURE OF THE AMOUNT OF HEAT PRESENT IN AN OBJECT AS MEASURED AGAINST A DEFINITE SCALE.
TERF	TERRAIN FOLLOWING.
TFU	TURRET FLIR UNIT.
TKE	TRACK ANGLE ERROR.
TOD	TIME OF DAY.
TOPPING	A PROCEDURE FOR ADJUSTING ENGINE FUEL CONTROL TO ACHIEVE ENGINE PERFORMANCE AT MAXIMUM OPERATING LIMITS.
TORQ	TORQUE.
TORQUE	THE AMOUNT OF POWER DELIVERED BY THE ENGINES TO THE GEARBOX.
TRACK	ALL BLADES ROTATING IN THE SAME HORIZONTAL PLANE, ASSUMING PERFECT BLADES.
TRANSEC/ COMSEC	TRANSMISSION SECURITY/COMMUNICATION SECURITY.
TRM	TERMINAL.
TRUE AIRSPEED	ACTUAL OR EXACT AIRSPEED. CALIBRATED AIRSPEED CORRECTED FOR TEMPERATURE, PRESSURE, AND COMPRESSIBILITY EFFECT.
TTI	TIME TO INTERCEPT.
T_2	COMPRESSOR INLET TEMPERATURE OR AMBIENT TEMPERATURE.
T_5	POWER TURBINE INLET TEMPERATURE.
UTC	UNIVERSAL COORDINATED TIME.
VFR	VISUAL FLIGHT RULES.
VGI	VERTICAL GYRO INDICATOR.
W_F.	FUEL FLOW.
WOD	WORD OF DAY.
WPTS	WAYPOINTS.
WRA	WEAPONS REPLACEABLE ASSEMBLY.
XMFR RECT	TRANSFORMER-RECTIFIER.
XTR	CROSS TRACK DEVIATION.
ZRO	ZEROIZE.
1553	MIL-STD-1553B.

PREFACE

SCOPE

The NATOPS Flight Manual is issued by the authority of the Chief of Naval Operations and under the direction of Commander, Naval Air Systems Command in conjunction with the Naval Air Training and Operating Procedures Standardization (NATOPS) Program. This manual contains information on all aircraft systems, performance data, and operating procedures required for safe and effective operations. However, it is not a substitute for sound judgement. Compound emergencies, available facilities, adverse weather or terrain, or considerations affecting the lives and property of others may require modification of the procedures contained herein. Read this manual from cover to cover. It's your responsibility to have a complete knowledge of its contents.

APPLICABLE PUBLICATIONS

The following applicable publications complement this manual:

A1-H53BE-CLG-000 Cargo Loading Manual

A1-H53BE-NFM-500 Pilot's Pocket Checklist

A1-H53BE-NFM-700 Functional Checkflight Checklist

A1-H53BE-NFM-900 Aircrew Pocket Checklist

OH 5-3A Helicopter External Cargo Loading

OPNAVINST 3710.7 NATOPS General Flight and Operating Inst.

NAEC-ENG-7576 Shipboard Aviation Facilities Resume

NAVAIR 00-80T-106 LHA/LPH/LHD NATOPS Manual

NAVAIR 00-80T-110 NATOPS Air Refueling Manual

NAVAIR 00-80T-112 NATOPS Instrument Flight Manual

NAVAIR 01-1ASH-1T Tactical Manual Pocket Guide

NAVAIR 01-230HM-75-17 Conventional Weapons Checklist CH-53 Crew Served Guns

NAVAIR 13-1-6.7 Aircrew Personal Protective Equipment

NWP 42 Shipboard Helicopter Operating Procedures

NWP 55-9-ASH Assault Support Helo Tactical Manual

FMFRP 5-31, Vol I, II, and III, Basic Operation/ Equipment and Single- /Dual-Point Hook procedures

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UPDATING THE MANUAL

To ensure that the manual contains the latest procedures and information, NATOPS review conferences are held in accordance with OPNAVINST 3710.7.

CHANGE RECOMMENDATIONS

Recommended changes to this manual or other NATOPS publications may be submitted by anyone in accordance with OPNAVINST 3710.7.

Routine change recommendations are submitted directly to the Model Manager on OPNAV Form 3710/6 (4-90) shown herein. The address of the model manager of this aircraft is:

Commanding Officer
ATTN: MODEL MANAGER
HMT-302 MCAS New River
PSC Box 21008
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Change recommendations of an URGENT nature (safety of flight, etc.) should be submitted directly to the NATOPS advisory group member in the chain of command by priority message.

YOUR RESPONSIBILITY

NATOPS flight manuals are kept current through an active manual change program. Any corrections, additions, or constructive suggestions for improvements of its content should be submitted by routine or urgent change recommendation, as appropriate, at once.

NATOPS FLIGHT MANUAL INTERIM CHANGES

Flight manual interim changes are changes or corrections to the NATOPS flight manuals promulgated by CNO or NAVAIRSYSCOM. Interim changes are issued either as printed pages or as a naval message. The interim change summary page is provided as a record of all interim changes. Upon receipt of a change or revision, the custodian of the manual should check the updated interim change summary to ascertain that all outstanding interim changes have been either incorporated or canceled; those not incorporated shall be recorded as outstanding in the section provided.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change might be material added or information restated. A change symbol in the margin by the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to "WARNINGS", "CAUTIONS", and "Notes" found throughout the manual.

WARNING

An operating procedure, practice, or condition, etc., that may result in injury or death if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition, etc., that may result in damage to equipment if not carefully observed or followed.

Note

An operating procedure, practice, or condition, etc., that is essential to emphasize.

WORDING

The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is optional.

"Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

NATOPS/TACTICAL CHANGE RECOMMENDATION
OPNAV 3710 / 6 (4-90) S / N 0107-LF-009-7900

DATE ____________

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FROM (originator)					Unit
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Complete Name of Manual / Checklist	Revision Date	Change Date	Section / Chapter	Page	Paragraph

Recommendation (be specific)

☐ CHECK IF CONTINUED ON BACK

Justification

Signature	Rank	Title

Address of Unit or Command

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REFERENCE

(a) Your Change Recommendation Dated ____________

☐ Your change recommendation dated ____________ is acknowledged. It will be held for action of the review conference planned for ____________ to be held at ____________

☐ Your recommendation is reclassified URGENT and forwarded for approval to ____________ ____________ by my DTG ____________

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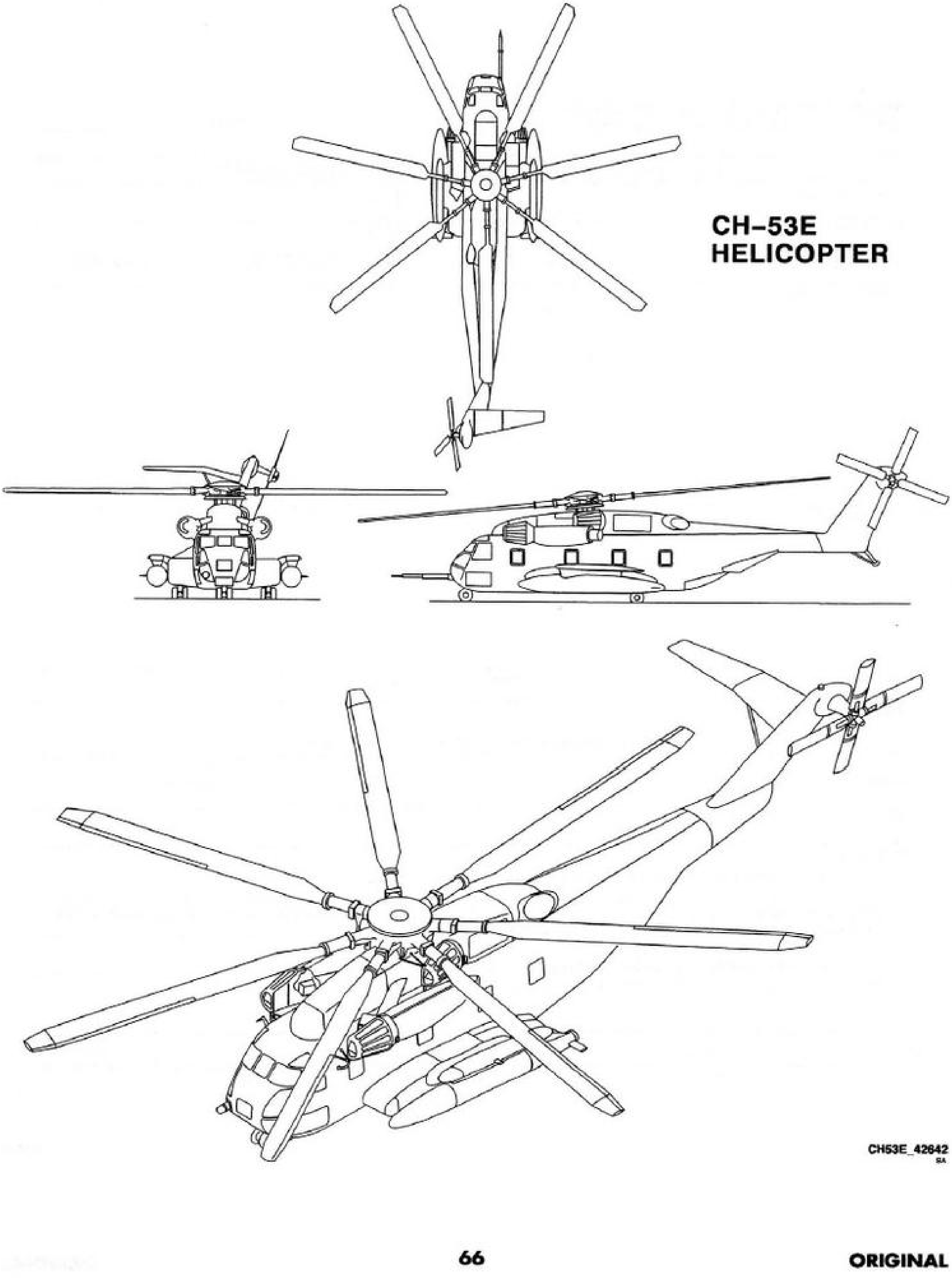


CH-53E
HELICOPTER

CH53E_42642
SA

PART I

THE AIRCRAFT

CHAPTER 1
General Description

1.1 THE HELICOPTER

The CH-53E assault transport helicopter is manufactured by Sikorsky Aircraft, 6900 Main St., P. O. Box 9729, Stratford, CT 06615-9129. The helicopter is a Class 2 aircraft equipped with a seven-blade main rotor and a four-blade canted tail rotor, designed for land- and ship-based operation, and with an emergency water operating capability. The tail rotor is canted 20° to the left. This provides 2% additional lift, improves hover capability, and permits the CG to be moved further aft. The main gear box is tilted 5° forward, which provides a level fuselage at cruising speeds. Power is furnished by three T64-GE-416 or T64-GE-416A engines, manufactured by General Electric Company, Aircraft Group, Lynn, Massachusetts. The engine is capable of producing 4380 shp at a power turbine output speed of 14,280 rpm. Automatic flight control and engine anti-icing systems give the helicopter an all-weather flight capability. An auxiliary powerplant (APP) gives the helicopter a self-starting capability. The helicopter is equipped with a fuel jettisoning system and utility hoist. It normally seats 37 passengers and, with centerline seats installed, 55 passengers. In addition, the helicopter is equipped with a rear ramp loading system, cargo winch, roller conveyors, and cargo tiedown facilities. Provisions are made for external auxiliary fuel tanks, internal range extension tanks, air-to-air and helicopter in-flight refueling (HIFR) capabilities, 24 litters, and structural provisions for two flexible guns. The helicopter's primary mission is movement of cargo and equipment. External cargo may be suspended from hooks using either single- or two-point suspension systems. When so equipped, the helicopter may be used for vertical delivery of cargo and equipment, and airborne mine countermeasures (AMCM). The design gross weight is 46,500 pounds and is the weight at which the maximum G load may be sustained. The maximum weight on wheels is 69,750 pounds. Maximum allowable gross weight is 73,500 pounds. The weight empty is about 33,226 pounds (Figure 6-1). Refer to the foldout pages at the end of the manual for illustrations of the instrument panel and upper and lower consoles.

1.2 PERFORMANCE

The helicopter is designed to carry 32,000 pounds of cargo externally at a cruise speed of at least 100 KIAS to a range of 50 nautical miles on a sea level tropical (32°C) day. At destination, the helicopter can hover for 5 minutes, release its cargo, return 50 nautical miles without payload at speed for best range, and have 20 minutes of fuel in reserve. The helicopter is also designed to be capable of retrieving another CH-53E at a range of 20 nautical miles. With the external auxiliary fuel tank pylons and auxiliary fuel tanks installed, range can be extended, but with reductions in the cargo carrying capability. Refer to Part XI, Performance Data, for specific capabilities. The range of the helicopter can be further extended by installing internal range extension tanks in the cabin, but the internal cargo and troop carrying capability will be reduced.

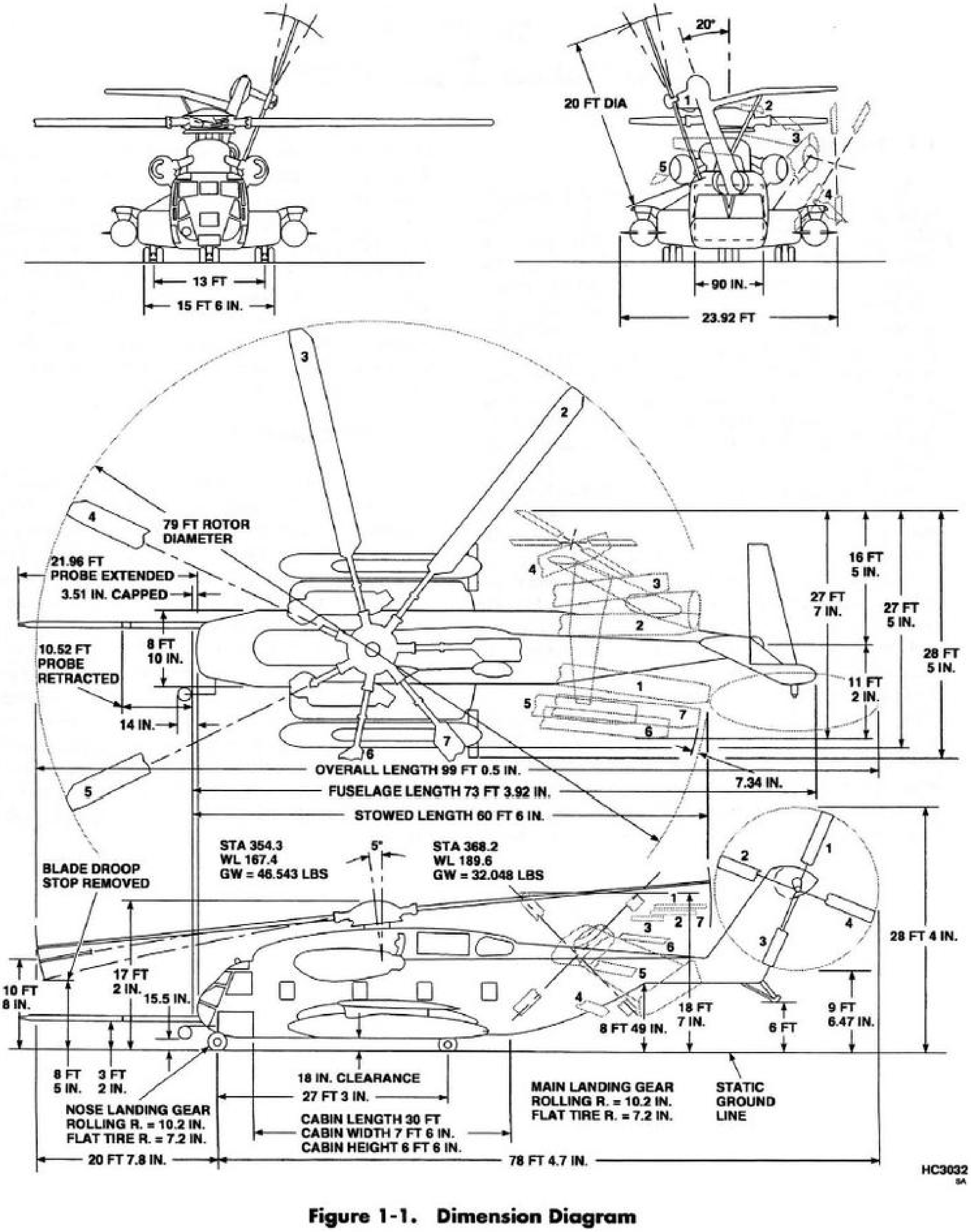
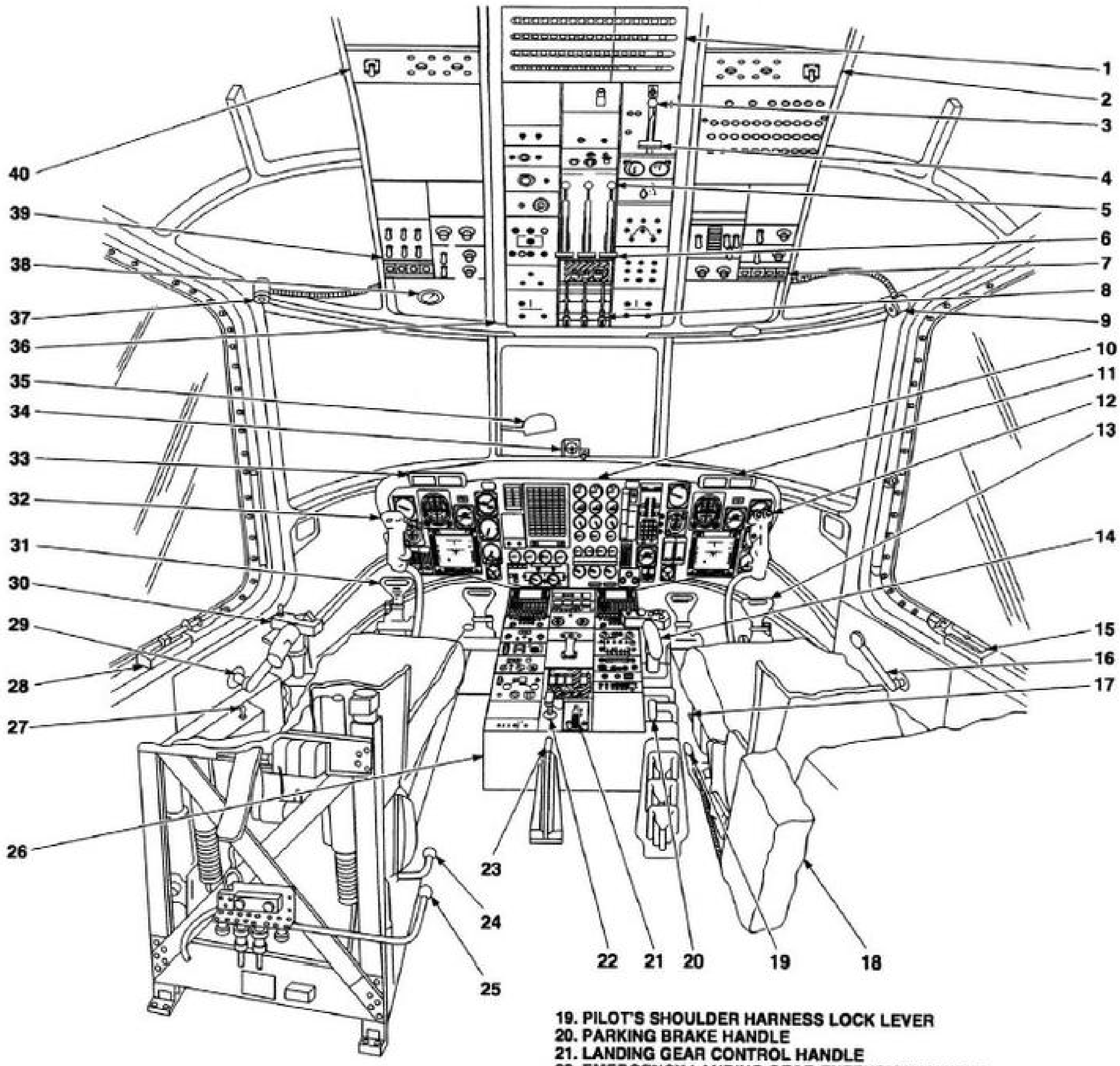


Figure 1-1. Dimension Diagram



1. EMERGENCY AC AND DC BUS CIRCUIT BREAKER PANEL
2. PILOT'S DOME LIGHT PANEL
3. APP CONTROL LEVER
4. APP FIRE EXTINGUISHER T HANDLE
5. FUEL SELECTOR LEVERS
6. ENGINE EMERGENCY T HANDLE
7. PILOT'S OVERHEAD CONTROL PANEL
8. ENGINE SPEED CONTROL LEVERS
9. PILOT'S UTILITY LIGHT
10. INSTRUMENT PANEL
11. MASTER CAUTION AND FIRE WARNING LIGHTS
12. PILOT'S CYCLIC
13. PILOT'S RUDDER AND BRAKE PEDALS
14. PILOT'S COLLECTIVE
15. PILOT'S WINDOW RELEASE HANDLE
16. PILOT'S WINDOW EMERGENCY RELEASE HANDLE
17. PILOT'S SEAT BLOWER SWITCH
18. JUMP SEAT
19. PILOT'S SHOULDER HARNESS LOCK LEVER
20. PARKING BRAKE HANDLE
21. LANDING GEAR CONTROL HANDLE
22. EMERGENCY LANDING GEAR EXTENSION HANDLE
23. CARGO HOOK EMERGENCY RELEASE HANDLE (INOPERATIVE WITH SINGLE POINT SUSPENSION)
24. COPILOT'S FORWARD AND AFT SEAT ADJUSTMENT LEVER
25. COPILOT'S SEAT HEIGHT ADJUSTMENT LEVER
26. CONSOLE
27. COPILOT'S RUDDER PEDAL ADJUSTMENT SWITCH
28. COPILOT'S WINDOW RELEASE HANDLE
29. COPILOT'S WINDOW EMERGENCY RELEASE HANDLE
30. COPILOT'S COLLECTIVE
31. COPILOT'S RUDDER AND BRAKE PEDALS
32. COPILOT'S CYCLIC
33. MASTER CAUTION AND FIRE WARNING LIGHT
34. STANDBY COMPASS
35. MIRROR
36. OVERHEAD CONTROL PANEL
37. COPILOT'S UTILITY LIGHT
38. FREE-AIR TEMPERATURE GAGE
39. COPILOT'S OVERHEAD CONTROL PANEL
40. COPILOT'S DOME LIGHT PANEL.

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Figure 1-2. The Cockpit

CHAPTER 2
Systems

2.1 ENGINES

The T64-GE-416 turboshaft engines (FO-13) are mounted on each side of the upper outboard fuselage, and behind the main gear box. The basic engine consists of a torque sensor shaft and housing, compressor section, combustion section, and turbine section. A clock numbering system is used to locate engine components. From the rear looking forward, the right and left sides of the engine correspond to the observer's right and left. The top of the engine is the 12-o'clock position, with the other clock numbers following clockwise.

2.1.1 Torque Sensor Shaft and Housing Assembly. This assembly (FO-13) transmits engine power to the nose gear box from the No. 1 and 3 engines and to the main gear box from the No. 2 engine. The shaft assembly, consisting of a shaft and sleeve, is used for torque measuring purposes.

2.1.2 Compressor Section. The section consists of a 14-stage compressor rotor assembly (FO-13) and the compressor stator assembly. The compressor rotor assembly is driven by a direct coupling to the gas generator turbine, and the compressor stator assembly contains the inlet guide vanes and 13 stages of stator vanes. The inlet guide vanes and the first four stages of stator vanes are variable and change their angular position to permit efficient operation throughout the entire speed range. The primary purpose of the compressor section is to compress air for combustion.

2.1.3 Combustion Section. The section includes a combustion chamber and frame, combustion liner, exit guide vanes, and the combustion air deflector. The combustion chamber contains twelve fuel nozzles (FO-13) to provide fuel to the compressed air, and two ignitor plugs to ignite the charge during engine starts. The combustion liner consists of inner and outer shells that are perforated by louvers and thimble hole spaces to provide the airflow required for liner cooling, combustion, and dilution of combustion products to maintain required engine temperatures.

2.1.4 Turbine Section. The section contains the gas generator and power turbines. Both turbines rotate counterclockwise but not necessarily at the same speed, as they are not mechanically coupled to each other. The gas generator turbine rotor (FO-13) receives hot combustion chamber gases, decreases their velocity, and extracts the power necessary to drive the compressor. The remainder of the power generated by the combustion is used to drive the power turbine. The power turbine rotor contains a shaft that extends coaxially through the engine to provide power output. Power turbine speed may be maintained, or regulated independent of output power, when operating within the normal operating range. This principle provides more rapid acceleration because of the availability of high engine torque at low output speeds. The free power turbine principle allows the pilot to set a desired power turbine speed (N_f) with the engine speed control lever. The N_f governor will set the gas generator speed (N_g) at a level necessary to maintain the selected N_f and provide constant rotor rpm (N_r). N_g is primarily dependent upon fuel flow and is monitored by the engine fuel control. N_g is monitored to control acceleration and deceleration characteristics, prevent overspeed, and establish a minimum idle setting. N_f is dependent upon engine speed control lever position, and is monitored to regulate fuel flow to maintain an essentially constant speed for a given engine speed control lever position.

2.1.5 Engine Air Particle Separator (EAPS) System. A removable EAPS (FO-11), in front of each engine air inlet duct is self-cleaning and can be swung away from the engine for maintenance accessibility. The EAPS removes visible moisture, sand, dust, and other foreign particles entrained in the engine inlet air, scavenges and exhausts the foreign particles overboard, and allows clean air to enter the engine. In addition when icing conditions are anticipated, engine ice ingestion can be prevented by manually closing the EAPS doors and keeping them closed until after engine shutdown.

The EAPS control panel on the overhead control panel (FO-1) contains three three-position switches, one for each EAPS. Placing a switch to OPEN manually opens the EAPS door, stops the scavenge blower, and uncleaned air then enters the engine air inlet. Placing a switch to CLOSED manually closes the EAPS door, starts the scavenge blower, and cleaned air then enters the engine air inlet. Placing a switch to AUTOMATIC causes the EAPS door to automatically close below 78 to 88 KIAS, and automatically open above this airspeed.

The EAPS DOOR CLOSED advisory light goes on when all EAPS doors are closed, and goes off when any door is open.

Two redundant primary pressure switches sense when airspeed is above or below 78 to 88 KIAS from the pitot-static system. When the automatic mode is selected the primary pressure switches automatically open the EAPS door above 78 to 88 KIAS and automatically close the door below that airspeed.

Each EAPS contains two separator panels, mounted in a D-shape around the frame, which contain a total of 759 STRATA-TUBES. As the inlet air passes through the STRATA-TUBES, it travels in a cyclonic motion that causes the foreign particles to migrate toward the walls of the tubes and pass into the scavenge ducting. The cleaned air continues on into the engine, and the scavenge blower exhausts the particle-laden scavenge air overboard. The scavenge blower operates whenever the EAPS door is closed and the main transmission oil pressure is above 14 psi.

Each EAPS has a secondary pressure switch that senses when the EAPS is partially clogged from the pressure loss that occurs across the separator panels. When the EAPS is partially clogged below 78 to 88 KIAS the secondary pressure switch causes the EAPS HIGH PRESS LOSS caution light to go on. The caution light is inoperative above 78 to 88 KIAS. When the EAPS is partially clogged below 78 to 88 KIAS and the automatic mode is selected, the secondary pressure switch automatically opens the EAPS door. When the door opens, the secondary pressure switch senses normal pressure and automatically closes the door. In this configuration the door cycles from open to closed and the EAPS HIGH PRESS LOSS caution light and EAPS DOOR CLOSED advisory light alternately go on and off. In addition, if both primary pressure switches fail when operating in the automatic mode the secondary pressure switch automatically opens the door at 120 to 130 KIAS and the door cycles as previously described. With the door closed at 120 to 130 KIAS the secondary pressure switch senses a pressure loss similar to that created by a partially clogged EAPS.

Note

> If all EAPS are in the automatic mode any secondary pressure switch can cause all EAPS doors to cycle.

The automatic control circuit and the EAPS caution light are powered from the No. 1 primary dc bus through a circuit breaker marked EAPS WARN, in the cabin. The manual control circuit is powered from the No. 1 primary dc bus, through a circuit breaker marked EAPS OVRD, in the cabin. This circuit breaker also controls the power supply to the EAPS DOOR CLOSED advisory light. Power is supplied to the No. 1 and 3 EAPS ac-operated scavenge blowers by disconnecting the nose gear box fairing anti-ice controllers, and connecting the nose gear box fairing anti-ice power leads to the scavenge motors. Power is supplied to the No. 2 ac-operated scavenge blower from the No. 2A primary ac bus through three circuit breakers in the cabin marked NO. 2 ENG EAPS BLOWER.

2.1.6 Engine Overspeed Protection System. Each engine has an overspeed protection system to prevent destructive overspeed of the power turbine. The electrical overspeed system is automatically controlled by an overspeed switch at the engine front frame, which receives an electrical signal from the transducer at the rear of the power turbine shaft. The overspeed switch actuates at about 110% ±2% N_f to protect against actual overspeed. A solenoid in the fuel control will energize and reduce fuel flow to 75% N_g. The engine will cycle near 110% until corrective action is taken. The engine overspeed test switches on the master switch panel (FO-1), marked NO. 1, NO. 2, and NO. 3, under the general heading ENGINE OVERSPEED, have marked positions OFF and TEST. The switches provide a test feature only and do not control the overspeed protective circuit. Placing a respective overspeed switch to TEST will energize the fuel control solenoid after 95% ±2% N_f has been attained, with a resultant decrease in operating parameters. Engine overspeed checks are made at 100% N_f and should indicate 100% N_f after the spring-loaded switch is released to OFF. The No. 1, No. 2, and No. 3 engine overspeed protection systems receive power from the No. 1, No. 2, and No. 3 primary dc buses respectively, through three circuit breakers, marked NO. 1, NO. 2, and NO. 3 ENGINE OVSP, respectively, in the cabin.

2.1.7 Engine Fuel System. Each system consists of an engine-driven fuel pump and filtration system, engine fuel control unit, a flow divider, two stator vane actuators, and the fuel manifold and discharge nozzles. The engine-driven fuel pumps are driven by the engine accessory gear box (FO-13). Fuel is supplied from the helicopter fuel system to the filtration system and engine-driven fuel pump, which passes the fuel to the engine fuel control, where it is filtered and metered. The fuel is then passed to the fuel flow divider, where it is filtered and directed to the fuel discharge nozzles. The fuel is first directed to the primary orifice of each nozzle for engine starting; then, as the fuel pressure reaches about 210 psi, fuel is allowed to also flow to the secondary orifice of each nozzle.

2.1.7.1 Engine Fuel Control Unit. The unit (FO-13), mounted on each engine, senses engine speed control lever position, N_g, compressor discharge pressure (P_3), compressor inlet temperature (T_2), N_f, and load signal to hold a desired N_f. N_g is controlled by the power turbine governor and load signal. Major fuel control components consist of a filter, a pressure regulating valve, a metering valve, a computing section, and gas generator and power turbine speed governors. All fuel entering the fuel control passes through the filter to the pressure regulating valve where a constant 40 psi pressure drop is maintained across the metering valve by returning excess fuel to the engine fuel pump inlet. The metering valve controls fuel flow to the engine according to a fuel flow to compressor discharge pressure ratio sensed by the computing section. The N_g governor positions the control to one that matches gas generator speed, and the power turbine speed governor maintains a constant N_f by correcting for any deviation between selected and actual N_f. The engine fuel control functions to prevent compressor stall, turbine overtemperature, rich or lean blowouts, govern gas generator idle and maximum speeds, and schedule inlet guide and stator vane positions to provide optimum compressor performance. Fuel control system malfunctions may be indicated by a relationship of engine speed control lever position to N_f, N_g, T_5, and fuel flow indicator readings. A malfunctioning fuel control will not produce the desired N_f for a corresponding engine speed control lever position, or will cause the engine to accelerate past GRD IDLE. Malfunctions would also be noted on the N_g tachometer by unusual indications and the inability to control the indicated N_f while in the governing range. Malfunction would also be indicated on the T_5 indicator when abnormal temperatures are indicated, excessive temperatures are noted after shutdown, and if the maximum T_5 for topping cannot be reached when the engine is not otherwise limited. Abnormal indications on the fuel flow indicator may also indicate a fuel control malfunction, especially high readings.

2.1.8 Engine Oil System. Each engine has an independent oil tank, a dry sump full scavenge oil system, and is replenished from an auxiliary oil system. Oil is gravity-fed from the oil tank to the oil pump mounted on the rear face of the engine accessory gear box. The oil pump is a six-element gear-type pump with all elements in tandem and driven by a common shaft. One element supplies oil to the engine and the other five elements scavenge the three engine oil sumps plus the accessory gear box. The oil pump distributes the oil under pressure through a filter to the accessory gears and engine bearings. Scavenge oil is used to heat the 6-o'clock frame strut, which aids in engine anti-ice. Oil from the scavenge elements is returned through an oil cooler to the oil tank.

2.1.8.1 Oil Tanks. There is an oil tank installed on the top forward end of each engine. Each fully-serviced tank contains 1.32 gallons of usable oil and expansion space for 1.15 gallons. It also holds 0.10 gallon of unusable oil and 1.45 gallons of dwell oil. It is necessary to have dwell oil in the tank to provide time for air to separate from returning oil. Depletion of dwell oil will furnish air-laden oil to the engine. The tanks shall be serviced by the engine auxiliary oil system.

2.1.8.2 Oil Coolers. The No. 1 and 3 engine oil cooler assemblies (FO-12) are on each nose gear box. Cooling air for the No. 1 and 3 engine oil coolers is supplied by oil cooler blowers, mounted aft of the oil cooler radiators, and belt-driven by the input shaft to the main gear box. The No. 2 engine oil cooler is mounted on the left side of the main gear box oil cooler. Operation of the oil cooler radiators is automatic. For the No. 1 and No. 3 engines, the engine and nose gear box oil cooler cores are housed in the same radiator and use the same blower assembly. The No. 2 engine oil cooler and main gear box oil cooler are in the same radiator. During cold engine starts, high oil pressures may be encountered until the oil has warmed. To hasten the warming of engine oil, oil bypasses the radiator until the oil has warmed, after which it is directed through the cores of the radiator, where it is cooled. The cooling air is exhausted into the helicopter slipstream.

2.1.8.3 Engine Oil Pressure Lights. Each engine oil system has a high/low pressure switch and two caution lights to visually indicate that engine oil pressure is either too low or too high. The caution lights are marked #1, #2, or #3 ENG OIL PRESS LOW or HIGH. The ENG OIL PRESS LOW light will go on whenever oil pressure is 10 ±3 psi or below; and the ENG OIL PRESS HIGH light will go on whenever oil pressure is 100 ±3 psi or above. When abnormal oil pressure indications are noted, all other associated engine instruments should be cross-checked to verify the malfunction. After it has been determined there is a malfunction, if flight conditions permit, the engine should be shut down immediately to prevent further damage. The engine oil pressure caution lights receive power from the emergency dc bus circuit breaker panel in the cockpit through circuit breakers marked OIL PRESS, under the general heading of its associated engine.

2.1.8.4 Engine Oil Low Level Caution Lights. The lights are marked #1, #2, or #3 ENG OIL QTY LOW. With the helicopter in level attitude, illumination of a light indicates the associated tank has been depleted by 25% of its fully serviced capacity and shall be replenished by the auxiliary oil system. The caution lights receive power from the No. 1, 2, or 3 primary dc bus, through circuit breakers, marked #1, #2, or #3 OIL QTY LOW in the cabin, under the general heading of its associated engine.

2.1.8.5 Engine Chip Detector System. Metallic chips circulating in an engine lubrication system are an indication of engine deterioration. Each engine has a chip detector (Figure 2-7) in the engine accessory gear box, that will cause chip locator lights, on the instrument panel, to go on when chips are detected. The engine lubricating system routes lubricating oil past the magnetic chip detector, causing ferrous chips to be deposited on the chip detector. When there are enough chips to form a conductive bridge, an electrical circuit is completed and the chip detector's associated chip locator light goes on. It is possible for conductive nonferrous material to pile up on the chip detector and cause the chip locator light to go on. The CHIP DETECTED caution light goes on simultaneously with the lighting of any chip locator light. The Nos. 1, 2, and 3 engine chip detectors operate the NO. 1 ENG, NO. 2 ENG, and NO. 3 ENG chip locator lights, respectively. Operating power is furnished by the emergency dc bus through three circuit breakers, marked NO. 1 ENG, NO. 2 ENG, and NO. 3 ENG, under the general heading CHIP DETECTOR, in the cockpit.

2.1.8.6 Engine Auxiliary Oil System. The system (Figure 2-1) consists of one tank, equipped with a handpump, three tank-full lights, three selector valves, and the necessary plumbing to allow the system to replenish the oil supply in the engine oil tanks. The engine oil tanks are replenished by holding the appropriate selector valve open and actuating the handpump until the NO. 1, NO. 2, or NO. 3 TANK FULL light goes on.

2.1.8.7 Auxiliary Oil Tank. The tank, on the right-forward side of the cabin compartment, has a capacity of 2.6 U. S. gallons. The tank is equipped with a filler cap, a drain valve, and the necessary plumbing to carry the oil to the handpump.

2.1.8.8 Handpump. This is mounted on the cabin wall next to the auxiliary oil tank, and is manually operated by moving the handle up and down.

2.1.8.9 Engine Oil Full-Level Lights. The lights, marked NO. 1, NO. 2, and NO. 3 TANK FULL, are above the auxiliary oil tank. The lights go on to indicate that the engine oil tanks have been replenished to the full-level by the auxiliary oil system. The lights shall not be used to determine when the engine oil tanks need servicing. The engine oil high-level lights are powered from the No. 3 primary dc bus, through a circuit breaker marked ENG OIL LEVEL, in the cabin.

2.1.9 Engine Speed Control Levers. Three levers, marked SPEED CONT and identified further on the quadrant as NO. 1 ENG, NO. 2, and NO. 3 ENG, with

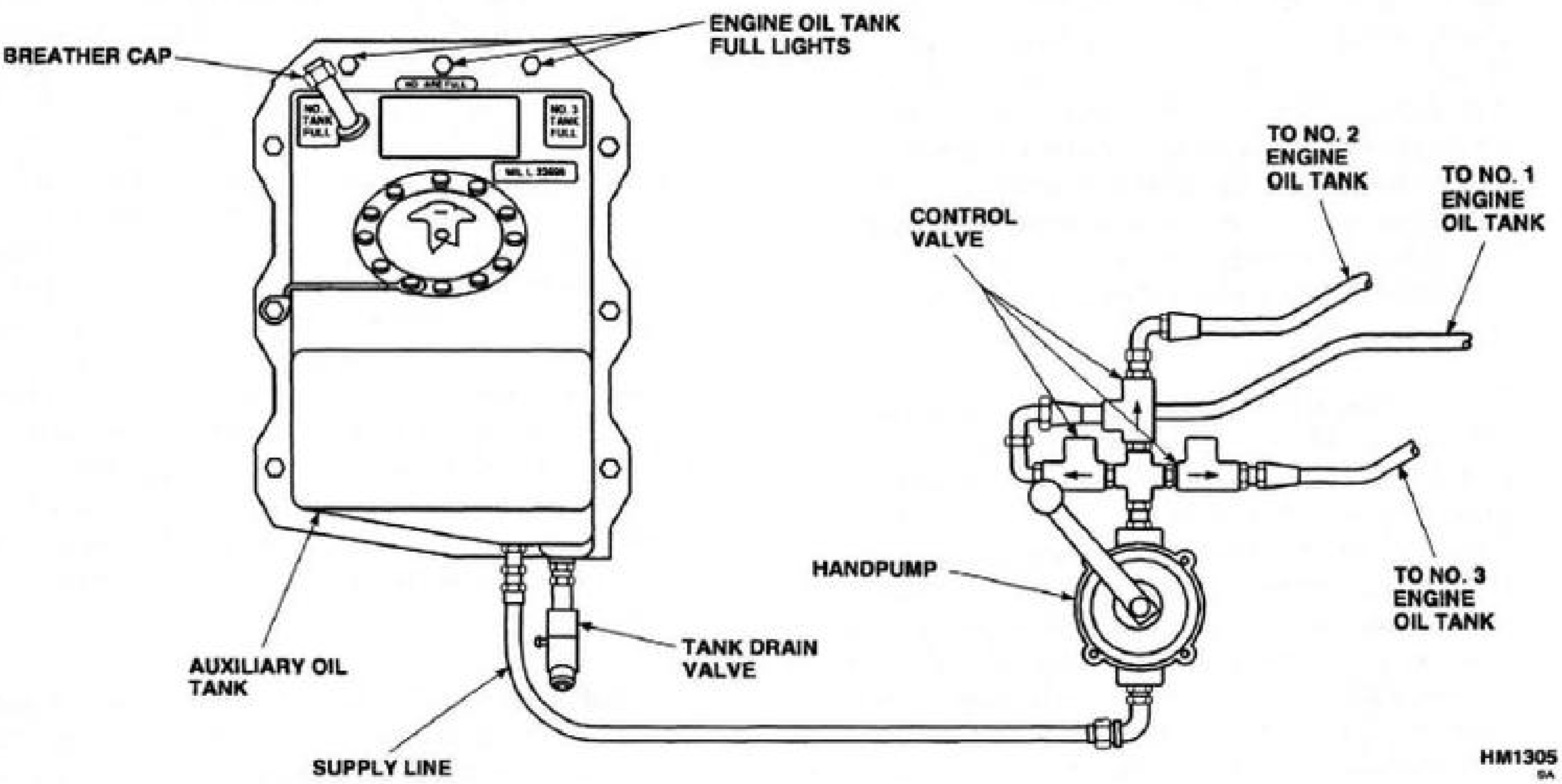


Figure 2-1. Engine Auxiliary Oil System

marked positions SHUT OFF, GRD IDLE, MIN GOV, and MAX GOV, are on the engine control quadrant (FO-1). Moving the engine speed control levers to SHUT OFF will stopcock the engines. The stopcock is open whenever an engine speed control lever is 6.5° or more from SHUT OFF. Ground idle N_g is variable with OAT and its range is 60.5% to 70%. The engine speed control levers may be advanced or retarded from the GRD IDLE stop by pulling down on the engine speed control lever. Engine speed control lever travel is divided between SHUT OFF, GRD IDLE, MIN GOV, and MAX GOV. MIN GOV is the minimum power turbine governing range. MAX GOV produces maximum N_f. Accurate power changes and engine synchronization can be obtained by the engine trim switches, on the collective pitch lever grips. A load signal shaft (collective bias), directly connected to the collective pitch lever by linkage, provides anticipation of load changes for reduction of transient droop; by resetting the fuel control governor proportional to the power required, it maintains rotor speed constant with changes in load. Since the connection of the load signal shaft to the collective is mechanical and fixed, minor changes (increases or decreases) in rotor speed can be experienced as ambient conditions change. Maximum power available is indicated by lack of further increase in N_g, T_5, and N_f, when collective is increased. When at this condition, an increase in speed lever position will not provide an increase in power available. The rotors must be engaged and the engine speed control lever at or above MIN GOV, for the load signal shaft to be effective.

2.1.9.1 Engine Speed Trim Switches. Three switches on each collective pitch lever grip (FO-5) are used to make fine speed adjustments for engine synchronization. Two of the switches are marked #1 and #3 + (plus) and - (minus), under the general heading ENGINE TRIM. The unmarked No. 2 switch is between the #1 and #3 switches and operates the same as the other two. The engine speed trim switches are moved forward to increase engine speed, aft to decrease engine speed, and are spring-loaded to return to the center position when they are released. The pilot's switches always have overriding authority over the copilot's. The engine speed trim switches are effective any time when beeping to increase, but can only be beeped to decrease when the engine speed control levers are above MIN GOV. The No. 1, No. 2, and No. 3 engine speed trim switches receive power from the No. 1, No. 2, and No. 3 primary dc buses, respectively, through three circuit breakers, marked NO. 1, NO. 2, and NO. 3 ENGINE SPEED TRIM, respectively, in the cabin.

2.1.10 Ignition System. The system consists of an ignition unit, two ignitor plugs, and a control circuit for each engine. The system provides ignition for starting only, as combustion is self-sustaining once ignition has been accomplished. Continuous ignition is provided whenever the respective engine anti-ice is selected to reduce the possibility of engine flameout during icing conditions. The system normally operates on 28 vdc. Normally the ignition system circuit operates through the starter relay and will be disconnected from its power source any time the start speed switch or start abort switch deenergizes the starter system control relay. The ignition unit will be energized whenever the starter system control relay is energized and the engine speed control lever is advanced from SHUTOFF to GRD IDLE, or the associated engine anti-ice system is on. The No. 1, No. 2, and No. 3 engine ignition systems receive power from the No. 1, No. 2, and No. 3 primary dc buses, respectively, through three circuit breakers, marked NO. 1, No. 2, and NO. 3 ENGINE IGN EMER (EMER START on helicopters modified by AFC 300) respectively, in the cabin. In addition, on helicopters modified by AFC 300, a NO. 1, NO. 2, and NO. 3 ENG IGN circuit breaker allows turning off electrical power to the respective engine ignitors. The ENG IGN circuit breaker is opened when desired to motor an engine without ignition.

2.1.11 Start System. Each engine start system has a hydraulic starting motor with a speed switch. The speed switch is electrically connected to the main engine start valve to close the start valve upon completion of a starting cycle. Power for starting engines is furnished by the engine start hydraulic pump. Since the engine start pump is driven by the accessory gear box, the APP must be used for all normal ground starts. The APP is not required for airborne starts, as the main rotor head will drive the accessory gear box. When the start valve is energized by depressing the engine starter button, the engine start pump provides 4000 psi hydraulic pressure for engine starting. The starter circuit to the start valve is routed through six protective interlocks. The starter will not operate if any of the interlocks are in this configuration:

1. Pylon is unsafe for flight.
2. Blade fold safety valve is open.
3. Pitch locks are advanced.
4. Rotor brake is not fully pressurized (975 psi).
5. Mechanical gust lock is engaged.
6. Head is not in start position.

An emergency mode that bypasses all interlocks may be selected.

CAUTION

If the emergency start mode is selected, the pilot must be sure the aircraft configuration (such as, head in start position, etc.) and its surrounding area is safe for engine start.

When the rotor is turning and main gear box oil pressure is up, as evidenced by the MGB OIL PRESS caution light going off, an oil pressure switch automatically causes the pitch locks advanced interlocks to be bypassed. When airborne, the rotor brake not fully pressurized, mechanical gust lock engaged, and head not in start position, interlocks are automatically bypassed by a microswitch on the main landing gear scissors switch.

The ENG STARTER ON advisory light will go on any time a starter circuit is energized. The start system cannot be energized unless the engine speed control lever is at SHUT-OFF. Fuel will be supplied to the fuel control when the fuel control lever is placed to DIRECT or either crossfeed position, and the engine is motoring. Low or inadequate fuel pressure will be indicated by the #1, #2, or #3 ENG FUEL BOOST caution lights. With the starter and ignition systems energized, the engine will start and accelerate as the engine speed control lever is moved to GRD IDLE. The starter speed switch will then automatically deenergize the ignition and start systems, and ignition will be self-sustaining. If the speed switch does not automatically disengage, the starter will have to be manually disengaged.

2.1.11.1 Start Switches. The switches, one for each engine, are in the engine control quadrant behind the appropriate engine speed control lever (FO-1). The starter circuit is energized by holding the speed control lever at SHUT OFF and depressing the starter button, which energizes the start switch, start valve, ENG STARTER ON advisory light, and starter control relay. The starter control relay and start valve are energized through the speed switch as soon as the start switch is activated. Therefore, the start switch does not have to be continually activated throughout the starting cycle, and the speed switch will automatically deactivate the starter circuit as soon as cutout speed is reached. If the speed switch should fail, the engines may be started by manually overriding the start system. The manual override system is used only when it is necessary to make an alternate engine start. An alternate engine start is made by keeping the starter button depressed until N_g readings reach the normal starter drop out of 51% to 58% N_g. The No. 1, No. 2, and No. 3 engine starting circuits receive control power from the No. 1 primary dc bus through a circuit breaker marked NO. 1 ENGINE START CONT, in the cabin. In addition, the No. 1, No. 2, and No. 3 engine starting circuits operate on power from the No. 1, No. 2, and No. 3 primary dc buses, respectively, through three circuit breakers, marked NO. 1, NO. 2, and NO. 3 ENGINE IGN EMER (EMER START on helicopters modified by AFC 300), respectively, in the cabin.

2.1.11.2 Emergency Start Switch. The switch, marked EMER START, with marked positions NORM and EMER, is on the emergency control panel (FO-1). With the switch at NORM, any one of the six protective interlocks can prevent the starter from operating, if the interlocks are not automatically bypassed by the helicopter configuration. The EMER position bypasses all six interlocks for emergency starts.

Note

All six interlocks should be bypassed in flight; however, to be sure the starter will operate in case of an emergency airstart, the switch should be placed to EMER.

2.1.11.3 Start Abort Switch. The switches, one for each engine, are in the engine control quadrant behind the appropriate engine speed control lever. The abort switch, when activated by pulling down on the appropriate engine speed control lever, deactivates the starter circuit by deenergizing the starter control relay.

Note

Since the start abort switches do not shut off fuel flow to the engines, the engine speed control lever should also be placed to SHUT OFF when aborting an engine start.

2.1.12 Engine Start Head Position Switch. The ENG ST HEAD POS switch positions the head for engine start so that hot engine exhaust gases do not damage the main rotor blades (Figure 7-3). The switch (spring-loaded to off) is on the pilot's overhead control panel. It uses the same hydraulic system that positions the head for blade and pylon fold. An advisory light, marked ENG START HD POS, indicates when the head is in the proper position. The advisory light will operate only while the ENG ST HEAD POS switch is held on. After the head positions, an additional 5 to 6 seconds are required before the ROTOR

BRAKE ON advisory light goes back on. An interlock prevents engine start until the head is in the proper position.

2.1.13 Engine Instruments. The engine instrumentation system provides the pilot with indications of proper and efficient engine operation, and warns of unsafe engine operating conditions.

2.1.13.1 Torquemeters. Two torquemeters (FO-5) are on the instrument panel one in front of each pilot. Each torquemeter is marked TORQUE % × 10 and contains three tape indicators, marked 1, 2, and 3, which indicate the amount of torque produced by each engine. (100% torque is the equivalent of 3200 hp at 100% N_r for each engine.) The torquemeter also contains a power failure flag marked OFF that will appear in a window whenever electrical power is removed from the torque system, and a torque digital window marked TOTAL. The TOTAL window displays the total average torque of the three engines. For example, with three engines operating at 100% the window will read 100%; with one engine shut down and the other two operating at 100%, (100% total average torque is the equivalent of 9600 hp from three engines) the window will read 66%. The torquemeter faces, marked in percent torque, are marked in units of 10% from 0% to 160%. Torquemeters are necessary so the pilot may monitor the power output of each engine and also limit the power output, to prevent overtorquing the engines or main gear box. The torque sensing system contains a shaft connected to the engine load and a reference sleeve. Both the shaft and sleeve have teeth machined on their outside diameter for torque measuring purposes. As the shaft rotates, the twist caused by the engine load will displace the teeth from each other. This displacement produces a phase angle difference that is converted to a proportional output voltage, which is read on the torquemeter as percent of torque. The emergency ac bus furnishes power to the torquemeters through two circuit breakers in the cockpit, marked TORQUE PILOT and TORQUE COPILOT.

2.1.13.2 Overtorque Warning System. Helicopters modified by AFC 307 have an overtorque warning system to alert the pilots when conditions exist which may cause engine overtorque or high tail rotor stress. The ENGINE OVERTORQUE caution light goes on anytime total engine torque is over 137%. The TAIL ROTOR HIGH STRESS caution light goes on when all these conditions occur: indicated airspeed is greater than 60 knots, average engine torque is equal to or greater than 110%, and climb rate is greater than 2800 feet-per-minute. When any of the initiating conditions are removed, the caution lights will go off. The overtorque warnings are initiated from the overtorque warning unit in the left electronics bay. It takes its signal for the ENGINE OVERTORQUE caution light from the copilot's triple torque indicator. Signals for the TAIL ROTOR HIGH STRESS caution light come from the pilots' triple torque indicators and the air data transducer, which provides both vertical velocity and airspeed information. Power for the system is provided from the No. 3 primary dc bus through a circuit breaker marked OVER TRQ WARN.

2.1.13.3 N_f/N_r Tachometers. Two quad tape tachometers (FO-5) are on the instrument panel, one in the pilot's instrument group and one in the copilot's instrument group. Each tachometer contains four tape indicators. The indicators marked 1, 2, and 3 indicate the power turbine speed of the No. 1, No. 2, and No. 3 engines, respectively, and the indicator marked R indicates main rotor speed. An OFF flag indicates electrical power removal. Each engine tachometer and the rotor tachometer are powered by their own tachometer-generator. Each indicator dial, marked TACH % RPM X 10 ENG, 1, 2, 3, and R, is marked in units of 20%, from 0% to 80%; 10%, from 80% to 90%; 2%, from 90% to 110%; and 10%, from 110% to 130%. A green RTR BK light, on the lower portion of the tachometer, goes on whenever N_r is between 50% ±4% and 25% ±4%. The emergency ac bus furnishes power to the tachometers through a circuit breaker in the cockpit, marked QUAD TACH. On aircraft with AFC 490, there are two circuit breakers marked PILOT and COPILOT under the general heading of QUAD TACH.

2.1.13.4 N_g Tachometers. Three gas generator tachometers (FO-5), one for each engine, are on the instrument panel. They indicate gas generator speed in percent of total rpm. Each engine gas generator tachometer is powered by a tachometer-generator that is mounted on, and driven by, the engine accessory gear box assembly.

2.1.13.5 T_5 Gage. Three power turbine inlet temperature indicators (FO-5), one for each engine, are on the instrument panel. The indicators are marked in degrees Celsius and operate from thermocouples in the turbine casing of each engine. The Nos. 1, 2, and 3 power turbine inlet temperature indicators are powered from the emergency ac bus through three circuit breakers, marked NO. 1, NO. 2, and NO. 3 ENGINE PTIT (T_5), respectively, in the cockpit.

2.1.13.6 Fuel Flow Indicators. Three indicators (FO-5), on the instrument panel, are calibrated in pounds-per-hour, and indicate the fuel consumption of the engines. The No. 1 and No. 3 indicators receive power from the No. 1 and No. 3 primary ac buses through two circuit breakers, marked NO. 1 and NO. 3 ENGINE FUEL FLOW, respectively, in the cabin. The No. 2 indicator receives power from the No. 2B primary ac bus through a circuit breaker marked NO. 2 ENG FUEL FLOW, in the cabin.

2.1.13.7 Engine Oil Temperature Gages. Three engine oil temperature gages (FO-5), on the instrument panel, are marked in degrees Celsius and indicate the engine oil temperatures sensed by each engine oil temperature bulb, on each engine oil inlet line. The Nos. 1, 2, and 3 gages receive power from the No. 1, No. 2, and No. 3 primary dc buses through three circuit breakers marked NO. 1, NO. 2, and NO. 3 ENGINE OIL TEMP, respectively, in the cabin.

Note

> The engine oil temperature gages should be constantly monitored when the engines are operating and the rotor is not turning, because the engine oil cooler blowers are not operating.

2.2 ROTOR SYSTEMS

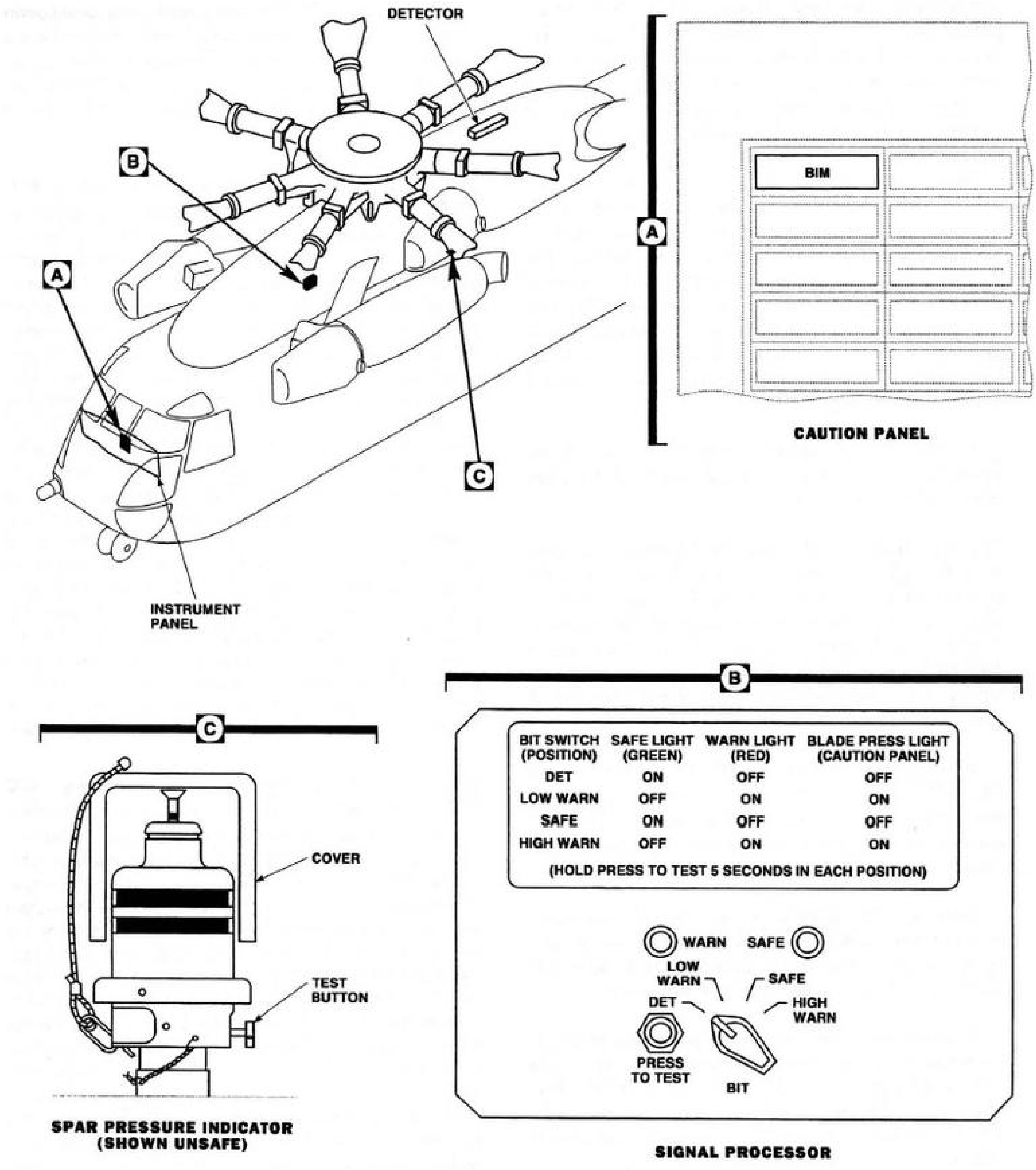
The rotor systems consist of a single, articulated main rotor and an antitorque tail rotor. Both systems are driven by the engines through the transmission system, and are controlled by the flight controls.

2.2.1 Main Rotor System. The main rotor system consists of the rotor head assembly (FO-11) and seven rotor blades. The rotor head assembly, mounted directly to the output shaft of the main gear box, consists of a hub assembly and a swashplate assembly. The hub assembly, consisting of the upper and lower hub plates, seven sleeve-spindle assemblies, and seven hydraulic dampers, is splined to the main rotor drive shaft. The root ends of the rotor blades are attached to extenders that, in turn, are attached to the sleeve-spindle assemblies, which permit each blade to flap vertically, hunt horizontally, and turn about their span-wise axis. Antiflapping restrainers and droop stops prevent excessive flapping of the blades when the main rotor head is static or is turning at low rpm. The antiflapping restrainers are automatically released as rotor speed is increased to about 25%, while the droop stops are automatically released as main rotor speed is increased to about 75%. The hydraulic dampers minimize the hunting movement of the blades about the vertical hinges as they rotate, prevent shock to the blades when the main rotor head assembly is started or stopped, and position the blades against the lag stops after rotor shutdown. The swashplate assembly consists of a rotating swashplate, driven by the main rotor hub assembly, and a stationary swashplate that is secured to the main gear box by a scissors assembly, to prevent rotation. The swashplate assembly is mounted on a ball ring and socket assembly that keeps it parallel at all times, but allows it to be tilted, raised, or lowered by components of the flight control system control connected to the stationary swashplate. Cyclic or collective pitch changes introduced at the stationary swashplate are transmitted to the blades by linkage on the rotating swashplate. A blade positioner assembly, installed on the back of the main gear box, will position the rotor blades before folding if it has been activated. The blade positioner also positions the head for engine starting.

2.2.1.1 Main Rotor Blades. The rotor blades (FO-11) are attached to extenders that, in turn, are attached to the sleeve-spindle assemblies on the rotor hub assembly. The blades have an abrasion strip bonded to the leading edge to prevent damage from dust and adverse weather conditions. The blades are made by forming a fiberglass and resin airfoil around a tubular titanium spar. Each rotor blade has a light assembly installed on the top of the blade tip to provide tip path lighting. Each rotor blade spar is pressurized and incorporates a spar pressure indicating system for spar crack detection.

2.2.1.2 IBIS (In-Flight Blade Inspection System). The system (Figure 2-2) consists of each main rotor blade's spar being pressurized with nitrogen to about 10 psi at an ambient temperature of 18° to 24°C, a pressure indicator (with a radioactive source) on the root of each spar, a radiation detector aft of the main rotor pylon area, a signal processor with a test panel in the cabin, and a BIM® (Blade Inspection Method) caution light. For visual inspection the pressure indicator shows two white stripes indicating spar pressure is safe. If spar pressure drops to 5 ±0.5 psi or less, the pressure indicator will show two black stripes, indicating pressure is escaping through a crack in the spar or through a faulty seal. A pressure indicator with a safe indication (two white stripes) can be checked by pressing the manual test button, on the indicator, causing an unsafe indication (two black stripes) to be displayed. Once two black stripes are displayed, regardless of the cause, the reset button, on the pressure indicator, has to be pressed to replace the black indication with a white indication, if spar pressure is normal. The test button is always pressed with the clear plastic shield over the indicator to prevent radiation escape.

The pressure indicator contains a radioactive source that is shielded when the indicator is at the safe (white) indication. When the indicator goes to the unsafe (black) position the radioactive source moves out of the shielded



BIT SWITCH (POSITION)	SAFE LIGHT (GREEN)	WARN LIGHT (RED)	BLADE PRESS LIGHT (CAUTION PANEL)
DET	ON	OFF	OFF
LOW WARN	OFF	ON	ON
SAFE	ON	OFF	OFF
HIGH WARN	OFF	ON	ON

(HOLD PRESS TO TEST 5 SECONDS IN EACH POSITION)

Figure 2-2. IBIS (In-Flight Blade Inspection System)

position and is exposed. As the rotating unsafe blade passes over the radiation detector the radioactive rays being released by the blade's unsafe indicator are sensed by the radiation detector. This sends an electrical signal to the signal processor, that deenergizes a relay in the processor and causes the BIM caution light to go on.

To be sure the detector is capable of detecting radiation, a small radioactive source, incorporated in the detector, continuously emits radiation at a lower rate than the radioactive source in the spar pressure indicator. The detector continuously senses its own radiation and sends a signal to the signal processor to energize a relay that extinguishes the BIM caution light. Therefore, loss of pressure in the spar, failure of the radiation detector, failure of the signal processor, or loss of 115 vac will result in the BIM caution light going on.

The No. 3 primary ac and the No. 2 primary dc buses furnish power to the system through two circuit breakers marked BIM, in the cabin.

2.2.1.3 Signal Processor Test Panel. The panel is on the signal processor (Figure 2-2), which is in the center of the cabin on the right side. The panel is used for built-in-test (BIT), to verify operation of the radiation detector and the signal processor. The panel contains a BIT SWITCH, a PRESS-TO-TEST pushbutton, a red WARN light, a green SAFE light, and a decal that gives the BIT procedure and the desired displays.

Selecting DET with the BIT SWITCH and pressing the PRESS-TO-TEST pushbutton simulates the detector's normal sensing of its own low radiation rate and lights the green SAFE light. This is an operational checkout of the detector.

Selecting LOW WARN and pressing the pushbutton simulates loss of the detector's own low radiation rate and lights the BIM caution light and the red WARN light. This is a functional checkout of the signal processor.

Selecting SAFE and pressing the pushbutton simulates the detector's normal sensing of its own low radiation rate and lights the green safe light. This is a functional checkout of the signal processor. The BIM caution light goes on for 8 to 12 seconds when the PRESS-TO-TEST pushbutton is released.

Selecting HIGH WARN and pressing the pushbutton simulates the detector sensing a high radiation rate from a spar pressure indicator with low pressure. The BIM caution light goes on for 8 to 12 seconds and the red WARN light comes on. This is a functional checkout of the signal processor.

2.2.2 Tail Rotor System (Not Modified by AFC 397). The system consists of the rotor hub assembly, sleeve and spindle assembly, pitch-changing mechanism which is supported by a bearing housing, and four rotor blades. The rotor hub assembly, mounted on the upper end of the pylon, is splined to and driven by the output shaft of the tail gear box. The rotor blades are attached to the sleeve and spindle assembly and flapping hinges, which permit them to flap and turn about their spanwise axis for pitch variation. Flap restrainers are provided to prevent the tail rotor blades from flapping when the tail rotor is stopped. The spar of each blade is pressurized for crack detection. A BIM pressure indicator is at the root of each blade. Any display of black on the indicator is an indication that spar pressure is below the minimum pressure and a cracked spar is suspect. A lever on the side of the indicator is used for testing. Pressing and holding the lever should give an all black (unsafe) indication (Figure 2-3) in 10 to 30 seconds. When the lever is released, the black indication should disappear immediately and the all white (safe) indication is displayed. The leading edge is protected by a nickel abrasion strip. A tail rotor positioning actuator provides for positioning and locking of the tail rotor so it will not turn during pylon folding operations.

2.2.3 Tail Rotor System (Modified by AFC 397). The system consists of the rotor hub assembly, sleeve and spindle assembly, pitch-changing mechanism which is supported by a bearing housing, and four rotor blades. The rotor hub assembly, mounted on the upper end of the pylon, is splined to and driven by the output shaft of the tail gear box. The rotor blades are attached to the sleeve and spindle assembly and flapping hinges, which permit them to flap and turn about their spanwise axis for pitch variation. Flap restrainers are provided to prevent the tail rotor blades from flapping when the tail rotor is stopped. The blades are all composite construction of laminated skin over an I-beam and honeycomb core. The leading edge is protected by a nickel abrasion strip. A tail rotor positioning actuator provides for positioning and locking of the tail rotor so it will not turn during pylon folding operations. A high strength roller and the instal-

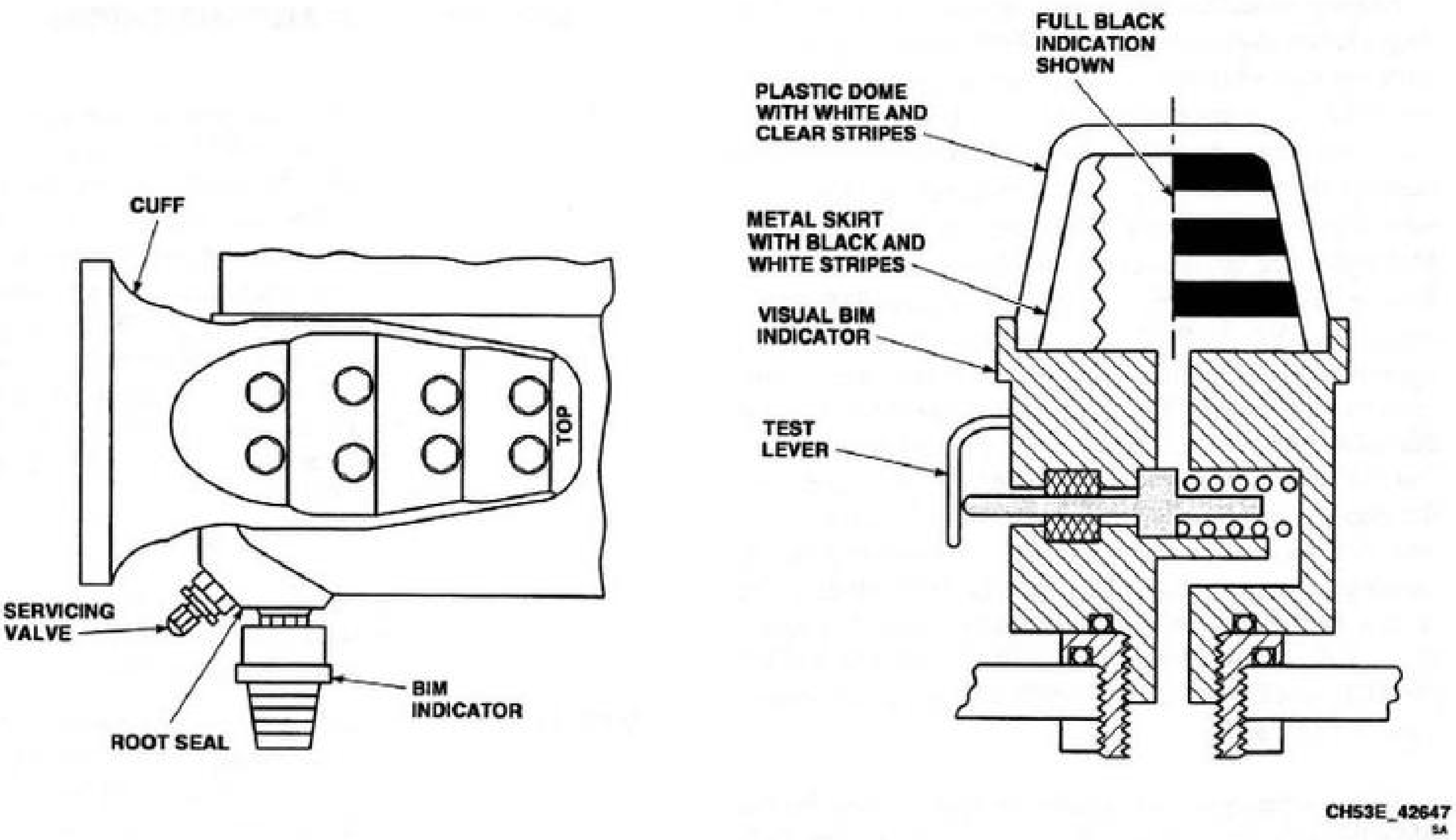


Figure 2-3. Tail Rotor BIM Indicator

lation of a block at the inboard end of the tail gear box horn allow engagement when the actuator is fully extended. The block reacts to the side loads from the blade positioner cam and thus reduces loads at the actuator mounting bolts.

2.2.4 Bearing Monitor System (AFC 491). The bearing monitor system (BMS) senses vibration and temperature levels of the swashplate and the tail rotor drive shaft (TRDS) disconnect coupling bearings. The BMS provides cockpit and cabin indications of degraded bearing condition. Primary BMS components include the following:

1. Two independent compound (vibration/ temperature) sensors on the main rotor swashplate, one sensor on the tail rotor drive shaft (TRDS) disconnect coupling duplex bearing housing, and one sensor on the main transmission oil cooler support

2. BEARING VIB LIMIT, BEARING TEMP DETECT, and BEARING TEMP LIMIT caution lights on the caution/ advisory panel (FO-7)

3. Bearing monitor panel (BMP) on the left side of the cabin wall, forward of the gunner's window (Figure 2-4)

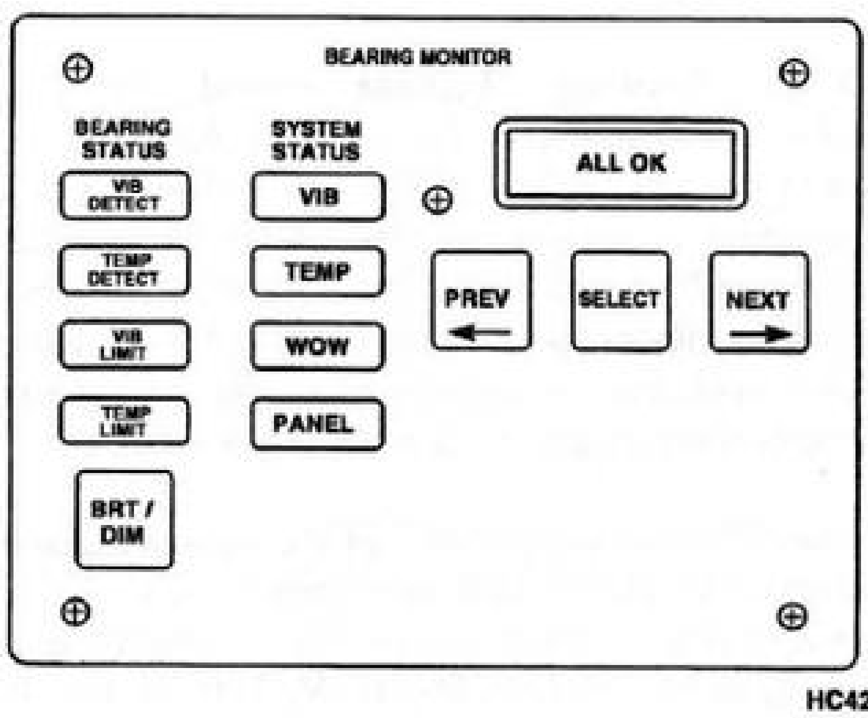


Figure 2-4. Bearing Monitor Panel (BMP)

The swashplate and TRDS disconnect coupling compound sensors send vibration and temperature signals to the BMP. The compound sensor on the main transmission oil cooler support is currently disabled. The BMP monitors, analyzes, and conditions these input signals. If the BMP identifies a signal that may indicate a degraded bearing condition, it gives cockpit and/or cabin indications as necessary.

Bearing condition indications depend on the level of degradation determined by the BMP using sensor temperature and vibration signals. Normal bearing wear is indicated by a gradual increase in bearing vibration levels over time. Bearing failure is caused by excessive bearing temperature that may or may not be associated with high vibration levels. Under normal conditions, the BMP lights are off. If bearing vibration levels are higher than normal, the VIB DETECT light on the cabin BMP panel comes on. VIB DETECT indicates that the bearing is approaching replacement limits. If vibration levels continue to increase, the VIB LIMIT light on the BMP and the BEARING VIB LIMIT caution light in the cockpit come on. The VIB LIMIT and BEARING VIB LIMIT lights indicate that the bearing has reached the replacement limit for vibration. If a bearing temperature level indicates a possible bearing failure, the TEMP DET and/or TEMP LIMIT lights on the BMP come on with their related cockpit caution lights. Refer to the BEARING VIB LIMIT, BEARING TEMP DETECT, or BEARING TEMP LIMIT Caution Lights procedure in Chapter 12.

The emergency dc bus supplies electrical power for the BMS through the BRG MON circuit breaker. The BRG MON circuit breaker is on the cockpit overhead circuit breaker panel.

2.2.4.1 Bearing Monitor Panel. The bearing monitor panel (BMP) in the cabin is the heart of the bearing monitor system. If there is a bearing and/or system fault condition, the BMP allows the operator to isolate the fault source(s). The BMP also provides for diagnostic information and built-in test (BIT) functions for aircrew and maintenance personnel. These functions are normally done during pre/postflight maintenance.

The BMP has four BEARING STATUS annunciator lights and four SYSTEM STATUS annunciator lights. An eight-character alphanumeric display shows system status or bearing/sensor location. The PREV, SELECT, and NEXT switches provide for operator select menu options. A BRT/DIM switch adjusts the display intensity. The BMP is NVG-compatible.

BMP BEARING STATUS INDICATORS

VIB DETECT — The BMS has sensed bearing vibration level(s) which are higher than normal. VIB DETECT indicates that swashplate bearing vibration levels have reached 1.2 g's or TRDS disconnect coupling bearing vibration levels have reached 1.5 g's. The bearing is approaching replacement criteria and will require maintenance action. For aircrew actions, refer to the Aircrew Pocket Checklist, A1-H53BE-NFM-900.

NOTE

Vibration limit levels are multi-sample averages and may not correspond to a one-time VATS reading.

TEMP DETECT — The BMS has sensed bearing temperature level(s) which are higher than normal. The BEARING TEMP DETECT caution light also comes on in the cockpit. TEMP DETECT indicates a bearing has reached 275°F and may be progressing toward failure. For pilot/aircrew actions, refer to Chapter 12.

VIB LIMIT — The BMS has sensed bearing vibration level(s) which are beyond normal replacement limits. VIB LIMIT indicates that swashplate bearing vibration levels have reached 2.5 g's or TRDS disconnect coupling bearing vibration levels have reached 4.0 g's. The BEARING VIB LIMIT caution light also comes on in the cockpit. For pilot/aircrew actions, refer to Chapter 12.

TEMP LIMIT — The BMS has sensed bearing temperature level(s) which are beyond maximum limits. The BEARING TEMP LIMIT caution light also comes on in the cockpit. TEMP LIMIT indicates a bearing has reached 350°F and is indicative of impending bearing failure. For pilot/aircrew actions, refer to Chapter 12.

SYSTEM STATUS INDICATORS

VIB	The vibration signal from any bearing sensor has failed.
TEMP	The temperature signal from any sensor has failed.
WOW	A weight-on-wheels signal fault has been detected.
PANEL	The BMP has an internal hardware or software failure.

The BMP alphanumeric display normally shows ALL OK. With an ALL OK indication, the PREV and NEXT switches change menu selections between LMP TEST, SYS TEST, and RESET. The SELECT switch starts the function shown on the display. The system provides for identifying a failed sensor or a sensor that is signalling a bearing degradation (VIB DET, VIB LIMIT, TEMP DET, or TEMP LIMIT light is on). The sensor status is shown by either the bearing or system status indicators. If the BMS indicates a system fault, refer to the applicable maintenance manuals for alternate bearing inspection requirements.

Note

- A plus sign (+) next to a fault indication means that additional faults exist. The PREV or NEXT switches let the operator review the status of other sensors. If the sensor shown on the BMP display is sending a sensor fault signal, an appropriate SYSTEM STATUS annunciator light comes on. If the sensor is indicating high vibration or temperature levels, an appropriate BEARING STATUS annunciator light comes on.

- Failure of both the swashplate (SP) SP1 and SP2 sensors, or failure of the bearing monitor panel (BMP) will result in a loss of swashplate monitoring capabilities. Refer to Chapter 12 for pilot/aircrew actions.

- Swashplate temperatures above 230°F will cause attenuation of signals from the vibration portion of compound sensors and will result in a VIB fault light and the corresponding alphanumeric display on the BMP.

BMS SENSOR LOCATION INDICATIONS ON THE BMP ALPHANUMERIC DISPLAY

SP-1 or SP-2	Swashplate
DISC	Tail rotor drive shaft disconnect coupling
TDS-2 through TDS-5	Tail rotor drive shaft bearings (N/A with AFC 491)
T-REF	Thermal reference sensor on the main transmission oil cooler support (N/A with AFC 491)
WOW NG	Weight-on-wheels
PNL NG	BMS bearing monitor panel

When a bearing or system fault is detected, the alphanumeric display reads FAULT instead of ALL OK and the associated bearing or system status light comes on. The operator can use PREV or NEXT to get the LMP TEST, SYS TEST, and RESET menu options.

Note

- Bearing and system faults are held in the non-volatile RAM of the BMP after electrical power is removed from the bearing monitor system. Existing BMS faults are seen each time electrical power is applied. The only way to reset the system is with the RESET switch.

- The system test cannot be done while the helicopter is off the ground (no WOW).

2.3 TRANSMISSION SYSTEM

The system (Figure 2-5) consists of two nose gear boxes, a main gear box, an accessory gear box, an intermediate gear box, and the tail rotor gear box. A freewheeling unit, at each main gear box input, permits any or all engines to be disengaged from the main gear box. The freewheeling units can disengage the engines during autorotation, or one or two engines for single- or dual-engine operation, or any time engine rpm decreases below rotor rpm.

CAUTION

Whenever accelerating an engine to re-match N_g/N_r, carefully advance the SCL to avoid abruptly reengaging the free wheeling unit (FWU) which may cause/contribute to FWU failure.

Engine torque is transmitted, through the No. 1 and No. 3 engine nose gear boxes and the gimbal assembly on the main gear box accessory section for No. 2 engine, to the main gear box, where it is transmitted to the main rotor drive shaft and aft to the tail rotor drive shaft. The tail rotor drive shaft transmits the torque to the intermediate gear box at the base of the pylon. From the intermediate gear box, a pylon drive shaft extends upward to the tail rotor gear box to drive the tail rotor. All six gear boxes have chip detectors. The main gear box has five, the accessory gear box has two, and the intermediate, tail rotor and both engine nose gear boxes each have one.

2.3.1 Nose Gear Boxes. The nose gear boxes (Figure 2-5), each forward of the No. 1 and No. 3 engines, contain high-speed bevel gears that reduce engine rpm from 14,280 rpm to about 6323 rpm for input into the main gear box. The input drive to the main gear box from the No. 2 engine is through a gimbal assembly. Initial reduction gearing for the No. 2 engine is contained in the main gear box.

2.3.2 Main Gear Box. The gear box (Figure 2-5), mounted above the cabin, couples the three engine inputs and provides output power for the main rotor head and tail rotor and accessory gear boxes. The main gear box reduces the 6323 rpm inputs to 179 rpm (100% N_r) for the rotor head, and to 4271 rpm for the intermediate gear box. Shafting extends vertically from the main gear box to the main rotor head, and aft from the rear cover housing to the intermediate gear box. The main gear box also drives the main gear box accessory section, which drives the No. 2 engine and main gear box oil cooler, the No. 2 generator, the rotor tachometer-generator, and the first-stage servo hydraulic pump. The main gear box drives the accessory gear box when N_r exceeds APP rpm, or when APP is not operating.

2.3.3 Accessory Gear Box. The accessory gear box (Figure 2-5), mounted forward of the main gear box, drives the No. 1 and No. 3 generators, second-stage servo hydraulic pump, engine start hydraulic pump, utility hydraulic system pump, and the accessory gear box oil pump. The accessory gear box may be driven by the main gear box when the main rotor is turning, or by the APP when the rotor is stopped. The APP, forward of the accessory gear box, is connected to the accessory gear box through a clutch and shaft assembly. The APP will drive the accessory gear box until the main gear box drive rpm exceeds APP rpm. The clutch disengages the APP from the accessory gear box when the APP is shut down.

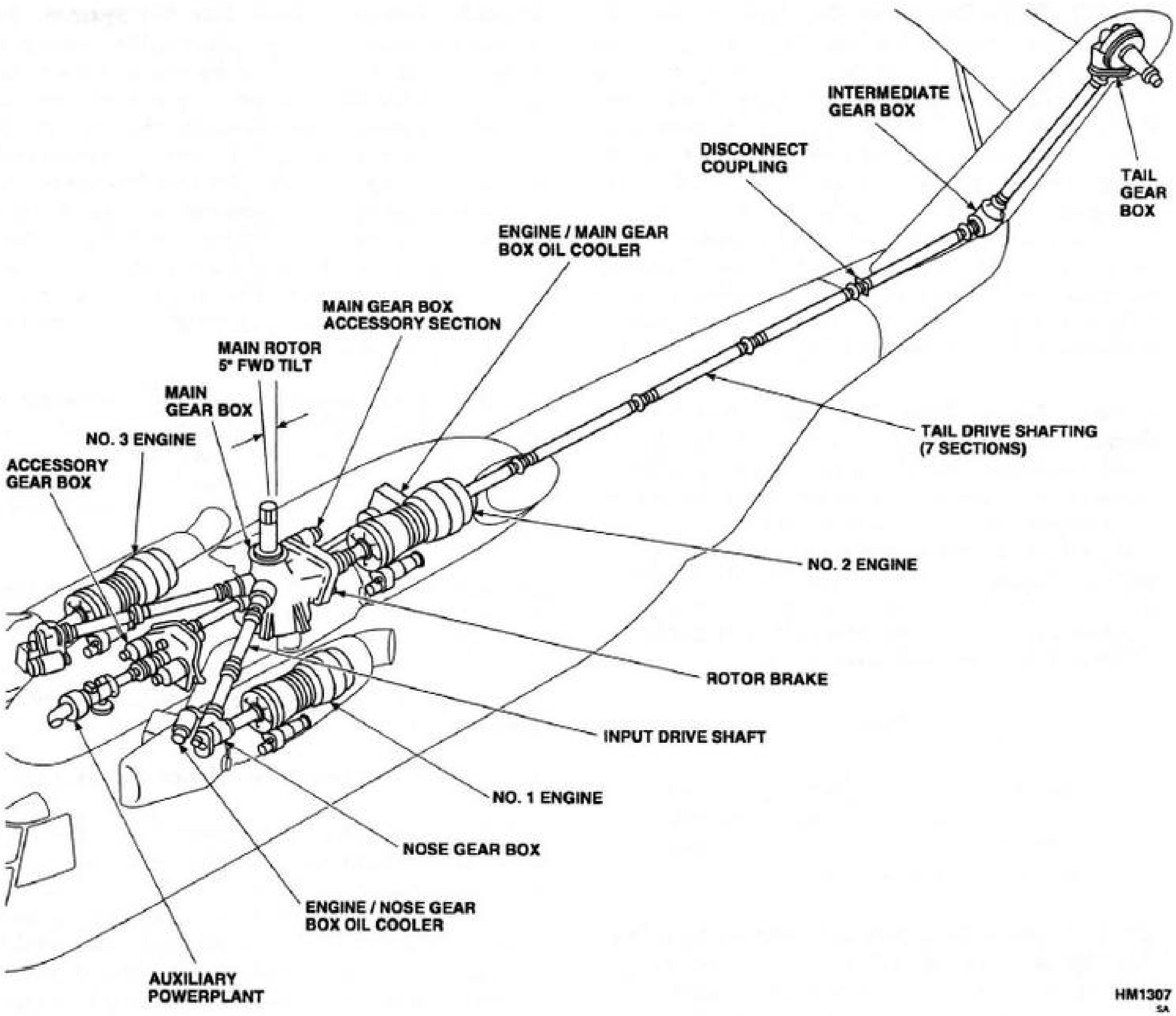


Figure 2-5. Transmission System

2.3.4 Intermediate Gear Box. The intermediate gear box (Figure 2-5), at the base of the tail rotor pylon, changes the angle of drive and provides an rpm reduction from 4271 to 2628 rpm.

2.3.5 Tail Rotor Gear Box. The tail rotor gear box (Figure 2-5), at the upper end of the tail rotor pylon, provides power transmission through a right angle at a reduction in rpm from 2628 to 699 rpm.

2.3.6 Transmission Oil Systems. Each of the six transmission system gear boxes has an individual oil system and all are pressure-lubricated.

2.3.6.1 Nose Gear Box Oil Systems. Each of the nose gear boxes is pressure-lubricated by a gear-type oil pump mounted on the lower housing of the gear box. Oil pressure is controlled by a pressure regulating valve, and oil temperature is controlled by the nose gear box oil coolers. After passing through the oil cooler, the oil is returned to the gear box and sprayed through jets to lubricate the gears and bearings. Each gear box has a filter, oil filler, drain plug, chip detector, and dipstick. The nose gear box is serviced through a filler port, on top of each gear box, and holds 5.5 quarts of usable oil.

2.3.6.2 Nose Gear Box Oil Coolers. These oil coolers (Figure 2-5) use the blower and ducting of the engine oil cooler system; however, the nose gear box oil coolers have individual cooler radiators and plumbing. The oil cooler assemblies are inboard of the nose gear boxes. Cooling air for the oil coolers is supplied by oil cooler blowers that are mounted aft of the oil cooler radiators and are belt-driven by the input shaft to the main gear box. During cold starts, high oil pressure may be encountered until the oil is warm. In this case oil bypasses the radiator until it has warmed. Once the oil is warm, it is directed through the cores of the radiator for cooling, then returned through external lines to the gear boxes.

2.3.6.3 Nose Gear Box Oil Temperature Gage. The gages (FO-5), on the instrument panel, indicate the oil temperature of a respective nose gear box in degrees Celsius, and indicate the temperature of the oil in the nose gear box sump. The temperature is sensed by a bulb on the front cover of each nose gear box. The No. 1 and No. 3 gages receive power from the No. 1 and No. 3 primary dc buses, respectively, through two circuit breakers, marked NO. 1 ENGINE NGB TEMP and NO. 3 ENGINE NGB TEMP, respectively, in the cabin.

Note

Nose gear box oil temperature indicated on the gage is detected from a separate source and may not coincide with nose gear box oil hot caution light illumination.

2.3.6.4 Nose Gear Box Oil Temperature Caution Lights. The #1 and #3 NGB OIL HOT caution lights are activated by a plugstat temperature control unit installed in each nose gear box. Each plugstat has switch contacts that close when the oil temperature reaches 121 ±5.5°C, completing a circuit to light the warning lights on the caution panel. The caution light indicates the nose gear box oil temperature after it leaves the nose gear box oil cooler. The #1 and #3 NGB OIL HOT caution lights receive power from the No. 1 and No. 3 primary dc buses, respectively, through two circuit breakers, marked NO. 1 ENGINE NGB HOT and NO. 3 ENGINE NGB HOT, respectively, in the cabin.

2.3.6.5 Nose Gear Box Oil Pressure Caution Lights. The #1 and #3 NGB OIL PRESS caution lights will go on when the oil pressure decreases to 14 ±2 psi. The caution lights receive power from the emergency dc bus through two circuit breakers, marked NO. 1 ENG NGB OIL PRESS and NO. 3 ENG NGB OIL PRESS, in the cockpit.

2.3.6.6 Accessory Gear Box Oil System. The accessory gear box is pressure-lubricated by a vane-type pump mounted on the back of the accessory case. The gear box is internally-lubricated and does not incorporate oil coolers for temperature control. The ability to dissipate heat through convection and radiation eliminates the need for supplementary oil cooling. The gear box has one oil filter, two chip detectors (one for the gear box, the other for returning oil from the APP clutch), an oil filler, a drain plug, and a dipstick. The dipstick is mounted on the lower aft side of the gear box. The accessory gear box is serviced through a filler port, on top of the gear box, and it holds 8 quarts of usable oil.

2.3.6.7 Accessory Gear Box Oil Temperature Caution Light. The ACC GB OIL HOT caution light will go on when the oil temperature is over 145°C. The caution light receives power from the No. 1 primary dc bus through a circuit breaker marked ACC GB OIL HOT, in the cabin.

2.3.6.8 Accessory Gear Box Oil Pressure Caution Light. The ACC GB OIL PRESS caution light will go on when the oil pressure decreases to 7 ±1 psi. The caution light receives power from the emergency dc bus through a circuit breaker marked ACCESS GB PRESS, in the cockpit.

2.3.6.9 Main Gear Box Lubrication System

2.3.6.10 Primary Lubrication System. The main gear box is pressure-lubricated by a vane-type oil pump mounted on the sump housing of the gear box (Figure 2-6). Oil pressure is controlled by a pressure regulating valve and the oil temperature is controlled by the main gear box oil cooler. Oil is passed through external lines to the oil cooler, then returned to the gear box to jet-lubricate the gears and bushings. The gear box has a filter, an oil filler port, drain plug, chip detectors, and dipstick. The main gear box is serviced through a filler port, on the right side of the gear box (Figure 3-1).

2.3.6.11 Auxiliary Lubrication System. This system (Figure 2-7) furnishes a limited amount of lubrication to the main gear box, to give the pilot more time to initiate emergency procedures if the primary oil system fails. The system is self-contained within the gear box and is not connected to the primary oil system, except for its oil supply. The auxiliary oil system has its own vane-type pump, lubrication jets, chip detector and caution light. The pump's oil supply is furnished from the auxiliary section of the sump, which is lower than the primary pump's source.

2.3.6.12 Main Gear Box Oil Cooler. The oil cooler (Figure 2-6) for the primary lubrication system is

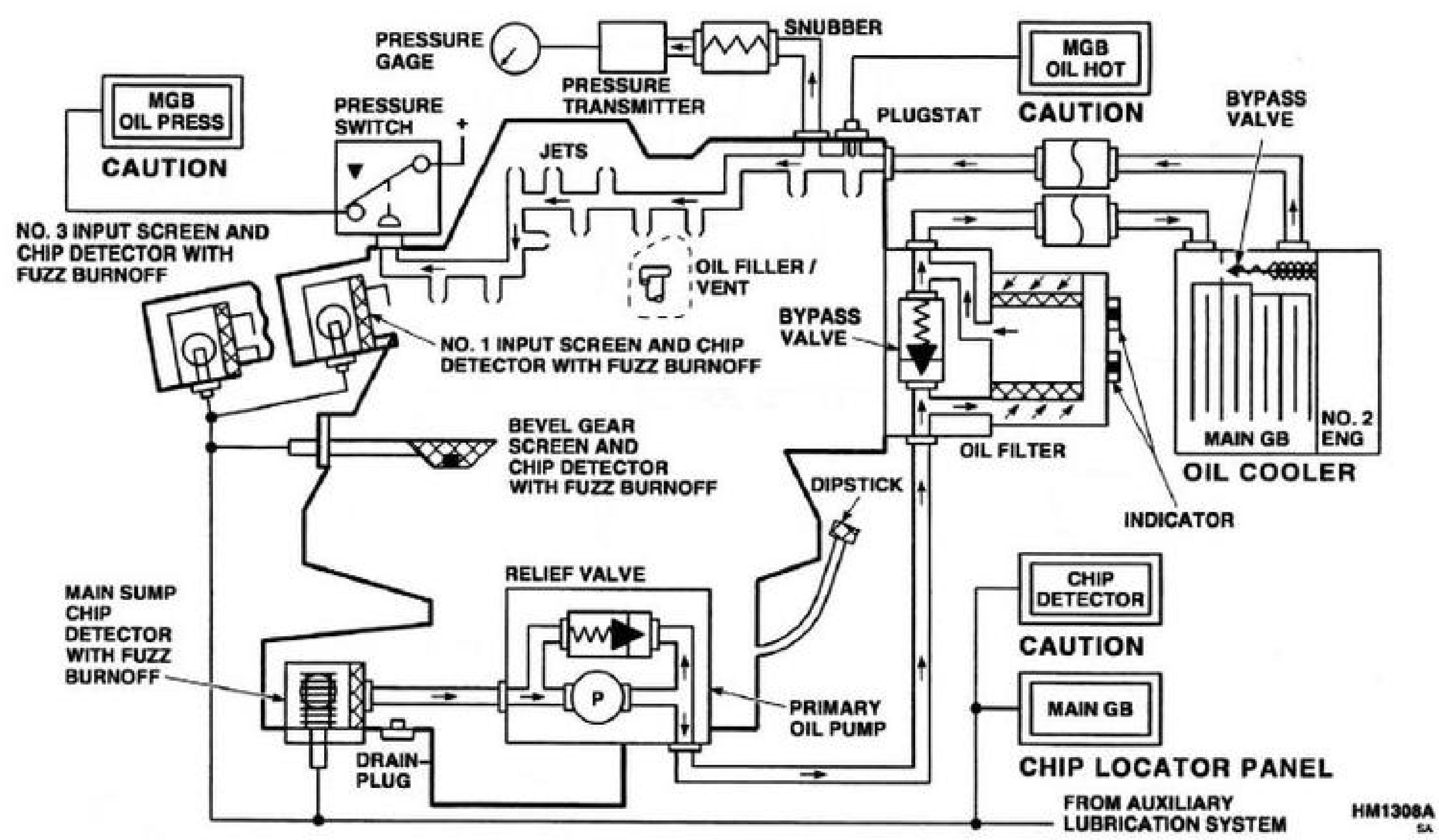


Figure 2-6. Main Gear Box Primary Lubrication Schematic

mounted aft of the main gear box. Cooling air for the oil cooler enters the main gear box fairing through a screened intake, and is forced through the cooler radiator by an oil cooler blower. The oil cooler blower is driven by a takeoff shaft from the main gear box. The air is then exhausted through an air outlet. After passing through the oil cooler, the oil is returned to the gear box, where it is sprayed onto the gears and bearings through lubricating jets.

2.3.6.13 Main Gear Box Oil Temperature Gage. The gage (FO-5), on the instrument panel, indicates the oil temperature in degrees Celsius. The temperature is sensed by a combination chip detector and temperature sensor in the auxiliary sump. The chip detector and temperature sensor operate independently. The gage receives power from the No. 2 primary dc bus, through a circuit breaker marked MAIN GB OIL TEMP, in the cabin.

Note

Main gear box oil temperature indicated on the gage is detected from a separate source, and will not coincide with main gear box oil hot caution light going on.

2.3.6.14 Main Gear Box Oil Temperature Caution Light. The MGB OIL HOT caution light is activated by a plugstat temperature control unit installed in the main gear box manifold. It has switch contacts that close when the temperature of oil returning from the oil cooler reaches 121 ±5.5°C, completing a circuit to light the caution light. The caution light receives power from the No. 2 primary dc bus through a circuit breaker, marked MAIN GB OIL HOT, in the cabin.

2.3.6.15 Main Gear Box Oil Pressure Gage. The gage (FO-5), on the instrument panel, indicates oil pressure in pounds per square inch. The gage reads the pressure of the primary lubrication system. The gage operates on 26 vac power from the autotransformer and the No. 3 primary ac bus, through a circuit breaker marked MGB OIL PRESS 26V, in the cabin.

2.3.6.16 Main Gear Box Oil Pressure Caution Light. The MGB OIL PRESS caution light will go on when the oil pressure decreases to 14 ±2 psi. The caution light monitors the primary lubrication system. The caution light receives power from the emergency dc bus through a circuit breaker marked MAIN/TR INT GB, in the cockpit.

2.3.6.17 Main Gear Box Auxiliary Oil Pressure Caution Light. The MGB AUX LUBE PUMP caution light will go on whenever oil pressure decreases to 14

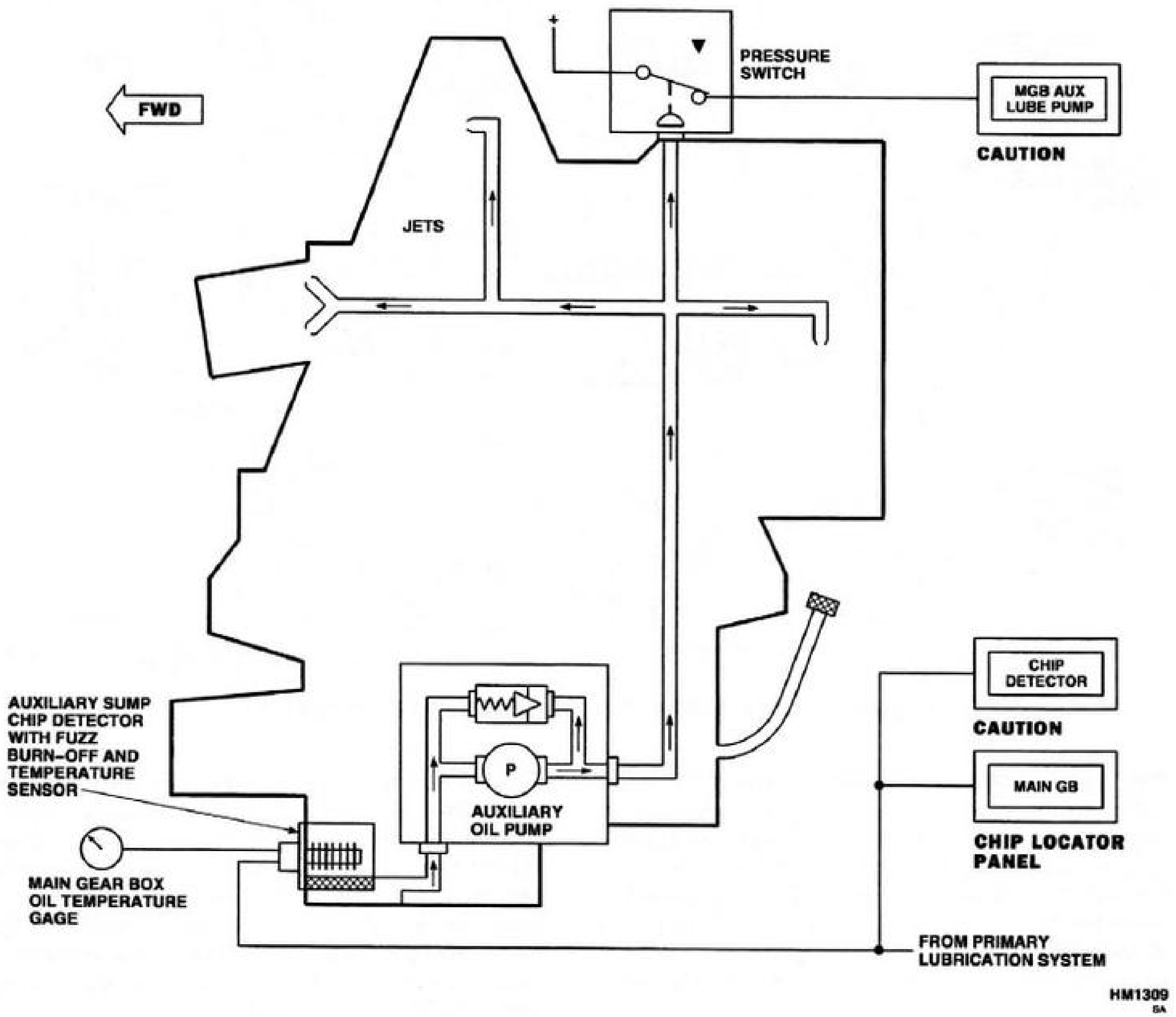


Figure 2-7. Main Gear Box Auxiliary Lubrication Schematic

±2 psi. The caution light monitors the auxiliary lubrication system. Power to operate the light is furnished by the emergency dc bus through a circuit breaker marked MAIN/TR INT GB, in the cockpit.

2.3.6.18 Intermediate and Tail Rotor Gear Box Oil Systems. Both the intermediate and tail rotor gear boxes are pressure-lubricated from individual sump pump systems. The tail gear box contains a scavenge pump to collect the oil and return it to the sump. An oil filler plug, drain plug, combination chip and temperature detector, a pressure switch to light the caution light if pressure drops to 7 ±1 psi, and a sight gage, are in each gear box casing. Screened air inlets in the pylon fairing permit the intermediate gear box to be cooled by circulating air. The tail rotor gear box is cooled by circulating air. Both gear boxes are serviced through filler ports at the top of each gear box. The intermediate gear box holds 3-1/4 quarts of usable oil, and the tail rotor gear box holds 6-3/4 quarts of usable oil.

2.3.6.19 Intermediate and Tail Rotor Pressure Caution Lights. The IGB OIL PRESS and TGB OIL PRESS caution lights will go on whenever oil pressure decreases to 7 ±1 psi. The caution lights receive power from the emergency dc bus through a circuit breaker marked MAIN/TR INT GB, in the cockpit.

2.3.6.20 Transmission Chip Detector System. Metallic chips circulating in a gear box lubrication system are an indication of gear box deterioration. The gear boxes have chip detectors (Figure 2-8) that will cause chip locator lights, on the instrument panel, to go on when chips are detected. The gear box lubricating systems route the lubricating oil past magnetic chip detectors, which will attract ferrous chips. When there are enough chips deposited to form a conductive bridge, an electrical circuit is completed and the chip detector's associated chip locator light goes on. It is possible for conductive nonferrous material to pile up on the chip detector and cause the chip locator light to go on. Aircraft bureau numbers 162517 and subsequent and those modified by AFC 379 have chip detectors (except the three engines) with the automatic fuzz burn-off feature that electrically burns off accumulations of small inconsequential particles that would cause a chip locator light to illuminate and give a false warning. The CHIP DETECTED caution light goes on simultaneously with the lighting of any chip locator light.

The tail rotor gear box combination chip and temperature detector lights the TAIL GB chip locator when chips are detected, or when lubricating oil rises to a tempera-

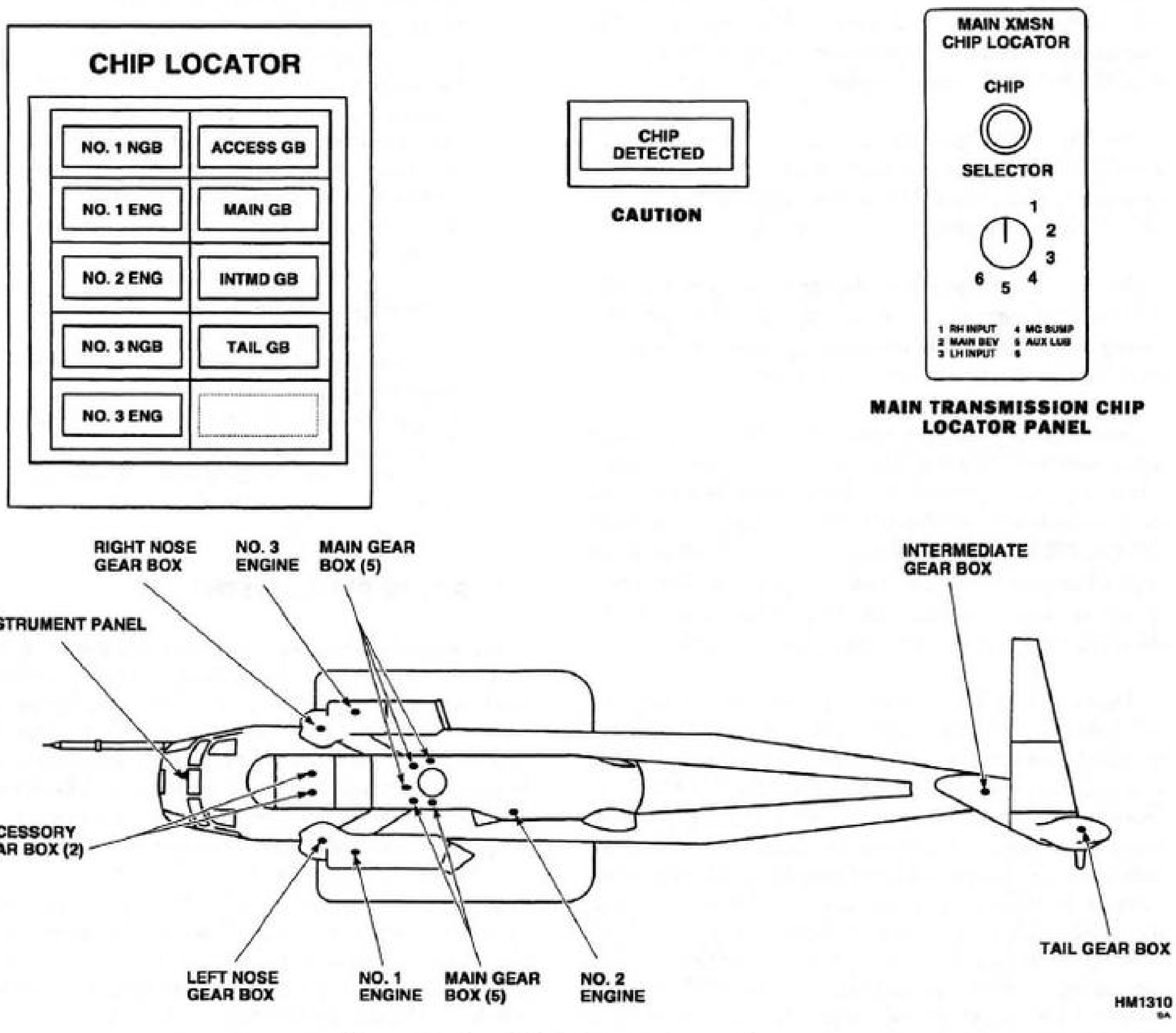


Figure 2-8. Chip Detector Locations

ture of 140 ±5.5°C. Helicopters without AFC 379 and modified by AFC 334 have a chip detector with automatic fuzz burn-off feature. The emergency dc bus furnishes operating power through the ACCESS INT/TAIL circuit breaker, in the cockpit.

The intermediate gear box combination chip and temperature detector lights the INTMD GB chip locator light when chips are detected, or when lubricating oil rises to a temperature of 140 ±5.5°C. Helicopters modified by AFC 334 have a chip detector with automatic fuzz burn-off feature that electrically burns off accumulations of small inconsequential particles that would cause the INTMD GB chip locator to light and give a false warning. The emergency dc bus furnishes operating power through the ACCESS INT/TAIL circuit breaker, in the cockpit.

The No. 1 nose gear box chip detector lights the NO. 1 NGB chip locator light when chips are detected. The emergency dc bus furnishes operating power through the NO. 1 NGB circuit breaker, in the cockpit.

The No. 3 nose gear box chip detector lights the NO. 3 NGB chip locator light when chips are detected. The emergency dc bus furnishes operating power through the NO. 3 NGB circuit breaker, in the cockpit.

The accessory gear box has two chip detectors, and either one will light the ACCESS GB chip locator light when chips are detected. The fuzz burnoff feature (AFC 379) is disabled when the ACC GB OIL HOT and/or ACC GB OIL PRESS caution lights go on, to prevent possible high lubricating oil temperature vapor ignition. The emergency dc bus furnishes operating power through the ACCESS INT/TAIL circuit breaker, in the cockpit.

The main gear box has five chip detectors and any one will light the MAIN GB chip locator light when chips are detected. The fuzz burnoff feature is incorporated on all five chip detectors on those aircraft modified by AFC 379. The main gear box sump chip detector and the auxiliary sump chip detector/temperature bulb have an automatic fuzz burn-off feature that electrically burns off accumulations of small inconsequential particles that would cause the MAIN GB chip locator to light and give a false warning. The fuzz burn-off feature is disabled at high lubricating oil temperatures (lighting of the MGB OIL HOT caution light), to prevent oil vapor fires. Fuzz burn-off is disabled at low oil pressures (lighting of MGB OIL PRESS or MGB AUX LUBE PUMP caution lights) to provide an immediate chip locator indication with this adverse condition. The emergency dc bus furnishes operating power through the MAIN GB circuit breaker, in the cockpit.

2.3.6.21 Main Transmission Chip Locator Panel. The panel (Figure 2-8), on the left side of the cabin, allows the aircrewman to identify which chip detectors have picked up chips. Turning the SELECTOR knob permits each of the five chip detectors to be isolated. Lighting of the CHIP light indicates that the chip detector associated with the knob position has picked up chips. The knob positions are 1. RH INPUT, 2. MAIN BEV, 3. LH INPUT, 4. MG SUMP, 5. AUX LUB.

Note

- It is possible for the main gear box chip detector light to go on, and remain on, because of minute metal particles that may have washed away. This condition, caused by holding relay action, will prevent chip detector isolation with the selector knob but can be verified by pulling out and resetting the appropriate circuit breaker. If the minute particles have washed away, the light will not go on when the circuit breaker is reset.
- The main gear box and auxiliary lube sump chip detectors are connected to a 30 second time delay relay which will energize when a chip has been present for approximately 30 seconds. The 30 second time delay relay ensures that a warning is not given for transient conditions or due to normal wear particles that could wash away or burn off.

2.4 ROTOR BRAKE SYSTEM

An electrically-actuated hydraulically-powered rotor brake, mounted on the main gear box at the tail drive shaft takeoff flange, stops rotation of the rotor system and locks it in position for prolonged periods. The two-pressure (low and high) rotor brake system consists of an independent hydraulic system and hydraulically-actuated pucks acting on a disc attached to the tail rotor takeoff flange. The low-pressure system operates at 350 ±35 psi and the high-pressure system at 975 ±25 psi. The rotor brake hydraulic system contains its own electric motor, hydraulic pump, a 1300 psi relief valve, internal low-and high-pressure switches, a 1-minute time-delay relay, and a combination spring-loaded accumulator and reservoir. The spring-loaded accumulator acts as a reservoir and provides thermal compensation of fluctuating ambient temperatures when the brake is on. Failure of a pressure switch or a shutoff circuit may cause the electric motor to operate excessively and overheat. A thermal protector is incorporated to shut the motor off when it overheats.

The system is electrically actuated by either of two rotor brake switches. Interlocks on the engine speed control tensioners prevent the brake from being actuated unless two speed control levers are at SHUT-OFF and the other speed control lever is at GRD IDLE, or SHUT-OFF.

For rotor brake engagement reference, a RTR BK light on the N_f/N_r tachometers goes on when N_r decays to 50 ±4% N_r, and remains on until N_r decays below 25 ±4%.

The rotor brake system receives power from the No. 2 primary dc bus through two circuit breakers under the general heading ROTOR BRAKE, marked CONT and PWR, in the cabin.

2.4.1 Rotor Brake Switches. Both switches are overhead on the MASTER SWITCH panel under the general heading ROTOR BRAKE. The low-pressure switch has marked positions ON (momentary) and OFF. Holding the low-pressure switch at ON for about 5 seconds engages the rotor brake with 350 psi hydraulic pressure and after a 1-minute delay 975 psi is automatically applied to the rotor brake. The high-pressure switch has marked positions RELEASE (momentary), OFF, and EMER. Momentarily holding the switch at RELEASE releases the rotor brake immediately. Placing the switch OFF permits the low pressure brake to be used. Placing the switch to EMER engages the rotor brake with 975 psi. The ROTOR BRAKE ON advisory light goes on when brake pressure reaches 975 psi, and the pressure switch will automatically deenergize the electric motor. If the high-pressure switch is at EMER and dc power is available, the pressure switch will monitor and maintain pressure.

2.4.2 Rotor Brake Advisory and Caution Light. The ROTOR BRAKE ON advisory light visually indicates that the rotor brake system pressure is 975 psi. The light will remain on as long as system pressure is maintained and dc power is available. The advisory light is powered by the same source and uses the same protective circuit breaker as the rotor brake control system. To warn the pilot that rotor brake pressure is building up when it is not called for, the ROTOR BRAKE PRESS caution light will go on whenever the manifold pressure is above 10 psi, and will go off when the manifold pressure drops below 10 psi. The caution light receives power from the No. 3 dc primary bus through a circuit breaker marked ROTOR BRAKE PRESS, in the cabin.

2.4.3 Rotor Brake Operation

2.4.3.1 Normal Brake Engagement. For prolonged brake life, the rotor brake is normally engaged with the low-pressure system after all engines are shut down and N_r has decayed to 25% (RTR BK light goes off) or less. The brake is activated by holding the low-pressure switch ON for about 5 seconds. For parking purposes, after the rotor has stopped, the high-pressure switch is placed to EMER. Brake lining life is estimated at 10,000 engagements.

2.4.3.2 High Energy Brake Engagement. The rotor brake may be engaged with two engines shut down and the other at GRD IDLE after N_r has decayed to 50% (RTR BK light goes on). The brake is actuated by placing the high-pressure switch to EMER. Brake lining life is estimated at less than 100 engagements.

2.4.4 Rotor Brake Manual Release Handle. The release handle is overhead in the center section of the cabin on the right side aft of the main gear box, and is reached through an access panel. The handle is marked ROTOR BRAKE MANUAL OVERRIDE, TO RELEASE ROTOR, PULL HANDLE. It is pulled to manually release the rotor brake, and is spring-loaded to return to the normal position when released. The manual release system releases rotor brake pressure, providing the capability to engage the rotor, if the APP should malfunction after the first engine is started. After the rotor is accelerated to about 91% to 96% N_r, the necessary hydraulic and electrical power will be available to start the second engine.

CAUTION

Before releasing the rotor by pulling the manual override release handle, be sure the high-pressure rotor brake switch is OFF. This will prevent the high pressure rotor brake from reengaging unintentionally the next time two speed control levers are in SHUTOFF and the other is in GRD IDLE with electrical power on (most typically upon shutdown after flight).

2.4.5 Mechanical Gust Lock. With the rotor stopped the gust lock can lock the rotor system when the hydraulically-operated rotor brake system is not being used. The gust lock is operated by the mechanical gust lock control handle, overhead in the center of the cabin, and is marked GUST LOCK, with marked positions, LOCKED and UNLOCKED. Placing the control handle to LOCKED causes the gust lock tooth to intermesh with teeth on the rotor brake disc and lock the rotor system; it also causes the ROTOR LOCKED and BLADE PYLON FOLD caution lights to go on. Protected circuits, described under appropriate headings, are routed through the mechanical gust lock to prevent inadvertent actuation of a system when the mechanical gust lock handle is at the engaged position.

CAUTION

- The mechanical gust lock shall not be applied when the main rotor head is turning.
- Operation of the protected circuits and caution lights associated with the gust lock are a function of the handle's position, not the gust lock's position. It is possible to have the gust lock engaged with the handle in the disengaged position, and have no cockpit indication.

2.5 FUEL SYSTEM

(Refer to Figure 3-4 for fuel grades and specifications.) The helicopter has three independent suction/pressure type fuel systems (FO-14), one for each engine, that are joined by a crossfeed system for maximum fuel utilization. The fuel system has ground, air-to-air, and HIFR pressure refueling systems, and auxiliary and range extension fuel transfer systems.

The fuel system is designed to reduce crash induced fuel spillage and ignition as much as possible and thereby enhance post crash survivability of personnel and the helicopter. To this end, the engines are suction fuel fed and the fuel lines are over the fuselage. A crash-generated force automatically causes the fire extinguishers to discharge into the engine compartments. Full self-sealing tanks provide fuel spillage control from any surface of the tank that may be pierced. In addition, the pressure refueling and fuel transfer lines can be purged after completion of system operation. Pressure-regulated engine bleed-air is introduced into the refueling system high point for pressurization, and low points drain residual fuel to the tanks. Purging is started by a purge switch and is controlled by an electric timing device automatically opening and closing appropriate valves in sequence, and then final shutdown after 8.5 minutes.

2.5.1 Fuel Supply System. Three separate fuel systems supply fuel from four main fuel tanks, two in each sponson, which are normally serviced through the ground pressure refueling, air-to-air, or HIFR pressure refueling systems, and may be replenished from the range extension and/or auxiliary fuel transfer systems. The main fuel tanks can also be gravity-fueled through filler accesses on top of the sponsons. A series of screws and a cover have to be removed from the auxiliary fuel tanks before they can be gravity-fueled. Strainers are incorporated in the gravity-refueling ports of the main fuel tanks, to prevent foreign objects from entering the fuel system during gravity-refueling operations. Fuel boost pumps (FO-14), mounted on the engine accessory gear box, draw fuel from the main fuel tanks to the engine fuel pump and filtration system. Each main fuel supply line has a check valve to make sure that fuel does not gravity-feed from the boost pump back into the tanks and cause the boost pumps and lines to lose their prime. A handpump, on the right side of the cabin, is used to replenish any fuel system prime that may have drained from the supply line between the boost pump and the line check valve. Instructions for priming the fuel system are on a decal next to the handpump. Three fuel selector levers, on the fuel selector quadrant, shut off fuel flow to the engine and control the crossfeed system. The No. 1 and No. 3 fuel selectors each manually operate a fuel selector and firewall shutoff valve. The No. 2 fuel selector manually operates its fuel selector valve and electrically controls its firewall shutoff valve. The crossfeed system permits any engine to be operated from any main fuel tank. Fuel for the APP is supplied from the NO. 2 (right) tank, and fuel for the cabin heater is supplied from the NO. 2 (left) tank. The helicopter may be gravity-defueled through the sump drain valves, suction-defueled through the single-point refueling adapter, or partially defueled in flight through the fuel dump system. For fuel tank capacities, refer to Figure 2-9.

2.5.1.1 Main Tanks. The No. 1 and No. 3 fuel systems each contain a single bladder-type fuel cell, one installed in each sponson, and the No. 2 fuel system contains two cells, one installed in each sponson. The cells are fully self-sealing. The tanks have the lines and components required for ground, air-to-air, or HIFR pressure refueling, and the range extension and auxiliary fuel transfer systems. Each tank contains a pressure-refueling shutoff valve, a high-level sensor, a surge valve, a vent system, and a sump drain valve. Normally the tanks are vented through the bottom of the fuselage. To prevent water from entering the tanks when on the water, atmospheric pressure from inside the cabin enters the tanks through the anti-siphon check valves on each side of the cabin. The sump drain valves are manually-operated to drain water from the tank or to completely drain the tank. The pressure refueling shutoff valves permit fuel flow during pressure refueling and fuel transfer, and are shut off by the high-level sensors when the tanks are full. The surge valves prevent damage from pressure surges by relieving excessive pressure. Fuel may be transferred from either auxiliary tank to the No. 1 and 2 (left), No. 3 and

FUEL QUANTITY DATA-PRESSURE FUELING-LEVEL ATTITUDE (JP-4, 6.5 LB/GAL, FUEL DENSITY AT STANDARD DAY TEMPERATURE)

TANKS	USABLE	
	U. S. Gallons	Pounds
NO. 1	300	1950
NO. 2	377	2450
NO. 3	300	1950
TOTAL MAIN	977	6350
TWO EXT AUX TANKS (650 GALLONS EACH)	1300	8450
RANGE EXTENSION TANK	285	1853
TOTAL FUEL WITH TWO 650-GALLON EXT AUXILIARY TANKS AND ONE RANGE EXTENSION TANK	2562	16,653
(JP-5, 6.8 LB/GAL, FUEL DENSITY AT STANDARD DAY TEMPERATURE)		
NO. 1	300	2040
NO. 2	377	2563
NO. 3	300	2040
TOTAL MAIN	977	6643
TWO EXT AUX TANKS (650 GALLONS EACH)	1300	8840
RANGE EXTENSION TANK	285	1938
TOTAL FUEL WITH TWO 650-GALLON EXT AUXILIARY TANKS AND ONE RANGE EXTENSION TANK	2562	17,421
(JP-8, 6.7 LB/GAL, FUEL DENSITY AT STANDARD DAY TEMPERATURE)		
NO. 1	300	2010
NO. 2	377	2526
NO. 3	300	2010
TOTAL MAIN	977	6546
TWO EXT AUX TANKS (650 GALLONS EACH)	1300	8710
RANGE EXTENSION TANK	285	1910
TOTAL FUEL WITH TWO 650-GALLON EXT AUXILIARY TANKS AND ONE RANGE EXTENSION TANK	2562	17,166

NOTE

Gravity fueling adds 8 gallons to the internal fuel tanks.
No. 1 and No. 3 tanks, 4 gallons each.
No. 2 tanks zero gallons.

Figure 2-9. Fuel Quantity Data

2 (right), or all main tanks, or simultaneously from both auxiliary fuel tanks to selected main fuel tanks. In addition, fuel may be transferred from the range extension tanks into the main fuel tanks. The fuel dumping system permits dumping of fuel from each main tank to reduce gross weight.

2.5.1.2 Auxiliary Tanks. The tanks, mounted on cantilever supports, are attached to the sponsons. The tank-to-support structure mountings are each equipped with two forced ejection cartridges that permit the tanks to be jettisoned electrically. The support structure and fuel quantity instrumentation accommodates 650-gallon capacity tanks. The mounting attitude of the tanks provide expansion space while refueling in a normal ground attitude, and maximum fuel usage during cruise. Each tank contains fuel and air drop valves to seal off appropriate lines when the tanks are jettisoned, a fuel quantity indicating system, a flow sensor, and a high-level float switch. The flow sensors sense fuel flow and cause the appropriate fuel flow indicator light to go on. The high-level float switch senses when the tank is full, and causes the auxiliary tank fuel valve to close. The auxiliary tanks vent into the main tank vent lines, and the vent valves close off the vents during fuel transfer. Engine compressor bleed-air, from the No. 1 and No. 3 engines, is used to force fuel out of the auxiliary tanks into the main tanks. Bleed-air from one engine is enough to operate the system; use of bleed-air has a negligible effect on engine performance.

2.5.1.3 Auxiliary Tank Jettison System. The system permits the auxiliary fuel tanks to be individually or simultaneously jettisoned. The system consists of forced ejection cartridges between the tank and support structure mountings, and guarded jettison switches, on the emergency control panel (FO-8). Both jettison switches, under the general heading AUX TANK JTSN, and marked LEFT and RIGHT, respectively, each have a marked position OFF. The tanks are jettisoned by raising the appropriate switch guard and placing that switch to the up (on) position. The tanks cannot be jettisoned when the weight of the helicopter is compressing the landing gear scissor switches. In addition, a safety pin for each tank, when inserted, opens a microswitch that disables the jettison and test circuit for the associated tank to prevent inadvertent jettisoning of the tanks during ground operation. An ejection cartridge circuit tester control panel (Figure 2-10) is mounted on each side of the cabin just forward of the sponsons. The control panels are associated with the auxiliary fuel tank on its side of the helicopter. Both panels are marked AUX TANK JETTISON CIRCUIT TESTER and contains a guarded switch with marked positions TEST and FIRE, and a test light. To test the circuit, remove the associated tanks safety pin, place the switch to TEST, and activate the associated AUX TANK JTSN switch on the emergency control panel. The test light should go on. After test, the AUX TANK JTSN switch is returned to OFF and the guarded AUX TANK JETTISON CIRCUIT TESTER switch is returned to FIRE. The jettison circuit for both auxiliary fuel tanks receives power from the emergency dc bus through two circuit breakers, under the general heading AUX TANK JTSN, in the cockpit.

Note

Helicopter handling characteristics will remain satisfactory if one full auxiliary tank does not jettison when both tanks have been selected for jettisoning.

2.5.1.4 Range Extension Tanks. These fuel tanks, molded from reinforced plastic, each have a capacity of about 314 gallons. Each tank contains a fuel quantity indicator, fuel transfer pump and float switch, a high-level sensor, and a refueling shutoff valve. Each tank also has eight mooring rings, two on each side, that are used as tiedown chain attaching points when securing the tanks to the tiedown rings in the cabin floor. A drain valve

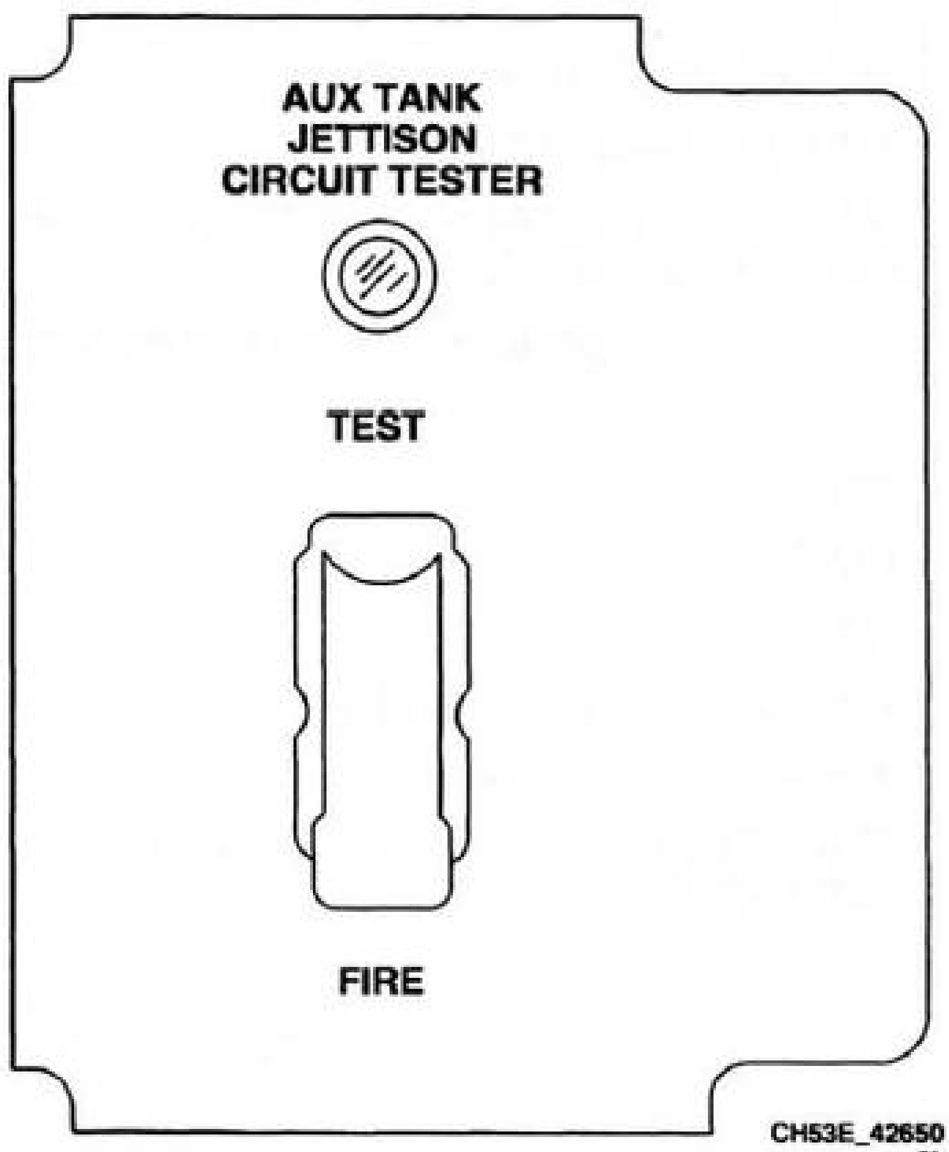


Figure 2-10. Ejection Cartridge Circuit Tester

is on the lower left side of each tank, so fuel samples can be taken from the tank's sump. Unlimited operations are permitted with tanks which incorporate accessory change (AYC) 566. Tanks which do not incorporate AYC 566 are limited to flights of operational necessity (as defined by OPNAVINST 3710.7) and then only when JP-5 fuel is used.

2.5.1.5 Fuel Boost Pumps. Three engine-driven fuel boost pumps, one mounted on each engine accessory gear box, supply fuel under pressure to a respective engine, any time that engine is operating. Because the boost pumps are not submerged in the tank and are above the fuel supply, it is necessary that the main fuel supply lines be primed with fuel for boost pump operation. The boost pumps draw fuel from the fuel tanks, then deliver it to the appropriate engine fuel pump and filtration system. A check valve in each main fuel supply line makes sure that the systems retain their prime.

2.5.1.6 Fuel Boost Pump Failure Caution Lights. Each of the three fuel boost pumps has a pressure switch connected to the pressure feed line from each pump. The fuel pressure switches actuate the #1, #2, and #3 ENG FUEL BOOST caution lights. A fuel boost pump caution light will go on any time fuel boost pump pressure has decreased to 8.5 ±0.5 psi. The caution light will stay on until fuel boost pump pressure is increased above 8.5 ±0.5 psi. The #1, #2, and #3 ENG FUEL BOOST caution lights receive power from the No. 1, No. 2, and No. 3 primary dc buses, respectively, through circuit breakers, marked FUEL PUMP, under the general heading of the associated engine, in the cabin.

2.5.1.7 Fuel Selector Levers. Three levers, one for each engine, are overhead on the fuel selector quadrant (FO-1). Each selector selects the No. 1, 2, or 3 fuel tank or shutoff fuel to its associated engine. The DIRECT positions select the No. 1 tank for the No. 1 engine, No. 2 tank for the No. 2 engine, and No. 3 tank for the No. 3 engine. For crossfeed operation, each lever selects either of the remaining tanks not selected by the DIRECT position. Each fuel selector lever will be moved to SHUT OFF when its associated ENG EMER OFF T-handle is moved aft.

2.5.1.8 Fuel Quantity Gages and Test Switch. Six fuel gages on the instrument panel (FO-3) display fuel quantity in pounds. Two are marked FUEL QUANTITY for the Nos. 1 and 3 tanks, one is marked FUEL QTY and has two pointers for the No. 2 left and right tanks, two are marked AUX FUEL for the left and right auxiliary tanks, and one that is marked TOTAL FUEL displays the total of the other five gages. The fuel quantity indicating system may be tested by pressing the FUEL GAGE TEST pushbutton, above the TOTAL FUEL gage, for about 10 seconds. This will cause the Nos. 1 and 3 tank pointers to drop below zero. The No. 2 tank pointers will spin continuously counterclockwise, and the total fuel pointer will go upscale. Upon release of the test switch, the pointers should return to the previous reading. This test shows that the fuel quantity indicating system is operating correctly. When electrical power is removed from the helicopter, the indicators will stay at the reading they were recording when power was removed. Fuel quantities are measured by probes in each tank. The No. 1 main tank, left auxiliary fuel tank, and totalizer indicating systems receive power from the No. 1 primary ac bus through three circuit breakers, marked MAIN NO. 1, AUX NO. 1, and TOTAL under the general heading FUEL QTY, in the cabin. The No. 2 main and right auxiliary fuel tank indicating systems receive power from the No. 2B primary ac bus through two circuit breakers, marked FUEL QTY and FUEL AUX, under the general heading NO. 2, in the cabin. The No. 3 main tank indicating system receives power from the No. 3 primary ac bus through a circuit breaker, marked FUEL QTY NO. 3, in the cabin.

2.5.1.9 Fuel Low Level Caution Lights. The #1 FUEL LOW caution light will go on when about 30 minutes of fuel to operate one engine at normal cruise remains in the No. 1 tank (666 ±30 lbs). The #3 FUEL LOW caution light operates the same way for the No. 3 tank. The #2 FUEL LOW caution light will go on to indicate that 15 minutes of fuel (333 ±15 lbs) remains in either the No. 2 left or right tank. Normally, when the #2 FUEL LOW caution light goes on, there will be a total of 666 ±30 pounds of fuel remaining in the No. 2 tanks. The amount of remaining fuel that will cause a tank's fuel low-level caution light to go on is sensed by a sensor attached to a probe in the tank. The sensor is independent of the fuel quantity indicating system. In addition, when a tank has been selected for fuel dump, dumping will stop automatically when the tank quantity decreases to 666 or 333 pounds, as appropriate.

The fuel low-level caution lights and low-level controls for the No. 1 and No. 3 tanks receive power from the No. 1 and No. 3 primary dc buses, respectively, through circuit breakers, in the cabin, marked FUEL LOW NO. 1 WARN and CONT, and FUEL LOW NO. 3 WARN and CONT. The fuel low-level caution light and low-level control for the No. 2 tank receives power from the No. 2 primary dc bus through a circuit breaker panel in the cabin marked FUEL LOW NO. 2 WARN.

2.5.1.10 Fuel Filter Bypass Caution Light. An airframe fuel filter system, consisting of a dual fuel filter and an engine filter bypass caution light, are between the fuel boost pump and the engine in each engine fuel supply system. Each fuel filter contains a filter and an impending bypass pressure switch, which is connected to the #1, #2, or #3 ENG FLTR BY-PASS caution light as appropriate. The ENG FLTR BY-PASS caution light will go on when the pressure drop across any one of the filters is over 1.37 ±0.5 psi. Each fuel filter will bypass when the pressure drop across it is over 2.80 psi.

2.5.1.11 Fuel Filter Bypass Valve. The valve consists of a motor-operated bypass valve installed in parallel with the airframe dual filter for each engine (FO-14). The bypass valves operate with the associated fuel boost pump caution light, marked #1, #2, or #3 ENG FUEL BOOST. It uses the same power source, pressure sensor switch, and circuit breakers as the caution lights. The bypass valve will open, routing fuel around the dual airframe filters whenever the associated ENG FUEL BOOST caution light goes on, and during engine starts until enough pressure is available at the switch to put the caution light off. During loss of boost pump pressure, the bypass valve will bypass the fuel filter to provide a more direct flow of fuel to the engine-driven fuel pump. When the fuel filters are bypassed, the associated ENG FLTR BY-PASS caution light will also go on.

2.5.2 Auxiliary Tank Transfer System. The fuel transfer system (FO-15) allows fuel to be transferred from the auxiliary to the main fuel tanks by reversing the flow of fuel through the same lines that are used to pressure refuel the tanks. Fuel may be transferred from either auxiliary fuel tank to either the No. 1 and the No. 2 (left) tank or the No. 3 and the No. 2 (right) tank, or simultaneously from both auxiliary fuel tanks to selected main fuel tanks. The auxiliary fuel tanks vent into the main tank vent lines, and the vent valves close off the auxiliary fuel tank vents during fuel transfer. The auxiliary fuel transfer system is controlled from the refuel control panel on the instrument panel (FO-5). The refueling master power switch, marked REFUEL PWR, must be OFF before auxiliary fuel can be transferred. The XFR position of the transfer/refuel switches control fuel transfer. Moving the left auxiliary tank's switch to XFR causes the left auxiliary tank bleed-air valve to open, the left auxiliary tank vent valve to close. Fuel will not transfer at this time. Moving the NO. 1 & 2 MAIN tank switch to XFR closes the right electric precheck valve and opens the left auxiliary tank fuel valve. Fuel will now transfer from the left auxiliary tank into the No. 1 and 2 left main tanks, and flow will be indicated by lighting of the L MAIN flow condition light. If the NO. 2 & 3 MAIN tanks' switch is moved to XFR instead of the NO. 1 & 2 MAIN switch, the left auxiliary tank fuel valve will open and the left electric precheck valve will close. Fuel may now transfer from the left auxiliary tank into the No. 3 and 2 right main tanks, and flow will be indicated by lighting of the R MAIN flow condition light. Fuel may be transferred from the left auxiliary tank into all main tanks by placing the NO. 1 & 2 MAIN and NO. 2 & 3 MAIN tank switches to XFR. Fuel may be transferred from the right auxiliary tank in the same manner, except the right auxiliary tank's switch is moved to XFR, which opens the right auxiliary tank bleed-air valve and closes the right auxiliary tank vent valve. Fuel may be transferred simultaneously from both auxiliary tanks to the No. 1 and 2 left tanks, or to the No. 3 and 2 right tanks, or to all main tanks. A time lapse of about 1 minute, depending on the fuel quantity in the auxiliary tanks, will be noted from the time the transfer switches are turned on until the transfer fuel actually starts flowing. The delay results from the time to pressure the tanks with bleed-air. Fuel is transferred to the main fuel tanks at a rate of about 292 pounds-per-minute (45 gpm). The status of auxiliary fuel transfer operations can be observed by monitoring the fuel quantity gages. When all auxiliary fuel has been transferred, the auxiliary fuel tank quantity indicators should read zero.

Note

> The REFUEL PWR switch, on the refueling control panel, must be placed off (light off) when transferring fuel from the auxiliary to main tanks.

2.5.3 Range Extension Tank Transfer System. The helicopter has connecting points to the main fuel system and electrical power sources for installation of the range extension fuel transfer system. The system (FO-18) consists of one to seven range extension tanks, a range extension control panel, and the fuel and electrical components necessary to operate the system. The number of range extension tanks installed is dependent upon mission requirements. The system provides the capability to transfer fuel from the range extension tanks in the cabin to the main tanks in the sponsons. Fuel is transferred by turning on the fuel transfer pumps, one for each tank, and opening the fuel selector valve, on the forward tank. When more than one range extension tank is installed, fuel is transferred through a common line that is connected to all tanks. Only two range extension tanks, one per control panel circuit breaker, can be operational at one time, due to the electrical load involved. The fuel selector valve is installed in the common line to control the flow of fuel to the main fuel tanks. Check valves prevent transfer fuel from entering other range extension fuel tanks. High-level sensors, in each main fuel tank, will automatically shut off the flow of fuel to the main tank when it is full.

The RANGE EXT CONT circuit breaker in the cabin furnishes No. 3 primary dc bus power to the FUEL circuit breaker on the range extension control panel. The RANGE EXTENSION circuit breaker, in the cabin, furnishes No. 2A primary ac bus power to two circuit breakers on the range extension control panel, marked TANKS 1-3-5-7 and TANKS 2-4-6.

WARNING

- Do not troubleshoot the range extension fuel system in flight. Removal of tank filler cap is prohibited any time electrical power is on the helicopter.
- An electrical malfunction is indicated if a circuit breaker trips or if fuel transfer stops while the pump is turned on (main fuel tanks not full). Do not reset the circuit breaker. Immediately turn off the transfer pump switch and remove the electrical harness from the control panel. Do not attempt to troubleshoot the cause of the malfunction or reconnect the harness in flight or when power is applied to the helicopter.
- When using multiple range extension fuel tanks, CG and gross weight must be carefully monitored to avoid exceeding the prescribed limits.

2.5.3.1 Range Extension Control Panel. When installed, the control panel (FO-18), marked RANGE EXTENSION CONTROL, is on the forward cabin compartment bulkhead. The panel contains the fuel transfer pump switches, tank empty lights, and circuit breakers for the tank components. The fuel transfer pump switches and tank empty lights, both under the heading FUEL CELL, are on each side of the numbers, 1 through 7, that identifies them with their associated tank.

AC operating power for the fuel transfer pumps is furnished through the two circuit breakers, marked TANKS 1-3-5-7 and TANKS 2-4-6, which identify the circuit breakers with their associated tanks. DC control power for the tanks is furnished through the circuit breaker marked FUEL.

Operation of the transfer switches is discussed under RANGE EXTENSION TRANSFER PUMPS AND FLOAT SWITCHES, and the tank empty lights are discussed under RANGE EXTENSION TANK EMPTY LIGHTS in this chapter.

2.5.3.2 Range Extension Fuel Quantity Indicators. The indicators on top of each tank indicate the amount of fuel, in gallons, that is in the tank. The indicator also provides a continuous reading while the tank is being serviced, so that known intermediate amounts of fuel may be added.

2.5.3.3 Range Extension Transfer Pumps and Float Switches. Each fuel transfer pump is controlled by a switch with marked positions PUMP and OFF, on the range extension control panel, and a float switch. Each switch is numbered 1 through 7, to identify it with the tank in which the pump is installed. When a switch is placed to PUMP, and the fuel selector valve handle is at MAIN TANKS, fuel will be simultaneously transferred to all main fuel tanks. To prevent the pump from overheating, the float switch causes the transfer pump to automatically shut off when all fuel is transferred from the tank.

Note

Both ac and dc power are furnished to each range extension tank when the electrical harness is connected. Placing a tank's transfer pump switch OFF does not remove electrical power from the tank. FO-18 does not depict the actual electrical system configuration.

2.5.3.4 Range Extension High-Level Sensors and Refueling Shutoff Valves. The high-level sensors, one for each tank, sense when the tank is full and cause the refueling shutoff valve to automatically shut off the flow of fuel to the tank.

2.5.3.5 Range Extension Tank Empty Lights. The lights, one for each tank, are on the range extension control panel. Each light marked EMPTY is next to the fuel transfer pump switch for the tank for which it is installed. The numbers 1 through 7 identify each light with its associated tank. The lights go on to indicate that the respective range extension tanks are empty. The lights receive dc power from the FUEL circuit breaker on the range extension control panel.

2.5.3.6 Range Extension Fuel Selector Valve. The valve is externally-mounted on the first range extension tank in the fuel line that connects to all tanks. The valve has marked positions REFUEL DEFUEL, MAIN TANKS, and AUX TANKS. The selector valve handle is moved to REFUEL DEFUEL when it is desired to pressure refuel the range extension fuel tanks. The handle is moved to MAIN TANKS when it is desired to transfer fuel simultaneously to all main fuel tanks. The handle is moved to AUX TANKS when it is desired to transfer fuel from one range extension fuel tank to other range extension fuel tanks.

CAUTION

Immediately after pressure refueling, when the helicopter is to be left idle for any length of time, move the selector valve from RE-FUEL DEFUEL to AUX TANKS. This will prevent overboard fuel siphoning by isolating the internal range extension tanks from the main tanks.

Note

- To completely defuel the helicopter when range extension fuel tanks are installed, the selector valve should be moved to MAIN TANKS while applying a negative pressure at the helicopter pressure refueling adapter, and selectively actuating the transfer pumps.
- To completely defuel the range extension tanks, fuel must be transferred to the main tanks, and the main tanks then defueled normally.

2.5.3.7 Range Extension Precheck Valve. A precheck valve, next to the fuel selector valve, is used to check the integrity of the system. When the normally closed precheck valve is placed to the open position, pressure refueling will be interrupted to indicate the system is operating satisfactorily. If fuel continues to flow, there is a malfunction in one or more of the refueling shutoff valves.

Note

The range extension fuel tank manual precheck system must be relieved of pressure following its use, by moving the fuel selector valve to AUX TANKS for about 15 seconds, in order to continue filling the range extension fuel tanks.

2.5.4 Pressure Refueling Systems. The ground, air-to-air, and HIFR pressure refueling systems use the same plumbing and system components, except the ground and HIFR refueling systems do not use bleed-air (FO-15). The ground pressure refueling system is refueled through a single-point refueling adapter, on the left side of the forward fuselage. The air-to-air refueling system is refueled through a probe extending from the right side of the nose section, and the HIFR refueling system is refueled through a Wiggins quick-disconnect pressure refueling nipple, mounted overhead in the forward section of the cabin. Since the control switches, indicator lights, and system components operate in the same manner for all systems, they will be discussed under the heading AIR-TO-AIR REFUELING SYSTEM in this chapter.

Refer to LIGHTING EQUIPMENT, in this chapter, for a description of the probe and drogue lights that aid night air refueling operations. The left main, right main and auxiliary fuel tank refueling control systems receive power from the No. 2 primary dc bus through four circuit breakers, marked MAIN TANK LEFT and RIGHT and AUX TANK LEFT and RIGHT under the general heading AERIAL REFUEL, in the cabin.

2.5.4.1 Ground Pressure Refueling System. The system is used to pressure refuel the main and range extension and auxiliary fuel tanks on the ground. The main tanks or the range extension fuel tanks may be serviced without electrical power. Electrical power must be available to open the auxiliary tank selection and pressure refueling shutoff valves to pressure refuel the auxiliary fuel tanks. Ground pressure refueling is controlled through the pressure refueling panel.

2.5.4.2 Pressure Refueling Panel. The pressure refueling panel (Figure 3-3), on the left side of the forward fuselage, provides a single-point refueling system. The pressure refueling panel contains the connecting adapter, four tank air pressure gages, and two manually-operated precheck valves, one for each side of the helicopter. It is impossible to close the door with either precheck valve selector in the CLOSED position. Since the door can be forced closed, precheck valve selectors should be checked in the OPEN position on preflight. When the access door is closed, the precheck valve handles are locked OPEN. The main tank vent system, an open line system containing no closing devices, must have the vent lines open for pressure refueling. When a precheck valve selector is placed to the closed position, ground pressure refueling will be interrupted to indicate the system is operating satisfactorily. If fuel continues to flow, there is a malfunction in a shutoff valve. Pressure that may have built up in the tank, due to a clogged vent, will always register on the respective pressure gage. A high-level sensor shutoff, in the top of the tank, will shut off the flow of fuel to that tank when the tank is full. A shutoff valve, in the bottom of each tank, makes sure that defueling is terminated before all the fuel in the tank is removed, to prevent the defueling action from collapsing the sides of the fuel cell. Specific instructions for conducting a pressure refueling precheck are on a decal below the four air pressure gages.

Note

The precheck valve selectors must be at OPEN for the fuel transfer and air-to-air refueling systems to operate.

2.5.4.3 Air-to-Air Refueling System. The system consists of a refueling probe, a probe bleed-air valve, a probe bleed-air control valve, flow sensors, precheck valves, vent valves, surge valves, pressure refueling and high-level sensor valves, and a control panel, to pressure refuel the main and range extension and auxiliary fuel tanks.

WARNING

- If a water landing has been made, air refueling operations should not be attempted, and the probe should not be extended or retracted, until an inspection has been done to make sure that the probe has not been damaged and the nozzle has not opened to permit water to enter the fuel system. Tank sumps and lines shall be inspected and drained following a water landing.
- Do not purge after a water landing until the probe has been inspected. Purging with a damaged probe may cause water to enter the fuel system, or fuel under pressure to be sprayed on the nose of the helicopter.

2.5.4.4 Refueling Control Panel. The control panel (FO-15), contains the control switches and condition lights for the ground pressure refueling, air-to-air, and HIFR pressure refueling systems. The auxiliary fuel tank transfer switches are discussed under the heading Auxiliary Tank Transfer System in this chapter. The control panel contains a power pushbutton, four fuel transfer/refuel switches, four fuel flow condition lights, a probe control switch and condition light, a fuel gage test pushbutton, a fuel shutoff test pushbutton, and a fuel purge pushbutton. Pressing the REFUEL PWR pushbutton turns system electrical power on and the pushbutton lights. Pressing the pushbutton again turns power off and the light goes off. The power pushbutton must be on to energize the pressure refueling systems, except when ground pressure refueling the main tanks, and off when fuel is being transferred from the auxiliary to the main fuel tanks. The four fuel flow condition lights are over the heading L AUX, L MAIN, R MAIN and R AUX. The fuel flow condition lights will go on and show the marking FLOW to indicate that fuel is flowing through the flow sensor and into the appropriate tank. When the appropriate tank is full, that condition light will go off to indicate that fuel is no longer flowing. The four fuel transfer/refuel switches have marked positions XFR, CLOSE and REFUEL. Placing the main tank switches to REFUEL opens the electrically-operated precheck valves and permits fuel flow to the main tanks. When the precheck valves are open, fuel will flow through the main tank pressure refueling shutoff valves, and the high-level sensors will be effective. Placing the auxiliary tank switches to REFUEL opens the auxiliary tank fuel valves and furnishes electric power to the high-level float switches. This permits fuel to flow into the auxiliary tanks, and when the high-level float switches are actuated by the fuel level, it causes the auxiliary tank fuel valves to close and stop fuel flow into the tanks. The CLOSE position stops the flow of fuel to the tanks. The No. 1 and No. 2 left tanks, the No. 3 and No. 2 right tanks, and the two auxiliary tanks may be simultaneously selected for refueling. Fuel will continue to flow to the other fuel tanks after one or more fuel tanks have been shut off by their high-level sensors, until they are also full. The test switch, marked FUEL SHUTOFF TEST, is depressed to test the integrity of the high-level sensor and pressure refueling shutoff valve in the fuel tanks. Pressing the test switch, after pressure refueling operations have started, will cause the electrically-operated precheck valves to close, which in turn will cause the main tank high-level sensors to simulate a tank full condition and cause the pressure refueling shutoff valves to close. The auxiliary fuel tank high-level sensors will also be energized, to simulate a tank full condition, and cause the auxiliary tank selection and pressure refueling shutoff valves to close. This will stop the flow of fuel and cause the fuel flow condition light to go off. Releasing the testing switch will restore the system to a normal condition. The probe condition light is under the heading REFUEL PROBE. The probe control switch, with marked positions EXTEND and STOW, is actuated to extend and retract the refueling probe. When the switch is placed to EXTEND, probe bleed-air valve and bleed-air control valve are actuated to permit bleed-air to extend the probe. When the probe is fully extended and locked, the probe condition light, marked READY, will go on. Placing the switch to STOW will cause the probe bleed-air valve and probe bleed-air control valve to actuate, to permit bleed-air to retract the probe to the stowed position. Pressing and lighting the PURGE pushbutton causes the pressure refueling and fuel transfer systems to start purging. The PURGING advisory light goes on at this time and remains on during the 8.5 minutes required for purging. Interlocks prevent purging if pressure refueling or fuel transfer is taking place. The refuel power pushbutton receives power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked MASTER PWR, under the general heading REFUEL. Probe control power is received from the No. 1 primary dc bus through a circuit breaker in the cabin, marked PROBE CONT, under the general heading REFUEL.

2.5.4.5 Refueling Probe. The retractable refueling probe (FO-11), on the right side of the nose section, can extend and retract. The extension/retraction system is operated by bleed-air from either the No. 1 or 3 engine, or from both engines simultaneously. Check valves prevent bleed-air from flowing to an inoperative No. 1 or 3 engine if either fails. The probe contains lock actuators that lock the probe in the extended or retracted position and cause the REFUEL PROBE light to go on when the probe is fully extended and ready for refueling.

2.5.4.6 Probe Bleed-Air and Probe Bleed-Air Control Valves. The valves control the flow of bleed-air to the refueling probe. Both valves are controlled from the refuel control panel. The bleed-air valve controls the flow of bleed-air to the bleed-air control valve, and the bleed-air control valve selects bleed-air to extend or retract the refueling probe. Both valves contain relief valves to vent very high pressures.

2.5.4.7 Flow Sensors. There are four sensors, one for the main tanks in the left sponson, one for the main tanks in the right sponson, one for the left auxiliary tank, and one for the right auxiliary tank. The sensors will sense a fuel flow above 2 $\pm$1 gpm and cause the appropriate fuel flow indicator light to go on. During the fuel transfer mode, fuel flow from auxiliary to main tanks should be verified by the change in fuel quantity indicated by both main and auxiliary tank fuel gaging systems.

2.5.4.8 Precheck Valves. The main tank precheck valves, two manually-operated and two electrically-operated, permit testing the system, and control the flow of fuel in the precheck and sensor lines on each side of the helicopter. The manually-operated precheck valves, on the ground pressure refueling panel, are normally OPEN. When a precheck valve is placed to CLOSED during ground pressure refueling operations, pressure refueling will be interrupted to indicate one side of the system is operating satisfactorily. If a precheck valve should be left at CLOSED, fuel could be used only from the main tanks, and the fuel transfer and air-to-air refueling systems would not be effective. The electrically-operated precheck valves, controlled from the refueling control panel, are normally in the open position. The electrically-operated precheck valves are closed only when energized, which is when the master switch is on and the tank selector switches are off, the shutoff test switch is activated, or fuel is being transferred to the other main tank. The valves are in the open position during actual pressure refueling operations. If the appropriate tank control switch is placed to CLOSE, pressure refueling will be interrupted as shown by the appropriate flow light going off, to indicate the system is operating satisfactorily. The electrically-operated precheck valves, controlled by the main fuel control switches, also act as shutoffs to control the flow of fuel to the main tanks.

2.5.4.9 Pressure Refueling Shutoff and High-Level Sensor Valves. Each main fuel tank has a pressure refueling shutoff and high-level sensor. The high-level sensor valves sense when the tanks are full, and in turn cause the pressure refueling shutoff valves to close and stop the flow of fuel. Each auxiliary fuel tank also has a high-level float switch that senses when a tank is full and causes electrical power to close the auxiliary tank fuel valve.

2.5.4.10 HIFR Refueling System. The HIFR refueling system consists of a Wiggins quick-disconnect pressure refueling fitting and a go/no-go filter canister to pressure refuel the main, range extension, and auxiliary fuel tanks. The Wiggins fitting is overhead in the center of the forward cabin. The go/no-go filter canister is mounted overhead on the left side of the cabin aft of the emergency escape hatch and permits only acceptable fuel to pass through. Flow is reduced to an extremely low level if the fuel is contaminated with water and particulate matter above a predetermined level.

2.5.5 Fuel Dump System. Fuel can be dumped selectively or simultaneously from the No. 1, No. 2 left, No. 2 right, and the No. 3 tanks (FO-15). The No. 1 and No. 2 left tanks in the left sponson each has a fuel dump valve, and motive flow for both tanks is furnished by one dump pump. Two switches on the console's emergency control panel control the dump operation for the tanks in the left sponson. The No. 2 right and No. 3 tanks in the right sponson are equipped with identical dump equipment. Each sponson will dump fuel at a rate of 75 gallons-per-minute with one or both tanks in the sponson selected for dump. Dump fuel is pumped overboard through an outlet and connecting discharge tube that is between each external auxiliary fuel tank and sponson. The location of the fuel dump port in the No. 1 tank permits all fuel to be dumped except the amount required to operate one engine for about 30 minutes at normal cruise power. The No. 3 tank also will dump down to about 30 minutes of fuel. The No. 2 left and 2 right tanks will each dump down to about 15 minutes of fuel. The fuel dump switches, when actuated, simultaneously actuate the fuel dump valve and fuel dump pump for the tank selected. A dump automatic shutoff sensor (FO-15) in each tank senses the 30 or 15 minute low fuel state as appropriate, causing that tank's FUEL LOW caution light to light, and automatically closing that tank's dump shutoff valve. When the dump shutoff valves for both tanks in the same sponson are closed, that sponson's dump pump automatically shuts off. Fuel cannot be dumped when the weight of the helicopter is compressing the landing gear scissors switches.

The left sponson fuel dump system receives control power from the No. 1 primary dc bus through two circuit breakers, marked NO. 1 and NO. 2 LH, under the general heading FUEL DUMP, and operating power from the No. 2A primary ac bus through a circuit breaker marked FUEL DUMP NO. 1 TANK. The right sponson fuel dump system receives control power from the No. 3 primary dc bus through circuit breakers, marked NO. 3 and NO. 2 RH, under the general heading FUEL DUMP, and operating power from the No. 3 primary ac bus through a circuit breaker marked FUEL DUMP NO. 3 TANK. All circuit breakers are in the cabin.

2.5.5.1 Fuel Dump Switches. There are four two-position dump switches, one for each main tank, on the FUEL DUMP portion of the emergency control panel, on the cockpit console (FO-15). Selecting NO. 1 MAIN or NO. 3 MAIN starts fuel dumping from the No. 1 or No. 3 tanks, respectively. Selecting LEFT or RIGHT under the general heading NO. 2 MAIN starts fuel dumping from the No. 2 left or No. 2 right tanks, respectively.

2.5.6 Purge System. The purpose of the system (FO-15) is to purge the refueling and transfer lines, within the fuselage, to eliminate fuel from this area in case of a crash-induced line separation or puncture. Purging is done by introducing regulated engine bleed-air into the upper portion of the refueling system. Pressurization forces fuel from these lines into the No. 2 left and No. 2 right fuel tanks via the vent lines. Varying capacities of the refueling lines require that they be isolated from each other for specific time periods. This is done by an electric controller opening and closing specific valves for limited time periods.

Note

Failure to purge the fuel system after fuel transfer has taken place reduces the post crash survivability of the fuel system by leaving fuel in lines within the cabin fuselage.

The PURGE pushbutton, on the refueling control panel, initiates the purge cycle when pressed and lit to read PURGE ON. The purge cycle lasts for 8.5 minutes and shuts down automatically without further action. The PURGING advisory light is lit during the purging cycle only. After automatic purge shutdown, it will be necessary to press the PURGE pushbutton to extinguish its PURGE ON light and remove power from the system. The purge cycle can be stopped at any time by pressing the PURGE pushbutton. Pressing the pushbutton again will start the entire 8.5-minute cycle.

Pressing and lighting the PURGE pushbutton closes the normally open left and right electric precheck valves. During the cycle the necessary valves open and close in this sequence: The purge bleed-air valve and the forward main purge valve are open for 8.5 minutes. The probe purge valve is open during the first 3 minutes of the cycle. The left and right main purge valves are open during the third minute. The left auxiliary fuel valve and the left auxiliary purge valve are open during the fourth minute. The right auxiliary fuel valve and the right auxiliary purge valve are open during the fifth minute. The left electric precheck valve is open during the sixth minute. The right electric precheck valve is open during the seventh minute. At the end of 8.5 minutes the purge bleed-air valve and the forward main purge valves close. Further, at the end of 8.5 minutes, the left and right electric precheck valves open.

2.6 AUXILIARY POWERPLANT (APP)

The P-7-2 auxiliary powerplant (FO-12), forward of the accessory gear box, enables ground starting of the engines and ground operation of the electrical and hydraulic systems. The APP is adjusted for operation up to 10,000 feet pressure altitude. The APP system consists of a control panel, an indicator panel, a hydraulic starting system, a turbine engine, a fuel system, a self-contained oil system, clutch, and a mechanical drive. The hydraulic start system consists of a No. 1 accumulator, a No. 2 accumulator, and a hydraulic motor. Normally the No. 1 accumulator furnishes the necessary hydraulic pressure to the hydraulic motor for APP start. If the first start fails a second start can be attempted by using the No. 2 accumulator. If necessary, a longer start interval may be obtained by using both accumulators simultaneously. The No. 2 accumulator is brought into the system by pulling a T-handle that is overhead on the right side of the cabin aft of the personnel door. The No. 2 accumulator is reset by pushing the T-handle back in place. The accumulators are normally charged from the utility hydraulic system to 3000 psi. A handpump (Figure 7-10), on the right side of the cabin aft of the personnel door can be used to manually recharge the accumulators or manually fold or spread the tail pylon. A selector valve, above the handpump, with marked positions A (No. 2 accumulator), B (tail pylon fold/unfold), and C (No. 1 accumulator) is used to select the accumulator to be manually recharged or to manually fold or spread the tail pylon. The APP control lever has to be at SHUT-OFF before the accumulators can be recharged with the handpump. APP starting is independent of external or helicopter electrical power, since ignition and control electrical power is supplied by the APP driven generator.

When the APP control lever is moved to START during the starting cycle, No. 1 accumulator hydraulic pressure is released to activate the start motor. An over-running clutch will disengage the turbine from the starter motor when the APP has started and the turbine speed exceeds that of the starter motor. As soon as the APP is driving the accessory gear box the APP accumulators will be recharged with 3000 psi hydraulic pressure. The APP should light off at about 20% speed, and bleed-air causes the clutch to start to engage the accessory gear box when speed is 92% and exhaust temperature reaches 204°C. The APP will actually light-off at 10% speed, but will indicate about 20% due to instrumentation lag in the system. As the clutch engages, the acceleration will slow down; then continue on until operating speed is reached. The APP control lever should be held at START until clutch engagement is confirmed (92% to 100%) by illumination of the #1 RECT, #2 RECT, #1 GEN, #3 GEN capsules on the caution/advisory panel. Make sure that APP ON light is on. Release lever, APP control lever should automatically return to RUN and APP will continue to accelerate to operating speed (100%). The start fuel valve and ignition are turned off and the clutch engages as the 92% speed switch closes, and burning is self-sustaining as long as there is a flow of fuel from the APP main fuel valve.

An advisory light marked APP ON, on the advisory panel, will go on when the APP is operating. Fuel is supplied to the APP from the No. 2 right fuel tank and there is a prime handpump on the right side of the cabin. Fuel consumption is 80 to 180 pph, depending on OAT and the accessory loads being used. A mechanical drive with an automatic clutch drives the accessory gear box. This automatically disengages to enable shutdown of the APP when the main rotor head is engaged.

Note

If conditions warrant, the APP may be started and operated during flight.

2.6.1 APP Control Panel. The APP CONTROL panel, on the overhead control panel (FO-1), contains a control lever, a circuit breaker control switch, and circuit breakers for high exhaust temperature, overspeed, and low oil pressure. The T-handle, forward of the control lever, is used to discharge the APP and cabin heater compartment fire extinguisher system and shut off fuel to the APP and cabin heater.

2.6.1.1 APP Control Lever. The APP control lever, with marked positions START, RUN, and SHUT-OFF, controls the operation of the APP. Moving the lever to START energizes the components of the automatic start system, and starts the APP. The lever should be held at START until clutch engagement, since it is spring-loaded to RUN. When the lever is released and it returns to RUN, the APP will run normally to drive the accessory gear box. The lever is moved to SHUT-OFF to close the main fuel valve and shut down the APP. The APP control circuit receives electrical power from the APP generator through the circuit breaker marked CKT BKR CONTROL, on the APP control panel.

2.6.1.2 Low Oil Pressure Circuit Breaker. The LOW OIL PRESS circuit breaker is on the APP control panel under the general heading AUTO SHUTDOWN MODE PRESS TO RESET. The circuit breaker, colored black, will pop out and show white to indicate the APP has automatically shut down due to a low oil pressure of 6 ±1 psi. The circuit breaker must be reset before restarting the APP. The automatic shutdown feature of the APP, due to low oil pressure, is bypassed during the main engine start cycle. The low oil pressure circuit breaker receives electrical power from the APP generator.

2.6.1.3 High Exhaust Temperature Circuit Breaker. The HIGH EXH TEMP circuit breaker is on the APP control panel under the general heading AUTO SHUTDOWN MODE PRESS TO RESET. The circuit breaker, colored black, will pop out and show white to indicate the APP has automatically shut down due to a high exhaust temperature of 621°C. The circuit breaker must be reset before restarting the APP. The automatic shutdown feature of the APP, due to high exhaust temperature, is bypassed during the main engine start cycle. The high exhaust temperature circuit breaker receives electrical power from the APP generator through a temperature control relay that is energized by an APP thermocouple.

2.6.1.4 Overspeed Circuit Breaker. The OVERSPEED circuit breaker is on the APP control panel, under the general heading AUTO SHUTDOWN MODE PRESS TO RESET. The circuit breaker, colored black, will pop out and show white, to indicate the APP has been automatically shut down because of an overspeed of 110%. The circuit breaker must be reset before restarting the APP. The circuit breaker is energized through the overspeed switch by electrical power from the APP generator.

2.6.1.5 APP Circuit Breaker Control Switch. The switch is on the APP control panel. The circuit breaker switch, marked CKT BKR CONTROL, with marked positions ON and OFF, provides circuit protection. The 5-ampere switch circuit breaker receives electrical power from the APP generator and furnishes electrical control power and ignition for APP operation.

2.6.2 APP Emergency Start Switch. The switch, marked APP, with marked positions NORM-EMER, is on the emergency control panel (FO-1). The emergency start switch is used to bypass the low oil pressure and high exhaust temperature circuit breakers, if either or both have popped, for an APP start. The emergency start switch uses the same power source and protective circuit as the normal APP control circuit.

CAUTION

The low oil pressure and high exhaust temperature circuit breakers should be bypassed only in an emergency.

Note

Extended periods of APP operation may cause the fire extinguisher containers to thermally discharge.

2.6.3 APP Indicator Panel. The panel, on the overhead control panel (FO-1), contains the APP tachometer and the APP exhaust gas temperature indicator.

2.6.3.1 APP Tachometer. The tachometer indicates the percentage of APP engine rpm. The tachometer receives power from the APP driven tachometer-generator.

2.6.3.2 APP Exhaust Gas Temperature Indicator. The indicator indicates the temperature of the APP exhaust in degrees Celsius. A thermocouple, in the APP exhaust, measures temperature and displays it on the indicator.

2.7 ELECTRICAL SYSTEM

Electric power is obtained from three ac generators and two ac to dc rectifiers (FO-19). In normal operation each generator supplies power to its associated primary ac bus. A No. 1 monitor ac bus is connected to the No. 1 primary ac bus and an emergency ac bus is connected to the No. 3 primary ac bus. In normal operation the #1 rectifier furnishes power to the No. 1 primary dc bus and also to the No. 1 monitor dc bus. The #2 rectifier furnishes power to the No. 3 primary dc bus and also to the No. 2 primary and emergency dc buses. If a generator fails, only the No. 1 monitor ac bus is dropped, and normal rectifier operation continues. If a rectifier fails, only the No. 1 monitor dc bus is dropped. For ground operation, electrical power can be supplied by external power or the APP driving the No. 1 and 3 generators.

2.7.1 Generators. Three self-cooled brushless generators with a nameplate rating of 40 kVA (overload 60 kVA), for operation under 10,000 feet, supply 115/200 volts, 400 Hz, three-phase power. The No. 2 generator is driven by the main gear box accessory section. The No. 1 and No. 3 generators are driven by the accessory gear box. The accessory gear box is driven by the rotor, or by the APP when it is on the line and rotor speed is below 100% N_r. When rotor speed exceeds APP rpm, the accessory gear box is driven by the main gear box. Each generator output is directed through a respective supervisory panel that provides control and protection of the electrical system from underfrequency, overvoltage, undervoltage, and feeder fault. Feeder fault protection will cause a generator to be disconnected from the ac load when there is a short in any of the main power lines from the respective generator to the primary ac buses. The underfrequency protection is provided to prevent possible equipment damage when N_r drops below 91% to 96%. When the N_r initially drops below the operating level, a time delay keeps the relays from being energized and deenergized for intermediate periods. If the underfrequency condition is sustained for a period of 2 to 5 seconds, the underfrequency protection circuit disconnects the generator from the ac load. When N_r rises to the acceptable level, the generator is automatically reconnected to the ac loads. The underfrequency protection is not available when the weight of the helicopter is removed from the landing gear. The No. 1 generator normally furnishes power to the No. 1 primary ac and No. 1 monitor ac buses. The No. 2 generator normally furnishes power to the No. 2A and 2B primary buses. The No. 3 generator normally furnishes power to the No. 3 primary and emergency ac buses. Each generator is controlled by an individual generator switch on the main switch panel in the cockpit. The generators are connected directly to the helicopter's ac system when the generator switches are placed ON and the supervisory panels are satisfied that voltage and frequency outputs are within prescribed limits (115 ±3 volts, 400 ±20 Hz). Generator failure is indicated by respective failure caution lights marked #1 GEN, #2 GEN, and #3 GEN on the caution panel. The generator caution lights are normally powered by permanent magnetic generator (PMG) voltage from each generator. However, if no PMG voltage is available from a generator, backup voltage is provided from the respective primary dc bus. Backup voltage to operate the generator caution lights is furnished through the No. 1, No. 2, and No. 3 primary dc bus circuit breaker panels in the cabin, through circuit breakers marked PMG BACKUP, under the respective general headings NO. 1 GEN, NO. 2 GEN, and NO. 3 GEN. All generators will continue to generate power during autorotation.

2.7.1.1 Generator Switches. The switches, on the master switch panel on the overhead control panel (FO-1), under the general heading GENERATOR, have switches marked 1, 2, and 3, respectively. The switch positions are marked TEST-RESET OFF-ON. When the generator switches are placed ON, generator power is connected through the respective primary bus relay to the appropriate buses. When either generator switch is placed to RESET OFF, the respective generator will be turned off. Placing the switch to RESET OFF; then ON, will bring the generator back on the line if a temporary overvoltage or undervoltage condition occurred and no longer exists. The TEST position of each switch is used by ground personnel when doing maintenance checks.

Note

> If the generators have not been turned off when external power is connected and the APP and/or main rotor head is to be shut down, relay chatter may be encountered on the next turn-up. Relay chatter can be eliminated by recycling the generator switches.

2.7.2 AC Buses. Normally the No. 1 generator furnishes power to the No. 1 primary ac bus and also the No. 1 monitor ac bus and #1 rectifier. If the No. 2 generator fails, the No. 1 primary ac bus will furnish power to the No. 2A primary ac bus and the No. 1 monitor ac bus will be dropped.

Normally the No. 3 generator furnishes power to the No. 3 primary ac bus and its associated autotransformer and to the emergency ac bus (and its associated autotransformer on aircraft without AFC 490). In addition, the No. 3 primary ac bus furnishes power to the #2 rectifier. If the No. 2 generator fails, the No. 3 primary ac bus will furnish power to the No. 2B primary ac bus and its associated autotransformer. The No. 1 monitor ac bus will be dropped.

Normally the No. 2 generator furnishes power to the No. 2A primary ac bus and the No. 2B primary ac bus and its associated autotransformer. If the No. 1 generator fails, the No. 2A primary ac bus will furnish power to the No. 1 primary ac bus and the No. 1 monitor ac bus will be dropped. All other functions of the No. 1 primary ac bus will continue. If the No. 3 generator fails, the No. 2B primary bus will furnish power to the No. 3 primary ac bus and emergency ac bus for normal operation. The No. 1 monitor ac bus will be dropped. If the No. 1 and No. 2 generators fail, the No. 3 generator will furnish power to the No. 2B primary ac bus and the emergency ac bus. The No. 1 monitor ac bus, No. 1 primacy ac bus and the No. 2A primary ac bus will be dropped. If the No. 2 and No. 3 generators fail, the No. 1 generator will furnish power to the No. 2A primary ac bus and the emergency ac bus. The No. 1 monitor bus, No. 2B primary ac bus, and the No. 3 primary ac bus will be dropped. If the No. 1 and No. 3 generators fail, the No. 2 generator will furnish power to the No. 1 primary ac bus, No. 2A primary ac bus, No. 2B primary ac bus, No. 3 primary ac bus, and the emergency ac bus. The No. 1 monitor ac bus will be dropped (Figures 2-11 and 2-12).

Note

> (AFC 490) When operating the aircraft with the No. 1 generator on, and the No. 2 and No. 3 generators off or failed; the No. 3 primary ac bus will be lost, failing the No. 2 AFCS computer, AHRS, TACAN, VOR, all 3 BDHIs, and the radar altimeter.

On aircraft modified by AFC 490, a three-phase voltage sensing relay also monitors the emergency ac bus for an open or short (undervoltage) condition in any phase. This feature is incorporated between the No. 3 primary ac bus and the emergency ac bus relay. If the voltage of any phase is degraded, the No. 1 primary ac bus provides power to the emergency ac bus.

2.7.3 Autotransformers. The electrical system has three autotransformers that reduce 115 vac down to 26 vac for operation of certain instruments and avionics gear. One transformer is associated with the emergency ac bus, one with the No. 3 primary ac bus, and one with the No. 2B primary ac bus. Aircraft with AFC 490 have two transformers associated with the No. 3 primary ac bus and one with the No. 2B primary ac bus.

EMERGENCY AC BUS (COCKPIT)

AFCS
- Accelerometers, lateral
- Accelerometers, longitudinal
- Accelerometers, vertical
- Barometric altitude controller
- Computers (No. 1 only with AFC 490)
- Rate gyros, pitch (No. 1 only with AFC 490)
- Rate gyros, roll (No. 1 only with AFC 490)
- Rate gyros, yaw (No. 1 only with AFC 490)
- Trim position sensor, collective (1)
- Trim position sensors, roll (2)
- Trim position sensors, yaw (2)

AHRS (Without AFC 490)
Attitude indicator, copilot
Attitude indicator, pilot (AFC 490)
Emergency bus autotransformer
- Compass cards (3) (Without AFC 490)

No. 2 engine dual thermal detection system (AFC 483)
Power turbine inlet temperature (3) (Without AFC 490)
Quad tachometers
Torquemeters
Two-point suspension solenoids
Vertical gyro, copilot, 1080y

NO. 3 PRIMARY AC BUS (COCKPIT)

AFCS
- Computer, No. 2 (AFC 490)
- Rate gyro, pitch, No. 2 (AFC 490)
- Rate gyro, roll, No. 2 (AFC 490)
- Rate gyro, yaw, No. 2 (AFC 490)

AHRS (AFC 490)
Autotransformer (Compass cards) (AFC 490)
VGI, Copilot (AFC 490)

EMERGENCY DC BUS (COCKPIT)

AFCS
- Computers
- Control panel
- FAS PRESS switch

Attitude indicators, yaw rate gyros
Auxiliary tanks, jettison
Chip detectors
- Accessory gear box
- Intermediate gear box
- Main gear box
- No. 1 engine and nose gear box
- No. 2 engine
- No. 3 engine and nose gear box
- Tail gear box

Engine
- Fire detection 1, 2, and 3
- Fire extinguisher 1, 2, and 3
- Nose gear box oil pressure 1 and 3
- Oil pressure 1, 2, and 3

FAS
Fire cabin heater/APP
Fire extinguisher control
Gear box pressures
Master caution lights
No. 2 engine dual thermal detection system (AFC 483)
Radio
- COMM JULIET (AN/ARC-182 radios, or AFC 455)
- COMM 1 (AN/ARC-182 radios, or AFC 455)
- Compass warning
- ICS left and right
- UHF and JULIET

Secondary instrument lights
Servo 1 and 2
Bearing monitor system (AFC 491)
Trim
Two-point suspension control

Figure 2-11. Electrical Buses (Sheet 1 of 4)

NO. 3 PRIMARY AC BUS

Anticollision light, aft
Anti-ice No. 3 engine
- Inlet
- Nose gear box
- Removable section

BIM
Doppler (AFC 471)
Flight lights, pilot
FLIR 26V (AFC 471)
Fuel dump right sponson
Fuel flow No. 3 engine
Fuel quantity No. 3 tank
GPS (AFC 453)
GPWS (115V) (AFC 501, Part 2)
GPWS (26V) (AFC 501, Part 2)
Hydraulic pressure
Main gear box oil pressure
No. 2 rectifier
No. 3 primary bus autotransformer
Omega Navigation (2) (without AFC 453)
Omega Navigation (2) (without AFC 453)
Radio
- LF/ADF
- RAD ALT
- TACAN
- UHF-DF
- VOR

Seat cushion blower, pilot
SDC Fan (AFC 453)
Two-point suspension power
TAS Transducer
TFU Heater (AFC 471)
Utility receptacle, No. 1 and No. 2
Windshield anti-ice, pilot

NO. 3 PRIMARY DC BUS

Cargo hook jettison
CDNU Pilot Doppler (AFC 471)
Engine oil level
External power control
Fuel dump right sponson
Fuel low No. 3 tank
GPWS (26V) (AFC 501, Part 2)
Landing gear warning
Lights
- Cabin dome
- Position

No. 3 engine
- Anti-ice warning
- Emergency start
- Fuel pump
- Ignition
- IGV anti-ice caution light, control
- Nose gear box temperature
- Oil quantity low
- Oil temperature
- Overspeed
- Speed trim

No. 3 generator, PMG backup, test receptacle
Overtorque warning
Pedal adjustment, pilot
Pitot heat, right
Radio
- Navigation No. 1 and No. 2
- Omega Navigation (AFC 327, without AFC 453)
- Omega Navigation (AFC 327)
- Radar warning (AFC 337)
- Radar beacon (without AFC 501, Part 2)
- TACAN
- UHF-DF
- VOR LOC-GS

Range extension tank control
Rotor brake pressure
Second stage servo failure and pressure
Spotlight, pilot
Tail rotor servo pressure
Two-point suspension warning
Utility hydraulic fluid hot
Utility pressure
Utility receptacle, pilot
Warning light test
Weight-on-wheels, right side
Windshield anti-ice, pilot
Windshield washer control

Figure 2-11. Electrical Buses (Sheet 2 of 4)

NO. 2B PRIMARY AC BUS

- CG hook indicator power
- Fuel
  - No. 2 quantity
  - Right auxiliary quantity
- Heat exchanger second stage hydraulic
- Hydraulic quantity
  - Utility hydraulic pressure
- Ice detector
- Lights
  - Console
  - Formation
  - Non-flight
  - Overhead control panel
- No. 2B primary bus autotransformer
- No. 2 engine fuel flow
- Radio
  - Altimeter pilot encoder
  - HF
  - IFF
- Second stage hydraulic pressure
- Windshield wiper

NO. 2A PRIMARY AC BUS

- Combustion air blower
- Fuel dump, left sponson
- No. 2 engine EAPS
- Range extension
- Vent blower

NO. 2 PRIMARY DC BUS

- Aerial refueling
- BIM
- Blade fold
- Cargo hook
- CG hook
- Firewall valve
- Fuel low No. 2 tank
- Heat exchanger second stage
- Isolation valve
- Landing gear
- Lights
  - Emergency exit lights
  - Land hover lights, No. 2 and No. 3
  - Pilots' emergency lights
  - Utility hoist light
- Main gear box oil temperature
- No. 2 engine
  - Anti-ice
  - Emergency start
  - Fuel pump
  - Ignition
  - IGV anti-ice caution light, control
  - Oil quantity low
  - Oil temperature
  - Overspeed
  - Speed trim
- No. 2 generator PMG backup, test receptacle
- Radio
  - COMM 1 antenna actuator (AN/ARC-182 radios)
  - COMM 2 (with a second ARC-182 or -210 installed)
  - VHF-FM and antenna actuator
  - COMM JULIET (AFC 455)
  - Radar altimeter
- Rotor brake
- Stick position indicator
- Utility hoist
- Windshield anti-ice center

Figure 2-11. Electrical Buses (Sheet 3 of 4)

The emergency ac bus (or the No. 3 primary ac bus on aircraft with AFC 490) circuit breaker panel in the cockpit furnishes power to the emergency ac bus (or the No. 3 primary ac bus on aircraft with AFC 490) autotransformer through a circuit breaker marked AUTO XFMR 115V, and the autotransformer furnishes power to two circuit breakers marked NO. 2 & 3 and NO. 1 under the general heading BDHI.

NO. 1 PRIMARY AC BUS

Anti-ice No. 1 engine
- Inlet
- Nose gear box or EAPS
- Removable section

Battery charge
Doppler compartment blower (AFC 471)
Drogue dim control
Flight light, copilot
Fuel
- No. 1 quantity
- Left auxiliary quantity
- Totalizer

Fuel flow No. 1 engine
GPS (AFC 453)
Heat exchanger, utility hydraulic
Landing gear warning
Lights (AFC 327)
- Copilot flight
- Lower console
- Non flight
- Pilot flight
- Upper console

No. 1 rectifier
Seat cushion blower, copilot
Windshield anti-ice copilot

NO. 1 MONITOR AC BUS

Utility receptacle, forward left cabin
Anti-exposure suit blowers
Windshield anti-ice, center

NO. 1 PRIMARY DC BUS

Accessory gear box oil temperature
Cabin heater
Cargo Winch
CDNU Copilot (162478 and subsequent)
EAPS
FLIR power
Fuel dump left sponson
Fuel low No. 1 tank
GPS (2) (AFC 453)
Heat exchanger, utility hydraulic
Ice detector
Lights
- Anticollision Light (Prior to AFC 342 Rev A)
- Anticollision light
- Cargo loading
- Cockpit dome
- Console avionic lighting
- No. 1 hover light
- Probe light

No. 1 engine
- Anti-ice warning
- Emergency start
- Fuel pump
- Ignition
- IGV anti-ice caution light, control
- Start control
- Nose gear box temperature
- Oil quantity low
- Oil temperature
- Overspeed
- Speed trim

No. 1 generator PMG backup, test receptacle
No. 1 monitor bus control
Pedal adjustment copilot
Pitot heat, left
Radio
- HF/COMM
- IFF
- LF/ADF

Ramp
Refuel
- Master power
- Probe
- Purge

First stage servo failure and pressure
Tail skid
Two-point suspension control
Hydraulic quantity
Weight-on-wheels, left side
Windshield anti-ice copilot

NO. 1 MONITOR DC BUS

Spotlight, copilot
Utility receptacle, copilot

Figure 2-11. Electrical Buses (Sheet 4 of 4)

	AC BUSES						DC POWER SOURCES		DC BUSES				
CONDITIONS	NO. 1 PRI AC BUS	NO. 1 PRI AC BUS	NO. 2A PRI AC BUS	NO. 2B PRI AC BUS	EMER AC BUS	NO. 1 MON AC BUS	NO. 1 RECT	NO. 2 RECT	NO. 1 PRI DC BUS	NO. 2 PRI DC BUS	NO. 3 PRI DC BUS	EMER DC BUS	MON DC BUS
ALL GENS OFF													
NO. 1 GEN ONLY	1		1		1		1		1	1	1	1	
NO. 2 GEN ONLY	2	2	2	2	2		2	2	1	2	2	2	1
NO. 1 AND NO. 2 GENS ON	1	2	1	2	2		1	2	1	2	2	2	1
NO. 3 GEN ONLY		3		3	3			3	2	2	2	2	
NO. 1 AND NO. 3 GENS ONLY	1	3	1	3	3		1	3	1	2	2	2	1
NO. 2 AND NO. 3 GENS ONLY	2	3	2	3	3		2	3	1	2	2	2	1
TRIPLE GEN	1	3	2	2	3	1	1	3	1	2	2	2	1
EXTERNAL POWER ONLY	E	E	E	E	E	E	E	E	1	2	2	2	1
	NUMBERS				IDENTIFY		GENERATOR		NUMBERS IDENTIFY RECTIFIER				

(AC POWER SOURCES: CONDITIONS column)

NOTE: 1, 2, 3, = GENERATOR POWERING BUS.
E = EXTERNAL POWER TO RESPECTIVE BUS.
▭ NORMAL IN-FLIGHT CONDITION

HC3965
SA

Figure 2-12. AC/DC Power Distribution

The NO. 3 primary ac bus circuit breaker panel in the cabin furnishes power to the No. 3 primary ac bus autotransformer through a circuit breaker marked AUTO XFMR 115V, and the autotransformer furnishes power to two circuit breakers above the general heading 26V, marked HYDR PRESS and MGB OIL PRESS, and to five circuit breakers under the general heading 26V RADIO, marked TACAN, UHF DF, DOPPLER, LF ADF, and VOR.

The No. 2B primary ac bus circuit breaker panel in the cabin furnishes power to the No. 2B primary ac bus autotransformer through a circuit breaker marked AUTO XFMR 115V, which furnishes power to three circuit breakers above the general heading 26V marked TRIPLE HYDR QTY, HYDR PRESS UTIL, and HYDR PRESS 2ND STAGE.

2.7.4 External Power Receptacle. The receptacle is used to introduce 400 Hz, 115/200 vac power into the helicopter from an ac external power source. This receptacle is on the lower right side of the fuselage, forward of the personnel door. Power to operate the necessary relays and light the EXT PWR CONNECTED advisory light is furnished by the external power monitor panel, which converts a portion of the ac power cart's input into 28 vdc. Introduction of external ac power into the helicopter is controlled by the external power monitor panel, which samples a portion of the external power for correct voltage, frequency, and phase rotation. If the external power is not within prescribed limits, the external power monitor panel will not energize the external power relays that would enable the external power to enter the helicopter. The EXT PWR switch, beside the receptacle, must be momentarily placed to RESET every time the external power monitor panel rejects the ac power cart's input. When the external power monitor panel is satisfied that the cart's power inputs are within the prescribed limits, dc power will energize the external power bus relays, ac power will enter the helicopter, and subsequently all ac and dc buses will be energized.

The external power rectifier, associated relays, and circuits are protected by the EXT PWR circuit breaker, beside the receptacle. When the helicopter is generating its own electricity, the EXT PWR CONNECTED advisory light is powered by the No. 3 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked EXT PWR CONT. With external power on and the No. 1 or No. 3 generator on the line, there is load sharing between external power and the generator. With three generators, or No. 2 generator only on the line; external power is automatically cut out.

2.7.5 DC Buses. Normally the #1 rectifier furnishes power to the No. 1 primary dc bus and subsequently to the No. 1 monitor dc bus. If the #2 rectifier fails, the No. 1 primary dc bus will furnish power to the No. 2 and 3 primary dc buses and the emergency dc bus. The No. 1 monitor dc bus will be dropped. Normally the #2 rectifier furnishes power to the No. 3 primary dc bus and also to the No. 2 primary dc bus and the emergency dc bus. If the #1 rectifier fails, the No. 3 primary dc bus will furnish power to the No. 1, 2, and emergency dc buses. The No. 1 monitor dc bus will be dropped. See figures 2-11 and 2-12.

2.7.6 Rectifiers. Two 200-ampere, 28 vdc rectifiers are incorporated in the electrical system. Direct current will automatically be provided whenever the ac system is energized. The No. 1 primary ac bus furnishes three-phase operating power to the #1 rectifier. The No. 3 primary ac bus furnishes power to the #2 rectifier. Power to light the #1 RECT caution light when the #1 rectifier fails is furnished by the No. 1 generator's supervisory panel. Power to light the #2 RECT caution light when the #2 rectifier fails is furnished by the No. 3 generator supervisory panel. The No. 1 primary ac bus circuit breaker panel in the cabin furnishes power to the #1 rectifier through a circuit breaker marked CONVERTER NO. 1. The No. 3 primary ac bus circuit breaker panel in the cabin furnishes power to the #2 rectifier through a circuit breaker marked CONVERTER NO. 2.

Note

> In the event of a dual rectifier failure, essential aircraft systems including AFCS computers, attitude indicators, fire detection/extinguisher, and landing gear control will be lost. Also, ICS, and communication equipment will be degraded.

2.7.7 Circuit Breaker Panels. These panels, protecting various ac and dc circuits, are in the cockpit and cabin. The emergency ac and dc circuit breaker panel is on the cockpit's overhead control panel. The No. 3 primary ac circuit breaker panel is on the forward right side of the cabin. Aircraft with AFC 490 also have some of the No. 3 primary ac circuit breakers on the cockpit overhead control panel. The No. 3 primary dc bus and the No. 2 primary dc bus circuit breaker panels are also on the forward right side of the cabin. Circuit breaker panels on the forward left side of the cabin are, the No. 2A and 2B primary ac bus circuit breaker panel, the No. 1 primary and monitor dc bus circuit breaker panel, and the No. 1 primary and monitor ac bus circuit breaker panel. All circuit breakers are the push-pull type that can be reset, and are marked to identify the circuit they protect.

To protect the No. 1 primary ac bus if a short develops in the emergency ac bus, three ac circuit breakers, one for each phase, are incorporated between the No. 1 primary ac bus and the emergency ac bus relay. The circuit breakers are on the No. 1 ac power junction box above the test receptacle. To protect the No. 3 primary ac bus if a short develops in the emergency ac bus, three ac circuit breakers, one for each phase, (and a three-phase voltage-sensing relay on aircraft with AFC 490) are incorporated between the No. 3 primary ac bus and the emergency ac bus relay. The circuit breakers are on the No. 3 ac power junction box above the test receptacle.

An additional exposure suit blower ac circuit breaker is beneath each pilots' and the aircrewman's seat.

2.7.8 Current Limiters. A current limiter restricts the maximum flow of current to a specific amount, regardless of applied voltage. A current requirement beyond the capacity of the current limiters, as caused by a short circuit, will cause the current limiter to break the flow of current and subsequently protect the power generation line from overload. A three-phase current limiter protects the No. 1 primary ac bus circuits when it is furnishing power to the No. 2A primary bus. A three-phase current limiter protects the No. 2A primary bus when it is furnishing power to the No. 1 primary ac bus. A three-phase current limiter protects the No. 3 primary ac bus when it is furnishing power to the No. 2B primary bus. A three-phase current limiter protects the No. 2B primary ac bus when it is furnishing power to the No. 3 primary ac bus. Four current limiters are in the dc current crossfeed lines to protect the primary dc buses if a short develops in the emergency dc bus. One is between the No. 1 and 2 primary dc buses, one between the No. 2 and 3 primary dc buses, one between the No. 1 and 3 primary dc buses, and one between the emergency dc bus relay and the emergency dc bus.

2.7.9 Utility Receptacles. There are two receptacles in the cabin at the ramp station on the left side. One is marked 28 VOLT DC and the other 115/200 VOLT AC.

There is a utility receptacle in the cockpit on the copilot's floodlight panel marked 28 VDC 7.5 AMP. Another ac receptacle is on the left side of the cabin aft of the circuit breaker panels.

2.8 LIGHTING EQUIPMENT

The lighting equipment operates on alternating and direct current through appropriately marked circuit breakers on the circuit breaker panels. Switches and rheostats for operating all lights, except the standby compass light, controllable spotlights, and the utility hoist floodlight, are on the overhead control panels (FO-1) in the pilot's compartment.

2.8.1 Pilot's and Copilot's Instrument Lights. The pilot's and copilot's flight instrument lights (Figure 2-13) are individually controlled by rheostats on the pilot's and copilot's overhead interior lights control panels. The pilot's flight instrument lights are controlled by a rheostat, marked PILOT FLIGHT INST LTS, with marked positions OFF and BRT, on the pilot's overhead INT LTS control panel. The pilot's flight instrument light rheostat is also used to control the dimming circuit for the landing gear handle light (when on), AFCS control panel lights, the blade/pylon fold panel lights, the refueling panel lights, and the pilot's and copilot's miscellaneous switch panel lights. All lights on the dimming circuit will be dimmed to one setting when the pilot's flight instrument light rheostat is turned on. In addition, when the pilot's flight instrument light rheostat is advanced out of OFF, the caution and advisory lights will be bright. The caution and advisory lights are dimmed by placing the momentary BRT/DIM toggle switch on the advisory panel to DIM. The copilot's flight instrument lights are controlled by a rheostat, marked CO-PILOT FLT INST LTS with marked positions OFF and BRT, on the copilot's overhead INTERIOR LTS control panel. The intensity of the flight instrument lights may be varied by turning the individual rheostats. The pilot's flight instrument lights receive power from the No. 3 primary ac bus, through a circuit breaker marked FLT LT PILOT, in the cabin. The copilot's flight instrument lights receive power from the No. 1 primary ac bus through a circuit breaker in the cabin, marked FLT LT CO-PILOT.

2.8.2 Nonflight Instrument Lights. These lights provide indirect lighting of the instrument panel for the engine and transmission instruments, hydraulic pressure gages, fuel gages and landing gear position indicators. The lights are controlled by a rheostat marked NON FLIGHT INST LTS, with marked positions OFF and BRT, on the pilot's overhead INT LTS control panel. The intensity of the lights may be varied by turning the rheostat. The nonflight instrument lights receive power from the No. 2B primary ac bus through a circuit breaker in the cabin, marked NON FLT under the general heading LIGHTS.

2.8.3 Upper and Lower Console Lights. The lights are individually controlled by two rheostats on the copilot's INTERIOR LTS control panel. The rheostat marked UPPER controls the upper console lights. The rheostat marked LOWER, controls the lower console and the ICS control panel. Both rheostats have marked positions OFF and BRT and are under the general heading CONSOLE

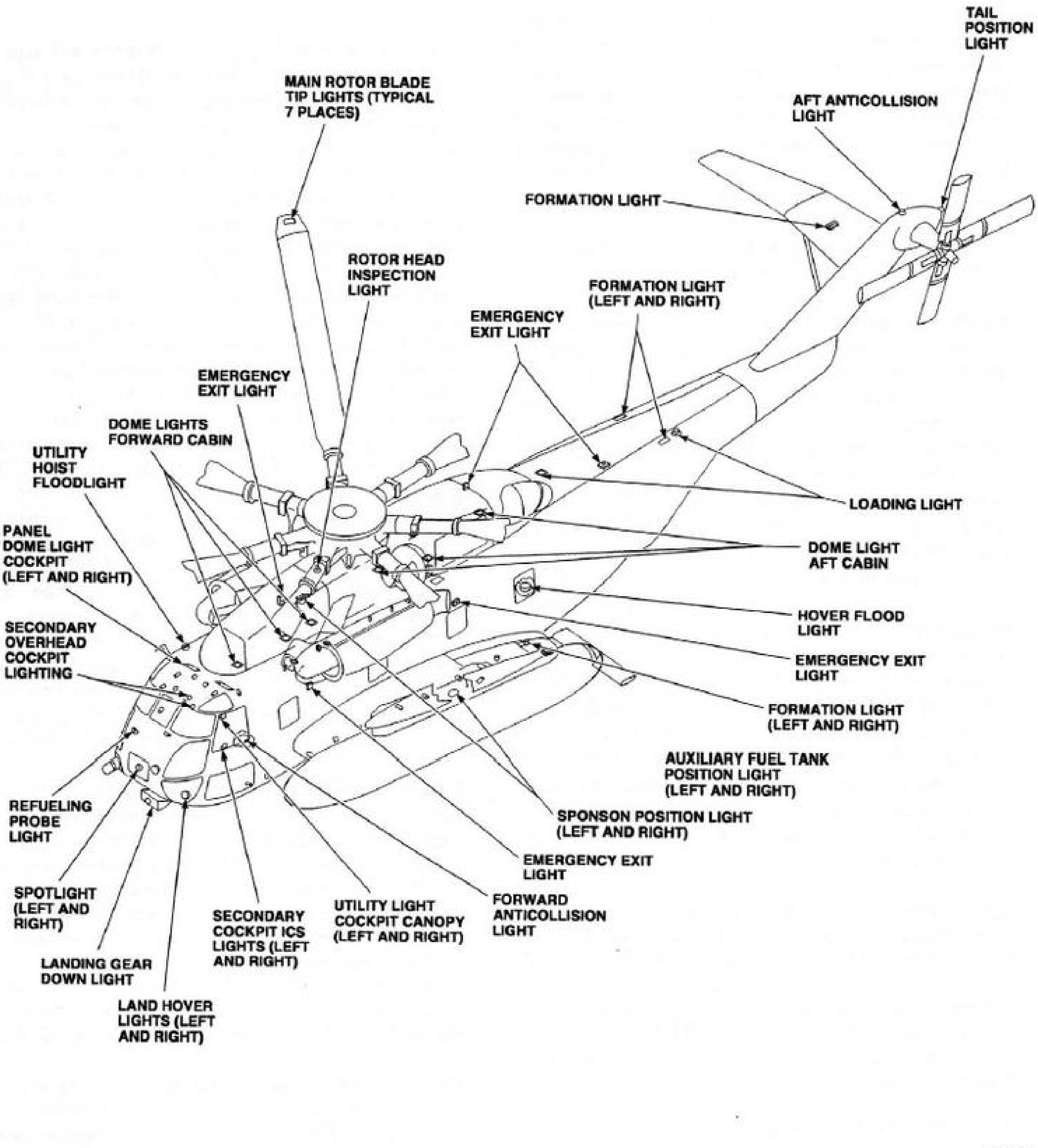


Figure 2-13. Lighting

LTS. The intensity of the lights may be varied by turning the proper rheostat. The upper and lower console lights receive power from the No. 2B primary ac bus through two circuit breakers in the cabin, marked CONSOLE UPPER and LOWER under the general heading LIGHTS.

2.8.4 Secondary Floodlights. These floodlights (Figure 2-13) provide a secondary source of lighting for the instrument panel, upper console, and the ICS control panels. Controls for the lights consist of a switch and a rheostat on the pilot's INTERIOR LIGHTS control panel. The rheostat, marked PILOT INSTRUMENTS, with marked positions OFF and BRT, may be turned to vary the intensity of the secondary instrument panel lights independently of the position of the console switch. Placing the console switch marked CONSOLE, with marked positions DIM, OFF, and BRT, to either DIM or BRT, will provide either dimmed or bright secondary lighting to the upper console, ICS control panels, and instrument panel. The cockpit red lights will also go on, even though the cockpit red light switch is OFF. When the CONSOLE switch is placed to BRT, the pilot's instrument light rheostat is bypassed and the light intensity cannot be varied. When the CONSOLE switch is placed to either DIM or BRT, the cockpit red lights will go on. The cockpit red lights may be operated independently of the other secondary lights by placing the cockpit red light switch (FO-1) marked COCKPIT RED LIGHT to ON. The secondary floodlights receive power from the emergency dc bus through a circuit breaker in the cockpit, marked SEC INST LTS.

2.8.5 Cockpit White Lights. These lights are controlled by a switch and rheostat on the pilot's INTERIOR LIGHTS control panel, both of which are under the general heading COCKPIT WHITE LIGHT. The control switch, with marked positions CONTROL, OFF, and BRT, is used to turn the cockpit white lights on. When the control switch is placed to CONTROL, the intensity of the lights may be varied by turning the rheostat marked DIM and BRT. Placing the control switch to BRT bypasses the rheostat control and increases the intensity of the lights. The cockpit white lights receive power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked CKPT DOME, under the general heading LIGHTS.

2.8.6 Utility Lights. There are two portable utility lights, with coiled extension cord, secured on swivel-type mountings overhead on each side of the cockpit canopy (Figure 2-13). They may be adjusted on their mountings to direct the light beams as desired. The utility lights are each controlled by a rheostat with marked positions OFF and BRT, and a pushbutton switch on the end of each light casing. Pressing the pushbutton switch provides full intensity of the lights. The rheostat provides control of the intensity of the lights. The lens casing of the light may be turned to focus the beam and to position a red filter, converting the white light to a red light. The lights operate from the No. 2 primary dc bus through a circuit breaker in the cabin, marked CKPT LTS, under the general heading EMERGENCY.

2.8.7 Cabin Dome Lights. The six cabin dome lights are controlled by a switch marked CABIN DOME, with marked positions WHITE, OFF, and RED, on the copilot's INTERIOR LTS control panel. The cabin dome lights each have a red and white lamp. Placing the cabin dome light switch to WHITE or RED will turn on the white (or red) lamp in that light. The cabin dome lights operate from the No. 3 primary dc bus through a circuit breaker in the cabin, marked CABIN DOME, under the general heading LIGHTS.

2.8.8 Cabin Panel Lights. The lights are controlled by two rheostats on the CABIN PANEL LIGHTS control panel (Figure 2-14) mounted above the circuit breaker panels on the left side of the cabin. The rheostat marked LH controls the panels on the left side of the cabin and the rheostat marked RH controls the panels on the right side. Turning the rheostat toward BRT increases panel lighting intensity, and turning the rheostats to OFF extinguishes the panel lights.

2.8.9 Emergency Exit Lights. The five removable emergency exit lights, four installed in the cabin above an emergency exit, and one installed on the aft cabin wall above the ramp opening, have a self-contained battery that will cause the light to go on whenever dc electrical power is interrupted to the light. The lights may be removed from the helicopter in case of an emergency

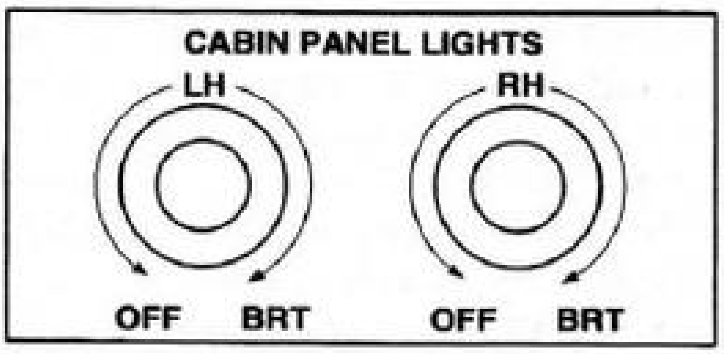


Figure 2-14. Cabin Panel Lights

evacuation by pulling on the handle marked PULL, at the top of each light. When the light is removed, a switch on the light housing is actuated, causing the light to operate on battery power. Once the light is removed, it may be turned off by pushing the handle in, and turned on again by pulling the handle out. The emergency exit lights are controlled by a switch marked EMER EXIT, with marked positions ARM, TEST and OFF, on the copilot's interior light control panel marked INTERIOR LTS. Placing the switch to ARM electrically charges the self-contained battery. The lights are tested by placing the switch to TEST, which interrupts electrical power to the lights. The lights are turned off by placing the switch OFF. The emergency exit lights receive power from the No. 2 primary dc bus through a circuit breaker marked EXIT LTS, under the general heading EMERGENCY, in the cabin. On aircraft bureau number 126517 and subsequent, and those aircraft modified by AFC 379, there are four emergency lights in the cabin. The power source for the emergency lights is two batteries, charged from the No. 1 primary ac bus through a circuit breaker marked BATT CHARGE. The four cabin emergency lights above the forward cabin door and each of the three cabin escape hatches light automatically when the helicopters dc electrical system fails, upon impact of 10 Gs, or when immersion switches at floor level are immersed in water (salt or fresh).

Note

If electrical power is momentarily interrupted to the No. 2 dc primary bus with the EMER EXIT switch at ARM, the emergency exit lights will go on.

2.8.10 Loading Lights. Two loading lights, one overhead in the cabin above the ramp and one in the bottom of the transition section, provide lighting for the ramp loading area. The lights are controlled from the CAR LDG panel on the overhead control panel (FO-1). Placing the LOADING switch ON turns the lights on. Placing the switch to CREW arms the RAMP control panel (Figure 2-41) so the lights can be controlled from the cabin. Placing the LOADING LTS switch, on the RAMP control panel, ON, turns the lights on. The loading lights receive electrical power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked CARGO LOAD, under the general heading LIGHTS.

2.8.11 Exterior Light Master Switch. The MASTER switch is on the EXTERIOR LIGHTS panel on the copilot's overhead control panel. The master switch must be placed ON before any of the position lights, anticollision lights, main rotor blade tip lights, rotor head light, or landing gear down light will operate. Placing the switch OFF will turn off all of the exterior lights controlled through the master switch.

2.8.12 Land-Hover Lights. These consist of three lights: two are on either side of the lower nose section and the third is on the bottom aft section of the fuselage. The lights are controlled by a switch on the EXTERIOR LIGHTS panel on the copilot's overhead control panel. Marked positions are LAND, OFF, and HOVER. When the switch is placed to HOVER, the hover light on the bottom aft section of the fuselage goes on and lights an area directly below the helicopter. Placing the switch to LAND will cause the hover light and the two landing lights on either side of the lower nose section to go on and light areas forward of and directly below the helicopter. Placing the switch OFF turns off all the land-hover lights. Control power for the land hover lights is provided from the No. 2 primary dc bus, through a circuit breaker in the cabin, marked CONT, under the general heading LAND HOVER LT. The hover light receives electrical power from the No. 1 primary dc bus through a circuit breaker, marked HOVER NO. 1 under the general heading LIGHTS. The left and right landing light receives electrical power from the No. 2 primary dc bus through circuit breakers in the cabin, marked NO. 2 LAMP and NO. 3 LAMP, respectively, under the general heading LAND HOVER LT.

2.8.13 Position Lights. These consist of two red lights, one on the outboard side of the left sponson and the other on the left outboard side of the left auxiliary fuel tank support; two green lights, one on the outboard side of the right sponson and the other on the right outboard side of the right auxiliary fuel tank support; and a white light, on top of the tail pylon. The red and green position lights on the outboard side of the sponsons are made inoperative by a relay when the auxiliary fuel tank supports and associated position lights are installed and operating. However, when the auxiliary fuel tank supports and associated position lights are not installed, the sponson position lights operate normally. The lights are controlled by three switches on the copilot's EXTERIOR LIGHTS control panel. A two-position switch, with marked positions FLASH and STEADY, to the left of the position light control switches, offers selection of either a steady or flashing mode of operation. The flasher operates only when the switch is at FLASH. The two position lights, on the outboard side of each sponson and auxiliary fuel tank support, are controlled by the switch marked SIDE, with marked positions, DIM, OFF, and BRT. The position light, on top of the tail pylon, is controlled by the switch marked TAIL, with marked positions DIM, OFF, and BRT. The side and tail position lights may be operated independent of each other. However, none of the position lights will operate until the exterior light master switch is placed ON. Placing the position light switches to DIM will cause the respective position lights to operate at a low intensity. Placing the position light switches to BRT will cause the respective position lights to operate at a high intensity. The position lights receive power from the No. 3 primary dc bus through a circuit breaker, marked POS, under the general heading LIGHTS, in the cabin.

2.8.14 Anticollision Lights. Two rotating anticollision lights, one on the top of the tail pylon and the other on the bottom of the forward fuselage, are normally controlled by two switches. Both switches are on the copilot's EXTERIOR LIGHTS control panel under the general heading ANTI-COLL. The left switch marked BOTH, with marked positions ON and OFF, is used to operate both lights simultaneously. Placing the switch ON will cause both anticollision lights to go on, and placing the switch OFF will cause both anticollision lights to go off. The right switch, marked FWD, with marked positions OFF and RESET, is spring-loaded to center. If it is desired to have only the aft anticollision light operating, the forward anticollision light may be turned off by placing the FWD switch OFF. Placing the switch to RESET will restore the forward anticollision light to operation. The exterior lights master switch must be ON to operate the anticollision lights. The aft anticollision light receives power from the No. 3 ac primary bus through a circuit breaker, marked ANTI-COLL LT AFT, in the cabin. The forward anticollision light receives power from the No. 1 primary dc bus through a circuit breaker, marked FWD, and the anticollision lights control circuit also receives power from the No. 1 dc primary bus through a circuit breaker, marked CONT. Both circuit breakers are in the cabin, under the general heading ANTI-COLLISION LIGHT.

Aircraft modified by AFC 342 have strobe anticollision lights. Switches to control the lights are on the copilot's exterior lights control panel under the heading ANTI-COLL. The left switch with marked positions BOTH-UPPER-LOWER, operates the lights. Placing the switch to UPPER will cause the upper anticollision light to go on, placing the switch to LOWER will cause the lower anticollision light to go on, and at BOTH the upper and lower lights will go on. The right switch with marked positions DAY-OFF-NIGHT, is used to select red or white lighting. When placed to DAY the strobes will pulse white. When placed to NIGHT the strobes will pulse red. OFF removes power from the system. The anticollision strobes are omnidirectional and pulse at 30 to 40 flashes per minute. The exterior lights master switch must be on to operate the anticollision lights.

The anticollision strobes receive power from the No. 3 ac primary bus through a circuit breaker marked ANTI-COL LT.

Note

> The forward rotating anticollision light should be turned off during flight when visibility is reduced, where the pilot might experience vertigo from the reflections of the rotating light against the clouds.

2.8.15 Formation Lights. These consist of one white light installed in each rotor blade tip, and seven green electroluminescent formation lights installed on the fuselage (Figure 2-13). The blade tip lights provide rotor blade tip path lighting that may be viewed only from 0° to an up angle of 25°. The fuselage formation lights are on the upper surface of each sponson, the top left and right sides of the fuselage aft of the main gear box, the top left and right sides of the fuselage forward of the tail pylon, and one on top of the horizontal stabilizer. They can only be viewed from above the helicopter. The lights are controlled by knobs marked FUSELAGE and BLADE TIP, under the general heading FORMATION LIGHTS, on the copilot's EXTERIOR LIGHTS control panel. Both switches have marked position OFF and BRT, and may be turned to vary the intensity of the lights. Both the blade tip and fuselage formation lights receive power from the No. 2B primary ac bus. The blade tip lights are protected by a circuit breaker marked TIP, the fuselage formation lights are protected by a circuit breaker marked FUSLG, and the input circuit is protected by a circuit breaker marked HV. All three circuit breakers are under the general heading FORMATION, in the cabin.

2.8.16 Spotlights. Two controllable spotlights, one for each pilot, are mounted beneath the fuselage nose section. The lights may also be used for refueling drogue illumination. The lights are controlled by two switches on each pilot's collective grip under the general heading SPOT LIGHT. Placing the MASTER switch ON turns the spotlight on and arms the TRAIN switch. Placing the MASTER switch to STOW, when the spotlight is extended, will turn the light off and retract it to the stowed position. The five-position TRAIN switch is spring-loaded to the center position (off), and operates only when the MASTER switch is ON. Pressing the TRAIN switch to the UP position extends the light from the stowed position up to an angle about 30° above the horizon. Releasing the switch stops the spotlight's travel at any desired angle. The DN position operates the same way, except the light is trained downward all the way to the stowed position. The L and R positions train the spotlight left and right to any point throughout 360°. The pilot's controllable spotlight receives power from the No. 3 primary dc bus through circuit breakers in the cabin, marked CONT PILOT-PWR PILOT, under the general heading SPOTLIGHT. The copilot's controllable spotlight receives power from the No. 1 monitored dc bus through circuit breakers in the cabin, marked CONT-PWR, under the general headings CO-PILOT-SPOTLIGHT.

The controllable spotlights are also used as drogue lights with the drogue light dimmer control and selector switch, on the REFUEL LTS control panel on the copilot's overhead control panel. After selection and intensity have been established, the controllable spotlights are operated normally.

Helicopters bureau number 161532 and subsequent (or appropriately modified) have selector switches on the pilot's and copilot's overhead consoles for control of the controllable spotlights or the mine countermeasures controllable mirrors when installed. The panels, marked CLTV BEEPER MODE SEL, each have a switch marked MIRROR-SPOTLIGHT. The respective switch must be at SPOTLIGHT for the SPOTLIGHT switches on the pilot's or copilot's collective to function. The pilot's controllable spotlight receives power from the No. 3 dc primary bus through circuit breakers, marked LT/MIR CONT and SPOT PWR under the general heading PILOT. The copilot's controllable spotlight receives power from the No. 1 dc monitored bus through circuit breakers marked LT/MIR CONT and SPOT PWR under the general heading CO-PILOT.

2.8.16.1 Drogue Light Controls. The REFUEL LTS panel, on the copilot's overhead control panel, contains two drogue light controls under the general heading DROGUE. The selector switch, with marked positions COPLT-OFF-PLT, is used to select either the pilot's or copilot's controllable spotlight for use as a drogue light. The light is then operated in the normal manner. The dimmer control, with marked positions OFF-BRT, is turned out of OFF to vary the intensity of the controllable searchlight that has been selected. The drogue light dimmer control receives power from the No. 1 primary ac bus through a circuit breaker, marked DROGUE DIM CONT, in the cabin.

2.8.17 Probe Light. This light, on the nose of the helicopter, lights the refueling probe. The REFUEL LTS panel, on the copilot's overhead control panel, contains the PROBE light control knob. The probe light is turned on and the intensity varied by turning the knob out of OFF. The light receives power from the No. 1 primary dc bus through a circuit breaker, marked PROBE LT, in the cabin.

2.8.18 Main Rotor Head Light. This light, mounted on the main gear box fairing, permits the main rotor droop stops to be visually checked at night. The light is controlled by a switch marked ROTOR HEAD LIGHT with marked positions ON-OFF, on the MASTER SWITCH panel. The switch is placed ON to light the main rotor head area. The light receives power from the No. 2 primary dc bus through the LANDING GEAR DOWN circuit breaker in the cabin.

2.8.19 Utility Hoist Floodlight. The floodlight, mounted externally on the hoist support structure, furnishes the necessary illumination for night hoist operations. The light is controlled by a switch marked HOIST LIGHT, with marked positions ON-OFF, on the hoist panel in the cabin. The light receives operating and control power from the No. 2 primary dc bus, through two circuit breakers in the cabin, marked PWR-CONT, under the general headings of RESCUE HOIST-LIGHT.

2.8.20 Infrared Exterior Lighting (AFC 479, AFC 481). Helicopters with AFC 479 and AFC 481 have infrared (IR) exterior lighting for effective use during NVG operations. AFC 481 installs IR position lights between the position light assemblies and the left and right auxiliary tank supports. They are controlled by a rotary switch on the cockpit overhead center console marked OFF and 1 through 5 for increasing levels of brightness.

AFC 479 installs an IR beacon between each upper and lower anticollision light assembly and the helicopter skin. An IR position light is also installed between the aft position light assembly and the tail pylon fairing. AFC 479 replaces the rotary switch (AFC 481) with the NVG EXT LTG control panel on the left side of the overhead center console (FO-1). All exterior IR lighting is controlled from this panel. The IR beacons are powered by the No. 3 PRI DC BUS through the IR BEACON circuit breaker, and the IR position lights are powered by the No. 2 PRI DC BUS through the IR POS circuit breaker.

2.9 HYDRAULIC POWER SUPPLY SYSTEM

The helicopter is equipped with separate hydraulic power supply systems; the utility hydraulic power supply system and the flight control hydraulic power supply systems (FO-21, FO-27, FO-29 and FO-32). The engine start hydraulic system has its own hydraulic pump, but is associated with the utility hydraulic power supply system. Each system is powered by a separate hydraulic pump that operates at 3000 psi pressure. The engine start hydraulic system provides 4000 psi for engine starting. All pumps are driven any time the main rotor is turning, to provide hydraulic pressure during autorotation. All pumps, except the first stage flight control system pump, may be driven by the auxiliary power plant to provide system hydraulic pressure when the rotor is not turning. The utility, first stage flight control, and second stage flight control hydraulic systems each have individual reservoirs.

All reservoirs are pressurized and equipped with a color-coded mechanical quantity indicator, quantity gage and a low quantity caution light. The utility hydraulic system furnishes fluid to replenish and control the engine start system. On aircraft modified by AFC 383, an in-flight hydraulic refill system has been incorporated to provide a method of servicing the three hydraulic power supply systems from inside the cabin section.

2.9.1 Heat Exchangers. The second stage and utility hydraulic systems each are equipped with a heat exchanger that maintains the temperature of the hydraulic fluid below 107°C. The hydraulic fluid is cooled as it returns to its respective hydraulic system reservoir. The heat exchanger blowers operate whenever the helicopter's electrical system is energized. The utility blower is powered by the No. 1 primary ac bus circuit breaker panel in the cabin through circuit breakers marked HEAT EXCHANGE UTILITY PWR. The second stage blower is powered by the No. 2B primary ac bus circuit breaker panel in the cabin through a circuit breaker marked HEAT EXCHANGE 2ND STAGE PWR. Control power for the utility blower is furnished by the No. 1 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked HEAT EXCH UTIL. Control power for the second stage blower is furnished by the No. 2 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked HEAT EXCH NO. 2.

On helicopters modified by AFC 308, the heat exchanger blower motors for the utility and second stage systems operate only when the respective system's hydraulic fluid is hot. Each motor turns on when fluid temperature rises above 74 ±3°C, and turns off when temperature drops below 57 ±3°C. Each blower motor is protected by an overheat thermal switch which will shut down the motor when it becomes hot. Neither motor will restart until it has cooled and electrical power to the motor is turned off. (Electrical power can be turned off by opening the system's power circuit breaker and then resetting it.)

In addition, the first stage hydraulic system is cooled by a heat exchanger (finned tube) at the inlet of the main transmission oil cooler, and uses the air flow of this blower. Further, a finned tube is mounted along the trailing edge of the tail rotor pylon, providing additional cooling for the first stage hydraulic system.

2.9.2 Hydraulic Mechanical Quantity Indicator. A color-coded mechanical quantity indicator is mounted on each reservoir. The indicators display red (underfilled) when servicing is required, green (safe) when serviced satisfactorily, and yellow (overfilled) when serviced excessively. A properly serviced system could indicate an overfilled or underfilled condition depending on ambient or system temperature (as temperature increases, fluid expands).

2.9.3 Cockpit Hydraulic Quantity Status Gage. The gage (FO-5 and Figure 2-15), marked HYD QTY, is on the instrument panel. An indicator for each reservoir is incorporated on the gage and the indicators are marked 1, 2, and U, respectively. Each indicator is composed of a vertical tape with color-coded marking to the left, to display the fluid status of its associated reservoir. The color codes are green (adequately serviced), yellow (servicing required) and crosshatch black and white stripes (fluid quantity unsatisfactory). The gage is powered by the No. 2B primary ac bus through a circuit breaker in the cabin, marked TRIPLE HYDR QTY above the general heading 26V.

2.9.4 Hydraulic Quantity Caution Lights. Caution lights for each reservoir are marked 1 STG QTY M/R T/R, 2 STG QTY M/R, and UTILITY QTY T/R, respectively. The caution light will go on when its associated hydraulic gage indicator tape moves from a yellow to a crosshatch indication, and will remain on as long as the indicator tape is in the crosshatch area. The caution light warning system is powered from the No. 1 primary dc power through a circuit breaker in the cabin, marked TRIPLE HYD QTY.

2.9.5 Utility Hydraulic System. The system provides subsystem pressure for the following: utility hoist, APP and engine starting, landing gear extension and retraction, cargo door and ramp operation, cargo winch operation, main wheel power brakes, main rotor and pylon folding, second stage of the tail rotor tandem servo, AFCS SERVO 2, the force augmentation system (FAS) actuator if AFCS SERVO 2 is selected, and main rotor head positioning for engine start. The reservoir is on the left side of the accessory compartment. A 3000 psi pump on the accessory gear box furnishes hydraulic pressure to the utility module. The module is the distribution point for all subsystems. The module contains a pressure filter, a return filter, a tail rotor servovalve, an AFCS turn-on valve, a landing gear emergency bypass valve, a landing gear control valve, an engine start control valve, a 1000 psi AFCS pressure reducer, a 1500 psi wheel brake pressure reducer, an 80 psi pressure reducer for engine start replenishment, a 270 psi engine start supercharge relief

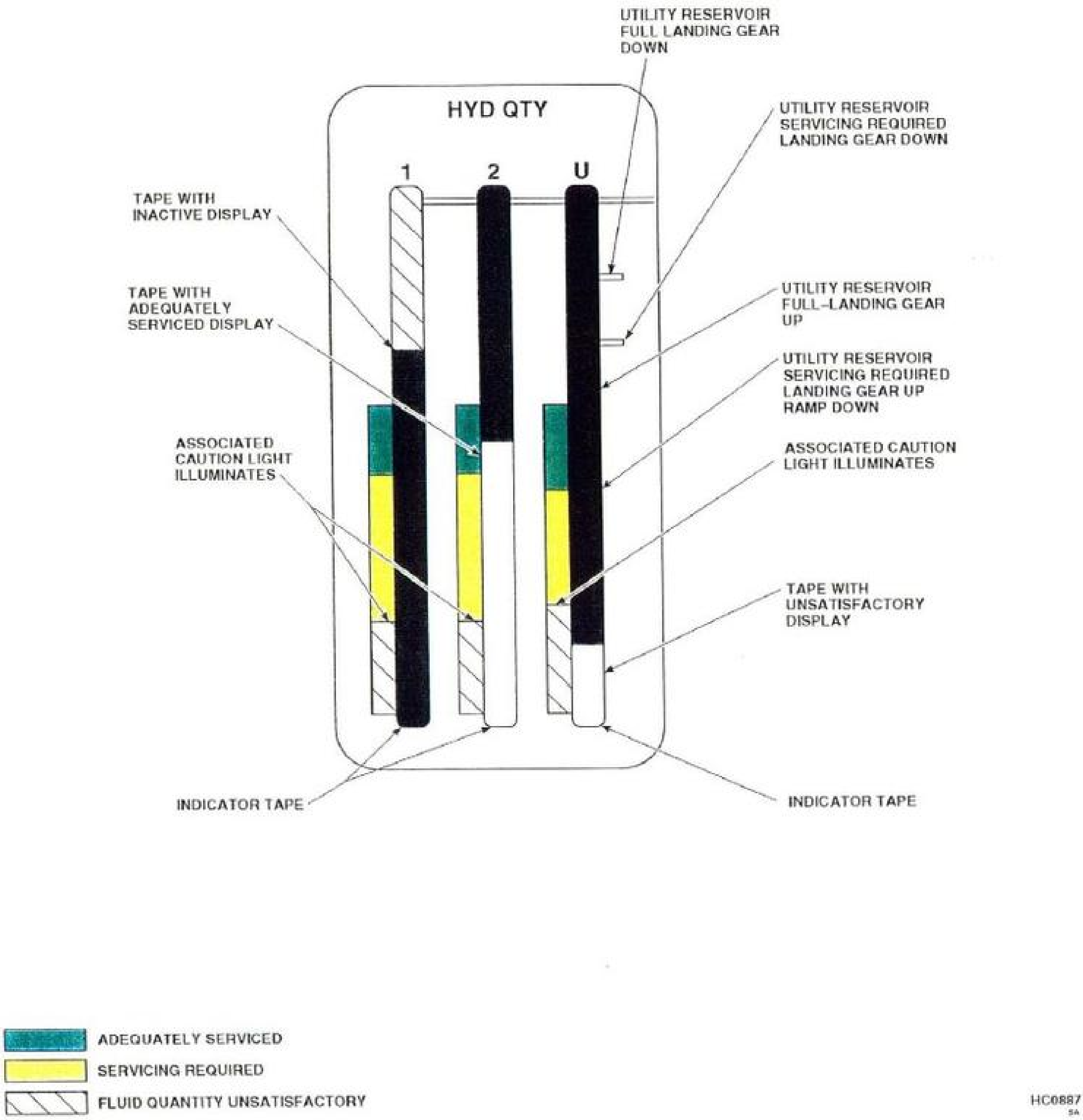


Figure 2-15. Hydraulic Quantity Status Gage

valve, a main system relief valve, an isolation valve, and a priority valve. The isolation valve remains closed in flight to render subsystems inoperative, except when a subsystem is activated. The isolation valve is continually energized (open) when electrical power is applied to the helicopter and the weight of the helicopter is on the landing gear. The flight control, landing gear, and APP accumulator recharge subsystems are not isolated by the isolation valve. The priority valve maintains pressure at the tail rotor tandem servo and SERVO 2 of the AFCS servo by closing if system pressure drops below 2000 psi.

2.9.5.1 Utility Hydraulic System Pressure Gage. The UTIL HYD PRESS gage, on the instrument panel, displays system pressure in psi. The gage operates on 26 vac power from the No. 2B primary ac bus through a circuit breaker marked HYDR PRESS UTIL, above the general heading 26V, in the cabin.

2.9.5.2 Utility Hydraulic System Oil Temperature Caution Light. The UTILITY OIL HOT caution light will go on when utility hydraulic fluid temperature is over 107°C. (On helicopter modified by AFC 308, the UTILITY OIL HOT light will go on when utility hydraulic fluid temperature is over 107°C and/or the utility heat exchanger blower motor shuts down.) The caution light receives power from the No. 3 primary dc bus through a circuit breaker marked UTIL OIL HOT, in the cabin.

2.9.5.3 Utility Hydraulic System Pressure Caution Light. The UTILITY PRESS caution light will go on when the utility hydraulic fluid pressure is below 2000 psi. The caution light receives power from the No. 3 primary dc bus through a circuit breaker marked UTIL PRESS.

2.9.6 Flight Control Hydraulic Pressure Supply. Pressure is supplied to the primary and tail rotor tandem servos by the first stage, second stage, and utility hydraulic systems. Three main rotor primary tandem servos are mounted on the main gear box and are designated forward, lateral, and aft. The primary tandem servos furnish the power boost to transmit control movements to the stationary swashplate of the main rotor head. Each primary tandem servo consists of two independent cylinder sections, which share a common housing, piston shaft, and input linkage. The top cylinder of each primary tandem servo is the second stage servo and the bottom cylinder is the first stage servo. Normally both work in unison. Either the first or second stage servos can provide control of the main rotor if the other servo is not operating. Each stage contains bypass valves interconnecting both sides of the respective power piston to each other and to return. This prevents hydraulic lock, by making the unit act as a pure mechanical linkage in the control system if a pilot valve or system malfunctions. All loads are then taken over by the alternate stage without increase in control forces. The tail rotor tandem servo operates the same way as the main rotor tandem servos. One stage is powered by the first stage hydraulic system and the other by the utility hydraulic system.

2.9.6.1 First Stage Hydraulic System. This system (FO-29) provides pressure to operate the first stage of the primary tandem servos, and the first stage of the tail rotor primary tandem servo. The 3000 psi first stage hydraulic pump is mounted on and driven by the main gear box, and will not operate unless the main rotor is turning. This arrangement will provide first stage hydraulic pressure in an autorotation. The reservoir is on the right side of the helicopter in the aft main rotor pylon. There is an accumulator mounted to the side of the reservoir which is nitrogen precharged from 1800 to 3200 psi. The accumulator gage and servicing valve are located on the bulkhead just to the right of the accumulator and reservoir.

2.9.6.2 Second Stage Hydraulic System. This system (FO-29) provides pressure to operate the second stage of the primary tandem servos, AFCS SERVO 1, and the FAS actuator if AFCS SERVO 1 is selected. The second stage 3000 psi hydraulic pump is mounted on the accessory gear box. The reservoir is in the accessory compartment on the right side. There is an accumulator mounted to the side of the reservoir which is nitrogen precharged from 1800 to 3200 psi. The accumulator gage is mounted with the servicing panel at the lower right side of the hydraulics compartment.

2.9.6.3 Flight Control Servo Switches. Power for the first and second stage primary and tail rotor servo is controlled by either of the three-position SERVO OFF switches on the pilots' collective grips (FO-8). Normally, both servos are in operation when both pilots' switches are in the unmarked center (ON) position and the main rotor is turning. The first stage side of the primary tandem servos and the first stage of the tail rotor tandem servo are turned off if either pilot selects 1 STG. The second stage side of the primary tandem servos and the utility side of the tail rotor tandem servo are turned off if either pilot selects 2 STG. The first and second stage sides of the main rotor primary tandem servos are interconnected electrically so that regardless of switch position, neither side of the tandem servos can be turned off unless there is 2000 psi in the other side, providing there is no electrical malfunction.

WARNING

- There are no interlocks to prevent turning off pressure to the tail rotor first stage if there is no utility pressure.
- There are no interlocks to prevent turning off pressure to either hydraulic stage when a servo in the other stage is in bypass. Turning off pressure to the unbypassed stage results in loss of control.

Before blade/pylon fold, second stage hydraulic pressure is maintained on the primary tandem servos to permit the servos to position the swashplate for blade/pylon fold. When the pitch lock switch is placed to PITCH LOCK the second stage isolation valve is closed and second stage hydraulic power is reduced to the primary tandem servos to prevent accidental damage to the swashplate. Then the pitch locks advance. The second and first stage servo shutoff valves receive power from the emergency dc bus circuit breaker panel in the cockpit through two circuit breakers, under the general heading PRIMARY SERVO, marked INTLK 1-INTLK 2.

2.9.6.4 Flight Control Hydraulic Isolation Valves. Helicopters modified by AFC 309 have a motor-driven flight control hydraulic isolation valve in the first and the second stage hydraulic pressure lines. The valves prevent damage to the swashplate caused by movement of the collective and cyclic controls when the pitch locks are engaged. Each valve closes when a pitch lock engage command is received from the fold control panel, and opens when a disengage command is received. The valves move only on electrical command, remain in position in case of electrical power interruption, and are independent of hydraulic pressure. When closed, the second stage isolation valve bypasses, through an 800 psi pressure reducer which provides adequate fluid for positioning the swashplate during pitch lock engagement. Interlocks for the second stage main rotor servo bypass valve are: (1) main gear box oil pressure switch below 14 psi, (2) gust lock UNLOCKED, (3) engine speed control lever at SHUT OFF, and (4) blade fold master power switch at MASTER POWER.

2.9.6.5 Flight Control Hydraulic Pressure Gages. The gages are on the instrument panel and indicate first stage, second stage, and utility hydraulic pressure in psi. Power to operate the first stage gage is furnished by the No. 3 primary ac bus circuit breaker panel in the cabin through a circuit breaker marked HYDR PRESS, above the general heading 26V. Power to operate the second stage gage is furnished by the No. 2B primary ac bus circuit breaker panel in the cabin, through a circuit breaker marked HYDR PRESS 2ND STAGE, above the general heading 26V.

2.9.6.6 Second Stage Hydraulic System Oil Temperature Caution Light. The 2 STG OIL HOT caution light is installed on helicopters modified by AFC 308. The light will go on when second stage hydraulic fluid temperature is over 107°C and/or the second stage heat exchanger blower motor shuts down. The caution light receives power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked 2 STG OIL HOT.

2.9.6.7 Flight Control Servo Pressure Caution Lights. The first and second stage servo caution lights will go on when pressure in the respective system drops below 2000 psi. The second stage (utility) tail rotor servo caution light will go on when utility pressure drops below 2000 psi. The 1 STG PRESS M/R T/R caution light receives power from the No. 1 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked SERVO PRESS, under the general heading 1 ST STG. The 2 STG PRESS M/R caution light receives power from the No. 3 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked SERVO PRESS, under the general heading 2ND STAGE. The UTILITY T/R PRESS caution light (utility pressure) receives power from the No. 3 primary dc bus circuit breaker panel in the cabin, through a circuit breaker marked TAIL ROTOR SERVO PRESS.

2.9.6.8 Flight Control Servo Failure Caution Lights. The 1 STG M/R SERVO BYPAS or 2 STG M/R SERVO BYPAS caution light will go on to indicate one or more cylinder sections on one side of the main rotor tandem servos may be jammed and is bypassing hydraulic pressure. Further, the caution lights will go on any time the electrical system is energized and the first or second stage systems are not pressurized. The 1 STG M/R SERVO BYPAS caution light receives power from the No. 1 primary dc bus circuit breaker panel in the cabin, through a circuit breaker marked SERVO FAIL, under the general heading 1 ST STG. The 2 STG M/R SERVO BYPAS caution light receives power from the No. 3 primary dc bus circuit breaker panel in the cabin, through a circuit breaker marked SERVO FAIL, under the general heading 2ND STG.

The 1 STG T/R SERVO BYPAS or the 2 STG T/R SERVO BYPAS caution light goes on to indicate one side of the tail rotor tandem servovalve may be jammed and is bypassing hydraulic pressure. Further, the caution lights go on any time the electrical system is energized and the first stage flight control or the utility hydraulic systems are not pressurized. The 1 STG T/R SERVO BYPAS caution light uses the same electrical power source as the 1 STG M/R SERVO BYPAS caution light and the 2 STG T/R SERVO BYPAS caution light uses the same electrical power source as the 2 STG M/R SERVO BYPAS caution light.

2.9.7 Hydraulic Refill. For aircraft modified by AFC 383, a manual hydraulic refill system to replenish the first stage, second stage and utility hydraulic systems is on the left cabin wall (Figure 2-16). It consists of a reservoir, handpump, service disconnect and selector valve. The 4-quart reservoir has high-level and low-level sight gages and a removable cap for filling. Attaching a hydraulic service unit to the disconnect valve provides for filling the reservoir or directly servicing the respective systems. Hydraulic oil gravity flows from the reservoir to a hand-operated pump which will deliver oil to the hydraulic system reservoir selected on the three-position selector valve. An integral filter element is included in the pump.

2.10 FLIGHT CONTROL SYSTEM

Pitch, roll, yaw, and vertical maneuvering of the helicopter is done with the pilots' controls by tilting the tip path plane, formed by the rotating main rotor blades, and varying the thrust of the tail rotor. The helicopter is maneuvered by the cyclic in pitch and roll, by the rudder pedals in yaw, and by the collective vertically (FO-33 and Figure 2-17).

2.10.1 Main Rotor Control System. The cyclic and collective are connected to the main rotor primary tandem servos by mechanical linkage. The linkage from these flight controls are connected first to the AFCS pitch, roll, and collective servos, which function as mechanical connections with AFCS hydraulic servo off. To smooth out pilot roll inputs, a viscous damper is incorporated in the roll linkage between the cyclic and the AFCS roll servo. The damper permits limited continued flight with reduced damping if the damper fails. A failed damper will be indicated by lighter than normal lateral forces. The force felt with a failed damper is fixed and almost imperceptible, about 1 pound. A slight decrease in this force is felt at the cyclic as it passes over the detent.

CAUTION

If the roll damper fails, the flight shall be aborted.

To smooth out pilot pitch inputs, the FAS actuator also acts as a damper, with FAS on or off. The FAS actuator (FO-33) is just above the AFCS pitch servo. The actuator's output piston is connected to the rod and shearpin assembly that extends through the pitch servo housing. The rod and shearpin connects the actuator output to the flight control linkage at the point where the cyclic linkage is attached to the servo input. The pitch, roll, and collective linkage continues on to the mixing unit where the necessary control couplings are made. In the pitch linkage between the AFCS pitch servo and the mixing unit there is a longitudinal bias actuator that functions as a mechanical connection with AFCS off. Finally, the linkage goes to the forward, aft, and lateral main rotor primary servos. These servos furnish the necessary hydraulic boost required to tilt, raise, and lower the stationary swashplate. In addition, the servos eliminate any feedback of the aerodynamic forces generated by the rotating main rotor. If the control linkage to a primary tandem servo fails, a self-centering spring cylinder assembly attached to the last control component before attachment to the primary tandem servo, sets that servo to an intermediate position to prevent a hardover. If a self-centering cylinder assembly jams the controls, a shearpin is incorporated in the support of the assembly that is sheared by the force of AFCS power boost. The pin is sheared by movement of the rudder pedals, cyclic or collective. The stationary swashplate causes the pitch control rods to change the pitch angle of the main rotor blades, that subsequently tilts the tip path plane of the main rotor blades.

2.10.1.1 Collective Pitch. The collective on the left side of the pilots' seats operates simultaneously to change the collective pitch of the main rotor blades and change tail rotor pitch. All aircraft have been modified by AFC 358 which is the collective viscous damper. The collective viscous damper is installed on the copilot's collective torque arm in the left electronics compartment (Figure 2-17). The collective grips (FO-8) contain the switches to turn the first and second stage of the primary servos on and off, the collective trim release switches, pedal trim release switches, plus other switches to operate auxiliary equipment.

2.10.1.2 Cyclic. The cyclic in front of the pilots' seats operates simultaneously to provide pitch and roll control. Moving the cyclic in any direction tilts the tip path plane of the main rotor blades and moves the helicopter in the same direction. The cyclic grips (FO-8) contain the cyclic beeper trim buttons, the cyclic trim release buttons, plus other switches to operate auxiliary equipment.

2.10.2 Tail Rotor Control System. The system compensates for main rotor torque and permits changing

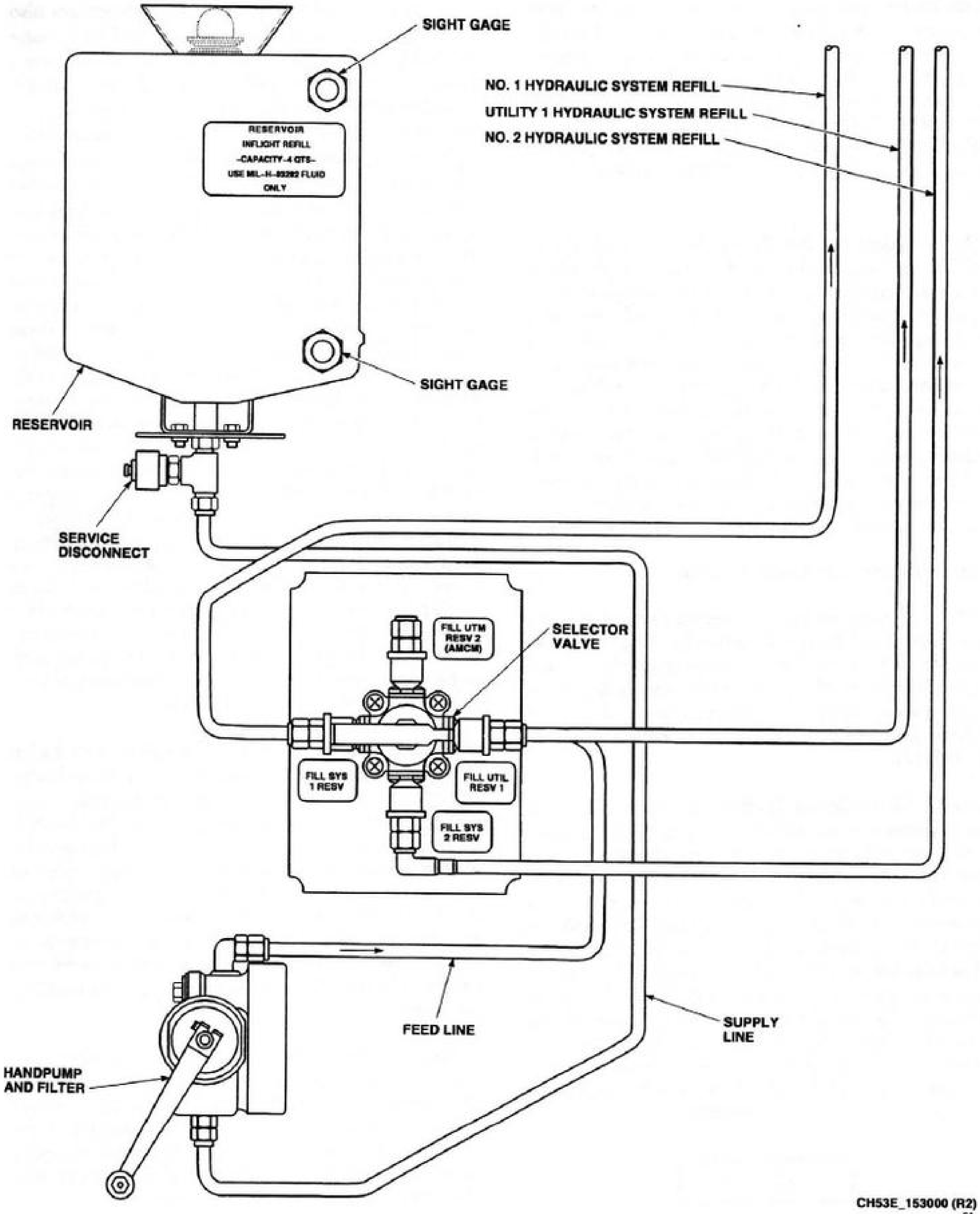


Figure 2-16. Hydraulic Refill System

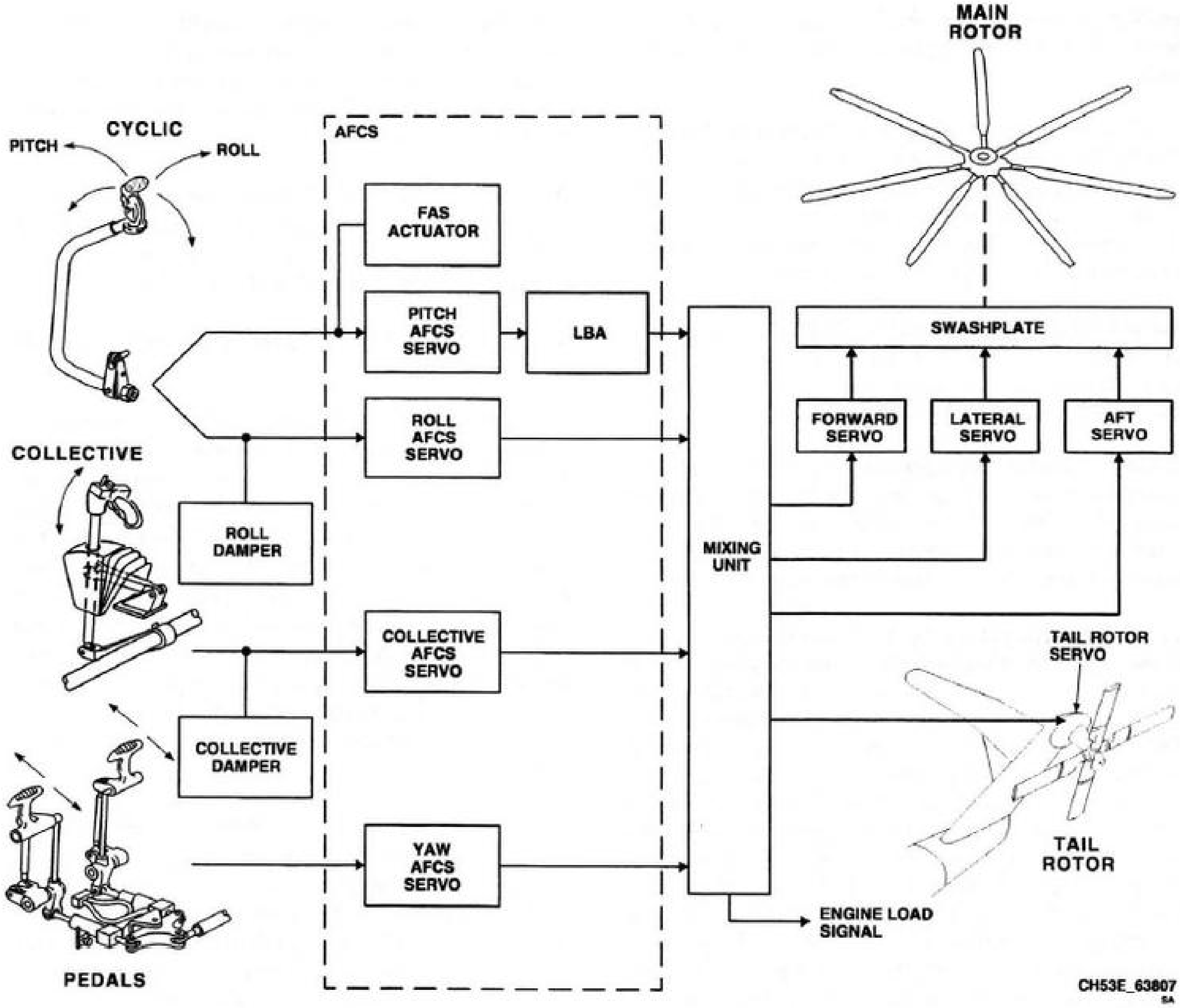


Figure 2-17. Flight Control System (Simplified)

the heading of the helicopter. The torque developed by the main rotor blades rotating counterclockwise tends to turn the fuselage clockwise. Tail rotor control couplings are programmed to compensate for all main rotor variations. The rudder pedals are connected to the tail rotor tandem servo by mechanical linkage. The linkage is connected first to the AFCS yaw servo, that functions as a mechanical connection with AFCS hydraulic power off. To prevent overstressing the helicopter from too rapid movement of the rudder pedals, a damper is incorporated in the AFCS yaw servo that functions with AFCS on or off. The linkage continues on to the mixing unit, where control couplings are made. Finally, the linkage leads to the tail rotor tandem servo, that hydraulically assists control inputs. The servo extends and retracts the tail rotor actuator shaft, causing the pitch beam and pitch change links to vary the pitch of the tail rotor blades. A self-centering spring that is part of the tail rotor tandem servo will set the tail rotor pitch angle to a position that may permit continued flight to a landing site if the tail rotor control system fails and the tail rotor tandem servo is pressurized.

2.10.2.1 Rudder Pedals. The rudder pedals in front of each pilot operate simultaneously to change the pitch/thrust of the tail rotor and subsequently the heading of the helicopter. Footrests on the outboard side of each rudder pedal prevent inadvertent actuation of the rudder pedal microswitches. The wheel brake power boost cylinders for the main landing gear are mounted on the rudder pedals.

2.10.2.2 Rudder Pedal Adjustment Switch. The PEDAL ADJ switch (FO-8) is alongside each pilot in front of the ICS control panels. Placing the switch to FWD or AFT enables the pilot to individually select a comfortable rudder pedal distance. Power to operate the copilot's adjustment is furnished by the No. 1 primary dc bus circuit breaker panel in the cabin through a circuit breaker marked PEDAL ADJ CO-PILOT. Power to operate the pilot's adjustment is furnished by the No. 3 primary dc bus circuit breaker panel in the cabin, through a circuit breaker marked PEDAL ADJ PILOT.

2.10.3 Control Couplings. The mixing unit (FO-33) makes these couplings: collective to yaw, collective to pitch, collective to roll, yaw to pitch, and yaw to roll. These couplings provide automatic proportional transfer between the axes when the appropriate control is moved.

2.10.3.1 Collective to Yaw Coupling. The collective to yaw coupling provides increased tail rotor thrust for collective increases. This transfer is irreversible, and combinations of collective pitch and rudder pedal motion that would exceed the tail rotor pitch limit cannot be realized. If the control positions are such that the left tail rotor pitch limit is reached; additional upward movement of the collective pitch lever is always possible. During this upward movement, the left rudder pedal will move aft, but the tail rotor pitch limit will still be realized. A yaw breakaway rod (FO-33) is incorporated in the yaw linkage aft of the mixing unit. Movement of the collective will shear a shearpin within the rod and permit continued control of the main rotor, if the tail rotor linkage jams. The pin is sheared by the mechanical advantage exerted through the collective channel. If the tail rotor linkage jams aft of the mixing unit, the force required on the collective to shear the shearpin is about 65 pounds with AFCS servo on and about 122 pounds with AFCS servo off.

2.10.3.2 Collective to Pitch Coupling. The collective to pitch coupling provides longitudinal cyclic (pitch) inputs proportional to collective inputs to compensate for pitching moments produced by main rotor thrust changes.

2.10.3.3 Collective to Roll Coupling. The collective to roll coupling provides lateral cyclic (roll) inputs proportional to collective control changes to compensate for tail rotor thrust produced roll moments caused by the collective to yaw coupling.

2.10.3.4 Yaw to Pitch Coupling. The yaw to pitch coupling provides longitudinal cyclic (pitch) inputs proportional to pedal inputs, to compensate for the pitching moment produced by the vertical thrust component of the canted tail rotor.

2.10.3.5 Yaw to Roll Coupling. The yaw to roll coupling provides lateral cyclic (roll) inputs proportional to pedal inputs, to compensate for tail rotor thrust produced roll moments caused by directional control inputs.

2.11 AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS)

The AFCS is used to improve the flight control characteristics and flight stability by improving short and long term dynamic stability, inherently reducing pilot workload. The AFCS interfaces with the mechanical flight controls at the AFCS servos (Figure 2-18). There are two types of control called inner loop and outer loop. Inner loop control improves short term dynamic stability by rate damping and does not move the cockpit controls. It has unlimited rate response but limited authority (approximately ±10%). Outer loop control improves long term dynamic stability, moves the cockpit controls, and has 100% authority but a limited rate (approximately 10% per second).

The AFCS servos, the interfacing between electrical and mechanical entities, perform several functions: (1) Providing power boost in all four axes for pilot initiated control inputs, (2) Converting electrical inner loop signals from the computers into mechanical motion of the main and tail rotor servos, without moving the cockpit controls, to improve short term dynamic stability, and (3) Converting electrical outer loop signals from the computers into mechanical movement of the cockpit flight controls to improve long term dynamic stability (autopilot) and providing cockpit flight control trim.

The longitudinal bias actuator (LBA), in series with the cyclic pitch flight controls, extends and retracts with airspeed to provide the pilot with a positive longitudinal cyclic gradient. It also improves maneuvering stability.

The force augmentation system (FAS) actuator performs several function: (1) Cyclic pitch damping, detent, and gradient functions, (2) Cyclic pitch position trim, (3) Pitch autopilot function (attitude and/or airspeed hold), and (4) FAS function. The FAS function applies a force at the cyclic pitch position for opposing pilot inputs, provid-

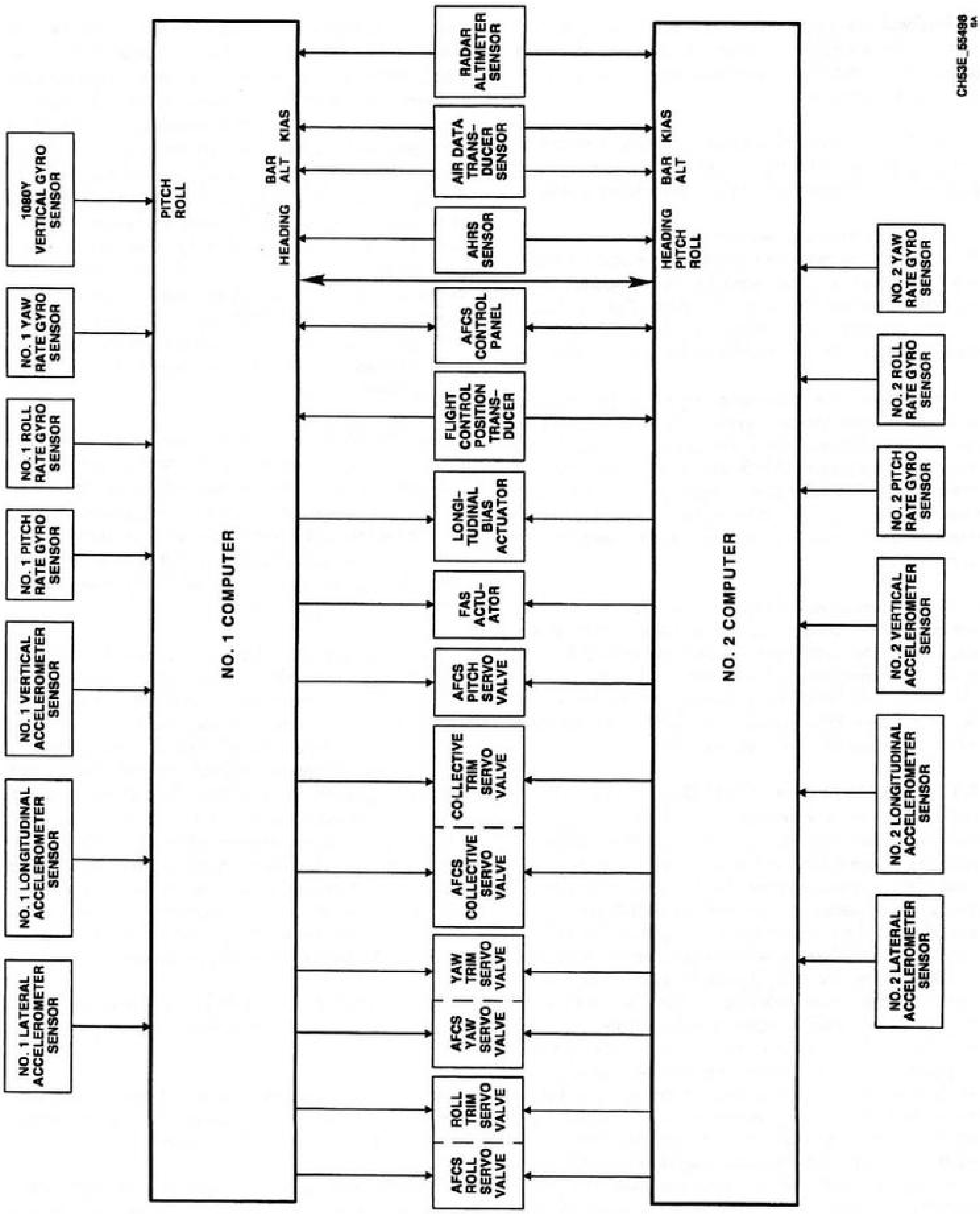


Figure 2-18. AFCS Block Diagram

ing feedback cueing that is directly proportional to gravity forces. This provides the capability to correlate pitch position inputs with helicopter response to preclude over-stressing the airframe.

The AFCS consists of sensors, controls, computers, actuating devices, mechanical flight controls, rotor system, and malfunction indicators acting in a closed loop system.

The sensors monitor helicopter displacement, rate and direction of movement, and position of cockpit controls. This information is acted upon by the computers as a function of control inputs by the pilot. Control inputs consist of switches on the control panels and switches on the collective, cyclic, and rudder pedal flight controls.

The computers output correction signals to the actuators depending upon control switch logic. Each computer normally supplies one-half of the correction signal to the actuator. The actuators (AFCS servos, LBA, FAS actuator) interface with the mechanical flight controls and rotor system to cause helicopter aerodynamic responses, monitored by sensors sending feedback to the computers to close the loop.

The computers monitor and test for malfunctions. Using two computers, running identical programs, ensures errors are detected and prevented from being output to the actuators. Malfunctions are also indicated to the pilot by FAIL ADVISORY lights on the control panels and as stored flight bite codes (FBC) in each computer that can be read out by maintenance after flight termination.

2.11.1 AFCS Servos. The AFCS servos (FO-33) are similar to the primary tandem servos; however, they can have only one stage pressurized at a time. Electrical interlocks prevent both AFCS servo stages from being pressurized at the same time. The first stage of the AFCS servos, when selected, are pressurized at 1000 psi by the second stage flight control hydraulic system. The second stage of the AFCS servos, when selected, are pressurized at 1000 psi by the utility hydraulic system. The AFCS servo's first stage is controlled by the SERVO 1 pushbutton on the AFCS CONTROL panel and the second stage by the SERVO 2 pushbutton. When the servos are not pressurized, their only function is to provide a mechanical link between the pilot input and the mixing unit. When pressurized, the servos convert inner and outer loop electrical signals to mechanical motion. The outer loop signals are applied to the outer loop actuator within the servo, except in pitch, where they are applied to the FAS actuator. This moves the servo input and subsequently the cockpit flight controls, and results in a servo output response identical to that caused by pilot initiated inputs. The inner loop stability signals are applied to the inner loop actuator and do not move the cockpit flight controls. The output of the AFCS pitch servo is linked through the longitudinal bias actuator to the mixing unit, providing mechanical outputs to the forward and aft primary servos. The output of the AFCS roll servo is linked directly to the mixing unit, which furnishes a single input to the lateral primary servo. The output of the AFCS yaw servo is linked directly to the mixing unit, which furnishes outputs to the tail rotor servo plus the forward, aft, and lateral primary servos. In addition, the AFCS yaw servo provides rudder pedal damping with the AFCS on or off. The output of the AFCS collective servo is linked to the mixing unit, which provides outputs to the tail rotor servo and the forward, aft, and lateral servos.

With the AFCS servos pressurized, pilot flight control input results in movement of mechanical linkage that displaces the servo pilot valves, which in turn routes pressure and return to the power pistons, causing them to drive in the required direction. Since the force at the servo output is the product of piston area and operating pressure, pilot manual control inputs need only move the pilot valves to achieve power-assist.

The trim system allows the outer loop to reposition (trim) the cockpit controls. When trim is engaged, a trim shutoff valve opens, allowing hydraulic pressure to activate the system. The (trim piston) outer loop actuator is held at a selected position by balanced forces, and is connected to the pilot input by means of a force gradient spring in roll, yaw, and collective. An electronically derived force gradient is furnished through the FAS actuator in pitch. Electrical error signals, from the computers, are applied to the trim flapper valve. These signals cause the trim flapper valve to deflect, producing an unbalance in pressure at the trim piston. The result of this unbalance is motion of the trim piston. The trim system is capable of 100% control authority at a limited rate (10% per second).

Trim position transducers provide an electrical signal to the computers, that is representative of trim piston position.

All four axes have two additional transducers, each monitoring cockpit flight control positioning and providing an electrical signal to the computers.

Since the outer loop is connected through force gradient springs, override of this system is through normal use of the cockpit flight controls.

Electrical error signals from the inner loop are applied to an electromechanical flapper valve, mounted on top of each servo. These signals cause the flapper valve to deflect, unbalancing the hydraulic pressures acting on the pilot valve. This pressure unbalance causes the pilot valve to move within its carriage. As the pilot valve moves, the power piston is hydraulically repositioned. Mechanical feedback again limits power piston travel; in this case, to approximately +10% of its total range. The pilot can override any inner loop signal, since the pilot has 100% authority.

2.11.2 FAS Actuator. FAS actuator operation is similar to the AFCS servos, in that there is a flapper valve that deflects, causing a pilot valve to displace, driving a power piston which is attached, via a piston and shear pin assembly, to the input linkage of the AFCS pitch servo. Pitch attitude hold, airspeed hold, and pitch trim are all done by the FAS actuator from computer inputs. Differential pressure transducers and a trim/cyclic position transducer monitor the action of the actuator to detect any malfunctions.

An additional cyclic pitch position transducer is mounted at station 162 below the pitch AFCS servo.

2.11.2.1 FAS Pressure Switch. The guarded switch is on the overhead control panel labeled AFCS MISC. Hydraulic pressure from the AFCS pitch servo is furnished to the FAS actuator with the FAS PRESS switch ON (guard closed). The switch is used to remove hydraulic pressure from the FAS actuator in case of a hydraulic leak in the FAS actuator.

The FAS actuator receives either second stage hydraulic pressure or utility pressure depending upon servo 1 or servo 2 selection.

2.11.3 Longitudinal Bias Actuator. This LBA is an electrical screwjack that is connected in series with the longitudinal flight control rods. It is located between the AFCS pitch servo and the mixing unit. It is programmed to extend and retract as a function of airspeed and pitch rate. The actuator if fully retracted from 0 to 60 knots and is fully extended at 180 knots (system design parameters). When a failure of this system occurs, the actuator may stop in any position; therefore, the pilot shall not rely on the position of the cyclic, on rotor shutdown, but must observe the position of the tip path plane or stick position indicator and move the cyclic as necessary to prevent damage to the droop stops as rotor speed decays. Electrical dc power is furnished to the longitudinal bias actuator from the AFCS CONTROL panel on computer command. The LBA has 30% authority and is limited in rate to 5.5% per second.

2.11.4 AFCS Computers. Two computers (Figure 2-18) are used for normal AFCS operation. The computers process incoming signals from sensors, servos, and actuators. Then the processed information is furnished to servos and actuators in the form of electrical correction signals for automatic flight control. Each computer compares its incoming and correction signals with the other computer's, and self-tests its internal circuits to detect and stop faulty correction signals from reaching the servos and actuators. During normal operation, each computer furnishes half of the correction signal to the AFCS servos and the longitudinal bias actuator. If the self-test fails in one computer, then that computer shuts itself off.

Both computers are powered through cockpit circuit breakers under the general heading of AFCS COMPUTER. They are powered by the emergency ac bus through circuit breakers marked NO 1 and NO 2. (On aircraft with AFC 490, the No. 1 computer circuit breaker is marked NO 1 on the emergency ac bus and the No. 2 computer circuit breaker is marked NO 2 on the No. 3 primary ac bus.) The emergency dc bus furnishes power to the No. 1 and No. 2 computers through two circuit breakers, under the general heading AFCS, marked PRI and SEC, respectively. Each circuit breaker panel furnishes dc power to both computers. The AFCS rate gyros are powered through cockpit circuit breakers under the general heading of AFCS RATE GYRO. They are powered by the emergency ac bus through circuit breakers marked NO 1 and NO 2. (On aircraft with AFC 490, the No. 1 rate gyro circuit breaker is marked NO 1 on the emergency ac bus and the No. 2 rate gyro circuit breaker is marked NO 2 on the No. 3 primary ac bus.) The emergency dc bus circuit breaker panel furnishes power to the collective, cyclic, rudder pedal trim release, and beeper switches through a circuit breaker marked TRIM. The emergency dc bus circuit breaker panel furnishes power to the FAS switch through a circuit breaker marked FAS TURN ON.

2.11.5 AFCS Modes of Operation. The following is an explanation of the AFCS modes of operation. In discussing these modes the terms FAIL SAFE and FAIL OPERATIONAL will be used.

FAIL OPERATIONAL means that the mode is important enough that it will continue to operate with a single failure.

FAIL SAFE means that the mode is not necessary for minimum safe operations and that a single failure will cause the mode to stop operating.

In order for any AFCS function to operate, servo 1 or 2 and computer power must be on (switch legends illuminated). (See Figure 2-19.)

When computer power switch is off, the AFCS caution light should be on, indicating that both computers are not receiving power, when computer power switch is on, switch legend illuminated, the AFCS caution light should be off and the AFCS DEGRADED advisory light and all FAIL ADVISORY lights on the AFCS CONTROL panel should be off to indicate both computers are receiving power and are operating. Depressing the AFCS switch sends a discrete signal to both computers to actuate inner loop AFCS. The computers in turn illuminate the AFCS switch legend to indicate to the pilot that inner loop AFCS modes are operating. Depressing the trim switch only, sends a discrete signal to both computers to activate cyclic, collective, and pedal trim. The computers in turn illuminate the trim switch legend to indicate that trim is engaged. If the AFCS switch legend is illuminated, depressing the trim switch will activate both trim and autopilot functions if weight is off the wheels.

2.11.6 Inner Loop AFCS Modes. AFCS switch on.

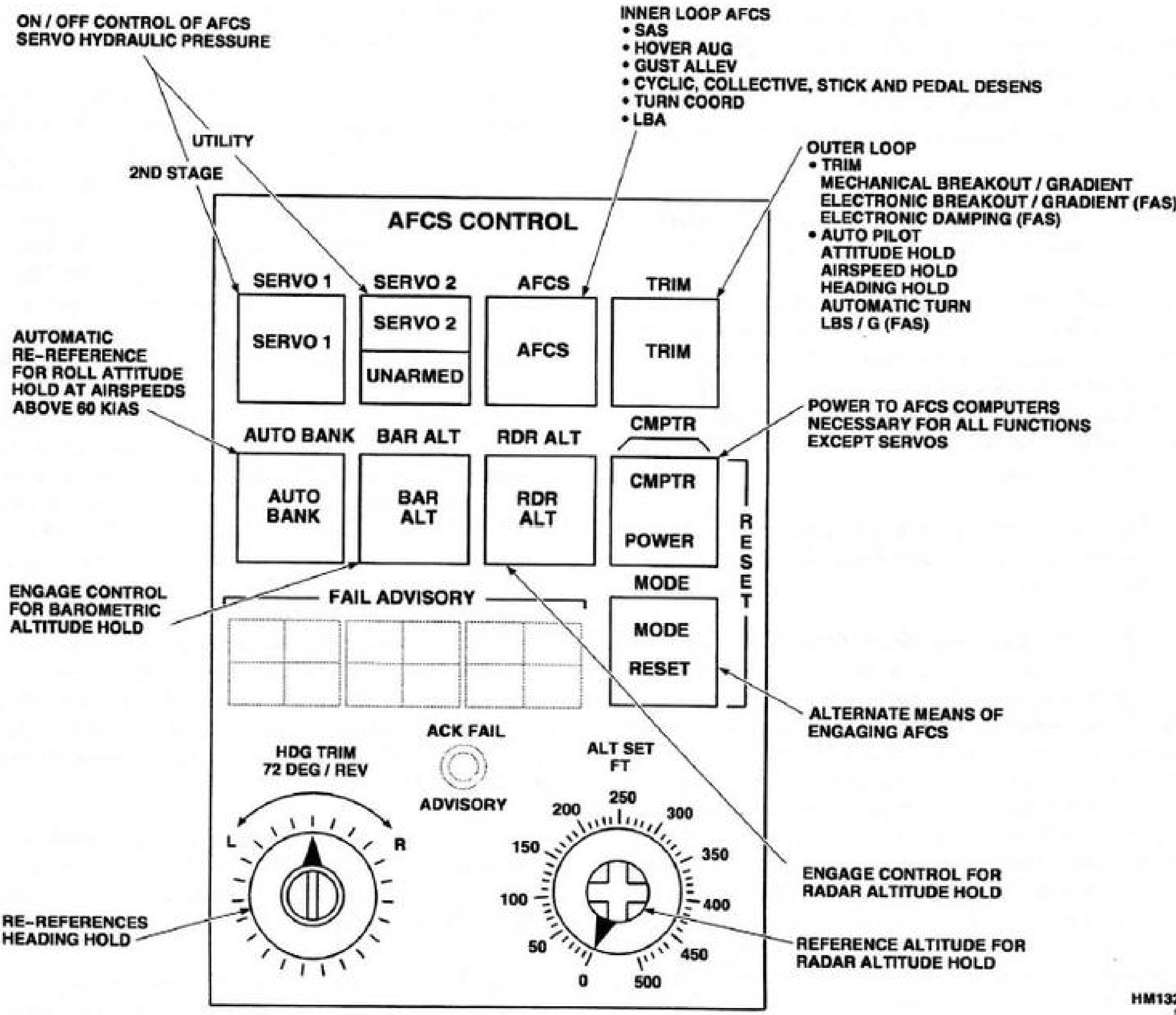


Figure 2-19. AFCS Engage Controls

2.11.6.1 SAS (Stability Augmentation System). SAS provides damping to improve short term dynamic stability in the pitch, roll, and yaw axes. It has approximately ±10% authority, fast response, and is engaged with the AFCS pushbutton. The sensors used to control this mode are pitch, roll, and yaw rate gyros. This mode of operation does not move cockpit flight controls and has FAIL OPERATIONAL function capability.

2.11.6.2 Hover Augmentation/Gust Alleviation. Hover augmentation and gust alleviation reduces pilot workload in the low airspeed regime and in gusty air conditions. Hover augmentation opposes aircraft acceleration along the lateral and longitudinal axes to improve helicopter stability in a hover. It has approximately 55% authority within the SAS authority. The monitoring sensors are the lateral and longitudinal accelerometers. Hover augmentation only works at airspeeds below 60 knots, and at attitudes between 13.3° nose up and 4.4° nose down and is in the FAIL SAFE category.

Gust alleviation improves aircraft stability at all airspeeds in gusty or windy conditions by using limited proportional signals in pitch and roll inner loop. It has approximately 55% authority within the SAS authority. The sensors used to control this mode are pitch and roll vertical gyros. This mode of operation is in the FAIL SAFE category.

2.11.6.3 Control Desensitizers. Collective, cyclic, and rudder pedal desensitizers have been added to the AFCS to reduce the effects of pilot interaction with the 1st (3.25 Hz) and 2nd (4.2 Hz) fuselage bending modes of the helicopter (PIO/PAO). The system attenuates pilot collective, cyclic, and pedal inputs in this frequency range, but does not affect handling qualities in the normal operating frequency range.

The following conditions may indicate an inoperative desensitizer for the -109 computer configuration:

1. DSEN fail advisory light on the AFCS control panel.

2. AFCS is off.

3. AFCS duplex failure.

4. FAS shear pin is sheared.

The sensors used to control this mode of operation are the cockpit flight control position transducers. The control desensitizer mode of operation is limited to the SAS and is FAIL OPERATIONAL capable.

2.11.6.4 Turn Coordination. Inner Loop turn coordination provides yaw channel inputs to coordinate turns above 60 knots. Roll rate and lateral acceleration are furnished to yaw inner loop. This capability is limited to the SAS. The sensors are the roll rate gyros, which initiate the yaw input, and the lateral accelerometers, which coordinate the turn. This mode of operation is FAIL SAFE capable.

2.11.6.5 Inner Loop LBA Interface. The LBA provides a positive cyclic position gradient and improves maneuvering stability. It is cyclic position versus airspeed gradient at airspeeds between 60 and 180 knots (system design parameters). It has 30% authority and is rate limited to 5.5% per second.

The sensors used to control this mode are air data transducer and pitch rate gyros. This mode of operation is FAIL SAFE for an actuator failure and FAIL OPERATIONAL for computer failures. If airspeed fails, the actuator is driven to its midposition (120 knots) and shutdown.

2.11.6.6 Flight Control Damping. Damping takes place in all axes. The FAS actuator provides damping in pitch. There are viscous dampers in both roll and collective, and the yaw AFCS servo provides damping in yaw.

2.11.7 Outer Loop AFCS Modes. TRIM switch or AFCS/TRIM switches on.

2.11.7.1 Trim. Trim capability is used to position/hold the cockpit flight controls at pilot desired positioning via a closed servo loop system consisting of the outer loop actuator (trim piston and servovalve), trim position transducer, and computers. The monitoring sensor is the trim position transducer. The trim mode of operation is FAIL SAFE except for simplex failure. The trim capability can be overridden by compressing the force gradient spring. The trim release switches on the collective, cyclic, and pedal allow temporary release of the respective trim. Pitch and roll trim can also be released and re-referenced by using the cyclic trim (beeper) button on top of the cyclic grip. It re-references pitch or roll trim at the rate of 5% per second by moving the cyclic position automatically.

2.11.7.2 Autopilot — Roll Attitude Hold. The parameters for roll attitude holding are ±1° up to 45° of bank angle and ±2° for bank angles between 45° and 60°. The monitoring sensor is the roll vertical gyro. This holding capability has 100% authority and moves roll cyclic positioning at 7.5% per second. Cyclic trim release actuation disengages and allows re-referencing of attitude. The roll trim (beeper) button re-references at the rate of 4° per second. This mode of operation is FAIL SAFE.

2.11.7.3 Autopilot — Pitch Attitude Hold. This mode of operation holds pitch attitude at ±1° for airspeeds below 60 knots. The monitoring sensor is the pitch vertical gyro. This mode of operation has 100% authority and moves the cyclic pitch position at 15% per second. Cyclic trim release capability disengages this mode and allows re-referencing. Pitch trim (beeper) button re-references at the rate of 2° per second and works only at airspeeds below 60 knots. This mode of operation is FAIL SAFE.

2.11.7.4 Autopilot — Airspeed Hold. This mode holds airspeed at ±5 knots up to 35° of bank angle, then fades out, and works only above 60 knots. The monitoring sensor is the air data transducer. This mode of operation has 100% authority and moves the cyclic pitch position at 15% per second. Cyclic trim release disengages and allows re-referencing this mode. Pitch trim (beeper) button re-references at the rate of 6 knots per second. If airspeed hold fails, the system degrades to attitude hold. This mode of operation is FAIL SAFE.

2.11.7.5 Autopilot — Heading Hold. This capability holds heading at ±2°. The monitoring sensor is the AHRS heading gyro. This mode of operation has 100% authority and moves the rudder pedals at 10% per second. The heading trim knob is used for fine tuning the control of heading (flat turns only). PED trim release disengages the mode and allows re-referencing. Pedal switches disengage this capability and allow re-referencing at airspeeds below 60 knots. This mode of operation is FAIL SAFE.

2.11.7.6 Autopilot — Auto Turn. When airspeed is above 60 knots, auto turn (outer loop turn coordination) improves turn coordination by adding lateral acceleration signals into yaw outer loop. It has 100% authority and moves the rudder pedals. The computers recognize auto turn by the following logic: (1) Cyclic trim release switch depressed, (2) Cyclic roll trim (beeper) button moved, (3) Cyclic roll displacement greater than 3.4% from trim. Any time auto turn logic is in effect, heading hold is also automatically disengaged. To reengage heading hold, the following criteria must be met: (1) Bank angle less than 2°, (2) Yaw rate less than 0.66° per second, (3) Roll rate less than 0.33° per second, (4) and the auto turn logic not being met. This mode of operation is FAIL SAFE.

2.11.7.7 Autopilot — Pedal Force Limiting. This capability limits the amount of force needed at the pedals to override the autopilot. Pedal force is limited to a maximum of about 24 pounds depending upon sideslip angle. Heading hold is automatically disengaged when pedal force limiting is in effect.

2.11.7.8 Autopilot — FAS. This mode provides for force feedback cuing at the cyclic pitch position to correlate pilot input versus aircraft response to prevent damaging the airframe during maneuvering. The monitoring sensors are the air data transducer and pitch rate gyro. This mode of operation has 100% authority and 100% per second rate function. It is FAIL SAFE except for airspeed failures at which time the computer assumes an airspeed of 120 knots (correlated positioning) for all calculations.

2.11.8 Auto Bank. This mode provides for automatic re-reference of roll attitude hold at airspeeds greater than 60 knots. The monitoring sensors are cyclic roll and trim position transducers and roll rate gyros. When pilot has AFCS and trim selected and the auto bank switch legend is illuminated, and the pilot moves the cyclic, roll attitude hold disengages until roll rate drops below 0.33° per second whereupon, it automatically reengages. If the helicopter is within 2° of wings level and heading hold has reengaged, the computers will level the wings. This mode of operation is FAIL SAFE.

Note

> If heading hold has not reengaged (bank angle greater than 2°) and roll attitude hold reengages, the heading will drift.

2.11.9 BAR ALT Hold. This mode provides barometric altitude hold of ±25 feet or 1% of engaged altitude, whichever is greater. The monitoring sensor is the air data transducer. CLTV trim release is a temporary release, causing BAR ALT switch legend to flash ON and OFF to signify BAR ALT not active. BAR ALT switch is used for permanent disengagement. RDR ALT hold must be disengaged to engage BAR ALT hold. This mode of operation is FAIL SAFE.

2.11.10 RDR ALT Hold. Radar altimeter holds ±7 feet or 5% of selected altitude, whichever is greater. The monitoring sensors are the radar altimeter and ALT SET potentiometer (0 to 500 feet). Approaching the altitude selected, the rate is limited to 540 FPM rate of descent and 960 FPM rate of climb when RDR ALT is engaged. (At altitudes less than 200 feet, the rate of descent will not exceed 200 FPM.) ALT SET potentiometer selects pilot desired altitude, radar altimeter indicates actual altitude, computer commands helicopter if there is a difference. There is a one time, one way transfer from RDR ALT hold to BAR ALT hold if RDR ALT hold fails. CLTV trim release is used for permanent RDR ALT hold disengagement. BAR ALT hold must be disengaged to engage RDR ALT hold.

2.11.11 AFCS Control Panel. The panel is on the cockpit console (FO-8 and Figure 2-19).

2.11.11.1 SERVO 1 Pushbutton. Pressing and lighting the SERVO 1 pushbutton to read SERVO 1 indicates that second-stage flight control hydraulic pressure is being used to operate the AFCS pitch, roll, yaw, and collective servos. Pressing the servo 1 pushbutton and turning the light off removes second-stage hydraulic pressure from the AFCS servos.

The AFCS Servo 1 Shutoff Valve requires electrical power to close and thereby remove power from Servo 1. Therefore, when electrical power is removed from the aircraft while the second stage hydraulic pump is operating, the AFCS Servo 1 Shutoff Valve will be open and second stage hydraulic power will be applied to AFCS Servo 1, regardless of the position of the Servo 1 pushbutton.

2.11.11.2 SERVO 2 Pushbutton. Pressing and lighting the SERVO 2 pushbutton to read SERVO 2 indicates that utility hydraulic pressure is being used to operate the AFCS pitch, roll, yaw, and collective servos. Pressing the SERVO 2 pushbutton and turning the light off indicates utility hydraulic pressure is removed from the AFCS servos. Pressing and lighting the SERVO 2 pushbutton to read UNARMED while SERVO 1 is on, indicates SERVO 2 switch is physically off.

2.11.11.3 SERVO Pushbutton Operation. SERVO 2 cannot be on when SERVO 1 is on. SERVO 2 pushbutton operation with SERVO 1 off is between off (light off) and on (lit to read SERVO 2). SERVO 2 pushbutton operation with SERVO 1 on is between armed (light off) and unarmed (lit to read UNARMED).

The normal configuration for flight is to have SERVO 1 on and SERVO 2 armed. In this configuration, failure of SERVO 1 automatically turn SERVO 2 on (pushbutton reads SERVO 2). To isolate SERVO 1, press the SERVO 1 pushbutton (with light off) once. SERVO 2 can be turned off after SERVO 1 has been isolated by pressing the SERVO 2 pushbutton.

With SERVO 1 on and SERVO 2 unarmed, failure of SERVO 1 automatically turns SERVO 2 on (pushbutton reads SERVO 2 and UNARMED). Pressing the SERVO 1 pushbutton (with light off) at this time will turn SERVO 2 off. To isolate SERVO 1 and keep SERVO 2, press the SERVO 2 pushbutton to turn UNARMED off. SERVO 1 can now be isolated by pressing the SERVO 1 pushbutton (with light off) once. SERVO 2 can be turned off after SERVO 1 has been isolated by pressing the SERVO 2 pushbutton.

With SERVO 2 on, failure of SERVO 2 automatically turns SERVO 1 on. Pressing the SERVO 2 pushbutton at this time will turn SERVO 1 off. To isolate SERVO 2 and keep SERVO 1, press the SERVO 1 pushbutton (with light on) once, and then press the SERVO 2 pushbutton to read UNARMED. SERVO 1 can be turned off after isolating SERVO 2 by pressing the SERVO 1 pushbutton.

2.11.11.4 AFCS Pushbutton (Inner Loop). SERVO 1 or SERVO 2 and CMPTR POWER has to be on before the AFCS pushbutton will operate. Pressing and lighting the AFCS pushbutton to read AFCS turns on SAS, hover augmentation and gust alleviation, cockpit flight control desensitizers, turn coordination for inner loop only, and the longitudinal bias actuator.

2.11.11.5 TRIM Pushbutton (Outer Loop). Without AFCS on. SERVO 1 or SERVO 2 and CMPTR POWER have to be turned on before the trim pushbutton will operate. With AFCS off, pressing and lighting the trim pushbutton to read TRIM turns on cyclic, collective, and pedal trim. Trim (breakout/gradient) in the pitch axis is electronically generated. SERVO 1 or SERVO 2, CMPTR POWER, and AFCS have to be turned on before the trim pushbutton provides autopilot functions. Pressing and lighting the trim pushbutton to read TRIM turns on attitude hold, airspeed hold, heading hold, auto turn (turn coordination for outer loop), pedal force limiting, and force augmentation (pounds per g). It also arms the AUTO BANK, BAR ALT, and RDR ALT switches.

2.11.11.6 AUTO BANK Pushbutton. SERVO 1 or SERVO 2, CMPTR POWER, AFCS, and TRIM have to be turned on before the AUTO BANK pushbutton will operate. Pressing and lighting the AUTO BANK pushbutton to read AUTO BANK allows automatic re-referencing of roll attitude hold.

2.11.11.7 BAR ALT Pushbutton. SERVO 1 or SERVO 2, CMPTR POWER, AFCS, and TRIM have to be turned on, and RDR ALT has to be off, before BAR ALT can be turned on. Pressing and lighting the BAR ALT pushbutton to read BAR ALT engages barometric altitude to provide altitude retention at the engagement altitude. BAR ALT will be turned on automatically if RDR ALT has been selected and the RDR ALT mode fails. Pressing the CLTV TRIM REL trigger switch will disengage the BAR ALT mode temporarily and cause the switch legend to flash. Pressing the BAR ALT pushbutton a second time will disengage the BAR ALT mode.

2.11.11.8 RDR ALT Pushbutton. SERVO 1 or SERVO 2, CMPTR POWER, AFCS, and TRIM have to be turned on, and BAR ALT has to be off, before RDR ALT can be turned on. Pressing and lighting the RDR ALT pushbutton to read RDR ALT allows the system to use signals from the radar altimeter and the ALT SET knob setting for comparison, and any difference between signals is furnished to the inner and outer loop systems to provide absolute altitude retention. Pressing the CLTV TRIM REL switch or pressing the RDR ALT pushbutton a second time will disengage the RDR ALT mode and it will have to be reengaged if needed. If the RDR ALT mode fails, the BAR ALT mode will be turned on automatically.

WARNING

- Do not rely on BAR ALT hold during low altitude operations.
- With RDR ALT hold turned on, any interruption of power to the radar altimeter can cause up to 30 feet of altitude loss before the AFCS detects the malfunction and switches to the BAR ALT retention mode.

2.11.11.9 ALT SET Control. With the RDR ALT mode engaged, the ALT SET knob, with cross-coded head, may be turned to select a reference, holding radar altitude between 0 to 500 feet.

2.11.11.10 HDG TRIM Control. The HDG TRIM knob, with bar-coded head, is normally used to make small heading trim changes; however, one full turn of the other knob will turn the helicopter about 72°.

2.11.11.11 CMPTR POWER Pushbutton. Illumination of the CMPTR POWER pushbutton normally indicates that power is being furnished to the computers. If one or both computers shut down all their outputs due to a temporary malfunction, they may be reengaged by pressing the CMPTR POWER pushbutton twice (off and back on).

2.11.11.12 MODE RESET Pushbutton. Failure of a mode will be indicated by appropriate light(s) on the FAIL ADVISORY light section of the AFCS CONTROL panel and the AFCS DEGRADED advisory light. If the malfunction is temporary, the function(s) can be reengaged by pressing the momentary MODE RESET pushbutton. The MODE RESET pushbutton also serves as an alternate AFCS turn on pushbutton. This pushbutton will not reengaged the computers.

2.11.11.13 FAIL ADVISORY Panel. The nomenclature for the AFCS CONTROL panel FAIL ADVISORY lights and their significance are shown and discussed in Figures 2-20 and 2-21. Any AFCS failure, other than a dual computer failure, will cause a flashing of the AFCS DEGRADED advisory light. The modes lost by the failure will be displayed by flashing FAIL ADVISORY lights.

2.11.11.14 ACK FAIL ADVISORY Pushbutton. Flashing AFCS CONTROL panel FAIL ADVISORY lights can be made to show a steady light by pressing the momentary ACK (acknowledge) FAIL ADVISORY pushbutton. This also stops the flashing of the AFCS DEGRADED advisory light to permit notification of a subsequent failure. Subsequent additional mode failures, affecting fail advisories that are not already lit, will cause the AFCS DEGRADED advisory light and the additional appropriate AFCS CONTROL panel FAIL ADVISORY lights to flash. AFCS CONTROL panel fail advisories that have been acknowledged will not flash unless cleared by a mode reset or computer power reset.

2.11.12 Cyclic

2.11.12.1 Cyclic Trim Button. The trim (beeper) button switch, marked STICK TRIM, on top of the cyclic grip (FO-8 and Figure 2-22), is spring-loaded to null and has four marked positions, FWD-AFT-L-R. Deflecting the button toward any of the positions will beep the cyclic in that direction. The button can beep the cyclic trim (5% per second) in any direction. Airborne below 60 KIAS, the button beeps helicopter attitude in pitch (2° per second); airspeed hold is not available. Beeping the button L (left) or R (right) beeps helicopter attitude in roll (4° per second).

The beep switch may be used in either axis, at any airspeed, to trim out cyclic trim forces. Above 60 knots and for large airspeed changes, the longitudinal beep may be used to accelerate, decelerate, and trim the helicopter to new airspeed. Upon establishing the required airspeed and being close to or in unaccelerated flight, the airspeed reference may be synchronized to the actual airspeed by momentarily pressing the beep switch. Small airspeed changes, about 10 knots or less, may be obtained by timing the duration the beep switch is pressed. (E.g., at a beep rate of 6 knots per second, a 6 knot change will be accomplished by pressing the beep for 1 second.)

2.11.12.2 Cyclic Trim Release Switch. The cyclic TRIM REL switch is on the left side of the cyclic grip (FO-8 and Figure 2-22). Pressing the switch permits the pilot to reposition the cyclic manually for trim. With AFCS

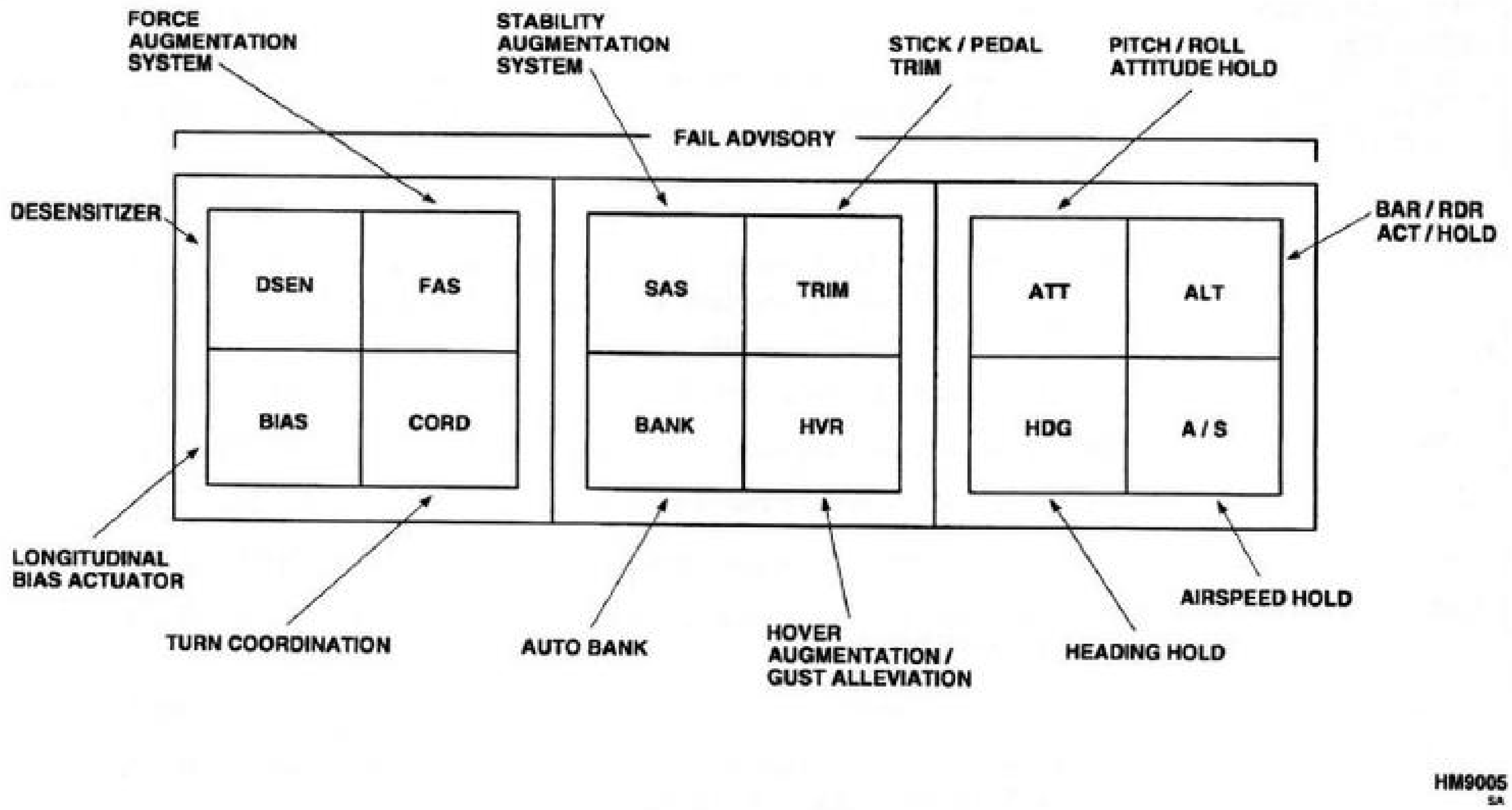


Figure 2-20. Fail Advisory Lights

and trim engaged, the switch permits referencing attitude hold or airspeed hold, depending on airspeed.

2.11.13 Collective

2.11.13.1 Collective Trim Release Switch. The CLTV TRIM REL trigger switch (FO-8 and Figure 2-22) is on the collective grip. When pressed, it temporarily releases collective trim, and BAR ALT hold. In addition, the RDR ALT mode will be disengaged permanently, and must be reengaged if needed.

2.11.13.2 Pedal Trim Release Switch. The PED TRIM REL switch is on the collective grip (FO-8 and Figure 2-22). When pressed, it temporarily releases pedal trim and permits re-referencing of heading hold at any airspeed.

2.11.14 Rudder Pedals

2.11.14.1 Rudder Pedal Switches. The pedal switches are on all rudder pedals (Figure 2-22). Pressing any pedal switch temporarily releases pedal trim. With only trim engaged, the pedal switches release pedal trim at all airspeeds. With AFCS and trim engaged, the pedal switches are only effective below 60 knots.

2.11.15 Malfunction Indications. The computers continuously perform self-test and indicate their status by the use of 12 fail advisory lights, one caution light labeled AFCS, one advisory light labeled AFCS DEGRADED, and up to five stored flight bite codes (FBC) in each computer. The first five FBCs are stored in the nonvolatile memory of each computer and can be read and erased after each flight by maintenance personnel to aid in troubleshooting the system.

2.11.15.1 Duplex Failure. A duplex failure, indicated by the AFCS caution light illuminating when CMPTR POWER switch legend is illuminated, is when both computers have shut down all outputs. All AFCS modes have been lost. Possible recovery is to cycle CMPTR POWER switch off then back on.

2.11.15.2 Simplex Failure. A simplex failure occurs when one computer has shut down all of its outputs. A simplex failure is indicated by the AFCS DEGRADED advisory light flashing and all FAIL ADVISORY lights flashing except SAS and DSEN. The only AFCS modes operating are SAS, cockpit flight control desensitizers, cockpit flight control trim (except pitch), and the LBA. Possible recovery is to cycle CMPTR POWER switch off then back on.

FAIL ADVISORY LIGHT ON	EFFECT	POSSIBLE RECOVERY
NONE, but AFCS caution light on	Loss of all AFCS functions.	CMPTR POWER
DSEN	Loss of cyclic, collective, or pedal control desensitizer(s).	MODE RESET
FAS	Loss of longitudinal force feel system. Loss of pitch trim. Loss of pitch autopilot. Possible loss of desensitizer on aircraft equipped with dash 104 and 105 computers.	MODE RESET
SAS	Possible loss of pitch, roll or yaw SAS.	MODE RESET
TRIM	Possible loss of pitch, roll, yaw or collective trim.	MODE RESET
ATT	Loss of pitch or roll attitude retention.	MODE RESET
ALT	Loss of radar or barometric altitude hold.	MODE RESET
BIAS	Loss of bias actuator or bias actuator degraded due to airspeed or pitch SAS failure.	MODE RESET
CORD	Loss of turn coordination.	MODE RESET
BANK	Loss of auto bank. Possible loss of desensitizer on aircraft equipped with dash 104 and 105 computers.	MODE RESET
HVR	Loss of hover augmentation.	MODE RESET
HDG	Loss of heading hold.	MODE RESET
A/S	Loss of airspeed hold. Computer selects 120 knots for all calculations.	MODE RESET

Figure 2-21. Fail Advisory Light Meaning

2.11.15.3 Mode Failures. Mode failures, indicated by the AFCS DEGRADED advisory light and one or more but not all fail advisory lights flashing, are when one or more modes have shut down as indicated by the lights. Possible recovery is to press and release the MODE RESET pushbutton. If unable to clear, press and release the ACK FAIL ADVISORY pushbutton to place all flashing lights to steady.

2.12 LANDING GEAR SYSTEM

The tricycle-configured landing gear system consists of dual-wheel retractable main and nose gear assemblies, tail skid, and a hydraulic system. The landing gear hydraulic system operates on 3000 psi hydraulic pressure from the utility hydraulic system. The landing gear system has a one-shot pneumatic emergency extension system to lower the landing gear in case of an electrical or hydraulic malfunction. The landing gear control panel (FO-8) marked LDG GEAR CONT is on the center cockpit console. Electrical power for the landing gear system operation is provided from the No. 2 primary dc bus circuit breaker, marked CONT, under the general heading LANDING GEAR, in the cabin.

2.12.1 Main Landing Gear. The main landing gear assemblies are below the sponsons, and retract forward and upward into the sponsons (FO-12). Each assembly has dual wheels and hydraulic brakes, plus a drag strut that contains the retracting cylinder downlock mechanisms. There is a fluid indicating pin installed on top of the shock strut that extends when hydraulic servicing is necessary (Figure 3-1).

2.12.2 Nose Landing Gear. The dual-wheel nose landing gear assembly (FO-11) is mounted vertically at the centerline of the helicopter and is free to turn 360° about the strut centerline. The nose gear retracts rearward and upward into the nose section of the airframe. The nose gear assembly has dual wheels with a co-rotating shimmy damper, a retracting cylinder, a pneumatic hydraulic strut and shimmy damper, and attaching drag

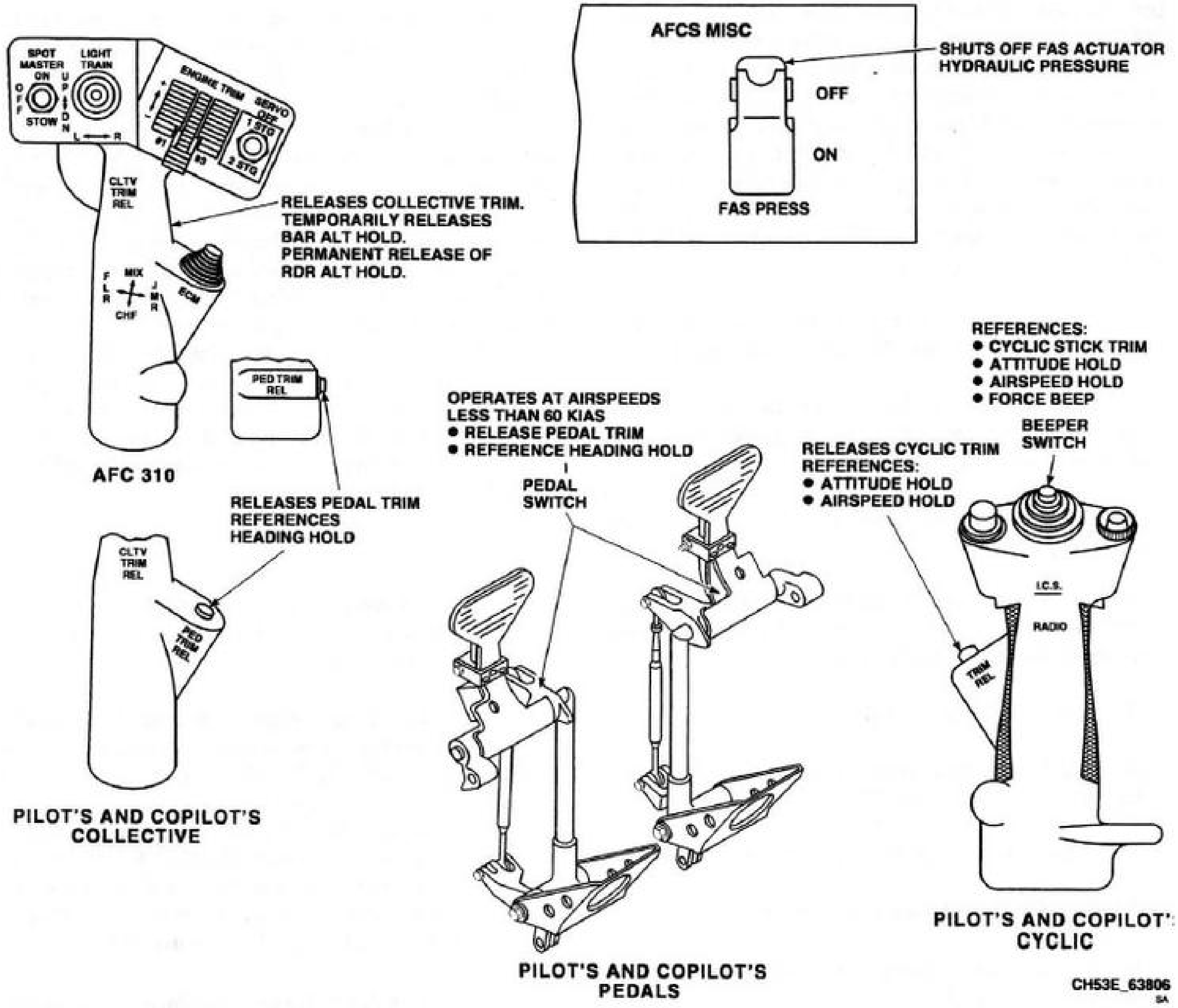


Figure 2-22. AFCS Switches

links and supports. The shimmy damper prevents nose gear vibration during forward motion on the ground. To dampen nose gear vibration further the nosewheels are interconnected with a co-rotating shimmy damper that causes both wheels to rotate together but allows them to split while making turns. An internal centering device, that starts to become effective at 75% of nose gear extension, holds the nosewheel centered during flight, to provide proper wheel orientation during landing. There is a fluid indicating pin installed on top of the strut that extends to indicate hydraulic servicing is necessary.

2.12.3 Tail Skid. The retractable tail skid (FO-12), mounted on the underside of the pylon, aids in the prevention of the tail rotor blades from striking the ground when landing with nose high attitudes. The tail skid is extended and retracted by an electrical actuator attached to the tail skid shock strut. The tail skid is automatically retracted when the main landing gear is retracted, and automatically extended when the main landing gear is down and locked. The electrical system is interconnected with the cargo ramp system and MAIN LANDING GEAR WEIGHT-ON-WHEELS SCISSORS switches, so that the tail skid, if extended, will automatically retract when the cargo ramp is lowered. The tail skid receives power from the No. 1 primary dc bus circuit breaker panel in the cabin, marked TAIL SKID.

Landing Gear Actuating System. This system operates on 3000 psi hydraulic pressure, supplied by the utility hydraulic system. Placing the landing gear control handle to UP retracts the landing gear, and placing the handle to DN lowers the landing gear. A mechanical spring-loaded downlock engages to lock the landing gear in the down position. Each main landing gear oleo strut has a scissors switch that is opened and closed by the extension and compression of the strut. When the struts are compressed, electrical circuitry does this:

1. Disables the landing gear downlock solenoid to prevent inadvertent retraction of the landing gear.

2. Disables the attitude hold portion of the AFCS outer loop, but not cyclic trim, to prevent excessive driving of the cockpit controls.

3. Disables the fuel dump and drop tank jettison capability.

4. Causes IFF mode 4 codes to be zeroized when electrical power is removed, if HOLD has not been selected with the MODE 4 code switch.

5. Opens the isolation valve.

6. Enables generator underfrequency to be displayed by the #1, #2, and #3 GEN caution lights.

7. Enables the stick position indicator to operate.

8. Enables CG indicator programming.

9. Enables the tail skid to retract automatically when the ramp is lowered.

10. Enables initialization of Omega navigation system.

When struts are extended the following interlocks are bypassed to permit engine starting in flight: rotor brake not fully pressurized, mechanical gustlock engaged, and head not in start position. Strut extension enables AN/ALE-39 operation.

Two relays associated with the left scissors switch have power furnished by the No. 1 primary dc bus through a circuit breaker marked WT ON WHEELS LHS in the cabin.

Two relays associated with the right scissors switch have power furnished by the No. 3 primary dc bus through a circuit breaker marked WT ON WHEELS RHS in the cabin.

When airborne, the oleo struts extend, closing the contacts of switches to energize the circuits that unlock the landing gear control handle and arm the system for retraction. Raising the landing gear control handle to UP retracts the landing gear, and lights the landing gear warning light in the control handle, while the landing gear indicators on the instrument panel indicate an unsafe (barber pole) condition. When the landing gear is fully retracted, the landing gear handle warning light will go off and the landing gear indicators on the instrument panel will show UP. Lowering the landing gear control handle DN extends the landing gear and lights the landing gear warning light in the control handle, while the landing gear indicators will show an unsafe (barber pole) condition. When the landing gear is fully extended, the landing gear handle warning light will go off and the landing gear indicators on the instrument panel will show a symbol depicting a wheel.

Note

> During extension and retraction of the landing gear, utility hydraulic pressure may drop to 2000 psi.

2.12.4.1 Landing Gear Control Handle Downlock Release. A manually-operated downlock release, marked DN LOCK RELEASE, on the landing gear control panel (FO-8) provides a mechanical override of the landing gear control handle downlock solenoid in case of an interruption of electrical power to the solenoid. Should the downlock solenoid become inoperative, the downlock release can be actuated to mechanically release the landing gear control handle from the DN position.

2.12.4.2 Landing Gear Position Indicators. The indicators (FO-5), on the instrument panel, operate on direct current from No. 2 primary dc bus and are protected by a circuit breaker in the cabin, marked POS under the general heading LANDING GEAR. The indicators read UP if the landing gear wheels are up and locked, and a symbol depicting a wheel if the wheels are down and locked. During landing gear extension or retraction, when an unsafe condition exists, or whenever electrical power is not available, the indicators show a barber pole.

2.12.4.3 Landing Gear Warning Light and Test Button. The landing gear warning light, in the handle of the landing gear control lever, will go on when any or all landing gear are in transit between the up and down positions, or when one landing gear is not in the position selected by the landing gear control handle. When all landing gear are fully up and locked, or fully down and locked as selected by the handle, the warning light will go off. The warning light operates on direct current from the No. 2 dc primary bus through the landing gear up warning system. A landing gear warning light test button, marked HANDLE LT TEST, is on the landing gear control panel. When pressed, it tests the warning light in the landing gear control handle.

2.12.5 Landing Gear Up Warning System. Normally the LDG GEAR UP warning light on the instrument panel will flash, and an ICS pulse tone will be heard in the headset when the landing gear is up, airspeed is below 60 knots, and radar altitude is below 150 feet. With the radar altimeter off or unreliable, the same warnings will be furnished at any altitude when the landing gear is up, and airspeed is below 60 knots. The warnings can be deactivated by lowering the landing gear, or increasing airspeed above 60 knots, or climbing above 150 feet with an operating radar altimeter. In addition, when the parameters that activate the warnings are in effect, the warnings can be deactivated by pressing the LDG GEAR UP warning light. However, the warnings will be reactivated any time the collective is lowered to lose altitude. An airspeed sensing switch activates the system below 60 knots and deactivates the system above 60 knots. The system senses altitude from the radar altimeter. The system's power circuit is routed through the landing gear limit switches to deactivate the system when the gear is down. The system receives power from the No. 1 primary ac bus through a circuit breaker marked LDG GEAR WARN, and the No. 3 primary dc bus through a circuit breaker marked LDG GEAR WARN. Both circuit breakers are in the cabin (Figure 7-8).

Note

Helicopters with Ground Proximity Warning System (GPWS, AFC 501, Pt 2) will also give an aural warning, "GEAR UP, GEAR UP" and a visual warning on the caution/advisory panel when the above conditions exist.

2.12.6 Attitude Warning System. With the landing gear down at low absolute altitude, to prevent damaging the tail skid, a continuous ICS tone is heard in the headset. This tone alerts the pilot to the fact that the helicopter is approaching a dangerous, nose-high attitude for the flight conditions. Normally, the ICS warning tone is activated by both AFCS computers; however, the system will operate with only one operating. The parameters analyzed by the computers to activate the warning tone are radar altitude, vertical velocity, pitch attitude, and pitch rate. Altitude and vertical velocity are furnished from the radar altimeter, pitch attitude from the AHRS and 1080y gyros, and pitch rate from the pitch rate gyros. Curves on Figure 7-8 show the attitudes and altitudes at which the AFCS computers will activate the warning tone. Note that for the same nose-up angle the warning is activated at a higher altitude for descent than for ascent. In addition, the system does not operate at nose-up attitudes of less than 7°. The attitude warning system receives power from the No. 3 dc primary bus through a circuit breaker in the cabin, marked LDG GEAR WARN.

2.12.7 External Landing Gear Down Light. An external landing gear down light, mounted on the nose gear door (Figure 2-13), is used to indicate to ground personnel that the landing gear is down and locked. The light will go on any time all landing gear are down and locked, and the exterior light master switch is on. The light operates on dc current from the No. 2 dc primary bus through a circuit breaker in the cabin, marked DOWN, under the general heading LANDING GEAR.

2.12.8 Landing Gear Emergency System. An orange-yellow and black colored T-handle lever, on the left side of the center cockpit console (FO-8), is used to lower the landing gear in case of an electrical or hydraulic failure. The T-handle, when turned and pulled, positions a directional valve and discharges a 3000 psi preloaded air bottle that drives the actuators to lower the landing gear. After an emergency actuation, the bypass valve must be manually reset before the landing gear air cylinder can be recharged or the landing gear retracted.

Note

Be sure the landing gear control handle is at DOWN before using the emergency T-handle. The emergency landing gear system will lower the landing gear in a hover in the same length of time as the normal system. However, during forward flight, with an airload on the nose gear door, emergency extension may take from 1 to 2 minutes.

2.12.9 Wheel Brake System. The main landing gear wheels each have self-adjusting hydraulic boost power brakes that are operated by toe pedals on the pilot's and copilot's rudder pedals. Hydraulic power for the wheel brake system is supplied from the utility hydraulic system through the isolation valve, whenever the weight of the helicopter is on the landing gear wheels. Wheel brakes may be applied by either the pilot or copilot, and the left and right wheel brakes may be operated independently. The parking brakes may be set with the parking brake handle by either pilot. The parking brakes are set by pressing the brakes and pulling the parking brake handle. The handle operates parking brake valves, which contain accumulators to maintain pressure and compensate for temperature changes. A parking brake advisory light marked PARKING BRAKE ON, on the advisory panel, indicates to the pilot that the parking brake is on. The parking brake advisory light receives power from the emergency dc bus through the caution panel circuit breaker marked CAUTION PANEL MASTER, in the cockpit.

Note

- During operation of the utility hydraulic system, the parking brake may release causing inadvertent movement of the aircraft. When using the utility systems with the parking brake set, pilots must monitor the brakes to ensure the aircraft does not move.
- With the utility hydraulic system not pressurized, the wheel brakes are capable of holding the helicopter, loaded to the design gross weight (46,500 pounds), on a 10° slope. With hydraulic pressure the helicopter is held on a 20° slope. It is recommended that consideration be given to starting the APP while on shipboard or during unusual ground handling operations.
- After a maximum braking application, a cool down period should be allowed prior to additional heavy braking application.

2.12.9.1 Parking Brake Handle. The PARKING BRAKE handle is attached to the center cockpit console (FO-8). The parking brakes are applied by pressing the rudder pedals, pulling the parking brake lever up; then releasing the rudder pedals. Pressing the rudder pedals will release the parking brakes, causing the parking brake handle to return to OFF.

Note

- The parking brake advisory light will go on any time the parking brake handle is pulled up, even though the parking brakes have not actually been set.
- Do not force the parking brake handle when releasing the parking brakes. This action may damage the parking brake actuating cable and cableway, causing the parking brakes to remain on when the advisory light is off.

2.13 BLADE AND PYLON FOLD SYSTEM

The blade and pylon fold system is designed to position the main rotor blades for either blade or pylon folding first, before folding. The spread cycle occurs in the reverse of that outlined for the fold cycle, and either cycle may be halted and reversed at any stage. Each may be selected and folded separately, but the main rotor blades cannot be folded if the pylon has already been folded. Any of the following interlocks prevent inadvertent actuation of the system: a speed control is out of SHUT-OFF, the gust lock is engaged, the pylon is unsafe for flight, or the main gear box oil pressure switch is pressurized. The system receives hydraulic pressure from the utility hydraulic system through the isolation valve, and electrical power from the No. 2 dc primary bus through a circuit breaker in the cabin marked BLADE FOLD.

2.13.1 Fold Control Panel. The panel, marked BLADE/PYLN, FOLD, on the pilot's overhead control panel (FO-1), contains the fold system controls. The control panel also contains lights that show the sequence of fold and spread cycles as they occur. The master power switch, marked MASTER, with marked positions POWER-OFF, must be at POWER before the system can be energized. The PITCH LOCK switch is used to engage the pitch locks before folding and to disengage the pitch locks after spreading, or as gust locks to prevent blade/wind loads from feeding into the control system when the helicopter is parked. The blade fold position switch, marked BLADE, has marked positions FOLD POSN-OFF. The switch is used to position the blades before folding. The blade fold/spread switch, marked BLADE, has marked positions FOLD-OFF-SPREAD. The FOLD position, with the high pressure rotor brake on, will fold the blades if the head is positioned for fold, the pitch locks are engaged, and the blade position switch is at FOLD POSN. The SPREAD position will spread the blades from the folded position. The pylon fold/spread switch, marked PYLON, at FOLD will fold the pylon and at SPREAD will spread the pylon.

When the master power switch is placed to POWER, the SAFETY VALVE OPEN light will go on to indicate the safety valve has opened and hydraulic pressure is available to the rotor head positioning, blade fold, and pylon fold selector valves.

The FLIGHT READY light will go off and the BLADE PYLON FOLD caution light will go on to indicate an unsafe-for-flight condition.

Seat the collective in the collective detent to light the cyclic stick position indicator. Move the cyclic to light the stick-center position arrows, on the stick position indicator, to position the rotor head for pitch lock engagement.

Placing the PITCH LOCK switch to PITCH LOCK causes the pitch locks to advance from the retracted position, and the PITCH LOCK ADVANCED light will go on when any one of the six pitch locks advance. In addition, the 2 STG PRESS M/R, 2 STG M/R SERVO BYPAS, 2 STG T/R SERVO BYPAS, and UTILITY T/R PRESS caution lights go on to indicate that the second stage side of the primary tandem servos are hydraulically deenergized, and the second stage hydraulic pressure gage indicates zero pressure. (On helicopters with AFC 309 incorporated, when the pitch locks advance from the retracted position only the 2 STG M/R SERVO BYPAS caution light will go on, and the second stage hydraulic pressure gage will indicate normal.) When all six pitch locks are fully extended, the PITCH LOCKS ENGAGED light goes on.

CAUTION

Applicable to helicopters not modified by AFC 309. With pitch locks engaged, blade fold interlocks prevent hydraulic pressure to the primary and tail rotor servos. However, without electrical power applied to the helicopter, the first stage main rotor, second stage main rotor, and second stage tail rotor servo shutoff valves are open. If hydraulic power is applied to the helicopter, pressure will be sent to the respective servos. This condition can exist whenever the pitch locks are engaged, the APP is on and the No. 1 and No. 3 generators are off. Any movement of the flight controls will result in damage to the flight control components.

Placing the blade fold position switch to FOLD POSN will cause the rotor brake pressure to be dumped and repumped to 40 psi, the ROTOR BRAKE ON advisory light to go off, and the rotor head to be driven to the proper position for blade fold. When the head is in the fold position the HEAD IN FOLD POSITION light and ROTOR BRAKE ON advisory light go on.

Placing the blade fold/spread switch to FOLD causes the blades to start folding and the BLADES SPREAD light to go off. When the blades are fully folded the BLADES FOLDED light goes on.

Placing the pylon fold/spread switch to FOLD will cause the PYLON UNSAFE FOR FLIGHT light to go on, to indicate the pylon is being folded. The tail rotor positioner actuator extends until it contacts the tail rotor cam, and then internal force limiters shut off the actuator motor until the drive shaft coupling is disengaged. Both pylon lockpins retract, and two red flags extend outward from the helicopter. The drive shaft coupling is disconnected, the coupling switch is actuated, and a third red flag extends downward from the helicopter. The pylon starts to fold after the previous conditions are met. The force limiters are now unloaded, the tail rotor positioner actuator extends all the way, which drives the tail rotor cam to position the tail rotor for minimum height when folded, and locking the tail rotor so it will not turn while uncoupled.

CAUTION

Ensure main rotor head is properly positioned prior to pylon fold or spread operations. Before applying electrical power, check for main rotor blade at the 5:30-6:00 position.

Manual fold and spread of the tail rotor pylon may be accomplished using the hydraulic handpump mounted forward on the right side of the cabin. Electrical power is not required for manual operation, and all system interlocks are bypassed (i.e., the main rotor in fold position and tail rotor positioner). If the tail rotor pylon is manually folded, the tail rotor positioner will remain in the retracted position, allowing the tail rotor to rotate freely unless manually restrained. If electrical power is applied following a manual fold, the tail rotor positioner will extend, rotating the tail rotor up to 45° in either direction. Main rotor blade to tail rotor blade contact may occur when one of the seven main rotor blades is not in the 5:30-6:00 position.

Placing the pylon fold/spread switch to SPREAD will spread the pylon, and the PYLON UNSAFE FOR FLIGHT light will go off. The pylon is fully spread when the pylon limit switch is actuated, both lockpins are in, the tail rotor coupling switch is deactuated, the tail rotor positioner is fully retracted, and the three red flags are retracted.

Placing the blade fold/spread switch to SPREAD causes the blades to start spreading and the BLADES FOLDED light to go off. When the blades are fully spread and all lockpins are in, the BLADES SPREAD light goes on.

Placing the PITCH LOCK switch to DISENGAGED causes the pitch locks to start to retract and the PITCH LOCKS ENGAGED light to go off. When all six pitch locks are retracted the PITCH LOCK ADVANCED light goes off.

At this time the 2 STG PRESS M/R, 2 STG M/R SERVO BYPAS, 2 STG T/R SERVO BYPAS, and UTILITY T/R PRESS caution lights go off and the second stage hydraulic pressure gage indicates normal operating pressure. On helicopters modified by AFC 309, the 2 STG M/R SERVO BYPAS caution light will go off and the second stage hydraulic pressure gage will continue to indicate normal operating pressure. Interlocks for the second stage main rotor servo bypass valve are (1) main gear box oil pressure switch below 14 psi, (2) gust lock UNLOCKED, (3) engine speed control lever at SHUTOFF, and (4) blade fold master power switch at MASTER POWER.

Placing all switches off will cause the SAFETY VALVE OPEN light to go off, and the FLIGHT READY light to go on.

2.13.2 Stick Position Indicator. The cyclic stick position indicator on the instrument panel permits the pilot, by use of the flight controls, to establish the necessary blade pitch position required for pitch lock engagement. The indicator is activated and lighted when the weight-on-wheels interlock is activated by compression of the oleo struts and the collective is positioned so that it is seated in the collective detent. The detent is slightly above the full down collective position.

The instrument has both a fore-aft (F-A) and a left-right (L-R) display axis. Each of the two axes consists of eight display segments on either side of the stick-center segment. Each of these segments consists of two parallel lamp filaments. The center segment consists of four parallel lamp filaments. The segment in each axis, when lit, indicates a cyclic position displacement from neutral (flat blade pitch). The indicator does not display complete cyclic travel since accurate cyclic position indication is only required about the flat blade pitch position. When an extreme segment is lit in each axis, this displays the quadrant the cyclic is in. The four stick-center arrows grouped around the stick-center lamp segment light when the cyclic is centered in both axes. The TEST pushbutton or positioning the collective in the detent lights all display segments at full intensity for a nominal 5 seconds. Instrument lighting intensity is controlled by turning the DIM knob.

No. 2 primary dc bus power is furnished to the instrument through a circuit breaker marked STICK POSN in the cabin. No. 2B primary ac bus power is furnished through a circuit breaker marked STICK POSN IND PWR in the cabin.

2.14 FLIGHT INSTRUMENTS

2.14.1 Pitot-Static System. Two electrically-heated pitot tubes with static ports are on the top of the fuselage over the pilot and copilot. The left and right pitot tubes and static ports are interconnected to compensate for asymmetrical rotor downwash (swirl) and yaw effects. The common pitot pressure line supplies pitot pressure to the airspeed indicators, and to the air data transducer; and the common static pressure line supplies static air pressure to the altimeters, vertical velocity indicators, and to the air data transducer.

2.14.1.1 Airspeed Indicators. Two indicators (FO-5), mounted on the instrument panel, indicate the forward airspeed of the helicopter in knots. The indicators are unreliable below about 40 KIAS.

2.14.1.2 Barometric Altimeter/Encoder. The AAU-32/A altimeter/encoder functions as a barometric altimeter for the pilot and a pressure altitude sensor for the AN/APX-72 IFF transponder. The altimeter/encoder is on the pilot's side of the instrument panel (FO-5). The face of the altimeter is marked from 0 to 9 (×100) feet, in 50-foot units. A counter window, next to the sweep hand, contains three digital drums that turn to indicate altitude in thousands and hundreds of feet. At altitudes below 10,000 feet, a barber pole appears in place of the left digit. The barometric pressure set knob permits altimeter settings from 28.10 to 31.00 inches Hg. A window in the lower right section of the altimeter displays the selected altimeter setting. The altimeter has a continuously operating dc powered vibrator to improve altitude indicating accuracy. The encoder provides a digital output of pressure altitude in units of 100 feet to the IFF transponder, with mode C selected, for automatic pressure altitude transmission. The encoder operates throughout the altimeter's operating range, but unlike the altimeter it uses a permanent altimeter setting of 29.92. If there is a loss of 115 vac, 400 Hz, the warning flag on the pilot's altimeter indicator, marked CODE OFF, will be displayed. The No. 2B primary ac bus circuit breaker panel in the cabin furnishes power through a circuit breaker marked ALT PILOT, under the general heading RADIO. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes power through a circuit breaker marked IFF TEST, under the general heading RADIO.

2.14.1.3 Barometric Altimeter. The AAU-31/A altimeter, installed on the copilot's side of the instrument panel (FO-5), is identical to and operates in the same manner as the pilot's AAU-32/A altimeter/encoder, except there is no encoder associated with the altimeter, and there is no warning flag on the indicator. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes power to operate the altimeter's vibrator through a circuit breaker marked IFF TEST under the general heading RADIO.

2.14.1.4 Vertical Velocity Indicators. Two indicators on the instrument panel (FO-5) indicate vertical velocity in thousands of feet-per-minute. The common static pressure line supplies static air pressure to the indicator.

2.14.2 Vertical Gyro Indicator (VGI). Two VGI's, installed on the instrument panel (FO-5), visually indicate the helicopter's attitude. The indicator face consists of a stationary miniature airplane representing the helicopter, a bank angle scale, bank index, and a moving two-colored sphere with a distinct white horizontal line dividing the two colors, light gray above, black below. Each indicator also has a turn and slip indicator, mounted at the bottom, that shows turn rate and degree of balanced flight. Two trim adjustment knobs are on the front of the indicators. The roll trim knob adjusts the bank index position for right and left bank, and the pitch trim knob turns the sphere to deflect the horizon line upward or downward. The copilot's vertical gyro indicator normally receives inputs from the 1080y vertical gyro, and the pilot's vertical gyro indicator receives inputs from the AHRS. There is a warning flag in the face of each VGI. When the 1080y gyro is selected to furnish inputs to either VGI, that VGI's warning flag will be visible if an unbalance in the three-phase power to the gyro's motor is sensed or if there is an ac power loss. In addition, the flag will be visible for about 1 minute after ac power has been applied to the circuit. When the AHRS has been selected to furnish inputs to either VGI, that VGI's warning flag will be visible when there is an ac power loss to the AHRS.

Power to operate the 1080y and AHRS gyros is furnished by the emergency ac bus through circuit breakers in the cockpit marked VGI/GYRO COPILOT and AHRS. On aircraft with AFC 490, the pilot VGI is protected by a cockpit circuit breaker on the emergency ac bus marked AI PILOT and the copilot VGI is protected by a cockpit circuit breaker on the No. 3 primary ac bus marked VGI CO-PILOT.

2.14.2.1 VGI Transfer Switch. Each pilot's miscellaneous switch panel (FO-1) has a two-position VG XFR switch. When pressed and lighted NORM, the 1080y gyro system furnishes attitude information to the copilot's VGI, and the AHRS furnishes information to the pilot's VGI. When either switch lights ALT, that VGI receives information from the other system. Control power for VGI transfer is furnished by the emergency dc bus through two circuit breakers, marked PILOT and CO-PILOT, under the general heading VGI, in the cockpit.

2.14.2.2 Turn Rate Switch. Each pilot's miscellaneous switch panel (FO-1) has a two-position TURN RATE switch. When pressed and lighted NORM, the copilot's turn rate gyro furnishes rate-of-turn information to the copilot's turn indicator and the pilot's turn rate gyro furnishes rate-of-turn to the pilot's indicator. When either switch is lighted ALT, that turn indicator is furnished rate-of-turn information from the other gyro. Power for the turn rate gyro operation and switching is furnished by the emergency dc bus through two circuit breakers, marked PILOT and CO-PILOT, under the general heading VGI, in the cockpit.

2.14.3 Attitude Heading Reference System (AHRS). The A/A24G-39 AHRS provides roll and pitch information for attitude control and indication, and directional information for navigation at all latitudes. As a heading reference, three modes of system operation are employed. In polar regions where magnetic heading references are not reliable, the system is operated in the directional gyro (DG) mode. In this mode, the system furnishes an inertial heading reference, with latitude corrections introduced manually. In areas where magnetic heading references are reliable, the system is operated in the SLAVED mode of operation. In this mode, the directional gyro is slaved to the compass transmitter, which supplies long-term magnetic reference for correction of the apparent drift of the gyro. During emergencies, when the DG or SLAVED modes are inoperable, the COMP mode of operation is used. In this mode, an emergency heading reference is provided by the compass transmitter. Pitch, roll, and heading (yaw) inputs are furnished to the AFCS. Pitch and roll inputs are furnished to the VGI's, and heading inputs are furnished to BDHI's course indicators, VOR, and TACAN set. In addition, the COMPASS FAIL caution light will go on when the AHRS malfunctions or fails. The caution light will go on for 2 minutes when the system is turned on, the period when the vertical gyro is in the automatic fast erect mode. The emergency ac bus (or the No. 3 primary ac bus on aircraft with AFC 490) circuit breaker panel in the cockpit furnishes power through a circuit breaker marked AHRS. The emergency dc bus circuit breaker panel in the cockpit furnishes power through a circuit breaker marked COMPASS FAIL.

2.14.3.1 AHRS Controller. The controller is on the overhead control panel (FO-1). The DG position of the mode selector operates the system with the directional gyro. In SLAVED, the system works with the directional gyro slaved to the compass transmitter. The COMP position provides emergency operation with the compass transmitter. The N/S switch selects polarity of latitude correction signal; N for northern hemisphere, S for southern hemisphere. The LAT knob selects latitude of flight (0° to 90°) to correct heading gyro for apparent drift. When in the SLAVED mode, pressing and holding down the HDG/PUSH knob automatically causes synchronization of heading outputs with the compass transmitter heading. In the DG mode, the HDG/PUSH knob may be pushed and turned clockwise or counterclockwise to set heading on the BDHI's. Pressing the HDG/PUSH knob when in the SLAVED mode also increases the roll and erection rates of the vertical gyro. In the SLAVED mode, the SYNC IND (synchronization indicator) window indicates synchronization between gyro heading and compass transmitter heading.

Note

> The AFCS HEADING HOLD mode is automatically disconnected whenever the HDG/PUSH knob is pressed or the COMP position is selected. Reengagement of HEADING HOLD is delayed by 20 seconds following release of the HDG/PUSH knob or selection of the SLAVED or DG modes from the COMP mode.

2.14.4 Radar Altimeter. The radar altimeter system provides instantaneous indication of actual clearance between the helicopter and terrain from 0 to 5000 feet. Altitude, in feet, is indicated by the two radar altimeter indicators on the instrument panel (FO-5). The indicators contain a pointer that indicates altitude on a linear scale from 0 to 200 feet in 5-foot units, 200 to 1000 in 50-foot units, and 1000 to 5000 in 200-foot units. A control knob, on the lower left corner of the indicator, serves as a test switch, a low-level warning index set control, and an on/off power switch. The system is turned on by turning the control knob, marked PUSH-TO-TEST, clockwise from OFF, and is the only control necessary for equipment operation. Continued clockwise turning of the control knob toward SET will permit the pilot to select any desired low-altitude limit, which will be indicated by the low-level warning index marker on the indicator. Pressing the PUSH-TO-TEST control switch provides a testing feature of the system at any time and altitude. When the PUSH-TO-TEST control knob is pressed, a visual indication of 100 ±15 feet on the indicator indicates satisfactory system operation. Releasing the PUSH-TO-TEST control knob restores the system to normal operation. The test capability is disabled when the AFCS RDR ALT mode is engaged. A low-level warning light, on the lower right corner of the indicator, will go on and show the marking LOW any time the helicopter is below the low-altitude limit that has been selected. Loss of system power or tracking condition will be indicated by a black and yellow striped flag in the indicator window, on the lower center portion of the indicator. At that time, the indicator pointer will go behind a mask, marked NO TRACK, to prevent erroneous readings. Fluctuations of about ±2.5 feet may be expected at altitudes below 200 feet. The RDR ALT switch on the pilot's miscellaneous switch panel (FO-1) allows selection of the radar tracking rate. The LAND mode tracks at 2,000 feet-per-second, while the SEA mode tracks at 50 feet-per-second.

WARNING

> Both altimeters will lag in high rates of descent (autorotation) if the RDR ALT switch is at SEA.

Note

- Allow about 3 minutes, after system is turned on, for it to reach operating temperature.
- The altimeter may furnish erroneous indications when carrying external loads.

The No. 3 primary ac bus furnishes power through a circuit breaker marked RADAR ALT, under the general heading RADIO, in the cabin. The No. 2 primary dc bus furnishes power through a circuit breaker marked RADAR ALT, under the general heading RADIO, in the cabin.

2.14.5 Bearing, Distance, Heading Indicator (BDHI). Three BDHI's are installed on the instrument panel (FO-5). The BDHI displays helicopter heading with navigational bearing data and range information. The BDHI consists of a rotating compass card, two bearing pointers, a range indicator, and a range warning flag. The compass card is driven by the AHRS to display magnetic heading in the slaved or compass mode, or heading reference in the directional gyro mode. The bearing pointers indicate magnetic bearing to the selected NAVAID. The range indicator displays slant range distance, in nautical miles, to a DME transponder. The range warning flag will appear if the DME signals are too weak or nonexistent. The emergency ac bus (or the No. 3 primary ac bus on aircraft with AFC 490) furnishes ac power to the pilot's BDHI through a circuit breaker marked NO. 1, under the general heading BDHI, in the cockpit. Power is furnished to the copilot's and the No. 3 BDHI through a circuit breaker marked NO. 2 & 3 under the same general heading.

2.14.5.1 BDHI Switch Panel. Both pilots' BDHI's and bearing pointer switches operate the same way. The two-position No. 1 pointer selector (BRG 1) switch can select DPLR (Doppler ground track) or ADF (LF/ADF or UHF-DF) displays. If the switching relay fails, Doppler information can be displayed with the No. 1 pointer. The two-position No. 2 pointer selector switch (BRG 2) can select NAV (navigation set), GPS TAC (TACAN), or VOR displays. If the switching relay fails, TACAN information can be displayed with the No. 2 pointer. After incorporation of AFC 453, the No. 2 pointer selector switch is changed to a two position switch which can select either a GPS/TAC or VOR display. The BDHI switches are marked GPS/TAC or VOR. TACAN, GPS, or VOR bearing can be displayed by the number two needle on all three BDHIs. To select GPS or TACAN, place the pilots course indicator switch to TAC Master/GPS, then place the BDHI switch to GPS/TAC. Use the GPS or TACAN Mode Select switch to display GPS or TACAN navigation information on the BDHI indicators. The copilot can select TAC Slave/GPS with his course indicator switch, GPS/TAC on the BDHI, and GPS or TACAN with his Mode select switch to display NAV information on his BDHI. With GPS selected, the number two needle will indicate course to the active waypoint. Distance to the active waypoint will be displayed on the BDHI. The Flight Mode Annunciator lights will be deenergized when VOR is selected on the BDHI panel.

Note

TACAN and GPS <u>cannot</u> be displayed simultaneously.

The No. 3 BDHI and its associated switch panel marked NO. 3 BDHI is integrated with the Pilot's BDHI selector panel. It contains a two-position switch that can select TACAN or VOR for display. If the switch relay fails, TACAN can be displayed with the No. 2 pointer (BRG 2). The No. 1 pointer always displays the opposite of the pilot's BDHI's No. 1 pointer (BRG 1). Therefore, if the pilot's switch relay fails, LF/ADF will be displayed by the No. 3 BDHI's No. 1 pointer. UHF-DF is never displayed by the No. 3 BDHI's No. 1 pointer. After incorporation of AFC 453, the BDHI switch will select GPS/TAC or VOR for display. The No. 3 BDHI switch has two positions, GPS/TAC or VOR, and is controlled by the pilots or copilots course indicator switch. When the pilots course indicator switch is in the TAC Master/GPS position, the No. 3 BDHI will display the same information as the No. 2 BDHI or the pilot may select VOR. When the pilot selects TAC Slave/GPS, the copilot may control the No. 3 BDHI by selecting VOR Master.

Note

The selection of GPS function is tied to the GPS/TACAN annunciator switch mounted on the instrument panel.

2.14.6 Clocks. The elapsed-time clocks, one each for each pilot, are mounted on the instrument panel (FO-5). The control knob for the elapsed-time mechanism is at the upper right corner of the clock face. The clock is stem-wound and stem-set, using a knob in the lower left corner of the clock face.

2.14.7 Course Indicator. Two course indicators, on the instrument panel (FO-5), are used to display helicopter heading and position relative to a selected VOR/TACAN course, and lateral and vertical position relative to an ILS localizer and glide slope. After incorporation of AFC 453 the course indicator (FO-5) will display GPS/TAC or VOR course information.

2.14.7.1 VOR or TACAN Display. The relative heading pointer, connected to the course SET knob and the AHRS, displays helicopter heading relative to the selected course. When the helicopter heading is the same as the course selected, the relative heading pointer indicates 0° heading deviation at the top of the course indicator. The heading deviation scales, at the top and bottom of the course indicator, are scaled in 5° units, up to 45°. The TO-FROM ambiguity window indicates whether the course selected, if properly intercepted and flown, will take the helicopter to the NAVAID. When the helicopter passes a line from the NAVAID perpendicular to the selected course, the TO-FROM ambiguity window changes. Helicopter heading has no effect on the TO-FROM indication.

The course deviation indicator (CDI) displays helicopter course deviation relative to the course selected. The indicators are adjusted for VOR and TACAN, so that the CDI is fully displaced when the helicopter is off course more than 10°. Each dot on the CDI scale represents 5°. Appearance of the course warning flag indicates that the course indicator is not receiving a signal strong enough for reliable navigation information.

Note

> Although the course indicator may be receiving a signal strong enough to keep the course warning flag out of view, reliability is indicated only if the warning flag is not displayed, the station identification is being received, and the No. 2 BDHI pointer is pointing to the NAVAID.

2.14.7.2 ILS Display. When used to display ILS signals, the course indicator provides precise ILS localizer course and glide slope information for a specified approach. The TO-FROM ambiguity window is unusable. Full-scale deflection on the CDI scale differs with the width of the localizer course (3° to 6°). Example: If the localizer course is 5° wide, then full-scale deflection is 2-1/2° and each dot is 1-1/4° if the localizer course is 3° wide, then full-scale deflection is 1-1/2° and each dot is 3/4°.

The course SET knob and the course selected have no effect on the CDI display. The CDI displays only if the helicopter is on course or in a 90 or 150 Hz zone of signals originating from the ILS localizer transmitter. The CDI always deflects to the left of the instrument case in the 150 Hz zone and to the right in the 90 Hz zone. It centers when the signal strength of both zones is equal.

Note

> Although the course selected has no effect on the CDI, always set the published inbound front course of the ILS in the COURSE selected window. The CDI is displaced with respect to the instrument case and is directional in relation to the relative heading pointer.

The glide slope indicator (GSI) displays glide slope position in relation to the helicopter. If the GSI is above or below center, the glide slope is above or below the helicopter respectively. Full scale deflection of the GSI differs with the width of the glide slope (1° to 1.8°). Example: If the glide slope width is 1°, full-scale deflection is 1/2°, and each dot is 1/4°. Appearance of the course or glide slope warning flags indicates that the course or glide slope signal strength is not sufficient. Absence of the identifier indicates the signal is unreliable. The MARKER beacon light and ICS aural tone are not provided in this helicopter.

2.14.7.3 Course Indicator-TACAN/VOR. The pilot's course indicator is the primary indicator when using TACAN. When he selects a course with the course SET knob, course deviation and to-from ambiguity resolution will be displayed by both pilot's course indicators. In addition, the course selected will be shown only in the pilot's COURSE selected window. Selecting the same course on the copilot's indicator will provide correct relative heading pointer display on his course indicator and has no control over his CDI. When using VOR, the copilot's course indicator is the primary indicator and operation is the reverse of the previous procedure.

2.14.7.4 Course Indicator Selector Switch. The two-position COURSE IND switch mounted beside each indicator selects a TACAN display or VOR/ILS display for each indicator. The pilot can select a TACAN display by moving the switch to TACAN MASTER. The copilot can select a TACAN display by moving the switch to TACAN SLAVE; however, the pilot's indicator must be displaying TACAN, because the copilot's CDI is slaved to the pilot's. The copilot can select a VOR/ILS display by moving the switch to VOR MASTER. The pilot can select a VOR/ILS display by moving the switch to VOR SLAVE; however, the copilot's indicator must be displaying VOR/ILS, because the pilot's CDI is slaved to the copilot's. If the pilot's switching relay fails, his course indicator will display TACAN only, and if the copilot's fails, his course indicator will display VOR/ILS only. Whenever the VOR/ILS set is receiving a valid glide slope signal, both GSIs will display glide slope information, regardless of switch position. After incorporation of AFC 453: To select GPS/TAC, place the pilots course indicator switch to TAC Master/GPS. Place the BDHI switch to GPS/TAC. Use the GPS/TAC Mode Select switch to display GPS/TAC navigation information on the course indicator. With GPS selected, the CDI vertical bar will indicate distance from Desired Track (DTK). Indicator Scale is determined by selecting Enroute (E), Terminal (T) or Approach (A), on the GPS/TACAN Mode Select switch. The copilot can select TAC slave GPS with his course indicator switch and GPS/TAC with his BDHI switch. Use the Mode Select switch to display GPS/TAC information on copilot course indicator.

2.14.7.5 GPS/TACAN Select Switch (After incorporation of AFC 453). The GPS/TACAN Mode Select switch has two positions and three annunciator lights. There is a mode select switch for each pilot. The switch controls GPS/TACAN or VOR when the BDHI switch is in the corresponding position. The three annunciators indicate the flight mode. The flight modes are ENR (Enroute), TRM (Terminal), and APPR (Approach). The flight mode annunciators are controlled by the CDNUs.

2.14.8 Free-Air Temperature Gage. The gage, mounted forward of the copilot's overhead window, indicates outside air temperature in degrees Celsius.

2.14.9 Standby Compass. A magnetic standby compass is at the top center of the instrument panel, and a compass correction card is on both sides of the instrument panel. A compass light switch, with marked positions ON and OFF, is attached to the compass case. The compass light receives power from the No. 1 dc primary bus through a circuit breaker in the cabin, marked AVIONIC LTG CONSOLE.

2.15 CAUTION AND ADVISORY PANELS

2.15.1 Caution Panel. The caution panel (FO-7), in the center of the instrument panel, visually indicates failure or unsafe conditions of certain critical equipment in the helicopter. The panel contains placard-type caution lights, each with its own operating circuit, to indicate a malfunction or unsafe indication in a particular system. The caution light for that particular system will remain on until the malfunction or unsafe indication is corrected. Bulbs are replaced by momentarily pressing the capsule, which releases a lock and extends the capsule out away from the face of the panel. The capsule can now be turned for bulb replacement. The caution panel operates on current from the emergency dc primary bus through a circuit breaker marked CAUTION PANEL MASTER, in the cockpit (Figure 2-23).

2.15.1.1 Master Caution Lights. These lights (FO-5), marked MASTER CAUTION PUSH TO RESET, each at the top of the pilot's and copilot's instrument group, will go on any time a caution light on the caution panel goes on to alert the pilots of a malfunction or condition within the helicopter. After the specific malfunction or condition has been noticed, the press-to-reset master caution lights may be reset to provide a similar condition if a second malfunction or condition should occur while the first is still present. The master caution light and test circuit uses the same power source and protective circuit breaker as the caution panel (Figure 2-24).

2.15.2 Advisory Panel. The advisory panel (FO-7), below the caution panel on the instrument panel, visually indicates certain operating conditions that exist while in flight or on the ground. The advisory panel contains placard-type advisory lights, each with its own operating circuit, to indicate a particular system is in operation or a certain flight condition exists (Figure 2-25). The advisory light for that particular system or condition will then go on and remain on until that system is turned off or the condition no longer exists. Bulbs are replaced as on the caution panel. The advisory panel operates on current from the emergency dc primary bus through a circuit breaker marked CAUTION PANEL MASTER, in the cockpit overhead control panel (FO-1).

2.15.3 Caution Advisory Panel Test. A press-to-test switch on the bottom of the panel is used to test the bulbs in the panel, blade and pylon fold lights, chip locator lights, landing gear up warning light, rotor brake lights, AFCS panel lights, and master warning lights.

2.16 ENVIRONMENTAL CONTROL SYSTEMS

2.16.1 Electronic Cooling System. A blower is installed in the Doppler compartment to cool AHRS and Doppler equipment. The blower operates continuously whenever there is power on the No. 1 primary ac bus. Power is furnished through a circuit breaker in the cabin marked DOPPLER FAN.

2.16.2 Heating System. The system (Figure 2-26) consists of fans, an internal combustion heater, a plenum chamber, and ducts which run along the upper left and right sides of the cabin, and into the pilot's compartment.

The 600,000 BTU heater, forward of the APP, operates on fuel supplied from the No. 2 left fuel tank and uses about 54 pounds of fuel per hour. Heater combustion air is supplied by a combustion air blower and ventilating air by the vent fan. Both operate on electrical power from the No. 2A primary ac bus. The circuits are protected by circuit breakers in the cabin marked COMB AIR BLOWER and VENT BLOWER. The control circuit receives power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked CAB HTR.

2.16.2.1 Heating System Control. The CABIN HTR control panel, on the overhead control panel (FO-1), controls the heating system with the HEAT rheostat. When the rheostat is beyond the OFF, the heater system is put into operation. Further turning of the rheostat will increase heater output until the desired heat level is reached. An overheat switch will shut off the heater if for any reason the heat in the plenum chamber rises to 204°C. When the desired setting of the rheostat is reached, the temperature controller will automatically maintain the desired temperature. Ignition and fuel to the heating system is auto-

NAME	MEANING
BIM	Loss of main rotor spar integrity or spar pressure indicator malfunctioning. IBIS radiation detector, signal processor, or ac power malfunction.
ICE DETECTED	Ice is building up on helicopter.
COMPASS FAIL	AHRS has malfunctioned.
ROTOR LOCKED	Gust lock is applied.
ROTOR BRAKE PRESS	Rotor brake system is pressurized to at least 10 psi.
CHIP DETECTED	Gear box or engine metallic chips have been detected.
AFCS	Dual computer failure.
#1 RECT	No. 1 transformer-rectifier has malfunctioned.
#2 RECT	No. 2 transformer-rectifier has malfunctioned.
#1 GEN	No. 1 generator has malfunctioned, or if on the ground and below 91% to 96% N_r, a momentary underfrequency has been experienced.
#2 GEN	No. 2 generator has malfunctioned, or if on the ground and below 91% to 96% N_r, a momentary underfrequency has been experienced.
#3 GEN	No. 3 generator has malfunctioned, or if in the ground and below 91% to 96% N_r, a momentary underfrequency has been experienced.
IGB OIL PRESS	Intermediate gear box oil pressure is below 7 ±1 psi.
BLANK CAPSULE	Possible system malfunction.
2 STG OIL HOT (AFC 308)	Second stage hydraulic temperature above 107°C and/or the second stage system heat exchanger blower motor has shut down.
#1 ENG FLTR BYPASS	Pressure drop across No. 1 fuel system airframe fuel filter is over 1.37 ±0.5 psi, and filter is partially clogged.
#2 ENG FLTR BYPASS	Pressure drop across No. 2 fuel system airframe fuel filter is over 1.37 ±0.5 psi, and filter is partially clogged.
#3 ENG FLTR BYPASS	Pressure drop across No. 3 fuel system airframe fuel filter is over 1.37 ±0.5 psi, and filter is partially clogged.
TGB OIL PRESS	Tail gear box oil pressure is below 7 ±1 psi.
BLADE PYLON FOLD	Blade/pylon fold system activated and/or gust lock engaged. Helicopter unsafe for flight.
UTILITY OIL HOT	Utility hydraulic temperature above 107°C. Helicopters modified by AFC 308 utility hydraulic temperature above 107°C and/or the utility system heat exchanger blower motor has shut down.
#1 ENG FUEL BOOST	No. 1 boost pump output below 8.5 ±0.5 psi.
#2 ENG FUEL BOOST	No. 2 boost pump output below 8.5 ±0.5 psi.
#3 ENG FUEL BOOST	No. 3 boost pump output below 8.5 ±0.5 psi.

Figure 2-23. Caution Light Summary Table (Sheet 1 of 3)

NAME	MEANING
1 STG M/R SERVO BYPAS	A servo has malfunctioned in a manner to cause it to bypass hydraulic pressure or loss of system pressure.
2 STG M/R SERVO BYPAS	A servo has malfunctioned in a manner to cause it to bypass hydraulic pressure or loss of system pressure.
UTILITY T/R PRESS	Utility pressure, downstream of the second stage servo shutoff valve in the utility module, has dropped below 2000 psi. Inadequate utility pressure to the second stage side of the tail rotor tandem servo.
#1 ENG OIL PRESS LOW	Low oil pressure in No. 1 engine (10 ±3 psi or below).
#2 ENG OIL PRESS LOW	Low oil pressure in No. 2 engine (10 ±3 psi or below).
#3 ENG OIL PRESS LOW	Low oil pressure in No. 3 engine (10 ±3 psi or below).
1 STG T/R SERVO BYPASS	The servo has malfunctioned in a manner to cause it to bypass hydraulic pressure or loss of system pressure.
BLANK CAPSULE	Possible system malfunction.
2 STG T/R SERVO BYPAS	The servo has malfunctioned in a manner to cause it to bypass hydraulic pressure or loss of system pressure.
#1 NGB OIL PRESS	No. 1 nose gear box oil pressure below 14 ±2 psi.
MGB OIL PRESS	Main gear box oil pressure below 14 ±2 psi.
#3 NGB OIL PRESS	No. 3 nose gear box oil pressure below 14 ±2 psi.
1 STG PRESS M/R T/R	First stage flight control system below 2000 psi.
2 STG PRESS M/R	Second stage flight control system hydraulic pressure below 2000 psi.
UTILITY PRESS	Utility hydraulic system pressure below 2000 psi.
#1 NGB OIL HOT	No. 1 nose gear box oil temperature above 121° ±5.5°C.
MGB OIL HOT	Main gear box above 121° ±5.5°C.
#3 NGB OIL HOT	No. 3 nose gear box oil temperature above 121° ±5.5°C.
1 STG QTY M/R T/R	Hydraulic fluid quantity is at an unsatisfactory low level.
2 STG QTY M/R	Hydraulic fluid quantity is at an unsatisfactory low level.
UTILITY QTY T/R	Hydraulic fluid quantity is at an unsatisfactory low level.
#1 ENG OIL PRESS HIGH	High oil pressure in the No. 1 engine (100 ±3 psi or above).
#2 ENG OIL PRESS HIGH	High oil pressure in the No. 2 engine (100 ±3 psi or above).
#3 ENG OIL PRESS HIGH	High oil pressure in the No. 3 engine (100 ±3 psi or above).

Figure 2-23. Caution Light Summary Table (Sheet 2 of 3)

NAME	MEANING
C/G HOOK INOP	CG hook load system not functioning or not functioning correctly.
BLANK CAPSULE	Possible system malfunction.
ACC GB OIL PRESS	Accessory gear box oil pressure below 7 ±1 psi.
#1 ENG OIL QTY LOW	No. 1 engine oil at or below refill level.
#2 ENG OIL QTY LOW	No. 2 engine oil at or below refill level.
#3 ENG OIL QTY LOW	No. 3 engine oil at or below refill level.
BLANK CAPSULE	Possible system malfunction.
BLANK CAPSULE	Possible system malfunction.
ACC GB OIL HOT	Accessory gear box oil temperature above 145°.
#1 ENG ANTI-ICE	Duct temperature below 35°C, or electrical failure in system.
TAIL ROTOR HIGH STRESS (AFC 307)	Indicated airspeed 60+ knots, average engine torque 110%+, and climb rate 2800+ feet per minute.
#3 ENG ANTI-ICE	Duct temperature below 35°C, or electrical failure in system.
BLANK CAPSULE	Possible system malfunction.
BEARING VIB LIMIT (AFC 491, otherwise blank)	Vibration level from at least one of the swashplate sensors (SP-1 and/or SP-2) has reached 2.5gs, or vibration level from the tail rotor drive shaft disconnect coupling bearing (DISC) has reached 4.0gs.
BEARING TEMP DETECT (AFC 491, otherwise blank)	Temperature level from at least one of the swashplate sensors (SP-1 and/or SP-2), or the tail rotor drive shaft disconnect coupling bearing (DISC) has reached 275°F.
BEARING TEMP LIMIT (AFC 491, otherwise blank)	Temperature level from at least one of the swashplate sensors (SP-1 and/or SP-2), or the tail rotor drive shaft disconnect coupling bearing (DISC) has reached 350°F.
MGB AUX LUBE PUMP	Main gear box auxiliary oil pressure below 14 ±2 psi.
ENGINE OVERTORQUE (AFC 307)	Total engine torque exceeds 137%.
EAPS HIGH PRESS LOSS	Dual pressure switch or relay malfunction. Too much drop in system pressure due to filter clogging.
IFF	When operating in MODE 4, system has malfunctioned, or being interrogated and no reply being made.
2 PT FLT UNARMED	LOAD/UNLOAD mode selected for two-point external cargo system.
#1 FUEL LOW	About 666 ±30 pounds of fuel remains in No. 1 tank.
#2 FUEL LOW	About 333 ±15 pounds of fuel remains in No. 2 left or right tanks.
#3 FUEL LOW	About 666 ±30 pounds of fuel remains in No. 3 tank.
#2 ENGINE OVERHEAT (AFC 483)	An overheat condition exists in #2 engine compartment.

Figure 2-23. Caution Light Summary Table (Sheet 3 of 3)

NAME	LOCATION	MEANING WHEN LIT
MASTER CAUTION	Instrument panel (Two places)	Caution light on caution panel is on
LDG GEAR UP	Instrument panel	Landing gear up when helicopter below 150 feet, and airspeed below 60 KIAS
FIRE	Instrument panel	Fire in engine or APP and heater compartments
ENG EMER OFF	Engine emergency T-handles	Fire in engine compartment
APP EMER OFF	APP emergency T-handle	Fire in APP and/or cabin heater compartment
Landing Gear Warning Light	Landing gear control handle	Landing gear is in transit or not locked up or down
UNLOCKED	Crewman's ramp control panel (Left side aft cabin)	Cargo ramp or door unlocked

Figure 2-24. Warning Light Summary Table

matically shut off whenever the APP emergency T-handle is actuated, an overheat condition occurs, or if there is no ignition 45 seconds after the heater is turned on.

2.16.2.2 Vent Fan Switch. The ventilating fan switch marked VENT, with marked positions OFF and ON, is on the cabin heater control panel; and is marked CABIN HTR on the overhead control panel (FO-1). When the cabin heat rheostat control is moved out of OFF, the vent fan operates in conjunction with the heating system, regardless of the position of the vent fan switch. Placing the vent fan switch ON, with the cabin heat rheostat control OFF, will draw outside air into the heater system and ventilate the pilot's compartment and cabin.

2.16.2.3 Heating and Ventilating Diffusers. The diffusers are in each of the heating ducts that extend along the sides of the cabin and into the pilots compartment. The pilot's compartment has four diffusers, two in the floor and two on the bulkhead over the pilot's and copilot's heads. There are 18 diffusers in the cabin, nine in each duct on each side of the cabin. Each diffuser can be adjusted to regulate the flow of heated or ventilating air through the diffusers.

Note

> The heater should be turned off 10 minutes before removing electrical power from the system. The heater is shut off by moving the cabin heater rheostat control OFF. The vent fan and combustion air fan will continue to operate after the heater is shut off, until the temperature in the plenum chamber drops to 49°C. If the temperature in the plenum chamber should rise to 49°C during hot weather, the fans will begin to operate as soon as the No. 2A primary ac bus is energized.

2.17 WINDSHIELD WASHER SYSTEM

The system consists of a reservoir, windshield washer motor/pump, and a control switch. The reservoir, behind the copilot's seat, holds 6 quarts. The windshield washer motor pumps the fluid through tubing to the spray bars in the windshield wiper blades. The windshield washer motor is controlled by a switch, with marked positions OFF and WASH, on the windshield wiper control panel (FO-1). Placing the switch to WASH causes the windshield washer motor to pump fluid through the wiper spray bars to the windshield. The windshield washer system is powered from the No. 3 primary dc bus through a circuit breaker marked WSHLD WSHR CONT, in the cabin.

2.18 WINDSHIELD WIPER SYSTEM

The electrically-operated system consists of a two-speed motor, two converters, and a rotary control switch. The windshield wipers are on the pilot's and copilot's windshields and have an approximate 56° range of travel. The system is controlled by a rotary-type switch with marked positions PARK, OFF, LOW, AND HIGH, on the overhead windshield wiper control panel, marked WINDSHIELD WIPER (FO-1). When the switch is placed to LOW or HIGH, the system is actuated and the desired

NAME	MEANING
ENG STARTER ON	Lights when any engine starter circuit is energized.
EXT PWR CONNECTED	External power connected to the helicopter.
RAMP OPEN	Cargo ramp or door is open.
#1 IGV ANTI-ICE ON	No. 1 engine air and inlet anti-icing systems are turned on.
#2 IGV ANTI-ICE ON	No. 2 engine air anti-icing system is turned on.
#3 IGV ANTI-ICE ON	No. 3 engine air and inlet anti-icing systems are turned on.
APP ON	APP is operating above 92%.
ISOLATION VALVE OPEN	Isolation valve is open.
PARKING BRAKE ON	Parking brake handle is extended.
EAPS DOOR CLOSED	All three EAPS bypass doors are closed.
ROTOR BRAKE ON	Rotor brake system is fully pressurized to 975 ±25 psi.
ENG START HEAD POS	Main rotor head is positioned for engine start.
AUTO RELEASE ON	Single-point cargo hook master switch is at AUTO to select automatic release mode.
FWD HOOK OPEN	Two-point hook release latch open or not fully closed.
OMEGA WARN (AFC 327)	Indicates system failure.
OMEGA WPT ALR (AFC 327)	Aircraft two minutes from selected TO waypoint.
PURGING	PURGE pushbutton on the 8.5 minute purge taking place. Advisory light goes off when purge automatically terminates or PURGE pushbutton pressure to off.
AFCS DEGRADED	Any AFCS failure, other than dual computer failure, will cause light to flash.
SINGLE HOOK OPEN	Hook release latch open or not fully closed.
AFT HOOK OPEN	Two-point hook release latch open or not fully closed.
BLANK CAPSULE	
GPWS ALERT (AFC 501 PT 2, otherwise blank)	Warns of potentially unsafe flight conditions in respect to ground proximity.
BLANK CAPSULE	
BLANK CAPSULE	
BLANK CAPSULE	
BLANK CAPSULE	
BLANK CAPSULE	
GPWS INOP (AFC 501 PT 2, otherwise blank)	Indicates system failure.
BLANK CAPSULE	
BLANK CAPSULE	

Figure 2-25. Advisory Light Summary Table

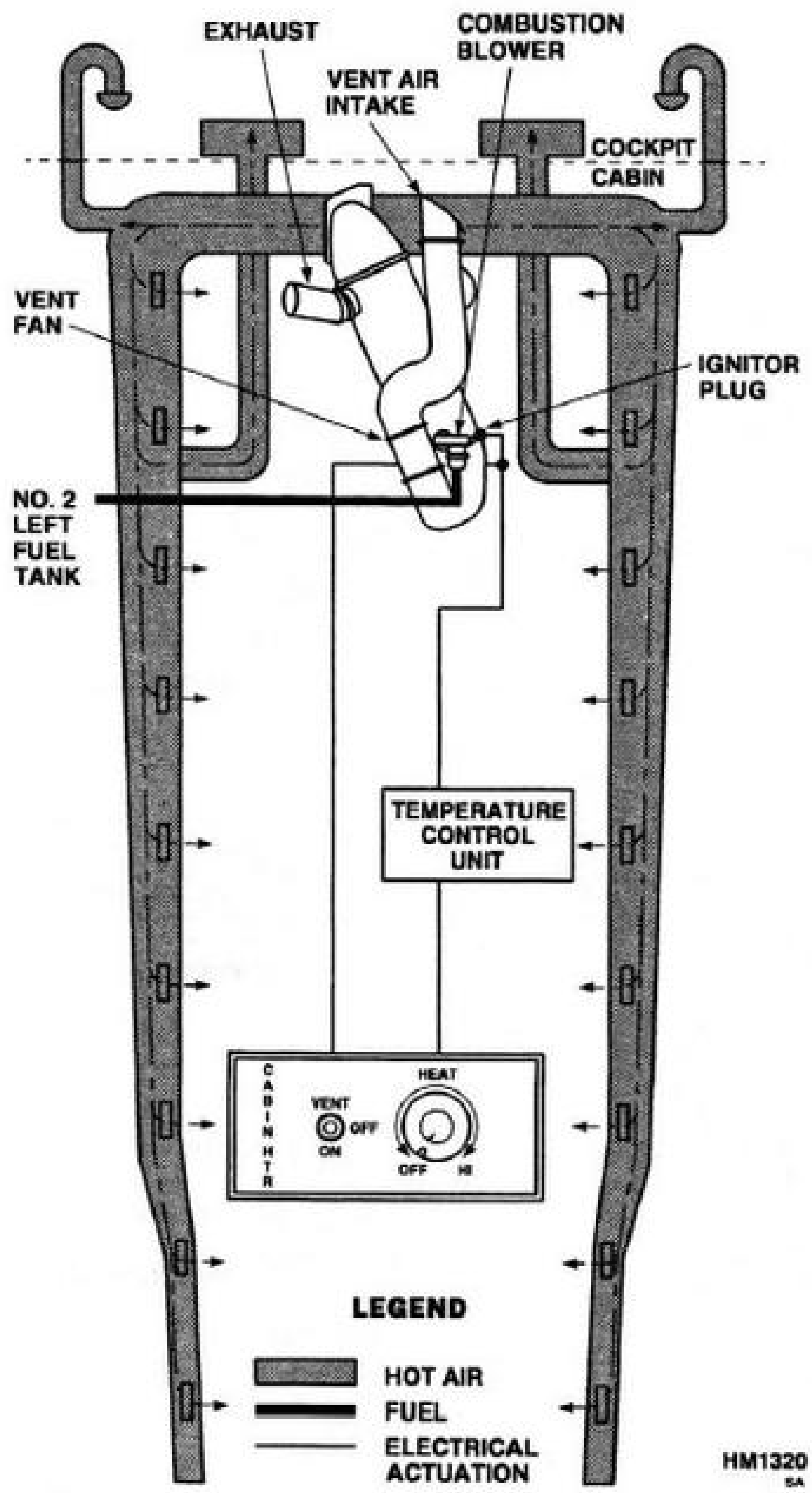


Figure 2-26. Heating/Ventilation Schematic

speed range is selected. When the switch is turned to PARK, the wipers automatically position to the inboard edge of the windshields. The wiper arms have high tension springs installed to increase visibility by reducing wiper blade buffeting and lifting at high speeds. The windshield wiper system receives electrical power from the No. 2B primary ac bus through a circuit breaker in the cabin, marked WINDSHIELD WIPER.

CAUTION

To prevent scratching the windshields, do not operate the wipers on dry glass.

2.19 ANTI-ICING SYSTEMS

Ice protection is provided for the engines, windshields, and pitot tubes. Fourteenth-stage compressor air is used to anti-ice the engines' inlet guide vanes and five of the front frame struts. The 6-o'clock front frame strut is anti-iced by hot scavenge oil from the engine. Continuous ignition is provided whenever the respective engine anti-ice is selected to reduce the possibility of engine flameout during icing conditions. The No. 1 and No. 3 engines' inlet duct, inlet removable section, and nose gear box fairing are electrically-heated. EAPS is installed permanently on the No. 2 engine. With EAPS installed on the No. 1 and No. 3 engines the nose gear box fairing anti-icing capability is disabled.

The anti-icing systems (Figure 2-27) should be turned on and the EAPS doors manually closed when operating during conditions in which ice may be formed, thereby eliminating the possibility of ice being formed and subsequently ingested into the compressor to cause power loss or engine failure. When the EAPS doors have been manually closed to prevent engine ice ingestion, the doors shall be kept closed until the engines are shut down after landing. This is necessary even if icing conditions no longer exist, to prevent ingestion of accumulated ice.

2.19.1 Ice Detector System. The system visually indicates icing conditions, and consists of ice detector probes, an ice detector controller, a caution light, and necessary switches and electrical circuits. The ice detector probes, one in the heater intake duct and the other above the upper frame of the pilot's window, indicate icing conditions as they accumulate ice. The probe above the pilot's window frame is visually monitored to assist in determining icing conditions during flight. The probe in the heater duct indicates ice accumulation if the ice detector switch is ON, by lighting the ICE DETECTED caution light. The system is controlled by a switch marked ICE DET with marked positions TEST, OFF and ON, on the anti-ice control panel. When the switch is placed ON, the system will function automatically. When the switch is placed to TEST, the MASTER CAUTION and ICE DETECTED caution lights will go on. Pressing the MASTER CAUTION light for reset will turn it off; however, the ICE DETECTED caution light will not go off for about 35 seconds. The probe in the heater duct contains radioactive strontium 90 that emits beta particle radiation across an air gap. When the air gap is obstructed by ice accumulation, the reduced amount of radiation received by the detector causes a current change to activate the system. When ice is detected and the system activated (ICE DET switch ON), the ICE DETECTED caution light will go on and the ice detector controller will simultaneously apply

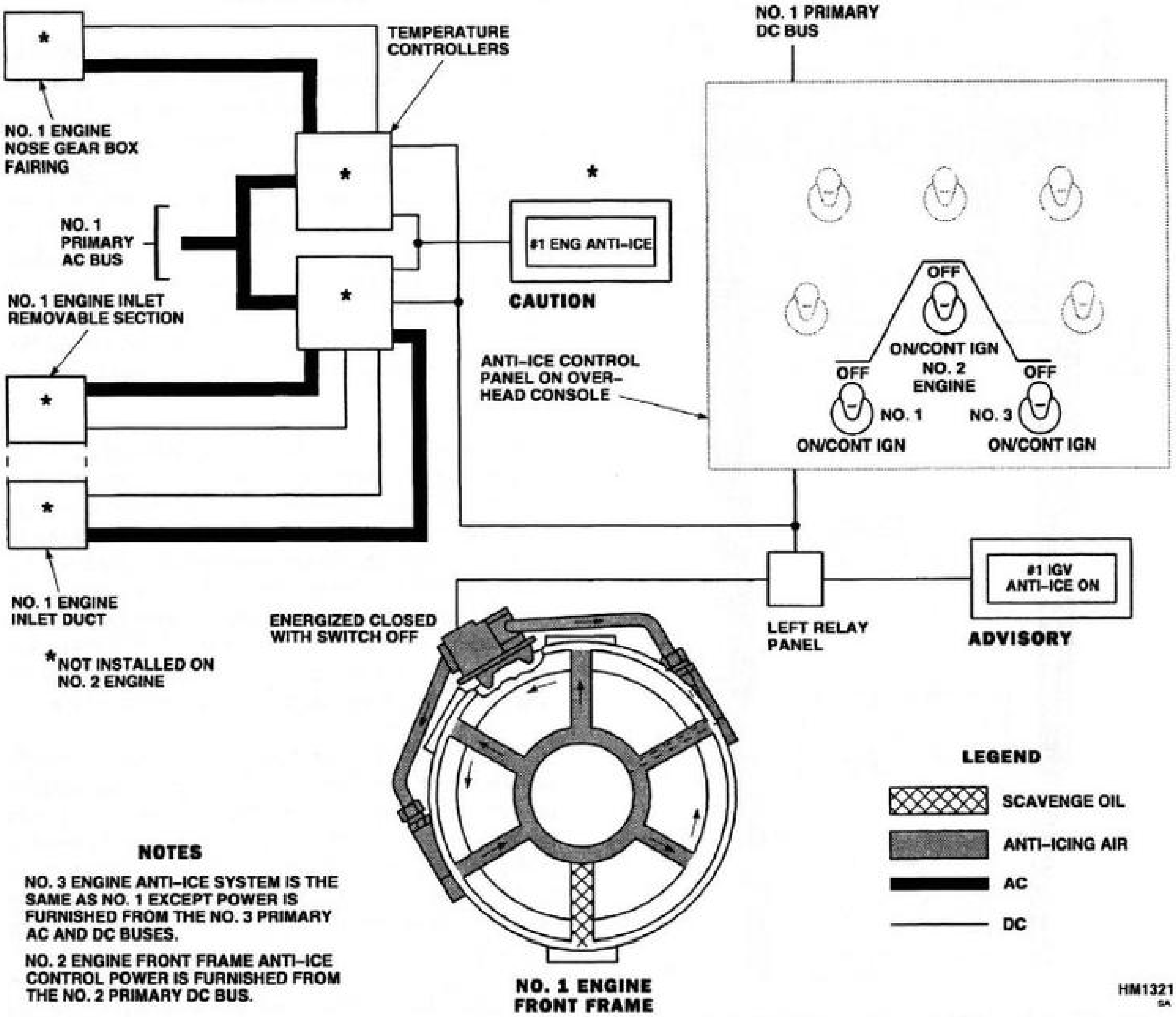


Figure 2-27. Anti-Icing Schematic

an electrical current to the probe to melt the ice. The ICE DETECTED caution light will remain on 35 seconds, or longer, until the ice has been melted from the air gap. The light will go on again each time ice accumulates in the air gap. The frequency at which the light goes on is an indication of the severity of icing conditions. The system receives power from the No. 2B primary ac and No. 1 primary dc buses through the circuit breakers in the cabin, marked ICE DET.

WARNING

There is no significant radiation danger when more than 3 feet from the probe; however, do not spend more than a few minutes looking into the heater duct at the probe. If the helicopter is damaged, or the probe has been physically damaged, exposed to temperatures above 500°F, or is obviously discolored, the condition should be reported to maintenance personnel so that special handling procedures can be used.

Note

The ice detection system warns of ice accumulation only and does not automatically activate the helicopter anti-icing systems.

2.19.2 Engine Anti-Ice System

Note

- Interlocks are provided to prevent more than one engine's anti-ice system from operating when the helicopter's electrical systems are powered by an external power cart.
- With EAPS installed, No. 1 and No. 3 engines nose gear box fairing anti-icing capability is disabled.
- Continuous ignition is automatically turned on whenever engine's anti-ice system is turned on.

2.19.2.1 Engine Inlet Anti-Icing System. The No. 1 and No. 3 engine air inlet ducts, engine nose gear box fairings, and the engine inlet removable sections are anti-iced by thermal-electric resistance elements embedded within epoxy glass linings. Temperature controllers will automatically maintain a normal anti-icing temperature, once the system has been turned on, between 88°C and 68°C. Low temperature sensors, in each area being anti-iced, will cause a respective engine anti-ice caution light to go on, provided the temperature is below the low temperature sensor setting, and the anti-icing system has been turned on. The engine anti-ice caution lights are marked #1 ENG ANTI-ICE and #3 ENG ANTI-ICE, respectively. If the caution lights go on after the engine anti-ice switches are turned on, they will remain on until the temperature increases above the low temperature sensor setting of 35°C. If the light does not go off, the system is not producing enough heat to raise the temperature above the low temperature sensor setting. Each engine anti-icing system is powered from a respective anti-ice bus.

The No. 1 primary ac bus circuit breaker panel in the cabin furnishes power to the No. 1 engine nose gear box fairing heating element through circuit breakers marked NGB; to the removable section through circuit breakers marked REM SECT; and the inlet section through circuit breakers marked NO. 1 ENGINE ANTI-ICE INLET. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes control power to the controllers and lights the #1 ENG ANTI-ICE caution light through a circuit breaker marked ANTI-ICE WARN. The No. 3 primary ac and dc bus circuit breaker panels in the cabin furnish control and operating power to the No. 3 engine anti-ice system in the same manner, through appropriately marked circuit breakers.

2.19.2.2 Engine Air Anti-Icing. The front frame struts and the inlet guide vanes of each engine are anti-iced by diverting fourteenth-stage compressor air to heat them. Actuating the engine anti-ice switches, on the anti-ice control panel, deenergizes an engine-mounted solenoid valve to the open position, allowing hot compressor air to flow through the front frame struts and inlet guide vanes. When the engine solenoid valves are deenergized, the advisory lights on the instrument panel (FO-7) marked #1, #2, and #3 IGV ANTI-ICE ON, will be simultaneously energized, to indicate that the systems are on. The engine air anti-icing system is turned on simultaneously with the engine air inlet anti-icing system. The engine solenoid valves are energized to the off position to make sure of a flow of anti-icing air in case of a complete electrical power failure. A loss of about 3% of each engine's horsepower will result at maximum power, when the engine air anti-icing system is on.

The No. 1 primary dc bus circuit breaker panel in the cabin furnishes control power through a circuit breaker marked CONT, and power to operate the #1 IGV ANTI-ICE ON advisory light through a circuit breaker marked WARN. Both circuit breakers are under the heading IGV ANTI-ICE. The No. 2 and 3 engine air anti-icing systems are powered by the No. 2 and 3 primary dc circuit breaker panels, respectively, in the cabin, through appropriately marked circuit breakers.

2.19.2.3 Engine Anti-Ice Switches. The ANTI-ICE panel on the overhead control panel contains the ENGINE anti-ice switches. The systems are controlled by switches, marked NO. 1-NO. 2-NO. 3, respectively, each of which has marked positions OFF-ON/CONT IGN. Placing the No. 1 and No. 3 engine anti-ice switch to ON/CONT IGN simultaneously turns on engine inlet anti-ice, engine air anti-ice, and continuous ignition. Placing the No. 2 engine anti-ice switch to ON/CONT IGN simultaneously turns on engine air anti-ice and continuous ignition. The appropriate engine IGV ANTI-ICE ON advisory light will go on to indicate that the engine air anti-icing system is satisfactory. The OFF position will simultaneously turn the systems of the respective engine off.

2.19.3 Windshield Anti-Ice System. The pilot's, copilot's, and center windshields are constructed of a layer of glass over two layers of stressed acrylic plastic. They are anti-iced by electric current that passes through a transparent electrically resistant coating on the inner surface of the outer laminate of the windshields. The windshield anti-ice system also serves to defog the windshields. Sensors, molded into each windshield, vary resistance with changes in windshield temperature to maintain the windshields at a constant temperature. The pilot's windshield is anti-iced by power received from the No. 3 primary ac bus through three circuit breakers, marked WINDSHIELD ANTI-ICE PILOT, and is controlled by power from the No. 3 primary dc bus through a circuit breaker, marked WSHLD ANTI-ICE PILOT, also in the cabin. The copilot's windshield is anti-iced by power received from the No. 1 primary ac bus through three circuit breakers, marked WINDSHIELD ANTI-ICE CO-PILOT, in the cabin, and controlled by power from the No. 1 primary dc bus through a circuit breaker marked WSHLD ANTI-ICE CO-PILOT, also in the cabin. The center windshield is anti-iced by power received from the No. 1 monitored ac bus through three circuit breakers in the cabin, marked WINDSHIELD ANTI-ICE CENTER, and controlled by power from the No. 2 primary dc bus through a circuit breaker, marked WSHLD ANTI-ICE CTR, also in the cabin. Failure of any generator will cause the No. 1 monitor ac bus to be dropped from the system, and center windshield anti-icing system will be inoperative. The pilot's and copilot's chin bubbles, cockpit side windows, and cabin windows are all made from molded Plexiglas and do not contain an anti-icing capability.

2.19.3.1 Windshield Anti-Ice Switches. The ANTI-ICE panel on the overhead control panel contains the WINDSHIELD anti-ice switches. The windshield anti-ice switches are marked CO-PILOT, CENTER, and PILOT, to designate the respective windshield anti-ice system they control, and all have marked positions: LOW, OFF, and HIGH. The LOW position is used for defogging and light icing conditions. The HIGH position is used to prevent ice formation on the windshields during heavy icing conditions. The OFF position is used to turn the system off.

Note

> The windshield anti-ice system does not have a visual indication of system operation. Inadvertent activation of the system or a controller malfunction may go unnoticed and result in windshield failure upon activation or with a reduction of air flow across the windshield. Windshield anti-ice should be secured prior to landing, conditions permitting.

2.19.4 Pitot Heaters. The ANTI-ICE panel, on the overhead control panel, contains the PITOT HEAT switch. When placed ON, an electric heater in each pitot head is turned on to prevent ice formation in the pitot head. The left (No. 1) pitot heater receives power from the No. 1 primary dc bus through a circuit breaker in the cabin, marked PITOT HEAT LEFT, and the right (No. 2) pitot heater receives power from the No. 3 primary dc bus through a circuit breaker, marked PITOT HEAT RIGHT, also in the cabin.

2.20 SEATS

2.20.1 Pilot and Copilot Seats (Helicopter Not Modified by Crash-attenuating Seats). Boron-carbide composite armored pilots' seats are track-mounted side by side in the cockpit. Each set is equipped with seat and back cushions. Each seat is equipped with an outboard armorplate wing release mechanism, adjustment levers, a lap belt, a shoulder harness attached to an inertia reel, and a shoulder harness lock lever. The outboard armorplate wing of each seat is hinged so that it may be opened outward to provide additional clearance for emergency exit.

2.20.1.1 Seat Cushion Blower. Each seat has an electrically operated blower assembly for ventilation and cooling, and a control switch. The blower assembly is under the seat pan by the left front corner of the seat, and has an identification plate marked CUSHION BLOWER. The control switch, next to each blower assembly, has marked positions ON and OFF. The control switch is placed ON by reaching down and under the left front corner of the seat, and moving the switch upwards. The switch is placed OFF by moving the switch downward. The pilot's seat blower is powered from the No. 3 primary ac bus and protected by a circuit breaker marked CUSHION BLOWER PILOT, in the cabin. The copilot's seat blower is powered from the No. 1 primary ac bus and protected by a circuit breaker marked CUSHION BLOWER, above the general heading CO-PILOT, in the cabin.

2.20.1.2 Anti-Exposure Suit Blower. A blower is installed below each pilot's seat for temperature regulation when wearing exposure suits. A control panel marked SUIT BLOWER is mounted beneath the forward lip of each seat. A toggle switch is mounted on the panel: up is on and down is off. Power to operate the blowers is furnished by the No. 1 monitor ac bus through a circuit breaker marked SUIT BLOWER, in the cabin, and through a circuit breaker on each SUIT BLOWER control panel.

Note

Since the blowers operate off the No. 1 monitor ac bus, they will operate only when all generators are on the line or external power is used.

2.20.1.3 Outboard Armorplate Wing Release Mechanism. The outboard armorplate wing of each seat is hinged so that it may be opened outward for additional clearance if necessary to exit or bail out. The outboard wing is released by striking the release bar, along the front edge of each outboard wing, with the hand or elbow. The wing is held in the open position by a latch. To close the outboard wing, press the release mechanism and pull the wing inward. The release mechanism is automatically reset when it has been returned to the closed position.

2.20.1.4 Seat Height Adjustment Levers. The seat height adjustment levers are the rear levers on the right of the pilots' seats. The levers are pulled up to release the height adjustment lockpins. The seats, aided by spring-loaded bungees, can then be adjusted for height by varying the weight upon them. The lockpins will automatically engage in any of 10 positions when the levers are released.

WARNING

When either pilot's seat is adjusted to a high and forward position, aft travel of the cyclic may be restricted.

2.20.1.5 Forward and Aft Adjustment Levers. These levers are the front levers on the right side of the pilots' seats. They are pulled up to release the forward and aft seat adjustment lockpins. The levers must be held up while the seat is moved on the tracks, forward or aft, as desired. The lockpins will automatically engage in any of 13 positions when the levers are released.

2.20.1.6 Shoulder Harness Lock Lever. A two-position shoulder harness inertia reel lock lever is at the left side of each seat. When the lever is in the unlocked (aft) position, the shoulder harness cable will extend to allow the occupant to lean forward; however, the inertia reel will automatically lock if an impact force over two Gs is encountered in any direction. When this occurs, the inertia reel will remain locked until the lever is moved to the locked position and then to the unlocked position. When the lever is placed to locked (forward) position, the shoulder harness cable is locked so that the occupant is prevented from leaning forward. The locked position is used as an added safety precaution over that of the automatic lock on the inertia reel, during takeoff or landing, or when a crash landing is anticipated.

WARNING

In the unlocked position, the pilot and copilot restraint system may be inadequate to prevent head strikes into the cyclic/instrument panel. The MA-6 inertia reel may fail to lock with an impact force.

2.20.2 Aircrewman's Seat. The aircrewman's seat (FO-12) is mounted on the right side of the cabin, against the forward bulkhead, facing inboard. The seat has safety belts, seat, and back cushions.

2.20.2.1 Anti-Exposure Suit Blower. A blower and control panel are beside the aircrewman's seat, on the right side of the cabin below the circuit breaker panels, for temperature regulation when wearing an exposure suit. An ON/OFF toggle switch is on the control panel for blower operation. Power to operate the blower is furnished by the No. 1 monitor ac bus through a circuit breaker marked SUIT BLOWER, in the cabin, and through a circuit breaker marked SUIT BLOWER on the control panel.

Note

Since the blower operates off the No. 1 monitor ac bus, it will operate only when all generators are on the line or external power is used.

2.20.3 Jump Seat. The jump seat (FO-12) is mounted on the right side of the entrance to the pilot's compartment. The seat may be folded against the control closet when not in use. The seat is not equipped with a safety belt, seat cushion, or back strap, and shall not be occupied during takeoff, landing, or adverse weather conditions.

2.20.4 Troop Seats. Folding troop seats (FO-12), equipped with safety belts for 55 passengers, may be installed. The seating arrangement is 37 troops on the cabin walls aft of the personnel door, and 18 seats facing right along the cabin center. The seats are attached to the compartment side panels with the seat legs attached to the cargo tiedown ring studs at the front of the seat assemblies. The seats may be folded against the compartment walls by disconnecting the front legs from the cargo tiedown attaching points, then folding them against the compartment walls. The troop seats in front of the left front cabin escape hatch may be folded up to provide room for the left gun station. With AFC 497, the troop seats are attached to the compartment side panels with telescopic legs that are attached to the cargo floor seat fittings. The seats may be stowed against the compartment walls by moving the seats to the up position and locking the seats with the quick disconnect pins located in the center of the leg. The center row troop seats are supported at the back by poles attached to the floor tiedown fittings, and at the front by support legs that can be folded for storage.

Note

The width of a fully combat-equipped troop may exceed the existing seat width, and thus prevent seating 55 troops. Care must be taken to be sure that the number of troops carried is restricted to the number for which there are adequate seats and safety belts.

2.20.5 Pilot and Copilot Seats (Helicopters Modified by Crash-attenuating Seats). The armor-plated crash-attenuating pilot and copilot seats are mounted side by side in the pilots' compartment. Each seat has a seat bucket with metal structural members, a five-point restraint system, padded seat cushions, headrest, and adjustable lumbar support. Each seat also is equipped with a blower assembly and switch, and armorplate wing release mechanism. Each outboard armorplate wing is hinged so that it may be opened outward to provide additional clearance if it is necessary to have access to the cockpit side windows. The five-point restraint system consists of shoulder harness, lap belt, and lap tiedown strap. The lap tiedown strap has a rotary buckle to which the shoulder harness and lap belt fasten. The lumbar support pad is attached to Velcro fastener strips to the seatback cushion and is adjustable for maximum comfort. Each seat has a vertical adjustment control lever, horizontal adjustment control lever, and restraint system control lever. In addition a variable-load energy absorber (VLEA) control dial is provided which adjusts the VLEA system limits for the individual pilot. The VLEA system limits sudden vertical deceleration to acceptable limits.

WARNING

In the unlocked position, the pilot and copilot restraint system may be inadequate to prevent head strikes into the cyclic/instrument panel. Failure of the MA-6 inertia reel to lock with an impact force over two Gs aggravates the problem.

2.20.5.1 Blower Assembly and Switch. Each seat is equipped with an electrically operated blower assembly, for ventilation and cooling, and a control switch. The blower assembly is under the seat pan by the left front of the seat and has an identification plate marked CUSHION BLOWER. The control switch, adjacent to each blower assembly, has marked positions ON and OFF. The control switch is placed to ON by reaching down and under the left front of the seat and moving the switch leftward. The switch is placed OFF by moving the switch rightward. The pilot seat blower is powered from the No. 3 ac primary bus and protected by a circuit breaker, marked CUSHION BLOWER PILOT, on the right side cabin circuit breaker panel. The copilot seat blower is powered from the No. 1 ac primary bus and protected by a circuit breaker, marked CUSHION BLOWER COPILOT, on the left side cabin circuit breaker panel.

2.20.5.2 Outboard Armorplate Wing Release Mechanism. The outboard armorplate wing of each seat is hinged so that it may be opened outward for additional clearance if necessary to have access to the cockpit side windows. The outboard wing is released by striking the strike plate, along the front edge of each outboard wing, with the hand or elbow. The wing is spring-loaded to open 96° when the release mechanism is actuated. To close the outboard wing, depress the release mechanism and pull the wing inward. The release mechanism is automatically reset when it has been returned to the closed position.

2.20.5.3 Vertical Adjustment Control Lever. A vertical adjustment control lever is at the right front underside of each seat. The lever is pulled forward to release locking pins, allowing the seat to be adjusted at increments of 0.625 inch, and can be varied a total of 5 inches. Weight will move the seat downward. When weight on the seat is reduced, the spring-loaded adjusting mechanism will move the seat to the highest position. Releasing the lever will set the locking pins and hold the seat at the desired position.

2.20.5.4 Horizontal Adjustment Control Lever. A horizontal adjustment control lever is at the left front underside of each seat. The lever is pulled forward to release locking pins, allowing the seat to be moved fore and aft on tracks. The seats can lock in position at increments of 0.50 inch. Releasing the lever will set the track locking pins and hold the seat at the desired position.

2.20.5.5 Shoulder Harness Lock Lever. A two-position restraint system inertia reel lock lever is at the left side of each seat. When the lever is in the unlocked (aft) position, the shoulder harness cable will extend to allow the occupant to lean forward; however, the inertia reel will automatically lock if an impact force over two Gs is encountered in any direction. When this occurs, the inertia reel will remain locked until the lever is moved to the locked position and then to the unlocked position. When the lever is placed to locked (forward) position the shoulder harness cable is locked so that the occupant is prevented from leaning forward. The locked position is used as an added safety precaution over that of the automatic lock on the inertia reel, during takeoff or landing, or when a crash landing is anticipated.

2.20.5.6 Variable-Load Energy Absorber (VLEA) Control Dial. A VLEA control dial is mounted on the inboard side of each pilot seat near where the rear horizontal portion of the seat intersects with the bottom vertical portion of the seatback. There are eleven equally spaced numbers, depicted in 10-pound increments from 160 to 260, with an adjacent identification labeling of CREWMAN AND EQUIPMENT TOTAL WEIGHT. The weight of the pilot and flight gear on his person is set into the dial, adjusting an energy absorber, to provide optimum protection for the pilot.

WARNING

Adjustments either higher or lower than actual pilot/equipment weight will increase crash hazards.

2.20.6 Anti-Exposure Suit Ventilating System. The system provides the pilot, copilot, and aircrewman with ventilating blowers for comfortable temperature regulation while wearing the anti-exposure suit. A fitting on the suit must be connected to the blower hose. The pilot, copilot, and aircrewman blowers are mounted underneath their respective seats. The blowers are controlled by individual blower control switches and circuit breakers in the vicinity of each blower. The pilot and copilot control switches and circuit breakers, marked SUIT BLOWER, are under the right front of their respective seats. The SUIT BLOWER ON/OFF switch positioned leftward, turns the blower on. The crewman forward right cabin compartment station control panel, mounted on the forward bulkhead just forward of the seat, contains one switch and a circuit breaker marked SUIT BLOWER. Each switch at each station has marked positions ON and OFF and is placed ON to energize a respective blower. The pilot, copilot, and crewman stations are powered from the No. 1 ac monitored bus through a circuit breaker, labeled SUIT BLOWER, on the left side cabin circuit breaker panel.

Note

Since the blowers operate off the No. 1 and No. 3 monitor ac buses, they will operate only when all generators are on line or external power is used.

2.21 EXTERNAL CARGO HOOK(S)

External cargo can be carried with a single-point suspension system using one cargo hook or with a two-point suspension system using two cargo hooks. Both systems are operated from the CARGO HOOK control panel on the overhead control panel.

2.21.1 Single-Point Suspension System. A 36,000 pound capacity cargo hook (Figure 2-28) is suspended by a pendant below the fuselage, near the CG. The pendant is attached to an explosive separator which is attached to a removable A-frame. The A-frame is attached to the main gear box supports. The hook is suspended beneath the helicopter through a hatch in the cabin deck with a steel cable. For a pickup, the helicopter is hovered over the load and a sling which is attached to the cargo is slipped into the cargo hook. The hook opens automatically when the weight on the hook is reduced to 525 ±225 pounds when in the automatic mode. Cargo release buttons, on each pilots' cyclic grip and on the aircrewman's pendant, are used to electrically release loads up to 36,000 pounds, either before or after ground contact.

CAUTION

Jettisoning of airborne cargo of over 20,000 pounds with the pilots' cargo release buttons or aircrewman's pendant may cause the cargo hook to recoil and strike the fuselage.

The single-point cargo hook can be opened mechanically by turning a manual release knob on the hook (see Figure 2-28). The hook incorporates an inspection window displaying internal linkage. A placard mounted on the cargo hook illustrates how the internal linkage should appear for a locked, safe hook or an unlocked, unsafe hook (see Figure 2-28). An emergency cargo hook jettison system allows cargo to be jettisoned by means of an electrically actuated explosive separator. A hand-operated winch is attached to the A-frame for hook and pendant deployment and retrieval. A pip pin on the winch line attaches to a lug on the cargo hook. See Figure 2-28 for electrical power sources.

CAUTION

Sufficient slack should be left in the hand operated winch cable after hook deployment to allow for pendant stretch.

2.21.1.1 Cargo Hook Control Panel (Single-Point). The CARGO HOOK panel (Figure 2-28) on the overhead control panel contains the necessary control switches and test light. The PWR SEL switch at SINGLE PT activates the single-point suspension system and when at OFF or TWO PT deactivates the system. The CONTROL switch at COCKPIT selects only the pilots' cyclic CARGO REL buttons for cargo release. The CONTROL switch at ALL selects the aircrewman's pendant as well as the pilots' CARGO REL buttons for cargo release. The MODE switch at AUTO RLSE arms the cargo hook for automatic cargo release on ground contact. The MODE switch at NORM disarms the automatic release function. The AUTO RELEASE ON advisory light goes on when the MODE switch is placed to AUTO RLSE. The SINGLE PT HOOK OPEN advisory light goes on when the cargo hook is unlatched or open, regardless of the MODE switch position. The SINGLE PT switch and JETT TEST light are discussed in the following paragraph.

2.21.1.2 Cargo Hook Jettison System. In an emergency the cargo can be jettisoned by means of the electrically-activated explosive separator. Electrically activating the separator causes an explosive cartridge to ignite and separate the pendant and hook from the A-frame. The explosive separator is sealed, so no flame or fragments are emitted when the cartridge is ignited. The system can be tested for electrical continuity of the explosive cartridge, wiring, and switches. The explosive separator is controlled by the SINGLE PT switch on the CARGO HOOK panel (FO-1) and the guarded HOOK switch on the EMERGENCY CONTROL panel (FO-8). The SINGLE PT switch at ARM arms the HOOK switch. Placing the HOOK switch to SHEAR with the SINGLE PT switch at ARM provides a signal to actuate the explosive separator. Placing the SINGLE PT switch to TEST and then placing the HOOK switch to SHEAR causes the JETT TEST light to go on if the electrical continuity is satisfactory. Be sure the HOOK switch is placed OFF before moving the SINGLE PT switch out of TEST. Placing the SINGLE PT switch OFF disarms the HOOK switch. No. 3 primary dc power is furnished through a circuit breaker in the cabin marked CARGO HOOK JTSN.

2.21.2 Two-Point Suspension System. Two 21,600 pound limit cargo hooks (Figure 2-29) limited to a combined capacity of 36,000 pounds, and a maximum of 60% of the external load on either hook, are tandem mounted on attachments under the cabin deck. The hooks are on the longitudinal axis of the helicopter, 10 feet apart. Each hook has its own access hatch in the cabin deck with a lever that is used to place the hook in either the stowed or operating position. The lever is marked PULL GRIP UP TO REL. For external cargo operations, the helicopter is positioned beside or hovered over the load, and slings attached to the hook end of special 7 1/2 foot pendants (Figure 9-14) which are attached to the aircraft cargo hooks. The normal method of load release is accomplished through individual manual actuation of the aircrew release handle located on each pendant. This ensures that after release the pendants remain with the helicopter and not with the load. Emergency release of the load is accomplished electrically through either pilot's cargo release buttons located on the cyclic grip or through the aircrewman pendant release switch which is located on the aircrewman pendant.

In the event of an electrical switch failure, upward motion of the EMERGENCY CARGO HOOK RELEASE handle at the rear of the cockpit lower center console, will result in the hooks being opened mechanically. The aircrewman can also release the load mechanically by pulling upward on the release lever on either hook. When any of the electrical/emergency release modes are used, the pendants will remain with the load, not with the helicopter. For inflight protection against exceeding C. G.

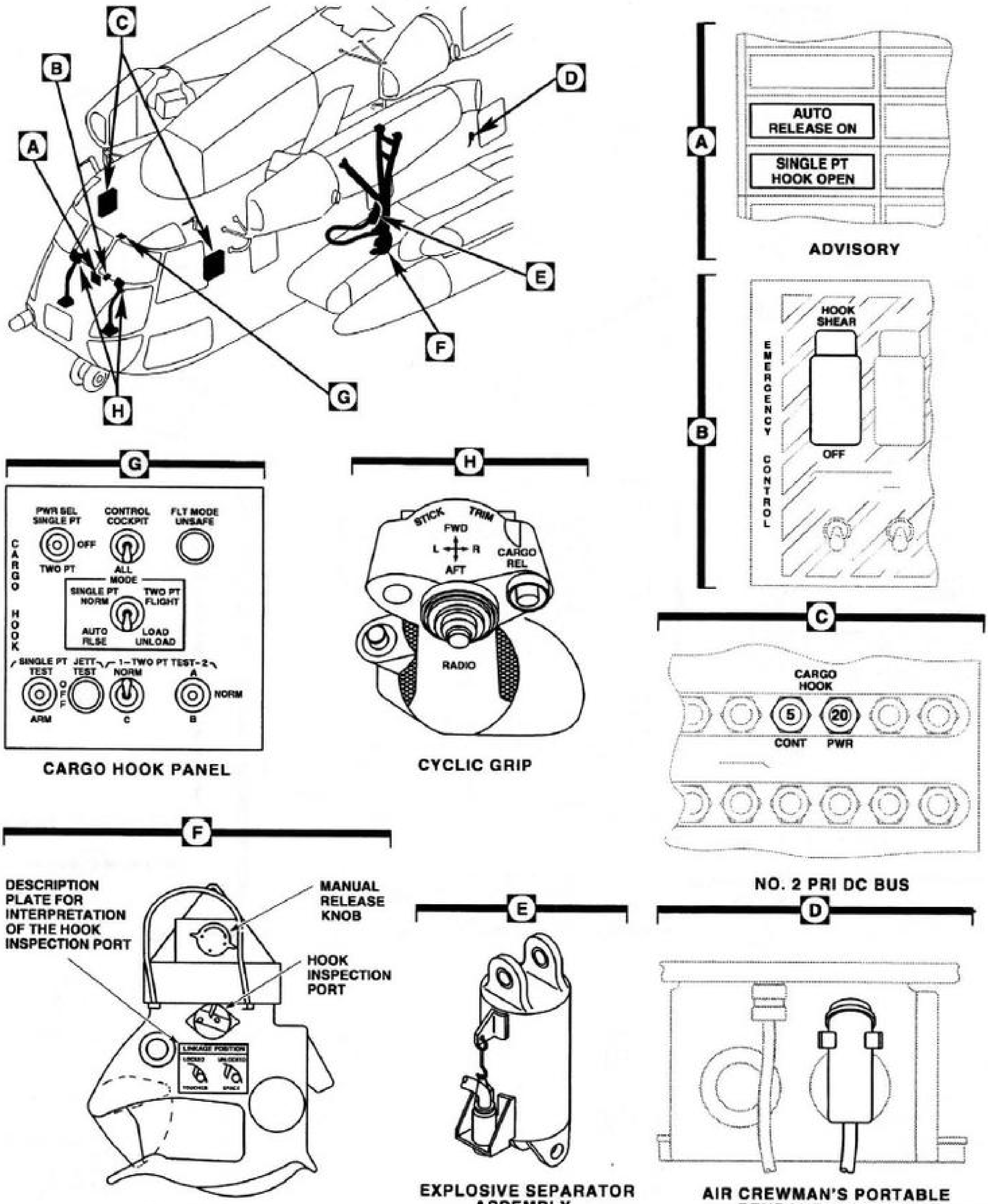


Figure 2-28. Cargo Hook Installation (Single-Point)

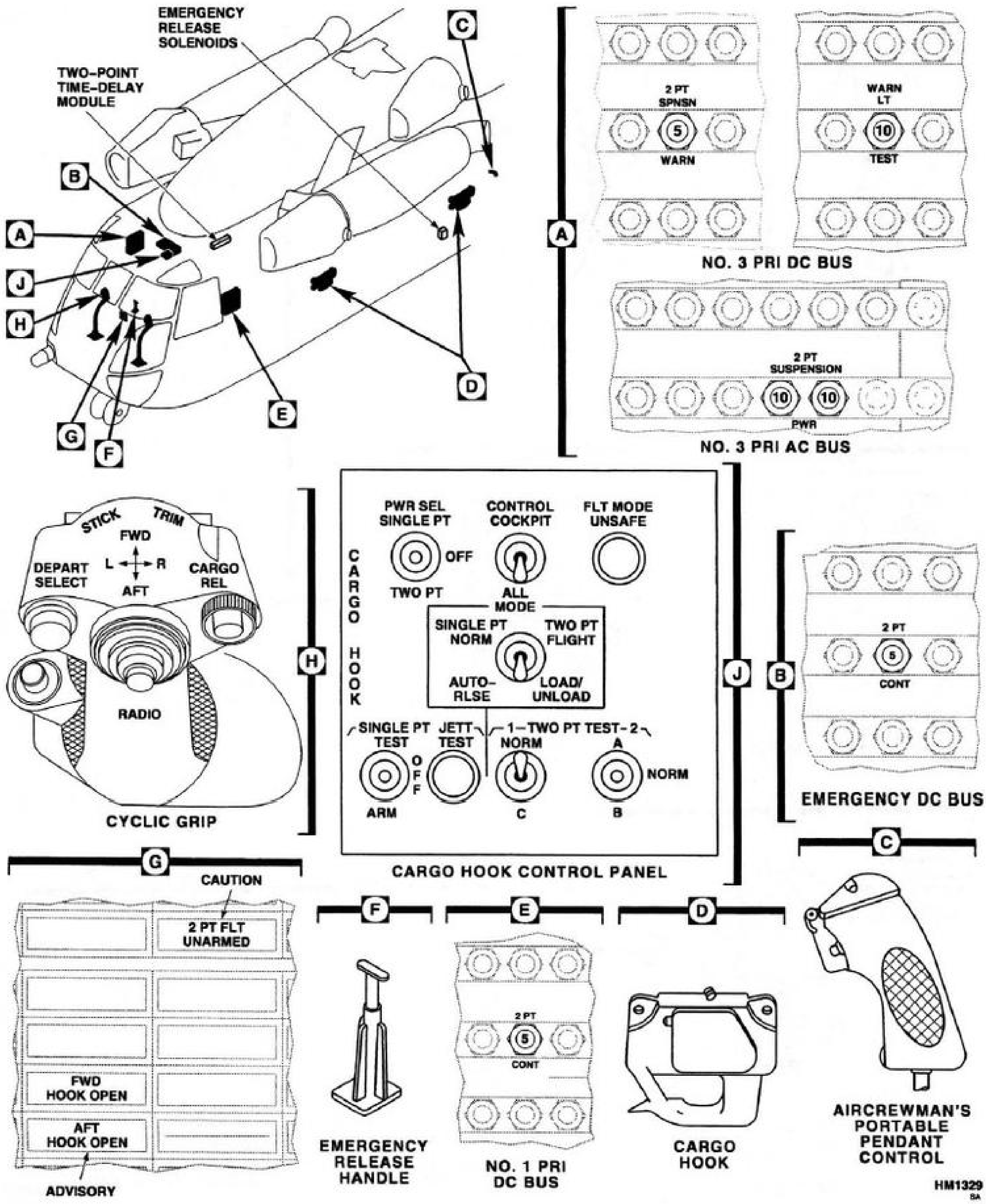


Figure 2-29. Cargo Hook Installation (Two-Point)

limits in the event of a sling/pendant failure of one hook, a no-load sensing system within each hook monitors for loss of load. Both hooks will automatically open when the load on either hook decreases to 200 plus or minus 50 pounds and the mode switch is set in the TWO PT FLIGHT position on the cargo hook control panel. Each cargo hook has a solenoid that opens the hook when energized. Each hook incorporates an overcenter-type latching mechanism which prevents the hooks from inadvertently opening whenever the hook release lever is in the fully locked position. Movement of the hook release lever out of the fully locked position eliminates the overcenter condition and allows the hook to open. The hooks are interconnected with a mechanical link to ensure both hooks open simultaneously. Each hook has a manual release. FWD HOOK OPEN and AFT HOOK OPEN advisory lights illuminate when either cargo hook latch mechanism begins to leave its full overcenter position. The advisory lights also illuminate briefly during the short period of time the hooks are open during cargo release. The hook interconnect release system is incorporated to make sure that both hooks open simultaneously, regardless of circumstances.

WARNING

- Illumination of either the FWD HOOK OPEN or the AFT HOOK OPEN advisory lights with a load indicates that the overcenter latching mechanism has disengaged and the hooks are in an unsafe condition.

- The cargo hooks will remain closed with a load without the latch mechanism fully overcenter. While in this condition the load is highly susceptible to inadvertent release and failure of the hook release lever to be in the fully locked position may result in the load releasing inadvertently.

The hooks are interconnected with a mechanical linkage, and the opening of one hook causes the other hook to open. Normally, each hook is opened electrically by its own solenoid. However, if one solenoid fails, that hook is then opened mechanically by the interconnect system at the same time. In addition, there is a redundant mechanical connection between the EMERGENCY CARGO HOOK RELEASE handle and the hook interconnect release systems linkage. The hooks can also be actuated mechanically from inside the cabin by simply pulling up on either hook's mechanical release lever. See Figure 2-29 for electrical power sources.

2.21.2.1 Cargo Hook Control Panel (Two-Point). The CARGO HOOK panel (Figure 2-29) on the overhead control panel contains the necessary control switches and a FLT MODE UNSAFE light. The PWR SEL switch at TWO PT activates the two-point suspension system. When at OFF or SINGLE PT, it deactivates the system. The CONTROL switch at COCKPIT selects only the pilots' cyclic CARGO REL buttons for cargo release. The CONTROL switch at ALL selects the aircrewman's pendant as well as the pilots' CARGO REL buttons for cargo release. The MODE switch at FLIGHT arms the hooks' no-load release switches for automatic hook opening when no load is sensed on either hook. The MODE switch at LOAD/UNLOAD disarms the hooks' no-load release switches for hook loading and unloading. The FLT MODE UNSAFE light goes on if either or both hooks are sensing no load. The light goes off when the load is lifted off the surface and both hooks' no-load switches sense the cargo's weight. If the light does not go off the MODE switch must not be placed to FLIGHT; the load shall be set back on the surface and released, and further lifts shall not be made until the system is fixed. With the PWR SEL switch set at TWO PT, setting the MODE switch to LOAD UNLOAD causes the 2PT FLT UNARMED caution light to go on. The caution light will not go off until the MODE switch is set to FLIGHT.

The TWO PT TEST-2 switch is used for system checking to verify independent operation of the hook solenoids. Holding the switch at B disables the forward hook's solenoid, and the dual emergency release solenoids. Holding the switch at A disables the aft hook's solenoid, and the dual emergency solenoids. In position A the signals from the No. 1 no load switches are prevented from reaching the dual emergency release solenoids.

CAUTION

Do not use test functions with external loads. Hooks will open during test operation to verify independent operation of the emergency release solenoids.

The TWO PT TEST-1 switch is used for system checking. Holding the switch at C disables both hooks' solenoids and signals from the No. 2 no load switches are prevented from reaching the hooks' solenoids.

2.21.3 Two-Point CG/Hook Load Indicating System. The system consists of a CG/hook load indicator (Figure 2-30) on the instrument panel and four load sensors, two per cargo hook. The indicator provides a computer updated display of helicopter CG, weight, moment, index, and also displays the loads on both the forward and aft cargo hooks. The system provides weight and balance information while the helicopter is on the ground and during flight. When performing dual-point external operations, an operable CG Hook Load Indication System is required, but may be waived by the Commanding Officer when lifting certified loads.

Note

The system may display erroneous readings during forward flight.

No. 2 primary dc bus power is furnished to the system through a circuit breaker marked CG/HOOK in the cabin. No. 2B primary ac bus power is furnished through a circuit breaker in the cabin, marked CG/HOOK IND PWR.

The indicator computes and displays center of gravity (CG), weight (WT), moment (MOMT), index (INDX), and external cargo hook loads from both the forward and aft cargo hooks. The CG and WT displays are continuously updated during flight, taking into account initial weight and balance takeoff data, cargo hook load data, and fuel burn-off. If CG or cargo hook limits are exceeded, the indicator provides visual warnings. The indicator monitors fuel quantity outputs from each of the six fuel quantity gages. A weight-on-wheels interlock prevents data alterations from the keyboard in flight.

The load sensors (two per hook) each provide two electrical outputs proportional to the applied tension load. These outputs consist of two electrically separate identical bridge outputs for redundancy. The two load sensors in each cargo hook share the total hook load and the bridge outputs from each sensor are combined in the indicator to form two channels (as, sensor A, bridge A combined with sensor B, bridge A to form channel 1; and sensor A, bridge B combined with sensor B, bridge B to form channel 2). These two channels are averaged in the indicator to obtain the total load. Power or excitation for the load sensors are provided by the indicator.

2.21.3.1 CG/Hook Load Indicator Panel

2.21.3.1.1 CG Display. The display (Figure 2-31) displays the center of gravity value computed by the indicator.

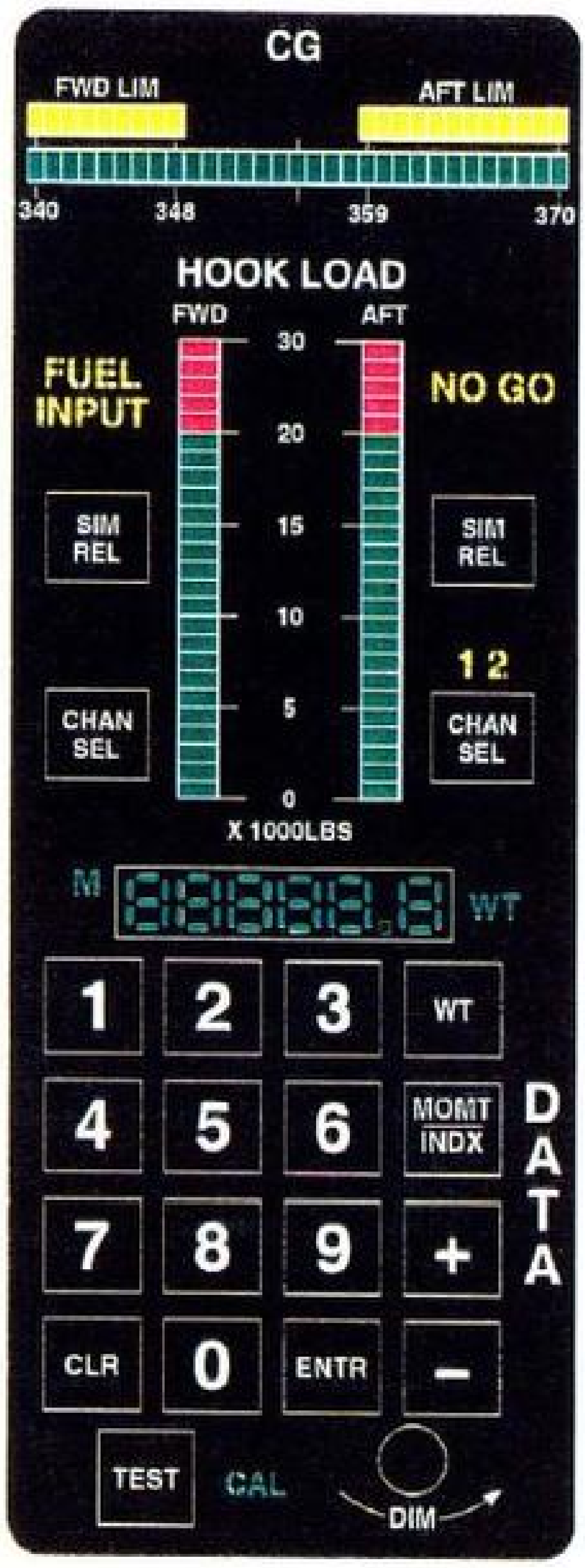
CG Indication. The CG on the display is indicated by the lighting of three green segments separated by unlit segments. The pointer is the center segment. Each of these segments consists of two parallel filaments. The pointer segment is at full intensity and the other two segments are at reduced intensity. The range of the CG indication is from 340 to 370 and there is one green segment per inch of CG indication except for the 0.5 inch segment used to designate 354.5.

CG Limits. The CG limits are presented above the CG indication in two separate limit displays (Figure 2-31). The limits change as a function of weight as shown in Figure 2-40. The CG limits are displayed by the lighting of one yellow segment only in each limit display. Each of these segments consists of two parallel filaments. The range of the forward limit (FWD LIM) is from station 340 to 348 and there is one yellow segment per inch of CG indication. The range of the aft limit (AFT LIM) is from station 359 to 370, and there is one yellow segment per inch of CG. When a CG overlimit occurs, all yellow segments in that limit display flash for 10 seconds, after which the segments remain steadily lit at the caution/advisory panel's selected lighting intensity until the CG returns to acceptable limits.

2.21.3.1.2 Hook Load Display. There are two vertical displays (Figure 2-32), one for the forward cargo hook, and one for the aft hook. Each display presents an average of the two output channels provided by each hook. Each display consists of 20 green and 5 red segments. Each of these segments consists of two parallel filaments. The red segments represent hook over-limits. As the hook load increases, the corresponding display indication is indicated by sequentially lit segments with the top segment (pointer) corresponding to the actual hook loading at full intensity (indicator's front panel DIM selected lighting intensity) and the preceding four segments at a reduced intensity. Each display provides a cargo hook load range of 0 to 30,000 pounds. From 0 to 20,000 pounds there are 20 green segments at 1000 pounds each. From 22,000 to 30,000 pounds there are five red segments at 2000 pounds each.

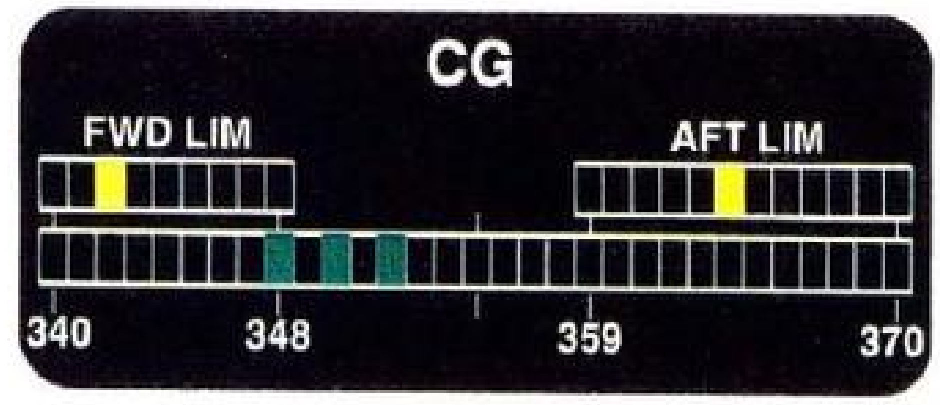
Individual Hook Overlimit Displays. Lighting of red segments (Figure 2-33) indicate an overload condition for that display. The preceding four segments are reduced in lighting intensity from that of the pointer segment. For an impending hook overload (Figure 2-33), the hook display lights every-other-segment when the cargo hook input to the indicator display is 21,600 pounds. Above this weight the overlimit display is in effect.

Combined Hooks' Overlimit Display. If the combined value of both hooks is over 36,000 pounds, all red overload segments (Figure 2-33) in both hook displays light. If the load on any hook is over 20,000 pounds, the



HC3946
SA

Figure 2-30. CG/Hook Load Indicator Panel



THE INDICATOR IS SHOWN DISPLAYING THE FOLLOWING:

CG LIMITS 342 FORWARD AND 364 AFT. CG POINTER INDICATES CG AT 350 INCHES.

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Figure 2-31. CG/Hook Load, CG Display

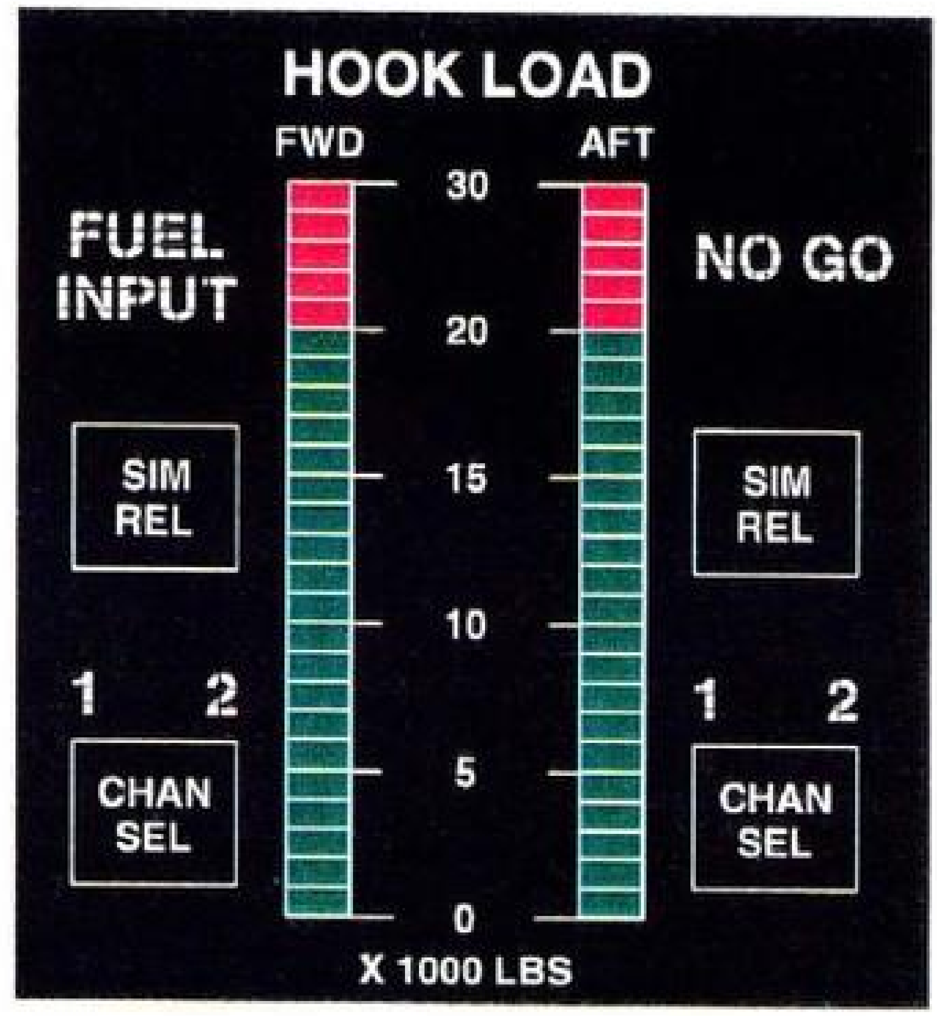

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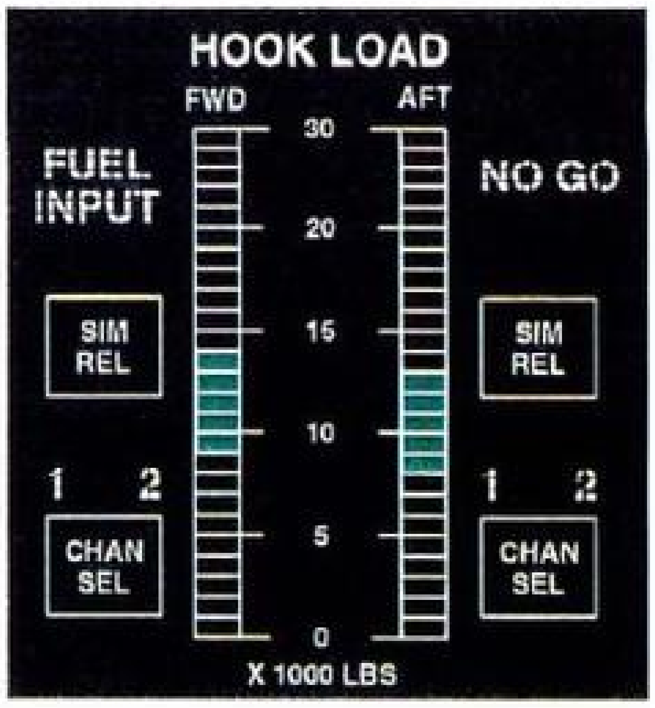
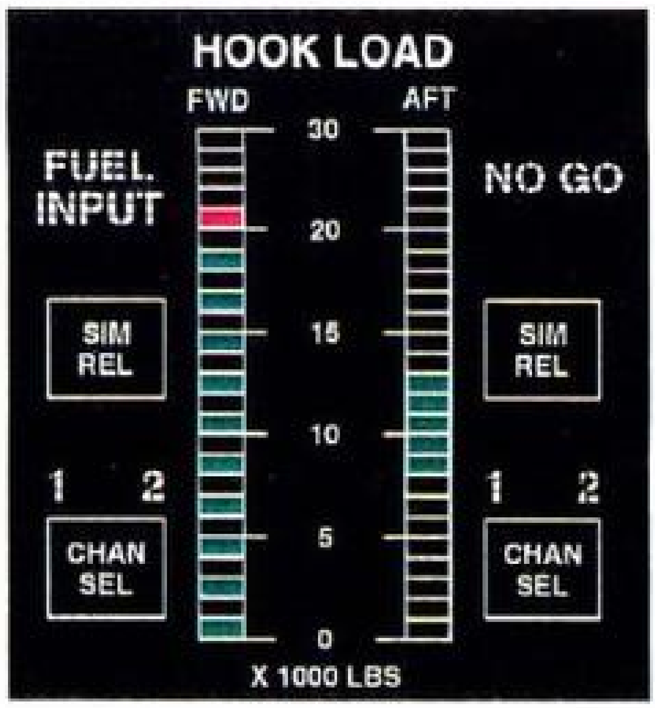
Figure 2-32. CG/Hook Load, Hook Load Display

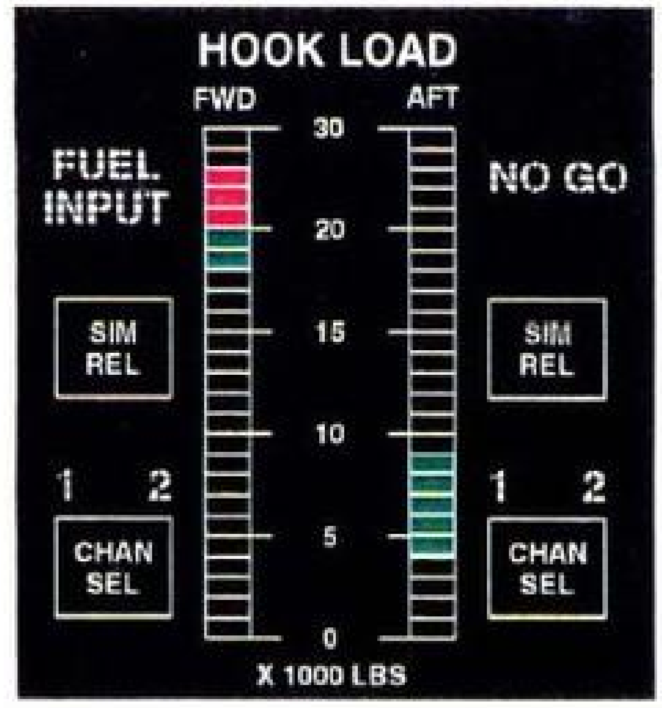
red pointer segment lights. The preceding four segments are reduced in lighting intensity from that of the pointer segment. The other hook display continues to operate in the green region with all red segments lit until the combined hook overload is removed. All red overlimit segments light when the hook inputs to the indicator total 36,000 pounds.



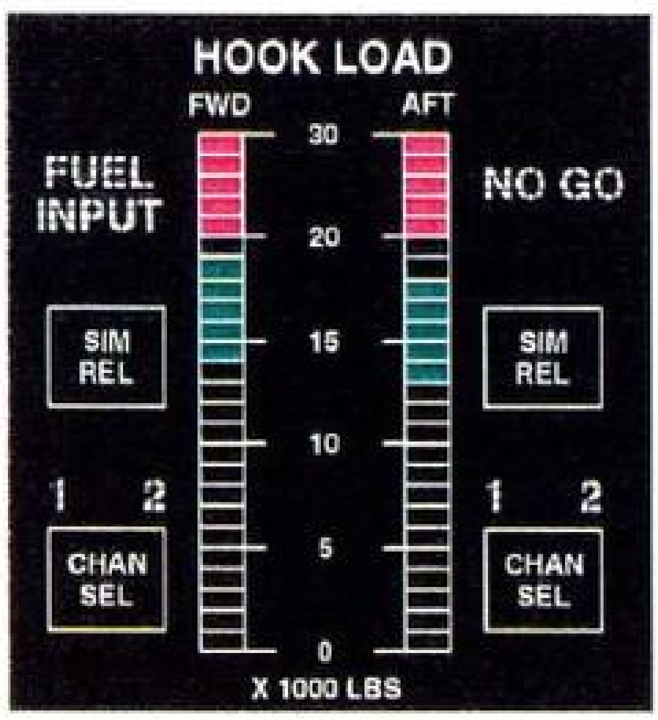
NORMAL LOADING
FWD HOOK – 14,000 LBS
AFT HOOK – 13,000 LBS



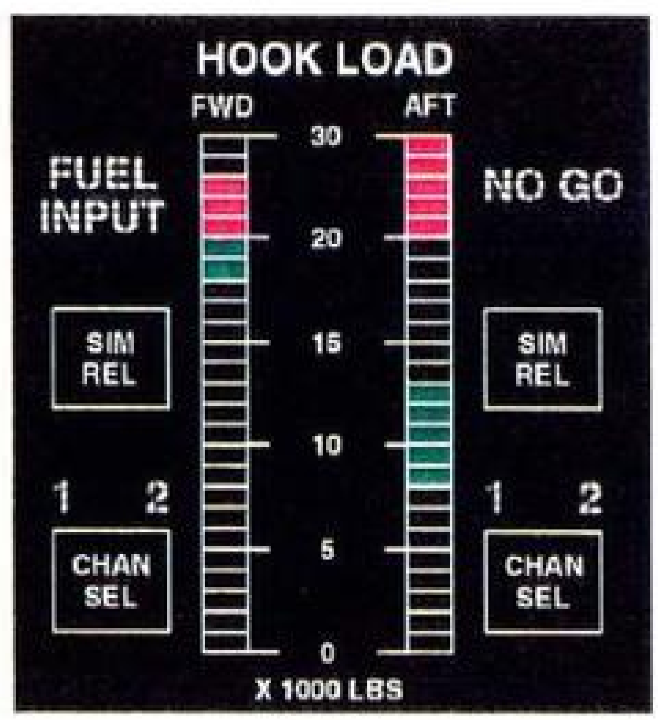
IMPENDING HOOK OVERLOAD
FWD HOOK – 21,600 ± 150 LBS



FWD HOOK OVERLOAD
FWD HOOK – 26,000 LBS



COMBINED HOOK OVERLOAD
FWD HOOK – 19,000 LBS
AFT HOOK – 18,000 LBS



COMBINED HOOK OVERLOAD
FWD HOOK – 26,000 LBS
AFT HOOK – 13,000 LBS

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Figure 2-33. CG/Hook Load, Hook Display/Presentations

Hook Channel Select (CHAN SEL). The presentation of hook load on each display is the average of the two output channels on each cargo hook.

When the output of the two channels differ by more than 1000 pounds in either display, the display shall automatically present the higher output and identify which channel is being displayed by lighting the appropriate channel selected light (1 or 2).

CHAN SEL Pushbutton. There is a CHAN SEL pushbutton for each hook display. The channel selection capability of the pushbutton is disabled during normal hook display operation. When an error is detected between the two channels, the pushbutton becomes activated and has the capability of selecting either hook channel. If the error clears itself, the CHAN SEL pushbutton retains the capability of selecting either hook channel until 115 vac is removed from the system.

Channel Selected Lights. There are two channel-selected lights (1 and 2) for each hook display. Either number lights yellow to identify the hook channel being displayed. The numbers blend in with the indicator face panel, until lit.

Fuel Input Light. The yellow FUEL INPUT light illuminates whenever the system's microprocessor detects any of the following:

1. Excessive rate of fuel change.

2. Electrical short or open in the system circuitry.

3. An internal failure of the indicator.

Steady illumination of the light requires that the test button be pushed to identify the specific fault. During flight, it is possible that fuel sloshing within the fuel tanks might erroneously be sensed as an excessive rate of fuel change and may cause intermittent fluctuation of the FUEL INPUT light. The FUEL INPUT light blends in with the indicator face until lit.

Simulated Release Pushbutton. Each hook has a SIM REL pushbutton. Momentarily pressing the FWD SIM REL pushbutton simulates loss of load on the selected hook, provides a zero load input to the indicator processor, drives the hook display to zero, displays the CG and AFT HOOK DATA and causes the FWD 1 and 2 CHAN SEL lights to flash, indicating the FWD HOOK LOAD display is indicating in the simulated release mode. Also, the AFT LIM display may flash if the AFT HOOK load exceeds the CG flight envelope. Momentarily pressing the AFT SIM REL pushbutton causes the same display as for the FWD HOOK, but now the FWD HOOK DATA is displayed and the AFT 1 and 2 CHAN SEL lights flash, indicating the AFT HOOK LOAD is in the simulated release mode. To return to normal operation, press the SIM REL keys, in any order, and the display returns to original load and 1s and 2s stop flashing. The purpose of this function is to assess the CG impact of releasing one hook load before the other or releasing the entire load.

2.21.3.1.3 Data Display. This display displays the weight and balance outputs of the indicator (weight, moment, and index) and also the data inputs from the keyboard. It is a six-digit numeric display as shown in Figure 2-34. The display has five digits to the left of a fixed decimal point and one digit to the right of the point.

Weight Address Key. Pressing the WT key addresses the weight value being used by the indicator processor and displays the value on the data display. The WT light on the face of the indicator panel goes on when weight has been addressed. Pressing the CLR or the MOMT/INDX key puts the WT light off. The WT key retains its function during flight. The CLR key only turns off the WT light while airborne.

DATA DISPLAY/INDICATOR KEYBOARD

Figure 2-34. CG/Hook Load, Data Display/Indicator/Keyboard

Weight Light. Lighting of the green WT light indicates that weight is addressed. The light blends in with the indicator face panel, until lit. Light intensity is controlled from the indicator's front panel DIM control.

Moment/Index Address Key. Pressing the MOMT/INDX key addresses the moment value being used by the indicator processor and displays the value on the data display. The M light on the face of the indicator panel goes on when MOMT is addressed. Pressing the key a second time addresses the index value being used by the indicator processor and displays the value on the data display. The M light goes off and the I light goes on when INDX is addressed. Continued pressing of the key alternately addresses moment and index and lights the M and I lights accordingly. Pressing the WT key turns the M or I light off, whichever is on at the time. The MOMT/INDX key retains its function during flight. Pressing the CLR key in flight also turns the M and I lights off.

$$\text{Moment is defined as: } \frac{(\text{TOTAL WT})(\text{CG})}{1000}$$

$$\text{Index is defined as: } \frac{(\text{WT})(350 - \text{CG})}{50 - 20{,}000}$$

Moment Light. Lighting of the green M light indicates that moment is addressed. The light blends in with the indicator face, until lit. Light intensity is controlled from the indicator's front panel DIM control.

Index Light. Lighting of the green I light indicates that index is addressed. The light blends in with the indicator face, until lit. Light intensity is controlled from the indicator's front panel DIM control.

2.21.3.1.4 Numeric Keys. The keys are numbered 0 through 9 and are used to input WT, MOMT, or INDX data. The DATA display accepts only the first six numeric inputs from the keyboard. As numbers are keyed in they are loaded in the data display from right to left. The numeric keys are disabled during flight to prevent inadvertent data changes.

Example: The sequence of key operations to enter 2600.0 pounds is as follows:

ACTION	VISUAL INFORMATION DISPLAYED
Press desired address key	0.0
Press 2 key	0.2
Press 6 key	2.6
Press 0 key	26.0
Press 0 key	260.0
Press 0 key	2600.0
Press + key	2600.0
Press ENTR key after all additions are complete	2600.0

CLEAR Function Key. The CLR key, when pressed after the WT or MOMT key is pressed, clears the data already stored in the indicator processor for the address key function selected. The CLR key also turns the M, I, and WT lights off in flight. On the ground it does not affect the M, I, or WT lights. The CLR key retains its function during flight.

ENTER Function Key. The ENTR key, when pressed, enters the data shown in the DATA display into the indicator processor for use in weight and balance computations. The addressed data previously stored in the processor is erased and replaced by the new data. The ENTR key is disabled during flight.

ADD Function Key. The add (+) key permits the addition of data to the addressed parameter. The add (+) key is disabled during flight. The sequence of key operations is as follows:

Press desired address key (WT or MOMT/INDX).

Key in numerical data to be added.

Press add (+) key.

Press ENTR key.

Observe sum on display.

SUBTRACT Function Key. The subtract (-) key permits the subtraction of data from the addressed parameter. The subtract (-) key is disabled during flight. The sequence of key operations is as follows:

Press the desired address key (WT or MOMT/INDX).

Key in numerical data to be subtracted.

Press subtract (-) key. Used for Form F Ref 14 corrections only.

Press ENTR key.

Observe difference on display.

2.21.3.1.5 TEST Key. The TEST key is used for manual test and calibration operations. After built-in-test is completed (i.e., CAL legend flashes), the indicator resumes normal operation after the TEST key is pressed again. Failure to meet any of the indicator's built-in-test criteria lights the yellow NO GO light. The TEST key retains its function during flight. For built-in-test see TWO-POINT SUSPENSION OPERATION in Chapter 9.

2.21.3.1.6 NO GO Light. The yellow NO GO light goes on if the system fails the built-in-test or has a 115 vac power loss. The light remains on until the malfunction is cleared or corrected. In addition, the display indicator shows the system component or indicator module that has most likely malfunctioned but not if there has been a 115 vac power loss. When the NO GO light goes on, a signal causes the CG HOOK INOP caution light to go on. The NO GO light blends in with the indicator face, until lit. Light intensity is controlled from the caution/advisory panel.

2.21.3.1.7 Calibration Light. Lighting of the green CAL light indicates that calibration is being performed. The CAL light also lights upon successful completion of the manual self-test. Deselection of manual self-test, with the TEST key, is only possible when the CAL light is flashing.

2.22 UTILITY HOIST

A 600-pound capacity, variable speed (0 to 200 fpm) hydraulic hoist (Figure 2-35), with about 245 feet of usable cable length, is suspended on a fixed truss over the personnel door. The hoist is capable of raising or lowering a maximum load of 600 pounds. The cable has a breaking strength greater than 3700 pounds. Feed rollers and a level-wind mechanism prevent the cable from snarling, and a load-holding brake is incorporated to automatically lock the cable in an intermediate position if the winch should stop. Limit switches will automatically turn the hoist motor off when the cable is completely reeled in or out. An integral limit switch will automatically slow the cable speed to 50 fpm as the hook nears the extremities of cable travel. The last 10 feet of cable is painted to visually indicate that the full cable length is being reached. The hoist winch motor receives hydraulic power from the utility hydraulic system and is controlled by an electrohydraulic hoist control valve. An electrically-operated cartridge-type guillotine, controlled by switches in the cockpit and cabin, allows a crewmember to cut the cable at the hoist winch if the hook becomes entangled in surface obstacles and cannot be released. The hoist receives electrical power from the No. 2 primary dc bus through a circuit breaker in the cabin, marked PWR, under the general heading RESCUE HOIST. A manual override system permits hydraulic operation of the hoist in case of electrical failure; however, the guillotine feature and limit switches will be inoperative.

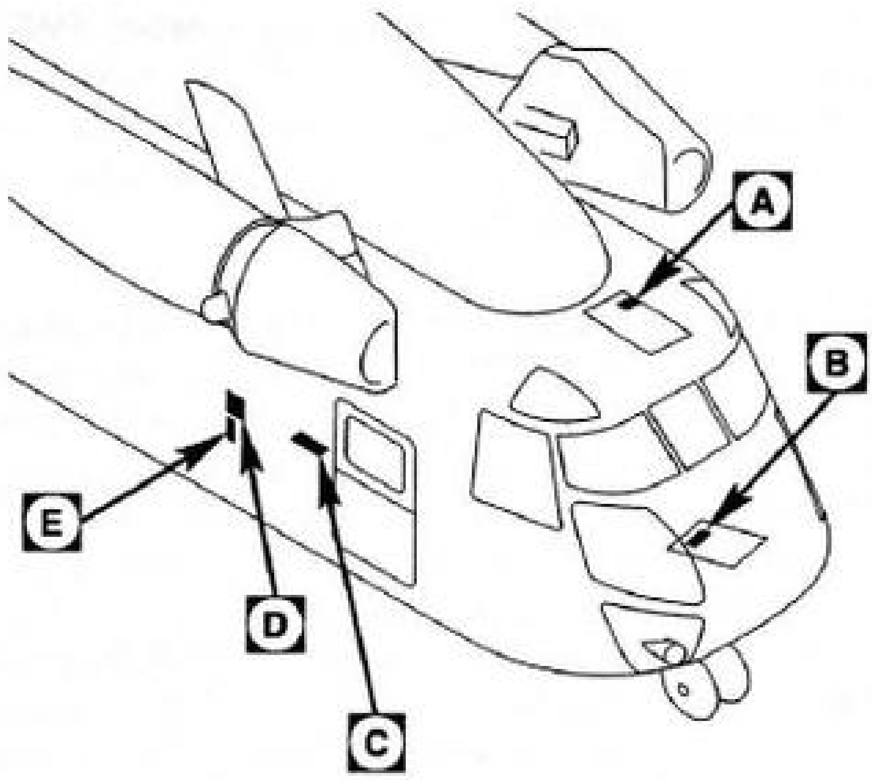
2.22.1 Pilots' Hoist Control Panel. The panel (FO-1), marked HOIST CONTROL, is on the overhead control panel. The panel contains a master switch, with marked positions CREW, OFF, and PILOT, and a control switch, with marked positions DOWN, OFF, and UP. When the master switch is placed to CREW, the hoist can be operated only by the crewman in the cabin compartment. When the master switch is placed to PILOT, the hoist can be operated only by the pilot. The OFF position renders both stations inoperative. Placing the control switch to either UP or DOWN will cause the hoist cable to travel in the mode selected at a maximum cable speed of 50 feet-per-minute.

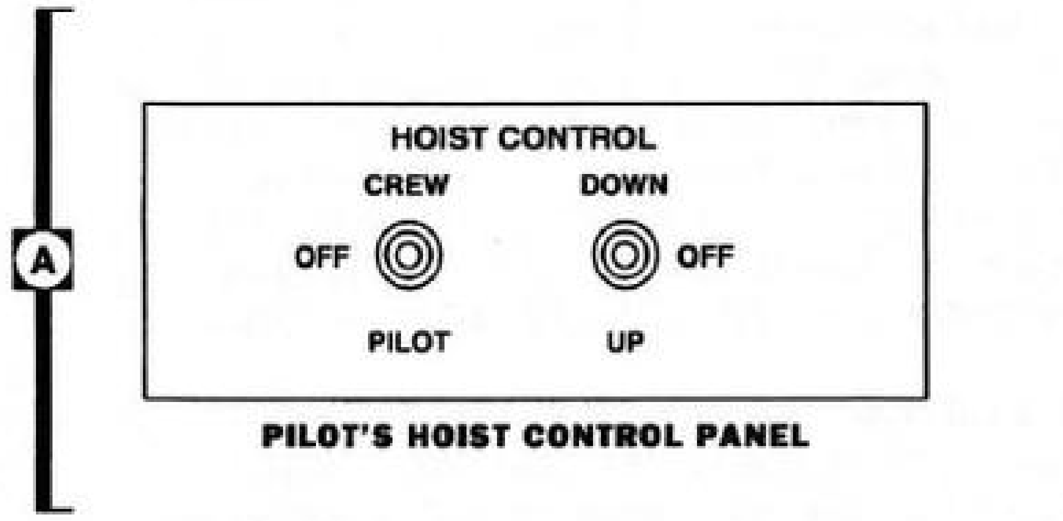
2.22.2 Crewman's Hoist Control. The crewman controls the lowering and raising of the hoist cable by means of a hoist grip (Figure 2-35) mounted to the right of the personnel door. The grip has a thumb switch with marked positions UP and DOWN. Releasing the spring-loaded thumb switch will stop cable movement. Cable speed is proportional to the displaced travel of the thumb switch. A maximum cable speed of 200 fpm can be obtained. Limit switches will automatically turn the hoist motor off when the cable is completely reeled in or out. An intermediate limit switch automatically limits the cable speed to a maximum of 50 fpm when the cable approaches 4 to 10 feet full-out, or 2 to 10 feet from the full-in position.

2.22.3 Crewman's Hoist Manual Override. The knob (Figure 2-35) mounted to the right of the hoist grip furnishes control of the hoist in case of electrical power failure. To lower the cable, turn the knob counterclockwise. To stop the hoist, return the knob to the center (detented) position. To raise the cable, turn the knob clockwise. Cable speed is proportional to the displaced turning of the knob.

CAUTION

The limit switches are inoperative when an electrical power loss has been experienced; adjust cable speed to avoid damage when operating near cable extremities.





PILOT'S HOIST CONTROL PANEL

OPERATING INSTRUCTIONS FOR F

EMERGENCY OPERATION
RESCUE HOIST

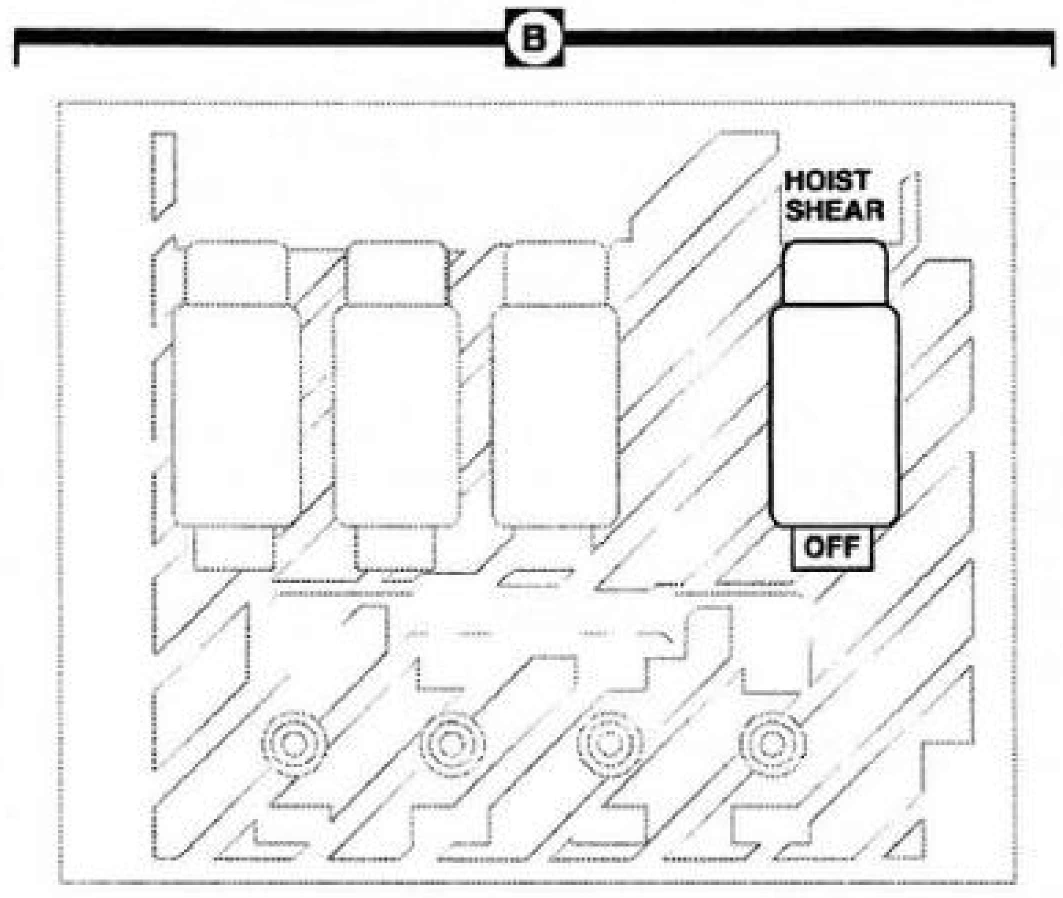
TO LOWER HOIST, ROTATE MANUAL OVER-RIDE KNOB ON HOIST CONTROL VALVE COUNTERCLOCKWISE.

TO STOP HOIST, RETURN OVERRIDE KNOB TO CENTER (DETENTED) POSITION.

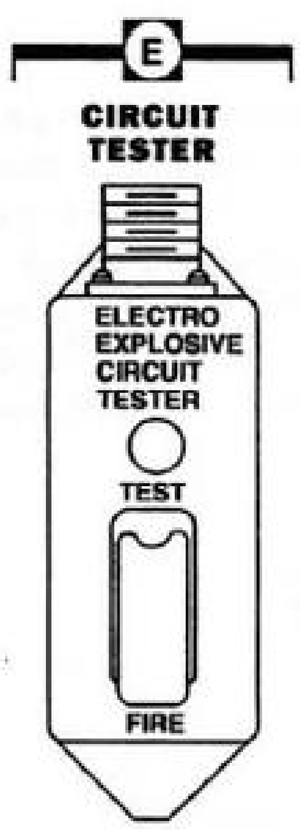
TO RAISE HOIST, ROTATE MANUAL OVER-RIDE KNOB CLOCKWISE.

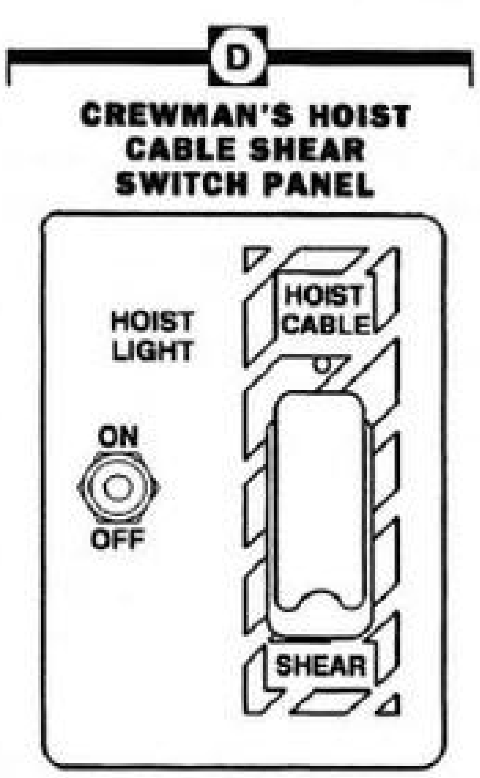
CAUTION

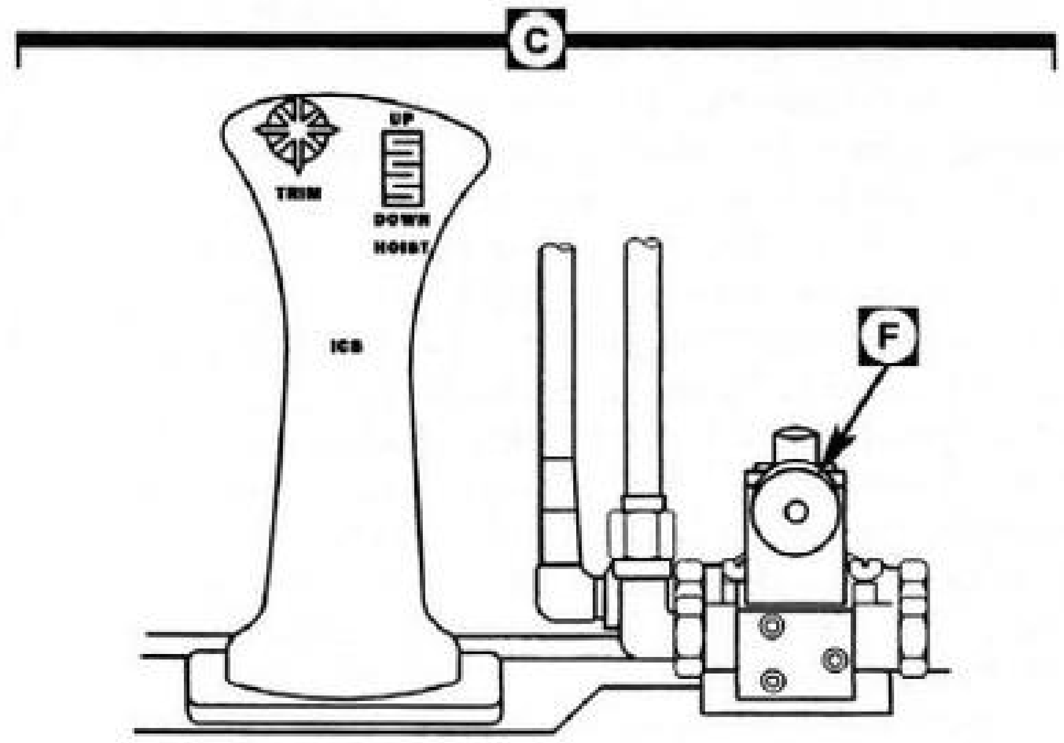
DO NOT FULLY EXTEND OR RETRACT CABLE DURING EMERGENCY OPERATING. WHEN EMERGENCY OPERATION IS COMPLETED, RETURN MANUAL OVERRIDE KNOB TO OFF (DETENTED) POSITION.



EMERGENCY CONTROL PANEL







CREW HOIST HOVER TRIM CONTROLS

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Figure 2-35. Utility Hoist Controls

2.22.4 Hoist Cable Shear Switches and Circuit Test Panel

2.22.4.1 Pilots' Hoist Cable Shear Switch. The EMERGENCY CONTROL panel, on the center cockpit console, contains the HOIST SHEAR switch (FO-8 and Figure 2-35). The guarded switch has a marked position OFF that is the normal switch position with the guard closed. When the guard is raised and the switch is thrown, an electrically-actuated charge in the guillotine will fire and cut the hoist cable. The master switch, on the overhead control panel, must be at CREW or PILOT before the pilots' hoist cable shear switch can shear the cable.

2.22.4.2 Crewman's Hoist Cable Shear Switch. The switch, marked HOIST CABLE SHEAR, is to the right of the personnel door on the hoist panel assembly (Figure 2-35). Raising the switch guard and throwing the switch will enable the crewmember to shear the cable. The master switch, on the overhead control panel, has to be at CREW before the crewman's hoist cable shear switch can shear the cable.

2.22.4.3 Hoist Cable Shear Circuit Test Panel. The panel, marked ELECTRO EXPLOSIVE CIRCUIT TESTER, to the right of the personnel door, contains a test light and guarded switch (Figure 2-35). The test light, marked TEST, lights during circuit testing to indicate the system is functioning properly. The guarded switch, with marked positions TEST and FIRE, is normally at FIRE. The switch is placed to TEST any time the circuit is being tested. For test procedures see UTILITY HOIST OPERATION in Chapter 9.

2.23 CABIN AND LOADING EQUIPMENT

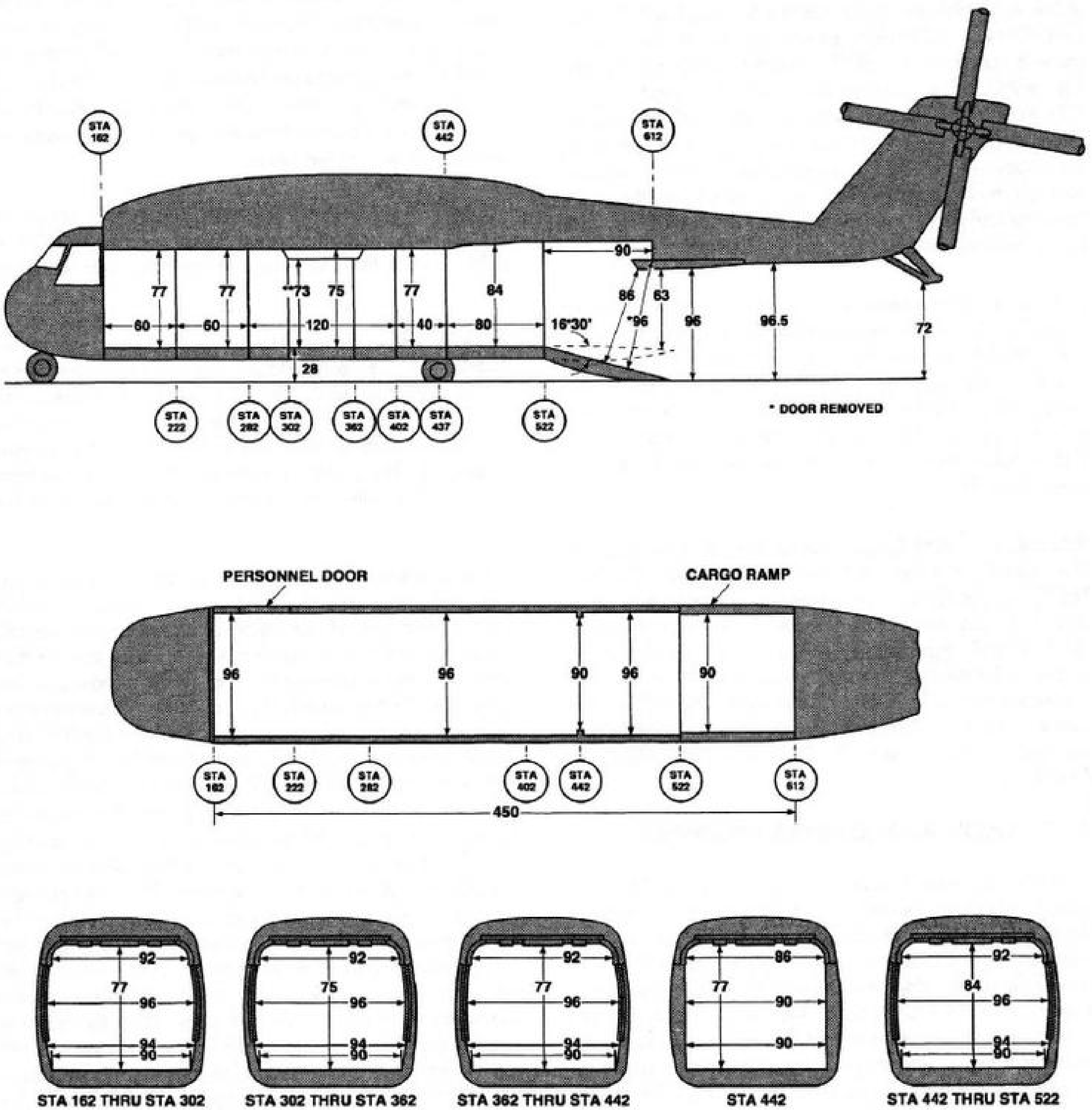
The cabin area (Figure 2-36), from station 162.0 to station 522.0, is capable of carrying cargo, personnel, litters, and wheeled vehicles, and is equipped with two roller conveyors and a removable centerline skid rail, to aid loading and unloading of cargo. Both roller conveyors may be inverted into the cabin floor when not being used for cargo, and the reverse sides will provide skid strip surfaces for vehicular cargo, or troop transport operation. Guide rails prevent cargo pallets from riding off the roller conveyors. The guide rails must be removed before the roller conveyors are inverted for troop carrier operation.

The cabin floor is capable of sustaining static loads of 300 pounds per square foot (Figure 2-37). Tiedown fittings (Figure 2-38), rated at 5000 pounds, are installed on the cabin floor to aid cargo tiedown, and have fittings that serve as troop seat and litter attachment points. Additional tiedown fittings (Figure 2-38), rated at 10,000 and 20,000 pounds, are installed at the intersection of the cargo floor and cabin walls. On certain helicopters a centerline cargo winch system is provided for cargo handling operations. The cabin also contains a personnel door and a cargo ramp and door, both of which may be used for loading cargo and personnel. When loading the helicopter, refer to Figures 2-39, 2-40; and the Handbook of Weight and Balance Data AN 01-1B-40 for center of gravity and weight limitations.

Figure 2-40 shows the approximate CG range of internal cargo loads that are permissible on the CH-53E in order to keep the CG range of the helicopter within its limits.

2.23.1 Litters. The cabin has provisions for the installation of 24 pole-type litters. The litters are arranged in tiers of four litters, each with three tiers on each side of the cabin. The litters are clamped by their outboard poles to the litter brackets on the sides of the cabin. The inboard poles of the litters are supported by straps that run from fittings in the ceiling to the cargo tiedown fittings in the floor.

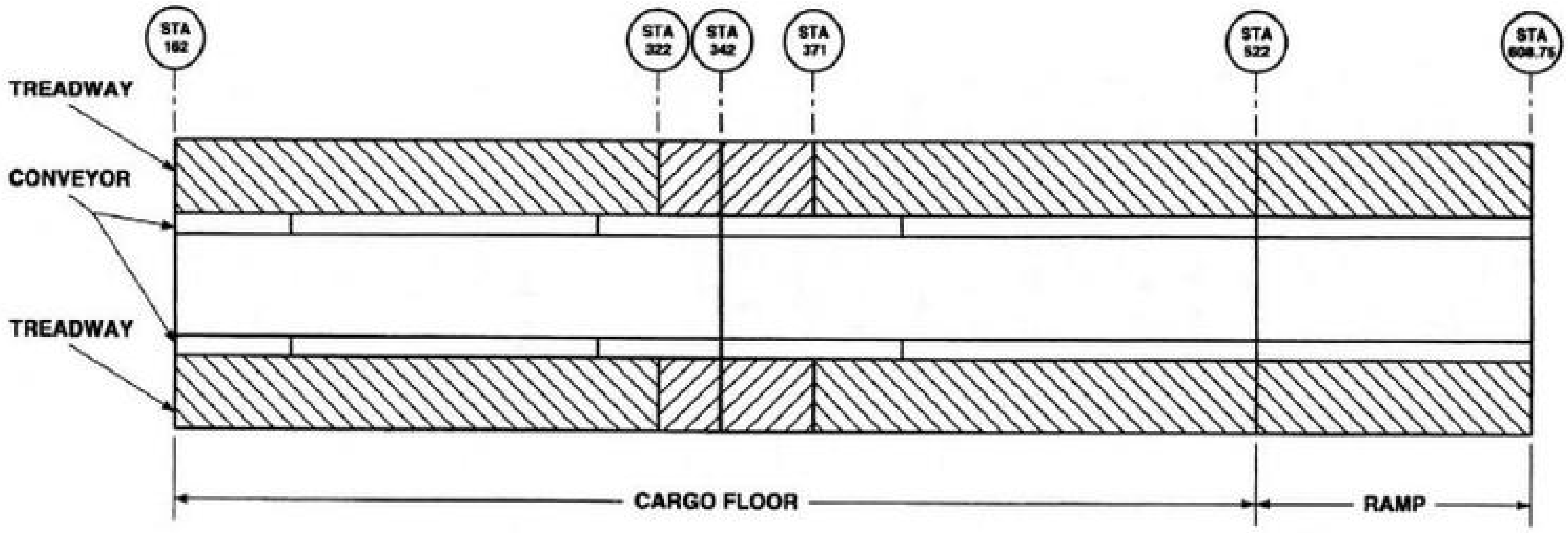
2.23.2 Cargo Ramp and Door. A cargo ramp and door, installed in the aft end of the cabin, is used to aid the loading and unloading of cargo and personnel. The ramp operates simultaneously with the door so that when the ramp is lowered the door retracts into the cabin. When the ramp is closed, the door extends down to meet the ramp, and forms a complete closure. The tail skid circuit is routed through the down side of the ramp control switch so that the tail skid will automatically retract when the cargo ramp is lowered and the helicopter is on the ground. The ramp surface, about 6 feet, 6 inches long, and 7 feet, 6 inches wide, contains two roller conveyor assemblies and two flipper assemblies. The roller conveyors aid in the loading and unloading of cargo. Both roller conveyors may be inverted into the ramp floor when not being used for cargo, and the reverse sides will provide skid-strip surfaces for vehicular, cargo, or troop transport operation. Flippers, which fold back when the ramp is closed, are at the end of each roller conveyor, to aid moving cargo onto the ramp. The cargo ramp and door are electrically-controlled and hydraulically-actuated by hydraulic pressure from the utility hydraulic system. The ramp and door is normally-operated from control panels in the cockpit or cabin. The ramp may be lowered manually, when hydraulic or electrical power is not available, by use of the uplock release and a mechanical override valve. The ramp uplocks are mechanically latched and released by hydraulic pressure. The ramp may be stopped at any intermediate position between closed and open to permit it to be used for loading. The



NOTES

ALL DIMENSIONS SHOWN IN INCHES.
EXTERNAL CLEARANCES WILL VARY WITH HELICOPTER AND GROUND SURFACE CONFIGURATION.

Figure 2-36. Cabin Dimensions



STATIC LOADS

BULK CARGO LIMIT 300 POUNDS PER SQUARE FOOT OVER ENTIRE CARGO FLOOR AREA

CONVEYOR LIMITS 2200 POUNDS FOR 48-INCH PALLET

TREADWAY LIMITS

5150 POUNDS PER AXLE FOR RUBBER-TIRED VEHICLES
2575 POUNDS PER TREADWAY FOR RUBBER-TIRED VEHICLES

3450 POUNDS PER AXLE FOR RUBBER-TIRED VEHICLES
1725 POUNDS PER TREADWAY FOR RUBBER-TIRED VEHICLES

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Figure 2-37. Cargo Floor and Ramp Strength Limits

ramp system incorporates a floating ramp capability, in the open position, in that relief valves are provided in the pressure lines of each actuating cylinder. This permits the helicopter to make taxi drops over rough terrain. If the ramp should strike the ground, the relief valves will cause the hydraulic pressure to bypass and allow the ramp to move toward the closed position until the force is removed. This feature lessens the possibility of ramp or actuating cylinder damage. The cargo ramp and door actuating system receives power from the No. 1 primary dc bus through circuit breakers in the cabin, marked OPEN WARN and CONT, under the general heading RAMP. A light, marked RAMP OPEN, on the advisory panel (FO-7), will go on when the door is not closed or the ramp is not fully up and locked. A light, marked UNLOCKED, on the crew ramp control panel (Figure 2-41), goes on if the pilot's master switch is placed to PILOT and the pilot's control switch is placed to OPEN, or if the pilot's master switch is at CREW and the crew ramp control switch is placed to OPEN.

2.23.2.1 Ramp and Door Control Panel, Pilots. The CAR LDG panel, on the overhead control panel, contains two operating controls. The ramp can be operated only from the cockpit with the MASTER switch at PILOT, and from the cabin only with the switch at CREW. With the MASTER switch at PILOT, turning the OPERATE knob to LEVEL will move the ramp to the level position. Turning the knob to HOLD will stop the ramp at any position. Turning the knob to OPEN moves the ramp full down and opens the door. Turning the knob to CLOSE raises the ramp and lowers the door to the closed position.

WARNING

When transferring ramp control from pilot to crew, or from crew to pilot, be sure that the ramp control knob at the receiving station is at HOLD. If the control is not at HOLD, the ramp will immediately move to the position selected, and injury to personnel, or damage to the helicopter, may result.

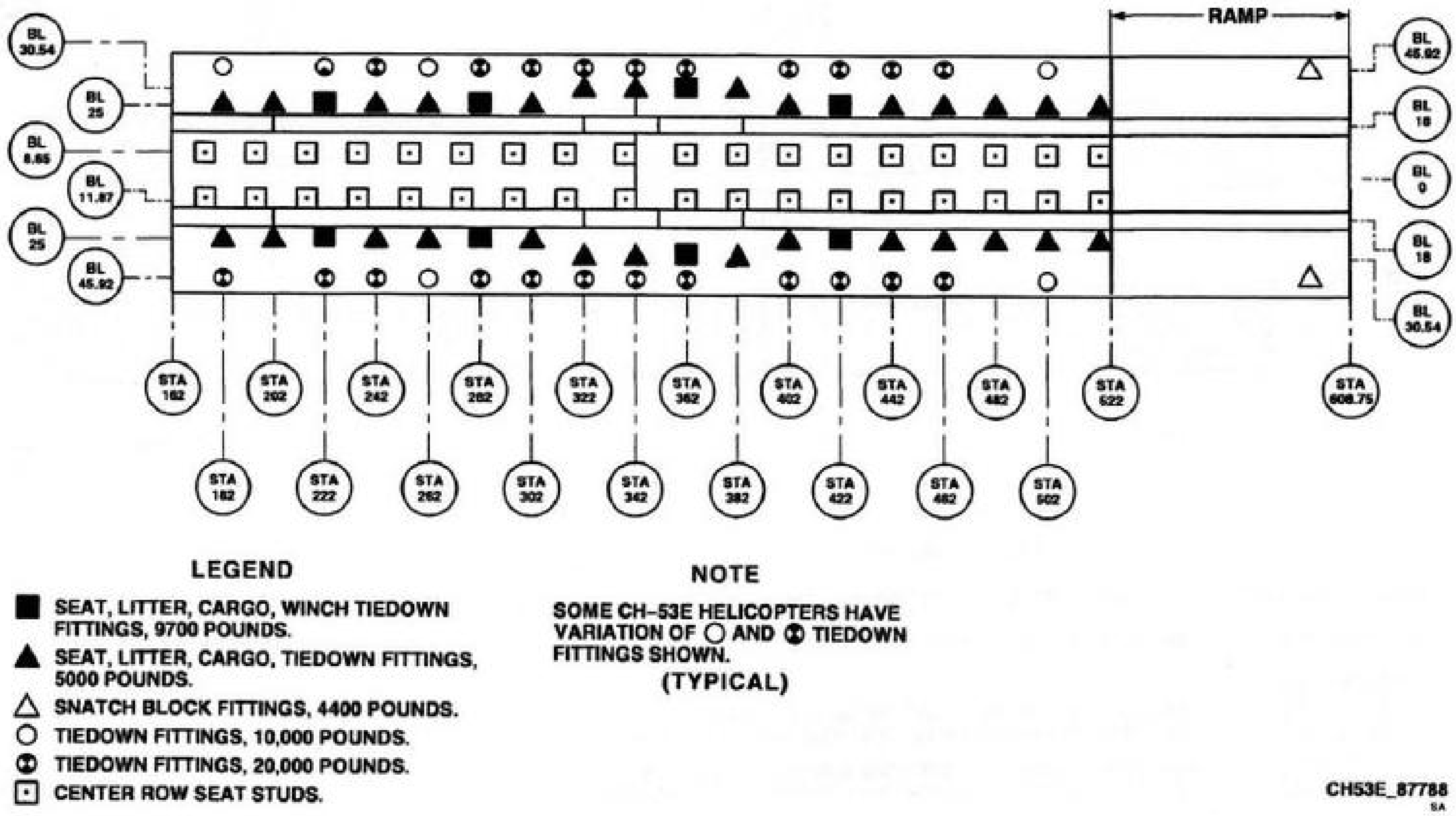


Figure 2-38. Location of Tiedown Fittings

CAUTION

Before lowering ramp, be sure that the area under it is clear of equipment, rocks, etc., that the ground is of equal load carrying capability to avoid twisting the ramp when heavy loads are applied, and that the flippers are up.

2.23.2.2 Ramp and Door Control Panel, Crew. The RAMP control panel (Figure 2-41) is aft on the left side of the cabin. An UNLOCKED light on the panel is on whenever the ramp and door are not fully closed and locked. The ramp positioning knob operates the same way as the pilot's OPERATE knob and operates only when armed, by placing the pilots' MASTER switch to CREW.

2.23.2.3 Cargo Door. The door may be operated independently of the ramp by placing the manually-operated valve, on the right aft side of the cabin, to DOOR ONLY. The valve is normally left at NORMAL so the door will operate in conjunction with the ramp. The OPEN and CLOSE positions of the pilots' OPERATE knob, or the cabin ramp positioning knob, control door operation.

2.23.2.4 Ramp Uplock Release Levers and Manual Override Valve. The manual ramp uplock release levers, on each ramp uplock, and the manual override valve, on the right aft side of the cabin, can be used to manually close or open the ramp and door when electrical or hydraulic power is not available. Instructions are on a decal next to the manual override valve.

WARNING

Care should be taken, when manually releasing the door latches, to be sure the door does not slam and injure personnel.

2.23.3 Cargo Winch Installation. A variable speed hydraulically-driven, electrically-controlled cargo winch (Figure 2-42) is provided for cargo operations on helicopters modified by AFC 299. The winch, if installed, is centerline-mounted on the cargo floor immediately behind the cockpit. It provides at least 80 feet of usable stainless steel cable. When cable is reeled out, one man

CENTER OF GRAVITY ENVELOPE

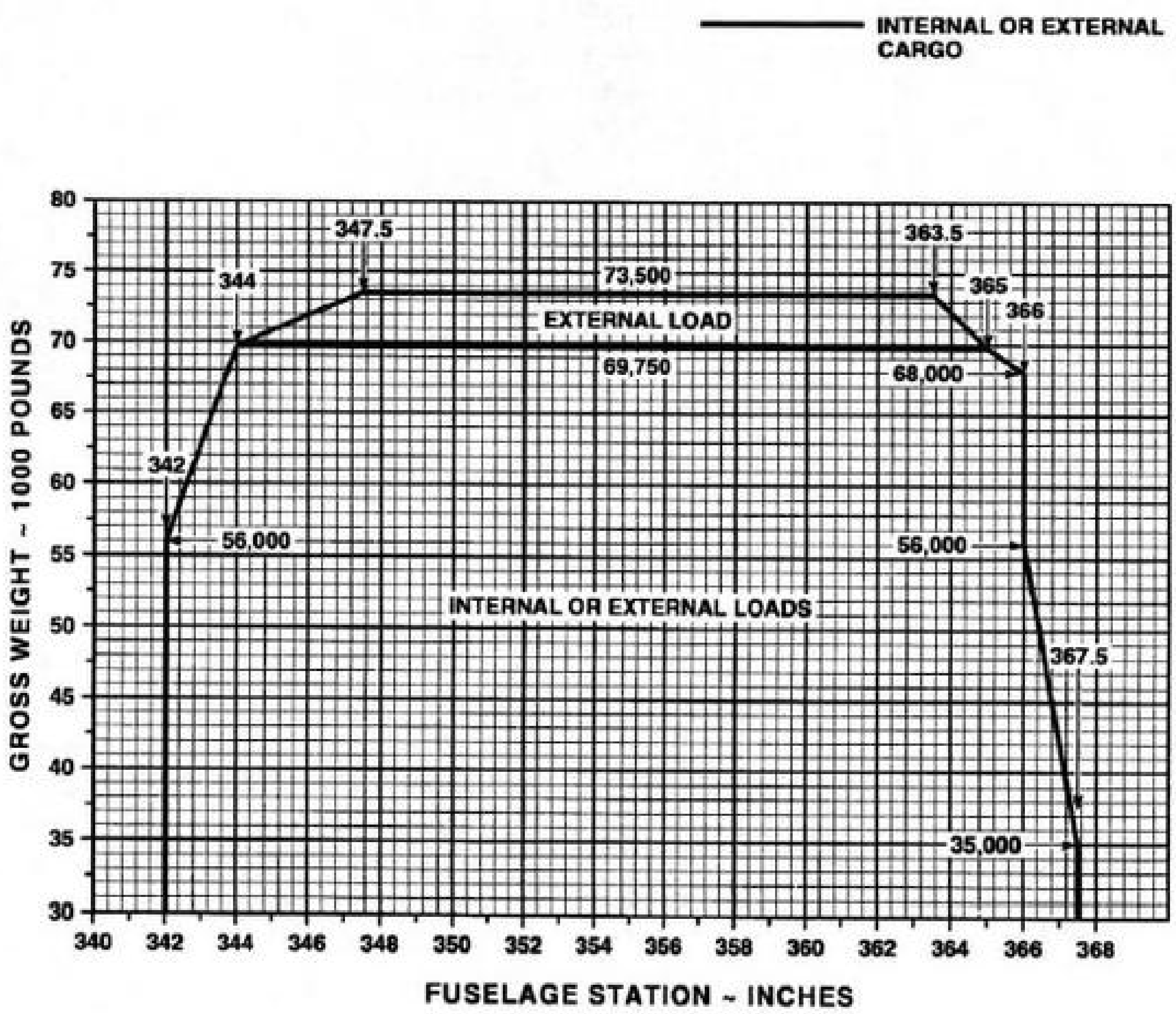


Figure 2-39. Longitudinal CG Limits vs. Gross Weight

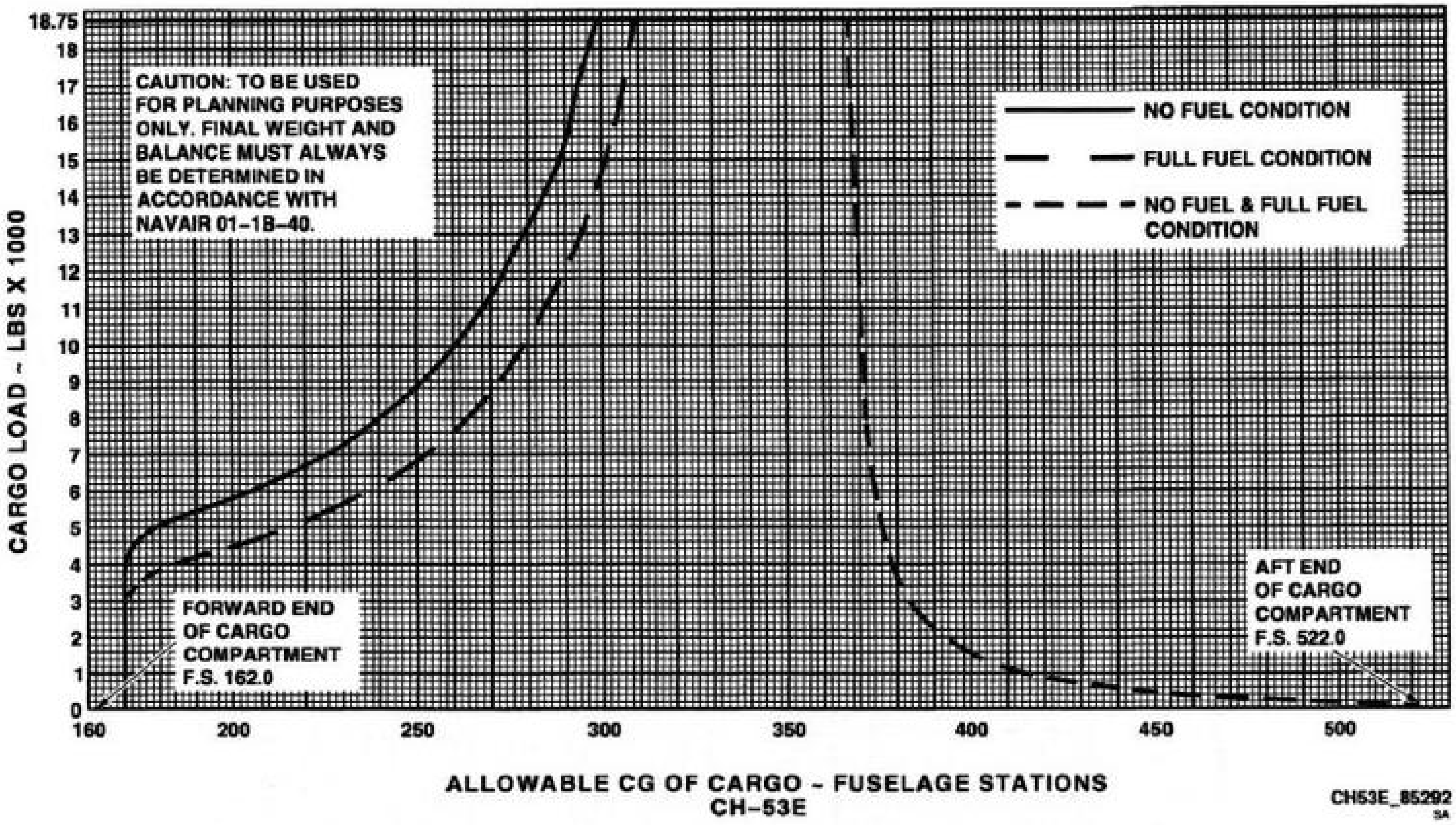


Figure 2-40. Cargo Center of Gravity Placement Chart

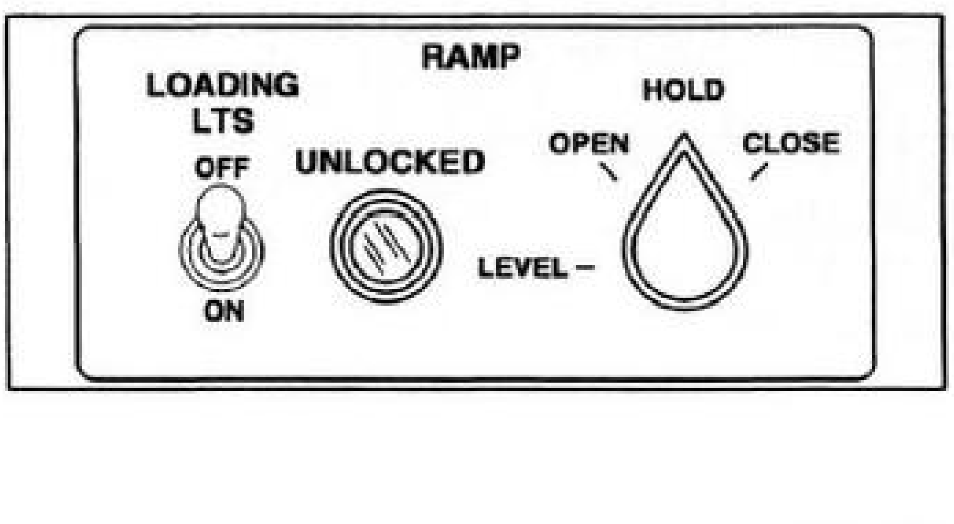


Figure 2-41. Ramp Control Panel, Crew

must pull on it (there is no freewheeling capability). A 4-foot painted length of cable reels off the winch just before an out-limit switch automatically stops the winch. A slowdown switch will slow cable reel-in to about 20 fpm when 4 to 6 feet of cable remains to be reeled in. Also, an in-limit switch stops the winch when about 6 inches of cable remains to the cable end fitting. Winch capacity is 5000 pounds at all speeds. The cargo winch hydraulic motor is powered by the 3000 psi utility system pump. Electrical control power comes from the No. 1 dc primary bus, and is protected by a CARGO WINCH circuit breaker on the left cabin circuit breaker panel. Operation of the winch is controlled through a pendant in the cargo compartment. A stowage case for removable cargo handling equipment is installed in the forward left corner of the cabin and replaces three troop position seats. The stowage case may be used for three seat positions, or it can be removed and the troop seats reinstalled. The forward most three-man troop seat assembly, on the helicopter centerline, can be used only when the winch assembly is removed from the winch support assembly. A step/cover protects the winch and provides a step to the cockpit in both winch assembly positions, and when the winch assembly is removed from the support assembly.

2.23.3.1 Cargo Winch Operation. The cargo winch is used for loading cargo through the cargo ramp door. A winch support assembly is bolted to the cargo compartment floor and holds the cargo winch assembly by two attaching plates. The support assembly contains four bearing points, which allow the winch assembly to be rotated on the attaching plates to either a horizontal position (for direct cable haul-in) or an angled position of 54° from the horizontal (for winch cable haul-in via the overhead sheave assemblies). The winch assembly is

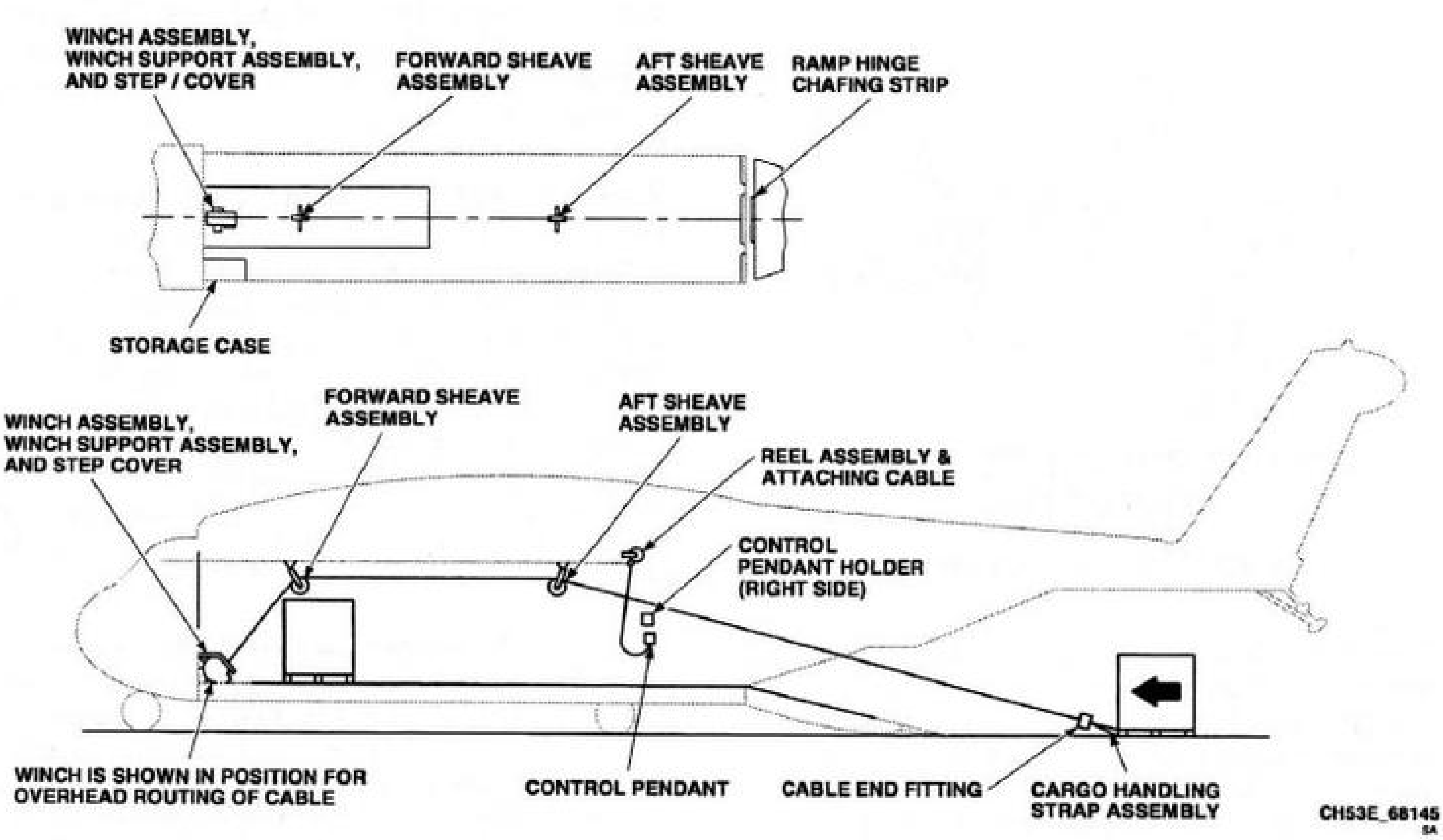


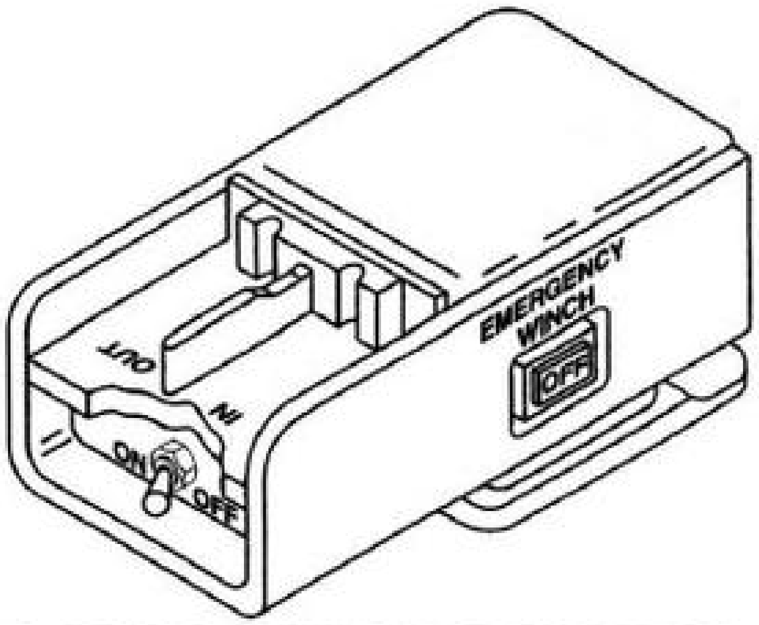
Figure 2-42. Cargo Winch Installation and Operation

locked into either position by four release pins. The forward and aft overhead sheave assemblies consist of a snatch block assembly with a 6-inch diameter sheave, and a fitting assembly which attaches to the overhead cabin structure with two quick-release pins. One or several pieces of cargo may be loaded at one time. Winch operation will cause the cargo to be pulled into the cargo compartment. Wheeled cargo, or cargo being loaded over the roller conveyors, of any weight, may be loaded as long as the force required to move the load is not over 5000 pounds. A chafing strip is installed over the ramp hinge to protect the cabin floor. Two nylon cargo handling strap assemblies are used to attach to the cable end fitting for moving cargo.

2.23.3.2 Control Pendant. The control pendant (Figure 2-43) and attaching cable, housed in a reel assembly, is mounted on the right side of the cargo compartment. The attaching cable, housed in a reel assembly on the aft cabin overhead, permits the crewman to operate the control pendant from various locations. When holding pressure is released from the reel assembly, the control pendant and attaching cable automatically retract. The assembly provides both winch and ICS functions for the winch operator. The pendant operates the cargo winch by an ON-OFF master power switch, an EMERGENCY WINCH OFF switch, and a winch control/speed/direction selector marked IN-OUT. The control/speed selector is spring-loaded to neutral and has variable speed/direction control that will provide a variable winch speed capability of 0-70 fpm in each direction. Pressing the emergency stop switch removes all power from the winch control/speed selector. When the master power switch is ON, it provides power to the winch control/speed selector. A "hot mike" ICS condition is produced when the control pendant is connected to the cable assembly. A holder on the right side of the cabin is for stowage of the control pendant.

2.24 EMERGENCY SYSTEMS

2.24.1 Fire Detection Systems. The engine, APP, and heater fire detector systems provide a warning in case of fire in either engine or the APP and heater compartments. Each system contains a control amplifier, infrared-type flame detectors, and warning lights. The control units monitor the frequency impedance of the flame detectors that are installed in fire zone areas of the engine and APP and heater compartments. The photocell-type flame detectors sense red light, which will cause the proper warning lights to go on. As the flame in the fire zone drops below the warning point, the system will be restored to its



CARGO WINCH CONTROL PENDANT CH53E_68146 SA

Figure 2-43. Control Pendant

original condition with all the warning lights off. Each engine has three photocell flame detectors, mounted through the fuselage fairing into the engine section. Each detector provides a 90° scan. The APP and heater compartment contains two photocell flame detectors, one mounted high on the firewall facing forward, and one mounted forward under the heater facing aft. All engine fire detector systems receive power from the emergency dc bus through a circuit breaker, marked FIRE DET, under the general heading of the associated engine. The APP and cabin heater also receives power from the emergency dc bus through a circuit breaker, marked FIRE CAB HTR APP. All circuit breakers are in the cockpit.

Note

Certain conditions of sunlight, especially during the early morning and late evening hours, may cause the engine fire warning lights to go on. The lights should go off when the helicopter changes its relative position to the sunlight.

2.24.1.1 Master Fire Warning Lights. Two lights (FO-5) marked FIRE PUSH TO RESET, are on the instrument panel, one each in front of the pilot and copilot. Both master lights will go on any time the photocell flame detectors of any system detect a fire. The fire warning lights can be pushed in and reset after having been lit.

2.24.1.2 Engine Fire Warning Lights. Each engine emergency T-handle on the fuel selector quadrant (FO-1) contains a fire warning light. The appropriate engine fire warning light will go on to indicate which engine compartment has developed a fire. The fire warning master lights will alert the pilot of a fire, and the engine fire warning light in the T-handle will designate which engine is affected.

2.24.1.3 APP and Cabin Heater Fire Warning Light. The APP emergency T-handle, on the APP control panel, contains a fire warning light. The fire warning light will go on to indicate that a fire has developed in the APP and cabin heater compartment, only after APP speed has reached 92%. Before 92%, there is no fire warning detection for the APP and cabin heater compartment. The master fire warning lights will alert the pilot of a fire, and the APP and cabin heater compartment fire warning light will designate the fire to be in the APP and cabin heater compartment. However, the warning light will not show whether the fire is in the APP or the cabin heater.

2.24.1.4 Fire Warning Test Control Panel. This panel (FO-1), on the overhead control panel, is used to test the engine and the APP and heater compartment fire detector systems. The control panel, marked FIRE WARN TEST, contains a tear-shaped rotating switch, with marked positions NORM-1-2-3, under the general markings APP-ENGS. The switch is spring-loaded to NORM. When the switch is turned to the 1 position, the master fire warning lights and the lights in the engine and APP emergency T-handles will go on, to indicate that the No. 1 detector circuit of each system is operating properly. Turning the switch to the 2 position will also cause the master fire warning lights and engine and APP emergency T-handles to light, to indicate the No. 2 detector circuit of each system is operating properly. When the switch is turned to the 3 position, the master fire warning lights and the lights in the engine emergency T-handles will light, to indicate the No. 3 detector circuit of each engine fire detector circuit is operating properly.

2.24.2 No. 2 Engine Dual Thermal Detection System (AFC 483). The No. 2 engine dual thermal detection system gives an indication of No. 2 engine compartment overheating. The system has a control unit, dual sensing elements, a warning light on the caution/advisory panel, and a NO. 2 ENGINE OVERHEAT WARNING PANEL on the cockpit overhead control panel. The control unit monitors the temperature detected by the sensing elements. When the temperature exceeds preset limits, the control unit sends an output signal which makes the #2 ENGINE OVERHEAT caution light come on. When the temperature drops below the preset limits, the system is reset and the #2 ENGINE OVERHEAT caution light goes out.

The NO. 2 ENGINE OVERHEAT WARNING PANEL (FO-1) has a press-to-test button labeled TEST. The TEST button checks the No. 2 engine dual thermal detection system electrical continuity. If the system check is good, the #2 ENGINE OVERHEAT caution light comes on.

The emergency ac bus supplies power to the No. 2 engine dual thermal detection system through the NO. 2 ENG THERM DET circuit breaker. The emergency dc bus supplies power to the No. 2 engine dual thermal detection warning light through another NO. 2 ENG THERM DET circuit breaker. Both NO. 2 ENG THERM DET circuit breakers are on the cockpit overhead control panel.

2.24.3 Fire Extinguisher Systems. These systems consist of the engine fire extinguisher system and an APP and cabin heater compartment fire extinguisher system. The fire extinguisher systems' containers are charged with 4.5 pounds of Monobromotrifluoromethane (CF_3Br) plus approximately 600 psi of nitrogen to propel the extinguishing agent. Nitrogen pressure is displayed by a gage on each container and the acceptable pressure for the ambient temperature is shown on a decal affixed to the container. The containers are not serviced at the organizational level. Both systems also contain discharge nozzles, overboard discharge tubes, discharge indicators, and necessary controls.

A crash-generated force of 10 Gs automatically discharges the fire extinguishers into the engine compartments. The automatic discharge is actuated by an omnidirectional inertial switch that is powered by a rechargeable battery and is on the line at all times. Power to operate the battery recharger is furnished by the No. 1 primary ac bus through a circuit breaker marked BATT CHARGE in the cabin.

2.24.3.1 Engine Compartment Fire Extinguisher System. The system includes three containers, in the accessory compartment forward of the accessory gear box. Each container is interconnected with a manifold that permits the extinguishing agent to be distributed to the compressor and power turbine sections of selected engine compartments. A safety outlet in each container is connected through a common line to a red thermal discharge indicator, on the left side of the fuselage. If the pressure in either container becomes too high, the appropriate safety valve will open, the thermal discharge indicator seal will be ejected, and the extinguishing agent will be discharged overboard. A pressure gage on each container aids a preflight pressure check. When the containers are properly charged, the pressure gages should indicate the value within the range shown on the decal next to the gages. Power for the engine fire extinguisher system is received from the emergency dc primary bus through circuit breakers in the cabin, marked FIRE EXT, under the general heading of the associated engine.

Note

> If two bottles were discharged into one compartment, the remaining bottle can be discharged into either of the remaining compartments. The last bottle will be discharged by either the MAIN or RESERVE selection, depending on which two bottles have already been discharged, and which compartment has been selected. In this case, the most expeditious thing to do is to select MAIN and then RESERVE.

2.24.3.2 Engine Emergency T-Handles. The three engine emergency T-handles, on the engine control quadrant (FO-1), direct the flow of the fire extinguishing agent. The emergency T-handle light covers are marked NO. 1 ENG EMER OFF, NO. 2 ENG EMER OFF, and NO. 3 ENG EMER OFF respectively, to designate which engine fire extinguisher system it controls. When any T-handle is pulled full aft, the handle will close the fuel selector lever for the selected engine. The fire extinguisher switch is then placed to MAIN OR RESERVE to discharge the fire extinguisher agent into the engine selected. If more than one emergency T-handle is moved full aft, the fire extinguishing agent will be directed to the engine compartment of the last emergency T-handle actuated.

2.24.3.3 Engine Fire Extinguisher Switch. This switch, marked FIRE EXT, is on the emergency control panel marked EMER, on the overhead control panel (FO-1). The switch has marked positions RESERVE, OFF and MAIN. The switch is left OFF, until an emergency T-handle has been actuated, then placed to either MAIN or RESERVE. When the switch is placed to MAIN, the contents of the engine's associated container is discharged in the engine compartment of the engine selected with the respective emergency T-handle. When the switch is placed to RESERVE, the contents of another engine's container is discharged in the engine compartment of the engine selected.

2.24.3.4 APP and Cabin Heater Compartment Fire Extinguisher System. This system includes a container, in the accessory compartment forward of the accessory gear box. The container is mechanically discharged whenever the APP emergency T-handle, marked APP EMER OFF on the light cover, forward of the APP power control lever, is pulled full aft. When the APP emergency T-handle is actuated, the APP and cabin heater fire areas will simultaneously receive fire extinguishing agent and fuel will be cut off to both systems. A safety valve in the container is connected to a red thermal discharge indicator, on the left side of the fuselage. If pressure in the container should become excessive, the safety valve will open, the thermal discharge indicator seal will be ejected, and the extinguishing agent discharged overboard. If the APP emergency T-handle has been actuated to put out a cabin heater fire, no fire extinguisher agent will be available for subsequent APP operation. The APP and cabin heater compartment fire warning lights, in the APP emergency T-handle, do not differentiate between an APP or cabin heater fire.

2.25 EMERGENCY ENTRANCE/EGRESS SYSTEMS

2.25.1 Cockpit Windows. The windows (Figure 2-44, E) are opened and closed with a handle attached to an actuating bar. The windows are opened by turning the handle up; then, using the handle as a lever, turning the actuating bar down until the latches release. The window is then pushed out to the open position, where the engage locks will hold it open. The windows are closed by releasing the engage locks and pulling the window partially closed. With the handle up, it is used as a lever to turn the actuating bar down to retract the latches. The window is then pulled in, fully closed, then the handle is turned down until its lock latch engages. Operating instructions are on each window sill. The windows may be opened on the ground, but should not be opened during flight. However, each window is equipped with a snap vent that may be extended for additional ventilation. The windows may be jettisoned to provide emergency exits by the manual emergency release handles, marked EMERGENCY EXIT PULL OUT AND TURN, at the bottom of each window inside the pilot's compartment. The windows can be jettisoned by turning the release handle and pushing out on the window. The windows can also be released from the outside by turning the handle, marked EXIT RELEASE-PRESS BUTTON-TURN.

2.25.2 Personnel Door. This door (Figure 2-44, A), on the right side of the helicopter, is normally used as an entrance to the cabin and cockpit. The door is divided into an upper and lower section, each of which may be opened separately. The upper half may be opened from the outside by turning the handle, marked TO OPEN - PRESS BUTTON - TURN, on the bottom of the upper section. The upper section of the door is normally opened and closed by the handle, marked TO OPEN - TURN, on the inside of the door. The handle also locks the upper section of the door open if needed for in-flight operations. The upper section may be jettisoned from the inside by turning both handles and pulling in on the door. The lower door swings inward on vertical hinges against the forward cabin bulkhead. The outer handle is recessed in the door and extends out when a button on the handle is depressed. To open the door from the outside, turn the handle counterclockwise. To open the door from the inside, turn the handle clockwise.

2.25.3 Cabin Emergency Escape Hatch. The hatch (Figure 2-44, D), on the left forward side of the cabin, may be removed to provide an emergency exit or a gun port. The hatch can be hinged open for use as a gun port by turning the lower handle clockwise and swinging the hatch inboard and up. The entire hatch can be removed for emergency exit by turning the upper handle clockwise and pulling the hatch inboard. The hatch can be removed from the outside by turning the handle below the hatch counterclockwise and pushing the hatch in.

2.25.4 Cabin Windows. The six cabin windows (Figure 2-44, C), three on each side, may be pulled inward for additional emergency exits. Each window has EMERGENCY EXIT stenciled above the window. Each of the cabin windows has a pull tab, marked PULL TAB, by which the locking strip may be pulled out of the rubber seal surrounding the window panes. The window panel may then be pulled inward using the strap attached to the upper right corner of the window pane. For emergency exits on helicopters not modified by AFC 303, pull the tab removing the rubber seal and forcibly push out against the window retainers.

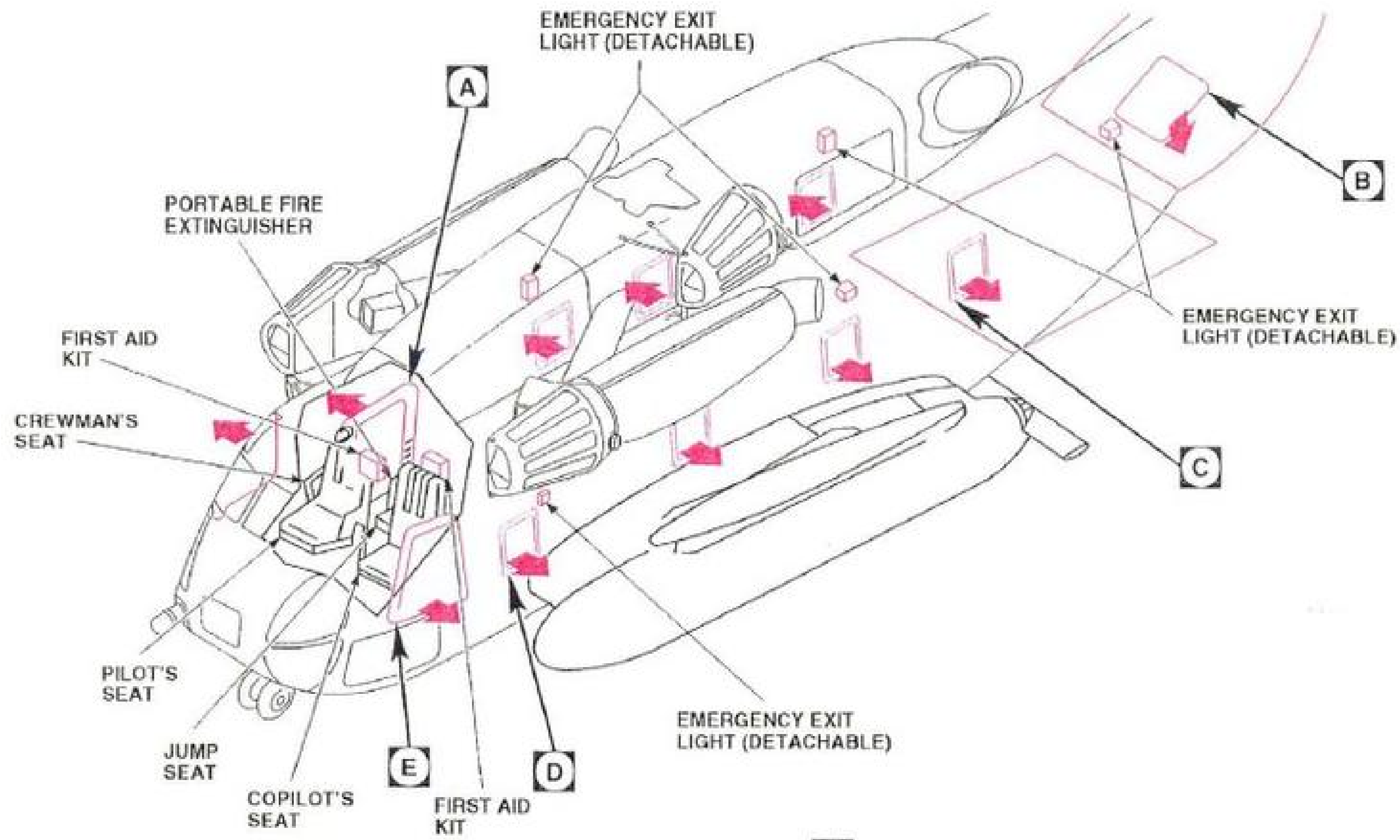
Note

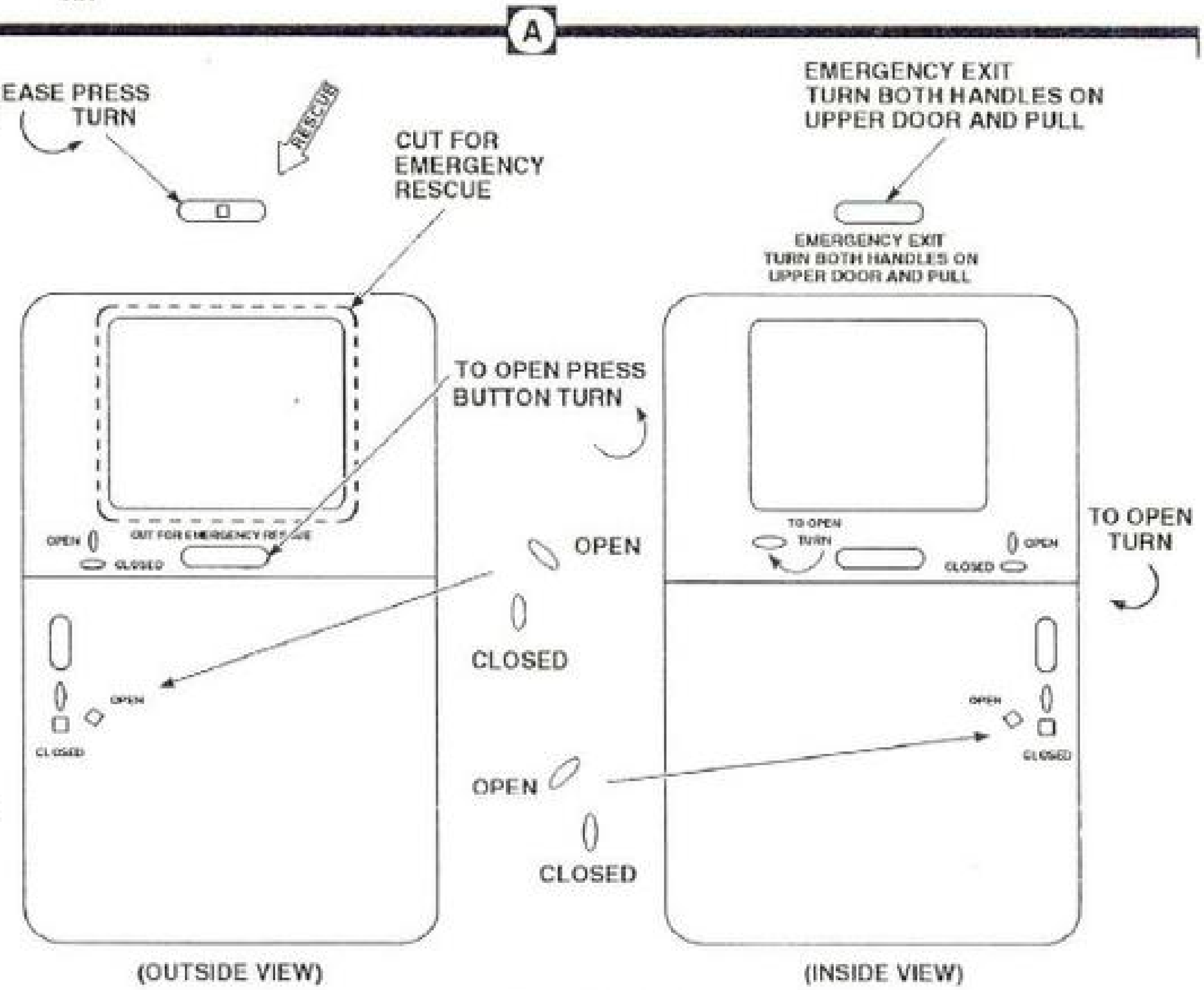
The single-point cargo hatch may be used as an exit, should an emergency situation warrant.

2.25.4.1 Cargo Door Window. The door has a window (Figure 2-44, B) marked EMERGENCY EXIT, that may be pulled inward, as an additional emergency exit. The window has a pull tab, by which the locking strip may be pulled out of the rubber seal surrounding the window pane. The window panel may then be pulled inward using the strap attached to the upper right corner of the window pane. For emergency exit on helicopters not modified by AFC 303, pull the tab removing the rubber seal and forcibly push out against the window retainers.

2.26 EMERGENCY EQUIPMENT

2.26.1 Emergency Exit Lights. These lights are portable and are discussed in this chapter under LIGHTING EQUIPMENT.





NOTES

1. ALL EMERGENCY HANDLES ARE PAINTED ORANGE–YELLOW, EMERGENCY EXIT INSTRUCTIONS ARE STENCILED IN YELLOW PAINT.
2. PULL TAB TO REMOVE KEY FROM SEAL; THEN FORCIBLY PULL WINDOW INWARD. FOR HELICOPTERS NOT MODIFIED BY AFC 303 PULL TAB TO REMOVE KEY FROM SEAL; THEN FORCIBLY PUSH WINDOW OUT.
3. TOP PART OF DOOR OPENS INWARD, BOTTOM PART OPENS INWARD AND FORWARD ON HINGES.
4. REMOVE WINDOWS OUTWARD ONLY.
5. CABIN EMERGENCY HATCH OPENS INWARD AND UP.

PERSONNEL DOOR
(SEE NOTES 1 AND 3)

HC3951_1
SA

Figure 2-44. Emergency Equipment, Exits, and Entrances (Sheet 1 of 2)

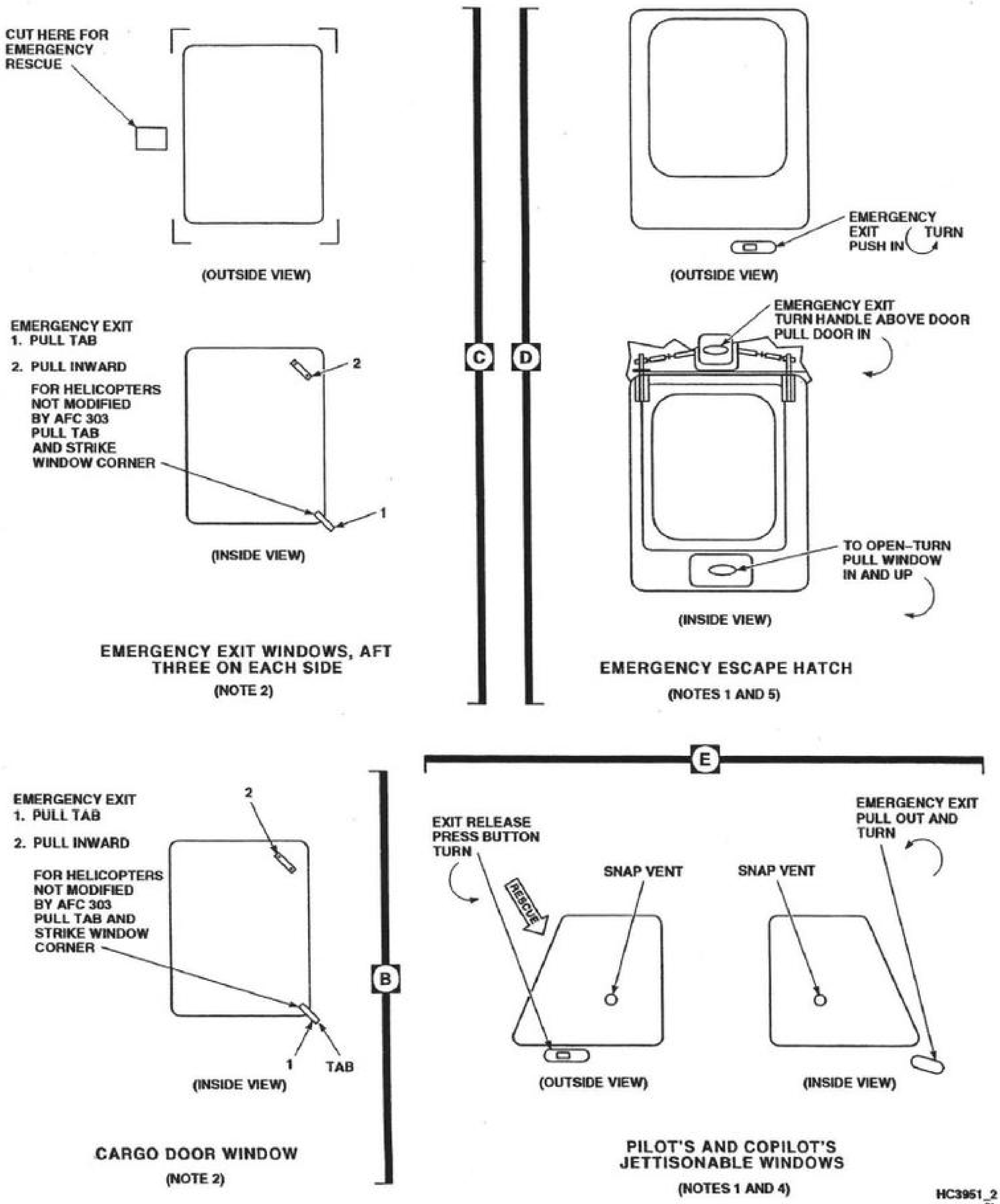


Figure 2-44. Emergency Equipment, Exits, and Entrances (Sheet 2 of 2)

2.26.2 First Aid Kits. One first aid kit is mounted on the bulkhead behind the copilot's seat. A second kit is mounted on the forward cabin bulkhead AFCS servo compartment door.

2.26.3 Portable Fire Extinguisher. Either a portable CO_2 fog-type or a portable (monobromotrifluoromethane (CF_3Br) fire extinguisher is mounted beneath the crew chief's seat. The fire extinguisher is held in place by a bracket with a tight-fitting quick-release lever.

2.27 MISCELLANEOUS EQUIPMENT

2.27.1 Cockpit

2.27.1.1 Ashtrays. An ashtray is installed on each side of the cockpit, between the windshield and the chin bubble.

2.27.1.2 CHECKLIST. A takeoff and landing checklist is mounted on the instrument panel in front of the pilot.

2.27.1.3 Curtain. Antiglare curtains are installed over the entrance to the cockpit, and the lower two windows on each side of the cockpit. The antiglare curtains are to prevent unwanted light from entering the cockpit during night and instrument flight conditions.

2.27.1.4 Map Cases. A map case is installed on each side of the cockpit outboard of the pilots' seats.

2.27.1.5 Mirror. A rearview mirror is attached to the center windshield's frame on the left side.

2.27.2 Armorplating. The pilots' seats are armorplated and are shown in Figure 2-45.

2.27.3 Mooring Rings. There are four mooring rings (Figure 3-6). One is aft and outboard of each sponson, and one is on each side of the fuselage aft of the electronics compartment. There is a water-tow point on the nose of the helicopter for bow line attachment.

2.27.4 Relief Tubes. One relief tube is mounted on the bulkhead behind the pilot's seat, and another is on the left side of the forward bulkhead in the cabin compartment.

2.27.5 Stowage Locker. A removable stowage locker is on the forward left side of the cabin (FO-12). The stowage box may be used for three seat positions.

2.27.6 Electronics Compartment Emergency Access Panel. Two access panels located on the forward cabin bulkhead behind the copilot and pilot seats provide access to either the port or starboard electronic compartment in the event of fire.

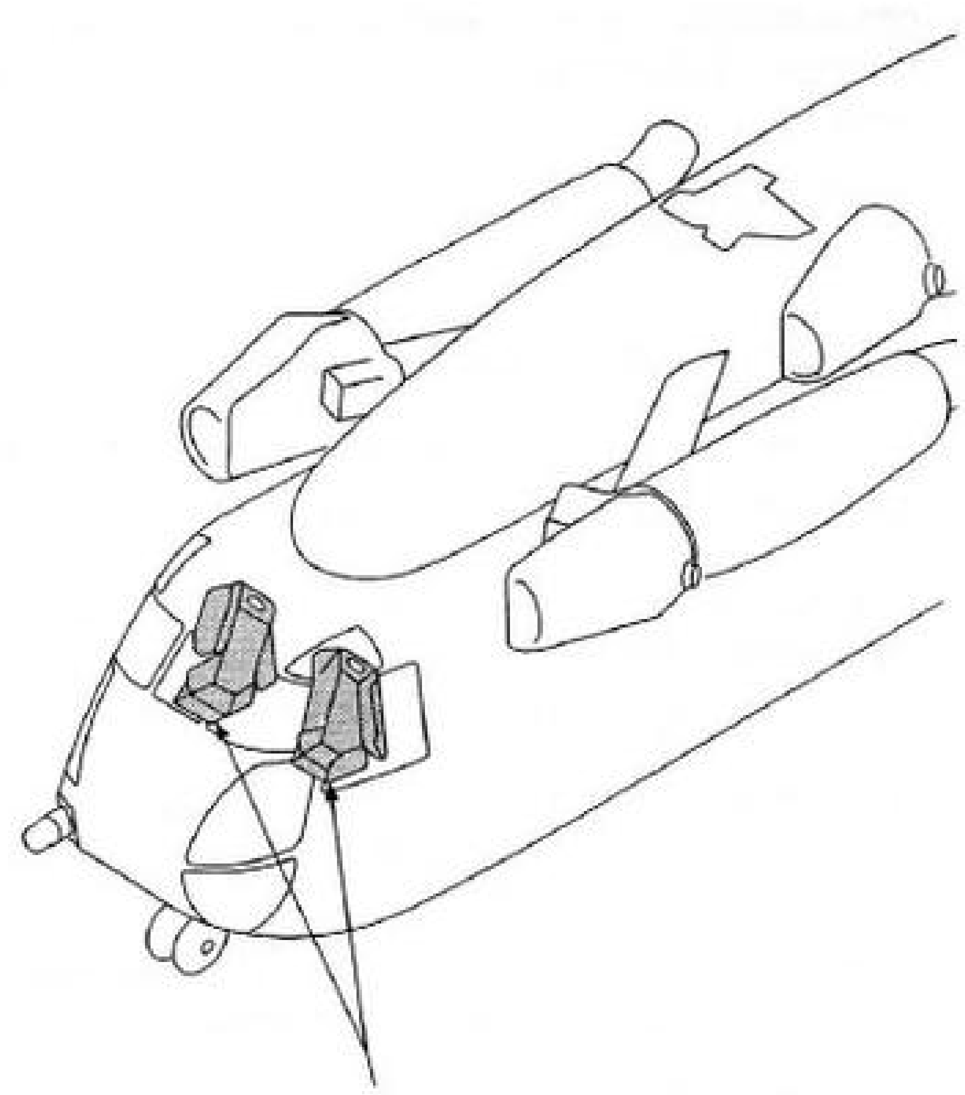


Figure 2-45. Armor Plate Installation

2.28 AN/AYQ-23(V) GROUND PROXIMITY WARNING SYSTEM (GPWS)

2.28.1 GPWS System Description. The AN/AYQ-23(V) GPWS consists of a GPWS processor and an air data computer (ADC). Together they use a combination of analog and digital input signals, provided by existing helicopter sensors, to calculate the helicopter's dynamic state and generate ground avoidance warnings. Appropriate aural warnings are issued through the aircrew ICS headsets for each of seven specific ground avoidance situations and a visual GPWS ALERT indicator light on the pilots' advisory panel. The aural warnings are as follows:

PRIORITY 1 WARNING: Altitude Loss After Takeoff warning issued to prevent controlled flight into terrain (CFIT) shortly after takeoff and during initial climb out. This warning protects against altitude loss due to in-air descent, rising terrain, or a combination of the two. This warning is enabled after takeoff between 40 feet AGL to 250 feet AGL and/or during the first minute of flight after passing 40 feet AGL. During the Climb Out state, a non-predictive warning level is maintained below the helicopter and penetration of this level causes a GPWS warning.

Helicopter's AGL Altitude	Warning Altitude
40 to 50 feet AGL	20 feet AGL
51 to 80 feet AGL	Helicopter altitude minus 30 feet
81 to 250 feet AGL	50 feet AGL

If the follow-up warning altitude is penetrated, the following GPWS warning is issued:

Aural Warning	"PULL UP PULL UP"
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.
Rearm Condition	Helicopter climbs to 80 feet AGL. The alert lamp is turned off.

PRIORITY 2 WARNING: Predictive CFIT warning issued when the GPWS computes that the predicted altitude loss for the helicopter is greater than the helicopter's height above ground level. This warning is enabled at all times the helicopter is more than 20 feet above ground level after takeoff and just before landing. From the Takeoff and Landing state and less than 20 feet AGL, no CFIT warning will be given by the GPWS.

Aural Warning	"WHOOP WHOOP PULL UP PULL UP"
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.
Rearm Condition	Helicopter climbs to 50 feet AGL. The alert lamp is turned off.

PRIORITY 3 WARNING: Glide Slope warning issued whenever the helicopter descends below the glide slope limits. The glide slope alert is issued between 1000 to 150 feet when the helicopter is 1.3 dots below the glide slope; at 100 feet when the helicopter is 2 dots below the glide slope; and at 50 feet when the helicopter is 2.7 dots below the glide slope as read on the ILS indicator.

Aural Warning	"BELOW GLIDE SLOPE BELOW GLIDE SLOPE"
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.
Rearm Condition	Re-intercept the glide slope.

PRIORITY 4 WARNING: Excessive Bank Angle warning issued whenever the helicopter's bank angle exceeds 60 degrees. This warning is enabled whenever the helicopter is in the air.

Aural Warning	"BANK ANGLE BANK ANGLE"
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.
Rearm Condition	Helicopter bank angle returns to 60 degrees or less. The alert lamp is turned OFF.

PRIORITY 5 WARNING: Non-Predictive Selectable Altitude warning issued when the helicopter descends below the low altitude warning settings selected on the pilot and copilot radar altimeter height indicators. This warning is enabled in the Climb Out, Flight, and Landing states. There is a 3-second inhibit to prevent duplicate warnings from being issued from the same height indicator setting. Separate warnings are issued for the pilot and the copilot low altitude warning settings. The warnings issued when descent below the low altitude warning index occurs are:

Aural Warning	"ALTITUDE"
Visual Warning	None
Rearm Condition	Helicopter climbs above the two index settings.

PRIORITY 6 WARNING: Landing Gear Up warning issued whenever the landing gear up criteria defined in the NATOPS manual is violated. This warning is enabled when the helicopter is in the air and either of the following occurs:

1. Radar altimeter signal is valid, helicopter less than 150 feet AGL, IAS is less than 60 knots, and the landing gear is up.

2. Radar signal is invalid, IAS is less than 60 knots, and the landing gear is up.

If the landing gear up warning criteria is violated, the following GPWS warning is issued:

Aural Warning	"GEAR GEAR" warning repeated every 3 seconds.
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.

Rearm Condition	Gear is lowered, or radar altitude ≥150 feet AGL, or IAS ≥60 knots, or the Landing Gear Reset switch is pressed. The alert lamp is turned off.

PRIORITY 7 WARNING: Tail Strike warning issued whenever a potential tail strike is detected. This warning is enabled when the helicopter is in the air. If the tail strike warning criteria are violated, the following GPWS warning is issued:

Aural Warning	"TAIL" warning repeated every 3 seconds.
Visual Warning	GPWS ALERT lamp on the caution/advisory panel illuminates and stays lit.
Rearm Condition	Initial warning conditions no longer violated. The alert lamp is turned off.

Note

Lower priority will not occur until higher priority has been cleared.

GPWS Operating Procedures

1. Ensure helicopter essential ac power is on.

Note

If any avionics signals are missing, a GPWS FAULT may be heard upon initial power up.

2. Turn on the RAD ALT. Turn the control knob labeled PUSH TO TEST clockwise from OFF and ensure the test switch is in the flight mode.

3. Ensure GPWS circuit breakers are on.

Note

The following power up annunciations will be heard:

a. "WHOOP WHOOP PULL UP PULL UP"
b. "BANK ANGLE BANK ANGLE"
c. "GPWS READY" or "GPWS FAULT" or "GPWS INPUT FAULT"

Visual warning: None

4. If "GPWS READY" is heard, and the GPWS caution/advisory panel lamps are extinguished, the GPWS is operating normally and is operational.

The GPWS processor is located on top of the right cabin circuit breaker panel. The ADC is in the left electronics bay. Power is supplied to the system via circuit breakers in the pilot's No. 3 primary ac bus, GPWS (CB22 115V) and GPWS (CB39 26V); and No. 3 primary dc bus GPWS (CB66 28V). The system has Built-In Test (BIT) functions that are initiated (I-BIT) at system turn-on and periodically (P-BIT) thereafter. On the ground, BIT indications are aural through the aircrew ICS headsets and visual via the GPWS INOP indicator on the pilot's advisory panel. In air, BIT indications are visual only.

2.28.2 Air Data Computer. The Air Data Computer (ADC) receives inputs from various helicopter sensors. Any position or systematic error in these inputs is corrected in the ADC. These corrected signals are used to compute accurate air data. ADC outputs are used for altitude reporting and unsafe landing warning.

CHAPTER 3
Aircraft Servicing

3.1 FUELING

Fueling equipment will be operated only by qualified and authorized personnel. The aircrewman is responsible for refueling his assigned helicopter after each flight, and visually checking that the proper type fuel is used. Loose pyrotechnics, smoking, striking matches, working on helicopter, or the use of any device producing flame within 50 feet of the helicopter is strictly prohibited. The helicopter should not be parked near possible sources of ignition such as blasting, drilling, or welding operations. A minimum of 50 feet should be maintained from other aircraft or structures and 75 feet from any operating radar set. All radio switches and electrical equipment will be turned off and a check made to be sure that no electrical apparatus, supplied by outside power (electrical cords, droplights, floodlights, etc.), are in or near the helicopter. Safety flashlights shall be used in place of helicopter lights for night fueling operations. During all fueling operations, fire extinguisher equipment will be readily available. Electrical power will have to be applied to the helicopter to obtain fuel quantity gage readings.

3.1.1 Pressure Fueling. Pressure refueling does not require electrical power for refueling the main fuel tanks (Figure 3-3). However, electrical power is required to refuel the external auxiliary fuel tanks. Always be sure that the helicopter is in a level attitude so that the maximum amount of fuel will enter the tanks. Make sure pressure from the fueling source is not over 55 psi, before beginning fueling. Before fueling, the helicopter and refueling unit grounding devices should be inspected by fueling personnel for proper ground. The system will automatically shut off when the tanks are full. Refer to Figure 3-3 for instructions regarding the pressure refueling precheck and appropriate warnings. Pressure refueling through the air refuel probe can be accomplished through extended or retracted probe utilizing a ground refueling adapter.

CAUTION

- When pressure refueling, fuel tank quantities should be monitored closely as the high-level shutoff valves may not secure refueling and a fuel spill will ensue.
- Continuing to fill either main tank after its companion tank is full, may result in a fuel spill despite proper operation of the high level sensors. Refueling should be managed so that both companion fuel tanks (i.e., #1 main and #2 left main or #3 main and #2 right main) reach capacity at the same time. If this is not possible, refueling to the sponson should be secured when either tank reaches capacity.

3.1.1.1 Pressure Refueling with Rotors Engaged. These procedures describe hot refueling operations (rotors engaged, engines operating) from a Marine Tactical Airfield Fueling Dispensing System (TAFDS), aboard ship, from a fuel truck, or any other single-point pressure refueling system. Except in tactical situations, all personnel except the pilot, copilot, and necessary refueling personnel shall disembark from the helicopter and move at least 50 feet away. Necessary radio and electrical equipment may be on.

1. The aircrewman will refuel the helicopter, making sure that the proper type fuel is used, and that the helicopter and single-point nozzle are properly grounded.

2. The pilot is responsible for positioning the helicopter in the fueling area, clear of all obstructions.

3.1.1.2 Pressure Partial Refueling. Normal pressure refueling procedures are used when a small quantity of fuel is required. If the tanks are not to be filled, the amount of fuel necessary will have to be determined by the fuel gage reading. This amount will then have to be read from the fuel counter on the refueling unit.

3.1.2 Gravity Fueling. The helicopter is gravity-fueled through filler caps on top of each sponson and the access panels on the auxiliary fuel tanks. Before fueling, grounding devices on the helicopter and drag chains on the fuel truck will be inspected by fueling personnel, to be sure of proper ground. Before using a fuel hose, the hose nozzle must be grounded to some metal part of the helicopter remote from the fuel tanks, to be sure that no static differential exists. Before removing the filler caps, attach the hose nozzle grounding attachment into the grounding jack above each sponson between the cabin windows. Remove the filler cap of one fuel tank at a time. Replace it immediately after filling the tank, and before removing the cap of the other tank. If dual fuel equipment with a full complement of personnel is available, more than one tank may be serviced simultaneously. Take care that the refueling nozzle is of the proper length and diameter, and be sure that the refueling hose does not damage the sponson.

3.1.3 Fuel Control Density Selector. The normal setting of the fuel control density selector is No. 4 for JP-4, JP-5, and JP-8 fuels.

3.2 OIL SERVICING

3.2.1 Engine Oil Servicing. The helicopter shall be in a level attitude before and during servicing. In flight, engine oil tanks shall be replenished only when directed to do so by the pilot. This permits the pilot to monitor each engine's oil consumption. On the ground, to prevent overservicing, if the engine has been idle or is cold, motor the engine for 30 seconds. This scavenges oil out of the sump and returns it to the engine oil tank. Now check the ENG OIL QTY LOW caution lights to see if replenishment is necessary. The engine oil tanks shall be replenished only from the auxiliary oil system, by turning and holding the appropriate selector valve to open and operating the handpump. The engine oil tank is fully serviced when the appropriate TANK FULL light goes on. The filler necks on each engine oil tank shall not be used for servicing.

3.2.2 Gear Box Oil Servicing. The intermediate and tail rotor gear boxes each have a filler port (Figure 3-1, M and N) and a sight gage that contains a bull's-eye. The gear boxes are full when the oil level is within the bull's-eye. The oil should be replenished if the level is below the bull's-eye. The main, accessory, and nose gear boxes each have a filler port (Figure 3-1; J, E, and D) and a dipstick. The gear boxes are full when the FULL mark is reached on the dipstick.

3.3 HYDRAULIC SERVICING

The utility hydraulic system and the first and second stage flight control hydraulic systems are serviced in the same manner; however, servicing is done at each system's ground service panel, using a hydraulic servicing unit. Attach the hose of the hydraulic servicing unit to the fill disconnect on the appropriate service panel and pump fluid until the indicator shows green (safe).

Note

- The fill disconnect is the smaller of the three quick-disconnects on each panel.
- Make certain that the servicing unit hose is full of fluid before connecting it to the panel.
- For ground servicing, the reservoir indicator should be used to determine proper fluid level. The cockpit quantity indicator should be used for in-flight monitoring of proper reservoir fluid level.
- A properly serviced system could indicate an overfilled or underfilled condition depending on ambient or system temperature (as, when temperature increases, fluid expands).

On those aircraft modified by AFC 383, an in-flight hydraulic servicing system has been incorporated. The utility and first and second stage flight control hydraulic systems can be serviced in flight from the hydraulic refill reservoir. With the refill system selector valve, select the hydraulic system to be serviced. While continuously depressing the selector valve, replenish fluid with the handpump until the respective cockpit hydraulic quantity gauge indicates green.

3.4 WINDSHIELD WASHER SERVICING

The windshield washer system is serviced by filling the reservoir (Figure 3-1, Z) behind the copilot's seat.

3.5 FIRE EXTINGUISHER SERVICING

The fire extinguisher containers are removed when they have been emptied for any reason, and are replaced with fully serviced units.

3.6 APP SERVICING

The APP has a filler port (Figure 3-1, W) and a dipstick. The oil system level is indicated by a dipstick.

3.7 EXTERNAL ELECTRICAL POWER REQUIREMENTS

The helicopter requires 115/200 volt, three-phase, 400 Hz ac external power. The ac external power receptacle is on the right side of the helicopter, forward of the personnel door and below the pilot's window. The helicopter does not have a dc external power receptacle.

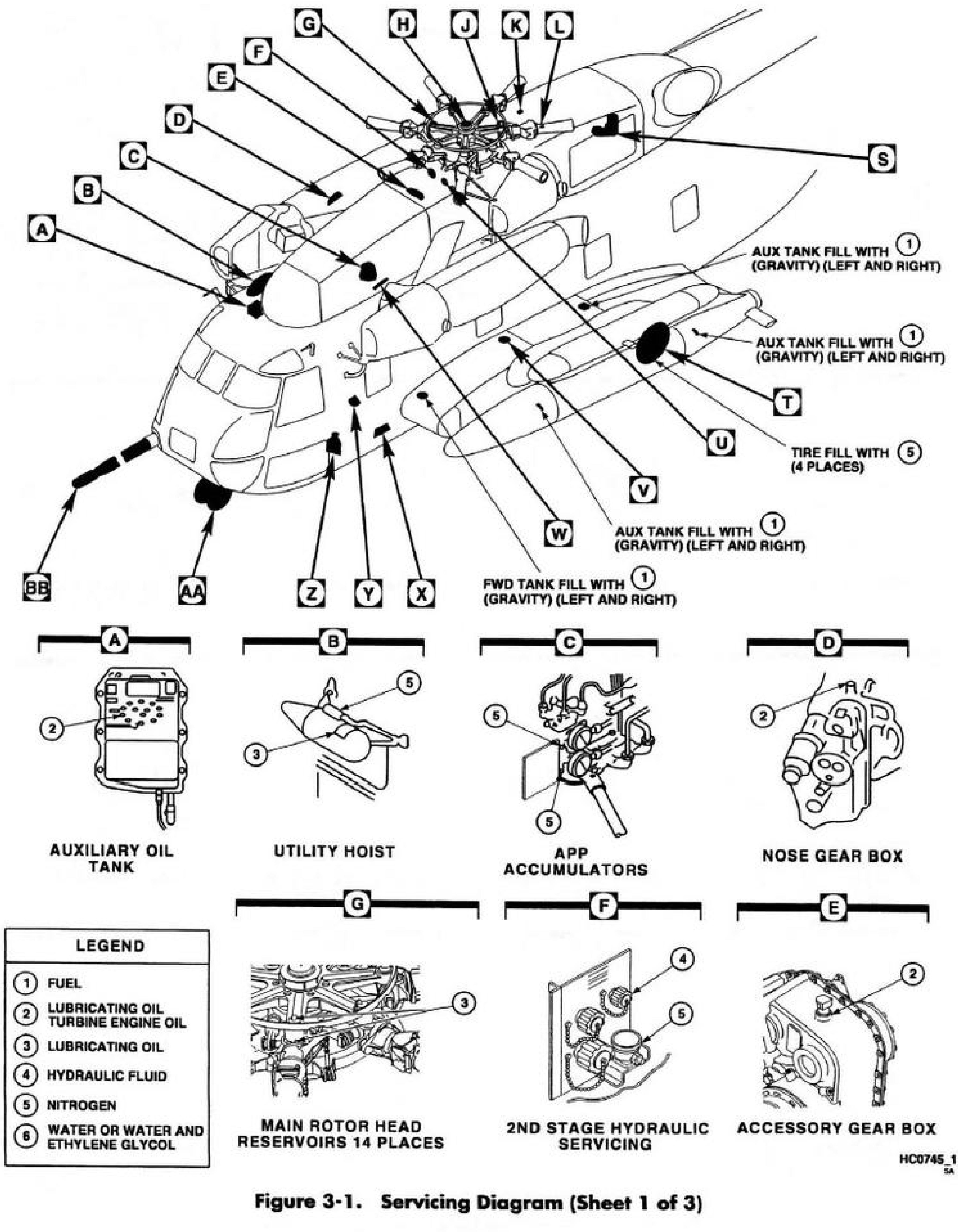


Figure 3-1. Servicing Diagram (Sheet 1 of 3)

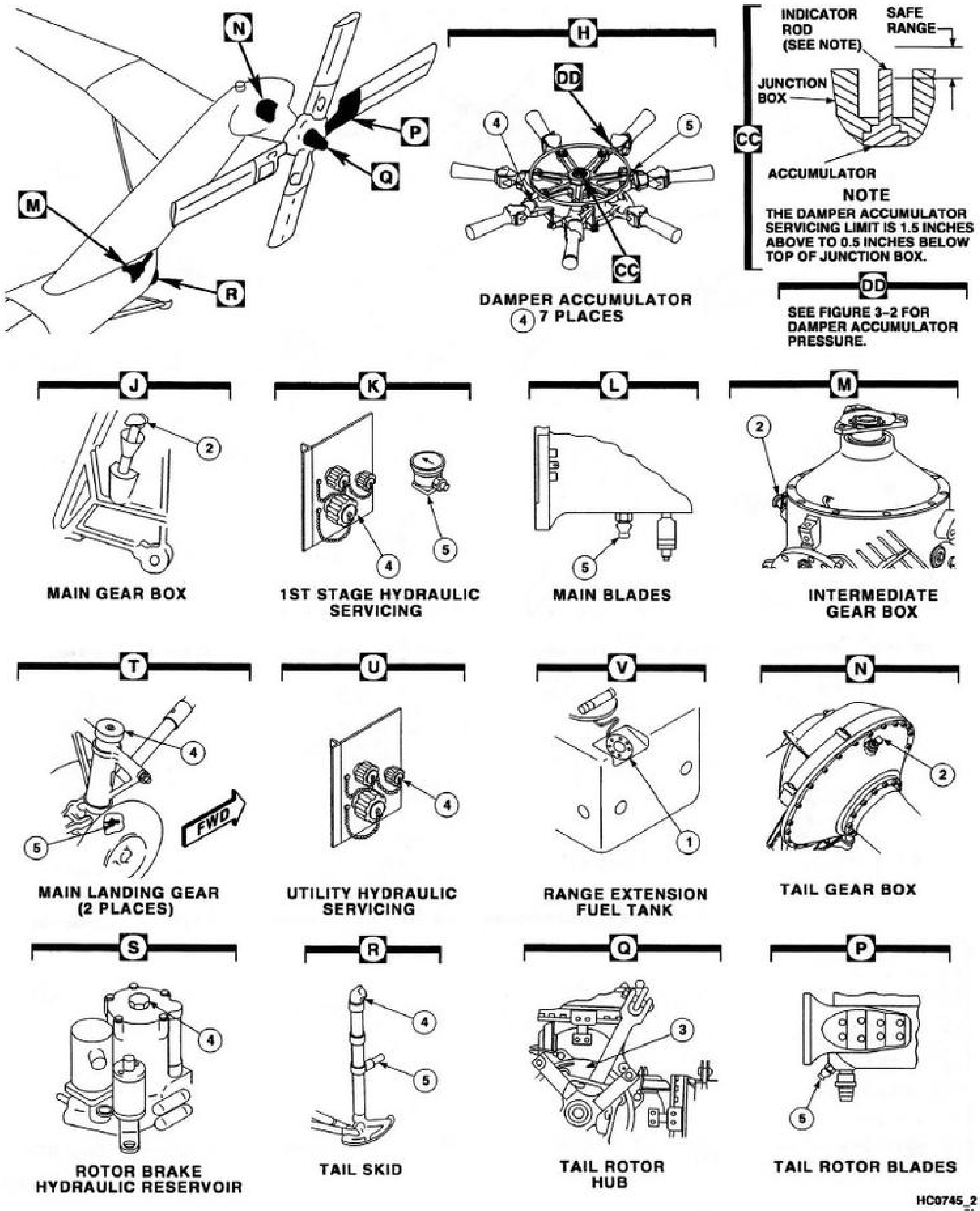


Figure 3-1. Servicing Diagram (Sheet 2 of 3)

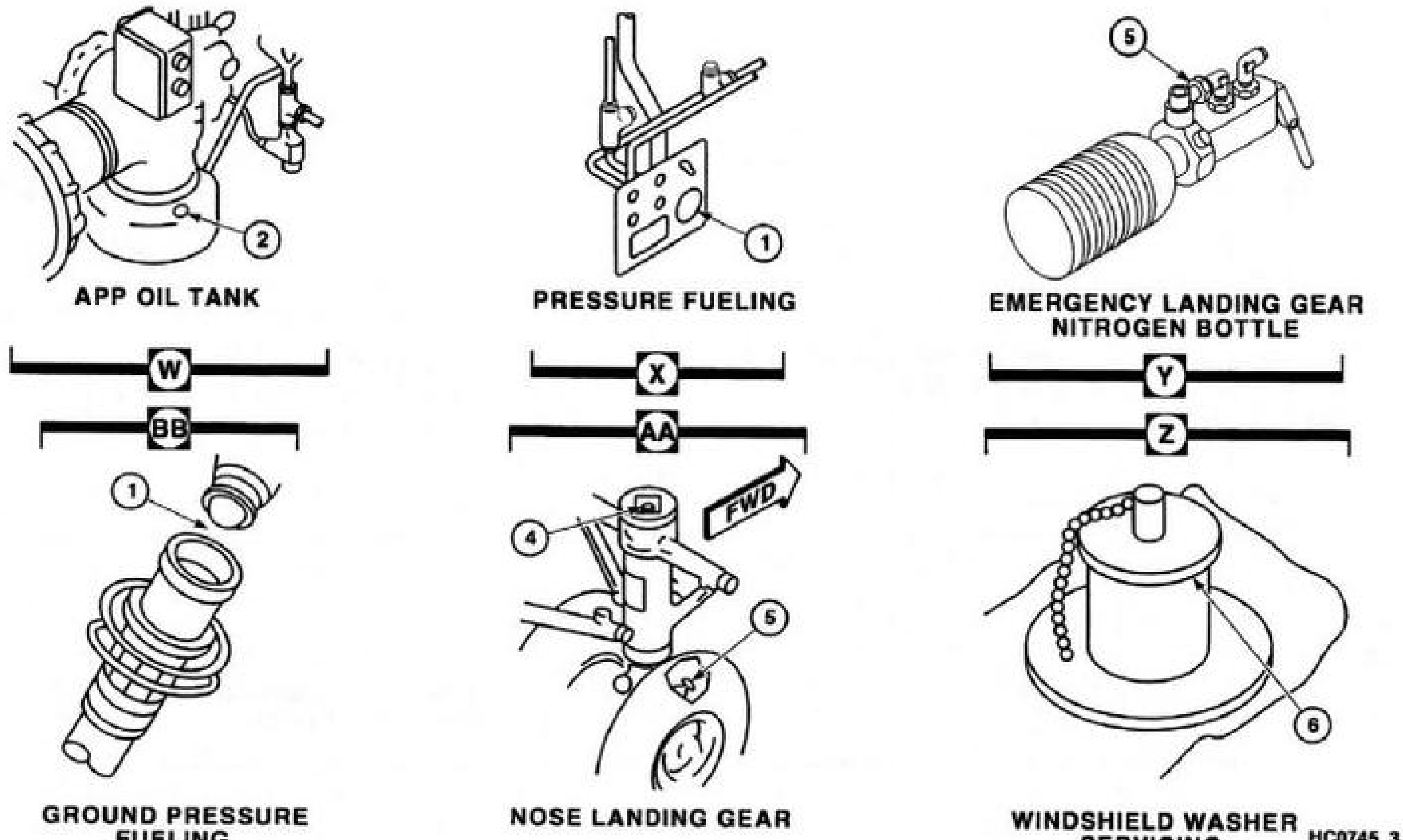


Figure 3-1. Servicing Diagram (Sheet 3 of 3)

The following is a partial list of external power sources which provide 115/200 volt, three-phase, 400 Hz ac power.

USN	USAF	CANADIAN
NC-2A	B-10	CAN-C (same as USN NC-5)
NC-5	B-10A	
NC-6A	B-10B	
NC-7	MD-3	
NC-7A	MD-3A	
NC-7B	M32A-10	
NC-7C	M32A-13	
NC-10		
NC-10B		
NC-12		
NC-12A		

3.8 GROUND HANDLING PROCEDURES

Due to the top-heavy configuration of the helicopter, precautions must be observed during all helicopter movement to prevent possible damage. When feasible, the helicopter will be moved with a tractor using an approved tow bar. Towing equipment shall be operated only by qualified personnel, who will be responsible for checking the approved towing couplings before towing. Towing shall not begin until a qualified individual is in the cockpit and ready to operate the brakes. When towing a helicopter, three wing walkers shall be used. A wing walker shall be stationed on each side of the helicopter, and another near the tail rotor, for adequate clearance. In addition, towing shall be supervised by a director with a whistle. During night towing operations, wing walkers shall carry a flashlight or luminous wand. All stop signals shall be given by a whistle or hand signal. Whistle signals should be supplemented by hand signals when possible. Wheel brakes shall be applied as soon as a stop signal is received from the director. See Figure 3-5 for turning radius.

CAUTION

Towing speeds shall not be over 5 miles-per-hour, and sudden stops and starts will be avoided.

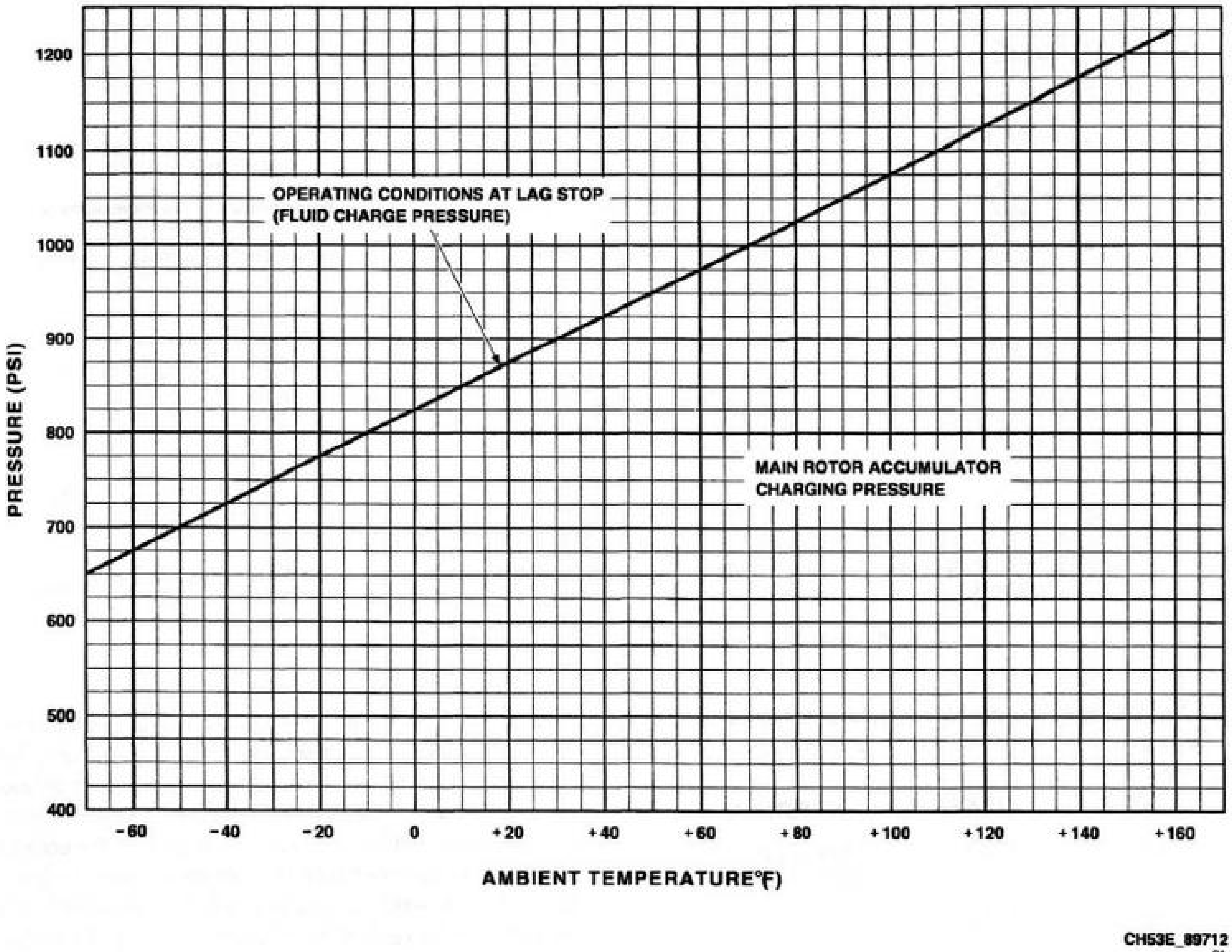


Figure 3-2. Damper Accumulator Pressure

3.9 TIEDOWN PROCEDURES

Helicopters, when tied down as directed, can withstand winds up to 60 knots. If winds above 60 knots are forecast, it is recommended that the helicopter be placed in a hangar or safe weather area. If winds are forecast to be above 60 knots and no safe area is available, remove the main rotor blades, conditions permitting, to prevent damage to blades and rotor head. The helicopter has tiedown rings on the aft outboard side of each sponson and below the pilot's and copilot's windows (Figure 3-6). Except during the cold weather operations, because of freezing due to condensation, the helicopter will have the parking brake set when tied down for high wind conditions. See Figure 3-7 for tiedown techniques.

CAUTION

- To prevent overtightening due to moisture absorption, there should be enough slack in all tiedown ropes.

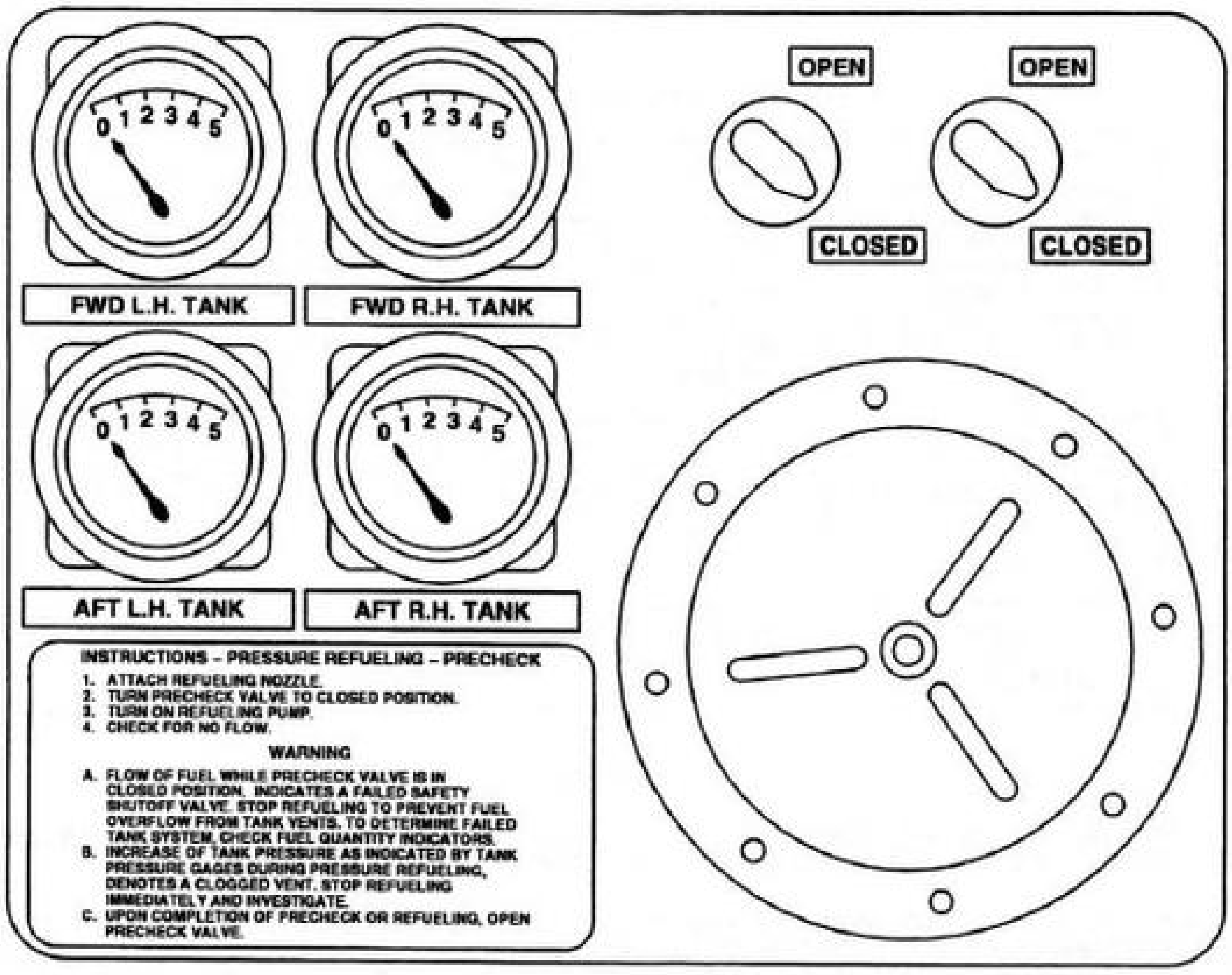


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Figure 3-3. Pressure Refueling Panel

- The helicopter should be positioned with the nose into the wind during high wind conditions.
- During high wind conditions the pitch locks should be engaged.

CH-53 FUEL REFERENCE CHART

MIL CODE	SPEC	COMMERCIAL CODE	BRITISH GRADE	NATO	ADD PRIST	WT	NOTES
JP-4	MIL-T-5624	JET B	AVTAG	F-40	YES	6.5	1,2,3C,5,7
JP-4*	NONE	JET B	NONE	F-42	NO	6.5	1,2,3C,5,7
JP-5	MIL-T-5624	JET A JET 40/50 JET 5	AVTOR-50	F-30 F-34 F-44	YES	6.8	1,2,3A,6
JP-5*	NONE	NONE	NONE	F-43	NO	6.8	1,2,3B
JP-8	MIL-T-83133	JET A JET A-1 JET 40/50 JET 5	AVTOR-50	F-34	YES	6.7	1,2,3A,6
JP-8*	NONE	NONE	NONE	F-35	NO	6.7	1,2,3B,5
*ALTERNATE FUELS							

NOTES

1. A U.S. MILITARY FUEL WHICH IS ESSENTIALLY IDENTICAL TO THE NATO AND / OR COMMERCIAL FUEL(S) LISTED EXCEPT THAT THE U.S. MILITARY FUEL CONTAINS ADDITIVES. SEE NOTE 2 BELOW.

2. COMMERCIAL FUELS ARE COMMONLY MADE TO CONFORM TO THE AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM), SPECIFICATION D-1655. THE ASTM FUEL SPECIFICATION DOES NOT CONTAIN ANTI-ICING ADDITIVES UNLESS SPECIFIED. AN ICING INHIBITOR SHALL BE ADDED TO COMMERCIAL AND NATO FUEL NOT CONTAINING AN ICING INHIBITOR DURING REFUELING OPERATIONS, REGARDLESS OF AMBIENT TEMPERATURES. ADDING PRIST DURING THE REFUELING OPERATION SHALL BE DONE USING ACCEPTED COMMERCIAL MIXING PROCEDURES. THE ADDITIVE PROVIDES ANTI-ICING PROTECTION AND ALSO FUNCTIONS AS A BIOCIDE TO KILL MICROBIAL GROWTHS IN HELICOPTER FUEL SYSTEMS.

3. A. PRIMARY FUEL - A FUEL FOR WHICH THE HELICOPTER WAS DESIGNED TO USE FOR CONTINUOUS UNRESTRICTED OPERATIONS.

   B. ALTERNATE FUEL - A FUEL WITH WHICH THE HELICOPTER CAN BE FLOWN WITHOUT OPERATIONAL RESTRICTIONS, BUT WHICH MAY HAVE A LONG-TERM DURABILITY OR MAINTAINABILITY IMPACT IF USED FOR CONTINUOUS OPERATIONS (MULTIPLE FLIGHTS).

   C. RESTRICTED FUEL - A FUEL WHICH IMPOSES OPERATIONAL RESTRICTIONS ON THE HELICOPTER WHEN USED. THESE FUELS MAY BE USED ONLY IF NO PRIMARY OR ALTERNATE MILITARY OR COMMERCIAL FUEL IS AVAILABLE.

CAUTION

ANY HELICOPTER SCHEDULED FOR IMMEDIATE SEA DUTY SHOULD BE FUELED WITH F-44 (JP-5) OR F-43 ONLY. THIS RESTRICTION IS NECESSARY TO ENSURE SHIPBOARD SAFETY.

4. SHOULD NOT BE USED AS SUBSTITUTE FOR JP-4 / 5 FOR HIGH ALTITUDE-MAXIMUM RANGE MISSION DUE TO HIGH FREEZE POINT OF FUEL. IF CARRIED EXTERNALLY, TRANSFER AS SOON AS PRACTICAL.

5. SHALL NOT BE DEFUELED INTO JP-5 STORAGE ABOARD SHIP DUE TO RELATIVELY LOW FLASHPOINT.

6. MAY ALSO BE DESIGNATED JP-1 BY COMMERCIAL SUPPLIERS.

7. EQUIVALENT TO F-40 (JP-4) EXCEPT FREEZE POINT OF JET B IS -60°F VICE -76°F.

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Figure 3-4. Servicing Summary Table (Sheet 1 of 2)

PRIMARY PRODUCT			ACCEPTABLE SUBSTITUTE		
SYSTEM	MIL SPEC	NATO CODE	MIL SPEC	NATO CODE	CAPACITY
ENGINE OIL (2)	MIL-L-23699	0-156			Engine: 2.8 U. S. gals Aux: 2.6 U. S. gals
APP	MIL-L-23699	0-156			0.75 U. S. gals
MAIN TRANSMISSION	DOD-L-85734		MIL-L-23699	0-156	20.0 U. S. gals
INTERMEDIATE GEAR BOX	DOD-L-85734		MIL-L-23699	0-156	3.25 qts
TAIL GEAR BOX	DOD-L-85734		MIL-L-23699	0-156	6.75 qts
ACCESSORY GEAR BOX	DOD-L-85734		MIL-L-23699	0-156	8.0 qts
NOSE GEAR BOX	DOD-L-85734		MIL-L-23699	0-156	5.5 qts
FIRST-STAGE HYDRAULIC	MIL-H-83282		MIL-H-5606	H-515	0.65 U. S. gals
SECOND-STAGE HYDRAULIC	MIL-H-83282		MIL-H-5606	H-515	0.65 U. S. gals
UTILITY HYDRAULIC	MIL-H-83282		MIL-H-5606	H-515	3.68 U. S. gals
ROTOR BRAKE HYDRAULIC	MIL-H-83282		MIL-H-5606	H-515	0.09 U. S. gals
DAMPER ACCUMULATOR					
RESCUE HOIST	MIL-L-7808		MIL-L-23699 (above -40°F (-40°C) only)	0-156	0.31 U. S. gals
CARGO WINCH	MIL-L-23699	0-156			0.054 U. S. gals
WINDSHIELD WASHER SYSTEM	WATER AND ALCOHOL, FED SPEC TT-1-735		WATER, ETHYLENE GLYCOL, MIL-E-9500		1.5 U. S. gals
FIRE EXT. BOTTLES (replace), LANDING GEAR BLOW-DOWN BOTTLE (3000 psi), APP ACCUMULATOR PRECHARGE (1600 to 1700 psi), BLADE DAMPER ACCUMULATOR PRECHARGE (910 psi at 60°F)	MIL-N-6011		MIL-N-6011 GRADE A, TYPE I or II		
1st, 2nd STAGE ACCUMULATOR PRECHARGE (1000 psi with accumulator piston bottomed)	MIL-N-6011		MIL-N-6011 GRADE A, TYPE I or II		
ENGINE, APP, and HEATER COMPARTMENT FIRE EXTINGUISHER SYSTEM (replace)	CF_3BR (MONOBROMOTRIFLUOROMETHANE)				
MAIN ROTOR HEAD, SLEEVE AND SPINDLE RESERVOIRS	MIL-L-21260 GRADE 50	C-642	MIL-L-2105 TYPE 1, GRADE 80/90		0.12 U. S. gals
TAIL ROTOR HUB RESERVOIR	MIL-L-21260 GRADE 50	C-642	MIL-L-2105 TYPE 1, GRADE 80/90		MAX on SIGHT GAUGE
MAIN ROTOR HEAD DAMPERS	MIL-H-83282		MIL-H-5606	H-515	

Figure 3-4. Servicing Summary Table (Sheet 2 of 2)

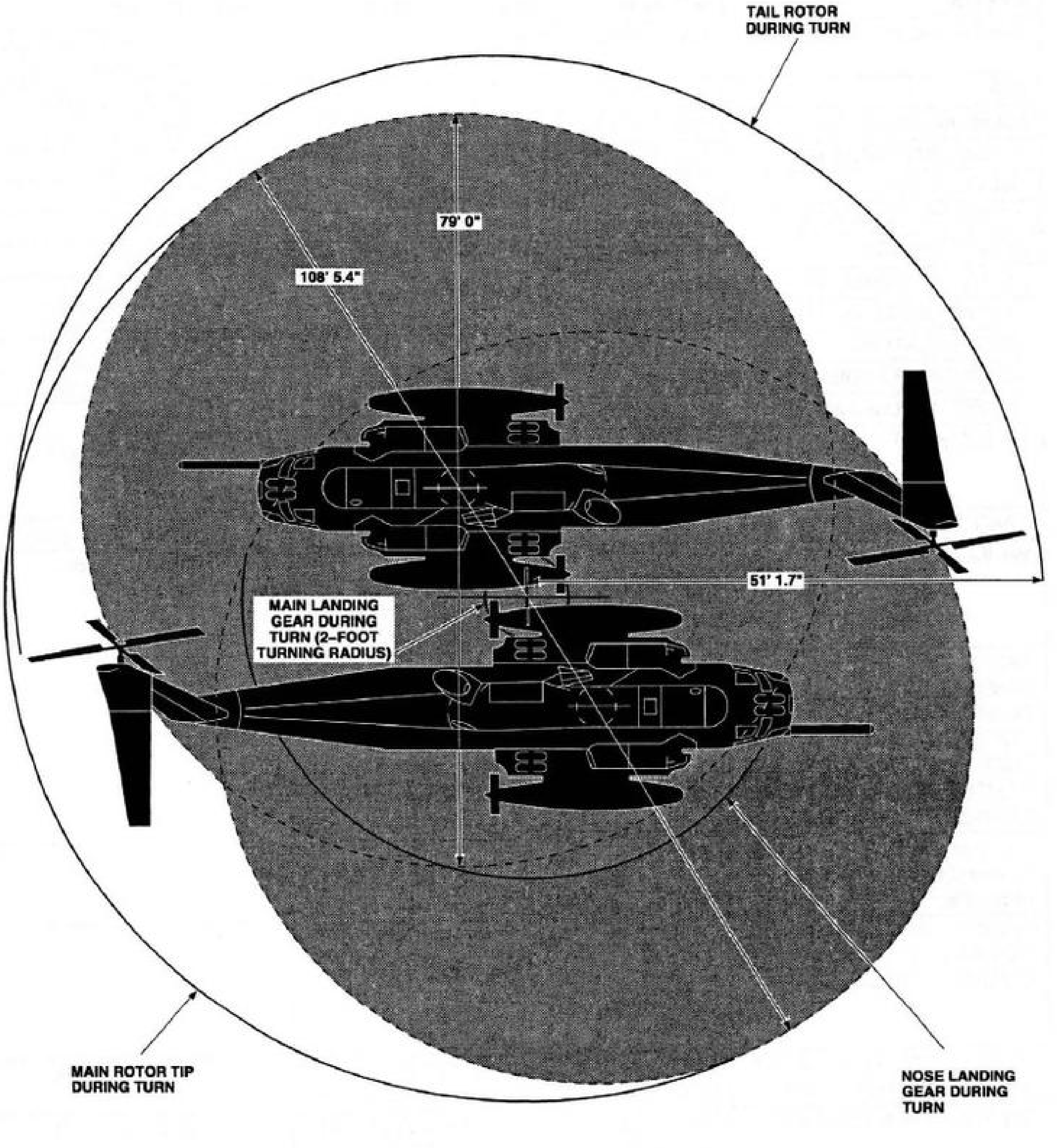


Figure 3-5. Turning Radius Diagram

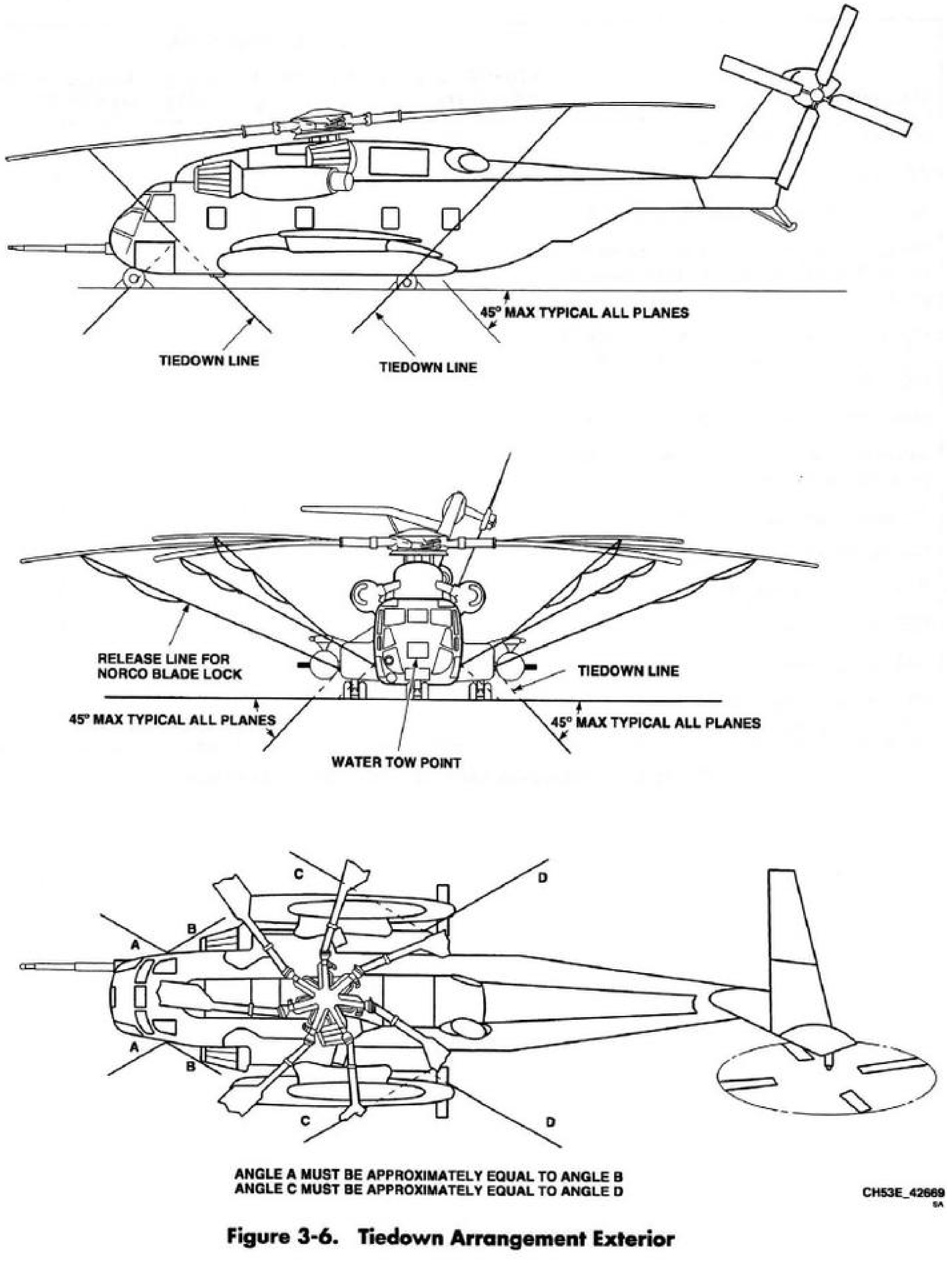


Figure 3-6. Tiedown Arrangement Exterior

TECHNIQUE	WIND CONDITION WINDS UNDER 45 KNOTS	WINDS BETWEEN 45 AND 60 KNOTS	WINDS ABOVE 60 KNOTS
Helicopter parked into wind	X	X	X
All wheels chocked	X	X	X
Front and rear chocks secured to each other		X	X
Helicopter chained to deck with at least 4 chains (where satisfactory deck tiedown points exist)		X	
Helicopter chained to deck with at least 8 chains (where satisfactory deck tiedown points exist)			X
Main rotor blades spread and tied down	X		
Main rotor blades folded and secured, and pylon folded and secured		X	
Mechanical gust lock engaged	X	X	X
Fuel tanks filled to capacity		X	X
Protective covers installed	X	X	X
Parking brakes set	X	X	X
Deflate shock struts		X	X
Main rotor blades removed and pylon folded and secured			X

Figure 3-7. Tiedown Technique vs. Wind Condition

CHAPTER 4
Aircraft Operating Limitations

4.1 MINIMUM CREW REQUIREMENTS

The minimum crew required to operate the helicopter under normal conditions is a pilot, copilot, and aircrewman. Additional crewmembers as required may be added at the discretion of the commanding officer.

4.2 SYSTEM OPERATING LIMITATIONS

Note

Should any system operating limit be exceeded, a Maintenance Action Form regarding the exceeded parameter and duration shall be completed.

4.2.1 Engine Operating Limitations. Engine operating limitations are illustrated in Figures 4-1 and 4-2 and are independent of one another. Whichever limit occurs first is the limit to be observed. Refer to the appropriate performance charts in Part XI to determine limitations under specific operating conditions. When the engine anti-icing system is being used, each engine will lose 3% of its power at maximum power.

4.2.1.1 Engine Torque Shaft Limits. No steady state combination of torque and speed shall exceed 4600 horsepower (144% torque at 100% N_f). See Figure 4-2.

4.2.1.2 Engine Operating Limits. N_g is limited to 60.5% to 100% for normal operation. The maximum allowable transient overspeed, 102.5% N_g is limited to not more than 30 seconds of operation. The T_5 is limited to 773°C (T64-416) or 792°C (T64-416A) for a maximum operation of 10 minutes. Both power plants are limited to 753°C for military operations of 30 minutes and 713°C for maximum continuous operation. If the time limit of a particular operating range (as, maximum or military power) is reached, the T_5 should be reduced to within the next lower range for about 1 minute before resuming operations in that particular range. Care must be taken not to exceed 30 minutes above military power without reducing T_5 to below 713°C for 1 minute. Momentary overtemperatures to 900°C are allowed. During post engine shutdown, T_5 should not be over 320°C. A momentary peak is a transient high-temperature condition of short duration, where the temperature peaks and falls off, either automatically or through corrective action. Any observed or suspected overtemperature shall be recorded, including maximum T_5 obtained and the time period over which the overtemperature occurred, for use by maintenance.

4.2.1.3 Engine Overspeeds

4.2.1.3.1 Gas Generator (N_g). If the maximum allowable N_g of 100% to 102.5% for 30 seconds is exceeded, the engine will require an overhaul. The engine will also require an overhaul any time 102.5% N_g is exceeded for any time period.

4.2.1.3.2 Power Turbine (N_f). If the maximum allowable N_f overspeed of 125% for 5 seconds is exceeded, the engine will require an overhaul. The engine will also require an overhaul any time 129% is exceeded for any time period.

Note

The quad tachometer does not read in excess of 130% N_f.

4.2.2 Rotor and Transmission Limitations. Normal operating limitations of the rotor and transmission systems are shown in Figures 4-1 and 4-2. However, rotor system overspeed imposes a severe load on the rotor and transmission systems and should be noted on the appropriate forms.

Note

The quad tachometer does not read in excess of 130% N_r.

When an overspeed condition occurs, this is required:

1. 118% to 129% N_r. Visual inspection of the main rotor hub, tail rotor hub, tail drive shafts, accessory drive shaft, and tail disconnect coupling jaw teeth. The nose to main gear box drive shaft will also require a visual inspection if the engine(s) has oversped.

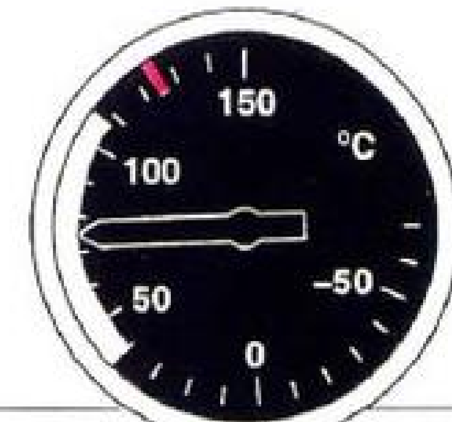
2. In excess of 129% N_r. Remove main rotor hub, tail rotor hub, and tail disconnect coupling. Disassembly inspection of tail drive shafts and accessory drive shaft. The nose to main gear box drive shaft will require a

POWER TURBINE INLET TEMPERATURE

- (red) 792 °C MAX FOR 10 MINS (T64-416A)
- (red) 773 °C MAX FOR 10 MINS (T64-416)
- (red) 753 °C MILITARY FOR 30 MINUTES
- (red) 713 °C MAXIMUM CONTINUOUS

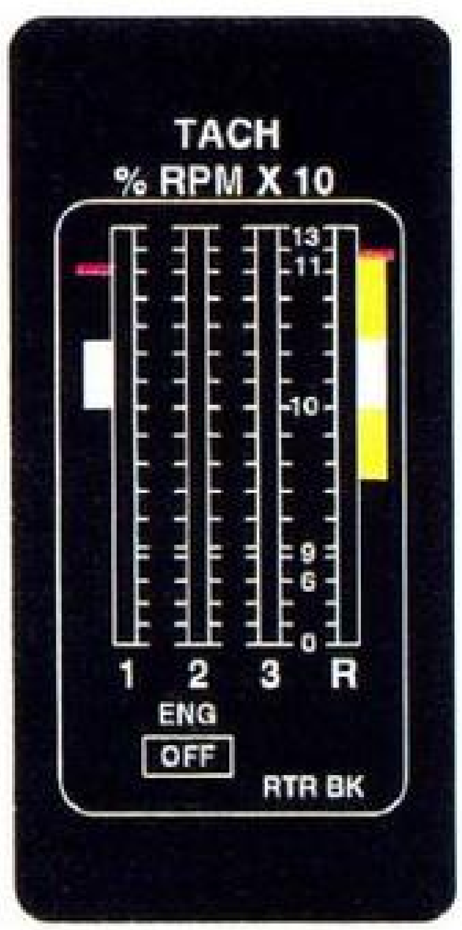
GAS GENERATOR TACHOMETER

- (white) 60.5% TO 100% NORMAL
- (red) 100% MAXIMUM
- (red) 102.5% MAXIMUM FOR 30 SECONDS



ENGINE OIL TEMPERATURE

- (white) 40° TO 107 °C NORMAL
  108 °C TO 125 °C FOR
  30 MINUTES
- (red) 125 °C MAXIMUM



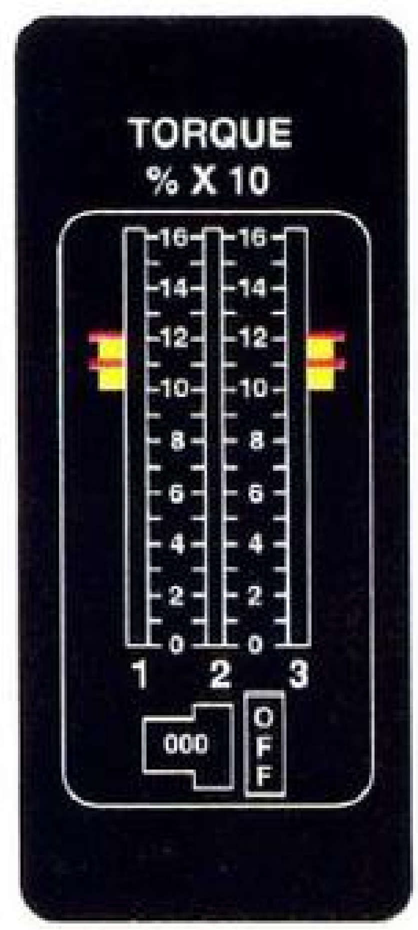
QUADRUPLE TACHOMETER

POWER TURBINE TACHOMETER

- (white) 100% TO 105% NORMAL
- (red) 110% MAXIMUM

ROTOR TACHOMETER

- (yellow) 95% TO 100% PRECAUTIONARY RANGE
- (white) 100% TO 105% NORMAL FOR GW LESS THAN 50,000 LBS.
- (white) 103 TO 105% NORMAL FOR GW 50,000 TO 73,500 LBS.
- (yellow) 105% TO 118% PRECAUTIONARY RANGE
- (red) 118% MAXIMUM



TORQUEMETER

- (yellow) 100% TO 137% PRECAUTIONARY RANGE
- (red) 121% MILITARY FOR 30 MINUTES
- (red) 110% CLIMB POWER AT LESS THAN 60,000 LBS.

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Figure 4-1. Instrument Range Markings (Sheet 1 of 3)

NO. 3 ENGINE NOSE GEAR BOX OIL TEMPERATURE

- 40° TO 120° C NORMAL
- 145° C MAXIMUM

NO. 1 ENGINE NOSE GEAR BOX OIL TEMPERATURE

- 40° TO 120° C NORMAL
- 145° C MAXIMUM

MAIN TRANSMISSION OIL TEMPERATURE

- 40° TO 120° C NORMAL
- 145° C MAXIMUM

MAIN TRANSMISSION OIL PRESSURE

- 25 PSI MINIMUM
- 50 TO 65 PSI NORMAL
- 150 PSI MAXIMUM

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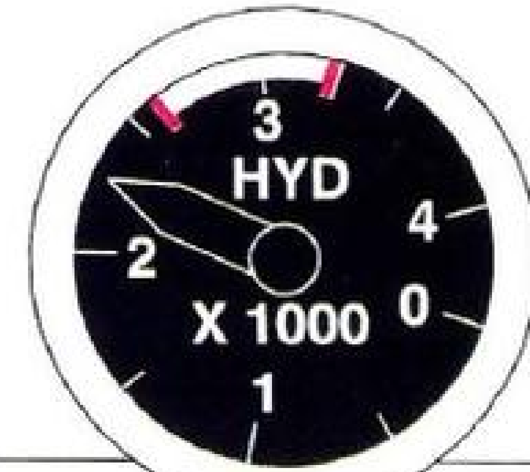
Figure 4-1. Instrument Range Markings (Sheet 2 of 3)

HYDRAULIC PRESSURE
1st STAGE

- 2600 PSI MINIMUM
- 2600 TO 3300 PSI NORMAL
- 3300 PSI MAXIMUM

HYDRAULIC PRESSURE
2nd STAGE

- 2600 PSI MINIMUM
- 2600 TO 3300 PSI NORMAL
- 3300 PSI MAXIMUM



UTILITY
HYDRAULIC PRESSURE

- 2600 PSI MINIMUM
- 2600 TO 3300 PSI NORMAL
- 3300 PSI MAXIMUM

AIRSPEED

- 150 KIAS MAXIMUM

140 KIAS – MAXIMUM LANDING GEAR ACTUATION SPEED

150 KIAS – MAXIMUM LANDING GEAR EXTENDED SPEED

APP P-7-2

EXHAUST TEMP

- 621° MAXIMUM

RPM

- 110% MAXIMUM

102 ± 1%
(GENERATORS OFF)
(Nr 95% OR LESS)

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Figure 4-1. Instrument Range Markings (Sheet 3 of 3)

RATING	DURATION	% Q/ENGINE	HP @ 100% N_r
	THREE-ENGINE OPERATION		
TRANSIENT OVERTORQUE	5 SECONDS 1 MINUTE	160† 144†	15,360 13,800
MAXIMUM	10 MINUTES	137*	13,140
MILITARY	30 MINUTES	121*	11,570
MAXIMUM CONTINUOUS	—	100*	9600
	DUAL-ENGINE OPERATION		
TRANSIENT OVERTORQUE	5 SECONDS 1 MINUTE	160† 144†	10,240 9200
MAXIMUM	10 MINUTES	137*	8760
MILITARY	30 MINUTES	121*	7712
MAXIMUM CONTINUOUS	—	100*	6400
	SINGLE-ENGINE OPERATION		
TRANSIENT OVERTORQUE	5 SECONDS 1 MINUTE	160† 144†	5120 4600
MAXIMUM	10 MINUTES	137*	4380
MILITARY	30 MINUTES	121*	3856
MAXIMUM CONTINUOUS	—	100*	3200

Note

† Engine limit (Transmission limit, 1 minute @ 160% Q)

* Transmission limit

Figure 4-2. Transmission/Engine Torque Limitations

disassembly inspection if the engine(s) have oversped. Visual inspection of all gear box chip detector plugs, strainers, and filters.

4.2.2.1 Rotor Speed (N_r) Gross Weight Limitations. 100% to 105% for gross weights less than 50,000 lbs.

103% to 105% for gross weights 50,000 to 73,500 lbs.

4.2.2.2 Rotor Blade Limitations. When N_r is over 125%, the main and tail rotor blades shall be removed.

4.2.2.3 Rotor Engagement/Disengagement. Rotors should not be engaged or disengaged in winds from any direction over 45 knots.

4.2.2.4 Blade Fold/Unfold. Blades should not be folded or unfolded in winds of over 45 knots, from any direction.

4.2.2.5 Pylon Fold/Spread. Pylon should not be folded or spread in winds of over 45 knots, from any direction. In winds over 20 knots the helicopter should be faced into the wind.

4.3 CABIN LIMITATIONS

The inboard cabin compartment floor is limited to static loads of 300 pounds per square foot. The outboard section of the floor is stressed to withstand greater loads at various positions. Refer to the Cargo Loading Manual.

4.4 AERODYNAMIC LIMITATIONS

4.4.1 Airspeed Limitations. The maximum authorized forward flight speed is 150 KIAS. For flights of 7 hours or less, do not exceed a 7-hour tail rotor BIM visual inspection. Flights longer than 7 hours require: (1) minimizing maneuvering, (2) complying with the table of maximum tail rotor BIM press-to-test intervals, and (3) performing a tail rotor BIM inspection before flight.

The maximum permissible airspeeds for normal flight regimes are as follows:

Forward flight	See Figure 4-4
Sideward flight	35 knots
Rearward flight	30 knots
External loads	150 KIAS
Landing gear actuation	140 KIAS
Landing gear extended	150 KIAS
EAPS doors closed	150 KIAS
Maneuvering flight	130 KIAS

An autorotative descent speed of 75 KIAS will produce a minimum sink rate, and 100 KIAS will provide the greatest distance. See Figures 12-13 and 12-14 for airspeeds to be observed during bailout, and the appropriate performance charts in Part XI for airspeeds associated with other flight factors.

The tail rotor blade BIM press-to-test is required every 10 flight hours. This interval can be extended for missions requiring longer duration as follows:

1. Minimize maneuvering.

2. Do not perform air combat or evasive maneuvering.

3. Comply with the following maximum tail rotor blade BIM press-to-test intervals:

AIRSPEED	DENSITY ALTITUDE	
(KIAS)	0 TO 6000 FT	ABOVE 6000 FT
up to 120	20 Hours	20 Hours
up to 130	20 Hours	12 Hours
up to 140	20 Hours	UNAUTHORIZED
up to 150	12 Hours	UNAUTHORIZED
above 150	UNAUTHO-RIZED	UNAUTHORIZED

For missions flown between 121 and 130 KIAS at multiple altitudes, the maximum tail rotor BIM press-to-test interval can be determined from Figure 4-3.

4.4.2 Angle of Bank Limitations (AOB). The maximum permissible AOB for normal flight regimes are as follows:

- GW less than or equal to 56,000 lbs and DA less than or equal to 3000 ft and A/S less than or equal to 130 KIAS — 60°
- GW less than or equal to 56,000 lbs and DA greater than 3000 ft, or GW less than or equal to 56,000 lbs and A/S greater than 130 KIAS — 45°
- GW greater than 56,000 lbs — 30°

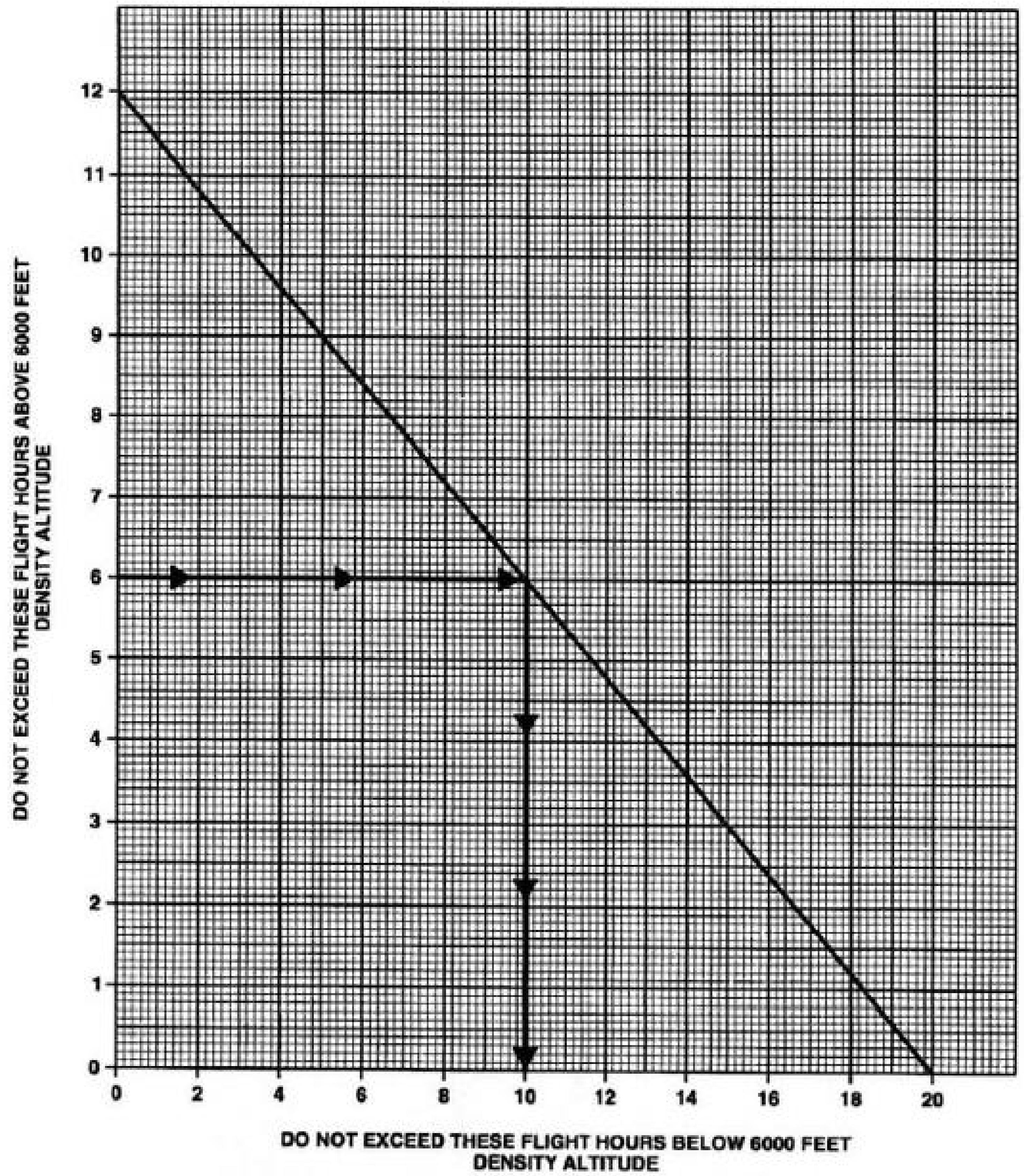
4.4.3 Acceleration Limitations. The helicopter is restricted from maneuvers which would exceed the demonstrated load factors capability. Some structural limitations are a function of gross weight, load factor and density altitude. The following acceleration limits apply:

1. GW less than or equal to 56,000 0.5 to 2.0 G lbs, and DA less than or equal to 3000 ft

2. GW greater than 56,000 lbs, or 0.5 to 1.5 G DA greater than 3000 ft

NOTE

CHART VALID ONLY BETWEEN 121 AND 130 KIAS.



EXAMPLE

ENTER THE FLIGHT TIME REQUIRED ABOVE 6000 FEET ON THE LEFT COLUMN. DRAW A HORIZONTAL LINE ACROSS UNTIL IT INTERACTS THE DIAGONAL LINE. AT THE INTERSECTION WITH THE DIAGONAL LINE, DROP DOWN AND READ THE FLIGHT HOURS AUTHORIZED BELOW 6000 FEET. THE TOTAL FLIGHT TIME AUTHORIZED IS THE SUM OF TIME ABOVE 6000 AND BELOW 6000.

FOR EXAMPLE: IF YOU WANT TO FLY ABOVE 6000 FEET FOR AN ESTIMATED 6 HOURS, ENTER THE LEFT COLUMN AT 6 HOURS AND DRAW A HORIZONTAL LINE OVER TO INTERSECT THE DIAGONAL LINE. DROP DOWN FROM THIS INTERSECTION AND READ 10 HOURS TIME AUTHORIZED BELOW 6000 FEET. TOTAL TIME IS 16 HOURS.

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Figure 4-3. Maximum Tail Rotor Blade BIM Press-to-Test Interval for Multi-Altitude Missions

MAXIMUM LEVEL FLIGHT SPEED VS DENSITY ALTITUDE

NOTE

LIMIT AIRSPEED TO 150 KIAS WHEN LATERAL CG EXCEEDS 2 INCHES.

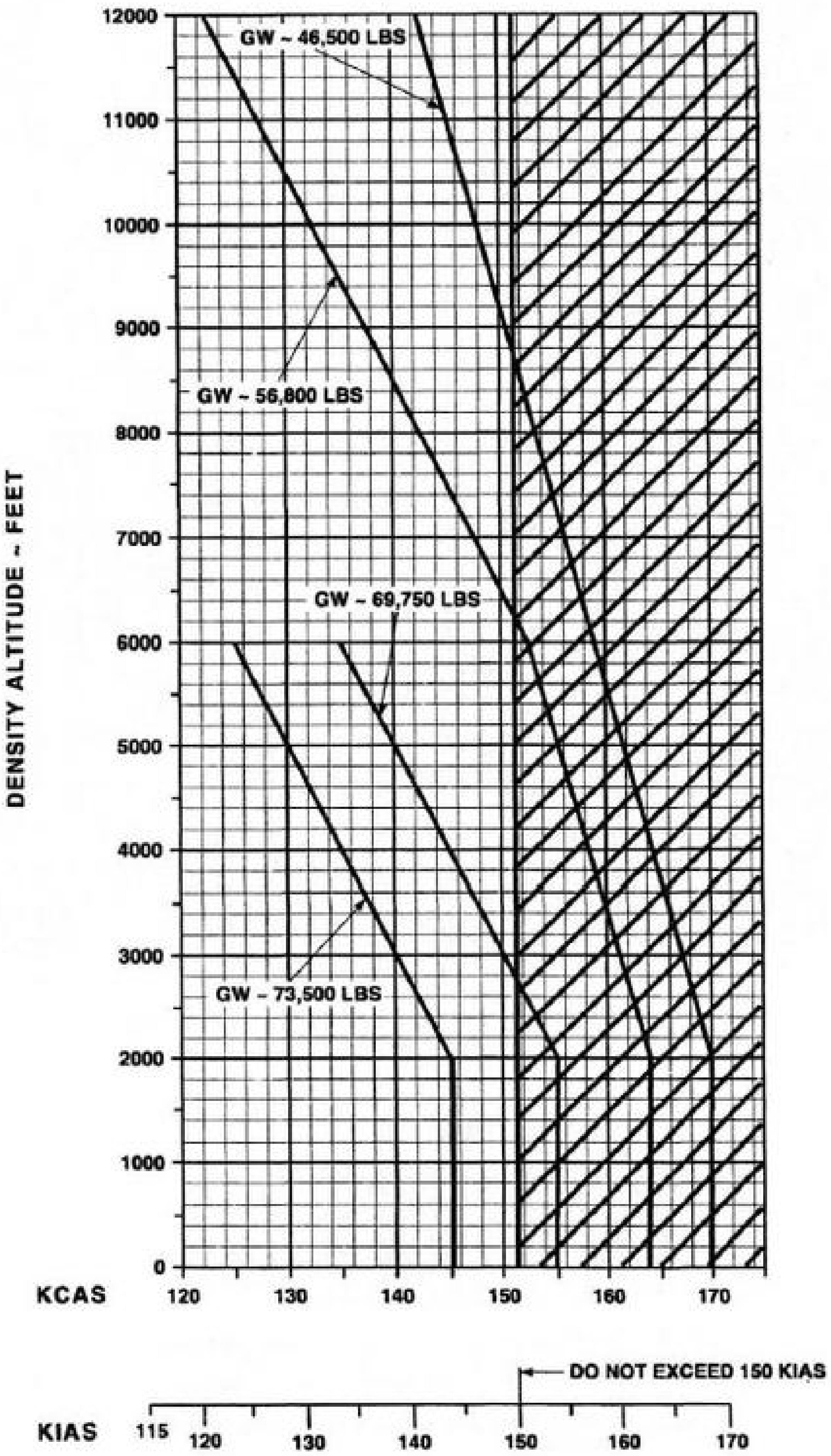

Figure 4-4. Airspeed Limitations

4.4.4 Maneuvering Flight Limitations

WARNING

- Rapid forward cyclic and reduced collective setting may cause blade/fuselage impact.
- The following conditions may indicate an inoperative desensitizer for the -109 computer configuration:

  1. DSEN fail advisory light on the AFCS control panel.

  2. AFCS is off.

  3. AFCS duplex failure.

  4. FAS shear pin is sheared.

- Loss of a control desensitizer will, under certain circumstances, allow the pilot to interact with the fuselage bending modes to create a PIO (pilot-induced oscillation) or PAO (pilot-assisted oscillation). This interaction can result in divergent helicopter oscillations. Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight. If encountered, releasing the flight controls for several seconds should eliminate the condition.
- If a desensitizer failure occurs, and does not clear after a MODE reset or resetting computer power, observe the following precautions:

  1. Minimize hover time.

  2. Avoid rapid control inputs.

  3. Do not pick up an external load. If flying with an external load, continue to the destination and gently set the load down. Do not attempt to re-lift the load.

Operations where maximum maneuvering capability is required such as low level, contour flights, etc., airspeed is limited to 130 KIAS.

Aerobatics such as loops, rolls, etc., are prohibited. Evasive maneuvering training or air combat maneuvering training is prohibited. Hovering turns over 360° in less than 15 seconds are prohibited.

4.4.5 Climb Limitation. At gross weights below 60,000 pounds, limit average torque to 110% in climb. At gross weights above 60,000 pounds, 121% average torque may be used.

4.4.6 Altitude Limitations. Helicopter operations are primarily limited by the ability to hover in and out of ground effect. Refer to the performance charts in Part XI to determine the hover ceiling for various flight conditions. Service ceilings for helicopters are normally the altitude that the helicopter can sustain the best rate-of-climb speed for specific conditions. Refer to the climb charts in Part XI to determine altitude limitations. Altitude limitations related to emergency operations can be obtained from the performance charts in Part XI when the emergency procedures outlined in this section are followed. Minimum autorotative altitudes and airspeeds are established to provide the altitude and airspeed combination that will permit the pilot to select the best available landing site and accomplish a safe autorotative landing.

4.4.7 Landing Limitations. Landings should be made so as not to subject the landing gear to a rate of descent greater than the design sink rate limitation of 672 feet per minute at 46,500 pounds gross weight and 360 feet per minute at 69,750 pounds gross weight. The tail skid air/oil shock strut will withstand inadvertent ground contact up to a sink rate of 672 feet-per-minute. The maximum takeoff and landing speed shall not exceed 40 knots groundspeed.

4.5 UTILITY HOIST LIMITATIONS

The maximum load that may be raised or lowered with the utility hoist is 600 pounds. Hoist recoveries are restricted to hover only.

4.6 EXTERNAL CARGO HOOK LIMITATIONS

The single-point suspension external cargo hook is limited to 36,000 pounds. The two-point suspension cargo hooks are limited to 21,600 pounds each and are limited to a combined capacity of 36,000 pounds.

WARNING

- One two-point suspension hook shall never be used independently of the other two-point suspension hook.
- One or both two-point suspension hooks shall never be used in conjunction with the single-point suspension hook.

4.7 WEIGHT AND BALANCE LIMITATIONS

The design gross weight is 46,500 pounds and is the weight at which the maximum G load may be sustained. The maximum weight on wheels is 69,750 pounds. Maximum allowable gross weight is 73,500 pounds. However, the structural limitations are based on a proportional gross weight to G load factor.

Gross weight is further limited by the ability of the helicopter to hover in- and out-of-ground effect for specific conditions. Refer to the performance charts in Part XI to determine the gross weight limitation related to power available, and other related factors. It is possible to go over the CG limits if the helicopter is not properly loaded. CG computations must account for CG shift which accompanies fuel burn-off, otherwise CG limits may be exceeded. See Figure 2-38 for most forward and aft CG limitations.

4.8 LATERAL CG LIMITS

The lateral CG limits are 8.5 inches right and 13.5 inches left regardless of the configuration (i.e., auxiliary tanks installed).

4.9 LONGITUDINAL CG LIMITS

See Figure 2-39.

4.10 JETTISONING EXTERNAL FUEL TANK LIMITATIONS

The external fuel tanks shall not be jettisoned if the conditions outlined in Figure 4-5 are exceeded.

	650 GAL TANK
MAX AIRSPEED LEVEL FLIGHT	0 to 150 KIAS
MAX AIRSPEED DESCENT	120 KIAS
MAX RATE OF DESCENT	1500 fpm
BANK ANGLE	0 degrees

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Figure 4-5. Fuel Tank Jettison Limits

4.11 EMERGENCY WATER OPERATING LIMITATIONS

Emergency water limitations are based on the ability to stay afloat for at least 2 hours in 1 to 3 foot waves with a wind of 7 to 16 knots, a roll of 10°, and a water taxi speed of 8 knots at 46,500 pounds.

4.12 FUEL DUMPING LIMITATIONS

Fuel shall not be dumped below 90 KIAS or above 130 KIAS. Fuel shall not be dumped if the rate of descent is greater than 1500 feet-per-minute.

4.13 ICING LIMITATIONS

See Figure 14-1.

4.14 IN-FLIGHT REFUELING

Figure 4-6 presents the safe in-flight refueling envelope. It is valid for NATOPS CG limits with the following restrictions:

1. Airspeed range: 105 to 120 KIAS.

WARNING

Helicopter handling qualities and predictability will change dependent upon density altitude, helicopter gross weight, and which side of the tanker is used for refueling. Refer to the Refueling Envelope for CH-53E, Figure 4-6.

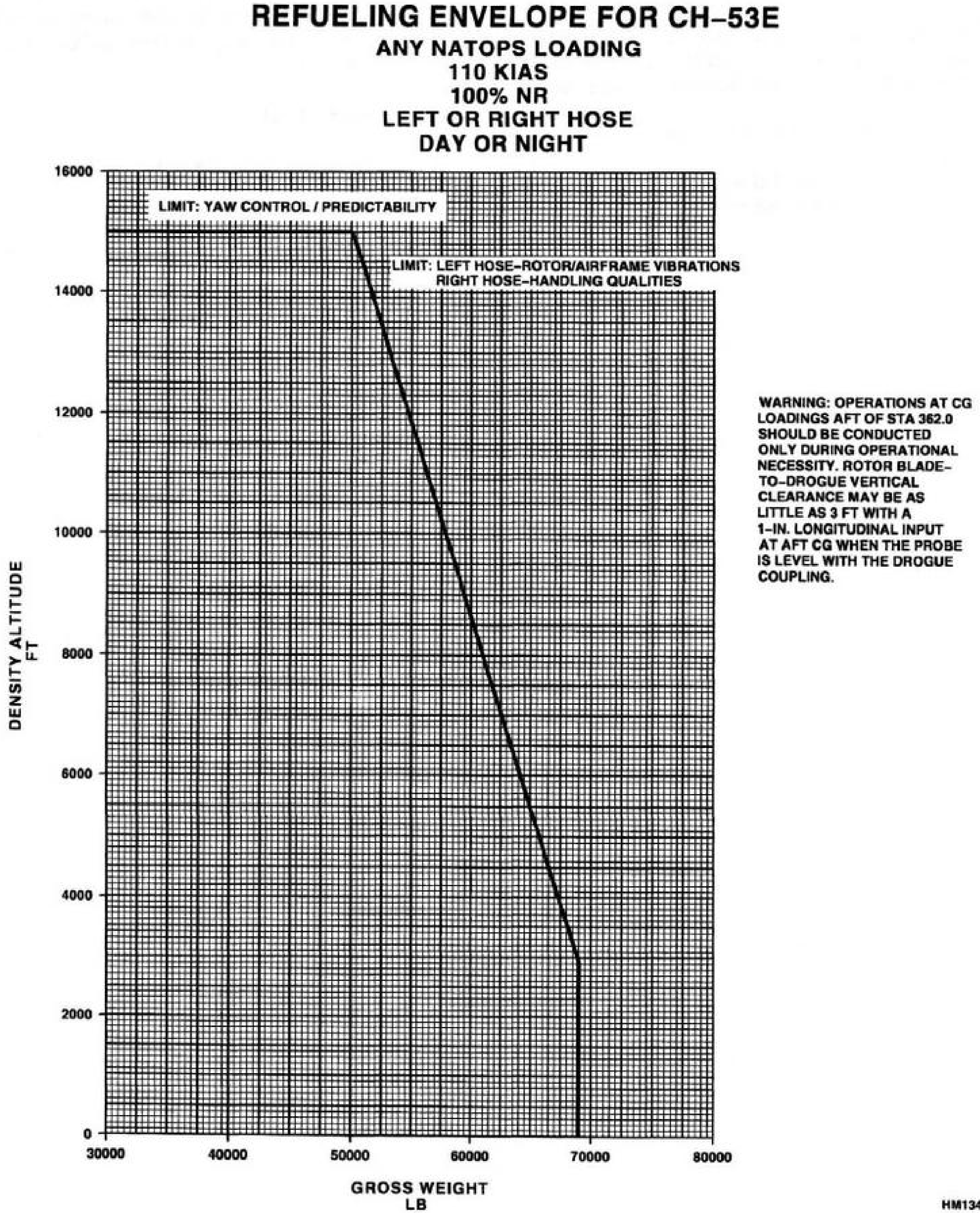

Figure 4-6. Aerial Refueling Envelope for the CH-53E with the C-130

2. AFCS must be functional (except altitude hold).

3. For density altitudes above 12,000 feet and for high density altitude/gross weight combinations, 105% N_r may be used and will improve handling qualities.

4. CG positions aft of 362 inches:

a. Must be avoided when possible and not used for initial aerial refueling training.

b. Must be used only when operational requirements exist and by pilots having extensive in-flight refueling experience at CGs forward of 362.

4.15 Landing Fuel.

Plan flights to land with no less than 1200 pounds of total fuel.

PART II

INDOCTRINATION

CHAPTER 5
Indoctrination Procedures

5.1 GROUND TRAINING SYLLABUS

A ground training program shall be established which shall ensure thorough training and a high degree of readiness for all flight personnel. The ground training syllabus required below is to be used as a guide. For USN activities, the syllabus is set forth in the CNO Approved CH-53E Training Syllabus. For USMC activities, the syllabus is set forth in the Aviation Training and Readiness Manual.

5.1.1 Pilot Ground Training. Pilot ground training will include NAMTG pilot familiarization, helicopter performance and emergency procedures, helicopter loading and weight and balance, communication, publications, flight planning and navigation, and flight safety and survival equipment.

5.1.2 Aircrew Ground Training. Aircrew ground training will include plane captain qualification, publications, ground handling and servicing, helicopter loading, weapons loading (as required), maintenance and troubleshooting procedures, communication, blade and pylon fold/spread operations, and safety and survival equipment.

5.2 FLIGHT SYLLABUS

5.2.1 Pilot Flight Training. A flight training syllabus shall be established by each command to accomplish maximum training for the mission and tasks assigned. The syllabus must be flexible and tailored to fit the situation and the varying nature of the tasks and commitments. The flight training syllabus will contain the following phases: familiarization, formation, instruments, navigation, night, shipboard, and special categories. For USN activities, the syllabus is set forth in the CNO Approved CH-53E Training Syllabus. For USMC activities, the syllabus is set forth in the Aviation Training and Readiness Manual.

5.2.2 Aircrewman Flight Training. A flight training syllabus shall be established by each command to accomplish maximum training for the mission and tasks assigned. The syllabus must be flexible and tailored to fit the situation and varying nature of the tasks and commitments. The flight syllabus will contain the following phases: familiarization, external cargo operations, confined area landings, and general flight duties. For USN activities, the syllabus is set forth in the CNO Approved CH-53E Training Syllabus. For USMC activities, the syllabus is set forth in the Aviation Training and Readiness Manual.

5.3 PERSONAL FLYING EQUIPMENT

In the interest of safety and survival, flying equipment shall be worn by all personnel engaged in flights as set forth in OPNAVINST 3710.7.

5.3.1 Equipment

1. Protective helmet.
2. Fire-resistant flight suit.
3. Flight safety boots.
4. Inflatable life preserver as required.
5. Survival vest (IAW NAVAIR 13-1-6.7).
6. Flight gloves.
7. Identification tags.
8. Parachutes as required.
9. Anti-exposure suit as required.
10. NATOPS Pilots' Pocket Checklist, A1-H53BE-NFM-500, and/or NATOPS Aircrew Pocket Checklist, A1-H53BE-NFM-900 (as appropriate).

In addition to the crew requirements for life preservers, all passengers shall be provided with an approved-type life preserver on all flights conducted over water. All survival equipment shall be secured so that it is easily accessible and will not be lost during an emergency. Additional survival information is available in: Survival Training Guide (NAVAER 00-80T-56), Polar Guide (NAVAER 00-80T-32), Safety and Survival Equipment Manual (NAVAER 00-80T-52), and Survival on Land and Sea (NAVAER 00-80S-56).

5.4 FLIGHT CREW QUALIFICATIONS AND CURRENCY REQUIREMENTS

The flight crew qualifications and requirements as set forth in the following paragraphs are minimums and are not to be interpreted as limiting in anyway the establishment of higher requirements by proper authority.

5.4.1 Pilot Qualification and Currency Requirements. A pilot must be qualified as a helicopter pilot under the provisions of OPNAVINST 3710.7 and complete a formal helicopter ground and flight training program before he can become qualified as a helicopter aircraft commander (HAC) or helicopter second pilot (H2P). A pilot who has qualified in one of the helicopter classifications shall have a certificate thereof signed by the qualifying authority. This certificate will state the model helicopter and modification thereto in which he is qualified, and shall be placed in his Aviator's Flight Log Book and Naval Aviator Naval Flight Officer Qualification Jacket. Commanding officers, or higher authority in the chain of command, are empowered to designate helicopter aircraft commanders and issue certification thereto. The immediate superior in command to the commanding officer, or higher authority, may assume the function. The authority assuming the function shall issue appropriate instructions.

5.4.2 Qualifications

5.4.2.1 Mission Commander. Multiple formation flight, i.e., two or more separate formations of aircraft, each of which is led by a separate flight leader, on a common helicopter support mission, shall be under the command of a designated mission commander. A mission commander should be designated when the helicopter support mission requires multiple sorties by a formation of four or more aircraft. The mission commander may be, but is not limited to being, one of the formation flight leaders. The status of each member of the flight or flights shall be understood prior to flight. The mission commander shall direct a coordinated plan of action and shall be responsible for both the effectiveness of the flight and for all phases of the assigned mission. Commanding officer shall establish policy to identify other helicopter support missions which require the assignment of a mission commander. To be eligible for designation as mission commander, the individual aviator shall be a qualified HAC in model.

Designation as mission commander is a function of command, and, as such, qualities of personal integrity, maturity, judgement and initiative, in addition to rank and flight experience, shall be considered by the commanding officer when designating mission commanders.

5.4.2.2 Helicopter Aircraft Commander. The helicopter aircraft commander shall have completed all of the requirements for, and possess to an advanced degree, the knowledge, proficiency and capabilities of a helicopter second pilot. He shall further meet the requirements as set forth in detail in OPNAVINST 3710.7. In addition, the HAC shall satisfactorily complete the unit's helicopter aircraft commander flight check.

5.4.2.3 Helicopter Second Pilot. A helicopter second pilot will be a designated helicopter pilot and shall meet all of the requirements as set forth in OPNAVINST 3710.7. In addition, the second pilot shall satisfactorily complete the units helicopter second pilot flight check.

5.4.2.4 Pilot Under Instruction. A pilot under instruction is a designated aviator under instruction.

5.4.2.5 Formation Leader. A formation of two or more naval aircraft shall be under the direction of a formation leader who is authorized to pilot naval aircraft. The formation leader may also be the mission commander when so designated. The status of each member of the formation shall be clearly briefed and understood before take off. The formation leader is responsible for the safe and orderly conduct of the formation.

Designation as formation leader is a function of command and, as such, commanding officers shall establish policy to control the number of aircraft an individual formation leader may command. Qualities of personal integrity, maturity, judgement and initiative, in addition to rank and experience, should be considered.

5.4.2.6 Functional Checkflight Pilot. A functional checkflight pilot is an aviator, designated in writing by the commanding officer, authorized to conduct functional checks of aircraft systems in flight as required by OPNAVINST 4790.2. To be eligible for designation as a functional checkflight pilot, the individual aviator shall be a qualified HAC in model. Prior to initial designation as functional checkflight pilot, the individual aviator shall satisfactorily complete the unit's written functional checkflight procedures examination and shall satisfactorily demonstrate the ability to perform functional checks of aircraft systems in flight.

5.4.3 Minimum Crew Requirements

1. The helicopter is designated a multi-piloted aircraft. The minimum crew required to fly the aircraft is a pilot, copilot and an aircrewman.

2. Commanding officers are authorized to permit single pilot operations on flights when, in his opinion,

conditions do not require two pilots. The minimum crew for single piloted operations is a helicopter aircraft commander (HAC), a qualified observer, and a crewman, one of the latter to be a qualified aircrewman.

3. A HAC shall command the aircraft and occupy one of the control positions on all flights except that commanding officers are authorized to permit training flights under VFR conditions, with two helicopter second pilots (H2Ps), one being designated as pilot in command.

4. All instructional flights shall be under the direct supervision of a HAC.

5. A pilot under instruction (PUI) may occupy one of the control positions on flights where passengers are carried, but he shall not perform takeoffs or landings with passengers embarked until he has completed the familiarization stage of a flight syllabus approved by a competent authority.

6. The pilot and copilot seats shall be occupied on all flights.

5.4.4 Currency Requirements

5.4.4.1 Annual Flying Requirements. To ensure that the skill of naval aviators is maintained at an acceptable standard of readiness for fleet operations, the annual flying requirements as set forth in OPNAVINST 3710.7 shall be adhered to by all active duty naval aviators.

5.4.4.2 Minimum Currency Requirements. The minimum requirements to remain current in any model helicopter are as follows:

1. Pilots are required to have flown at least 10 hours as HAC or H2P, as applicable, within the past six months.

2. To regain currency in any model, sufficient refresher flights shall be flown with a HAC to obtain a minimum of 10 hours in the last 6 months.

5.4.4.3 Shipboard Qualifications. Five day landings aboard any ship, constitute day qualification. Designated helicopter second pilots should qualify whenever a deck is available. No minimum hour requirements are set prior to shipboard qualification; however, it is expected that all H2Ps and HACs will more than meet any minimum pilot hour requirement that might be set. Five day and five night FCLPs shall be accomplished within 30 days prior to shipboard qualification. Designated HACs and H2Ps must satisfactorily complete day qualification before participating in night shipboard qualification programs. Initial night shipboard qualifications shall be restricted to LPD, LPH, LHA, and CVs.

5.4.4.4 Air Refueling Qualification. The following minimum initial qualification shall be met by all pilots:

1. Day — At least one rendezvous and join-up with a total of three day plugs.

2. Night — Same requirement as day. Day initial qualifications shall be completed before night qualifications are attempted.

After initial qualification a pilot will be considered current for deployment involving refueling operations if he has completed a minimum of 2 day and 2 night plugs in the last 180 days. Night currency is not required for day-only operations.

5.4.4.5 NATOPS Evaluation. On assignment to another unit, helicopter aircraft commanders and helicopter second pilots will not be required to receive a NATOPS evaluation if the log book entry indicates successful completion of the evaluation within the guidelines set forth in OPNAVINST 3710.7 or if he has a current NATOPS Evaluation Report Form, OPNAV 3510.8, on file.

5.4.4.6 Waivers. Unit commanders are authorized to waive in writing minimum flight assignment and/or training requirements where authorized by OPNAVINST 3710.7.

5.4.5 Aircrewman and Additional Crewmember Qualifications, Requirements, and Designations. An aircrewman shall be assigned aboard the helicopter for the performance of duties necessary for the successful completion of the mission. In the event an additional crewmember is required for mission accomplishment, he must meet all the requirements and qualifications as set forth below. These flight crew qualifications and requirements are minimums and are not to be interpreted as limiting in any way the establishment of higher requirements by proper authority.

5.4.5.1 Qualifications

1. Shall be a volunteer for aircrew training.

2. Shall possess the qualities of personal integrity, maturity, judgement and initiative which are vital to the satisfactory performance of assigned tasks.

3. Shall meet the physical and psychological requirements of the medical department.

4. Shall be a qualified swimmer in accordance with OPNAVINST 3710.7.

5.4.5.2 Requirements

1. Must complete the applicable training syllabus for designation.

2. Must have a current flight physical.

3. Must be designated in writing.

4. Must satisfactorily complete a NATOPS evaluation.

5.4.5.3 Designation. Commanding officers shall designate helicopter aircrew members and ensure certification in his aircrew member qualification jacket and service record book.

5.4.5.4 Currency Requirements. The minimum requirements to remain current as an aircrew member in the helicopter will be to have performed the duties of a crewmember as outlined in this manual within the last 90 days and to have a current NATOPS evaluation. If an aircrewman has not functioned as a crewmember during the preceding 90-day period, as a minimum requirement, he shall be provided refresher training.

5.4.5.5 NATOPS Evaluation. On assignment to another unit, an aircrewman will not be required to receive a NATOPS evaluation if his service record indicates successful completion of the evaluation within the guidelines set forth in OPNAVINST 3710.7.

5.4.5.6 Aircrew Member Permanent Qualification Jacket. An aircrew member's permanent qualification jacket shall be established and maintained to reflect his previous designation and completion of current qualifications and requirements.

5.4.5.7 Waivers. Unit commanders are authorized to waive, in writing, minimum flight and/or training requirements where authorized by OPNAVINST 3710.7.

PART III

NORMAL PROCEDURES

CHAPTER 6
Flight Preparation

6.1 MISSION PLANNING INTRODUCTION

Mission planning has two basic requirements. The first, that of preparation of planning documents for a future helicopter support mission, is normally done from weather summaries and predictions in the desired area. All factors that contribute to successful mission accomplishment, such as weather, performance, terrain, tactical situations, etc., should be planned and documented before every flight. Additional information is normally contained in intelligence summaries and estimates. The second requirement is for pilots and operations personnel to calculate performance capabilities on a daily basis before every flight.

Note

A specially programmed Hewlett-Packard (HP-41C) calculator is available for weight, balance, and helicopter performance computations.

6.2 FACTORS AFFECTING HOVER PERFORMANCE

6.2.1 Density Altitude. Density altitude varies with atmospheric pressure, temperature, and humidity.

6.2.2 Temperature. High outside air temperatures (OAT) have an adverse effect on the power output of gas turbine engines. An increase in OAT, at a constant pressure altitude, causes decreased engine performance.

6.2.3 Humidity. The effect of humidity is considered negligible in this helicopter.

6.2.4 Wind. Wind affects helicopter performance by producing translational lift. Therefore, less power is required to hover in a wind than under no wind conditions, or, using the same power, the helicopter can hover at a higher gross weight in winds. The relative wind generated by ships underway can be used to increase the hover performance of the helicopter, in the same way that running takeoffs are used ashore.

Note

At very low hovers the wind washes the ground effect from beneath the helicopter. Therefore, higher wind velocities are required at low AGL hovers than at higher AGL hovers before translational lift reduces the power needed. See the Torque Required to Hover Charts in Part XI.

6.2.5 Ground Effect. Ground effect will increase the lifting capability of the helicopter. A helicopter hovering close to the ground requires less power than a helicopter at the same gross weight hovering at a greater height.

6.3 FACTORS AFFECTING RANGE AND ENDURANCE

6.3.1 Cruise Control. Fuel consumption may be minimized during cruise by proper selection of altitude, airspeed, rotor speed, and CG location.

6.3.2 Altitude. The decrease in OAT, associated with altitude increases, generally increases engine efficiency; however, the increased density altitude will also decrease rotor efficiency. Overall helicopter/engine performance, operational requirements, and weather should be considered when selecting a cruising altitude.

6.3.3 Minimum Altitude Navigation Flight. Minimum altitude navigation flights may be conducted for these reasons:

1. Special tactical requirements.
2. To train pilots in low level map reading navigation (without radio aids).

Note

Special care must be taken to avoid flying over populated areas, civilian airports, etc. Conformance with existing FAA Regulations and OPNAVINST is mandatory.

6.3.4 Weight and Balance. This helicopter is a class 2 helicopter for weight and balance purposes. The responsibility for safe loading of class 2 helicopters before requesting clearance is assigned to the operating activity. The requirement to attach a Form F to the flight clearance is waived when a current form is on file at the operating activity. Further information may be found in OPNAVINST 3710.7 and NAVAIR 01-1B-40. The aircraft commander is responsible for computing the CG location and gross weight of his assigned helicopter, and making sure that the maximum allowable limits are not exceeded.

Note

A specially programmed Hewlett-Packard (HP-41C) calculator is available for weight and balance computations.

6.3.4.1 Weight Definitions. (Figure 6-1).

6.3.4.2 Weight Empty. Weight empty is the weight of the helicopter structure plus powerplant, instruments, control system, hydraulic system, electrical system, communicating system, armament provisions (including gunfire protection), furnishings, anti-icing equipment, and auxiliary powerplant. It is a term used for design purposes, and usually does not affect service activities.

6.3.4.3 Basic Weight. The basic weight of a helicopter includes all fixed operating equipment and trapped fuel and oil, to which it is only necessary to add the variable or expendable load items for the various missions.

Note

The basic weight of a helicopter varies with structural modifications and changes in the fixed operating equipment. The term basic weight, when qualified with a word indicating the type of mission, such as basic weight for ferry, may be used in conjunction with directives stating what the equipment shall be for these missions. For example, extra fuel tanks and various items of equipment installed for long range ferry flights which are not normally carried on other missions shall be included in basic weight for ferry, but not in basic weight for combat.

6.3.4.4 Operating Weight. The operating weight of a helicopter is the basic weight plus those variable items which remain substantially constant for the type mission. The items include oil, crew, crew's baggage, emergency, and extra equipment that may be required.

Note

The operating weight of a transport helicopter is the weight of the helicopter including the crew and all equipment required for the mission, but not including fuel or payload.

6.3.4.5 Gross Weight. The gross weight is the total weight of a helicopter and its contents. The takeoff gross weight is the operating weight plus the variable and expendable load items which vary with the mission. These items include fuel, cargo, passengers, ammunition, and external auxiliary fuel tanks if to be jettisoned during flight. The landing gross weight is the takeoff gross weight minus the expended load items.

6.3.4.6 Footprint Weight. The distribution of weight on the landing gear (footprint weight) is dependent on the CG loading of the helicopter.

At 46,500 pounds gross weight and a forward CG loading of 342.0 the nose gear load is 13,509 pounds or 117 psi and the footprint area is 116 square inches. Each main gear load is 16,495 pounds or 154 psi and the footprint area is 107 square inches.

At 46,500 pounds gross weight and an aft CG loading of 366.0 the nose gear load is 10,046 pounds or 117 psi and the footprint area is 86 square inches. Each main gear load is 18,202 pounds or 154 psi and the footprint area is 118 square inches.

At 69,750 pounds gross weight and a forward CG loading of 343.9 the nose gear load is 19,858 pounds or 117 psi and the footprint area is 170 square inches. Each main gear load is 24,946 pounds or 154 psi and the footprint area is 162 square inches.

At 69,750 pounds gross weight and an aft CG loading of 359.0 the nose gear load is 16,638 pounds or 117 psi and the footprint area is 142 square inches. Each main gear load is 26,556 pounds or 154 psi and the footprint area is 173 square inches.

Note

Footprint weight versus the bearing capacity of decks, elevators, runways, taxiways, and parking areas should be considered.

6.3.5 Atmospheric — Power Conditions vs. Weight Limit. The relationship of lift capability to atmospheric conditions may impose a weight limit less than the maximum gross weight. Decreased helicopter performance caused by increased density altitude is reflected in the indicated torque required to hover in and out-of-ground effect figures in Part XI. While flight opera-

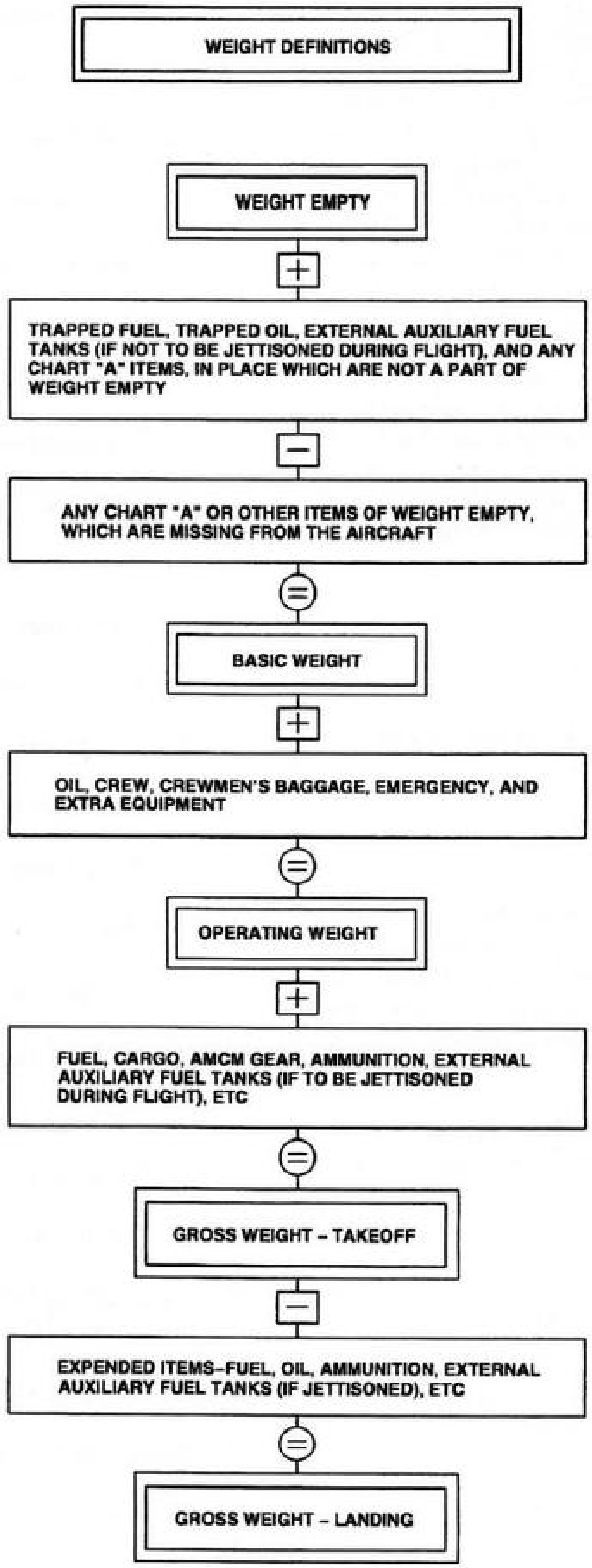

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Figure 6-1. Weight Definition

tions based on the HIGE (hovering in-ground effect) limit will permit an increase in lift capability the HOGE (hovering out-of-ground effect) weight computations will be used for normal training operations. Exceptions to this will be when operational and service flights are made under favorable conditions which require carrying internal payloads at an altitude beyond the capability of the helicopter to HOGE. Roll-on landings and takeoffs will further increase payloads but require a smooth surface of sufficient length in an area free of obstacles. HOGE and HIGE altitudes should be computed for information before takeoff or landing in these circumstances. Flight operations, based on the atmospheric condition-power vs. weight limits found in the performance charts in Part XI, will ensure maximum usage and flexibility consistent with flight safety. When existing atmospheric conditions permit a weight lifting capability which is over the maximum gross weight (structural limit), the latter must be followed.

6.4 FERRY FLIGHTS

Ferry flights will be conducted in accordance with OPNAVINST 3510.9 and 3710.7.

6.5 MISSION EQUIPMENT REQUIREMENTS

Refer to OPNAVINST 5442.4.

6.6 BRIEFING

A briefing guide will be used to conduct the required briefing. The appropriate syllabus guide should be used for briefing training flights. Each pilot will maintain a knee-pad and record all flight numbers, call signs, and other data necessary to successfully assume the lead and complete the assigned mission.

6.6.1 General Mission Briefing Guide. The following applicable items should be briefed to all aircrew prior to each flight:

A. GENERAL

1. Helicopter assignment/call sign
2. Flight leader/alternate
3. Primary/alternate mission
4. Mission essential equipment
    a. Aircraft
    b. Personal
5. Time for manning, taxi, takeoff, overhead
6. Navigation and flight planning
    a. Fuel planning
    b. Power computation/weight and balance
    c. Enroute/destination NAVAIDS
    d. Route of flight/operating and landing areas
    e. Obstacles/hazards
    f. Charts and cross country packet
    g. NOTAMS
7. Communications
    a. Frequencies/call signs/controlling agencies
    b. Radio procedure and discipline
    c. Identification and recognition procedures
    d. Lost communication
    e. Visual signals
8. Weather
    a. Local, enroute, destination forecast
    b. Minimum operational weather
9. Downed pilot and aircraft
    a. On scene commander
    b. SAR facilities

B. CREW COORDINATION (PAC/PNAC/AIRCREW)

1. Preflight/postflight responsibilities
2. Seat assignment/lookout doctrine
3. ICS/radio procedures
4. Control transfer
5. Passenger/cargo/ramp control

6. HNVS Use

   a. HNVS use during takeoff/enroute/landing

   b. Crew coordination

      (1) Consent for FLIR

      (2) Communication

      (3) Lookout doctrine

      (4) Spatial disorientation/vertigo

   c. HNVS mission-specific concerns

      (1) NVGs

      (2) Externals

      (3) CALs/MALs

      (4) MOUT

      (5) Shipboard

      (6) Video camcorder use

   d. Emergencies/system failures

      (1) Aircraft

      (2) HNVS (BIT/FIT)

7. IFR/night responsibilities

   a. Instrument takeoff

   b. Instrument flight/approaches

   c. Inadvertent IFR

   d. Vertigo

   e. Lighting

8. Wave-off/unsafe situations

9. Simulated emergencies

C. EMERGENCIES/SYSTEMS FAILURES (PAC/PNAC/AIRCREW)

1. Engine failures (takeoff/hover/inflight/landing)

   a. Single

   b. Dual

   c. Triple (autorotation)

2. Tail rotor malfunctions/failure (takeoff/hover/inflight/landing)

   a. Control

   b. Drive

3. Hydraulics

4. Flight controls/AFCS

   a. Computer malfunctions

   b. AFCS Hardover/Restriction or Binding in flight controls

5. Electrical

   a. Generators

   b. Rectifiers

6. Chip lights/gear boxes

7. Fire

8. Forced landing/ditching

   a. Water landing

      (1) Controlled

      (2) Uncontrolled

      (3) Egress/regroup

   b. Prepared/unprepared sites

      (1) Controlled

      (2) Uncontrolled

      (3) Egress/regroup

D. MISSION CONSIDERATIONS

1. FAM/TAC/INST

a. Flight maneuvers

2. FCF

3. Externals

   a. CG/Form F/weight limitations/operational power checks

   b. Load hookup/release/grounding procedures

   c. Single-/dual-point

   d. HST/LSE brief

   e. Emergencies/release-jettison

4. Cargo and troops

   a. Passenger brief

   b. Special loading

   c. Emergencies

5. Formation

   a. Type formation (takeoff, enroute, landing)

   b. Maneuvers

   c. Rendezvous

   d. Lead change

   e. IFF

   f. Dissimilar aircraft

   g. Visual signals

   h. Lookout doctrine

   i. Emergencies

6. Ship operations

   a. Ship name/type/hull number

   b. Mission scenario

   c. Deck spotting

   d. Flight deck procedures

   e. Wave-off

   f. PIM

   g. Wind limitations

   h. Emergencies

7. HIFR

   a. Ship name/type hull number

   b. Deck spotting/positions

   c. Hookup/refuel/disconnect/grounding

   d. Hoist operations

   e. Fuel leaks

   f. Emergency breakaway/wave-off

   g. Wind limitations

   h. Emergencies

8. Aerial refueling

   a. Operating altitudes/airspeeds/altimeter setting

   b. Visual checkpoints/positions

   c. Rendezvous/breakup/fuel transfer/post air refueling procedures

   d. Lighting/light signals

   e. Hose markings

   f. Probe operation/malfunctions

   g. Emergencies

      (1) Streaming fuel

      (2) Emergency breakaway

      (3) Inadvertent IMC

      (4) Hose guillotine

6.7 DEBRIEFING

A proper debriefing conducted under tactical or training conditions is an important part of a flight. Under tactical conditions, debriefing is a primary source of information leading to the location of targets, distribution of troops, and many other important considerations. An outline should be followed for proper debriefing and should contain all the items for briefing, plus the following:

1. All unusual circumstances encountered.

2. Discrepancies arising which do not conform to an established doctrine.

A proper debriefing should contain constructive criticism and be conducted in such a manner that all concerned can participate and present their ideas on the conduct of the flight.

CHAPTER 7
Shore-Based Procedures

7.1 PREFLIGHT INSPECTION

The pilot's preflight aircraft inspection during the first two FAM flights should be conducted in accordance with the Daily Maintenance Requirement Cards. A pilot shall not accept the helicopter for flight until assured that the helicopter is satisfactory for safe flight and mission accomplishment. The two major steps to be taken before acceptance of the helicopter are a careful examination of the helicopter's recent discrepancies and a thorough preflight inspection. For his information, the pilot shall review at least the last 10 flights and all associated maintenance discrepancy forms in accordance with OPNAVINST 3710.7. Any additional discrepancies shall be brought to the attention of the pilot. The pilot will ensure a standard Daily/Turnaround Inspection has been conducted as set forth in A1-H53BE-MRC-300/A1-H53BE-MRC-200 prior to accepting the aircraft. When satisfied with the yellow sheet information, the pilot will sign applicable portions of the yellow sheet. The preflight inspection shall consist of an exterior inspection (which includes items on the exterior of the helicopter that contribute to safety of flight, reference Figure 7-1) and an interior inspection. The interior inspection shall include the presence of equipment, positioning of switches, and reading of indicators. Insofar as possible, switches shall be positioned as required for engine starting. When the helicopter is flown by the same crew in regularly scheduled airline-type operations, or when assigned tactical or administrative missions requiring intermediate stops, it is not necessary to perform all preflight checks. Those items that are required to be done on a through-flight inspection will be preceded by an asterisk.

Note

All listed items shall be checked for condition, security, leakage when applicable, and specifically as indicated.

7.1.1 Before Exterior Inspection

1. Aircraft forms and flight publications — CHECKED.

2. Fuel samples — CHECKED.

3. Chocks — IN PLACE.

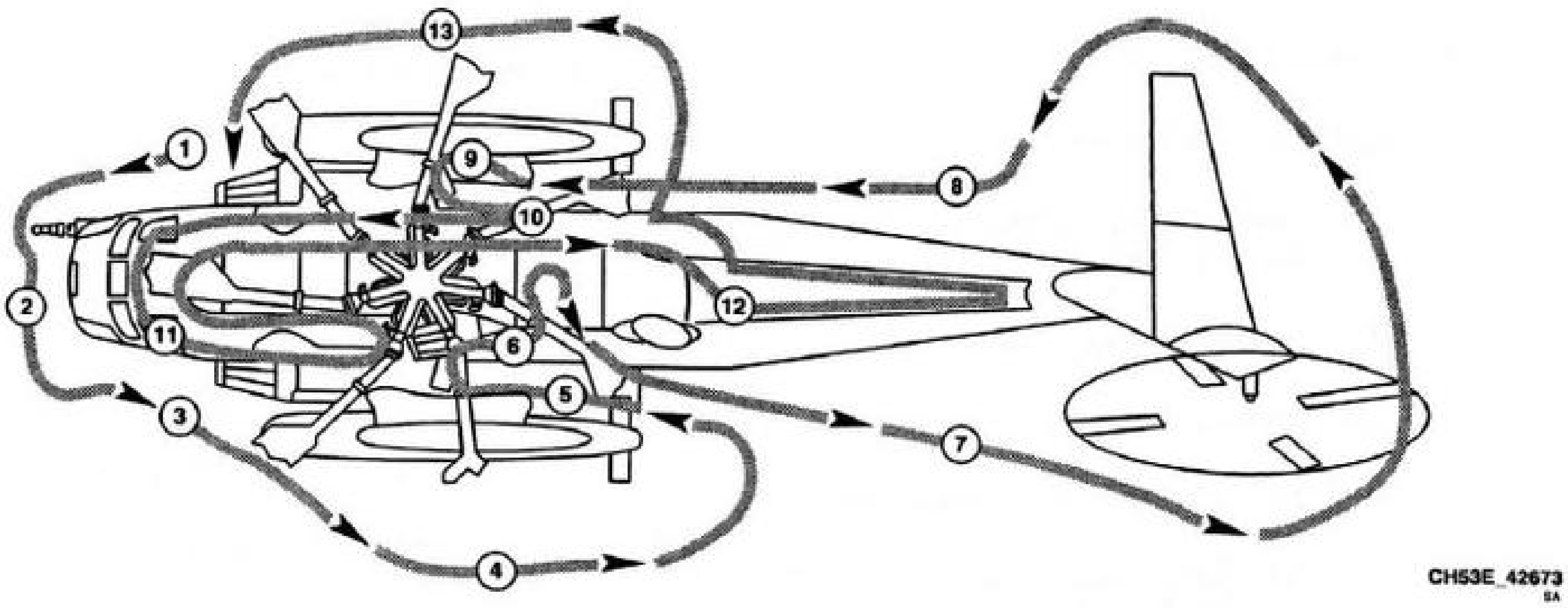

Figure 7-1. Exterior Inspection Diagram

4. Fire extinguisher — POSITIONED OUTSIDE HELICOPTER.

5. Weapons safety check — GUNS SAFETIED AND STOWED.

6. Passengers — BRIEF. Refer to Chapter 6.

7.1.2 Exterior Inspection. See Figure 7-1.

Note

Only those items marked * are required on through-flight inspection. Those items marked ** may be omitted with EAPS installed except before the first flight of the day, or if maintenance has been done.

1. Right Front Fuselage.

   a. Upper personnel door emergency release handle — SECURE.

   b. Personnel door — SECURE AND FREE OF DAMAGE.

   *c. Utility hoist and light — SECURE, UNDAMAGED, AND FREE OF LEAKS.

   d. External power receptacle cover — CLOSED AND SECURE.

   e. Pilot's window emergency release handle — SECURED.

   f. External ICS cover — CLOSED.

   g. Electronics compartment.

      (1) Check control bellcranks and tubing secure and free.

      (2) Fuel probe solenoid secure.

      (3) Check avionics gear.

         (a) AHRS synchro transformers.

         (b) Radar beacon (Removed by AFC 501, Part 2).

         (c) RAD ALT test switch at FLT.

         (d) No. 2 AFCS computer.

         (e) Display Electronics Unit.

         (f) Signal Conditioning Module.

         (g) GPWS Relay Panel.

      (4) Ensure that compartment door support struts are tightly secured.

WARNING

An unsecured compartment door support strut could jam the roll and/or directional bellcrank (even with the refueling probe installed).

      (5) Closed and secure.

   *h. Refueling probe — SECURITY, WIRING INTEGRITY, VENT OPEN, FREE OF LEAKS AND DAMAGE.

   i. Fuselage — FREE OF DAMAGE, DENTS, OR CRACKS.

   j. Probe light — CLEAN AND SECURE.

   k. Spotlight — CLEAN AND SECURE.

   l. Landing light — CLEAN AND SECURE.

2. Front Fuselage.

   a. Nose access door.

      (1) Control pedals free and clear.

      (2) Check wiring secure.

      (3) Check avionics gear.

         (a) Turn rate gyros.

         (b) Air-to-air refueling relay panel.

         (c) UHF-DF group.

         (d) VOR/ILS

         (e) Navigation relay unit.

      (4) Closed and secure.

*b. Nose gear well — UNDAMAGED, EMERGENCY BLOWDOWN CABLE/DUAL POINT RELEASE CONTROL ROD INTEGRITY, AND FREE OF HYDRAULIC LEAKS.

*c. Nosewheels and tires — UNDAMAGED AND TIRES FREE OF CUTS, BLISTERS, AND ARE PROPERLY INFLATED.

*d. Nose gear — SAFETY PIN INSTALLED, DOWN AND LOCKED INDICATION, UNDAMAGED, CLEAN, PROPERLY INFLATED (3 INCHES OLEO MINIMUM), FLUID INDICATING PIN FLUSH NOT EXTENDED, COROTATING VISCOUS DAMPER-SETSCREWS SECURE AND UNDAMAGED.

e. Nose gear door — SECURE AND UNDAMAGED.

f. Landing gear down light — CLEAN AND SECURE.

g. All protective covers — REMOVED.

h. Windshields and glass — CLEAN AND UNDAMAGED.

i. ILS glide slope antenna — SECURE AND UNDAMAGED.

3. Left Front Fuselage.

a. Landing light — CLEAN AND SECURE.

b. Spotlight — CLEAN AND SECURE.

c. Anticollision light — CLEAN AND SECURE.

d. Turret FLIR Unit/Support assembly — BUMPERS SECURE, TFU BOOM DEPLOYED, HARNESS SECURE.

e. Turret FLIR Unit wrist and elbow bolts — SECURE.

f. Electronics compartment.

(1) Check control bellcranks and tubing secure and free.

(2) Check avionics gear.

(a) Rate switching gyro for vertical gyro.

(b) Vertical gyro power failure detector.

(c) Landing gear warning amplifier.

(d) LF/ADF.

(e) IFF/transponder.

(f) HF/COMM.

(g) IFF/transponder test set.

(h) No. 1 AFCS computer.

(i) TACAN.

(j) Vertical gyro (1080Y).

(k) Air data transducer (Removed by AFC 501, Part 2).

(l) Dimming controls.

(m) Signal data converter.

(n) True airspeed transducer.

(o) GPWS air data computer.

(3) Inspect TFU fixed boom fitting, nut and bolt.

(4) Closed and secure.

g. Copilot's window emergency release handle — SECURE.

h. Escape hatch emergency release handle — SECURE.

i. Engine waterwash door — SECURE.

j. Fueling panel — SECURITY AND PRECHECK VALVES OPEN.

k. Fire extinguisher discharge plugs — INTACT.

l. Sponson position light — CLEAN AND UNDAMAGED.

*m. Fuselage — FREE OF DAMAGE, DENTS, OR CRACKS.

4. Left Side Fuselage.

*a. Auxiliary tank — FUEL FILLER CAPS ARE SECURE. ALL ACCESS PANELS SECURE. BE SURE JETTISON SAFETY PIN IS INSTALLED AND CONTACTS MICROSWITCH. CHECK THAT JETTISON CARTRIDGE RETAINERS ARE LOCKWIRED, NO MOVEMENT OF TANK IN RACK.

CAUTION

Access panels must be secure, or fuel may siphon overboard when helicopter is in forward flight.

b. Pylon position light — SECURE.

c. Landing gear well — GEAR PIN INSTALLED, DOWN AND LOCKED INDICATION, UNDAMAGED AND FREE OF LEAKS, FLUID INDICATING PIN FLUSH NOT EXTENDED.

d. Landing gear strut — UNDAMAGED, CLEAN, AND PROPERLY INFLATED.

*e. Wheels, brake disc, brake lines, and housing — UNDAMAGED.

f. Scissors switch — SECURITY.

*g. Tires — FREE OF CUTS, BLISTERS, AND PROPERLY INFLATED.

*h. Grounding drag wire — CHECK FOR SECURITY AND GROUND CONTACT.

i. Check fuel dump line and mounting clamps — SECURE.

*j. Sponson and fuselage — FREE OF DAMAGE, DENTS, OR CRACKS.

5. Left Side Fuselage (Upper Sponson).

a. No. 1 engine tailpipe EGR nozzle — SECURE, FREE OF DAMAGE AND OBSTRUCTIONS.

b. Engine — SECURE, FREE OF LEAKS, AND NO HOT SPOTS OR BULGES.

**c. EAPS — CLEAN AND FREE OF FOD (DURING COLD WEATHER REFER TO COLD WEATHER OPERATIONS SECTION).

d. EAPS rear support — FREE OF CRACKS.

**e. Nose gear box — LEAKAGE, SECURITY OF CHIP DETECTOR.

**f. Engine intake — FREE OF FOD.

g. Engine fuel filter canisters — SECURE.

h. Engine nacelle — SECURE.

i. Engine fuel purifier — FILTER BUTTON IN.

j. 14th stage bleed air line — SECURE

k. Engine fire detection sensors — CLEAN AND UNDAMAGED.

l. Engine isolators — SECURE WITH CLEARANCE BETWEEN PISTON MOUNTING BOLT AND ISOLATOR BODY.

m. Engine cowling — FOR DAMAGE AND OBSTRUCTIONS.

*n. Main fuel tank filler caps — SECURE.

6. No. 2 Engine Platform — OPEN.

**a. Intake — CLEAR.

b. EAPS — CLEAN AND FREE OF FOD.

c. Main rotor head, left side aft.

*(1) Dampers — UNDAMAGED AND RETAINER IN PLACE, FREE OF LEAKS.

*(2) Pitch rods — CHECK PLAY, BOLT HEADS DIRECTION OF ROTATION.

(3) Droop stops — IN.

(4) Flap restrainers — CLEAN AND FREE.

*(5) Sleeve and spindles — RESERVOIRS SERVICED AND FREE OF LEAKS.

*(6) Vertical hinge pin — RESERVOIRS SERVICED AND FREE OF LEAKS.

(7) Beanie ring — SECURED.

(8) Pitch locks — NOTE ENGAGED OR DISENGAGED.

(9) Blade lockpins — SEATED.

(10) Spar pressure indicators — ALL WHITE AND TEST AS REQUIRED.

WARNING

- The spar pressure indicator contains Strontium 90, a beta ray radiation source. Procedures outlined here shall be followed to avoid exposure beyond limits allowed by the Nuclear Regulatory Commission. Keep eyes at least 24 inches from any indicator which does not have a test/shipping cover secured in place. The cover shall be secured in place when any black color shows on the indicator, or before testing, or if it is necessary to work with eyes less than 24 inches from the indicator.
- Black indicates an unsafe spar/indicator condition and the rotor shall not be turned up.

CAUTION

- Do not use IBIS indicator as a handhold. Any bending or side load put on indicator or installed protective cover will seriously damage indicator. Before each indicator is tested, turn main rotor so indicator is easy to reach.
- When resetting indicator, press, do not strike or use excessive force on protective cover, as it may make indicator inoperative.

Note

Under the special condition where the helicopter is kept in a warm hangar and it is rolled out into cold ambient conditions, the spar pressure indicators may erroneously trip due to differential warming of the gas in the indicator's bellows and the gas in the spar. In this case it is permissible to reset the pressure indicator(s) one time only.

(a) Place the test/shipping cover over the pressure indicator and lock the retaining chain to the lockwire hole at the indicator's base. Allow 0.5-inch space above the indicator to allow reset button to pop out.

(b) Press and hold test button. Do not place hand on indicator's body, as heat of hand may change internal reference pressure and cause erroneous readings.

(c) Reset button must pop out and a full-black (unsafe) indication appear within 60 seconds. When the button is released, the full black indication will remain.

WARNING

When the test button is pressed, a full black indication should be displayed. If not, the helicopter shall not be flown. At temperatures below -31°C a full black indication may not be obtained.

Note

If checking indicator below -6°C the indicator may not operate normally.

(d) Press test/shipping cover firmly against reset button until shaft is fully retracted and color bands return to white. Reset button must latch in this position.

WARNING

Do not remove test/shipping cover if reset button does not latch or any black color shows.

(e) Remove test/shipping cover.

(11) Swashplate and scissors — SECURE, UNDAMAGED, FOD.

(12) Main rotor blades — UNDAMAGED.

(13) Damper accumulator gage — CHARGED.

d. Formation lights — CLEAN AND UNDAMAGED.

e. No. 2 engine.

(1) Engine fuel filter canisters — SECURE.

(2) Engine — SECURE, FREE OF LEAKS, AND NO HOT SPOTS OR BULGES.

(3) Engine fuel purifier — FILTER BUTTON IN.

(4) Engine fire detector sensors — CLEAN AND UNDAMAGED.

(5) Engine isolators — SECURE WITH CLEARANCE BETWEEN PISTON MOUNTING BOLT AND ISOLATOR BODY.

(6) Engine cowling — FOR DAMAGE AND OBSTRUCTIONS.

(7) Tailpipe — FREE OF DAMAGE AND OBSTRUCTION.

7. Left Rear Fuselage.

a. VHF-FM (AM/FM/VHF/UHF with AFC 455) antenna — SECURE AND UNDAMAGED.

b. Hover light — CLEAN AND UNDAMAGED.

*c. Pylon and aft fuselage — UNDAMAGED.

d. ALE dispenser pod — SECURE, LEVER LOCK/SAFE.

e. Ramp and door — UNDAMAGED AND SECURE.

f. VOR/ILS localizer antenna — SECURE AND UNDAMAGED.

g. Pylon lockpin and flags — IN.

h. Tail skid — UNDAMAGED AND SECURE.

*i. Tail rotor and intermediate gear box oil levels — SERVICED.

j. Tail rotor blades — UNDAMAGED.

k. Tail rotor BIM indicators (on aircraft not modified by AFC 397) — VISUALLY CHECK ALL WHITE.

l. Tail rotor pitch change links — SECURED AND LOCKWIRED, BOLTS ALIGNED.

*m. Tail rotor hub — UNDAMAGED AND FREE OF LEAKS.

n. Tail rotor hub reservoir — SERVICED.

o. Tail rotor positioner — RETRACTED.

CAUTION

If pylon was spread manually, tail rotor positioner will be extended. With positioner extended, movement of main rotor will damage positioner actuator.

8. Right Rear Fuselage.

a. Stabilizer — UNDAMAGED AND SECURE.

b. Inspection panels — SECURE.

c. Pylon hinges — UNDAMAGED AND SECURE.

d. Pylon and fuselage skin — UNDAMAGED.

e. VOR/ILS localizer antenna — UNDAMAGED AND SECURE.

f. ALE dispenser pod — SECURE, LEVER LOCK/SAFE.

g. HF antenna — UNDAMAGED AND SECURE.

9. Right Side (Upper Sponson).

a. No. 3 engine tailpipe EGR nozzle — FREE OF DAMAGE AND OBSTRUCTIONS.

b. No. 3 engine — SECURE, FREE OF LEAKS, AND NO HOT SPOTS OR BULGES.

**c. EAPS — CLEAN AND FREE OF FOD (DURING COLD WEATHER REFER TO COLD WEATHER OPERATIONS SECTION).

**d. Nose gear box — LEAKAGE, SECURITY OF CHIP DETECTOR.

**e. Engine intake — FREE OF FOD.

f. Engine fuel filter canisters — SECURE.

g. Engine fuel purifier — FILTER BUTTON IN.

h. 14th stage bleed air line — SECURE.

i. Engine fire detector sensors — CLEAN AND UNDAMAGED.

j. Engine isolators — SECURE WITH CLEARANCE BETWEEN PISTON MOUNTING BOLT AND ISOLATOR BODY.

*k. Engine cowling — DAMAGE OR OBSTRUCTIONS.

*l. Main fuel tank filler caps — SECURE.

10. Right Side Upper Fuselage.

a. Rotor brake and manifold — SERVICED AND SECURE.

b. Main gear box and No. 2 engine oil cooler — CLEAN, SECURE AND FREE OF LEAKS.

*c. First stage hydraulic reservoir — PROPER SERVICE AND FREE OF LEAKS.

1st stage precharge accumulator gage, proper pressure should read:

SYSTEM TEMPERATURE	GAGE PRESSURE
Above 80°F	2850 ±350 psi
80°F to 50°F	2700 ±300 psi
50°F to 0°F	2200 ±200 psi
0°F to -65°F	2000 ±200 psi

d. First stage filter — TWO FILTER BUTTONS IN, FREE OF LEAKS.

e. IBIS detector — CLEAN, SECURE.

f. Tail rotor drive shaft — SECURE, FOD.

g. Rotor brake assembly — SECURE AND FREE OF LEAKS.

h. Gust lock — AS DESIRED.

i. Main gear box filter buttons (2) — IN.

j. Access panels — SECURE.

k. Control rods — UNDAMAGED, COTTER-KEYED, ROD END PLAY.

l. All bellcranks — SECURITY AND PLAY.

*m. Main transmission — UNDAMAGED, LEAKAGE, AND MOUNT BOLTS.

n. Main transmission.

(1) Oil level — PROPER SERVICE.

(2) Main gear box sump/filter — UNDAMAGED.

*o. Forward and lateral primary servos — FREE OF LEAKS, LOCKWIRED, AND SECURE.

p. Servo centering springs — SHEARPIN SECURE AND DOES NOT PIVOT.

q. No. 3 engine input shaft and Thomas coupling — UNDAMAGED.

r. Flight control mixing unit — UNDAMAGED AND COTTER-KEYED, YAW BREAKAWAY ROD SHEARPIN.

*s. Transmission deck — FREE OF LEAKS AND SPILLAGE.

t. Accessory gear box oil level — CHECKED.

u. Swashplate and scissors — SECURE, UNDAMAGED, FOD.

v. Main rotor head, right side.

*(1) Dampers — UNDAMAGED AND RETAINER IN PLACE, FREE OF LEAKS.

*(2) Pitch rods — CHECK PLAY, BOLT HEADS DIRECTION OF ROTATION.

(3) Droop stops — IN.

(4) Flap restrainers — CLEAN AND FREE.

*(5) Sleeve and spindles — RESERVOIRS SERVICED AND FREE OF LEAKS.

*(6) Vertical hinge pin — RESERVOIRS SERVICED AND FREE OF LEAKS.

(7) Beanie ring — SECURED.

(8) Pitch locks — NOTE ENGAGED OR DISENGAGED.

(9) Blade lockpins — SEATED.

(10) Spar pressure indicators — ALL WHITE AND TEST. Test as specified in 6.c. (10) observing WARNINGS and NOTES.

(11) Swashplate and scissors — SECURE, UNDAMAGED, FOD.

(12) Main rotor blades — UNDAMAGED.

(13) Spar pressure radiation detector — SECURE AND WINDOW CLEAN.

w. Formation lights — CLEAN AND UNDAMAGED.

x. No. 3 engine.

(1) Input drive shaft and cowling — SECURE.

(2) Oil cooler fan belts — SECURE AND NOT FRAYED. TENSION.

(3) Blower fan — UNDAMAGED.

**(4) Nose gear box oil level — SERVICED.

**(5) Intake — CLEAR.

(6) Nose gear box cowling and EAPS — UNDAMAGED, SECURED.

**(7) Nose gear box radiator and transfer tube — UNDAMAGED, FREE OF OBSTRUCTION, FREE OF LEAKS.

y. Accessory gear box section.

(1) Flight control mixing unit — SECURE, FOD.

(2) Deck — FREE OF SPILLAGE/FOD.

(3) Second stage reservoir — PROPERLY SERVICED AND FREE OF LEAKS.

2nd stage precharge accumulator gage, proper pressure should read:

SYSTEM TEMPERATURE	GAGE PRESSURE
Above 80°F	2850 ±350 psi
80°F to 50°F	2700 ±300 psi
50°F to 0°F	2200 ±200 psi
0°F to -65°F	2000 ±200 psi

(4) All hydraulic lines — SECURE.

(5) Second stage filter — TWO FILTER BUTTONS IN, FREE OF LEAKS.

(6) Second stage heat exchanger inlet duct — FREE OF OBSTRUCTION.

(7) Generators and pumps — SECURITY LEAKS.

(8) Clutch assembly — FREE OF LEAKS.

(9) Engine and APP fire bottles — PROPER PRESSURE.

(10) Engine start hydraulic system filter — TWO FILTER BUTTONS IN, FREE OF LEAKS.

z. Main rotor head (top front).

*(1) Damper hydraulic accumulator — SERVICED.

(2) Beanie ring — SECURED.

(3) Dampers — UNDAMAGED, RETAINER IN PLACE, NO LEAKS.

(4) Main rotor blades — UNDAMAGED.

(5) Upper fwd rotary wing hydraulic access — SECURE.

(6) Sliding doghouse — CLOSED SECURE.

aa. APP compartment.

(1) All lines and hoses — FREE OF LEAKS.

(2) APP air inlet duct — CLEAR.

(3) Exhaust pipe — SECURE.

(4) Combustion section — NO HOT SPOTS OR BULGES.

(5) Forward supports and aft struts — SECURE.

(6) APP fuel pump, starter motor, and fuel control — FREE OF LEAKS AND SECURE.

(7) APP oil level — CHECKED.

(8) APP bleed air reservoir — SECURE.

(9) APP compartment — CLOSED, SECURE.

CAUTION

Operation of the APP with the folding cover open can result in heat damage to the main rotor blades. If folding cover must be open, position main rotor blades away from APP exhaust.

(10) APP and heater exhaust — CLEAR OF OBSTRUCTIONS.

ab. UHF (AM/FM/VHF/UHF with AFC 455) antenna — SECURE AND UNDAMAGED.

11. Upper Left Side.

a. No. 1 engine

(1) Nose gear box cowling and EAPS — UNDAMAGED, SECURE.

**(2) Intake — CLEAR.

**(3) Nose gear box oil level — SERVICED.

(4) Blower fan — UNDAMAGED.

(5) Oil cooler fan belts — SECURE AND NOT FRAYED, TENSION.

(6) Input drive shaft and cowling — SECURE.

**(7) Nose gear box radiator and transfer tube — UNDAMAGED, FREE OF OBSTRUCTION, FREE OF LEAKS.

b. Utility filter — TWO FILTER BUTTONS IN, FREE OF LEAKS.

c. Utility module landing gear emergency extension valve reset button — IN.

d. Utility hydraulic reservoir — PROPERLY SERVICED AND FREE OF LEAKS.

e. Utility heat exchanger inlet duct — FREE OF OBSTRUCTION.

f. Main rotor head, left side.

*(1) Dampers — UNDAMAGED AND RETAINER IN PLACE, FREE OF LEAKS.

*(2) Pitch rods — CHECK PLAY, BOLT HEADS DIRECTION OF ROTATION.

(3) Droop stops — IN.

(4) Flap restrainers — CLEAN AND FREE.

*(5) Sleeve and spindles — RESERVOIRS SERVICED AND FREE OF LEAKS.

*(6) Vertical hinge pin — RESERVOIRS SERVICED AND FREE OF LEAKS.

(7) Beanie ring — SECURED.

(8) Pitch locks — NOTE ENGAGED OR DISENGAGED.

(9) Blade lockpins — SEATED.

(10) Spar pressure indicators — ALL WHITE AND TEST. Test as specified in 6.c. (10) observing WARNINGS and NOTES.

(11) Swashplate and scissors — SECURE, UNDAMAGED, FOD.

(12) Main rotor blades — UNDAMAGED.

*g. Main transmission — UNDAMAGED, LEAKAGE, AND MOUNT BOLTS.

*h. Aft primary servo — FREE OF LEAKS, LOCKWIRED AND SECURE.

i. Servo centering spring — SHEARPIN SECURE AND DOES NOT PIVOT.

j. Control rods — UNDAMAGED, COTTERKEYED, ROD END PLAY.

k. All bellcranks — SECURITY AND PLAY.

l. Main transmission — UNDAMAGED, LEAKAGE, AND MOUNT BOLTS.

*m. Transmission deck — FREE OF LEAKS AND SPILLAGE.

n. No. 2 engine EAPS — UNDAMAGED AND SECURE.

*o. Access and servicing panels — UNDAMAGED AND SECURE.

12. Upper Rear Transition Section and Pylon.

a. Fuselage, tail rotor drive shaft cowlings, and pylon — FREE OF DENTS OR CRACKS, WRINKLES, SECURE.

b. Formation lights — CLEAN AND UNDAMAGED.

c. Antennas — SECURE.

d. Pylon lockpin and flag — IN AND SEATED.

e. Tail rotor — PITCH LINKS LOCKWIRED, FREE OF LEAKS, AND BOLTS LINED UP.

f. Stabilizer and strut — FREE OF DISTORTION, CRACKS, STRESS, NO POPPED RIVETS.

13. Right Side Fuselage.

a. Check fuel dump line and mounting clamps — SECURE.

b. Landing gear well — GEAR PIN INSTALLED, DOWN AND LOCKED INDICATION, UNDAMAGED AND FREE OF LEAKS, FLUID INDICATING PIN FLUSH NOT EXTENDED.

c. Landing gear strut — UNDAMAGED, CLEAN, AND PROPERLY INFLATED.

*d. Wheels, brake disc, brake lines, and housing — UNDAMAGED.

e. Scissors switch — SECURITY.

*f. Tires — FREE OF CUTS, BLISTERS, AND PROPERLY INFLATED.

g. Pylon position light — CLEAN AND UNDAMAGED.

h. Auxiliary fuel tank — FUEL FILLER CAPS ARE SECURE. ALL ACCESS PANELS SECURE. BE SURE JETTISON SAFETY PIN IS INSTALLED AND CONTACTS MICROSWITCH. CHECK THAT JETTISON CARTRIDGE RETAINERS LOCKWIRED. NO MOVEMENT OF TANK IN RACK.

i. Sponson position light — SECURITY.

*j. Sponson and fuselage — FREE OF DAMAGE, DENTS, OR CRACKS, AND ALL BILGE COMPARTMENT DRAIN PLUGS INSTALLED.

7.1.3 Post Exterior Inspection

1. Covers, plugs and all tiedowns — REMOVED.

2. All access panels — SECURED.

3. EAPS — SECURE.

4. Blades — CONDITION.

5. Tools — ACCOUNTED FOR.

7.1.4 Interior Inspection

1. Jump seat — STOW.

2. AFCS servo compartment — SECURITY, FOD, LEAKS, FAS SHEAR PIN INTACT, AND VALVE ADJUSTMENTS SLIPPAGE MARKS.

WARNING

Do not fly helicopter if slippage marks show indication of adjustment screw movement.

3. First aid kit — COMPLETE AND SECURE.

4. HUD system — CHECK.

5. Speech security system (KY-58).

6. AN/ALE-39 programmer — PROGRAMMED.

7. Countermeasures override switch — OFF.

8. Circuit breaker panels — CHECK.

9. GPWS processor
(After AFC 501, Part 2) — SECURE.

10. Portable fire extinguisher — SECURE AND CHECK SEAL.

11. Wiggins fitting — COVERED, UNDAMAGED, NO LEAKS.

12. Portside emergency escape hatch — SECURE.

13. HIFR filter canister — NO LEAKS.

14. Landing gear emergency blowdown bottle — CHARGED AND SECURE. (2500 to 3000 psi).

15. Left auxiliary tank jettison switch — FIRE/COVER CLOSED. CANNON PLUG CONNECTED

16. Rotor brake manual override handle — AS DESIRED.

17. Gust lock — AS DESIRED.

18. Cargo — SECURE.

19. Cargo hook doors — AS REQUIRED.

20. Crewman's ramp control switch — HOLD.

21. Aft transition section — INSPECT.

22. Ramp door — UNRESTRICTED.

23. Ramp door actuator — UNDAMAGED, PROPERLY CONNECTED.

WARNING

If ramp door actuator is not installed, inflight separation of ramp door and subsequent airframe damage is possible. Ramp door must be pinned in the up position before flight.

24. Cargo ramp release levers and ramp door override valve — AS DESIRED.

25. Ramp actuating valve — CENTER.

26. Right auxiliary tank jettison switch position — FIRE/COVER CLOSED. CANNON PLUG CONNECTED.

27. Hoist shear circuit test switch position — FIRE/COVER CLOSED.

28. Hoist cable shear switch — OFF, SHEAR-WIRED.

29. Hoist light switch — OFF.

30. Fuel handpump — SECURE, NO LEAKS.

31. Auxiliary oil tank — SECURE, QUANTITY.

32. Both APP accumulator pressure gages — 3000 PSI MINIMUM.

33. APP accumulator selector handle — AS DESIRED.

34. APP/pylon fold handpump — SECURE, NO LEAKS, HANDLE STOWED.

35. Range extension tanks, control panel, and harnesses — SERVICED, SECURE, NO DAMAGE OR LEAKS, FUEL SELECTOR MAIN TANKS POSITION.

36. Emergency exit lights, escape hatches — SECURE AND ACCESSIBLE.

37. Single/Dual-Point Cargo Hook(s) — refer to paragraph 9.13 EXTERNAL TRANSPORT OF CARGO AND AIRCRAFT for preflight items.

38. Doppler well — INTEGRITY AND SECURITY.

39. Cargo winch — SECURE, FREE OF LEAKS.

7.2 PRESTART

CAUTION

Applicable to helicopters not modified by AFC 309. To prevent possible damage to the flight control components, the flight controls shall not be moved until hydraulic and electrical power are within normal operating limits.

7.2.1 Consoles

*1. Seat belts and harness — ADJUSTED.

2. VLEA control dial — SET. (Helicopters modified by crash-attenuating seats.)

*3. Seat cushion and exposure suit blower switches — OFF.

4. Cockpit window emergency release handles — SECURED/SHEARWIRED.

5. ICS and radio control panels — SET.

6. Gear handle and downlock release — DOWN, SET.

7. Emergency gear handle — SHEARWIRED.

8. Emergency cargo release handle — DOWN.

*9. Parking brake — SET.

*10. COMM and NAV sets — OFF.

11. ALE control panels — SAFE AND OFF.

*12. Emergency control panel switches — OFF, COVERS SHEARWIRED.

*13. Servo switches — CENTER.

7.2.2 Instrument Panel

1. Radar altimeters — OFF.

2. BDHI/course indicator switches — AS DESIRED. (Pre-AFC 471)

*3. Transfer-refuel switches — CLOSE.

*4. Refuel PROBE switch — STOW.

7.2.3 Copilot's Overhead Panel

1. Switches — AS DESIRED, FM ANTENNA IN AUTO.

7.2.4 Pilot's Overhead Panel

1. BLADE/PYLON FOLD MASTER POWER switch — OFF.

2. PYLON BLADE FOLD and BLADE FOLD POSN switches — OFF.

3. Pitch locks as required:

a. Blades spread — DISENGAGED.

b. Blades folded — ENGAGED.

4. Other switches — AS DESIRED.

7.2.5 Overhead Control Panel

*1. Engine speed controls — SHUTOFF.

*2. Emergency start panel — NORM, NORM, OFF.

*3. Engine fire T-handles — FORWARD.

*4. Fuel selector levers — CROSSFEED, 2-1-2.

5. AHRS — SLAVED.

6. Radar beacon (Removed by AFC 501, Part 2) — OFF.

7. FAS switch — COVERED.

*8. Emergency circuit breaker panel — CHECK.

9. Hoist control panel switches — OFF.

10. Cargo loading panel switches — OFF/HOLD.

11. Windshield wiper/washer — OFF.

12. Cabin heater and vent blower — OFF.

13. Cargo hook control panel switches — OFF.

14. EAPS switches — AS DESIRED.

*15. BDHI/course indicator switches — AS DESIRED.

*16. High-pressure rotor brake switch — EMER.

17. Rotor head light — OFF.

*18. Generators — OFF.

19. Engine overspeed test switches — OFF.

*20. Anti-ice panel switches — OFF.

*21. Fire guard — POSTED.

*22. Main rotor head position — MAIN ROTOR BLADE AT 5:30 to 6:00 (PYLON FOLDED).

*23. APP — CHECK AND START.

CAUTION

- Restarting of APP before a 2-minute wait may cause a hot start.
- Applicable to helicopter not modified by AFC 309. Although the flight controls are not to be moved until hydraulic and electrical power are within normal operating limits, it is especially important that they are not moved when the APP is operating and the No. 1 and No. 3 generators are off. In this configuration, hydraulic boost is furnished to the flight controls and, if the pitch locks are engaged, any movement of the flight controls will result in damage to the flight control components.

a. Emergency T-handle — FWD.

b. Automatic shutdown circuit breakers — SET.

c. Circuit breaker control switch — ON.

CAUTION

The low oil pressure and high exhaust temperature circuit breakers should be bypassed only in an emergency.

d. APP control lever — START.

Hold lever in start position until clutch engagement. Light off should occur at about 20% speed. Clutch engagement should occur at 100% speed.

Note

- Before reaching 92% speed, the only automatic shutdown protection available is high exhaust temperature. After 92% speed, overspeed and low oil pressure will also be available.
- Following APP start, engine start hydraulic system may chatter. This chatter may be eliminated by placing emergency start switch to EMER, and actuating engine starter, after generators are on.

e. APP ON advisory light — ON.

f. APP rpm — CHECK.

CAUTION

Any time an APP start is not completed, abort the start by placing the APP control lever to SHUTOFF and placing the circuit breaker control switch to OFF. An APP start shall be aborted whenever (1) acceleration hangs up for more than 4 seconds, (2) there is no RPM indication, (3) exhaust temperature reaches or exceeds 621°C, or (4) the APP clutch fails to engage, as indicated by the No. 1 rectifier, No. 2 rectifier, No. 1 generator and No. 3 generator capsules on the caution/advisory panel do not go on within 4 seconds after APP reaches 100% RPM.

7.3 POST APP START

CAUTION

With the APP driving the AGB, combined AGB loads shall be avoided. APP maximum operating thresholds can be exceeded when combined AGB loads (simultaneous control movements, engine starter engagement, cargo winch use, etc.) are encountered. The overloading conditions may lead to an internal APP drive failure which will result in APP turbine failure.

*1. No. 1 and No. 3 generators — ON.

Note

- If generators were not turned off before APP and/or main rotor was shut down, there may be relay chatter. This can be eliminated by recycling the generator switches.
- After generators are turned on, the BIM caution light may be on for as long as 2 minutes while the IBIS system is warming up.

*2. ICS — CHECK.

*3. Hydraulic pressure/quantity — CHECK.

CAUTION

If pitch locks are engaged, be sure second stage pressure is zero, for helicopters not modified by AFC 309.

*4. Caution advisory panel — CHECK AND TEST.

Note

- Check that UTILITY OIL HOT, ACC GB OIL PRESS, and ACC GB OIL HOT caution lights are off, or shut down generators and APP.
- Be sure all warning, master caution, caution advisory, chip locator, blade/pylon, and AFCS control panel lights go on.

*5. Interior and exterior lights — AS REQUIRED.

*6. Emergency exit light — ARM.

*7. Parking brake — RESET.

8. Fire warning — TEST.

Turn through 1, 2, and 3 positions and observe that master fire warning lights go on for each position, engine emergency T-handle light go on for all three positions, and APP emergency T-handle light goes on for positions 1 and 2.

9. NO. 2 ENGINE OVERHEAT WARNING panel TEST switch — PRESS. Note that #2 ENGINE OVERHEAT caution light comes on.

*10. COMM/NAV radios, RAD ALT, IFF, CMPTR POWER — AS DESIRED (Note AFCS caution light goes off).

*11. HNVS/RNS — AS DESIRED.

a. HNVS — COOL DOWN.

b. RNS — PWR ON.

c. FLIR lamp test — HOLD DOWN and RELEASE.

(1) No lamps lit = normal indication.

(2) SYS POWER or PROC lamp = SDC failure.

(3) DSP PWR lamp lit = DEU or PDU failure, run BIT.

12. Miscellaneous panel switches — SET.

13. Blade/pylon spread — AS REQUIRED.

a. Area — CLEAR.

b. Struts — REMOVED.

c. PITCH LOCK switch — PITCH LOCK.

PITCH LOCK ADVANCED and PITCH LOCKS ENGAGED lights on. BLADE PYLON FOLD, 2 STG PRESS M/R, 2 STG M/R SERVO BYPASS, 2 STG T/R SERVO BYPAS, and UTILITY T/R PRESS caution lights, on. Second stage hydraulic pressure gage zero. (With AFC 309 only the 2 STG M/R SERVO BYPAS caution light goes on, and second stage hydraulic pressure remains normal.)

CAUTION

Movement of flight controls after PITCH LOCK ADVANCE light has illuminated can damage spindle bore and pitch lock receiver bushings. If pitch locks will not engage with stick position indicator lit, maintenance on the pitch locking system is required.

d. Master power switch — POWER.

e. Pylon fold/spread switch — SPREAD.

Pylon starts to spread. PYLON UNSAFE FOR FLIGHT goes off when pylon is fully spread and tail rotor actuator is fully retracted.

f. Pylon fold/spread switch — OFF.

g. Blade fold/spread switch — SPREAD.

Blades start to spread and BLADES FOLDED light goes off. When blades fully spread and locked for flight BLADES SPREAD light goes on.

h. Blades fold/spread switch — OFF.

i. PITCH LOCK ENGAGED light goes off after any pitch lock disengages. PITCH LOCK ADVANCED light goes off after all pitch locks are retracted. In addition the 2 STG PRESS M/R, 2 STG M/R SERVO BYPAS, 2 STG T/R SERVO BYPAS, and UTILITY T/R PRESS caution lights go off and the second stage hydraulic pressure gage returns to normal. (With AFC 309 only the 2 STG M/R SERVO BYPAS caution light goes off, and second stage hydraulic pressure remains normal.)

j. Master power switch — OFF.

BLADE PYLON FOLD caution light and SAFETY VALVE OPEN lights go off. FLIGHT READY light goes on.

CAUTION

To ensure complete retraction of the pitch locks, visual confirmation shall be performed prior to movement of the flight controls.

*14. High-pressure rotor brake — CHECK EMER.

*15. ROTOR BRAKE ON advisory light — ON.

16. Gust lock — DISENGAGED.

ROTOR LOCKED caution light off.

*17. Area clear — CLEAR TO POSITION FOR ENGINE START.

CAUTION

Prior to positioning the main rotor head for engine start, ensure that the pitch lock switch on the blade/pylon fold panel is in the disengaged position. The safety valve opens when the rotor positioner switch is placed to ENG START POSN, and with the pitch lock switch in the pitch lock position, the pitch locks will try to advance.

*18. ROTOR POSITIONER switch — ENG START POSN.

Note

When ROTOR POSITIONER switch is held for over 5 seconds after the head has reached the engine start position, the safety valve will latch open. If this happens, cycle the BLADE/PYLON FOLD MASTER POWER switch to ON and back to OFF.

ENG START HEAD POS advisory light should go on. Continue holding switch until ROTOR BRAKE ON advisory light goes on, indicating rotor brake pressure has built back up. Release switch, ENG START HEAD POS advisory light goes off.

CAUTION

Any time the safety valve open light on the blade fold panel is on and the pitch lock switch is placed to engage, the pitch locks will attempt to engage regardless of head position. Insure the pitch lock switch is in the disengage position before:

1. Positioning the rotor head for start.

2. Opening the safety valve for blade or pylon fold.

19. BLADES SPREAD/FLIGHT READY lights — ON.

20. Bearing monitor system (BMS) tests (AFC 491) — COMPLETE.

Note

BMP startup BIT (SBIT) is activated when power is initially applied to the system. The panel startup BIT will cause the display to indicate flashing TESTING for about 1 minute. When SBIT is complete, ALL OK appears in the alphanumeric display. If a bearing/ system fault exists, the fault and fault location is displayed.

Aircrew Checks:

a. BMS lamp/LED test:

(1) BMP display — ALL OK.

(2) CABIN PANEL LIGHTS control panel:

(a) Rotate LH knob counter-clockwise — CHECK LIGHTS DIM.

(b) Rotate LH knob clockwise — CHECK LIGHTS BRIGHT.

(3) Press and hold BRT/DIM button — BRIGHT OBSERVED.

(4) Press and release NEXT button — LMP TEST DISPLAYED.

(5) Press and hold SELECT button — 01030100 DISPLAYED. ALL LIGHTS ILLUMINATE. OBSERVE NO DARK AREAS IN CHECKERBOARD PATTERN.

(6) Release SELECT button — 8 LIGHTS GO OUT/ALL OK. LAMP TEST COMPLETE.

b. BMS self-test:

Note

BMS self-test lasts approximately 1.5 minutes.

(1) BMP display — ALL OK.

(2) Press and release NEXT button — SYS TEST DISPLAYED.

(3) Press and release SELECT button — 01030100 DISPLAYED. DISPLAY FLASHES TESTING. CAUTION LIGHTS ILLUMINATE. BEARING STATUS LIGHTS FLASH. SYSTEM STATUS LIGHTS FLASH.

(4) Press PREV button — RESET DISPLAYED.

(5) Press PREV button — SYS TEST DISPLAYED.

(6) Press PREV button — ALL OK DISPLAYED. TEST COMPLETE.

21. IBIS BIT — COMPLETE.

7.3.1 Instrument Panel

1. Fuel quantity gages — TEST/QUANTITY.

2. REFUEL PWR pushbutton — OFF.

3. PURGE pushbutton — OFF.

4. Clocks — SET.

*5. Barometric altimeter — SET.

*6. Attitude indicators — SET.

7. Airspeed indicator — CHECK.

*8. Compass (BDHI) — SLAVED/ALIGNED.

9. VSI — CHECK.

10. Landing gear position indicators — CHECK.

11. MAIN/TR/INT GB circuit breaker — PULL AS REQUIRED (if operating in desert environment).

12. MAIN/TR/INT GB circuit breaker — RESET IF PULLED.

7.3.2 Console

1. Landing gear warning light — TEST.

2. Second stage servo interlock — CHECK.

Place flight control servo switch to 2 STG OFF. 2 STG PRESS M/R caution light should not go on and second stage hydraulic pressure should remain at 2600 to 3300 psi. Return servo switch to centered position.

*3. Flight controls — ADJUST/CHECK.

a. All AFCS servos off. Slowly move cyclic, collective, and rudder pedals through full range of control movement. No restriction should occur. Mechanical coupling among all flight controls may be apparent. While moving the flight controls, have aircrewman observe movement of main and tail rotor blades.

b. AFCS servo 1 on. With the collective full down, slowly move the cyclic, then the pedals through full range of control movement. Repeat with the collective full up. No restriction should occur and there should be no coupled response between any flight controls. Any coupled response between the cyclic and the collective could indicate an engaged pitch lock.

CAUTION

If any restriction or mechanical coupling in control movement is noted, do not engage rotor.

Note

Rapid movement of controls may cause second stage pressure to drop below 2000 psi and light 2 STG PRESS M/R caution light.

4. AFCS servos — ENGAGE, RELEASE AND TRANSFER.

CAUTION

Center the cyclic before engagement or disengagement of the AFCS servos. Failure to do so may cause the FAS shear pin to fail.

a. Verify SERVO 1 light and SERVO 2 UNARMED light on. Center cyclic and pedals and place collective in midposition.

b. Press SERVO 1 pushbutton. SERVO 1 light and SERVO UNARMED light should go off.

c. Press SERVO 2 pushbutton. The SERVO 2 light should go on.

d. Press SERVO 2 pushbutton again. SERVO 2 light should go off.

e. Press SERVO 1 pushbutton. SERVO 1 light and SERVO 2 UNARMED light should go on.

f. Press SERVO 2 pushbutton. SERVO 2 UNARMED light should go off.

g. Transfer SERVOS from SERVO 1 to SERVO 2 and back to SERVO 1 by pressing SERVO 1 pushbutton.

•5. AFCS — CHECK.

a. SERVO 1 on and servo 2 armed (UNARMED light off).

b. Press and light AFCS pushbutton. No FAIL ADVISORY lights should go on.

c. Press and light TRIM pushbutton. No FAIL ADVISORY lights should go on.

d. Press SERVO 1 off. SERVO 2 goes on automatically, AFCS and TRIM pushbuttons stay lit.

e. Press SERVO 2 off. AFCS and TRIM pushbutton lights go off.

f. In sequence press SERVO 1, SERVO 2, AFCS, and TRIM. SERVO 1, AFCS, and TRIM pushbuttons light. Servo 2 is armed (UNARMED light off).

g. Press and light AUTO BANK pushbutton. No FAIL ADVISORY lights should go on.

h. Press AFCS pushbutton off. Note AFCS and AUTO BANK lights go off.

i. Press MODE RESET pushbutton momentarily. Note that AFCS pushbutton relights.

6. Barometric/radar altitude hold — CHECK.

a. BAR ALT pushbutton — PRESS.
BAR ALT light should go on and there should be no FAIL ADVISORY lights on.

b. RDR ALT pushbutton — PRESS.
RDR ALT light should not go on.

c. CLTV TRIM REL button — PRESS.
BAR ALT light should go off while pressed. Release button. Copilot repeat check.

d. BAR ALT pushbutton — PRESS.
BAR ALT light should go off.

e. RDR ALT pushbutton — PRESS.
RDR ALT light should go on and there should not be FAIL ADVISORY lights on.

f. ALT SET knob — INCREASE.
Collective should rise slightly. Return ALT SET knob to null position.

g. CLTV TRIM REL button — PRESS.
RDR ALT light should go off. Engage RDR ALT again and disconnect with copilot's CLTV TRIM REL button.

h. RDR ALT pushbutton — PRESS.
RDR ALT light goes on.

i. Radar altimeter PUSH-TO-TEST control knobs — PRESS.
Pointer does not move, test disabled.

j. RDR ALT pushbutton — PRESS.
RDR ALT light goes off.

k. Radar altimeter PUSH-TO-TEST control knob — PRESS.
Altimeter reads 100 ±15 feet, test satisfactory.

7. Trim systems — CHECK.

SERVO 1, CMPTR POWER, AFCS, and TRIM on.

a. Cyclic stick trim release button — PRESS.

Move cyclic in lateral and fore-and-aft directions.

b. Cyclic trim release button — RELEASE.

Move cyclic in lateral directions from trimmed position and note that resistance increases with increased displacement and cyclic returns to the trim position. Move cyclic in longitudinal direction; the force should not increase beyond 1/2-inch displacement. Longitudinal cyclic may not return to trim from end stops. In this case, lightly assist cyclic to within 2 inches of trim, at which point it should return.

Note

In the fore and aft axis, if the cyclic does not return to the trim position, the FAS shearpin may be sheared.

c. Cyclic beeper trim — OPERATE CYCLIC STICK TRIM BEEP BUTTON FORE, AFT, LEFT, AND

RIGHT. CHECK CYCLIC MOVEMENT IS SMOOTH AND IN THE PROPER DIRECTION.

d. Collective trim release button — PRESS.

Move collective up and down.

e. Collective trim release button — RELEASE.

Move collective up and down from holding position and note that resistance increases with increased displacement and collective returns to trim position.

f. Cyclic and pedals — CENTERED.

g. Collective — DOWN.

h. Pedal trim — CHECK.

Move pedals without pressing collective pedal trim release switch or pedal switches. Pedals should return to trim position.

i. Heading trim — CHECK.

Turn HDG TRIM knob clockwise and note that right pedal advances; press pedal switch and note that pedal motion stops. Repeat, turning HDG TRIM knob counterclockwise and press collective pedal trim release and note that pedal motion stops.

8. Single- and two-point cargo hooks — AS REQUIRED.
See EXTERNAL TRANSPORT OF CARGO AND AIRCRAFT in Chapter 9.

9. Utility hoist function check and guillotine test — AS REQUIRED.
See UTILITY HOIST OPERATION in Chapter 9.

7.4 STARTING ENGINES/ROTORS

The engine exhaust danger areas are shown in Figure 7-2. The pilot in command will make sure that preflight inspections have been completed and that all crewmembers are present and at their stations. Designated checks shall be made with participating crewmembers at their respective stations and shall extend through the post engine start check. A qualified pilot or person designated by the commanding officer shall be in the pilot's seat any time the engines are started. Starting personnel shall receive and acknowledge crewman and fire guards' all clear signals before starting engines. To make the No. 2 engine accessible for fire fighting during engine start, engines 3, 2, and 1 are started in that order; however, no special sequence is required for technical reasons.

WARNING

Before engine start, the pilot in the right seat shall check that the head has positioned correctly by observing that there is a blade at the 12:30-o'clock position (Figure 7-3).

CAUTION

- Locked-rotor starts are mandatory during shipboard operations or in high or gusty wind conditions.
- Should APP flame out before engine reaches starter dropout speed, abort the start. Return APP control lever to SHUT OFF.

*1. Area — CLEAR/FIRE GUARD POSTED.

*2. Flight Controls — START POSITION.

a. Collective down.

b. Pedals centered.

c. Cyclic shaft vertical.

*3. No. 3 engine — START.

Note that ENG STARTER ON advisory light goes on when starter button depressed.

Advance No. 3 engine speed control lever to GRD IDLE at a MINIMUM of 20% N_g.

CAUTION

- If fuel flow exceeds 175 pph before light-off at GRD IDLE, a hot start may occur if the start is not aborted.

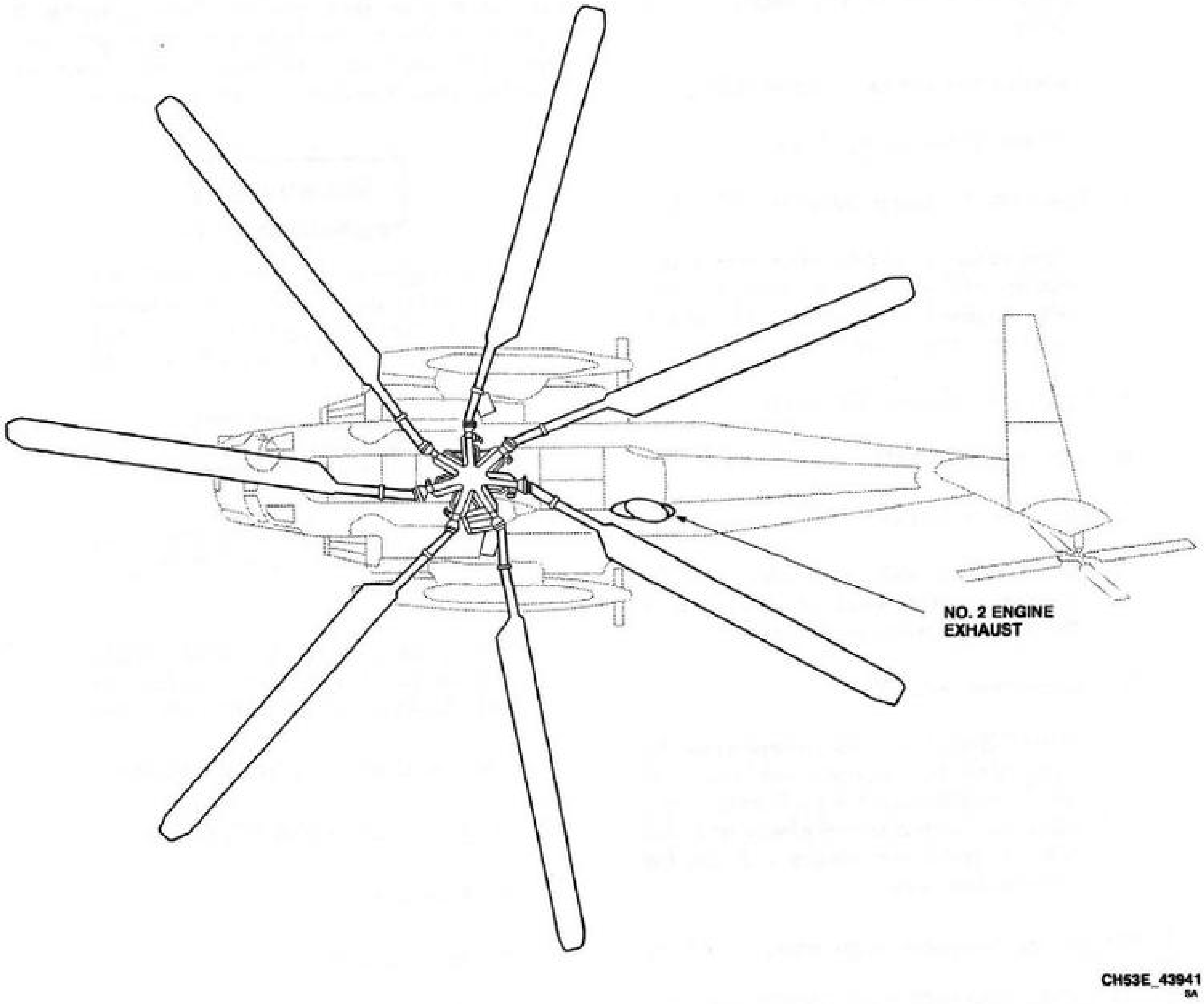

Figure 7-3. Engine Start - Blade Position

- If engine light-off does not occur within 10 seconds after fuel flow indication, abort the start by pulling down on the engine speed control lever and returning it to the shutoff position. To purge the engine of fuel, motor engine with the starter for at least 1 minute and until no further fuel spray is noted from the tailpipe. Wait an additional minute to drain excess fuel from the engine.

- Due to the probability of damaging the start system, the gas generator speed shall be zero before engaging the starter.

- If T_5 reaches 650°C before idle, abort the start immediately as a hot start is indicated. To purge the engine of fuel, motor engine with the starter for at least 1 minute and until no further fuel spray is noted from the tailpipe. Wait an additional minute to drain excess fuel from the engine.

- A hung start is indicated by failure of the gas generator to accelerate to proper idle speed, accompanied by high T_5 indications. If T_5 reaches 650°C and/or start time exceeds 60 seconds, abort the start. Failure to do so may create a fire hazard caused by hot exhaust gas backflow into the aft engine compartment.

- A cold hangup will be indicated by failure of the gas generator to accelerate to proper idle speed, accompanied by a low T_5 indication.

- During engine purge operations, excess fuel may be sprayed into the power turbine and tailpipe section and drip onto the exterior surfaces of the helicopter. To prevent a serious fire, ground personnel shall wipe tailpipe, EGR nozzle, and fuselage area dry of fuel before attempting starts.

*4. No. 3 engine instruments — CHECK.

a. #3 ENG FUEL BOOST and #3 ENG OIL PRESS LOW and HIGH caution lights off.

CAUTION

Engine oil high pressure light may stay on for as long as 3 minutes, until oil has warmed. Should engine oil high light stay on for over 3 minutes, secure engine. Do not go over ground idle until oil pressure is within normal operating limits. (Caution lights off.)

b. T_5 — WITHIN LIMITS.

c. Fuel flow — ABOUT 200 TO 350 LBS/HR.

d. N_g ABOUT 60.5% to 70%. (Ground idle is variable with OAT.)

CAUTION

Should APP flame out before rotor engagement, there will be no hydraulic or electrical power available. Return APP control lever to SHUT OFF. If the rotor brake slips or is released without electrical power, there will be no positive indications of complete rotor brake release and a rotor brake fire hazard exists. Pilot should be sure rotor brake switch is in the OFF position.

Note

- If engine should shut down, or abnormal T_5, N_g, or fuel flow indications are noted, fuel lines may have lost their prime.

- The starter should drop out by the time the engine reaches ground idle. Normally the starter should automatically drop out at about 51% to 58% N_g. If the starter does not drop out, manually disengage the starter by pulling down on the engine speed control lever.

*5. No. 2 engine — START.

Procedure for starting No. 2 engine is same as for No. 3 engine.

*6. No. 2 engine instruments — CHECK.

*7. No. 1 engine — START.

Procedure for starting No. 1 engine is same as for No. 3 engine.

*8. No. 1 engine instruments — CHECK.

*9. Fuel selector levers — CROSSFEED, 3-3-1.

*10. Area — CLEAR.

*11. Seat belt and shoulder harness — FASTENED, LOCKED.

*12. Crew — ALERTED.

*13. Flight controls — NEUTRAL.

CAUTION

High velocity or gusty winds can cause excessive blade flapping. When engaging rotor in high or gusty winds, monitor tip path and engage rotor rapidly and smoothly.

*14. High-pressure rotor brake — RELEASE.

Hold for about 5 seconds and make sure that ROTOR BRAKE ON advisory and ROTOR BRAKE PRESS caution lights are off. Make sure that the 1 STG M/R SERVO BYPAS caution light is off when 1 STG PRESS M/R T/R caution light is off.

CAUTION

Before releasing the rotor brake by pulling the manual override release handle, make sure the high-pressure rotor brake switch is off.

*15. First stage hydraulic pressure/quantity — CHECK.

CAUTION

- Shut down engines immediately if either nose gear box oil pressure caution light remains illuminated after main rotor speed has stabilized at ground idle.
- On all rotor engagements, check that BLADES SPREAD and FLIGHT READY lights go off with MGB OIL PRESS caution light at above 14 psi. If all lights on blade/pylon fold panel do not go off, secure rotor engagement and investigate.

*16. MGB OIL PRESS, BLADES SPREAD and FLIGHT READY lights — OFF.

*17. Control response — CHECK.

Note

- Do not turn any stage off until all servo bypass lights are off.
- Keep thumb on servo switch and be prepared to return switch to center (on) position if controls respond abnormally during any portion of check.
- There are no interlocks to prevent turning off pressure to either hydraulic stage when a servo in the other stage is in bypass. Enough force can be generated by a bypassed stage to drive a servo to its extreme if pressure is unavailable to the nonbypassed stage.
- Although a slight displacement is permissible, there should not be large or cycling fluctuations in the tip path plane when switching servo positions. There should be no jump in the flight controls.

With rotor at ground idle, turn off first stage servo, move cyclic a small amount laterally and longitudinally and check for tip path response. Move collective a small amount and check for tip path response. Move pedals a small amount and be sure you see and feel response. Repeat check with second stage servo turned off.

Note

- Appropriate flight control servo failure caution lights will go on as various flight control systems are depressurized, and will go off when the system is again pressurized.
- When doing interlock check, and/or securing individual servo stages, blinking of first or second stage servo pressure caution lights is not a cause for servo removal.

*18. Rotor — 100% N_r.

As rotor speed is increased, gradually raise the collective to the detent position. Once the droop stops are disengaged, lower the collective to the full down position.

WARNING

Rapid cyclic control movements, particularly forward, may cause main rotor blades to strike the fuselage.

CAUTION

- A ground roll/shuffle or one-per-revolution vibration may indicate one, or a combination of the following: Improper strut servicing, improper tire inflation, improper track and balance, or a bad damper. Abort start and consult maintenance personnel for proper diagnosis and maintenance action.
- Do not advance speed control levers beyond 100% N_r until the APP is secured. Running speed control levers above 100% N_r before securing the APP will backdrive the APP and cause spline adapter failure and/or APP turbine failure.

*19. No. 2 generator — ON.

*20. APP — SHUTDOWN.

*21. PURGE pushbutton — AS DESIRED.

CAUTION

Do not activate PURGE if helicopter is topped off with fuel.

ALTERNATE (UNLOCKED) START:

1. Area — CLEAR/FIRE GUARD POSTED.
2. Seat belt and shoulder harness — FASTENED/LOCKED.
3. Crew — ALERTED.
4. Flight controls — START POSITION.
5. Starter safety interlocks — CHECK.
6. Emergency start switch — EMER START.
7. High pressure rotor brake — RELEASE.
8. No. 3 engine — START.
9. No. 3 engine instruments — CHECK.
10. First stage hydraulic pressure/quantity — CHECK.

(Cont)

ALTERNATE (UNLOCKED) START:

11. No. 2 engine — START.
12. No. 2 engine instruments — CHECK.
13. No. 1 engine — START.
14. No. 1 engine instruments — CHECK.
15. MGB OIL PRESS, BLADES SPREAD, FLIGHT READY lights — OUT.
16. Fuel selector levers — CROSSFEED 3-3-1.
17. Control response — CHECK.
18. Rotor — 100% N_r.
19. No. 2 generator — ON.
20. APP — SHUTDOWN.
21. EMER START switch — NORM.
22. PURGE pushbutton — AS DESIRED.

7.5 PRE-TAXI

1. Engine overspeed — CHECK.

Match engine torque at 100% N_r. Collective full down. Momentarily actuate each overspeed switch. Look for decrease in N_g, N_f, T_5, fuel flow, and torque when each overspeed switch is moved to TEST.

2. Flat pitch — CHECK.

   a. Engine speed control levers — FULL FORWARD.

   b. Check N_r at 104% to 107%.

      Engines' N_g, T_5 and torque approximately matched.

   c. Return to 100% N_f/N_r.

*3. Anti-ice — AS REQUIRED.

*4. Fuel selector levers — DIRECT.

*5. Instruments — CHECK.

*6. Caution panel — CHECK.

•7. BAR ALT — SET/CHECK.

•8. Communications, NAVAIDS, RAD ALT, and IFF — TEST AS REQUIRED, TUNED AND SET (See Instrument Flight Checklist).

•9. HNVS operational readiness test — AS REQUIRED.

a. FLIR power switch (after 10-minute cooldown) — ON.

b. PDUs — NT or DAY AS REQUIRED.

(1) Check for FLIR image.

(2) Check for CHOT. If displayed, let cool down another 18 minutes. If still displayed, run BIT.

(3) Adjust SYS BRT (black or white as desired).

(4) Adjust PDU BRT and CONT as desired.

c. Menu page 1 — SELECT ON PDU.

d. GRSC — SELECT ON PDU.

(1) Adjust brightness and contrast until 10 shades of gray are visible.

e. GRSC — DESELECT VIA PDU WHEN COMPLETE.

f. Flight page — SELECT VIA PDU.

g. AHD — DESELECT IF SELECTED.

h. ARE calibration:

(1) With MFCU, point TFU — CLEAR SKY.

(2) NFOV — SELECTED.

(3) ARE function — INITIATE VIA MFCU or PDU.

(4) Wait for STOP to go out on PDU, ARE complete.

i. WFOV — SELECTED.

j. TFU — WITH MFCU, SLEW TO DESIRED POSITION.

k. Check PDU symbols vs. cockpit indicators — ABOUT THE SAME. If not, calibrate altitude, airspeed, torque, or Doppler.

•10. Heater/vent blower — AS DESIRED.

•11. Windshield wiper/washer — AS REQUIRED.

•12. Pitot heater/anti-icing — AS REQUIRED.

•13. Ice detection — AS REQUIRED.

•14. Exterior lights — AS REQUIRED.

•15. Clocks — CHECKED.

16. Fuel transfer — CLOSE.

17. EAPS — AS DESIRED.

•18. Pins and chocks — REMOVED.

•19. Ramp and doors — CLOSED.

20. Ramp flippers — SECURED/STOWED.

•21. Crew and passengers — ALERTED.

•22. Ground personnel — CLEAR.

23. Auxiliary tank jettison test — AS REQUIRED.

WARNING

Make sure that no personnel are in the vicinity of the tanks during this test and only one crewmember, in the cabin, is in the vicinity of the auxiliary tank circuit tester panels.

a. Right auxiliary tank circuit tester switch — TEST.

Right auxiliary tank jettison circuit tester panel.

CAUTION

Be sure utility hoist electro-explosive circuit tester is not confused with right auxiliary tank circuit tester.

b. Right test switch at TEST — VERIFIED BY CREWMAN.

c. Right AUX TANK JETTISON switch — RIGHT.

Console emergency control panel.

d. Test light — ON.

Right auxiliary tank jettison circuit tester panel.

e. Right AUX TANK JETTISON switch — OFF, COVER CLOSED.

Console emergency control panel.

f. Right jettison test complete — VERIFIED BY PILOT.

g. Right auxiliary tank circuit tester switch — FIRE, COVER CLOSED.

h. Left auxiliary tank circuit tester switch — TEST.

Left auxiliary tank jettison circuit tester panel.

i. Left test switch at TEST — VERIFIED BY CREWMAN.

j. Left AUX TANK JETTISON switch — LEFT.

Console emergency control panel.

k. Test light — ON.

Left auxiliary tank jettison circuit tester panel.

l. Left AUX TANK JETTISON switch — OFF, COVER CLOSED.

Console emergency control panel.

m. Left jettison test complete — VERIFIED BY PILOT.

n. Left auxiliary tank circuit tester switch — FIRE, COVER CLOSED.

24. Fuel probe extension test — AS REQUIRED. See HELICOPTER AIR REFUELING PROCEDURES in Chapter 9.

25. ATC/TAXI clearance — RECEIVED.

*26. HEEDS bottles — OPEN.

7.6 TAXI

CAUTION

- The pilot is responsible for the safe and orderly taxi of the helicopter. Sufficient ground control personnel shall be available for the safe taxiing of helicopters, when in vicinity of obstructions or other aircraft.
- During ground taxiing, right pedal inputs will cause the tip path plane to dip due to yaw to pitch coupling.
- Because of rotor turbulence, use caution when taxiing near light planes and other aircraft. Take particular care during air taxiing due to increased rotor downwash and its effect on loose equipment and debris near helicopter.
- Taxiing with nose landing gear strut extended may cause damage to nose landing gear, due to restricted swivel range.
- Using a tight radius of turn at a high gross weight increases the potential for rolling the main landing gear tires off their rim. Cyclic should be displaced in direction of turn, for an even distribution of weight on main landing gear.

Note

Do not force the parking brake handle when releasing the parking brakes. This action may damage the parking brake actuating cable and cableway, causing the parking brakes to remain on when the advisory light is off.

Requirements for taxiing will vary according to conditions in operating area. Only approved standard taxi signals will be used and no one will be permitted to taxi a helicopter except those authorized to fly it. Except for mandatory emergency stop signal, taxi director's signals are of an advisory nature only. Use extreme caution when taxiing at night. To initiate a taxi movement, use collective as necessary to move at a safe rate of speed, and use rudder pedals to control direction. Keep cyclic and brake action at a minimum. Place cyclic in direction of turn.

*1. Wheel brakes — CHECK.

2. Heading indicators/turn needles — CHECK.

7.7 PRE-TAKEOFF

*1. Fuel quantity — CHECK.

*2. Fuel transfer — OFF.

3. Fuel selector levers — DIRECT.

4. Compass — SET.

*5. Cockpit windows — CLOSED AND SECURE.

*6. Crew and passengers — ALERTED.

7. Landing gear handle — DOWN AND LOCKED.

*8. Panel takeoff checklist:

a. APP — OFF.

b. Engine instruments — CHECK.

c. AFCS — ON.

d. RPM — SET.

e. Brakes — AS REQUIRED.

f. Harness — LOCKED.

g. Caution/Advisory panel — CHECK.

7.8 FLIGHT

WARNING

The HNVS system provides for increased situation awareness and aids navigation. The FLIR image and symbology shall not be used exclusive of other flight instruments.

CAUTION

Caution is required during air taxi maneuvers and downwind hover to preclude possible engine power fluctuations due to exhaust gas ingestion.

7.8.1 Takeoff. The governing factors for determining the type of takeoff to be made are gross weight, density altitude, and size and condition of the takeoff area. Vertical climbs are possible; however, at high gross weights, the ability of the helicopter to climb vertically exceeds the ability to make a safe landing if one engine fails. The minimum height and airspeed for safe landing after engine failure should be used as a guide in determining takeoff climb speeds. The best airspeed to be used for obstacle clearance should be determined from the performance charts. The objectives during takeoff are to clear obstacles at a safe altitude and airspeed, and then to establish a rate-of-climb airspeed. The following paragraphs describe the types of takeoff to be made under various conditions.

7.8.1.1 Operational Power Check. Operational power checks are completed to ensure that each engine is capable of producing calculated maximum power available or, at a minimum, the calculated power required to perform the mission. An operational power check should be performed prior to conducting heavy-lift or terrain flight (TERF) operations. If at the completion of the operational power check calculated maximum power available was not obtained, conduct a single-point performance check to ensure that the engine(s) is/are producing at least minimum acceptable torque. Based on mission considerations, operational power checks may be performed either at altitude enroute to the operating area or on the ground. During operational power checks, care must be taken to ensure that engine limits are not exceeded (773°C (T64-416)/792°C (T64-416A); 100% N_g or 137% Torque).

Operational power check procedures (in-flight):

1. Set 29.92 in barometric altimeter and establish base altitude.

2. Check OAT and calculate maximum power available for selected altitude.

3. While maintaining level flight and 100% or 103% N_r, manipulate collective and speed control levers to verify that calculated maximum power available can be obtained for each engine without exceeding 100% N_g, 773°C T_5, or 137% Q. Note actual power available for each engine. If mission requirements dictate, T64-416A engines may be capable of producing greater torque than calculated on the 773°C T_5 Maximum Power Available chart at a T_5 of 792°C.

4. Perform a single-point performance check for any engine that did not produce the calculated maximum power available.

Operational power check procedures (on deck):

1. Set 29.92 in barometric altimeter and note altitude.

2. Check OAT and calculate maximum power available.

3. Advance one speed control lever full forward and retard the other two speed control levers to ground idle.

4. Smoothly increase collective until calculated max power or 100% N_g, 773°C T_5, or 137% Q is reached. Note power available. If mission requirements dictate, T64-416A engines may be capable of producing greater torque than calculated on the 773°C T_5 Maximum Power Available chart at a T_5 of 792°C.

5. Repeat procedure for remaining two engines.

6. Perform a single-point performance check for any engine that did not produce the calculated maximum power available.

7.8.1.2 Normal Takeoff. A normal takeoff (Figure 7-4) is made by adjusting the engine speed control levers as required for helicopter weight with the collective pitch lever in minimum pitch, then increasing collective pitch to raise the helicopter vertically. As the helicopter lifts off, maintain heading with the rudder pedals and maintain attitude with the cyclic. Increase collective pitch until helicopter is about 10 feet off surface. Check engine and transmission instruments, and flight controls before continuing flight.

7.8.1.3 Maximum Performance Takeoff. The primary objective of a maximum performance takeoff is to clear an obstacle within a minimum of horizontal distance. Apply power smoothly and increase collective pitch to raise the helicopter to a low hovering altitude of about 2 to 3 feet, where maximum power shall be smoothly applied to continue the takeoff. For light gross weight takeoffs, climb vertically while maintaining hover attitude, until sufficient altitude is reached to clear any obstacles. Then apply forward cyclic to accelerate to best rate-of-climb speed. When conditions of gross weight and/or density altitude prohibit a vertical climb, the minimum horizontal distance to clear an obstacle can best be obtained by hovering at 2 to 3 feet and simultaneously applying forward cyclic with the collective necessary to obtain maximum power. From this point, accelerate and climb until the obstacle is cleared. After the obstacle is cleared, adjust cyclic and collective to obtain the airspeed that will produce the best rate-of-climb.

7.8.1.4 Heavy Lift Takeoff.

WARNING

> If engine power is limited (engine topped), droop N_r as required, but do not allow to droop below 100%.

For heavy lift takeoffs, head into the wind and set engine speed control levers full forward (about 105% N_r). Apply power as required until either engine limits or maximum torque is achieved.

7.8.1.5 Running Takeoff. Running takeoffs are used under certain conditions of high gross weight and/or high density altitude where there may not be enough power developed by the engines and/or lift developed by the main rotor blades for a vertical takeoff. Under these conditions it is necessary to obtain translational lift through forward motion on the ground before becoming airborne. Do not attempt running takeoffs over rough or rocky terrain, due to the possibility of damage to the helicopter. Make running takeoffs into the wind when practical, then increase collective pitch and apply forward cyclic as necessary to start the ground run and obtain takeoff speed. Use rudder pedals to maintain directional control during the ground run. When desired takeoff speed is reached, move cyclic aft while simultaneously increasing collective to maximum power. When the helicopter becomes airborne before reaching best climb speed, maintain level flight until best climb airspeed is obtained.

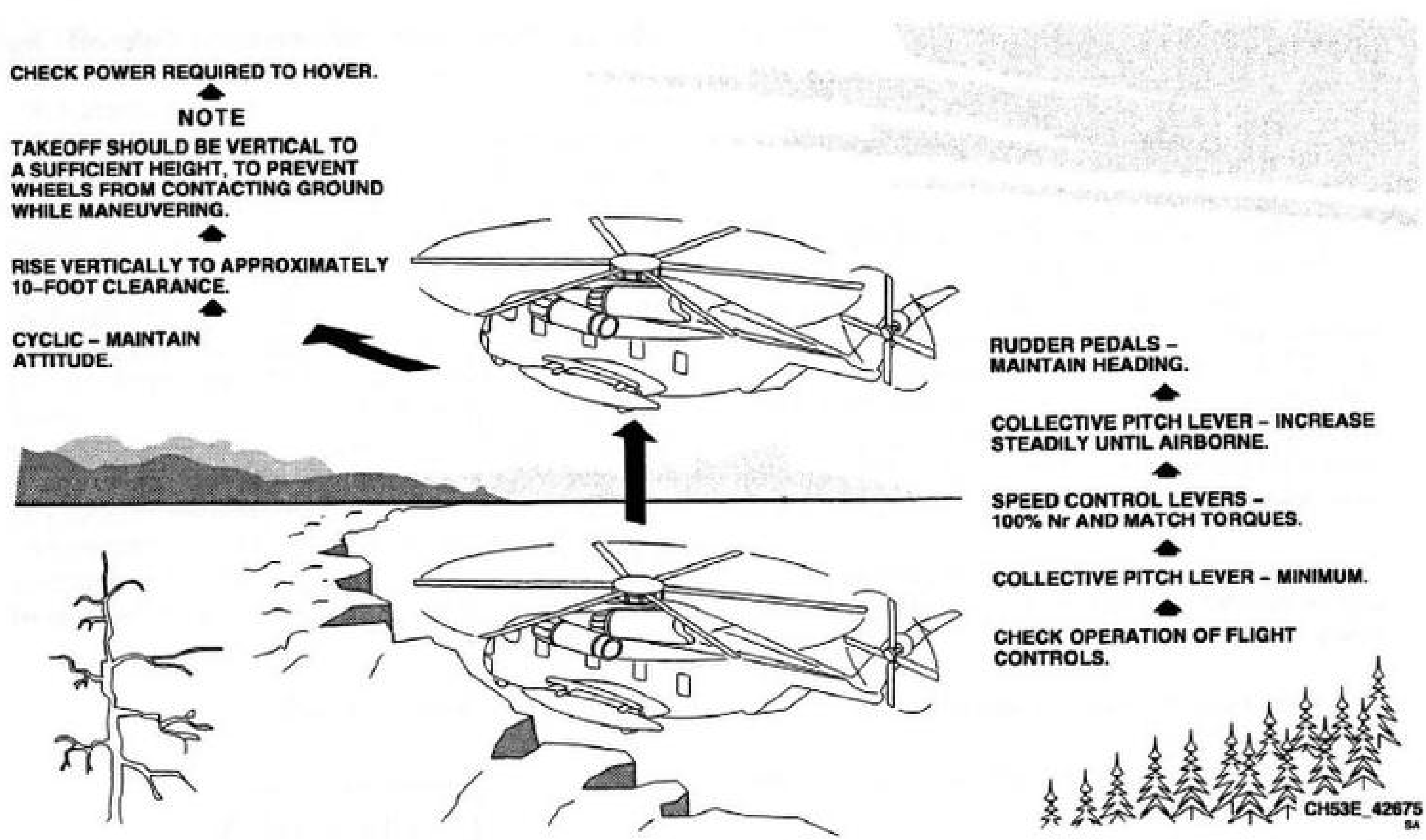

Figure 7-4. Normal Takeoff (Land)

7.8.1.6 Crosswind Takeoff. Crosswind takeoffs are the same as takeoffs into the wind, with the exception of lateral cyclic required to correct for drift. Greater care must be taken in maintaining directional control.

7.8.2 Transition To Forward Flight. As the helicopter transitions from hovering to forward flight, the loss of ground effect and/or the change in direction of the main rotor thrust vector will result in a loss of lift which tends to cause the helicopter to settle. As airspeed increases above approximately 15 knots, translational lift will become effective and tend to cause the helicopter to climb. Transition to forward flight is best made by smoothly moving the cyclic forward to increase airspeed, meanwhile making coordinated adjustments to the collective control and rudder pedals to maintain altitude and directional control. As the desired climb speed is approached, rotate the helicopter and adjust collective pitch to establish the desired rate-of-climb and climb airspeed.

7.8.3 Climb Procedures. The procedures for establishing a climb will vary if the climb was initiated from transition to forward flight, a running type takeoff, or from a selected altitude. Regardless of the type of climb desired, refer to the climb charts in Part XI to obtain the factors that will produce the best rate-of-climb speed.

7.8.3.1 Initial Climb to Altitude. This will normally start after the helicopter has transitioned to forward flight and the desired climb speed is approached. Then adjust the collective and cyclic to obtain the climb attitude that will produce the best climb speed for the specific gross weight, pressure altitude, and OAT conditions. Maintain directional control with the rudder pedals.

7.8.3.2 Cruise Climb. This is normally made to climb from an established to a selected altitude. This type of climb may be varied by sacrificing rate-of-climb for airspeed, or airspeed for rate-of-climb, depending on the time and horizontal distance desired before reaching the newly selected altitude. After determining the desired rate-of-climb and associated airspeed, adjust the collective and cyclic to obtain the climb attitude that will produce the results for specific gross weight, pressure altitude, and OAT conditions. Maintain directional control with the rudder pedals.

7.8.3.3 Maximum Performance Climb. The climb is usually made to gain altitude in the least amount of time, or when gross weight and density altitude prohibit a normal climb with associated power. When a maximum performance climb is initiated after a maximum performance takeoff, adjust the collective to maintain maximum power while simultaneously applying forward cyclic to accelerate to the airspeed that will produce the best rate-of-climb. Other maximum performance climbs are made by adjusting collective to obtain maximum power while simultaneously adjusting cyclic to obtain the climb attitude that will produce the maximum rate-of-climb and associated climb speed permitted by the gross weight, density altitude, and OAT conditions. Directional control is maintained on all maximum performance climbs with the rudder pedals.

CAUTION

At gross weights below 60,000 pounds, limit average torque to 110% in climb. At gross weights above 60,000 pounds, 121% average torque may be used.

7.8.4 Cruise. Conduct normal cruise at a safe altitude and as dictated by weather, terrain and obstacles, mission of the flight, and safety of the helicopter and crew. For specific speeds, power settings, and fuel consumption rates, refer to the cruise charts in Part XI.

1. Landing gear — AS REQUIRED.
2. Radios NAVAIDS/IFF — CHECKED.
3. Aircrew Flight Checklist — COMPLETE.
4. Operational Power Check — AS REQUIRED.
5. Fuel transfer — AS REQUIRED.
6. Instruments — CHECK.
7. Caution/Advisory Panel — CHECK.

7.8.5 Two-Engine Cruise. During some operations it may be desirable to completely secure one engine. Reference should be made to the performance charts in Part XI to determine where slight fuel economies may be realized. The decision to conduct two-engine cruise operations shall be guided by command policy and then only when operating at an altitude which, when all factors of aircraft performance are considered, in case of an engine failure a normal start could be accomplished on the secured, good engine. See ENGINE SHUTDOWN IN FLIGHT and ENGINE RESTART DURING FLIGHT procedures in Chapter 12 to shut down and restart an engine in flight.

WARNING

For elective dual-engine cruise, shut down the No. 1 or No. 3 engine. If the No. 2 engine is shut down and subsequently restarted, reduce airspeed to less than 85 KIAS during the shutdown and start sequence to reduce the possibility of a fire hazard caused by hot exhaust gas backflow into the aft engine compartment.

7.8.6 Single-Point Performance Check. A single-point performance check is done to determine if the engine is producing minimum acceptable power at a specific T_5, OAT, and pressure altitude. If the indicated torque is less than the value indicated for the specific conditions, the engine fails the check and requires maintenance before further flight. The single-point performance check table (Figure 7-5) is most accurate at 6000 ft pressure altitude, 90 KIAS, and 100% N_r.

1. Establish forward flight with EAPS doors open at 80 to 100 KIAS.

2. Cabin heater, APP, engine anti-ice, BAR ALT HOLD, fuel transfer and purge system — OFF.

3. Set barometric altimeter to 29.92.

4. Manipulate engine speed control levers/collective pitch to obtain 750°C T_5. Hold target pressure altitude and airspeed while maintaining 100% N_r.

5. Allow engine to stabilize at this point for 2 minutes, then record torque.

6. Use Figure 7-5 to determine if torque value is acceptable.

7. Repeat steps 1. through 6. for the remaining two engines as required.

7.8.7 Fuel Transfer. To transfer fuel from auxiliary to main fuel tanks:

T64 – 416 / 416A SINGLE – POINT PERFORMANCE CHECK WITH EAPS DOORS OPEN
80 TO 100 KIAS, N_r = 100%, T_5 OF 750°C PERCENT MINIMUM ACCEPTABLE TORQUE

	PRESSURE ALTITUDE (FEET)															
OAT °C	SL	500	1000	1500	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	OAT °C
50	73	72	70	69	68	65	63	61								50
48	76	74	73	72	70	66	64	63	61							48
46	78	76	75	74	72	70	68	65	62	60						46
44	80	79	77	76	74	72	69	67	64	62						44
42	82	81	79	78	77	74	71	68	66	64	61					42
40	84	83	81	80	78	76	73	70	68	65	63	60				40
38	87	85	84	82	81	78	75	72	69	67	64	62	60			38
36	89	87	85	84	82	79	77	74	71	68	66	63	61			36
34	90	89	87	86	84	81	78	75	72	70	67	65	62	60		34
32	93	91	89	88	86	83	80	77	74	71	69	66	64	61		32
30	94	93	91	89	88	84	82	79	76	73	70	67	65	62	60	30
28	96	94	93	91	89	86	83	80	77	74	71	69	66	64	61	28
26	99	97	95	93	92	88	85	82	79	76	73	70	68	65	63	26
24	100	98	97	95	93	90	87	83	80	77	74	72	69	66	64	24
22	102	100	99	97	95	92	89	85	82	79	76	73	70	68	65	22
20	105	103	101	99	97	94	91	87	84	81	78	75	72	69	67	20
18	107	105	103	101	99	96	92	89	85	82	79	76	73	70	68	18
16	109	107	105	103	101	98	94	91	87	84	81	78	75	72	69	16
14	111	109	107	105	103	99	96	92	89	86	82	79	76	73	70	14
12	113	111	109	107	105	101	98	94	90	87	84	81	78	75	72	12
10	115	113	111	109	107	103	100	96	92	89	85	82	79	76	73	10
8	117	115	113	111	109	105	101	97	94	90	87	84	80	77	74	8
6	119	117	115	113	111	107	103	99	95	92	88	85	82	79	76	6
4	121	119	117	115	112	108	105	101	97	93	90	86	83	80	77	4
2	123	121	118	116	114	110	106	102	98	95	91	88	84	81	78	2
0	125	122	120	118	116	112	108	104	100	96	93	89	86	82	79	0
–2	126	124	122	120	118	113	110	105	101	98	94	90	87	84	80	–2
–4	128	126	123	121	119	115	111	107	103	99	95	92	88	85	81	–4
–6	130	127	125	123	121	116	113	108	104	100	96	93	89	86	83	–6
–8	132	129	127	125	122	118	114	110	105	102	98	94	91	87	84	–8
–10	133	131	129	126	124	120	116	111	107	103	99	95	92	88	85	–10
–12	135	133	130	128	126	121	117	112	108	104	100	97	93	89	86	–12
–14	137	134	132	130	127	123	119	114	110	106	102	98	94	91	87	–14
–16		137	134	132	129	125	121	116	111	107	103	99	96	92	88	–16
–18			136	133	131	126	122	117	113	109	105	101	97	93	90	–18
–20			137	135	133	128	124	119	114	110	106	102	98	94	91	–20

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Figure 7-5. Single-Point Performance Check

Note

Fuel flow will not be indicated until about 1 minute after turning on transfer selector switches. The amount of time required for bleed-air pressure to build up in the auxiliary fuel tank(s) for fuel transfer depends on the amount of fuel in the tank(s). It takes about 5 minutes for enough pressure to build up in half-full tanks.

1. REFUEL PWR switch — OFF.

2. Transfer selector switches — AS REQUIRED.

3. Transfer completed, switches — CLOSE.

Note

Fuel transfer is prohibited during takeoff and landing. In addition, when transferring fuel while hovering, or during HIFR, or in-flight refueling operations, stop transfer to the left sponson when the No. 1 fuel quantity gage reaches 2000 pounds, or the No. 2 fuel gage's left pointer reaches 1400 pounds. Stop transfer to the right sponson when the No. 3 fuel gage reaches 2000 pounds, or the No. 2 fuel gage's right pointer reaches 1400 pounds.

4. PURGE pushbutton — ON.

Note

- In flight, all three engines should not be operated from the same fuel tank. Three engine flameout may occur if contaminated fuel is present in selected tank.

- Failure to purge the fuel system after fuel transfer has taken place reduces the post crash survivability of the fuel system by leaving fuel in lines within the cabin fuselage.

7.8.8 Fuel Dumping. Fuel dumping may be required to reduce weight for mission requirements, in case of single- or dual-engine operation, or to adjust fuel loading in case of fuel system malfunction. Fuel shall not be dumped below 90 KIAS or above 130 KIAS. Fuel shall not be dumped if the rate of descent is greater than 1500 feet-per-minute. Dump fuel as follows:

1. Minimum altitude — 6000 FEET AGL.

In emergency situations, or where conditions dictate dumping at lower altitudes, avoid populated areas.

2. Determine desired fuel to remain after dumping.

3. Smoking lamp — OUT.

4. Fuel dump switches — AS REQUIRED.

5. Fuel quantity — MONITOR.

6. Fuel dump switches — SECURE.

When desired fuel level reached. If fuel dump is not secured it will dump down to the level that turns the fuel low level caution lights on, at which time fuel dump shuts off automatically.

CAUTION

After securing fuel dump switches, allow 2 minutes for fuel dump lines to drain. Securing fuel dump immediately before overflying a ship or landing area will result in fuel draining onto that ship or area, creating a personnel hazard and a fire hazard if static electricity is discharged on touchdown.

7.8.9 Descent Procedures. The factors governing the type of descent to be made are the conditions existing at the time. The conditions that vary the type of descent to be made are gross weight, density altitude, condition of landing site and terrain, and the amount of time desired in which to accomplish the descent. The autorotative descent can be used whenever a rapid descent is desired.

7.8.9.1 Descent to Landing. The descent to landing is the most common type of descent made. Descents from cruising to traffic pattern altitudes are made by lowering the collective to obtain the power that will produce the desired rate-of-descent while simultaneously using the cyclic and rudder pedals to maintain attitude and directional heading. The following should be done before beginning the descent:

1. Crew and passengers — ALERTED.

2. Safety belt and shoulder harness — SECURED.

7.8.9.2 Cruise Descent. Descents from an established to newly selected altitude are made by lowering the collective to obtain the power that will produce the desired rate-of-descent while simultaneously using the cyclic and rudder pedals to maintain attitude and heading. Descents that are made to establish lower cruising altitudes may be varied, depending on the time and horizontal distance desired before attaining the newly selected altitude.

7.8.9.3 Autorotative Descent. The autorotative descent is used whenever a rapid descent is desired. An autorotative descent is made by lowering the collective to minimum and entering autorotation, then using collective to control N_r. Refer to Figure 12-10 for minimum sink rate and maximum glide distance. To recover, raise the collective at about 200 feet above the selected altitude to slow the rate of descent; then ease the cyclic forward to maintain altitude and establish a cruise airspeed. If a higher rate of descent is desired, increase airspeed.

7.8.10 Pre-Landing. Figure 7-6.

The density altitude, landing gross weight, and center-of-gravity of the helicopter are important factors to be considered when determining the feasibility of a helicopter landing. Refer to WEIGHT AND BALANCE LIMITATIONS in Chapter 4 and the performance charts in Part XI to be sure that the maximum gross weight for landing or center-of-gravity limits are not exceeded.

1. Crew and passengers — ALERTED.
2. Fuel transfer — OFF.
3. EAPS — AS REQUIRED.
4. ALT hold — AS DESIRED.
5. Panel landing checklist:
   a. RPM — AS REQUIRED.
   b. Gear — DOWN/TAIL SKID EXTENDED.
   c. Brakes — ON OR OFF AS REQUIRED.
   d. Harness — LOCKED.
   e. FM Antenna — RETRACTED.
   f. Ramp — UP.
   g. Cabin heater — OFF.
   h. Windshield anti-ice — AS REQUIRED.
6. Landing checklist — COMPLETE.

7.8.11 Landing. The versatility of the helicopter permits safe operation from unfamiliar and unprepared operating sites such as open fields, mountain knolls, ridges, desert, snow, and ice areas. Although the helicopter is capable of operating from closely confined areas, the final analysis of the situation and the decision to land must be made by the pilot. Before operating the helicopter from unprepared areas, the pilot must make on the spot evaluations and plan his approach, landing, and subsequent takeoff accordingly. On the spot evaluations may be made by making passes into the wind over the intended landing site at various altitudes and airspeeds. A refined flying technique that includes all phases of flight contributing to desert, mountain, and rough terrain landings is included under mountain and rough terrain flying in Chapter 14. The procedures outlined herein will produce the results stated in the landing distance-ground roll chart in Chapter 24.

CAUTION

- Do not use tail skid as a normal landing point.
- Due to normally nose-high attitude during hovering, use caution during landings and hovering maneuvers to avoid striking ground with tail rotor blades (Figures 7-7 and 7-8).
- Landing with tail skid in retracted position may allow tail rotor to contact ground.
- Hydraulic power boost will not be available to wheel brakes until helicopter has settled on oleo struts enough to allow isolation valve to open.
- Excessive nose high attitude with low fuel state can cause flameout.

7.8.11.1 Normal Landing. Before commencing a normal landing, complete prelanding checklist. The landing is approached from an abeam position of 500 feet AGL, and an airspeed of 80 to 100 KIAS so as to arrive at the 90° position at 350 feet AGL, and 60 to 80 KIAS with 100% N_r. Continue the descent to a final approach into the wind with an approximate 1000 foot straight-

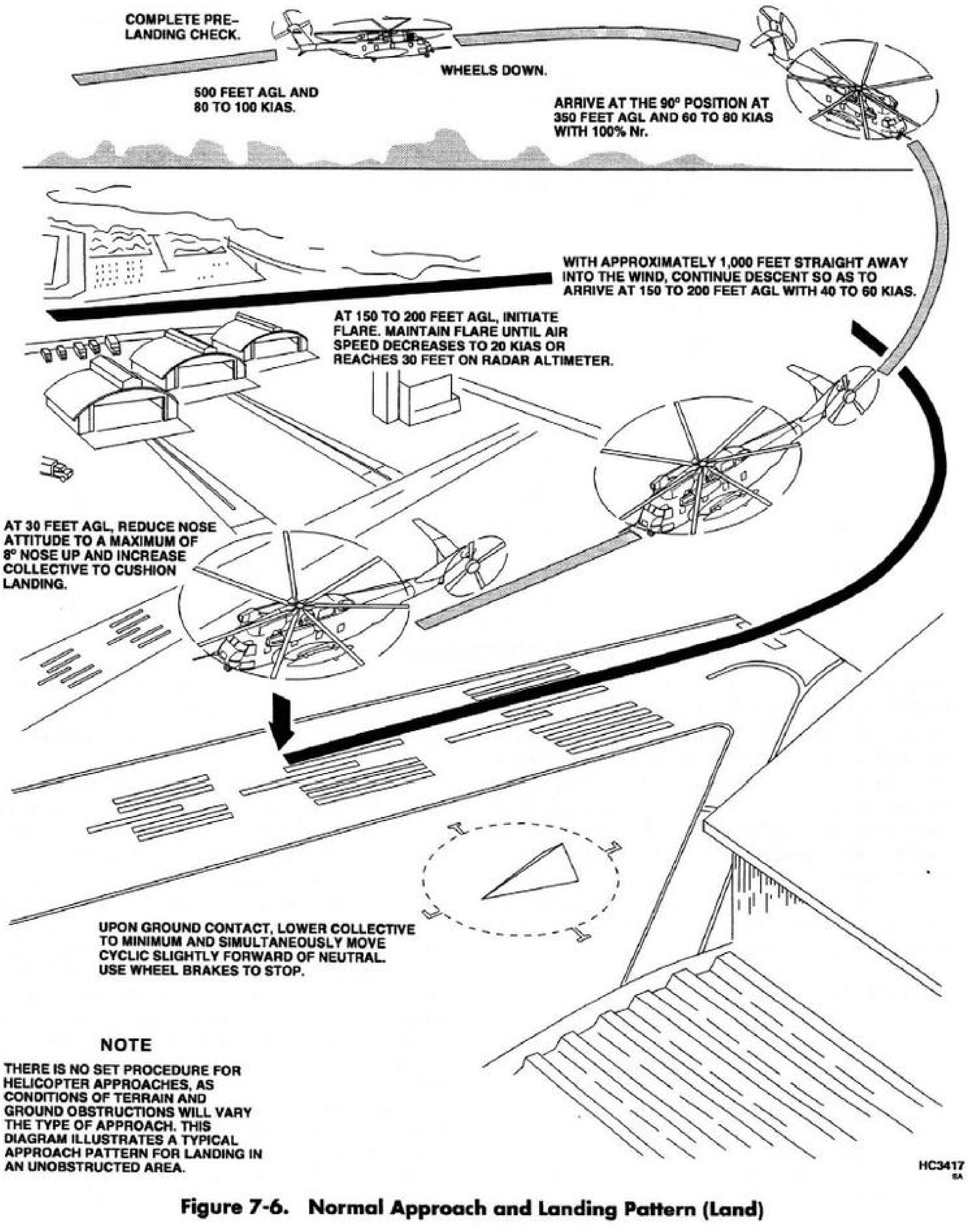


Figure 7-6. Normal Approach and Landing Pattern (Land)

The tail rotor blades or tail skid may be struck with the following combinations of nose-up attitude and altitude. This chart is based on zero setting of vertical gyro and accurate radar altimeter.

RADAR ALTITUDE IN FEET	DEGREES OF NOSE-UP ATTITUDE	TAIL SKID	MAIN GEAR STRUTS	GROUND CONTACT
45	51	—	—	Tail rotor
40	46	—	—	Tail rotor
35	40.5	—	—	Tail rotor
30	35	—	—	Tail rotor
28	33	Down	Extended	Tail rotor and skid
25	29.5	Down	Extended	Skid
11.5	17	Up	Extended	Tail rotor and skid
7	13	Up	Extended	Skid
6	10	Down	Extended	Skid
6	10	Up	Compressed	Closed ramp
4.5	8.5	Down	Compressed	Skid

Figure 7-7. Tail Rotor/Skid Ground Contact Chart

away at 150 to 200 feet AGL, and an airspeed of 40 to 60 KIAS. Initiate a flare at 150 to 200 feet AGL. Maintain this until the airspeed decreases to 20 KIAS or 30 feet on the radar altimeter. At 30 feet, reduce the nose attitude to a maximum of 8° nose-up and increase collective pitch to cushion the landing. Maintain heading and attitude by use of the rudder pedals and cyclic. After ground contact, steadily reduce collective pitch and simultaneously move cyclic to the neutral position. When transition to a hover is not possible and running landings are not feasible, normal approach procedures may be used for a no-hover landing at a ground speed less than 5 knots.

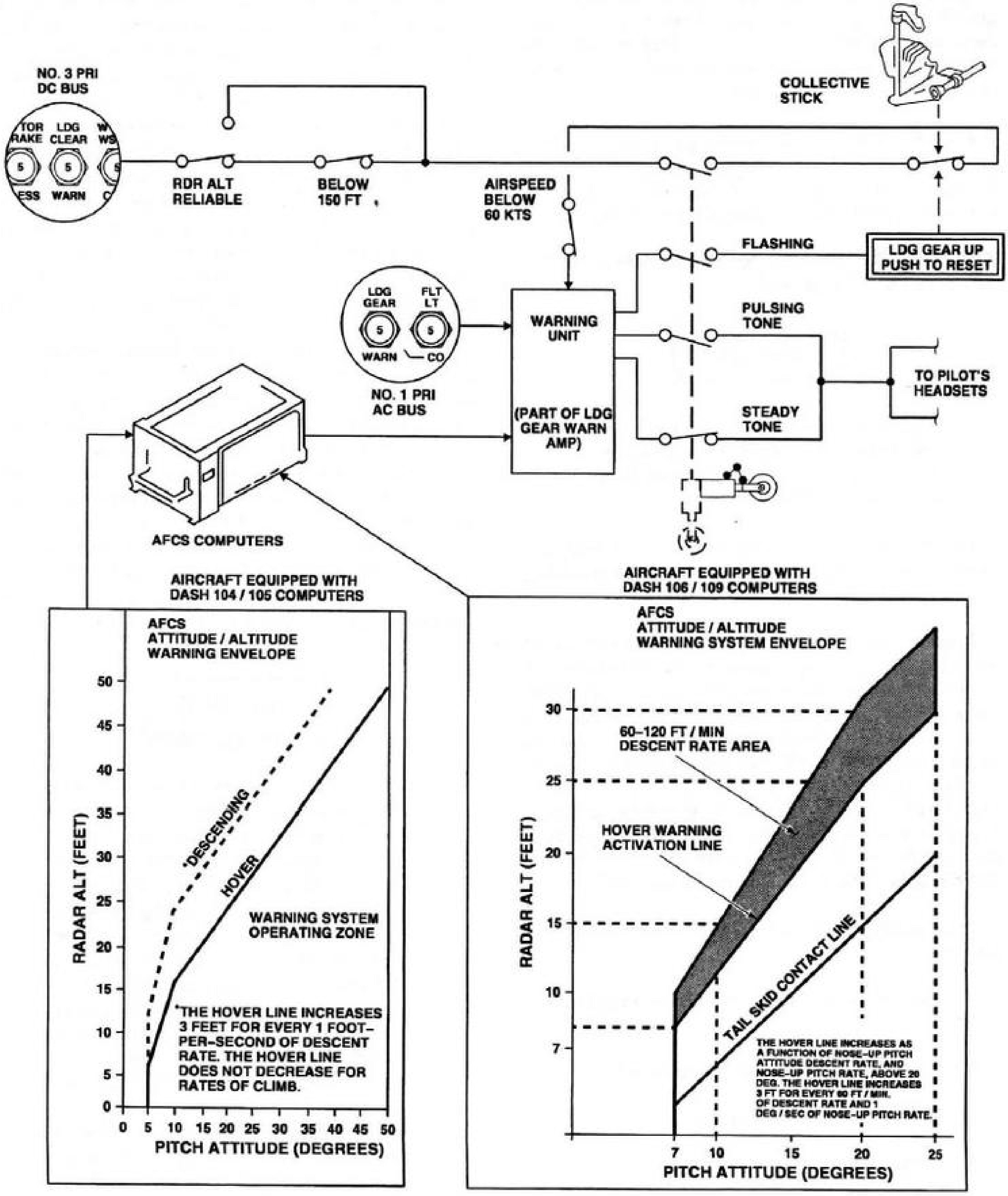
7.8.11.2 Heavy Lift Landing

WARNING

If engine power is limited (engine topped), droop N_r as required, but do not droop below 100%.

For heavy lift landings, set speed control levers full forward (about 105% N_r). Apply power as required until either engine limits or maximum torque is achieved.

7.8.11.3 Running Landing. Running landings are usually made from a shallow approach when the helicopter cannot be hovered due to a high gross weight or density altitude. Adjust collective pitch as necessary to maintain the desired approach angle (about 8°), and dissipate speed gradually throughout the approach so the landing can be made while maintaining translational lift. Before attempting a running landing, the surface should be checked from low altitude to determine the feasibility of landing. A running landing should not be attempted on rough terrain. Running landings should be made with the parking brakes off and 100% to 105% N_r. Establish a straight track over the ground and a shallow approach with a slow rate-of-descent. Use rudder pedals to maintain heading in direction of track and cyclic to control drift. Eliminate all side drift before touchdown. As the helicopter approaches the ground, increase collective pitch slightly to reduce rate-of-descent and airspeed to a minimum value (not over 40 knots ground speed) compatible with gross



NOTE: NO ATTITUDE WARNING WHEN RDR ALT UNRELIABLE, APPLICABLE TO ALL COMPUTERS.

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Figure 7-8. Landing Gear/Attitude Warning System

weight and altitude conditions. As the wheels contact the ground, move cyclic to the neutral position and slowly decrease collective pitch to minimum. Stop the helicopter with the wheel brakes. To prevent fire, avoid overbraking, especially at high gross weights.

7.8.11.4 Crosswind Landing. Crosswind landings are the same as into the wind vertical landings except the cyclic must be displaced into the wind. It is important to have no sideward drift during crosswind landings.

7.8.11.5 Practice Single- or Dual-Engine Approaches and Landings

CAUTION

Practice single engine takeoffs are prohibited. While simulating dual engine failures, the speed control levers shall not be retarded below MIN GOV.

For training, and to maintain pilot proficiency, it is desirable to practice emergency procedures by simulating an engine failure(s).

Practice single- or dual-engine approaches may be made to simulate engine failures in which altitude cannot be maintained and an immediate landing is desirable. These approaches can be made at other than approved landing areas or airfields; however, recovery shall be made at not less than 200 feet above the terrain and not less than 40 KIAS. Practice single- or dual-engine landings should be made into the wind, should be performed at approved landing areas or airfields (preferably a hard, flat, smooth surface clear of approach and roll-out obstructions), and should have a crash crew available.

Practice single- or dual-engine failure and recovery as follows:

1. One or two speed control levers — retard to MIN GOV.

2. Collective — as required to maintain N_r.

3. Engine instruments — analyze.

4. Speed control levers — as desired.

5. Execute approach and/or landing depending on location/terrain.

7.8.11.6 Slope Landing. When hovering over a slope, ground effect is less than when hovering over level ground. The percentage of ground effect lost will vary with the degree of slope. Before landing on slopes, the parking brake should be applied. Ground contact should be made using a vertical descent. Sideward motion of the nose gear should be avoided. Landings on slopes up to approximately 4° differ very little from normal, level landings, and any direction of landing may be accomplished. On slopes greater than 4°, a cross-slope landing with the right side upslope is recommended whenever possible. The normal left side low hover attitude makes this type landing easier to accomplish than in other directions. If a right side upslope landing is not possible, the following order of preference in landing is recommended: Nose upslope, left side upslope, and nose downslope. Nose downslope landings should be avoided due to danger of ground contact by the tail skid and/or tail rotor. Takeoffs and landings should be made with smooth positive control movements to permit stopping or aborting the maneuver at any time. The helicopter will have a tendency to slide downslope slightly during landings; however, rapid or excessive control movement should not be used to avoid dynamic rollover. Proper cyclic trim position for takeoff will be retained if the trim is not adjusted after landing. See ROLLOVER CHARACTERISTICS in Chapter 11.

WARNING

A combination of excessive cyclic and low collective settings or rapid or excessive control movement should not be used to avoid dynamic rollover. During slope operations with the AFCS engaged, cyclic control inputs will be induced by the AFCS due to fuselage attitude changes. These inputs will be in a direction to hold the helicopter on the slope but will reduce rotor-to-fuselage and rotor-to-ground clearance. If a large cyclic control movement or rapid reduction of collective is applied, excessive rotor blade flapping may occur. If the cyclic control is near the fore or aft position and the collective is lowered rapidly, the rotor blade may flex or dip enough for the blades to contact the helicopter.

Note

For slope landings, utility hydraulic pressure can be made available to the wheel brake power boost system by placing ramp master switch to PILOT, to open isolation valve.

7.8.11.7 Cross-Slope. After the upslope gear is on the ground, use smooth control inputs to maintain a near-level attitude. Reduce collective to place the nose gear on the ground and further reduce collective to lower the downslope gear to the ground. As the collective is reduced, additional lateral cyclic control may be used to help control the rate of roll; however, avoid overcontrolling that could result in rotor blade contact with obstructions on the upslope side of the helicopter. After the helicopter is firmly on the ground, decrease the collective to full down.

WARNING

When the thrust of the rotor system is approximately equal to the weight of the helicopter and one main landing gear is on the ground, the helicopter may roll over on its side if the bank angle (roll angle) reaches 15° with the right gear upslope or 13° with the left gear upslope. Reduce collective to stop the roll and correct the bank angle to a wings-level attitude.

To take off from a cross-slope, slowly increase collective to bring the helicopter to a level attitude before breaking clear of the ground. The helicopter will normally roll towards the downslope side just as the last tire breaks ground. A large upslope lateral cyclic input should not be used as they may reduce rotor-to-ground clearance on the upslope side.

When cross-slope landings and takeoffs are made, the "one-wheel-on-the-ground" maneuver is unavoidable because the upslope wheel touches down first and lifts off last. If the helicopter starts to roll toward the upslope side (5° to 8° bank angle), reduce the collective pitch to correct this condition. Return to a wings-level attitude before continuing the takeoff or landing.

CAUTION

Do not increase collective pitch suddenly to get airborne in attempting to recover from the banked condition. The angle of roll will increase and accelerate before the wheel will lift off the ground. The angle of roll may increase beyond the critical roll angle and/or roll rates may become excessive causing dynamic rollover resulting in the helicopter rolling over on its side. Use smooth moderate collective movements when recovering from a banked attitude with one wheel on the ground. Rapid reduction of collective may cause fuselage-rotor contact or a high rate of roll in the opposite direction. See Dynamic Rollover in Chapter 11.

7.8.11.8 Nose Upslope. Use a normal vertical rate of descent until the nose gear contacts the ground. As the nose gear touches, slow the rate of descent slightly and use a small (approximately 1 inch) forward cyclic input to hold the nose gear firmly on the ground as the strut compresses. Then lower the main gear at normal rate of descent by reducing collective to the full down position. When the slope is near the limit of 8°, there will be more of a tendency for the helicopter to roll down hill as the main gear descends; however, the roll is normally negligible. Use extreme care in applying additional forward cyclic, as it could result in rotor-blade-to-fuselage contact as the collective is lowered. Monitor rotor blade to ground clearance. After the initial forward cyclic input to get the nose gear firmly on the ground, only very small input (1/4 to 1/8 inch) are required to stabilize the pitch and roll attitude.

Takeoff is made by increasing collective to establish a level attitude as the nose gear breaks clear of the ground. The cyclic control is used only to stabilize the attitude and not to lift the main gear off the ground.

7.8.11.9 Nose Downslope. The ramp door should be opened to permit a crewmember to observe and report tail skid and rotary rudder clearance. While descending vertically and as the main gear touches down, hold the cyclic essentially fixed, using only small stabilizing inputs, to prevent rotating the tail into the ground. Then decrease the collective to lower the nose gear to the ground. There is very little tendency for the helicopter to slide or to roll if brakes are applied prior to landing.

CAUTION

Slope angles of 5°, with nose-down slope, may cause the tail skid to strike the ground on landing or on rotating for takeoff. This condition is aggravated by tail winds.

Takeoff is made by increasing collective to establish a level attitude. As the main gear breaks ground, there is a tendency for the helicopter to move forward. Extreme caution must be used if this movement must be stopped, since any aft cyclic input may rotate the tail into the ground. If possible, it is best to let the helicopter move forward with little or no aft cyclic input until well clear of the ground. If this is not possible, a crisp and positive vertical rate of climb should be used from just before main gear lift-off until well clear of the ground.

7.8.12 Precision Obstacle Approach. A normal approach will be flown until reaching the final inbound course to the landing site. At this time transition to 45 to 50 KIAS and allow for adequate obstacle clearance. Intercept the glide slope (about 20° to 30°) and reduce power to begin the descent. While descending, do not go over 700 feet-per-minute rate of descent and maintain translational lift until reaching ground effect. Should rate of descent become excessive, or glide slope become excessively steep, execute a wave-off. The approach shall be flown to a hover or no hover landing as desired.

7.8.13 Operation From Confined Area Landing (CAL) Sites and Unprepared Areas. Confined area landings and unprepared areas present varied problems and definite procedures cannot be established in all cases. However, certain factors will be standard for all CAL landings and unprepared areas.

1. Before any CAL or unprepared area landing, the parking brakes should normally be unlocked unless the site dictates otherwise.

2. When approaching power and telephone lines, it is advisable to fly over the poles or tower rather than over the wire.

3. Utilization of zones for landings which have the potential for producing IMC (snow, sand, or dust) requires that the pilot continually maintain visual reference with the ground. This visibility may be reduced to within the rotor arc during landing transition to touchdown. Failure to maintain visual contact with the ground within the rotor arc shall require an immediate wave-off.

7.8.13.1 Selection of Landing Sites

1. Always check the site for wind direction, velocity, and obstacles before attempting to land.

2. LANDING APPROACH.

The approach shall be a precise maneuver and should not be either so low that the pilot loses sight of the landing point or so high that a very low power setting with a high rate-of-descent is necessary. Approach speed will depend on weight, altitude, and wind conditions. Maintain translational lift as long as possible while avoiding excessive flares and large changes of power. Do not continue in a poor approach. Wave-off before a dangerous condition arises.

7.8.13.2 Night Lighting of Confined and Unprepared Areas. Refer to the Assault Helicopter Tactical Manual (NWP 55-9-ASH) under Landing Zone Lighting for a complete discussion of lighting equipment, arrangements, and considerations.

WARNING

To decrease the possibility of pilot disorientation, a minimum of two lights shall be observed by the pilot at the controls throughout the final landing phase.

7.8.14 Practice Autorotative Approach. Practice full autorotations to touchdown shall not be conducted. Practice power-recovery autorotations shall always be made into the wind and to approved landing areas or airfields. Always plan an autorotation to an area that will permit a safe landing in an actual emergency, preferably a hard, flat, smooth surface clear of approach and takeoff obstructions. Under conditions of high gross weight, the transition to flare to slow forward speed and stop rate-of-descent becomes very critical. Special precautions must be taken to ensure the security of internal weights. Practice autorotations should be made only during day and dusk conditions. Deviations from straight-in autorotations should be practiced to fully demonstrate helicopter capabilities and provide additional pilot training. Practice autorotations shall begin at an altitude that permits a power-off approach to the desired landing spot and shall be terminated at 50 feet AGL. The desired altitude to start practice autorotations is at a minimum of 1000 feet over the terrain. Main rotor RPM (N_r) should be set at 100% to 103%. After completion of the cockpit landing checklist and at a selected cruising speed, smoothly lower the collective all the way. Maintain N_r below 110%, and airspeed as determined from Figure 12-10. Entry airspeed for the cyclic flare should be the airspeed (based on gross weight) for maximum glide distance providing for flare effectiveness. At about 300 feet AGL (avoiding continuous flight in the shaded area of the height-velocity diagram, Figure 24-1), execute a smooth, progressive flare by adjusting nose-up pitch attitude as necessary (about 20° to 30°) to reduce ground speed and rate-of-descent. Allow N_r to increase throughout the flare and adjust collective as necessary to prevent N_r from exceeding 110%. Nose-up pitch attitude will be dependent on aircraft gross weight and ambient conditions. At 100 to 150 feet AGL, lower the nose to the landing attitude (8° maximum nose-up) and raise collective to arrest the helicopter's rate-of-descent. This power recovery should be smoothly executed and should terminate in a wave-off with the helicopter having come no lower than 50 feet AGL. Airspeed at recovery will generally be 0 to 50 KIAS, based on flare effectiveness and landing site options.

Note

- Flare effectiveness at airspeeds for minimum rate-of-descent will be marginal in arresting descent rate.
- The maximum glide distance airspeed provides improved flare effectiveness.
- Practice autorotations should not be attempted under conditions of high gross weight or critical center of gravity loading.
- Simulated emergencies over other terrain may be executed wherein an autorotative state is entered; however, recovery will be made at not less than 200 feet above the terrain, and not less than 40 knots. These simulated emergencies are primarily for the purpose of developing sound judgment in the selection of the best available landing site in an emergency situation.

7.8.15 AFCS Off/AFCS Servos Off Practice Maneuvers. AFCS servo off practice flight is permitted in the CH-53E. However, the following minimum guidelines and restrictions apply:

1. AFCS/AFCS SERVOS OFF FLIGHT/HOVER shall be briefed prior to flight. Briefing shall include procedures, acknowledgment, and mode of flight for disengaging/reengaging AFCS/AFCS servos. Engagement/disengagement of AFCS servos shall be made with minimum pilot input to the controls.

2. The AFCS servos shall be engaged/disengaged with the helicopter on the deck with flight controls neutral, or in level flight at or above 200 feet AGL.

3. Verbal acknowledgment by the pilot on the controls is required prior to AFCS/AFCS servo engagement/disengagement.

WARNING

There is a decrease in required collective force of 20 pounds down to 4 pounds when the AFCS servos are reengaged. If the pilot is moving the collective at the moment an AFCS servo is reengaged while airborne, an overshoot or overcorrection with the collective will occur. This overcontrolling motion can result in a violent vertical movement in the helicopter that could progress into a pilot-assisted oscillation situation.

4. External operations with an inoperative AFCS is prohibited.

5. Avoid AFCS OFF/AFCS servos off flight in turbulent conditions.

7.8.16 Wave-off. Whenever an unacceptable approach is recognized, it may become necessary to wave-off and to attempt another approach. If a wave-off is necessary, it is important to execute it as early in the approach as possible to provide more latitude in clearing obstacles and executing the most advantageous departure route. Each wave-off is different and varies with airspeed, altitude, and the condition of the zone.

Note

Execute a wave-off (Figure 7-9) by initiating a climb and/or accelerating as required. Adjust power after obtaining climbing speed and clearing all obstacles.

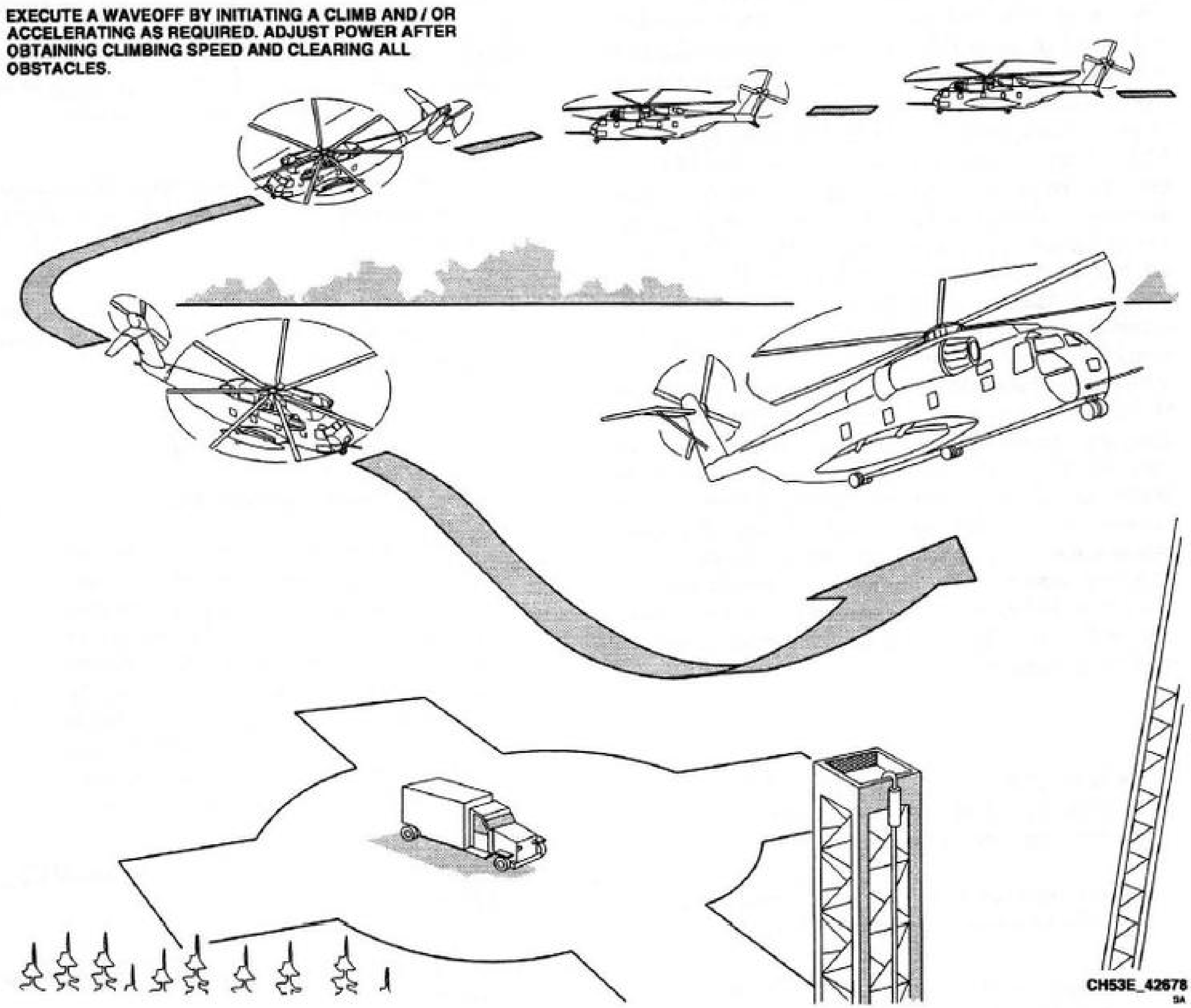


Figure 7-9. Wave-off Diagram (Land)

7.9 PRESSURE REFUELING WITH ROTOR HEAD ENGAGED

PILOT:

1. Radar altimeter — OFF.

2. Radios and electrical equipment — MINIMUM REQUIRED.

3. Portside windows/vents — CLOSED.

4. Refuel master power switch — ON.

5. Fuel samples — AS REQUIRED.

6. Refuel switches — REFUEL.

7. Shutoff test — CHECK.

8. Refuel switches — CLOSE.

9. Refuel master power switch — OFF.

10. Purge as desired.

11. Radar altimeter — AS REQUIRED.

12. Radios and electrical equipment — AS REQUIRED.

CREW:

CAUTION

- Observe fueling precautionary procedures.
- When pressure refueling, fuel tank quantities should be monitored closely as the high-level shutoff valves may not secure refueling and a fuel spill will ensue.

1. Ramp — LEVEL.
2. Aux tank safety pins — INSTALLED.
3. Wheel chocks — IN.
4. Passengers — DEBARK.
5. Portside windows/vents — CLOSED.
6. Ground helicopter and refueling unit.
7. Open pressure fueling access door and remove refueling cap. Be sure of serviceability of single-point fuel servicing nozzle before connecting to helicopter. After connecting to helicopter and before applying fuel pressure, turn fuel nozzle on and further make sure that the nozzle cannot be turned or disconnected.
8. Make sure refueling unit is set for a line pressure of 35 to 55 psi.
9. Manual precheck valves — OPEN.

WARNING

With precheck valves closed, any fuel flow indicates an inoperative shutoff valve. Increased tank pressure during refueling denotes clogged vent lines. Tank pressure must not be over 1.5 psi. In either case, stop refueling operations immediately.

Note

Refueling rate is 150 ±10 gpm maximum.

*10. Shut down refueling unit on PILOT'S DIRECTION.

*11. Disconnect refueling nozzle, disconnect all ground wires, and secure access door. Access door will not close unless manual precheck valves are OPEN. Do not attempt to force door closed.

12. Chocks — REMOVED.

13. Aux. tank safety pins — AS REQUIRED.

14. Ramp — AS DESIRED.

15. Pre-taxi Checklist — COMPLETE.

7.10 SHUTDOWN

*1. Parking brake — SET.

2. Landing lights — OFF.

*3. Landing gear, auxiliary tank pins, and chocks — INSTALLED.

*4. Fuel transfer switches — CLOSED.

5. ROTOR — 100% N_r.

*6. APP — START.

*7. No. 2 generator — OFF.

*8. Flight controls — POSITION FOR SHUTDOWN.

Note

To provide engine cooling before engine shutdown, one of the following conditions must occur before moving the speed control levers to SHUT-OFF. (However, in an emergency the engines may be shut down immediately.) (a) One minute of taxiing. (b) One minute of operation at or above the minimum governing range and with minimum collective pitch. (c) One minute at GRD IDLE.

*9. Any two engines — GRD IDLE, SHUTDOWN.

Note

If an engine post shutdown fire should occur as indicated by a continuous or rising power turbine inlet temperature T_5 above 320°C, engage starter and motor engine until fire is put out.

*10. Third speed control lever — RETARD TO GRD IDLE.

As rotor speed decreases, gradually raise the collective to the detent position. Once the droop stops are engaged, lower the collective to the full down position.

*11. Droop stops — IN.

CAUTION

If the longitudinal bias actuator fails, the actuator may stop in any position; therefore, the pilot shall not rely on the position of the cyclic on rotor shutdown, but must observe the position of the tip path plane and move the cyclic as necessary to prevent damage to the droop stops as rotor speed decays.

Note

If, during rotor shutdown, one or more droop stops fail to go in, increase N_r above 75% using third engine. Recheck tip path plane at neutral position and reattempt rotor shutdown by retarding third speed control lever. If droop stop does not go in, check that rotor area is clear of personnel, and then proceed with normal shutdown procedure while maintaining cyclic in a neutral position. If a droop stop comes out, or is out after rotor brake has been applied, continue shutdown procedure.

*12. Third engine — SHUT DOWN.

*13. Low-pressure rotor brake — HOLD AT ON 5 SECONDS.

This starts the rotor brake hydraulic pump and the ROTOR BRAKE PRESS caution light goes on after 10 psi is reached. After 350 psi is reached the pump automatically stops for 60 seconds and then automatically restarts. The ROTOR BRAKE ON advisory light goes on after 975 psi is reached.

A normal brake application is made with all engines shut off, N_r 25% or less, low-pressure rotor brake switch ON.

For shipboard or high gusting wind conditions, a high energy brake application is made with all engines shut off, N_r 50% or less, high-pressure rotor brake switch at EMER.

An emergency brake application can be made at any N_r with all engines shut off and high-pressure rotor brake switch at EMER.

WARNING

A fire hazard exists during emergency brake application due to the heat generated and the presence of debris and oil in the rotor brake area.

CAUTION

If the APP is inoperative and external power is not available, shut down engines and allow rotor to coast to a stop. If an immediate shutdown is necessary without an APP or external power, place the high-pressure rotor brake switch to EMER and shut down all engines immediately. With all engines shut down the rotor brake will stop the rotor within 30 seconds after high-pressure brake application.

Note

The RTR BK light on the N_f/N_r tachometers goes on when N_r decays to 50% N_r and remains on until N_r decays below 25%.

*14. High-pressure rotor brake switch — EMER.

*15. Engine fuel selectors — SHUTOFF.

CAUTION

Before fold sequence, make sure flap and droop restrainers are in. Restrainers not in may allow a blade to fold at an improper angle and damage the blade or airframe.

16. Blade/pylon fold — AS REQUIRED.

a. Area — CLEAR.

b. High-pressure rotor brake — EMER.

c. Gust lock — UNLOCKED.

d. Master power switch — POWER.

CAUTION

When the SAFETY VALVE OPEN light on the blade fold panel is on and the pitch lock switch is placed to PITCH LOCK, the pitch locks will attempt to engage regardless of head position. Make sure the pitch lock switch is in the DISENGAGE position before:

1. Positioning head for start.

2. Opening safety valve for blade or pylon fold.

SAFETY VALVE OPEN light goes on. FLIGHT READY light goes off. BLADE PYLON FOLD caution light goes on.

e. Blade fold position switch — BLADE FOLD POSN.

ROTOR BRAKE ON advisory light goes off during positioning. HEAD IN FOLD POSITION light and ROTOR BRAKE ON advisory light go on after head positions.

f. Pitch locks — ENGAGE.

(1) Rudder pedals neutral.

(2) Collective seated in detent as indicated by the initial illumination of the stick position indicator.

(3) Move cyclic to light stick-center position arrows.

(4) Pitch lock switch — PITCH LOCK.

The stick position indicator may deviate from the center indication as pitch locks engage. PITCH LOCK ADVANCED light goes on as locks start to advance. In addition, 2 STG T/R SERVO BYPAS, UTILITY T/R PRESS caution lights go on. Further, the second stage hydraulic pressure gage indicates zero. (With AFC 309 only the 2 STG M/R SERVO BYPAS caution light goes on, and the second stage hydraulic pressure remains normal.) PITCH LOCKS ENGAGED light goes on when all six pitch locks extend and engaged.

CAUTION

- For helicopters not modified with AFC 309 if second stage hydraulic pressure does not indicate zero after pitch locks advance, movement of flight controls may cause overstress or fracture of flight control components.
- With pitch locks engaged, do not push blade fold control valve's manual override (on rotor head) to fold until rotor head has been positioned for blade fold.
- Movement of flight controls after PITCH LOCK ADVANCE light has illuminated can damage spindle bore and pitch lock receiver bushings. If pitch locks will not engage with stick position indicator lit, maintenance on the pitch locking system is required.

g. Blade fold/spread switch — FOLD.

BLADES FOLDED light goes on when blades are fully folded.

WARNING

When winds are over 45 knots the pylon fold sequence shall not be initiated. When winds are over 15 knots the tail rotor shall be manually secured before pylon fold/spread. Winds of over 15 knots may cause the tail rotor positioning actuator and cam to fail and the tail rotor to spin uncontrollably when the tail rotor drive shaft is uncoupled.

h. AFCS servos — OFF.

i. Pylon fold/spread switch — FOLD.

PYLON UNSAFE FOR FLIGHT light goes on.

j. Blade fold position, blade fold/spread, and pylon fold/spread switches — OFF.

k. Master power switch — OFF.

17. Gust lock — AS DESIRED.

*18. All radio/electrical switches — OFF.

*19. HEEDS bottles — CLOSED.

*20. Emergency exit light — OFF.

Note

Turn off emergency exit lights before the last operating generator is shut down. Otherwise, lights will automatically go on whenever dc buses are deenergized, and then cannot be turned off until dc buses are again energized.

*21. Computer bite code — CHECK.

*22. CMPTR POWER — OFF.

*23. Exterior/interior lights — OFF.

*24. No. 1 and No. 3 Generators — OFF.

CAUTION

Applicable to helicopters not modified by AFC 309. Although the flight controls are not to be moved until hydraulic and electrical power are within normal operating limits, it is especially important that they are not moved when the APP is operating and the No. 1 and No. 3 generators are off. In this configuration, hydraulic boost is furnished to the flight controls and, if the pitch locks are engaged, any movement of the flight controls will result in damage to the flight control components.

*25. APP — SHUTDOWN.

*26. Side circular vents — CLOSED.

7.10.1 Postflight Inspection. The crew should do a postflight inspection immediately after completing the assigned mission. This shall consist of a visual inspection of the landing gear, fuselage, rotor and transmission system, and engines. The pilot should enter, on the maintenance discrepancy sheet, all discrepancies noted in flight and during postflight. To aid in discrepancy analysis, specific information related to the discrepancy noted in flight, such as position of controls, instrument readings, etc., should be included with the report. Qualified maintenance personnel should be available for consultation. The pilot will make sure that all discrepancies have been completely and comprehensively conveyed, both orally and in writing.

7.11 BLADE/PYLON FOLD/SPREAD SEQUENCING

Refer to FO-35.

7.12 MANUAL PYLON FOLD/SPREAD SYSTEM

The system uses hydraulic pressure developed by the handpump (Figure 7-10) mounted forward on the right side of the cabin, to fold and spread the pylon. A red flag on the bottom of the tail cone is visible when the tail rotor drive shaft is uncoupled. Two red flags on the left side of the tail cone are visible when the locking pins are not seated. The flags move in direct proportion to lockpin travel.

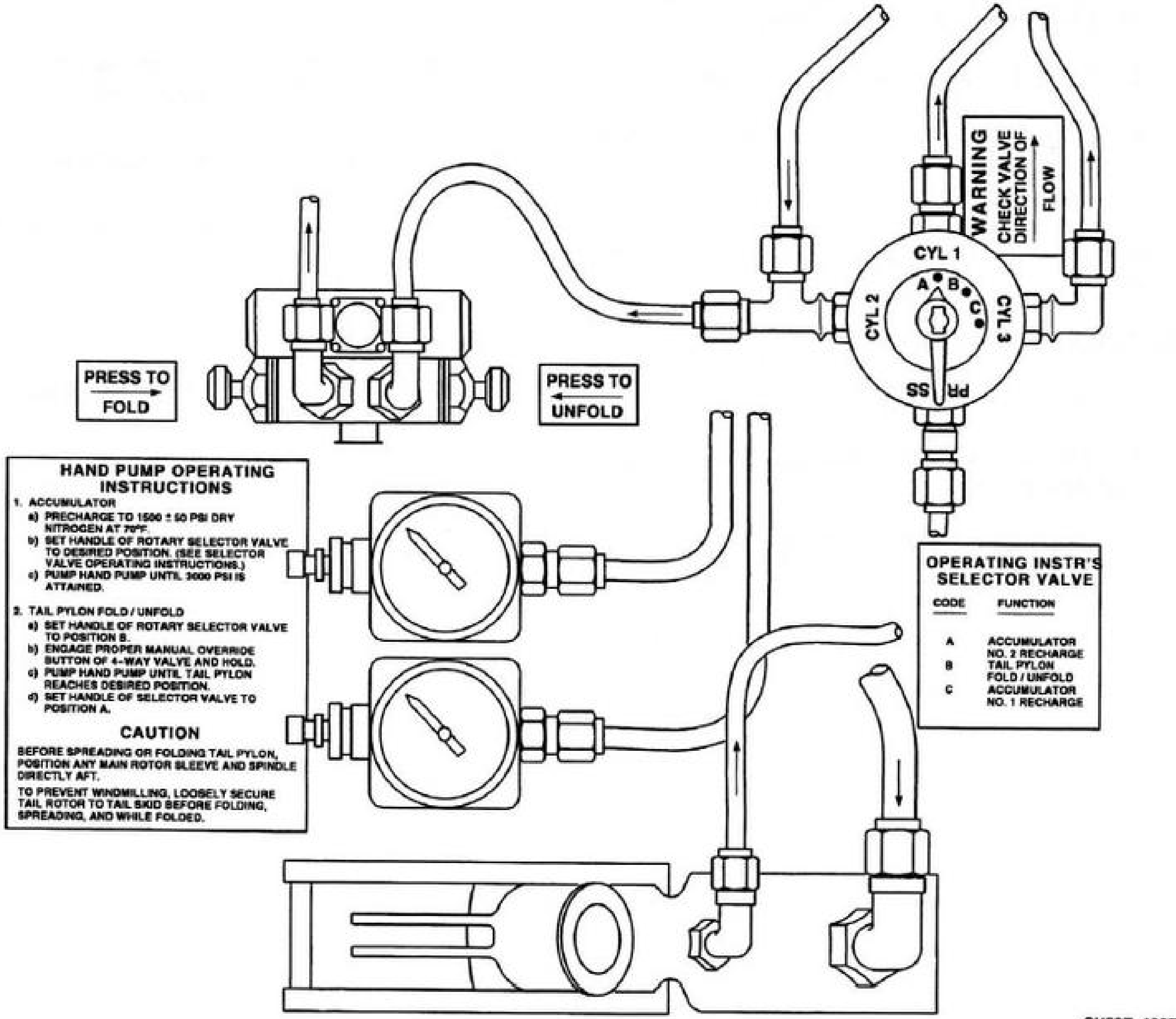


Figure 7-10. Hydraulic Handpump

7.12.1 Manual Pylon Fold/Spread Operation

WARNING

- When folding and spreading pylon manually, the tail rotor must be restrained. Rope does not safely provide adequate means of restraint. While shipboard, the tail rotor must be restrained until actuator is electrically extended, or until it is tied off securely.
- When folding and spreading pylon; the yellow blade strut, pylon strut, straps, and ropes on starboard side of helicopter must be removed prior to starting APP. Failure to remove these items will result in damage to pylon, stabilizer, fuselage, and tail rotor blades.

7.12.1.1 To Fold

1. Tail rotor — SECURED.

2. Position any main rotor sleeve and spindle directly aft.

3. Gust lock — ON.

4. Observer stationed to monitor main rotor blade and pylon clearance during fold cycle.

5. Handpump selector valve — POSITION B.

6. PRESS TO FOLD valve button — HOLD PRESSED.

7. Handpump — PUMP.

8. Pylon folded, and pump selector valve — POSITION A.

7.12.1.2 To Spread

1. Tail rotor — SECURED.

2. Make sure any main rotor sleeve and spindle is positioned directly aft.

3. Area/strut — CLEAR/REMOVED.

4. Gust lock — ON.

5. Observer stationed to monitor main rotor blade and pylon clearance during spread cycle.

6. Handpump selector valve — POSITION B.

7. PRESS TO UNFOLD valve button — HOLD PRESSED.

8. Handpump — PUMP.

9. Three external flags — RETRACTED Figures 7-2 through 7-9 COMPLETELY.

10. Handpump selector valve — POSITION A.

11. Tail rotor — UNSECURED.

CHAPTER 8
Shipboard Procedures

8.1 COMMAND RESPONSIBILITY

Command relationships and general procedures to be followed are contained in NWP 42, APP-2/Supplement (HOSTAC) and CV, LHA/LPH/LHD NATOPS Manuals.

8.2 FIELD CARRIER LANDING PRACTICE

Five-day and five-night FCLPs shall be made within 30 days before initial shipboard qualification or when requalifying if qualification has expired. The number of periods will depend on the experience and ability of the individual pilot. FCLPs will be conducted to simulate shipboard operations as closely as possible.

8.2.1 Briefing Prior to FCLP. Briefing before FCLPs will include the information set forth in this section and shall be in addition to the following:

1. Patterns, altitudes, and airspeeds.

2. Helicopter director signals.

8.3 SHIPBOARD QUALIFICATION

Initial day/night carrier qualifications should be made under ideal weather conditions to include a visible horizon. Nothing in this manual precludes the commanding officer from exercising his own judgment concerning the ability of a pilot to perform a mission involving recovery on board or when dictated by operational necessity.

8.3.1 Shipboard Qualification Requirements

1. Day initial qualification — Not less than five landings and takeoffs.

2. Night initial qualification — Day qualified and not less than five night landings and takeoffs. At least two day landings must be made on the day of night qualifications.

8.3.2 Requalification Requirements in Model (Not Type)

1. Day — Not less than two landings.

2. Night — Not less than two landings. At least two day shipboard landings must be made on the day of night qualifications.

3. Currency:
   Day — 2 day landings within 12 months.
   Night — 2 night landings within 12 months.

8.4 FLIGHT SCHEDULING

The squadron training and operational requirements must be coordinated with the needs of the ship through the ship's air operations officer. The squadron's flight schedule is derived from the ship's air plan. This is a complete daily schedule of flights and mission to be performed. The air plan is promulgated by the operations department and becomes an order of the commanding officer of the ship.

8.5 BRIEFING

All pilots shall receive a thorough briefing on the ship's air operations and flight procedures. The briefing will be given by the ship's air department officer or his representative. Flight briefings will be conducted by the unit's operations section before each flight. This detailed briefing will include the following:

1. Helicopter director signals.

2. Wind direction and velocity for flight operations.

3. Use of helicopter lights (if night operations are conducted).

4. Traffic patterns and altitudes about the ship.

5. Type recovery and/or scheduled recovery time.

6. Special safety precautions during shipboard operation.

7. Ship's point of intended movement and nearest land.

8. Aircraft deck spotting.

9. Ship's navigation aids.

10. Weather forecast and weather over nearest land.

11. Ship's position in the force.

12. Emergency procedures.

13. Lost communications procedures.

8.6 HANGAR AND FLIGHT DECK PROCEDURES

General flight and hangar deck procedures can be found in the applicable NATOPS manuals and NWP series.

CAUTION

The weight limitation of the elevators on LPHs is less than 50,000 pounds.

8.6.1 Precautions in Movement of Helicopters

WARNING

The APP shall be started before moving the helicopter on the flight deck, to be sure of adequate braking action.

CAUTION

Tow tractors are not capable of handling the weight of the helicopter on slippery or pitching decks.

Precautions must be observed in all movement to prevent the possibility of damage to the relatively light structural members and rotor blades. Normal movement of helicopters on the hangar and flight deck will be made by using a tractor equipped with a tow bar. In all cases of deck movement, a qualified individual will be in the cockpit to be sure the helicopter will be moved at a slow and safe speed.

8.6.2 Starting Engines. The auxiliary powerplant (APP) and the engines will not be started on the hangar deck unless operational necessity dictates, and prior approval is received from the ship's air department.

WARNING

Flight deck personnel shall be familiar with the APP and engine exhaust profiles (Figure 7-2).

8.6.3 Flight Deck Procedures

1. Flight deck handling procedures and aircraft handling signals are contained in the applicable NATOPS manuals.

2. Starting the auxiliary powerplant (APP), the engines, rotor turn-up, and taxiing will be done only upon direction of personnel from the ship's air department.

3. Movement of helicopters will be under positive control of directors.

4. The maximum safe relative wind conditions for unfolding or folding the rotor blades or rotor engagement is 45 knots from any quadrant.

8.6.4 Manning Helicopters. Upon receipt of the word to "man aircraft", flight crews will expedite movement to the helicopter and complete the preflight inspection. The helicopter will then be manned in accordance with existing conditions of readiness.

WARNING

Extreme caution shall be taken by pilots and crew during preflight inspection of the rotor head, pylon, and while walking along the upper fuselage walkways. Due to possible slippery footing conditions, ship's motion, and the lack of good handholds, personnel injury may result.

8.6.5 Starting Engines. Preparation for starting the auxiliary powerplant and engines shall be made by the helicopter crew immediately after they enter the helicopter. Upon signal from the Landing Signalman Enlisted (LSE), the auxiliary powerplant and the engines will be started and the checklist completed as far as possible in accordance with existing prestart and starting checklists.

A visual signal will be passed to the LSE as soon as the pilot determines that he is ready to engage rotors.

8.6.6 Starting Rotors. Rotors will be engaged only upon the signal from the LSE. The mandatory requirements for engagement of the rotors are:

1. Rotor blade tiedown removed.

2. Flight deck area clear of unnecessary personnel and loose gear.

3. Deck tiedowns secure and chocks in place.

WARNING

If it is necessary to engage the rotor while the helicopter is tied down, it is mandatory that the tiedown chains be attached with slack, thus relieving any tension in the chains attached above the oleos. Engagement of the rotor while the helicopter is tied down tightly will result in ground resonance.

After the rotor engagement is completed, the pilot will continue with the cockpit checklist. When completed and ready for takeoff, he shall indicate an (up status) signal to the LSE. The checklist should be made as rapidly as possible, consistent with safety. However, one pilot shall keep the LSE in sight and be prepared to receive signals at any time. When directed and following an up status signal from the pilot, the tiedowns shall be removed. In case of a down status signal from the pilot, chocks and tiedowns will be left on. Upon getting a disengage signal from the LSE, the pilot will proceed with a normal shutdown, and fold the rotor and pylon if directed. If the pilot deems it necessary to shut down immediately, he will do so and advise the ship.

8.7 LAUNCH AND RECOVERY OPERATIONS

See appropriate Ship/NATOPS Manual.

8.7.1 Relative Wind for Launch and Recovery

1. Launch and recovery should be made into the relative wind, never exceeding a 35-knot crosswind component.

CAUTION

Takeoff and landing in high relative winds may increase the hazardous effects of turbulence from rotor downwash to personnel and unsecured equipment. (Refer to Figure 11-3 through 11-6.)

2. Operations in the island wash area should be held to a minimum.

3. See LHA/LPH NATOPS for launch and recovery wind limits.

8.7.2 Final Landing Procedures. The approach turn from the 180° position is begun at 80 knots. Adjust speed as necessary to maintain a rate of closure commensurate with the relative speed of the ship. The final approach should be relatively flat to eliminate the necessity of exaggerated power changes or excessive flares near the deck. Final movement of the helicopter onto the deck position is normally made at air taxi speed from the deck edge and about 10 to 15 feet above the deck. The pilot is governed by signals from the landing signalman. Touchdown must be smooth and positive to reduce the possibility of ground resonance. Tiedowns and chocks normally will be used before shutdown. Rotors will be stopped and engines shut down upon signals relayed by the LSE.

WARNING

It is mandatory to obey a wave-off or hold signal from the LSE.

8.8 EMERGENCY PROCEDURES

Refer to Chapter 12 and appropriate Ship/NATOPS Manual.

8.9 NIGHT OPERATIONS

See appropriate Ship/NATOPS Manual.

Night operations are always the most critical for both pilots and flight deck crews. The tempo of operations must be reduced in both volume and speed when compared to day operations. Slow and careful handling of helicopters by pilots and flight deck crews is mandatory. Particular attention must be given to be sure that all personnel involved in night operations are well briefed in their duties and procedures by the appropriate ship and squadron authority. Preflight and postflight inspections will be done in the same manner as for day operations.

8.10 AVIATION FACILITY SHIP

The certification or waiver status of each aviation ship should be examined before operations such as landings, VERTREP, and HIFR are commenced. Certification of a facility for operations guarantees adequate clearance, deck strength, firefighting, lights, markings, communications, etc., according to the level and class of operation as designated by CNO. However, Fleet Commanders in Chief have waiver authority to provide for required helicopter operations when a facility is not certified. Pilots operating from these ships should be aware that personnel training and operational familiarity are normally less than that found aboard an LHA, LPH, and LHD. Thus, the pilots and crew will have to be more alert. Launching procedures are the same as for shipboard operations. However, due to the configuration of these ships, limited deck space, gun mounts, cranes, and antennas, the helicopter director will launch the helicopter to either port or starboard. The pilot must be sure he is being launched into the relative wind. Recovery procedures will be the same as for shipboard operations. The pilot should not land until assured by the copilot and aircrewman that the area is clear for landing and that the main gear is over the flight deck. The areas certified for landings are of adequate size, providing the forward wheels are within the 24-foot diameter circle (preferably on the 4-foot dot) and the helicopter is aligned with the lineup line. Clearances during VERTREP over certified facilities, are provided when the helicopter is aligned over, 15 feet above, and parallel the dashed VERTREP lineup lines. Clearance is also provided when similarly aligned over the top of a series of Ts found on some ships with large VERTREP areas. VERTREP may also be safely conducted aft of the Ts to either another reversed series of Ts or the edge of the VERTREP area.

Note

- Specific data can be found in the Air Capable Ships Helicopter Facility Resume NAEC-ENG-7576.
- Non-aviation ship's deck edge power may not be compatible with the helicopter's electrical system. Use of the APP will be needed for ground electrical power checks.

CHAPTER 9
Special Procedures

9.1 FORMATION FLYING

It is essential that the fundamentals of formation flying be practiced. The procedures and positions contained herein provide a foundation for formation flying which will meet most combat and noncombat mission requirements. The signal for a change in a formation may be made by the radio, on a squadron common frequency, or by appropriate aircraft signals outlined in Figure 9-1. However, no changes in formation will take place until all helicopters in the formation understand and acknowledge the signals given.

9.1.1 Elements of a Formation. The elements of a formation are a section consisting of two aircraft and a division consisting of three or four helicopters (two sections). Two or more divisions form a flight. The disposition of members within a formation, i.e., heavy right, heavy left, etc., will be at the discretion of the flight leader.

9.1.2 Basic Formations. The three basic formations are parade, tactical, and other. Parade is used primarily when there is a requirement for aircraft to fly a fixed bearing in close proximity and when maximum maneuverability is not essential. It is most frequently employed during arrival at or departure from ships and airfields or during flight demonstrations. Power is varied to maintain position. When maneuverability is a prime consideration for formations engaged in combat tactics, tactical formations are used. Through the use of a tactical formation the leader is able to maintain formation integrity and still be free to maneuver with few restrictions. The tactical formations outlined herein afford this flexibility. Radius of turn rather than power is varied to maintain position.

9.1.3 Parade Formations

9.1.3.1 Types. The four basic types of parade formation are echelon, fingertip (Figure 9-2), diamond (Figure 9-3), and column.

9.1.3.2 Positions. The parade position for echelon, fingertip, and diamond is on a 45° bearing with 10 feet of step-up and one and one-half rotor diameter diagonal clearance. This position provides adequate longitudinal and lateral clearance between helicopters. In fingertip and diamond, the section leader will fly the same position on the leader as the number two man. The column position is on a 0° bearing with 10 feet of step-up and two rotor diameters longitudinal clearance.

9.1.4 Parade Turns

9.1.4.1 Echelon and Fingertip. Wingmen will rotate about the leader's longitudinal axis during all turns.

SIGNAL	MEANING	RESPONSE
Series of zooms by lead aircraft	Join up; join up on me (Given from cruise, column, or scout lines)	Repeat signal to pass to subsequent aircraft and to acknowledge, then execute
Wing dip	Given from column following join-up signal to indicate section join-up on side of dip (heavy side)	Execute
Lead plane swishes tail	All helicopters in this formation form step-up column in tactical order behind leader	Execute. Leader steps down slightly to aid formation of column
Leader's rotating beacon on	No. 2 helicopter has lead	No. 2 helicopters turns beacon off (if on) and assumes lead

Figure 9-1. Supplementary Signals for Helicopters

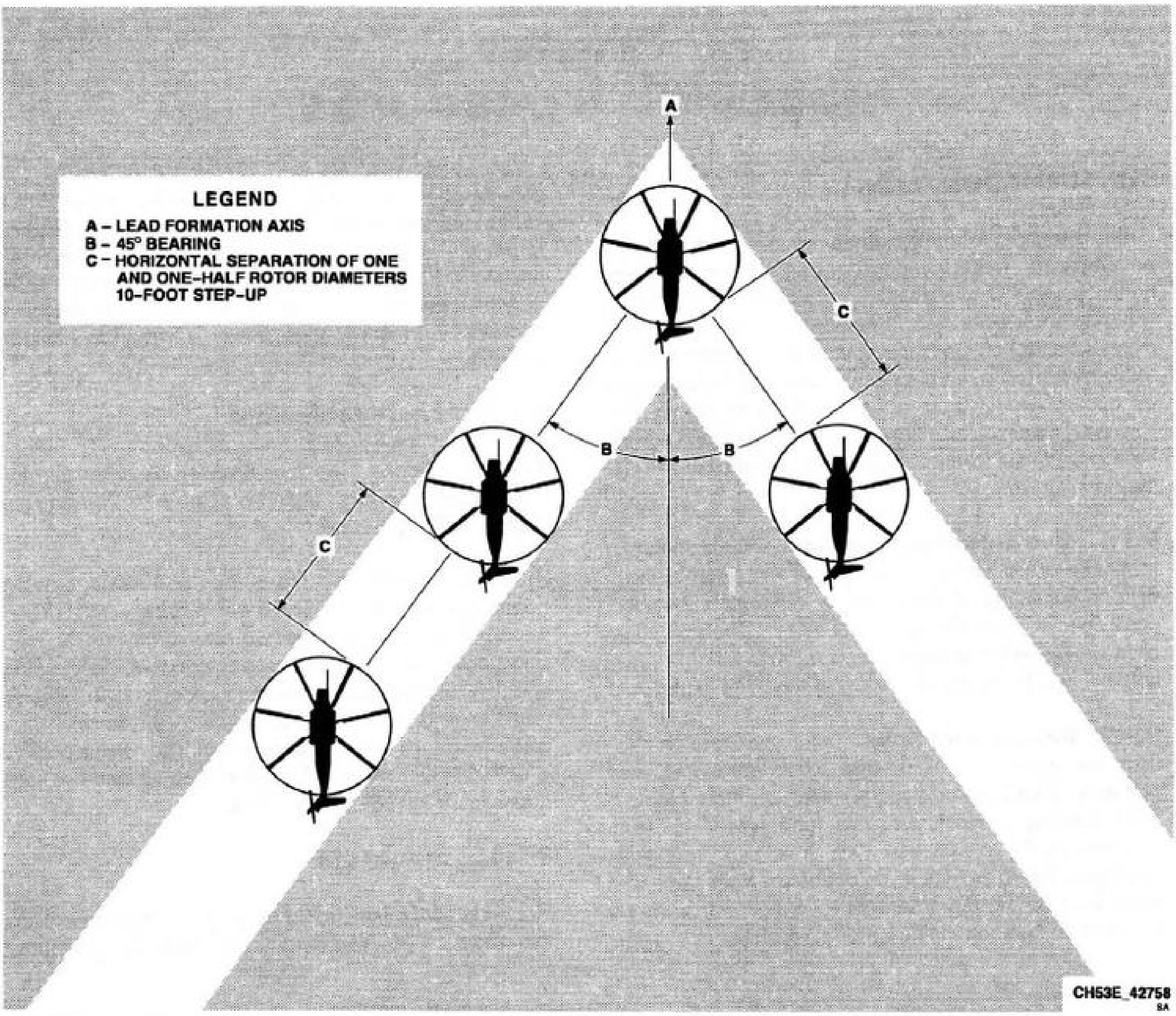


Figure 9-2. Four-plane Division Parade (Fingertip)

9.1.4.2 Diamond and Column. Wingmen will maintain a fixed position and roll about the leader's longitudinal axis on all turns.

9.1.5 Tactical Formations. Refer to NWP 55-9-ASH.

9.1.6 Formations

9.1.6.1 Cruise. The cruise position (Figure 9-4) is on a 45° bearing with 10 feet of step-up and a minimum of two rotor diameters separation. This position will provide adequate longitudinal and lateral clearance between helicopter for maximum maneuverability. The wingman will primarily use radius of turn rather than power adjustments to maintain position and is free to maneuver between the 45° left and 45° right bearings. If another helicopter or section is in the formation, dash three will allow room for dash two to maneuver freely between dash three and the leader.

9.1.6.2 Tail Chase. The tail chase formation is flown in a loose column and all wingmen will utilize basic cruise turn principles to maintain longitudinal clearance between helicopter. The formation is most commonly used in conjunction with the basic cruise formation when the leader is required to maneuver extensively through climbs, dives, and turns for the purpose of defensive evasive maneuvering, approaches to confined LZs, etc. When the

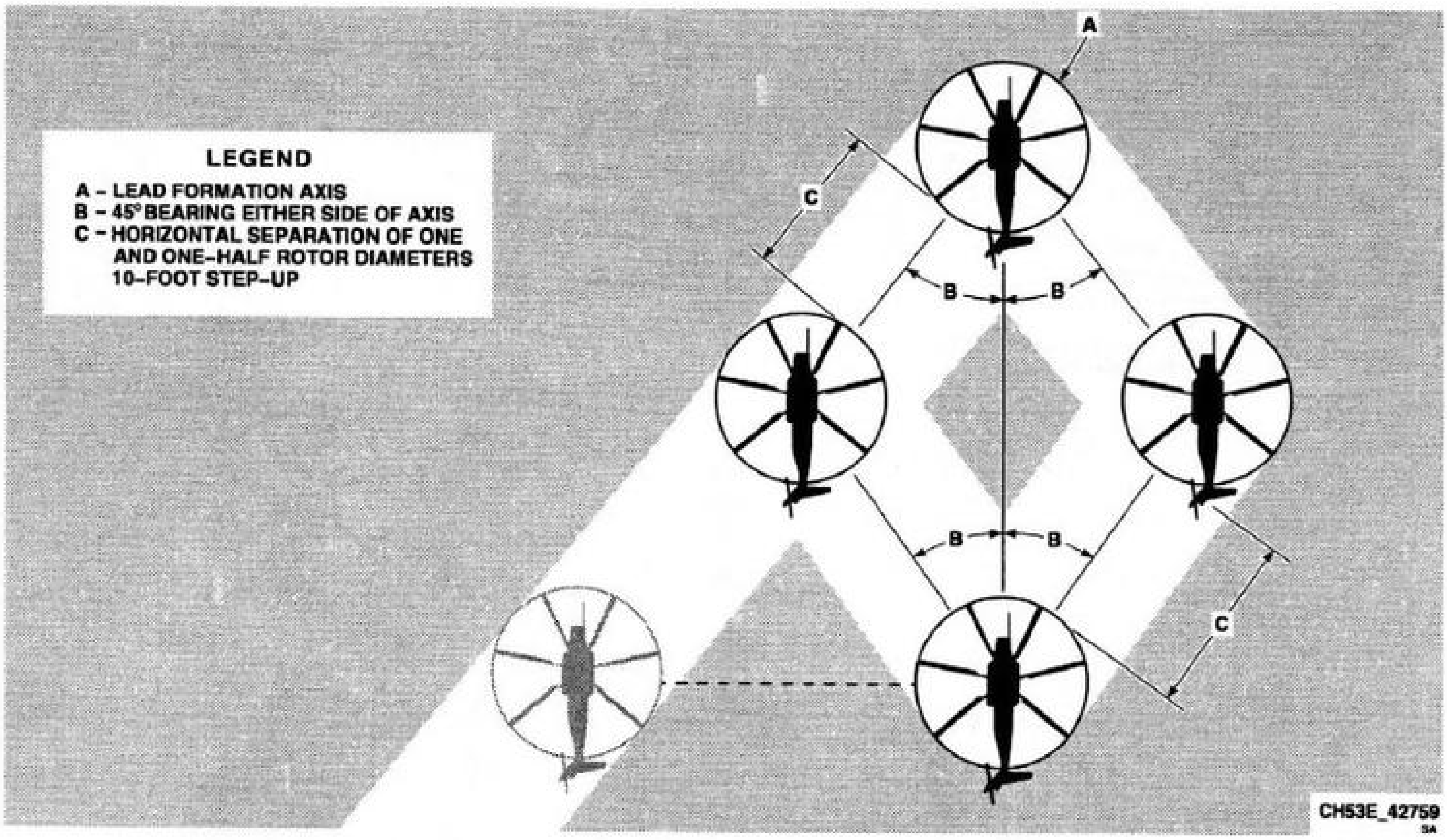


Figure 9-3. Diamond Parade

need for the tail chase ceases, the leader should return the formation to normal cruise formation.

9.1.6.3 Scouting Line. During flights that require increased lookout capability and where a high degree of maneuverability is not required, the leader may desire to move his wingmen forward and out from the normal cruise position. The degree of maneuverability required will dictate the bearing and distance between helicopter in the formation. The more forward the bearing, the greater lookout support and ease of maintaining position and the less maneuverable the flight. This type of formation is generally employed on routine flights over extended distances.

9.1.7 Crossovers. Crossovers will be made by individual wingmen or sections when directed by the leader. The leader must make sure that all helicopters in formation are aware of an impending change in formation. The following procedures will be followed:

1. When a wingman is required to cross over, he will move to the corresponding position on the opposite side while maintaining longitudinal blade tip clearance. The section leader will slide out on bearing, allowing room for number two when applicable.

2. When the section is required to cross over, it shall be made by the section moving across to the appropriate position on the opposite side. The section leader's wingman will not effect his crossover on the section leader until the section leader is in his new position.

9.1.8 Lead Changes. All lead changes should be accomplished with positive two-way radio communications. In the event of lost communications or when EMCON conditions preclude the use of radio communications, prebriefed visual signals shall be utilized. All changes of the lead position in a formation shall be acknowledged in such a manner as to preclude the possibility of misunderstanding by any member of the formation. Lead changes shall be executed from level flight and from echelon formation. Pilots at the controls should be occupying seats on complementary sides of the formation. Visual contact must be established and maintained between the original formation leader and the new formation leader before a lead change is effected.

A lead change shall be done in the following manner:

1. Lead — "Prepare to take the lead."

2. Wing — "Roger, moving into position."

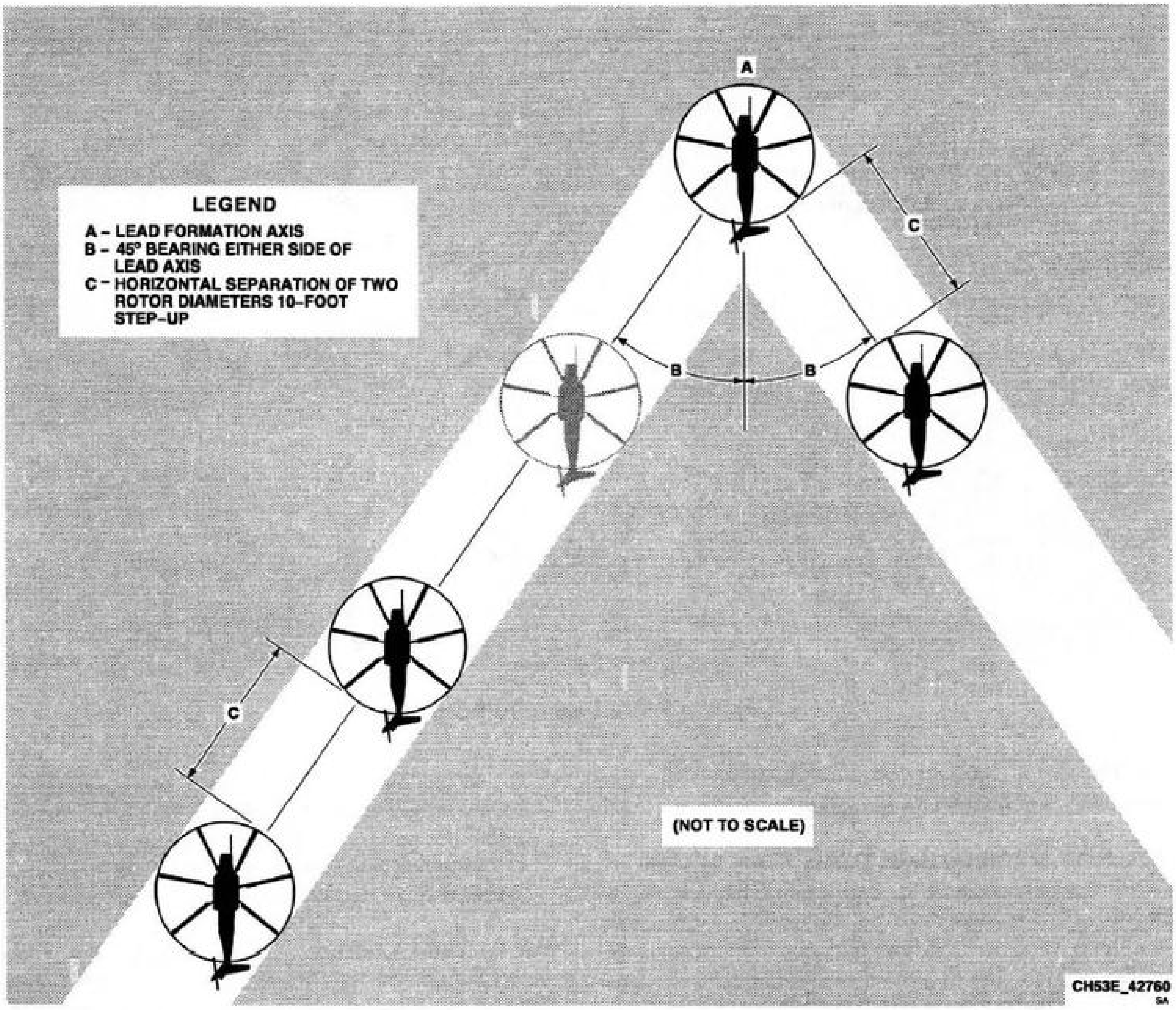


Figure 9-4. Four-plane Division Cruise

a. Wing increases lateral separation and moves abeam of leader.

3. Wing — "In position to assume the lead."

4. Lead — "Roger, you have the lead."

5. Wing — "Roger, I have the lead."

a. Original leader is now the wingman, responsible for separation. He moves back to the wing position. Normal formation flight maneuvering may now be resumed.

The responsibility of the new leader is to maintain a constant heading, altitude, and airspeed throughout the lead change. The original formation leader (new wingman) has the responsibility to maintain a minimum of one and a half rotor diameters with 10 feet of step-down until in position of the 45° bearing at which time he will increase to a 10 foot step-up. The new formation leader is obligated to continue straight and level flight until the original formation leader transmits, "In position." Normal formation flight maneuvering may then be resumed.

9.1.9 Rendezvous. The two types of basic rendezvous are the running rendezvous and the carrier type rendezvous. A combination of the principles of these two are generally employed to join aircraft after takeoff.

9.1.9.1 Running Rendezvous. The leader will depart maintaining a prebriefed airspeed that will allow wingmen to use an airspeed differential and/or radius of turn that will allow them to overtake the leader and join as briefed.

9.1.9.2 Carrier Type Rendezvous. Basically this is a join-up executed while the division leader makes a 180° level turn using a 10° angle of bank and 120 knots airspeed, or as prebriefed. Joining helicopters will assume a rendezvous bearing on the division leader using the cutoff vector to effect the join-up. The final phase of the rendezvous will be on a 45° rendezvous bearing. Join-ups will be made to the inside of the turn. After relative motion is stopped, effect a crossover when required. When practicing carrier-type rendezvous, breakups will be executed from an echelon. The leader will break and maintain altitude and a 30° bank throughout his turn. Each succeeding wingman breaks at a prebriefed interval with 30° of bank, adjusting his bank to be in an extended column position when the leader completes his turn.

9.1.10 Formation Takeoff and Landing. Formation takeoffs and landings are frequently used during normal missions and should be practiced. Power available, size of zone, obstacles to flight, wind direction and velocity, enemy fire, terrain features, rotor turbulence, and other considerations will determine the positions to be assumed by members of a formation.

9.1.11 Wake Turbulence. Every aircraft/ helicopter generates wake turbulence while in flight. Wake turbulence is generated in the form of two counter-rotating cylindrical vortices trailing behind the aircraft. The strength of the vortex is governed by the weight, speed, G-loading/disc loading, and wing shape of the generating aircraft. The usual hazard is an induced rolling moment which can exceed the roll capability of the encountering aircraft. Characteristics which can help the pilot visualize the wake location and take avoidance precautions are:

1. Vortices are generated about the wing tip/rotor tip from the moment the aircraft leaves the ground.

2. The vortex flow field is normally two wing spans/rotor diameters in width, and one wing span/rotor diameter in depth.

3. Flight tests have shown that the vortices sink at a rate of 400 to 500 feet-per-minute, with a leveling off about 900 feet below the flight path.

4. When the vortices sink close to the ground (within about 200 feet), they tend to move laterally outward over the ground at a speed of about 5 knots.

WARNING

Wake vortices must be avoided while maneuvering at low altitude. An encounter with wake vortices while maneuvering at low altitude may result in conditions from which recovery may be impossible.

9.2 INTERNAL TRANSPORT OF CARGO/ PASSENGERS

Mixed loads of bulky cargo and passengers are not recommended if access to cabin doors and escape hatches would be restricted during an emergency. Care should be taken when computing the weight and balance to be sure that CG limitations are not exceeded. All cargo will be properly secured before takeoff. Passenger comfort should be stressed and abrupt changes in power or attitude should be avoided whenever possible.

Refer to NAVAIR A1-H53BE-CLG-000 (H-53 Cargo Loading Manual) for procedure to be followed for internal transport of selected cargo, passengers, including CG limits, floor loading, and tiedown requirements.

WARNING

The internal transport of fueled collapsible fuel bladders is prohibited.

9.3 PARATROOP DELIVERY OPERATIONS

Successful paratroop delivery operations require close coordination between the pilots and aircrewman. Specific duties and responsibilities related to each are indicated herein.

9.3.1 Pilots' Procedures

	RAM-AIR (SQUARE PARACHUTE) Static Line System (Static Line Deployed)	**ROUND PARACHUTE** Static Line System (Static Line Deployed)	**FREE-FALL PARACHUTE** System (No Static Line Deployed)
1. Airspeed	100 KIAS	80 to 100 KIAS	80 to 120 KIAS
2. Cargo Ramp	5° Below Level	10° to 15° Below Level	10° to 15° Below Level
3. Tail Skid	Retracted	Retracted	Retracted
4. Jump Altitude	3000 ft. AGL Min. See remarks 1, 2, 3, and 4	Below 90 KIAS: 1500 ft. AGL Min. At or above 90 KIAS: 1250 ft. AGL Min. See remarks 1, 2, 3, and 4	In accordance with minimum requirements for parachute and automatic opening device used

Remarks:

1.

NOTE

Static lines, when used, may be rigged in a number of acceptable configurations. They should normally be attached in the left side of the helicopter (right side looking aft) to a point no higher than two feet above the cargo compartment floor and rigged so the aft end of the static line extends between 9 and 19 feet beyond the ramp edge when the ramp is lowered 5° to 15° below level. This configuration assures that parachute pack opening and canopy release will occur clear of the helicopter, and that static lines and parachute deployment bags will trail in a stable pattern, well clear of the tail rotor and succeeding jumpers.

2.

WARNING

For cargo ops — Use of tail rotor cowlings is recommended to preclude entanglement with the tail rotor drive shaft.

3.

WARNING

For cargo ops — Use of breakaway static lines may result in their entanglement with tail skid or tail rotor.

4.

NOTE

For cargo ops — Non-breakaway static lines should be used in lieu of breakaway static lines to preclude tail rotor entanglement.

9.3.2 Aircrewman's Procedures Anchor cables, when used, may be rigged in a number of acceptable configurations. However, they should normally be attached on the port side of the helicopter to a point no higher than 2 feet above the cargo compartment floor and rigged so that the aft end of the static line extends between 9 and 16 feet beyond the ramp edge when the ramp is lowered 5° to 15° below level. This configuration ensures that pack opening and canopy release will be safely clear of the helicopter and that static lines and deployment bags will trail in a stable pattern well clear of the tail rotor and succeeding jumpers. In addition to all normal responsibilities the aircrewman shall:

1. Act as communication link between pilot in command and jumpmaster, if ICS communication between pilot in command and jumpmaster breaks down.

2. Make sure that all personnel follow necessary safety precautions enroute and during paratroop delivery operations.

If using ram-air (square parachute) static line system (static line deployed):

3. Open cargo ramp door and position cargo ramp 5° below level.

4. Ensure a 10-foot static line extension is used and the static line stop is at station 482.

WARNING

Failure to adhere to the static line extension and static line stop requirements may allow parachute deployment bags to become entangled with the tail rotor.

If using a round static line parachute system (static line deployed):

3. Open cargo ramp door and position cargo ramp 10° to 15° below level.

4. Ensure a 5-foot static line extension is used and the static line stop is at station 502.

WARNING

Failure to adhere to the static line extension and static line stop requirements may allow parachute deployment bags to become entangled with the tail rotor.

If using a free-fall parachute system (no static lines used):

3. Open cargo ramp door and position cargo ramp 10° to 15° below level.

4. N/A

5. Make sure that the number of personnel in the vicinity of the ramp is never so great that the acceptable aft CG limit is exceeded. He will receive instructions concerning the CG from the pilot in command during the preflight brief, and supervise the course of paratroop delivery operation.

6. Make sure that all paratroopers leave the helicopter from the right side (left side looking aft) of the cargo ramp.

7. Notify pilot in command of status of paratroopers as they leave helicopter.

8. Make a positive statement to pilot, reporting as follows:

   a. Number of passengers aboard.

   b. All passengers; safety belts fastened.

   c. Cabin occupants and/or internal cargo ready for taxi/takeoff.

9. Make sure that all troop life preservers are removed and returned when overwater flight is completed.

10. Signal passengers when clear to leave.

9.4 COUNTERMEASURES DISPENSING SET OPERATION

Refer to CH-53 Tactical Manual NWP 3-22.5-CH53 for operating procedures.

9.5 HOISTING OPERATIONS

WARNING

- Before all hoist operations the cable shall be inspected for proper rigging.

- Ground/ships crews shall be briefed before hoist operations on the static electricity potential of the helicopter.

- Ground the hoist cable before permitting personnel on the surface to touch it, to prevent injury to personnel caused by the discharge of static electricity.

- Before the conduct of (HIFR etc.) operations, ground/deck crews will be briefed on the downwash potential of the helicopter and safety considerations. See DOWNWASH in Chapter 11.

The hoist is used as a means of lifting or lowering cargo during a hover. The three types of lifts usually required in the use of the utility hoist are:

1. Pickups from water.

2. Pickups from boats or ships where helicopter cannot land.

3. Pickups from wooded or obstructed areas.

For all hoisting operations, a crewman must accompany the flight to operate the hoist. The crewman will keep the pilot advised of both the status of the hoisting operation and the helicopter position over the object being hoisted. All preplanned flights of this type require that two qualified pilots be in the cockpit. In many hoisting operations the pilot will find he has very little, if any, visual reference points for accurate hovering and will have to rely on the directions of a crewman or his copilot to maintain a steady position during the hover. Normally the pilot will maintain a steady hover over the spot until the hook is raised into the cabin and all personnel are strapped in.

9.5.1 Pickup From Open Water. In making an approach for a pickup from open water, the pilot must keep the pickup point in sight as long as possible. A right-hand orbit is preferable. If smoke lights are available and their use is indicated, they should be placed in the 2-o'clock position from the pickup point. They should not be placed directly upwind. The last part of the approach should be slow and deliberate to avoid overrunning the target.

9.5.2 Lost Communication Procedures During Hoisting Operations. In case of lost communications between the hoist operator and the pilot, the hoist operator will tap the non-flying pilot on the shoulder and indicate lost communications by pointing to his mike and giving a thumbs down.

Note

Once the hoist is clear, no further hoist operations shall be initiated.

9.5.3 Pickups From Wooded or Obstructed Areas. Pickups from wooded or obstructed areas require a stable hover, without drift, to keep the winch cable from snagging in trees or obstructions. The winch cable should be guillotined if this occurs.

9.5.4 Hover Transfers to Air Capable Ships. When possible, the helicopter should land to transfer internal material and personnel. Transfers involving destroyers and most smaller ships not having landing platforms should be conducted by hovering over the VERTREP area if available. When transferring material on ships equipped with a VERTREP area, a LSE should be available. When transferring material externally attached to the cargo hook, the weight of the material shall not be great enough to exceed the gross weight limitations or the weight specified by the pilot as being the maximum for safe helicopter operations.

Prior to initiating an approach to an air capable ship for a hover transfer, the approach path and hover area should be determined after evaluating the following:

1. Ship certification and characteristics.

2. Crew abilities.

3. Wind/sea state/weather.

4. Transfer requirements.

5. Disposition of ships in company.

The ship must be certified for transfer in accordance with OPNAVINST 3120.28 and the configuration of the ship, specifically obstructions, noted. The abilities of the crew, including current qualifications and present status of training, must be considered in relation to the difficulty of the transfer depending on the wind, sea conditions and other significant weather and their effect on visibility and stability of the platform to be serviced. The hoisting station to be employed and the nature of the material to be transferred should also be considered as well as the disposition of other ships in company.

WARNING

Although no hover altitude can be dictated, sufficient altitude shall be maintained to allow the helicopter a safe transition clear of the hover area and obstructions in case of a helicopter system malfunction.

9.6 UTILITY HOIST OPERATION

WARNING

- Personnel should not be hoisted from altitudes less than 100 feet AGL due to significant rotor downwash.
- If the lower half of the personnel door is to be removed, it shall be done only in a hover or low speed (less than 40 knots flight) to avoid its hitting the main or tail rotor.
- The crewman's safety belts shall be used when operating the hoist from the cabin compartment with the personnel door open.
- During all hoist operations the hoist crewman should avoid contact with the hoist cable as the load/hoist hook touches the surface. Touching the cable could cause the crewman to become part of the path for static electricity discharge.
- Before the conduct of (HIFR etc.) operations, ground/deck crews will be briefed on the downwash potential of the helicopter and safety considerations. See DOWNWASH in Chapter 11.
- Due to hazards created by the static electricity generated by the helicopter, make sure hoist contacts the surface before contacting personnel.

9.6.1 Utility Hoist Functional Check and Guillotine Test

1. Hoist master switch — PILOT
2. Hoist selector switch — DOWN.

Check cable downward movement.

3. Hoist selector switch — OFF.
4. Hoist selector switch — UP.

Check cable upward movement. Check up-limit switch operation.

5. Hoist selector switch — OFF.
6. Hoist master switch — CREW.
7. Hoist crewman activate cable down and up.

CAUTION

Before conducting electro-explosive circuit test, make sure that crewmember conducting test does not confuse the AUX TANK JETTISON TEST SWITCH for the ELECTRO-EXPLOSIVE CIRCUIT TESTER.

8. Electro-explosive circuit test switch panel — TEST.

CAUTION

ELECTRO-EXPLOSIVE CIRCUIT TESTER switch must be at TEST before checking shear circuit.

9. Hoist cable shear switch (hoist operator's control panel) — SHEAR.
10. Electro-explosive circuit tester test light — ON.
11. Hoist cable shear switch (hoist operator's panel) — OFF, COVER CLOSED.
12. Pilot's HOIST SHEAR switch (emergency control panel) — ON.
13. Electro-explosive circuit tester test (good) light — ON.
14. Pilot's HOIST SHEAR switch — OFF, COVER CLOSED.

15. Electro-explosive circuit tester switch (hoist operator's panel) — FIRE, COVER CLOSED.

16. Hoist control selector switch (overhead console) — OFF.

9.6.2 Pilot Operation

1. Hoist master switch — PILOT.

2. Hoist control switch — DOWN.

3. Hoist control switch — UP.

When informed by crewman load is ready to be hoisted.

4. Hoist master switch — OFF.

9.6.3 Crewman Operation

1. Hoist control master switch — CREW.

2. Hoist grip — THUMBSWITCH DOWN TO LOWER CABLE.

3. Hoist grip — THUMBSWITCH UP TO RAISE CABLE.

Note

The thumbswitch is spring-loaded to the stop position.

4. Hoist control master switch — OFF.

9.6.4 Emergency Operation

WARNING

When lifting loads of over 550 pounds, the hoist shall be slowed down before stopping. Rapid stopping or reversing of the hoist may cause loss of control. If control is lost while lifting, control may be recovered by rapidly moving the crewman's hoist control valve handle to the maximum raise rate position.

9.6.4.1 Crewman's Emergency Hoist Operation. Turn the manual override knob counterclockwise to lower the cable and clockwise to raise the cable. Return the knob to the detented center position to stop the cable.

9.7 CARGO WINCH OPERATION

1. Connect control pendant and short cord to cable reel assembly.

2. Control pendant MASTER PWR switch — ON.

3. Cargo loading area — CLEAR.

4. Control speed/direction selector — IN-OUT.

CAUTION

- When control speed/direction selector is in neutral position, cargo load may creep.
- Tension must be applied to the cable during rewind to prevent damage to the cable and winch when winding on the reel. Be sure slack is out of cable before attempting to draw a heavy load into helicopter.
- During operation of the cargo winch, the parking brake may release causing inadvertent movement of the aircraft. When using the cargo winch with the parking brake set, pilots must monitor the brakes to ensure the aircraft does not move.

Note

An emergency winch OFF button is provided on the side of the control pendant which will remove power from the control speed/direction selector when pressed.

9.8 SEARCH AND RESCUE PROCEDURES

When emergencies occur, the lives and safety of personnel are often jeopardized unless immediate assistance is available. If the designated search and rescue helicopter is not available and/or additional assistance is required, any helicopter may be directed to do SAR duties.

Most searches entail the saving of lives or the location and recovery of military hardware. Therefore, every effort must be made to complete the search as rapidly and as efficiently as possible. Accurate navigation is mandatory and precise headings, turns, altitudes and airspeeds must be maintained. The search area must be thoroughly scanned and reactions to sightings must be timely and accurate.

Note

For SAR mission information, refer to Search and Rescue, NWP 37.

9.8.1 Aircrew Briefings. The Aircraft Commander will brief and discuss with his crew the procedures and crew duties for the mission. The briefing will include:

1. Objective of the search.
2. Weather.
3. Plan of operation for the search.
4. Other aircraft involved.
5. Position reporting.

Note

Minimum recommended equipment for preplanned SAR mission is specified in the NWP-19-1, Search and Rescue (SAR) manual.

9.8.2 Planning The Search. The Aircraft Commander will evaluate the situation for search coverage required, appropriate method of search, type of pattern required, altitude, airspeed and tracking spacing.

1. Search Planning Checklist:
    a. Review factors affecting the search.
    b. Determine intensity of coverage required (preliminary or concentrated).
    c. Select search area (location/size) and search pattern.
    d. Determine track spacing (greater for preliminary search coverage).
    e. Determine search altitude (higher for preliminary search).
    f. Determine airspeed (higher for preliminary search).
    g. Determine "Bingo" time for planned recovery location.

2. The following factors should be considered when determining appropriate search procedures for a specific mission:
    a. Weather conditions.
    b. Terrain characteristics if over land.
    c. Sea conditions if over water.
    d. Time of day for the search.
    e. Signal aids of survivors.
    f. Object's size, shape and color contrast.
    g. Status of objective: overdue, lost, crashed or ditched.
    h. Estimated location of objective.
    i. Endurance of the search aircraft.

Track spacing must be carefully established and never greater than twice the detection (TACAN) range. Recommended search altitudes for visual searches range from 500 feet to 3000 feet depending on the object of the search, visual aids, weather, etc. Altitudes shown in Figure 9-5 are recommended when other known factors will permit their use. During preliminary searches the helicopter should be flown at a speed that will permit rapid coverage of the search area yet will allow observers an opportunity to detect large objects, signals or wreckage visually. Optimum airspeed is 120 KIAS during preliminary searches and 70 KIAS during concentrated searches.

9.8.3 Lookout Doctrine. Good lookout doctrine is mandatory for successful search and rescue operations. Because the pilots must involve themselves with the actual operation of the helicopter, especially at night when actual instrument flight is required, the efficiency of pilot lookout doctrine is degraded and the importance of the aircrewman as lookout becomes paramount. The crewmen should be assigned specific lookout stations, one at the after port station and the other at the personnel door

Over Water in Feet	
500 and below	Survivor without raft or dye marker
500 to 1000	Survivor in raft without dye marker or signaling device
1000 to 2500	If survivor has dye marker
1000 to 3000	If survivor has signaling device/radar reflector
2000 to 3000	When expecting to find wreckage during initial phase of the mission
3000	During night over water
Over Land in Feet	
1000	Survivors of an aircraft incident over level terrain with little foliage
500	Survivors of an aircraft incident over level terrain with heavy foliage
500 to 1000	Survivors of an aircraft incident in mountainous terrain
2000	When expecting to find wreckage
3000	Over land at night

Figure 9-5. Recommended Search Altitudes

or after starboard window. Both crewmen should use crewman's safety belts. Crewmen must be specifically briefed as to the nature of the objects for which the search is being conducted.

9.8.4 Procedures On Arrival At Scene. Control of the rescue is assumed by the first helicopter to arrive at the scene and remains with this helicopter until it is relieved by proper authorities. This involves control of aircraft in the immediate area to avoid congestion and hindrance to rescue as well as direction of the actual rescue operation. Other aircraft should be used as radio relays when necessary.

WARNING

Heavy rotor downwash can cause survivors to drown at hover altitudes lower than 100 feet, depending on wind conditions, gross weight, and power requirements.

Note

Rotor downwash can hold flames away from a cockpit or small area long enough for rescue to be affected, but the danger of explosions must be considered.

9.8.5 Search Procedures. The Aircraft Commander will supervise and coordinate activities of the crewmembers. The copilot should plot the search pattern, record sighting information, monitor the altimeter and accomplish other duties as requested by the HAC (Figure 9-6).

1. The route search will be employed when the only information available is a known or dead reckoning position or the intended track of the search objective.

2. A parallel search will be used to cover large rectangular areas where the objective is expected to be between two points and possibly off track due to navigation errors.

3. The creeping line search may be used to cover an area on both sides of the search objective's intended track spacing during and after route searches.

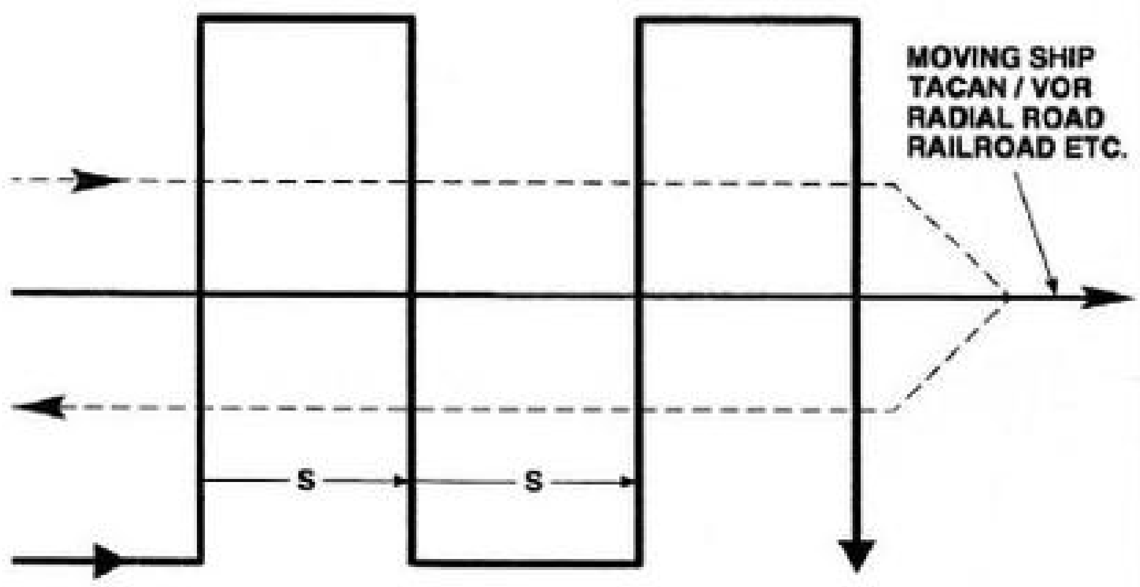
4. An expanding square search will be used for a concentrated search of a small area where a sighting or search objective has been reported.

5. The sector search will be used when the position of distress is known within close limits and the area to be searched is not extensive.

NOTES

1. FLYING LOWER ALTITUDE WITH LESS TRACK SPACING(----)
2. HELICOPTER AIRSPEED CAN BE 70 TO 120 KNOTS DEPENDING ON CRITICALITY OF TIME AND / OR FUEL.

S = TRACK SPACING

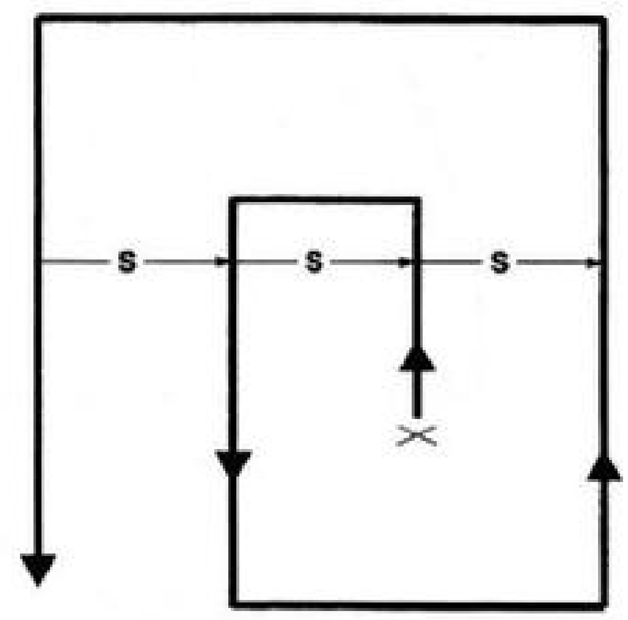


ROUTE SEARCH

NOTES

1. TRACK SPACING WILL VARY WITH SEARCH ALTITUDE.
2. ACCURATE WIND READINGS FOR WIND DRIFT CORRECTION AND GROUNDSPEED ARE NECESSARY TO CORRECTLY FLY THIS PATTERN.

S = TRACK SPACING

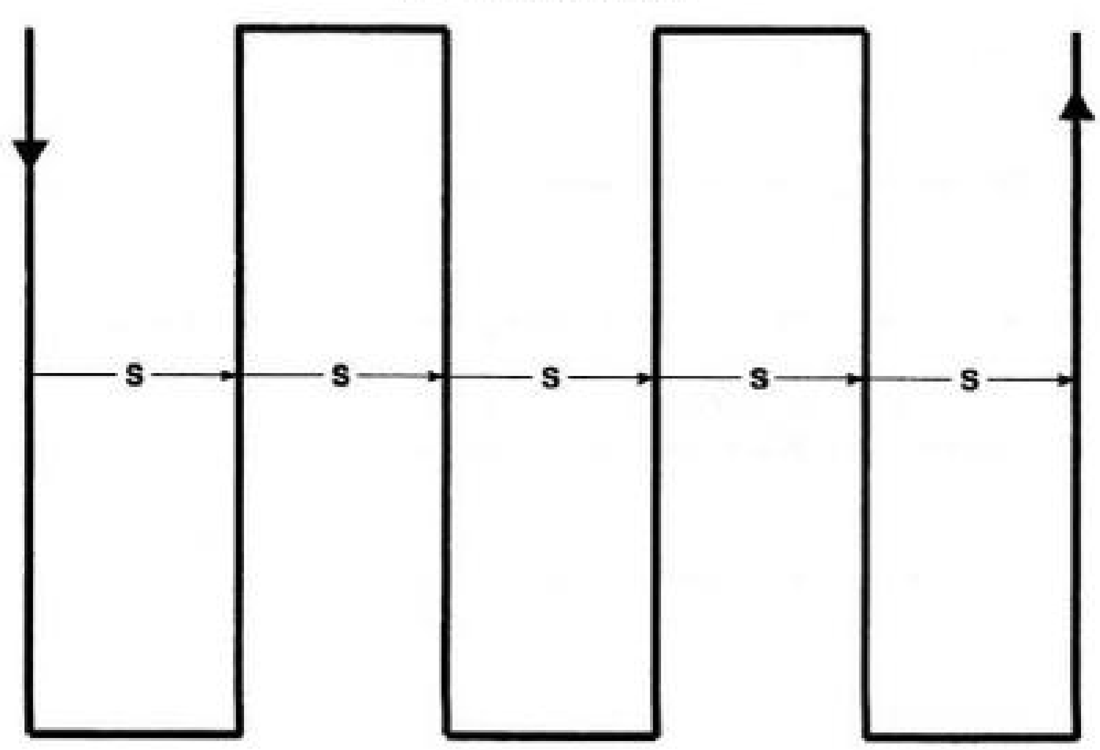


EXPANDING SQUARE SEARCH

NOTES

1. AIRSPEED WILL BE 70 OR 120 KNOTS DEPENDING ON CRITICALITY OF TIME AND / OR FUEL
2. ACCURATE WIND READINGS FOR WIND DRIFT CORRECTION AND GROUND SPEED ARE NECESSARY TO CORRECTLY FLY THIS PATTERN

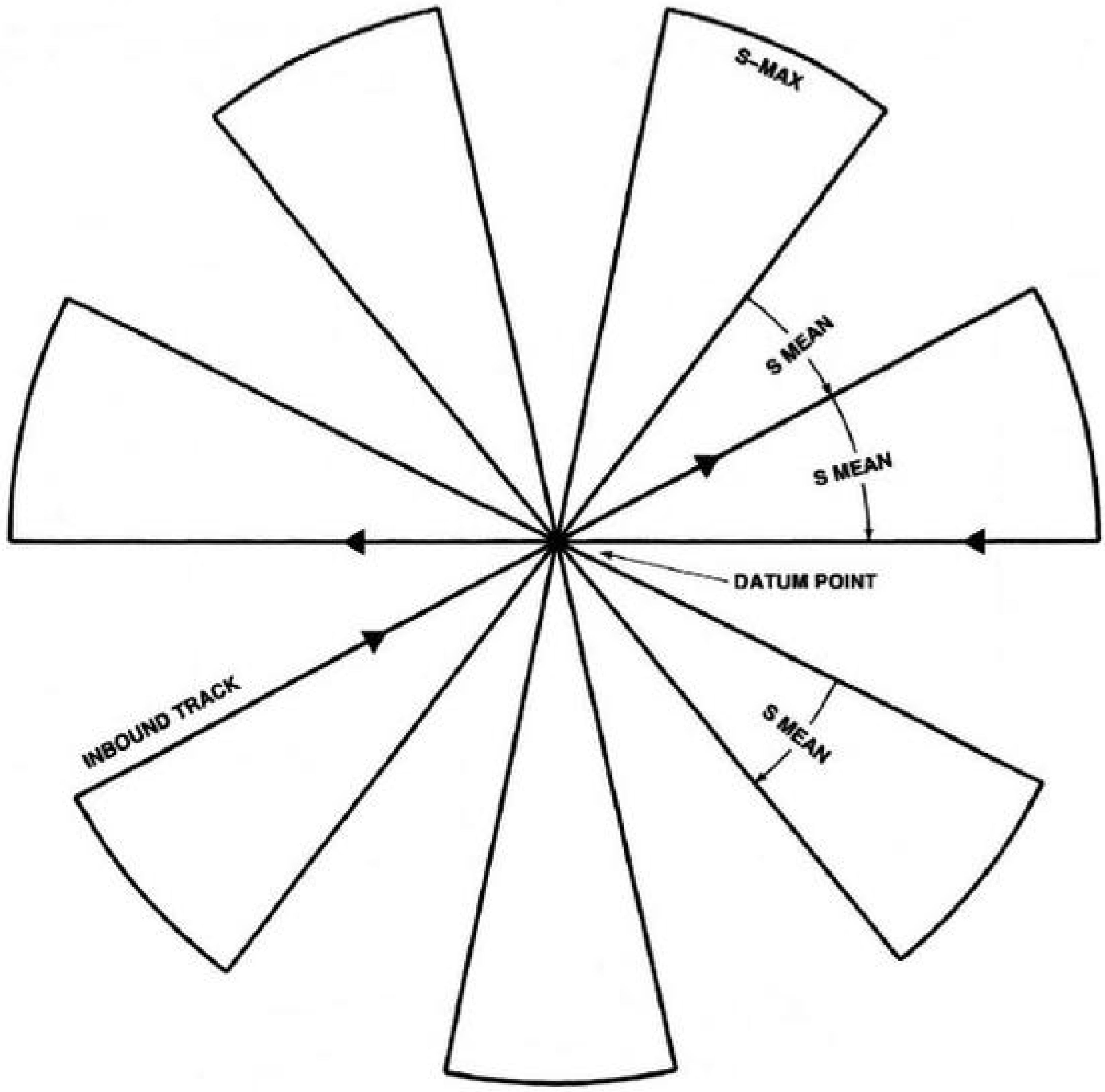
S = TRACK SPACING



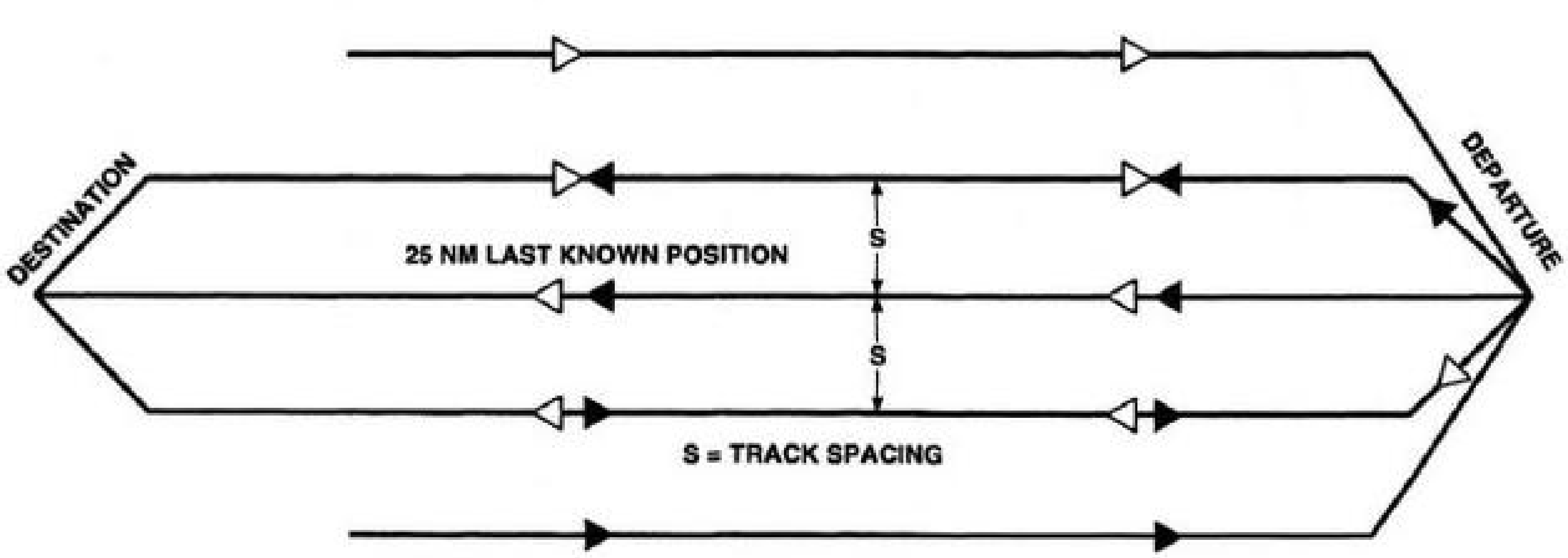
CREEPING LINE LOW ALTITUDE SEARCH

HM1356_1

Figure 9-6. Search Patterns (Sheet 1 of 3)



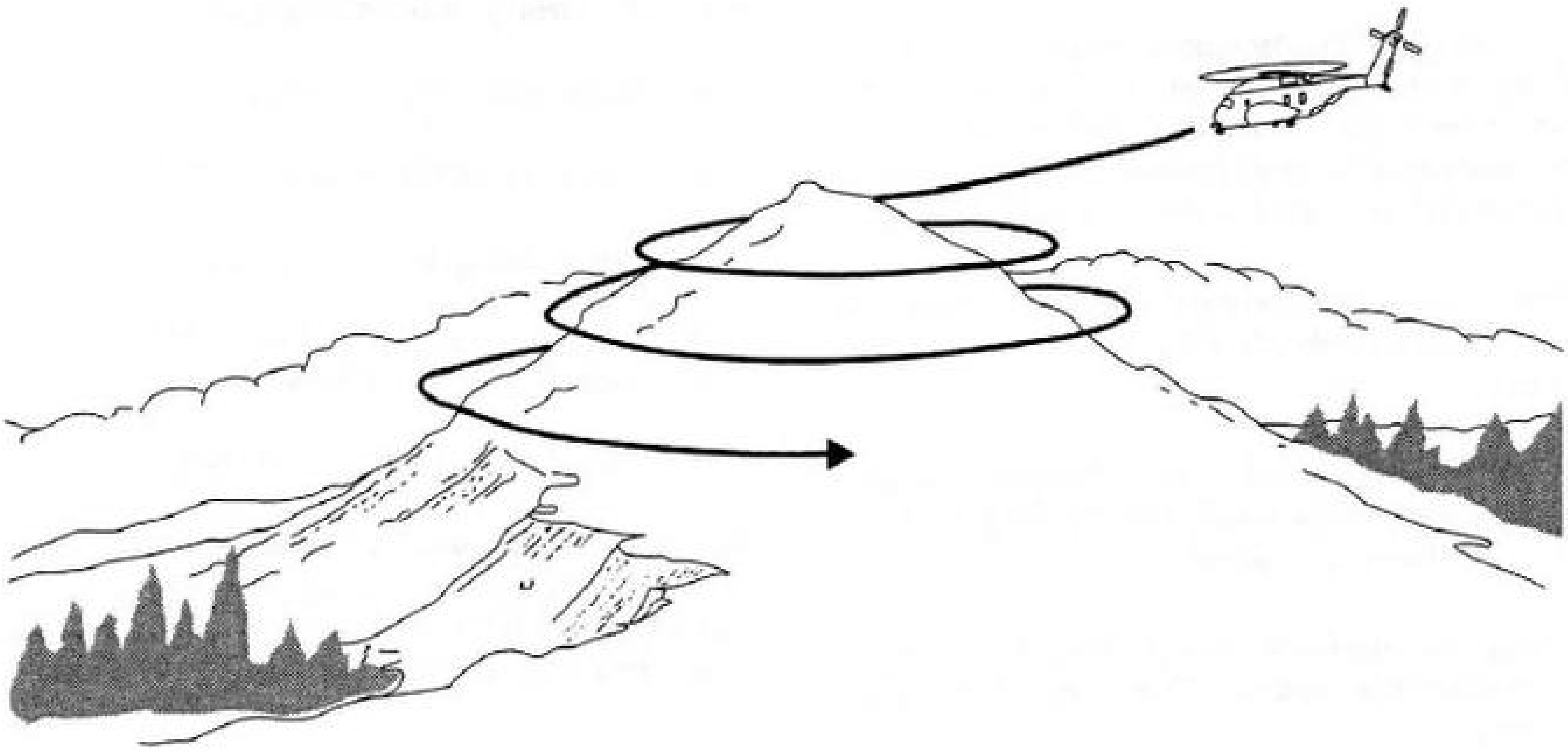
SECTOR SEARCH



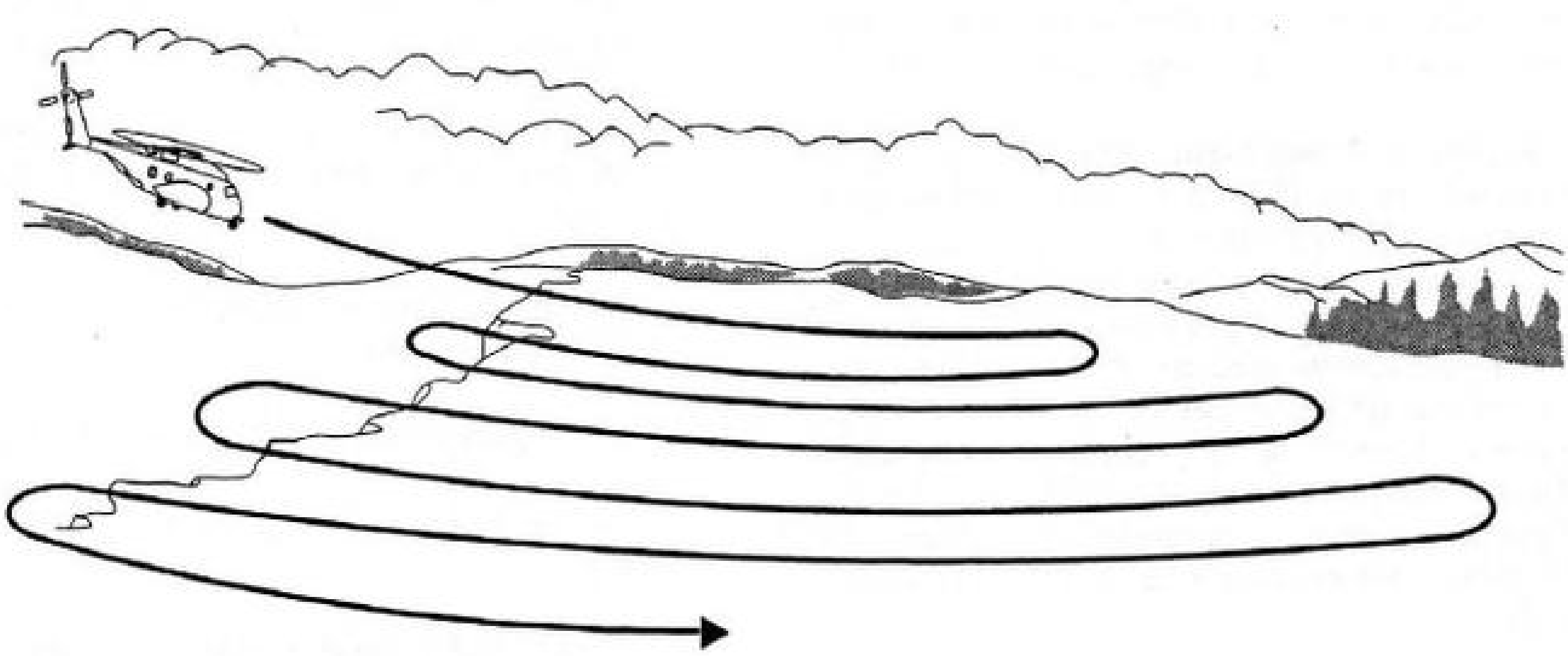
PARALLEL SEARCH

HM1356_2
SA

Figure 9-6. Search Patterns (Sheet 2 of 3)



PEAK SEARCH



TERRAIN FOLLOWING SEARCH

HM1356_3
SA

Figure 9-6. Search Patterns (Sheet 3 of 3)

6. The contour search is used to search mountains or hilly terrain.

9.8.6 Scanning Techniques. Precise scanning is one of the most important aspects of a search. The helicopter crewmembers in the cabin will be the primary scanners. Sighting characteristics and detection possibilities of the objectives must be included in the briefing.

1. When over water the most probable objectives of the search will be lifeboats, rafts, debris, oil slicks, and personnel.

2. Over land scanners should look for smoke, broken or scarred trees, shiny metal, fresh looking burnt-out areas, parachutes, and signals.

3. With three available crewmembers to scan, positions should be rotated every 30 minutes (left side, right side, rest).

4. A routine scanning pattern should be used when searching. The eyes should move and pause for each 3° or 4° of lateral/vertical distances at a rate which will cover 10° per second. The scanner's eye movement should be away from the helicopter to the effective visibility and then back toward it to a point as near under the helicopter as can be comfortably seen. Scanners must avoid turning away from the scanning pattern, closing their eyes, looking around the helicopter, or focusing short of the surface being scanned.

9.8.7 Sighting Procedures. When a sighting is made the crewmember will notify the rest of the crew over the ICS and indicate the position of the sighting by using the clock system and distance. Immediately upon making a sighting, a smoke signal or sea marker will be dropped to mark the appropriate location of the sighting. Use caution when dropping a smoke device over a wooded area, to prevent forest fires. The pilot should immediately turn in the direction of the target, if possible, the observer will continue to call out the target position and distance to orient the pilot. If the sighting is confirmed these procedures apply:

1. Keep the target in sight at all times. Mark with dye marker/smoke floats.

2. Turn on IFF to appropriate code.

3. Report sighting to rescue center, on-scene commander, air/ground station or operating agency as appropriate.

9.8.8 Aircrewman Duties

9.8.8.1 Utility Hoist Checklist

1. Cable cutters (hand) — STOWED.

2. Pneumatic webbing cutter — STOWED.

3. Heavy duty gloves — STOWED.

4. Crewman Safety belts (2) (1 Optional) — ANCHORED, ADJUSTED, STOWED.

5. Life raft (as required) — STOWED.

9.8.8.2 Aircrewman Procedures. When ordered to rig hoist, report, unstrapping to rig hoist. Before opening personnel door, plug into hoist station ICS, put on crewmember's safety belt, and heavy duty gloves.

WARNING

If the lower half of the personnel door is to be removed, it shall be done only in a hover or low speed (less than 40 knots) flight after receiving positive clearance from the pilot. This is necessary to prevent the personnel door from hitting the main rotor blades, sponson, auxiliary fuel tank, or tail pylon.

1. Open personnel door, remove lower half of personnel door. When ready, report to pilot, "Ready for hoisting."

2. When load/spot is in sight, report to pilot, "I have the load/spot in sight."

3. Direct pilot over load using standard terminology.

4. When load is attached, report to pilot, "Load is attached."

5. When load is clear of surface, report, "Load is clear."

6. Report, "Load is safely aboard ready for forward flight."

7. Replace lower half of personnel door as directed.

9.8.8.3 Approach Procedures. When hoist load/spot is in sight, report to pilot, "I have the hoist load/spot in sight." Pilot may continue his approach, without assistance from crewman, until he loses sight of the spot, at which time pilot will give crewman verbal control to direct helicopter by use of following standard terms. These directions must be given in a calm, clear voice, keeping pilot informed of situation at all times. Combinations of terms may be used when making diagonal approaches, such as forward and right.

9.8.8.4 Standard Terms. Following is a list of standard terms and their meanings:

1.	Forward	Direction of movement — straight ahead.
2.	Back	Direction of movement — straight back.
3.	Right	Direction of movement — slip to the right, maintain present heading.
4.	Left	Direction of movement — slip to the left, maintain present heading.
5.	Up	Direction of movement — gain altitude, maintain relative position.
6.	Down	Direction of movement — lose altitude, maintain relative position.
7.	Steady	Hold present position.
8.	Easy	An indication of rate-of-movement — Precedes the basic command.

Note

The preceding list of terms are in relation to the helicopter axis.

9.8.8.5 Utility Hoist Situation. Following is a list of utility hoist situations with reports and action required to make pickup:

The Situation	The Report
Helicopter is to the left of pickup	Right — Easy
Helicopter is aft of pickup	Forward — Steady
Sling is halfway down	Sling is halfway down
Sling is on deck	Sling is on deck
Sling is even but to left of pickup	Right — Easy Right — Steady
Sling is in a good position	Steady
Load is hooked up	Load is attached
Helicopter is ahead of pickup	Back — Easy
Sling is coming up	Sling is coming up
Load is clear	Load is clear
Load is halfway up	Load is halfway up
Load is safely aboard	Load is safely aboard
After station secured	Ready for forward flight

9.8.8.6 Inform Pilot. Always try to keep the pilot informed of the pickup's position and of any possible danger to the helicopter, using the above terminology and any other words that are concise and clearly understandable.

WARNING

Any time personnel door is open during flight, all occupants shall wear a crewman's safety belt or remain strapped to troop seat. Crewman's safety belt must be thoroughly checked for security of attachment to airframe.

9.8.8.7 Utility Hoisting Emergencies

9.8.8.7.1 Fouled Cable. During hoisting operation if it appears that the cable has become fouled or otherwise attached to any surface object (tree, ship's rail, etc.) the crewman shall immediately act to keep a slack cable while informing the pilot of the emergency and be prepared to shear the cable on command or as prebriefed.

9.8.8.7.2 Hoist Control Failure. If normal hoist operation fails, control may be regained by use of the manual override feature.

CAUTION

The limit switches are inoperative when an electrical power loss has been experienced; adjust cable speed to avoid damage when operating near cable extremities.

9.9 HELICOPTER IN FLIGHT REFUELING (HIFR) PROCEDURES

9.9.1 General. HIFR is done to extend the on-station time and should be initiated with enough fuel remaining to Bingo to the nearest land base or carrier if it is not possible to in-flight refuel. Daylight VFR refuel operations can be made in the same manner as normal utility transfers to mail or cargo. Night in-flight refueling is a more demanding operation and can be scheduled as operational necessity requires. Hot refueling (refueling on the ground while rotors are turning) is preferable to night HIFR. Additional information is available in the NWP-42.

WARNING

- Prior to conducting of (HIFR etc.) operations, ground/deck crews should be briefed on the downwash potential of the helicopter and safety considerations. See DOWNWASH in Chapter 11.
- Deck crews should be briefed before HIFR on the static electricity potential of the helicopter. Deck crews shall use a CH-53E approved grounding rod to maintain helicopter grounding while attaching or releasing HIFR saddle.

9.9.2 Helicopter Grounding

1. Before planned HIFR operations the utility hoist should be checked for proper grounding by applying a light download (25 to 35 pounds) on the hook and checking for electrical continuity from the helicopter to the hoist hook.

2. The ship's HIFR hose and HIFR assembly provide a continuous grounding path between the helicopter and the ship. When the HIFR assembly and hose are being raised or lowered, the grounding path is through the hoist hook to the saddle. When possible, obtain verbal assurance from the ship that a ship's system ground check was made prior to HIFR operations.

3. Certain lack of grounding continuity problems may cause the helicopter to discharge static electricity as the grounding jack is touched by a crewman or as the jack is touched to the helicopter. The grounding jack must always be connected before plugging the refueling hose into the aircraft receptacle (Wiggins fitting) and disconnected after the hose is unplugged from the aircraft receptacle, to be sure that any static electricity arcing that might take place is not from the fueling adapter.

4. Use of insulated (lineman's) gloves by one hoist crewman, when grounding the HIFR saddle, is recommended.

5. If static electricity arcing takes place during step 4, or any other indication of poor grounding is manifested (shocks, etc.), HIFR should be conducted only if essential.

9.9.3 HIFR Rigs. All HIFR capable ships are equipped with one of two different rigs (Figures 9-7 and 9-8).

9.9.3.1 Wiggins/North Island (NI) HIFR Rig. This rig has a ship's Hose (> 100 feet in length) and a HIFR assembly which is a 10 foot section of 1-1/2 inch hose outfitted with a saddle for hoisting the HIFR assembly and hose to the helicopter. Both ends of the HIFR assembly are equipped with female closed circuit refueling (CCR) fittings (also referred to as Wiggins fittings). A manual emergency disconnect lanyard (emergency release T-handle) is located near the Wiggins fitting on the HIFR assembly which connects to the male Wiggins fitting in the helicopter. The second Wiggins fitting connects the HIFR assembly to the ship's hose. This rig incorporates a manual breakaway which requires a helicopter crew member to pull a lanyard to effect breakaway (Figure 9-7).

9.9.3.2 NATO Compatible High Capacity (NHC) HIFR. This new rig features a 110 foot long 2 inch lightweight hose, unisex couplings, automatic emergency breakaway and facilitates the use of either a CCR nozzle or a D-1 nozzle (SPR) for HIFR operations. The NHC has two major assemblies: the 100 foot HIFR hose and the 10 foot HIFR assembly. During routine HIFR operations the H-53 helicopter will receive the CCR nozzle attached to the HIFR Assembly. This nozzle has a built-in 45 psi pressure regulator and an on/off flow control handle which allows the crewman to turn fuel flow on and off. Emergency breakaway is initiated when 450 ±50 pounds of straight tensile pull is exerted on the automatic breakaway coupling. The mount for the hoist cable has been designed for self alignment between the winch and deck tiedown to assure a straight pull (Figure 9-8).

Note

Emergency breakaway occurs automatically as the helicopter moves away from the ship. No action by aircrew is necessary.

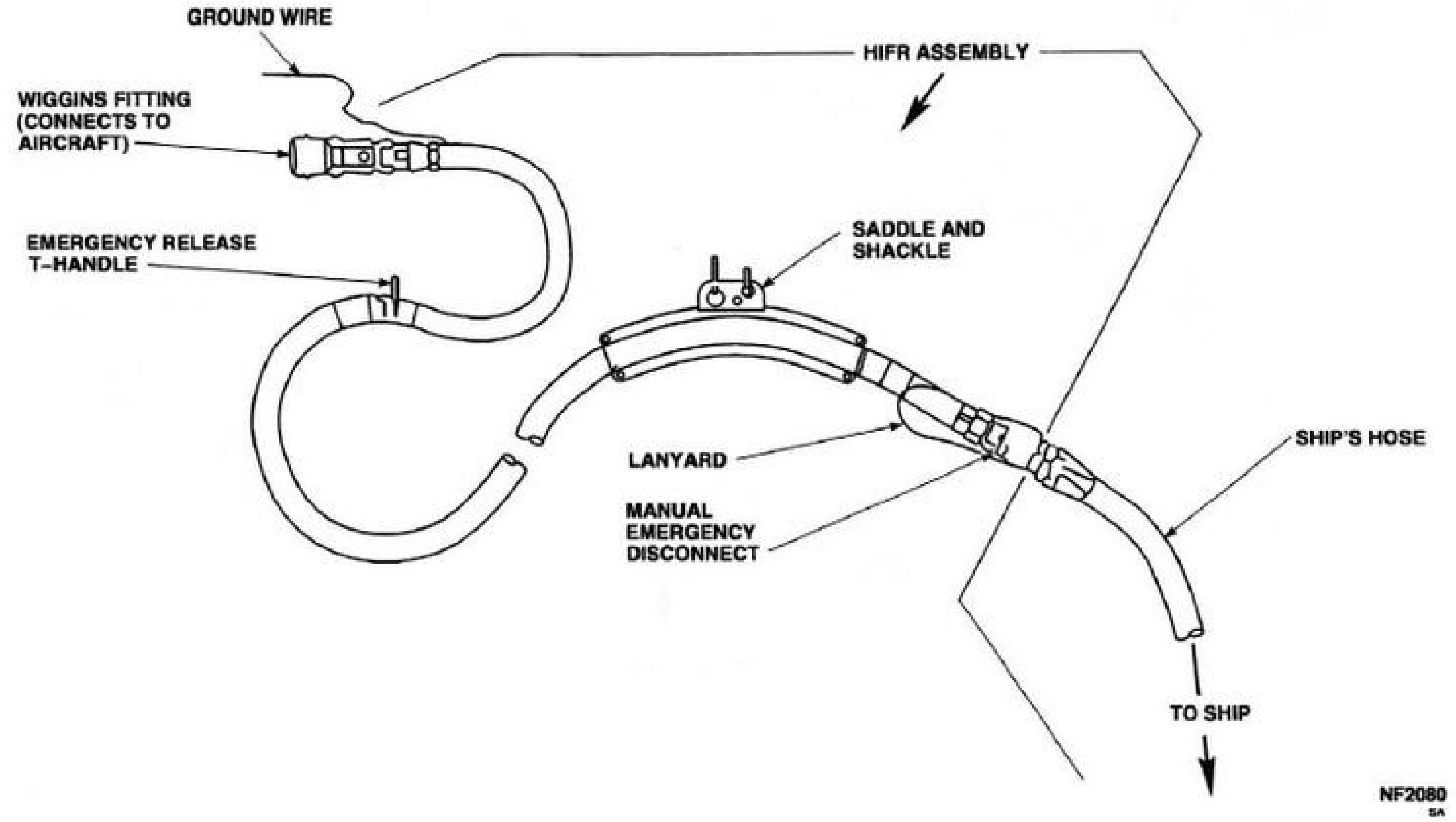


Figure 9-7. Wiggins North Island (NI) HIFR Rig

Most US helos are configured with a CCR-type connection for HIFR refueling while all other NATO countries with HIFR capability, use an SPR connection. Therefore, if a US helicopter is HIFR'd by a non-US ship, it will be given a SPR nozzle and must carry an adapter to convert it to a CCR-type connection.

9.9.4 Normal Operations. Day and night HIFR fueling hookups shall be conducted over the fantail of the surface vessel, with the helicopter hovering into the relative wind. The wind should be 330° to 355° relative to the ship's heading at a velocity of 15 to 20 knots. Density altitude and true wind velocity will dictate whether a higher relative wind velocity will be required to hover. During high true wind conditions, the most stable hover with the least amount of turbulence is normally encountered when the ship is at a speed slightly above that required to maintain steerageway. The ship's speed may be adjusted to minimize the pitching, rolling, and fishtailing of the transferring ship in high seas.

9.9.5 Communications. Signals to start and stop pumping shall be exchanged between helicopter crewman and the ship's director, with the radios as the backup means of communication. In addition to the normal hover positioning reports (refer to search and rescue standard terms in this section), the terminology and visual signals in Figure 9-9 shall be used.

To request HIFR, the pilots shall contact the refueling ship and request HIFR and the amount of fuel in pounds required.

9.9.6 Procedures

1. Approach.

Approach to the ship should be made from the stern at an altitude of 150 feet and 90 knots. At a point one-half mile astern the ship, a transition should be started so as to arrive in a 40-foot hover over the flight deck with the same relative movement as the ship. When established in a hover, secure the personnel door in the open position. Aircrewman shall wear a crewman's safety belt whenever the personnel door is open.

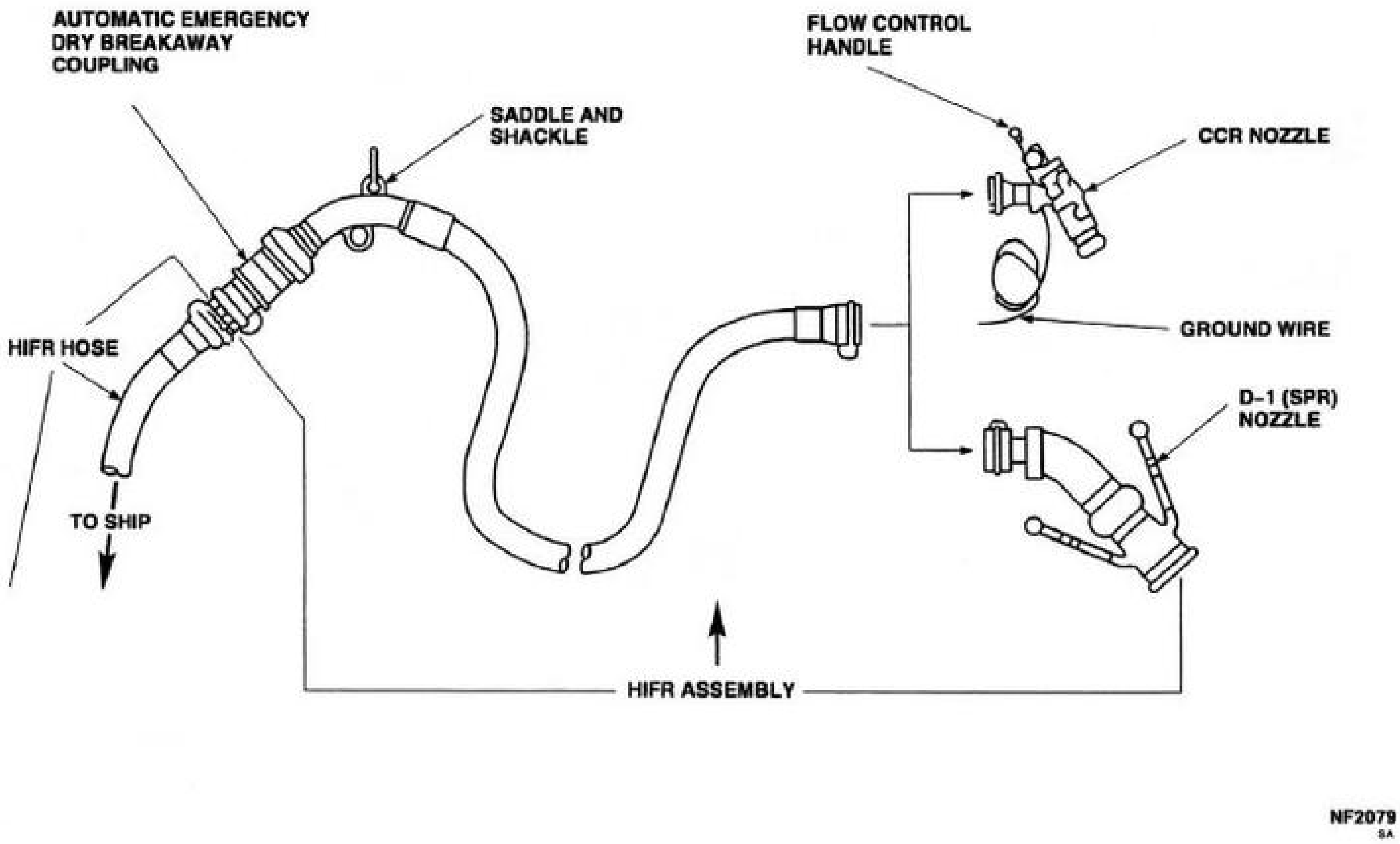


Figure 9-8. NATO High Capacity (NHC) HIFR Rig

CAUTION

- The salt spray circulated by the downwash can create visibility problems for the pilot, especially if the windshields become covered. Further, when the sun shines through the salt covered windshield the visibility is reduced.
- When the relative wind is off the bow of the ship, significant turbulence can be experienced from the wind blowing through the top of the ship's superstructure.

2. Lower utility hoist hook.

When in position over the ship, lower the utility hoist hook to the deck. Aircrewman reports: "Hoist going down." Crewman on ship will allow hook to contact deck thereby discharging static electricity. The aircrewman shall observe and ensure that the hoist is grounded before it is touched by deck crew personnel. This can be accomplished by having the deck crew touch the hook to a cable or chain grounding device. The device has one end grounded to the ship so that when the other end touches the utility hoist hook (or cable) it completes an electrical circuit that will discharge the continuing static electricity buildup in the cable. The grounding device must remain in contact with the hoist hook (or cable) until the saddle hose is connected to the hoist. Aircrewman reports, "Hoist is on the deck" while observing deck crew attaching the hose saddle.

CAUTION

Under no circumstances shall a fuel sample be taken from the petcock on the HIFR assembly inside the helicopter. A fuel spill may result.

HIFR COMMUNICATIONS				
From	To	When	Report/ Visual Signal	Response
CREW	PILOT	Hoist is going down.	HOIST GOING DOWN.	ROGER
CREW	PILOT	Hoist in on the deck.	HOIST IS ON THE DECK.	ROGER
CREW	PILOT	Hose connected to hoist hook.	HOSE COMING UP.	ROGER
CREW	PILOT	Hose is in the cabin.	Hose is in the cabin, CLEARED TO MOVE LEFT.	ROGER, MOVING LEFT
CREW	PILOT	Ready to receive fuel (hose connected).	HOSE CONNECTED.	ROGER, COMMENCE PUMPING
CREW	SHIP	Directed to commence pumping.	CREWMEMBER MAKES CIRCULAR MOTION WITH HAND.	
PILOT	CREW	Desired quantity of fuel has been received.	STOP PUMPING.	ROGER, STOP PUMPING
CREW	SHIP	Stop fueling.	CREWMEMBER MAKES CUTTING MOTION ACROSS THROAT.	
CREW	PILOT	Fueling has stopped.	FUELING STOPPED, HOSE DISCONNECTED CLEAR TO MOVE RIGHT.	ROGER MOVING RIGHT
CREW	PILOT	Ready to lower hose.	HOSE GOING DOWN.	ROGER
CREW	PILOT	Hose on deck.	HOSE IS ON THE DECK.	ROGER
CREW	PILOT	Hose disconnected from hoist hook and hoist is being raised.	HOIST HOOK CLEAR.	

Figure 9-9. HIFR Communications (Sheet 1 of 2)

Note

- A fuel sample will be made available by the deck crew for inspection before commencing HIFR operations. A fuel sample bag with the fuel sample inside can be attached to the utility hoist and inspected by the aircrew before attaching the saddle hose assembly to the utility hoist hook.
- A one-cell light should be connected to the hoist hook during night operations to give visual references to hook position at all times.

3. Raise hose to helicopter.

When deck crew gives "thumbs up," the aircrewman will raise the hoist to retrieve the hose. Aircrewman reports: "Hose coming up." Stop hose just below the hoist seat position. Aircrewman reports: "Hose is in the cabin, cleared to move left."

CAUTION

- Constant attention and crew coordination is required in order to keep the HIFR hose from becoming taut.
- The NI HIFR assembly can be installed backwards. The air crewman must ensure the emergency release T-handle is located near the Wiggins fitting which he attaches to the aircraft's fitting. Opposite connection is possible and will force the helicopter to shear the hoist to effect an emergency breakaway.

NOTE

THE VISUAL SIGNALS WILL BE THE SAME AT NIGHT EXCEPT RED AND GREEN LENS FLASHLIGHT SHALL BE USED

HC0800

Figure 9-9. HIFR Communications (Sheet 2 of 2)

Note

Position the helicopter on the port side clear of the deck. The amount of hose available and the need to keep clear of the ship will determine the HIFR position.

4. Attach restraining strap to HIFR saddle to relieve lateral tension on hoist.

5. Connect grounding wire.

6. Connect CCR nozzle (NHC rig) or Wiggins fitting (NI rig) to the aircraft receptacle.

Open access panel to aircraft receptacle and remove dust cover. Pull back on bail (collar) on the CCR nozzle or Wiggins fitting and fit nozzle onto aircraft receptacle. Aircrewman reports: "Hose connected."

Note

If there is pressure in the line, it will not be possible to connect the fuel hose to the helicopter. When using the NHC rig, crewman shall check to determine hose is pressurized and then place flow control handle in the OPEN position.

When using the NI rig, crewman shall place one hand on the emergency release T-handle and keep it there until fueling is complete and the NI Wiggins nozzle has been disconnected from the aircraft receptacle.

CAUTION

Constant attention and crew coordination is required to keep HIFR hose from becoming taut.

7. Raise hoist to near seat position.

CAUTION

The HIFR saddle must be raised as near as possible to the hoist seat position to permit proper and safe operation of the emergency breakaway on either rig.

8. Commence pumping.

When directed by pilot, signal ship to start pumping. Signal is a circular motion with the hand. Pilot directs: "Commence pumping." Crewman responds: "Roger, commence pumping."

WARNING

The copilot must monitor the fuel quantity indicators during the pumping phase to avoid overfilling and possibly rupturing the fuel tanks in the event the high-level shutoff valves fail.

Note

A slow pumping rate of less than 100 pounds-per-minute total for all tanks may indicate a clogged fuel filter in the helicopter's receiving system. Reducing the helicopter's altitude over the deck of the ship may aid in increasing the pumping rate.

9. Cease pumping.

When directed by pilot, signal ship to stop pumping. Stop signal is a cutting motion across the throat. Pilot directs: "Stop pumping." Crewman responds: "Roger, stop pumping."

Note

Crewman has ability to stop fueling with flow control handle on the NHC rig's CCR nozzle. In addition, this CCR nozzle will automatically stop flow and the red pin behind the flow control handle will extend under the following conditions:

1. Pressure has exceeded 45 psi.

2. Tanks are full.

10. Disconnect CCR nozzle (NHC rig) or Wiggins fitting (NI rig).

When pumping has stopped and hose is depressurized, place CCR nozzle (NHC rig) flow control handle in the OFF position. Pull back on bail (collar) to release nozzle or Wiggins fitting from the aircraft's receptacle. Aircrewman reports: "Fueling stopped, hose clear, ready to move right." Replace dust cover on Wiggins fitting and close access panel. Release restraining strap from HIFR saddle.

Note

Pilot will reestablish position over deck. Crewman will assist through verbal control.

11. Disconnect ground wire.

12. Lower hose to deck.

After helicopter is repositioned over ship's fantail, lower hose to deck. Aircrewman reports: "Hose going down." "Hose is on the deck." Aircrewman should attempt to reduce tension on the hoist cable.

WARNING

With a pitching deck, it is possible to have too much slack in the cable. A slack cable can cause personal injury or entangle with obstacles on the deck.

13. Retrieve utility hook.

Observe deck crew disconnect hose from hoist hook. When "thumbs up" received from deck crew, raise hoist. Aircrewman reports: "Hoist hook clear." Secure hoist and close lower half of personnel door. Aircrewman reports: "Cabin Section secure."

Note

- At the pilot's discretion and when hoist is reported clear of ship deck, the pilot will move left and depart area.
- All visual signals from the helicopter will be the same at night except a red lens flashlight shall be used. (See Figure 9-9.)

9.9.7 Night/Low Visibility HIFR Approach.

(See Figure 9-10.)

The recommended approach pattern is a 90° to 270° turn pattern which will enable the pilot to arrive at a gate position, either using the ship's radar for positive control, the ship's TACAN if installed, or a dead reckoning visual flight path. After the course and speed of the surface vessel have been determined, either visually or by radio, the helicopter will descend to 300 feet and 90 KIAS. The helicopter will then fly over the refueling ship on a heading 180° relative to the ship's heading. When over the ship's stern, this procedure should be done:

Note

The pilot in the left seat should fly the helicopter and the pilot in the right seat should perform all copilot responsibilities until just before the helicopter arrives at the ship's fantail. Then, the pilot in the right seat should assume control and make a visual transition to a hover over the fantail.

1. Commence a standard rate turn to the left. Passing through 90° of turn reverse direction and execute a 270° standard rate turn to the right.

2. As the reversal course is approached, and upon completion of the 270° turn, the copilot should attempt to establish visual reference with the refueling ship's wake. As visual reference is established, the copilot should advise the pilot as to corrections to course in order to establish level flight over the ship's wake and on the ship's heading.

3. Descend to 150 feet and about 90 knots ground speed before reaching a point 1/2 mile astern of the ship.

4. The copilot will direct the pilot as necessary to keep the helicopter over the ship's wake until good visual reference is established with the ship.

5. When a green deck signal is received from the ship, the helicopter descends to HIFR altitude, the pilot in the left seat will secure the forward rotating anticollision light (about 100 yards astern of the ship).

WARNING

- Do not rely on BAR ALT hold during low altitude operations.
- With RDR ALT hold turned on, any interruption of power to the radar altimeter can cause up to 30 feet of altitude loss before the AFCS detects the malfunction and switches to the BAR ALT retention mode.

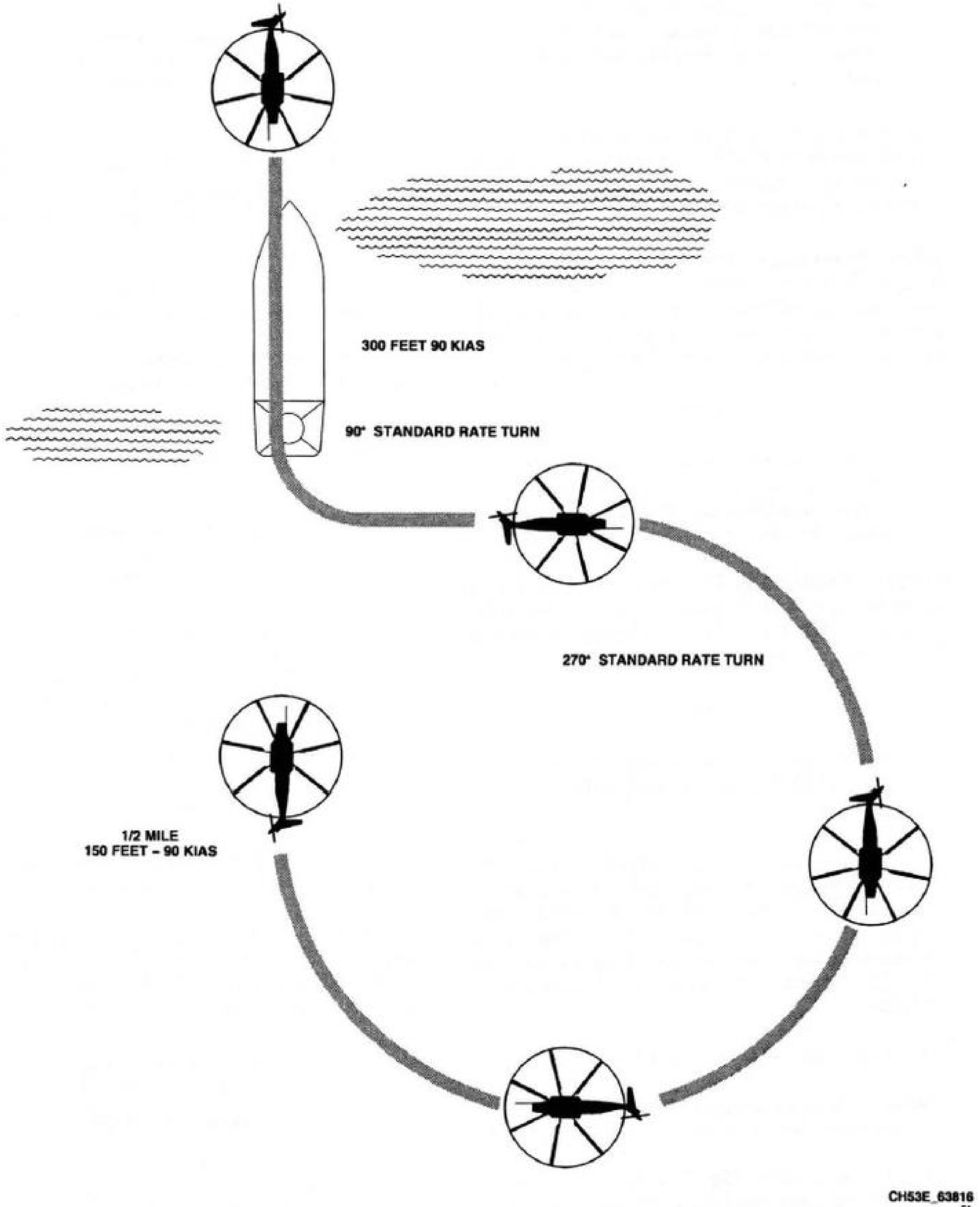


Figure 9-10. Night/Low Visibility HIFR Approach

Note

Be prepared for collective jumps when the radar altimeter acquires or loses the height of the ship's fantail, if the RDR ALT mode is used.

6. Upon completion of the refueling evolution, make a 20° turn to the left and after receiving a "ready for forward flight," report from the crew chief slide clear of the ship to port and climb to departure altitude.

9.9.8 Emergency Breakaway Procedures. During HIFR when an emergency condition is observed, or when the command "Breakaway" is received, one of the following emergency breakaway procedures should be followed depending on the type of HIFR rig being used:

Note

If emergency breakaway is necessary with either rig, the HIFR assembly, which includes the saddle and a 10 foot section of hose, will remain attached to the helicopter.

9.9.8.1 NI HIFR Rig. The crewman with his hand on the emergency release T-handle must pull the device thus releasing the HIFR hose and letting it fall back to the ship. The pilot then flies away from the ship.

Note

The NI rig has a manual emergency breakaway which requires aircrew action to disconnect.

1. When directed or when deemed necessary, the crewman shall pull the emergency breakaway lanyard (T-handle) on the HIFR hose. The command "Breakaway" will be repeated 3 times, that is: "Breakaway, Breakaway, Breakaway" by the initiating station over the ICS. The report and action should occur simultaneously.

2. Report when hose is clear of the helicopter.

When the fueling hose separates and drops away from the helicopter, the aircrewman reports: "Hose Clear."

9.9.8.2 NHC HIFR Rig. This rig incorporates an automatic emergency breakaway. No crewman action is necessary to disconnect system. Once the NHC rig has been attached, the pilot can effect emergency breakaway at anytime by flying from the ship and climbing. See paragraph 9.9.3.2 for details on this automatic system.

CAUTION

All slack hose between aircraft and deck tiedown point near HIFR hose will be pulled taunt upon fly away. Injury may result if deck crew becomes tangled in the HIFR hose.

Once emergency condition has passed, return the HIFR assembly to the ship and resume HIFR operations.

When position is reestablished over the deck, disconnect fuel hose from aircraft receptacle and lower HIFR assembly to the deck. Deck crew will reconnect fuel hose to the saddle assembly or remove saddle assembly from hoist depending on pilot decision to continue or secure HIFR.

CAUTION

If HIFR operations are to be continued, make sure that the hose has been thoroughly flushed before pumping is resumed. It is probable that sea water entered the line when the hose fell into the water on breakaway.

Note

With a helicopter emergency, it may not be possible to return the saddle assembly.

If either rig fails to disconnect when an emergency breakaway is attempted, it will be necessary for the crewman to quickly disengage the nozzle and grounding wire from the aircraft and cut the hoist cable.

WARNING

If the hoist cable is cut with either HIFR rig connected to the aircraft fitting, the possibility exits that the HIFR rig or aircraft fitting could rupture, causing pressurized fuel to leak into the cabin.

9.9.9 Clogged HIFR Filter

1. Stop fueling.

When a pump rate of less than 100 pounds-per-minute is observed by pilot, he will command, "Stop pumping." Upon this command, aircrewman will report, "Roger, stop fueling" and signal ship with "Cease fueling" hand signal (cutting motion across his throat).

2. Disconnect nozzle from Wiggins fitting.

After pressure has been removed from hose, pull back on bail wire or collar to release lock. While holding collar back, pull straight out on nozzle. Return saddle assembly to ship before starting troubleshooting.

3. Remove filter cover.

Before removing cover, drain filter from both drain valves. Locate T-bar in center of filter cover which is next to Wiggins fitting. Turn T-bar counterclockwise until cover can be removed. Lay cover aside.

4. Remove old fuses/install new fuses.

Remove five old fuses. Check bottom of filter for FOD. Insert five new fuses. If fuses are in plastic bags, make sure bags are removed before installing.

5. Replace filter cover.

Replace filter cover and turn T-bar until cover is secure. Cover need be handtightened only.

6. Retrieve saddle assembly and reconnect.

Reconnect nozzle to Wiggins fitting. Check security of connection.

7. Inform pilots.

After nozzle is connected, report "Hose connected." Pilots will report, "Roger, commence pumping." Crewman will signal ship with "commence pumping" hand signal. (Circular motion with the hand.)

8. Check for leaks.

Inspect filter and receptacle area for leaks.

WARNING

If leaks are present, fueling will be secured until corrective action can be taken.

9.10 HELICOPTER AIR REFUELING PROCEDURES

Helicopter air refueling is divided into four stages of operation: Rendezvous (intercept/escort), join-up, contact/fuel transfer, and post air refueling. A complete description of air refueling procedures is contained in the NATOPS Air Refueling Manual and the CH-53 Tactical Manual. Air-to-air refueling emergency procedures are discussed in Chapter 12.

9.10.1 Fuel Probe Extension Test

1. REFUEL PWR pushbutton — ON.

2. PROBE switch — EXTEND.

WARNING

During extension of the refueling probe, be sure no personnel or vehicles are directly in front of the refueling probe. There is enough bleed-air pressure to propel the probe from the helicopter if the external lock actuator fails.

Note

- If probe does not extend completely, stop and recycle by first pressing REFUEL PWR pushbutton OFF, recycling PROBE switch, and then pressing the REFUEL PWR pushbutton ON. Allow 1 minute between stowing and reextending probe for system bleed.

- Total time to extend air refueling probe should not be over 1 minute, and total time to retract probe should not be over 2 minutes, with the No. 1 and No. 3 engines above GRD IDLE.

3. REFUEL PROBE light — READY.

4. PROBE switch — STOW.

5. REFUEL PROBE light — OFF.

6. REFUEL PWR pushbutton — OFF.

9.10.2 Precontact Checklist

1. Crew briefing — COMPLETED.

   a. Review type rendezvous, number tankers, refueling altitude, airspeed, and any other information pertinent to the refueling operation.

   b. All normal and emergency equipment required during refueling operations will be available.

2. Fuel — CHECKED.

3. Altimeter setting — "SET (STATE SETTING)".

4. Refueling panel — SET.

   a. REFUEL PWR pushbutton — ON.

   b. Tank selector switches — AS REQUIRED.

   c. Fuel flow lights — PRESS-TO-TEST.

5. PROBE switch — EXTENDED.

CAUTION

Takeoffs and landing should not be made unless the probe is fully retracted and locked.

Note

If probe does not extend completely, stop and recycle by first pressing REFUEL PWR pushbutton OFF, placing PROBE switch to STOW, recycling PROBE switch, and then pressing the REFUEL PWR pushbutton ON. Allow 1 minute between stowing and reextending probe for system bleed.

6. REFUEL PROBE light — READY.

7. REFUEL PWR pushbutton — AS REQUIRED.

9.10.3 Join-up Checklist

1. Windows, doors, and hatches — SECURED.

2. EAPS — CLOSED.

3. Heater/vent blower — OFF.

4. ALE-39 — OFF/SAFE.

5. Join-up altitude — ESTABLISHED.

6. Refueling airspeed — ESTABLISHED.

WARNING

Helicopter handling qualities and predictability will change dependent upon density altitude, helicopter gross weight, and which side of the tanker is used for refueling. Refer to the Refueling Envelope for CH-53E, Figure 4-6.

7. Air refueling lights — AS REQUIRED.

WARNING

Intensity of refueling probe light or searchlight is adjusted to pilot's desire. Bright lights reflecting on probe or drogue may induce vertigo.

8. Join-up checklist — COMPLETED.

WARNING

Receiver crews should not attempt probe to drogue contact while in a turn at night. The possibility of spatial disorientation exists when the pilot must divide his attention between the drogue and coordinating a turn while having less visual reference at night. Once in contact, turns are permitted, as the pilot's reference is solidly on the tanker.

CAUTION

Main rotor-to-drogue/probe clearance can be as little as 4.0 feet during 1.0 inch longitudinal cyclic inputs. Additionally, clearance is severely reduced in the event of a missed plug, especially if the miss occurs from the 3- to 9-o'clock position relative to the drogue. Extreme caution should be exercised to prevent excessive main rotor tip path overlap of the paradrogue assembly. This occurs when the tip of the refueling probe is allowed to progress forward of the paradrogue assembly. Rotor downwash from an excessive overrun of the drogue can result in the downward displacement of the drogue and a possible pop-up of the drogue while maneuvering the helicopter back to the stabilized position.

Note

If aerial refueling is attempted following flight in icing conditions, off-center contacts with drogue basket are made to remove ice from probe. This will properly seat the drogue. Visual verification of an ice-free probe is accomplished by the scanner in the tanker. Wet refueling is not started until probe is free of ice.

9.10.4 Contact/Fuel Transfer. Refer to the CH-53 Tactical Manual for positions and checkpoints.

WARNING

- Under no circumstances should the pilot stare at the drogue, as this will result in poor aircraft control and leads to spatial disorientation.
- Refueling directly behind the refueling pod is not recommended. An inadvertent hose guillotine while in this position could cause the hose to contact the main rotor blades.

CAUTION

- Excessively hard contact between probe and drogue can damage the refueling nozzle.
- If tanker hose-reel response is improperly adjusted, an inadvertent disconnect may occur. A lateral disconnect while in the refueling position may result in probe damage, loss of probe nozzle and subsequent fuel siphoning. Prior to commencing aerial refueling, the first aircraft should evaluate hose-reel response both in and out before moving to the refuel position.
- Wing/prop turbulence can cause uncontrolled settling. If settling occurs while connected to the drogue, disconnect immediately. Failure to disconnect may result in damage to the probe and possible rotor blade-to-drogue contact.
- Air refueling with an aft center of gravity with this helicopter gives the minimum amount of tip path plane to probe and drogue clearance. Air refueling with an aft center of gravity should only be attempted if mission requirements so dictate.

Note

A small amount of fuel spray may be present upon drogue engagement/ disengagement. No fuel spray should be evident during fuel transfer.

When initiating refueling operations, the following procedure is done immediately at the start of fuel flow:

1. FUEL SHUTOFF TEST pushbutton — PRESS AND HOLD.

Observe that fuel flow stops and flow indicator lights go off.

Note

If high-level shutoff is inoperative, closely monitor fuel gage and manually secure fuel transfer when desired fuel level is reached.

2. FUEL SHUTOFF TEST pushbutton — RELEASE.

Observe that fuel flow resumes and flow indicator lights go on.

Since the receiver pilot must devote his full attention to flying formation, the receiver copilot or aircrewman will monitor the fuel flow lights and all engine instruments. The receiver copilot informs the pilot when fuel flow ceases/fuel transfer is complete. The copilot reports to the pilot all premature fuel flow stoppage. The receiver copilot must be cognizant of maintaining coordinated flight during fuel transfer. The receiver copilot monitors the turn and slip indicator and informs the pilot when flight is uncoordinated.

9.10.4.1 Disconnect. To effect a normal disconnect, the receiver pilot reduces power slightly and reduces airspeed by applying aft cyclic while maintaining the normal disconnect position (about 5 to 10 feet above the contact position). This causes the tanker to gradually pull away from the receiver and the refueling hose to extend. A normal disconnect will occur when the refueling hose reaches its maximum extension. BREAKAWAY PROCEDURES are discussed in Chapter 12.

WARNING

- The receiver pilot will not descend below disconnect position during this operation, to assure maximum rotor blade to drogue separation during and after disconnect.
- If the receiver cannot disconnect from the tanker, refer to Chapter 12, EMERGENCY AIR REFUELING PROCEDURES.

CAUTION

Off-center disconnects can damage the refueling nozzle.

9.10.5 Post Air Refueling Checklist

1. PROBE switch — STOW.
2. REFUEL PROBE light — OFF.
3. REFUEL PWR pushbutton — OFF.
4. Refueling lights — OFF.
5. Tank selector switches — AS REQUIRED.
6. PURGE pushbutton — AS REQUIRED.
7. EAPS — AS REQUIRED.

WARNING

EAPS will remain closed until after shutdown after flight in icing conditions.

8. ALE-39 — ON/ARMED.
9. IFF — AS REQUIRED.
10. Post air refueling checklist — COMPLETED.

9.11 CARGO RAMP AND DOOR PROCEDURES

The procedures outlined here describe the normal operating procedures for ground operation. The system is operated in the same manner in flight, except the APP will not have to be operating.

9.11.1 To Lower Cargo Ramp

WARNING

Before requesting ramp power from pilot, crew shall make sure ramp control switch is at HOLD, and visually check that ramp and ramp area are clear of personnel before operating ramp.

1. APP — ON.
2. Ramp master switch — PILOT OR CREW.
3. Flippers — UP.
4. Area — CLEAR.
5. Ramp control switch — OPEN OR LEVEL.

RAMP OPEN and UNLOCKED lights on.

CAUTION

Before lowering ramp, be sure that area under ramp is clear of equipment, rocks, stumps, etc., and that ground is of equal load-carrying ability, to avoid twisting ramp when heavy loads are applied.

6. Flippers — ADJUSTED AND EXTENDED.

CAUTION

To prevent damage to cargo ramp hydraulic system, ramp control switch shall be left at OPEN when the ramp is used for cargo loading.

9.11.2 To Raise Cargo Ramp

1. APP — ON.
2. Flippers — UP.
3. Ramp master switch — PILOT OR CREW.
4. Ramp control switch — CLOSE.

RAMP OPEN advisory light and UNLOCKED light off.

5. Ramp control switch — HOLD.
6. Ramp master switch — OFF.

9.11.3 Manual Ramp Operation. To open cargo ramp and door:

1. APP — ON.
2. Flippers — UP.
3. Area — CLEAR.
4. Manually operated valve — NORM.
5. Ramp control handle — AFT.

To close cargo ramp and door.

1. APP — ON.
2. Flippers — UP.
3. Manually operated valve — NORM.
4. Ramp Control Handle — FORWARD.

Note

To operate ramp door, position manually-operated valve to DOOR ONLY.

9.12 EXTERNAL TRANSPORT OF CARGO AND AIRCRAFT

Prior to conducting external operations, refer to appropriate MCRP 4-11.3 (Multiservice Helicopter Sling Load) manuals for basic operation/equipment and rigging/ flight procedures for single- dual-point loads.

Overflight of populated areas shall be avoided when carrying external loads.

WARNING

- Adequate clearance between the hovering helicopter and ground personnel should be maintained at all times during hookups. The aircrewman observer as well as the plane director advises the pilot of the relative position of the helicopter and the necessary corrective action to maintain it directly over the load through use of the standard ICS signals. Do not start lift-off until ground personnel are clear of helicopter and load.
- For all external cargo operations, the ground hookup crews will be briefed on the static electricity potential of the helicopter and proper grounding procedures. An approved ground rod will be used at all times. When available, insulating (lineman's) gloves will be worn.
- Before the conduct of external cargo operations, ground/deck crews will be briefed on the downwash potential of the helicopter and safety considerations. See DOWNWASH in Chapter 11.

- During external cargo operations, flight crewman shall avoid reaching through the cargo hook hatch to assist in attaching loads. Doing so may cause the crewman to become part of the path for static electricity discharge.

- If engine power is limited, droop N_r as required but do not allow N_r to droop below 100%.

- This mission should not be conducted in turbulent air. Unstable loads will increase the probability of catastrophic loss of helicopter control.

- Loss of a control desensitizer will, under certain circumstances, allow the pilot to interact with the fuselage bending modes to create a PIO (pilot-induced oscillation) or PAO (pilot-assisted oscillation). This interaction can result in divergent helicopter oscillations. Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight. If encountered, releasing the flight controls (HAND REMOVED FROM COLLECTIVE) for several seconds should eliminate the condition. During external load operations, if PIO/PAO is encountered and the oscillations do not dampen following release of the flight controls for several seconds, jettison the load.

- Recycling computer power will momentarily disable all AFCS functions, including the desensitizer in all flight control axes, and may cause a slight jump in the controls. Recycling computer power while carrying an external load should be attempted while in stable, nonmaneuvering flight.

- If a desensitizer failure occurs, and does not clear after a MODE RESET or recycling computer power, the following precautions must be observed:

  1. Minimize hover time.

  2. Avoid rapid control inputs.

  3. Do not pick up an external load. If flying with an external load, continue to the destination and gently set the load down. Do not attempt to re-lift the load.

  The following conditions may indicate an inoperative desensitizer for the -109 computer configuration:

  1. DSEN fail advisory light on the AFCS control panel.

  2. AFCS is off.

  3. AFCS duplex failure.

  4. FAS shear pin is sheared.

- One two-point suspension hook shall never be used independently of the other two-point suspension hook.

- One or both two-point suspension hooks shall never be used in conjunction with the single-point suspension hook.

- The crew chief and aerial observer shall switch positions in the helicopter cabin to call external lift directions only while the helicopter is on the deck or in a low hover and after positive two-way communication with the pilots. During flight at night, cabin lighting should be turned on prior to conducting such a crew position change or when conducting any crew-intensive cabin actions around an open single-point external hatch.

- During night operations, cockpit curtain may be closed to reduce cockpit glare.

- Any time single-point external hatch is unsecured, troop seats next to the hatch should be up and secured, and movement on the port side of the hatch is prohibited. If the single-point hatch is in the open position and the troop seats are in the down position, limited walking space exists between the starboard side of the single-point external hatch and the troop seats. Aircrewmen must exercise extreme caution when walking in this area to prevent falling from the helicopter.

- When the single-point external hatch is open, all aircrew shall remain attached to the helicopter via the approved safety belt. If movement is required, it shall only be conducted while on the deck or in a low hover.

- The radar altimeter may furnish erroneous indications when carrying external loads.

9.12.1 External Transport of Cargo. External cargo may be carried beneath the helicopter suspended from a single-point or two-point suspension system. The single-point system uses one cargo hook and the dual-point system uses two hooks. This type of airlift normally requires a plane director and rigger at the pickup and delivery zones. In addition, an aircrewman observer will be stationed in the cabin for the necessary duties associated with the mission. Flight over personnel, buildings or equipment should be avoided. For heavy lift takeoffs and landings, set rotor speed to about 105% N_r. Apply power as required, until either engine limits or maximum torque is achieved. Before conducting external transport operations, helicopter performance capabilities must be verified by referring to Indicated Torque Required to Hover-In-Ground Effect charts in Chapter 20 and performing an operational power check.

WARNING

If collective bounce is encountered in any regime of flight with any loading configuration, the safest and quickest method of elimination is for the pilot to immediately remove his hand completely from the collective grip. Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight. During external cargo operations, if collective bounce is encountered and cannot be controlled, jettison the load.

Note

- Initial tensioning of the cargo sling legs, and load lift-off, should be done with the cargo hook(s) directly over the apex of the sling legs.

- Lift-off should be made by applying power smoothly and slowly. Rely on directions from the plane director to assure a vertical lift-off to prevent the load from being dragged over the surface.

- Normal small oscillations (2 to 3 feet) of heavy external cargo loads (over 20,000 pounds) cause very positive aircraft reactions which may cause crew concern. For non-aerodynamic loads, these oscillations may be expected to be self damping. In turns, above 60 knots, the coordinated turn feature of the AFCS may allow unbalanced flight to develop (as much as one ball out). The above reactions provide very strong sensory cues to the pilot but will be quickly accepted as normal and are likely to only become a critical factor during flight in IMC (instrument meteorological conditions) with heavy external loads. Under these conditions, pilot effort to fly the helicopter reacting to sensory cues may aggravate load oscillations and result in severe disorientation.

If ambient conditions dictate a weight reduction, exercise careful judgment when stripping the helicopter so that the CG is not significantly affected. (Refer to WEIGHT REDUCTION LIST in Chapter 9.

A rigger should be available to disconnect the cargo or retrieved aircraft at the delivery point when the cargo is resting on the surface or when all wheels of the retrieved aircraft are on the surface. Approaches for a pickup should be made so as to arrive in an airtaxi condition short of the pickup point and into the wind. See Figure 9-11 for appropriate hand signals. Figure 9-12 describes various aircraft load configurations as well as weight, V_{max}, and recommended cruise. The pilot can best control the approach until he can no longer see the load; at this time, the plane director should supply the necessary information to aid the pilot in positioning the helicopter over the load. When positioned over the load, the aircrewman will supply more detailed information so the pilot can maneuver the helicopter to where the cargo rigger can make the hookup.

The aircrewman stations himself in a position to observe the load, cargo sling, and pendant when conducting external cargo operations. While the load is airborne, he informs the pilot of any unusual load movement, indications of improper load security, or other conditions affecting load safety.

THESE SIGNALS HAVE BEEN EXCERPTED FROM **NWP–41** FOR THE CONVENIENCE OF THE USER. FOR COMPLETE SIGNALS OR IF ANY DISCREPENCY EXISTS, **NWP–41** SHALL GOVERN.

THE SIGNALS IN BLACK ARE AUTHORIZED FOR USE IN U.S. NAVY OPERATIONS AND WHEN OPERATING WITH NATO FORCES. **HOLD POSITION** (U.S. NAVY USE ONLY).

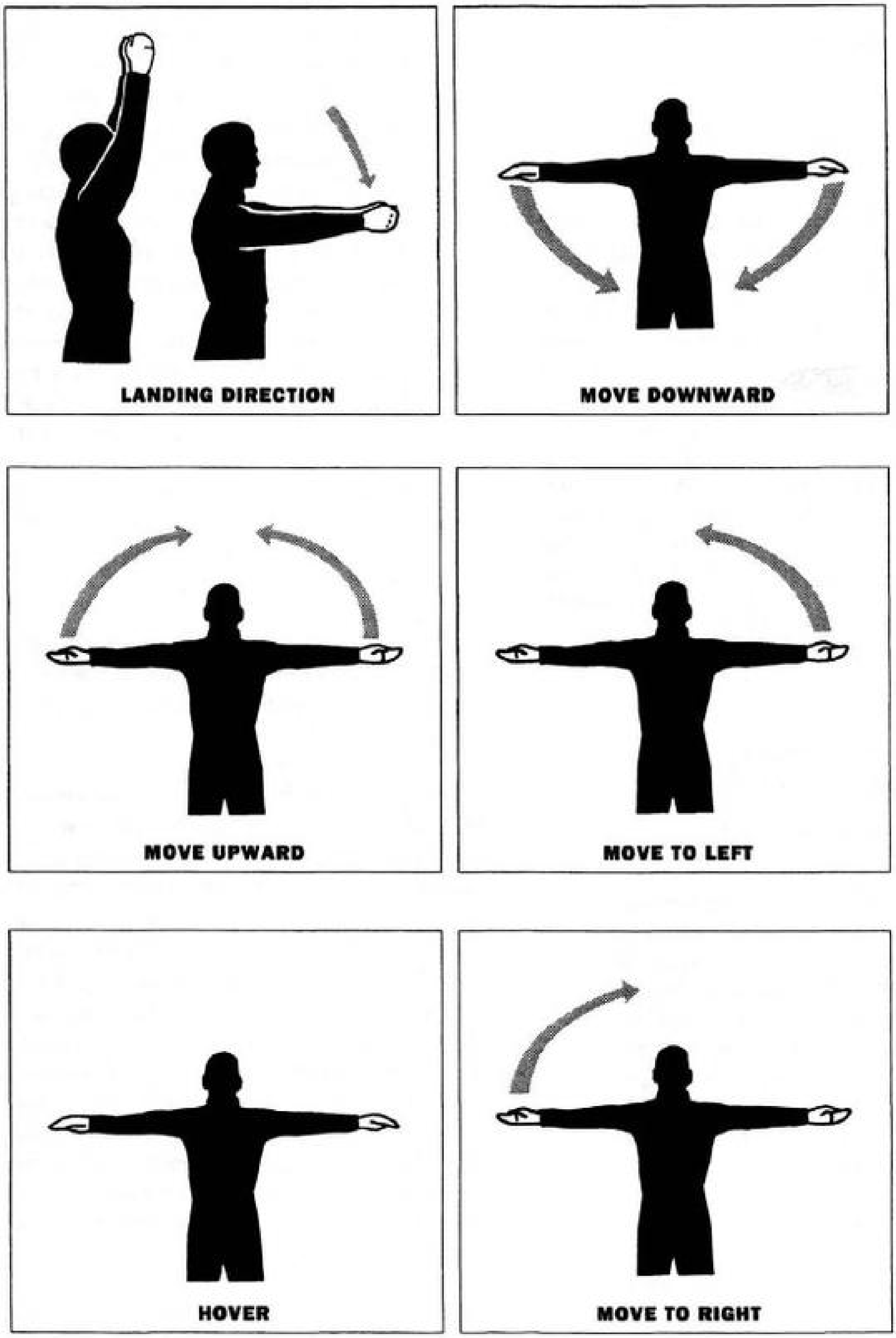


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Figure 9-11. Hand and Arm Signals for External Lifts (Sheet 1 of 2)

Figure 9-11. Hand and Arm Signals for External Lifts (Sheet 2 of 2)

LOAD DESCRIPTION	FLIGHT CHARACTERISTICS	SINGLE- OR TWO-POINT	WEIGHT POUNDS	V_{max} KIAS	RECOMMENDED RANGE KIAS
A-4C Engine, Avionics Seat, Hook Removed. Note 1.	Unstable on pickup. Stable in forward flight. Note 2	Single	8500	100	100
A-6A A-6C EA-6A All aircraft had engines in. EA-6A had no avionics gear. Note 1.	Stability is better as airspeed increases.	Single	26,500 (Heaviest Aircraft EA-6A)	100	70 to 90
A-6A Full systems aircraft. Note 1.	Very stable	Two	25,725	100	80 to 90
A-7A Engine, Avionics Seat, Hook Removed, Wings Spread. Note 1.	Unstable on pickup. Stable in forward flight. Doesn't follow well in turns.	Single	15,000	90	80 to 90
AV-8A Full systems aircraft. Note 1.	Stable	Single	12,175	90	90
S-3A Engines, Avionics Seats, Canopy, and Hook Removed. 1080 lbs. ballast in cockpit to adjust CG. Note 1.	Stable in forward flight. Comes around slow in turns.	Single	20,500	90	80 to 90
F-18A. NOTE 1.	Stable.	Two	24,066	85	60 to 85
CH-53 A/D Tail pylon attached. NOTE 2.	Stable, side/side.	Two	24,649	100	60 to 80
CH-53 A/D Tail pylon removed. NOTE 2.	Side/side oscillations above 50 KIAS.	Two	19,698	70	50

NOTE

1. All aircraft were rigged with belly bands using a prototype aircraft recovery kit. Drogue chutes were not used.
2. Drogue chutes were not used.

Figure 9-12. External Transport of Aircraft (Sheet 1 of 2)

The pilot informs the crew of the intended mode of release, before the approach at the cargo release site. The approach to the delivery point should be slightly high to prevent dragging the load on the surface. The helicopter is hovered when the cargo is about 6 to 8 feet above the surface. A vertical descent is then made until the load is resting on the surface. The load will be released upon signal from the aircrewman. Although care should be exercised when lowering all equipment to the ground, those items which are designed to sustain shock loads (in general, sprung and wheeled vehicles) need not be treated so delicately as huts, shelters, containers, and other nonwheeled items which, in addition to their inherent inability to withstand shock loads, are liable to contain electronic and other delicate equipment. After the equipment has been lowered to the ground, the helicopter

LOAD DESCRIPTION	FLIGHT CHARACTERISTICS	SINGLE- OR TWO-POINT	WEIGHT POUNDS	V_{max} KIAS	RECOMMENDED RANGE KIAS
A-6A A-6C EA-6A All aircraft had engines in. EA-6A had no avionics gear. Note 4.	Stability is better as airspeed increases.	Single	26,500 (Heaviest Aircraft EA-6A)	100	70 to 90
A-6A Full systems aircraft. Note 4.	Very stable	Two	25,725	100	80 to 90
A-7A Engine, Avionics Seat, Hook Removed, Wings Spread. Note 4.	Unstable on pickup. Stable in forward flight. Doesn't follow well in turns.	Single	15,000	90	80 to 90
AV-8A Full systems aircraft. Note 4.	Stable	Single	12,175	90	90
S-3A Engines, Avionics Seats, Canopy, and Hook Removed. 1080 lbs. ballast in cockpit to adjust CG. Note 1.	Stable in forward flight. Comes around slow in turns.	Single	20,500	90	80 to 90
F-18A. NOTE 4.	Stable.	Two	24,066	85	60 to 85
CH-53 A/D Tail pylon attached. NOTE 5.	Stable, side/side.	Two	24,649	100	60 to 80
CH-53 A/D Tail pylon removed. NOTE 5.	Side/side oscillations above 50 KIAS.	Two	19,698	70	50

NOTE

1. Truck/truck cargo weight must be known and aircraft CT must be figured.
2. Limit of testing only.
3. Limit of testing only. Airspeeds should be restricted pending results of further testing.
4. All aircraft were rigged with belly bands using a prototype aircraft recovery kit. Drogue chutes were not used.
5. Drogue chutes were not used.

Figure 9-12. External Transport of Aircraft (Sheet 2 of 2)

should descend slowly until spreader bars (if fitted) or sling hardware components are either resting on top of the equipment, or have otherwise been rendered incapable of inflicting damage to the equipment by falling on it.

9.12.2 Two-point Suspension Rigging. Suspension of external cargo from the two-point system uses an inverted Y as indicated in Figure 9-13. The inverted Y is achieved with single leg pendants suspended from each two-point cargo hook. As the helicopter approaches a load, the pendants allow slings which are secured to the load to be attached to releasable hooks on the pendants by ground crewmen.

9.12.2.1 Two-Point External Cargo Pendants. The two-point external cargo pendants (Figure 9-14) have a 21,600-pound capacity. They are used in sets, with one pendant for each two-point cargo hook. The pendant swivel hook extends about 7-1/2 feet below the cargo hook. The pendant hook can be opened by the aircrewman with a release handle from the cargo compartment, or by a ground crewman with a twist knob on the side of the hook. Each pendant hook has a lockout feature which prevents release of loads greater than approximately 300 pounds. A security strap is provided to retain the pendant if the cargo hook opens inadvertently. The aircrew shall ensure that the cargo hook pendant security strap is attached to the correct cargo tiedown fitting (Figure 9-14). This allows for adequate slack in the security strap and permits the strap guard to rest over the edge of the hole.

WARNING

When the security strap is not attached to the correct cargo tiedown fitting, it is possible for the strap to share load with the pendant and may cause either hook to sense no load and open.

9.12.3 Single-point Suspension Operation

9.12.3.1 Preflight (Single-Point Suspension)

1. A-Frame, Tube, Links — WEAR, CORROSION, CRACKS, AND SECURE AT ATTACHMENT POINTS.

2. Pendant Cover — BREAKS, CHAFING, DETERIORATION.

3. Pip Pins — WEAR AND CORROSION.

4. Electrical connection at hook and explosive separator — SECURE.

5. Winch and Lifting Line — WEAR AND CORROSION.

6. Mechanical release — TURN MANUAL RELEASE KNOB CLOCKWISE AND PULL ON LOAD BEAM. USING INSPECTION PORT, VERIFY THE SPRING LOADED RELEASE MECHANISM RETURNS TO SAFE AND LATCHED POSITION. ENSURE MANUAL RELEASE KNOB RETURNS TO SPRING-LOADED POSITION.

7. Note the I. D. plate for serial numbers modified with suffix A.

9.12.3.2 Single-Point Cargo Hook Guillotine/ System Check. After attaching or reattaching the single-point cargo hook, the following checks shall be made.

WARNING

Failure to visually confirm the hook's lock status through the inspection window prior to each lift (unmodified hooks with no A suffix after serial number) may result in uncommanded load release.

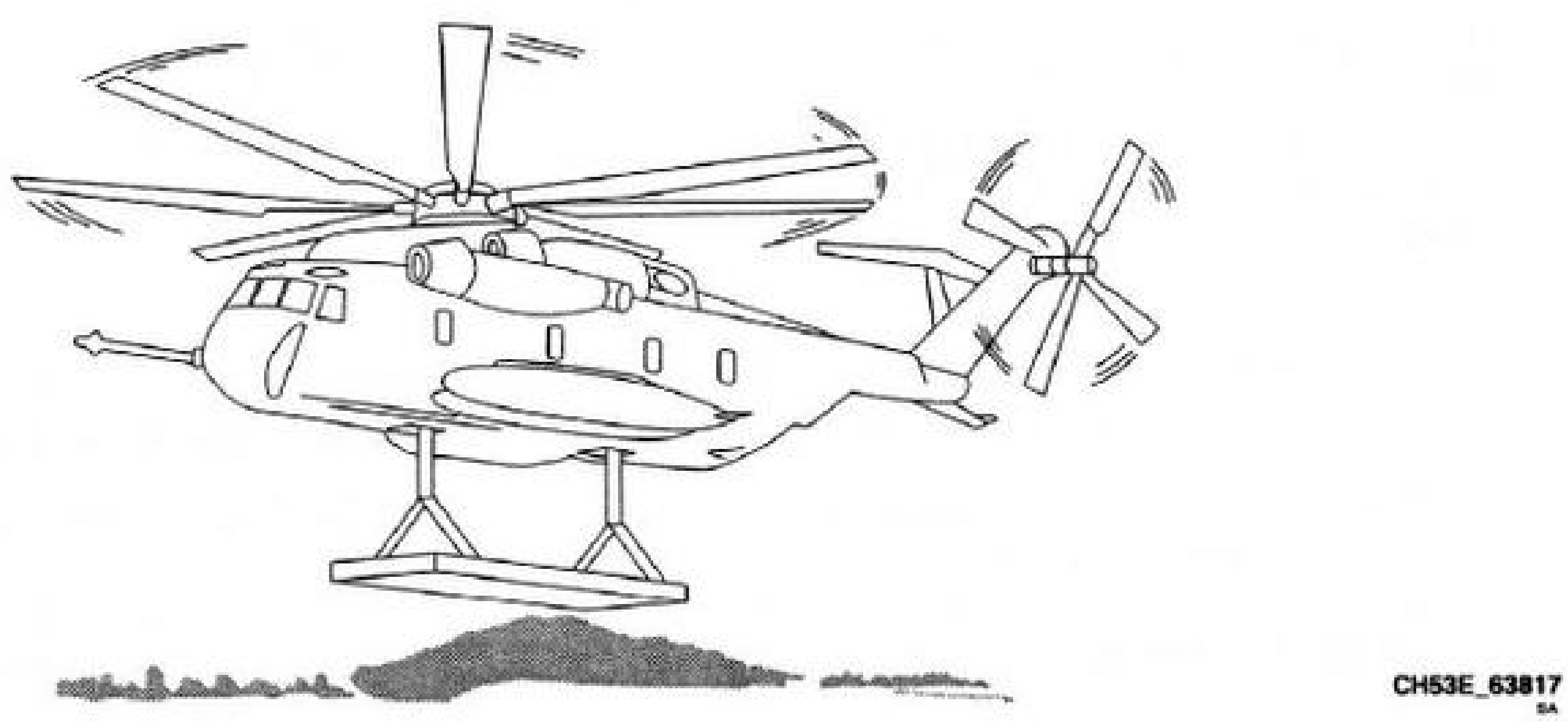
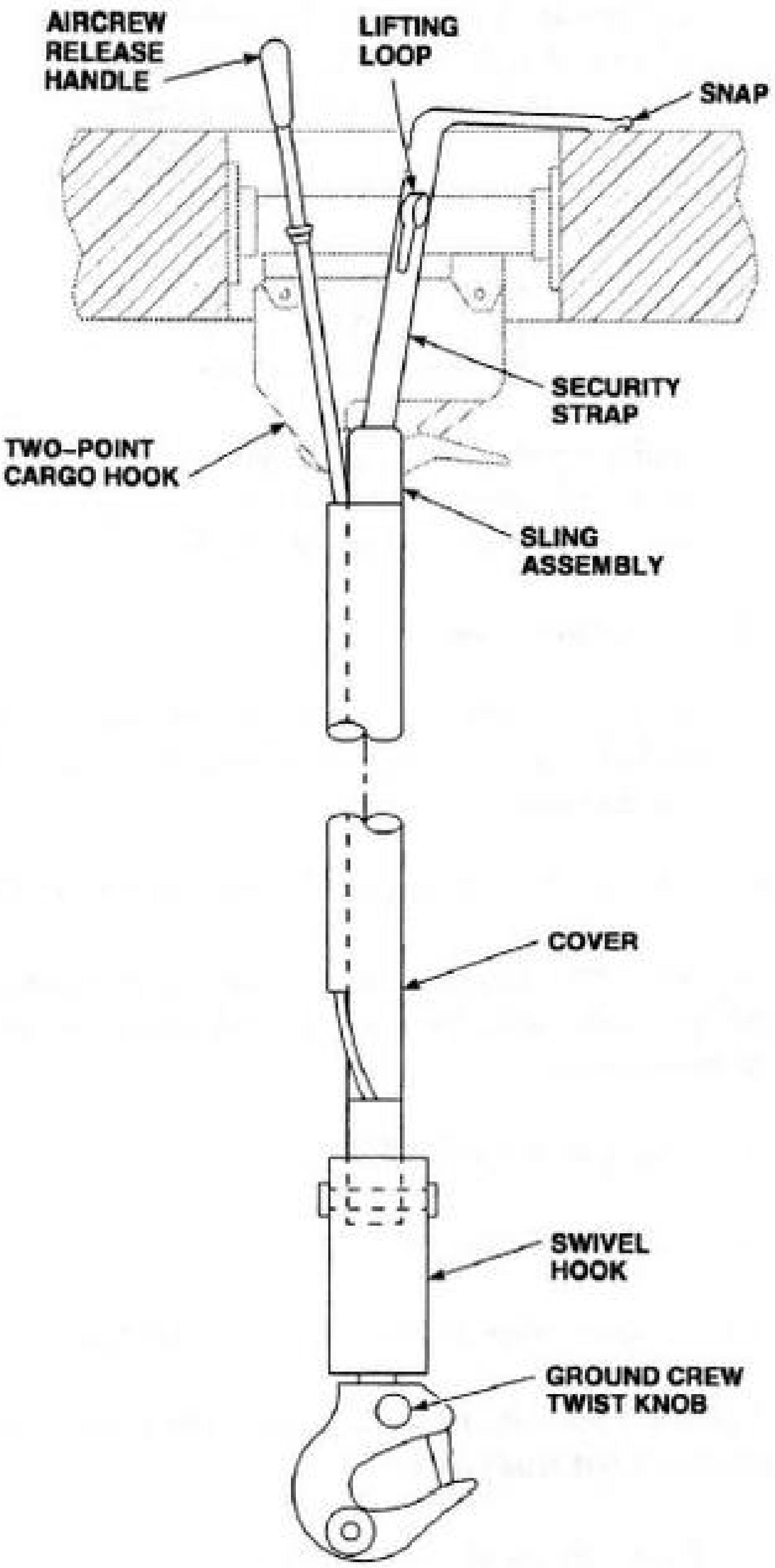


Figure 9-13. Two-point Suspension Inverted Y Rigging



NOTE

THE SECURITY STRAP MUST BE ATTACHED TO THE CARGO TIEDOWN RING INDICATED BELOW FOR PROPER OPERATION.

PENDANT SECURING STRAP	CARGO TIEDOWN FITTING	ACFT SIDE
FORWARD	STA 302	STARBOARD
AFT	STA 402	PORT

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Figure 9-14. Two-point External Cargo Pendants

1. PWR SEL switch (CARGO HOOK panel) — SINGLE PT.

2. CONTROL switch — ALL.

3. MODE switch — NORM.

4. Pilot's, copilot's, and aircrewman's electrical releases by activating and observing SINGLE PT HOOK OPEN advisory light flicker as long as CARGO REL button is pressed — CHECK.

5. SINGLE PT HOOK OPEN advisory light — OFF.

6. Hook inspection port — Check for positive latch indication.

Note

Hook must be in a near vertical/upright position when checking the manual release system.

7. Hook manual release — Check by activating and observing the SINGLE PT HOOK OPEN advisory light flicker while the knob is actuated.

8. Manual release knob should be free of binding and should return to the locked position — CHECK.

9. SINGLE PT HOOK OPEN advisory light — OFF.

10. Hook inspection port — Check for positive latch indication.

11. SINGLE PT switch — HOLD AT TEST.

12. HOOK SHEAR switch (EMERGENCY CONTROL panel) — HOLD AT SHEAR.

13. JETT TEST light — ON.

14. HOOK SHEAR switch — OFF, COVERED.

15. SINGLE PT switch — OFF.

16. PWR SEL switch — OFF.

9.12.3.3 To Attach Cargo (Single-Point Suspension)

CAUTION

To prevent inadvertent load release, the minimum weight for the single-point external cargo hook automatic release mode is 4000 pounds.

1. PWR SEL switch — SINGLE PT.

2. CONTROL switch — AS DESIRED.

3. MODE switch — NORM.

4. Check the manual release knob to ensure that it has returned to the fully closed position prior to first lift.

If cargo hook is not modified with suffix A, perform the following prior to each lift:

a. Inspect using hook's window port and placard.

b. Visually confirm hook mechanism — CLOSED.

CAUTION

Failing to confirm visually the hook's locking status via the inspection window port (on hooks not modified by serial numbers identified with suffix A) prior to each lift, may result in uncommanded load releases.

5. Lower cargo hook from stowed position.

CAUTION

Sufficient slack should be left in the hand operated winch cable after hook deployment to allow for pendant stretch.

6. Hover over load.

7. Descend so that rigger on ground can discharge static electricity with wand and can attach cargo sling into cargo hook.

8. SINGLE PT HOOK OPEN advisory light — OFF.

9. When aircrewman advises hookup completed, lift off vertically until load is clear of deck, monitoring plane director.

10. Torque — CHECKED.

11. SINGLE PT switch-ARM.

12. Depart when cleared by plane director.

9.12.3.4 To Automatically Release Load (Single-Point Suspension)

1. PWR SEL switch — SINGLE PT.

2. MODE switch — AUTO-RLSE. Check AUTO-RELEASE ON advisory light on.

Prior to touchdown.

3. Descend slowly with no forward speed or drift. Cargo hook will release on ground contact and SINGLE PT HOOK OPEN advisory light will go on.

Note

When load is resting on the ground, the weight of the cargo sling may be enough to keep the cargo hook from opening automatically. In this case decrease altitude to reduce cargo sling weight on the cargo hook.

9.12.3.5 To Release the Load Electrically (Single-Point Suspension)

CAUTION

- To prevent accidental release of the load when releasing with the crewman's pendant, do not lift the pendant's switch cover until ready to release load.
- The aircrewman's electrical release should be in the aircrewman's hand at all times with an external load attached to prevent inadvertent release.

1. Descend slowly with no forward speed or drift until cargo rests on surface.

WARNING

Be sure that all load tension is removed from the helicopter pendant before release of cargo. Release of cargo with high tension loads on the pendant may cause the cargo hook to recoil at the aircrewman or strike the airframe.

2. Descend slowly until spreader bars or apex are resting on top of the equipment or move to one side to prevent damage to the load by any metal parts of the sling.

3. PWR SEL switch — SINGLE PT.

4. CONTROL switch — COCKPIT OR ALL.

COCKPIT for pilot release, ALL for aircrewman release.

5. MODE switch — NORM.

6. CARGO REL button — PRESS.

7. SINGLE PT HOOK OPEN advisory light — ON.

8. PWR SEL switch — OFF.

9. Aircrewman stow cargo hook.

9.12.3.6 To Mechanically Release Load (Single-Point Suspension)

1. Descend slowly with no forward speed or drift until cargo rests on surface.

2. Descend slowly until spreader bars or apex are resting on top of the equipment.

3. Ground crew actuate mechanical release on side of cargo hook.

4. SINGLE PT HOOK OPEN advisory light lit as long as release is actuated.

5. Check the manual release knob to ensure that it has returned to the fully closed position after each mechanical release.

6. Aircrewman stow cargo hook.

9.12.4 Two-point Suspension Operation

9.12.4.1 Preflight (Two-Point Suspension)

1. On each hook there is a quick release "PIP PIN". Ensure the pin can be inserted and removed freely through the clevis into the hook output arm without movement of the arm. Failure of the pin to move freely may indicate the hook was installed improperly and the system will not have the full overcenter protection from the internal hook mechanism. If the hook does not meet this requirement and the hole in the clevis is not perfectly aligned, the threaded linkage rod must be adjusted prior to use of the dual point system.

2. Hooks and suspension equipment condition — CHECK.

   a. Each hook load beam moves, is free to open and pivots smoothly (pivot once before testing).

   b. Mechanical link moves smoothly from fully locked position without assistance (before testing).

   c. All visible parts secure and free of damage.

3. Emergency cargo hook release T-Handle — PULL.

CAUTION

T-handle must be pulled straight up to minimize possibility of binding.

a. Mechanical release is smooth and free of binding.

b. Manual release lever mechanical link return springs reengaged.

4. Emergency cargo hook release T-Handle — CONFIRMED RESEATED.

CAUTION

Failure to reseat T-Handle properly may result in inadvertent pendant release.

5. MODE switch — LOAD/UNLOAD.

6. CONTROL switch — ALL

7. PWR SEL switch — TWO PT.

FLT MODE UNSAFE light and 2 PT FLT UNARMED caution light goes on.

8. TWO PT TEST - 2 switch — HOLD AT A.

9. Pilot's cyclic CARGO REL button — PRESS.

FWD and AFT HOOK OPEN advisory lights go on, indicating forward hook solenoid is energized.

10. Repeat check with copilot's CARGO REL button and crewman's pendant switch.

11. MODE switch — FLIGHT.

FWD and AFT HOOK OPEN advisory lights go on. 2 PT FLT UNARMED caution light goes off, indicating one set of no-load switches (No. 2) energized the forward hook's solenoid.

12. MODE switch — LOAD/UNLOAD.

2 PT FLT UNARMED caution light goes on.

13. TWO PT TEST - 2 switch — HOLD AT B.

14. Pilot's cyclic CARGO REL button — PRESS.

FWD and AFT HOOK OPEN advisory lights go on, indicating aft hook solenoid is energized.

15. Repeat check with copilot's CARGO REL button and crewman's pendant switch.

16. MODE switch — FLIGHT.

FWD and AFT HOOK OPEN advisory lights go on. 2 PT FLT UNARMED caution light goes off, indicating one set of no-load switches (No. 1) energized the aft hook's solenoid.

17. MODE switch — LOAD/UNLOAD.

2 PT FLT UNARMED caution light goes on.

18. TWO PT TEST - 2 switch — RELEASE TO NORM.

19. TWO PT TEST - 1 switch — HOLD AT C.

20. MODE switch — FLIGHT.

FWD and AFT HOOK OPEN advisory light go on. 2 PT FLT UNARMED caution light goes off, indicating one set of no-load switches (No. 2) energized the dual emergency release solenoids.

21. MODE switch — LOAD/UNLOAD.

2 PT FLT UNARMED caution light goes on.

22. TWO PT TEST - 1 switch — RELEASE TO NORM.

23. PWR SEL switch — OFF.

FLIGHT MODE UNSAFE light and 2 PT FLT UNARMED caution light goes off.

9.12.4.2 Preflight (CG/Hook Load Indicating System). Manual self-test initialization shall be initiated by momentarily pressing the TEST key. Upon successful completion of the manual self-test, the CAL legend shall light. Deselection of manual self-test is possible only when the CAL legend is flashing.

The manual self-test sequence shall be as follows:

1. Within 1 second after pressing the TEST key, all CG display lights shall go on with full brightness and remain on for 3 (±0.5) seconds to allow the pilot to check for burnt-out lamps.

2. Within 1 second after the CG display lights go off, all HOOK display lights, including display lighting, annunciators, yellow lights, limit lamps, etc., shall go on with full brightness and remain on for 3 (±0.5) seconds to allow the pilot to check for burnt-out lamps. In addition, the C/G HOOK INOP legend lights on the caution panel.

3. Within 1 second after the HOOK display lights go off, all DATA display lights, including display lighting, annunciators, etc., shall go on with full brightness and remain on for 3 (±0.5) seconds to allow the pilot to check for burnt-out lamps.

4. Within 1 second after the DATA display lights go off, the following self-test responses shall appear on the indicator and remain for 5 (±0.5) seconds.

CG limits	FWD	348 inches
	AFT	359 inches
CG scale	Pointer at	354.5 inches
Hook load	FWD	15K pounds
	AFT	15K pounds
Data display	All 8s shown	

The indicator displays are at full brightness during self-test.

5. When the indicator passes its BIT, the CAL legend goes on, if on the ground (weight-on-wheels), indicating automatic calibration is being done. As calibration is being done the yellow channel selected lights sequence as follows: AFT-1, FWD-1; AFT-2, FWD-2. After successful completion of calibration, the CAL legend shall flash. If airborne (weight-off-wheels), automatic calibration is not done and the CAL legend flashes. If calibration is not needed or if calibration is complete, pressing the TEST switch shall extinguish the CAL legend, the AFT and FWD hook channel legends and return the indicator to normal operation.

6. During the previous sequences, the indicator exercises its internal BIT function. Failure of the BIT lights a yellow NO-GO light and furnishes a 28 vdc discrete which lights the C/G HOOK INOP caution light. The NO-GO light shall remain on until the malfunction is cleared or corrected. In addition, the numerical display shows which system component or indicator module has most likely malfunctioned, as shown in the following:

DISPLAY	RESULTS
8 8 8 8 8 .8	Pass test.
1 - - - - .1	System failure, Load cell failure.
1 1 - - - .1	FWD Hook, FWD load cell failure.
1 - 2 - - .1	FWD Hook, AFT Load cell failure.
1 - - 3 - .1	AFT Hook, FWD Load cell failure.
1 - - - 4 .1	AFT Hook, AFT Load cell failure.
1 1 2 3 4 .1	Multiple load cell failure.
1 - - - - .2	System failure, Fuel input failure.
2 - - - - .1	Indicator failure, Module 1
2 - - - - .2	Indicator failure, Module 2
2 - - - - .3	Indicator failure, Module 3
2 - - - - .4	Indicator failure, Module 4
2 - - - - .5	Indicator failure, Module 5
2 - - - - .6	Indicator failure or loss of 28 vdc input, Module 6

For automatic self-test, the indicator continuously exercises its BIT function during normal operation. The BIT function tests the processor memories and associated internal electronics to continuously verify proper operation.

9.12.4.3 CG/Hook Load Data Entry. Data to be entered into the CG/hook load indicator shall be taken from the Weight and Balance Clearance Form F (DD Form 365F). The procedure shall be as follows:

1. Press — WT.

2. Press — CLEAR.

3. Enter operating weight data (Form F, Ref 9); then press — (+).

4. Enter fuel data (Ref 10); then press — (+).

5. Enter internal cargo data (Ref 13); then press — (+).

6. Enter changes data (Ref 18); then press — (+).

7. Press — ENTER.

8. Press — MOMT.

9. Press — CLR.

10. Enter operating moment data (Ref 9); then press — (+).

11. Enter fuel moment data (Ref 10); then press — (+).

12. Enter internal cargo moment (Ref 13); then press — (+).

13. Enter change moment (Ref 18); then press — (+).

14. Press — ENTER.

Note

- Operating weight and fuel inputs are mandatory before pressing ENTER. (Fuel input is ignored and entered automatically from sensors, but an input is still required.)
- Internal cargo and changes inputs are only required as applicable.

15. Compare indicator's weight and moment/index with weight and moment/index for takeoff condition (corrected) (Ref 19).

Note

The CG/hook load indicator's readings shall not vary from the values on Form F by more than ±500 pounds for weight, ±160 inch-pounds for moment per 1000, and ±2 for index. If the difference is greater than the tolerances given, the data should be reentered. If the difference is still too great, Form F should be rechecked for accuracy.

16. Compare indicator's CG to that of Form F takeoff CG (Ref 20).

Note

The CG/hook load indicator's reading shall not vary from the value on Form F by more than ±1 inch for CG. If the difference is greater than the tolerance given, the data should be reentered. If the difference is still to great, Form F should be rechecked for accuracy.

9.12.4.4 Pre-Takeoff (Two-Point Suspension)

CAUTION

To prevent inadvertent load release, the minimum weight for two-point external cargo operations is 1000 pounds per hook.

1. Park beside or hover over load.

2. MODE switch — LOAD/UNLOAD.

3. PWR SEL switch — TWO PT.

FLT MODE UNSAFE light goes on.

2 PT FLT UNARMED caution light goes on.

4. FWD and AFT HOOK OPEN advisory lights — OFF.

5. FWD cargo hook security strap — ATTACHED TO STA 302, STARBOARD SIDE.

6. AFT cargo hook security strap — ATTACHED TO STA 402, PORT SIDE.

WARNING

When the security strap is not attached to the correct cargo tiedown fitting, it is possible for the strap to share the load with the pendant and may cause either hook to sense no load and open.

CAUTION

Failure to place the two-point external cargo pendant sling assembly in the aircraft two-point cargo hook saddle may cause the hook to sense a no-load condition and inadvertently open.

7. CONTROL switch — AS REQUIRED.

Plane director will signal when load is hooked up and ground personnel are clear.

8. Hover with load airborne.

9. FLT MODE UNSAFE light — OFF.

10. CG/hook load indicator — CHECKED (IF UTILIZED).

CAUTION

The original data display may indicate ±800 pounds total gross weight fluctuations while the helicopter is hovering. The average of the above values may be ±2000 pounds from actual helicopter gross weight. A cross check of engine torque shall be used to avoid exceeding helicopter gross weight or power available limits.

11. Torque — CHECKED.

12. MODE switch — FLIGHT.

WARNING

Aircrewmen should remain clear of the two-point external cargo pendant security strap while the load is under tension to avoid being struck by the attachment fitting should the aircraft hooks open.

CAUTION

Load will be released if the MODE switch is placed to FLIGHT before the load is airborne or the FLT MODE UNSAFE light is on. If the FLT mode unsafe light does not go out the load shall be set back on the surface and released, and further lifts shall not be made until the system is corrected.

13. 2 PT FLT UNARMED caution light — OFF.

14. Normal takeoff.

WARNING

- Select FLIGHT with the MODE switch throughout the flight, because the no-load sensing microswitches in the hooks operate only in this mode. Therefore, in this mode, failure of a cargo sling in one closed hook will cause both hooks to open automatically and prevent the helicopters CG limits from being exceeded.

- The PWR SEL switch shall be kept at TWO PT throughout flight since it furnishes electrical power for system operation.

- The jump seat should not be occupied during two-point external cargo lifts. The jump seat occupant may inadvertently activate the cargo release handle.

CAUTION

While carrying light weight loads or loads which tend to generate lift, ensure that all helicopter attitude and altitude changes are executed at a slow rate. A high helicopter flare rate or a high rate-of-descent could generate sufficient lift from some loads to cause the no-load sensing system to open both cargo hooks. Additionally, flight during gusty/turbulent wind conditions could cause both cargo hooks to open for the same reason. Extreme caution should be exercised during flight with a dual-point load in gusty/turbulent wind conditions.

Note

Radar altimeter indications may not be accurate when carrying external loads.

9.12.4.5 Load Release (Two-Point Suspension)

CAUTION

To prevent accidental release of the load when releasing with the aircrewman's pendant, do not lift the pendant's switch cover until ready to release load.

1. MODE switch — LOAD/UNLOAD (prior to load contacting deck).

2. Normal approach to a hover.

3. Air taxi to load release point.

4. Descend slowly with no forward speed or drift until cargo rests firmly on surface with slack in both pendants.

WARNING

- Ensure that the load is in full contact with the ground/deck, with slack in both pendants prior to mechanically opening either pendant cargo hook. The manual pendant hook release mechanism may not function if either pendant hook is under tension.

- Do not use pendant release mechanism to release floating cargo. Water currents, wave action and rotor downwash may cause cargo to drift. Reapplication of tension due to drift may cause nonrelease of pendant. To release floating loads, the helicopter cargo hook must be used to release the pendants.

5. Release the load manually using the aircrew release handle on each pendant.

CAUTION

If forward flight is to be resumed with unloaded pendants attached to the helicopter cargo hooks, the control panel MODE switch must be kept in the LOAD/UNLOAD position.

6. Depart off-loading hover after aircrewman and plane director have indicated cargo released and ground riggers are clear.

9.12.5 External Cargo Crew Signals.

In order for pilots to receive standard working signals from aircrewman, the following signals should be briefed and utilized when possible:

SIGNAL	MEANING
LOAD IN SIGHT	Aircrewman has visually acquired the load.
RIGHT/LEFT/FORWARD/ BACK (number of feet)	Move the helicopter in this direction.
UP/DOWN (number of feet)	Move the helicopter up/down.
TAIL LEFT/RIGHT	Move the tail of the helicopter to provide proper alignment over the load (dual-point only).
HST HAS THE HOOK(S)	Ground personnel have acquired/grounded the hook(s).

SIGNAL	MEANING
FORWARD HOOK IS LOADED	The forward pendant is attached to the load (dual-point only).
AFT HOOK IS LOADED	The aft hook is attached to the load (dual-point only).
LOAD IS HOOKED UP	The pendant(s) is/are attached to the load.
UP SLOW FOR TENSION	Lift helicopter straight up.
GROUND PERSONNEL CLEAR	Ground personnel are clear of the load.
TENSION ON THE LOAD	Tension on the cargo sling and pendant(s).
LOAD IS OFF THE DECK, (CLEAR TO SWITCH)	Cargo is off the deck, (CLEAR TO SWITCH to dual-point only).
LOAD CLEAR FOR FORWARD FLIGHT	The load is clear of the deck and all obstacles.
LOAD IS RIDING STEADY	The load is not swinging or experiencing any difficulties.
STEADY	Hold at present position.
POWER	Any time the helicopter or load is dangerously low.
ZONE IN SIGHT, (CHECK SWITCHES)	Aircrewman has visually acquired the drop-off point, (CHECK SWITCHES) for dual-point only).
HOLD HOVER, CHECK SWITCHES	Helicopter hovering over drop zone. (CHECK SWITCHES for load/unload).
LOAD ON THE DECK	The load is on the deck but not yet released.
FORWARD HOOK RELEASED	The forward hook is released, hold steady (dual-point only).
AFT HOOK RELEASED	The aft hook is released, hold steady (dual-point only).
LOAD IS RELEASED	The load has been released from the pendant(s), clear to come up.

9.12.6 Weight Reduction List. The following list indicates some of the items that may be removed to reduce the basic weight of the helicopter by the amount indicated.

Item	Weight lbs
Both auxiliary tanks	858
Both tank pylons	312
Cargo ramp	256
Soundproofing	238
EAPS No. 1 and No. 3 (total)	224
Cargo tiedown straps (32 each)	196
Troop seats installation (without AFC 497) (seats, belts, tubes)	155
Troop seats installation (AFC 497) (seats, belts, tubes)	187
Centerline troop seats and belts	145
Cargo tiedown chains (4 ea at 25.3 lbs) (4 ea at 10.3 lbs)	142
Cargo conveyers	136
Cargo guide rails	122
Single-point hook	114
Heater assembly (not ducts)	111
A-frame assembly	101
Utility hoist	80
Upper aft door (complete)	59
Ramp flippers	51
Single-point pendant	51
Cargo centerline skid rail	16
Aircrewman's seat	12
Jump seat	3
Refueling probe (including trapped fuel)	307
Winch and support	166

9.12.7 External Transport of Aircraft. To conduct external transport operations, an aircraft recovery kit must be used that contains all the necessary lifting equipment required for the mission. If ambient conditions dictate a weight reduction in the aircraft being retrieved, exercise careful judgment when stripping the retrieved aircraft so that the CG is not significantly affected. Figure 9-12 describes the various load configurations as well as weight and recommended airspeed.

9.12.7.1 Checklist for External Transport of Aircraft

1. Standard mission brief.
2. Tactical or administrative lift.
3. Type aircraft to be recovered.
4. Items removed by damage (if any).
5. Items removed intentionally (if any).
6. Final net weight of downed aircraft (estimated).
7. CG of downed aircraft (lift by Bay City type crane, if applicable).
8. Area of downed aircraft.
9. Altitude of downed aircraft.
10. Computed power available.
11. Reduction of own aircraft weight (see weight reduction list).
12. Payload possible.
13. Recommended airspeed and elapsed time en-route (to and from).

CHAPTER 10
Functional Checkflight Procedures

10.1 FUNCTIONAL CHECKFLIGHT AUTHORITY

Functional checkflights are made to determine if the airframe, engines, rotors, or flight controls/AFCS are functioning to manufacturer tolerances in flight. These flights should normally be conducted within autorotative distance of a safe landing field or in recoverable distance from flight deck, and during day/VMC. Those portions of the flight that are considered flight critical should be conducted using the same guidelines as minimum distances. If necessary, unit commanders may authorize functional checkflights under conditions other than above. Prerequisites for alternate flight conditions are:

1. If the Commanding Officer only decides, in his opinion, that a checkflight can be conducted with an acceptable margin of safety under the existing conditions.

2. "Test and Go's", or functional checkflights in combination with operational flights, can be authorized only by the Commanding Officer; provided (1) FCF card is completed prior to operational flight, (2) the card is signed by the aircraft commander, and (3) the card returned to the maintenance department prior to operational sortie.

10.2 FUNCTIONAL CHECKFLIGHTS

The appropriate functional checkflight shall be made when specified by the Maintenance Instruction Manual (MIMS) and the OPNAVINST 4790.2 NAMP manuals. Appropriate checklists are provided to correspond to specific guidance in MIMS, by general heading, to facilitate ease in determination of type of check required. The checklist shall be used and in the sequence depicted. Boxed numbers to the right of the PROFILE have been established for each checklist condition. The number prefaces the condition on the FCF card (A1-H53BE-NFM-700) and an explanation of the check in this chapter. Checkflight crews are required to familiarize themselves and brief as crews all the applicable conditions to be flown, prior to the flight. Special attention is required to ensure that all required ground checks are completed and documented prior to briefing functional checkflight. Daily and turnaround inspection is required for a functional checkflight.

Note

These procedures are intended for the use of designated functional check pilots only. Use for troubleshooting by squadron pilots is not authorized.

10.2.1 Conditions Requiring Functional Checkflight. The MIMS requirements relate to a general function profile. The extent and type of maintenance performed may warrant the deletion of certain profile steps at the discretion of the Commanding Officer or a designated-in-writing representative. Satisfactory completion is required prior to the release of the helicopter for operational use. The general conditions are as follows:

A Is a COMPLETE functional checkflight. All checklist items required are prefixed **A** in the PROFILE.

B Is an AFCS (only) functional checkflight. All checklist items required are prefixed **B** in the PROFILE.

C Is a MECHANICAL FLIGHT CONTROL (only) functional checkflight. All checklist items required are prefixed **C** in the PROFILE.

D Is an ENGINE PERFORMANCE (only) functional checkflight. All checklist items required are prefixed **D** in the PROFILE.

10.2.2 Reference to Pilots Pocket Checklist A1-H53BE-NFM-500. "Refer to PCL" is a prompt to use the A1-H53BE-NFM-500 until the next required functional checkflight item. It is necessary to look at the next required item in the functional checkflight card, as the Pilots Pocket Checklist does not have responses to prompt the use of the FCF card.

PROFILE

10.3 FUNCTIONAL CHECKFLIGHT CHECKLIST

10.3.1 Preflight. To be performed per Chapter 7 of this manual.

10.3.2 Prestart. Refer to PCL until after **Overhead Control Panel** checklist, engine speed controls shutoff.

10.3.2.1 Overhead Control Panel

A D 1. Engine Speed Control Levers — Move speed control levers through full range of motion, both forward and aft. Motion should be smooth and free of binds. Check latch on lever at ground idle and for worn guide on quadrant faceplate. At any position above ground idle, check for dead band play in each direction. Light spring force should center speed control in dead band.

A D 2. Emergency Start Panel — Ensure panel is in NORM, NORM, OFF.

A D 3. Engine Fire T-handles — Move each T-handle through the full range of motion. Ensure when moving from front to aft that selector micro-switch is heard to open.

A D 4. Fuel Selector Levers — Check operation of each individual fuel selector lever to physically feel detent at each of three positions. Move all fuel selector levers to DIRECT. Engage each fuel selector lever with the corresponding Engine Fire T-handle. Pull T-handle aft and bring Fuel Selector Lever to SHUT OFF. Return T-handle to full forward position.

5. Refer to PCL until after APP start.

A 6. APP Fire Protection, generators off — Check APP fire protection for operation with No. 1 and No. 3 generators OFF.

10.3.3 Post APP Start

1. Refer to PCL until after hydraulic pressure/quantity check.

A D 2. Engine Air Particle Separator (EAPS) — Pull IGB/MGB oil pressure circuit breaker. Have crewman report operation of each EAPS blower. Move EAPS control switch to open. Have crewman report all three EAPS upper and lower doors open and blowers off. Move switch to CLOSED. Have crewman report all three EAPS upper and lower doors closed and blowers on. Move switch to AUTOMATIC on No. 1 and No. 3, leave No. 2 at CLOSE. Check that all three sets of EAPS doors are closed prior to engine start.

3. Resume PCL at **POST APP START** checklist caution/advisory panel check and test, until after **Instrument Panel** checklist compass (BDHI) slaved/aligned.

A 4. VGI Transfer

a. Check that indices are lined up when trim knobs are set on dots.

b. Ensure AFCS is off. Pull AHRS circuit breaker on EMERGENCY AC BUS panel. Pilot's attitude indicator will become inoperative with OFF flag showing. Place pilots VG XFR switch to ALT. Note pilot's attitude indicator to lose OFF flag and to cage. Reset AHRS circuit breaker and place transfer switch to NORM.

c. Pull VGI/GYRO COPILOT circuit breaker on EMERGENCY AC BUS panel. Copilots attitude indicator will become inoperative with OFF flag showing. Place copilots VG XFR switch to ALT. Note copilots attitude indicator to lose OFF flag and to cage. Reset VGI/GYRO COPILOT circuit breaker and place transfer switch to NORM.

5. Resume PCL at **Instrument Panel** checklist VSI check, until after **Console** checklist second stage servo interlock check.

A C

6. Flight Controls

a. Freedom of Response — On lower console at AFCS control panel, ensure all control switches are off. Slowly operate flight controls (cyclic, collective, and rudder pedals) through their limits. Check for freedom of movement and binding. Feel for momentary restrictions.

Note

Deviations from designed control forces will lead to AFCS degradation. Control force malfunctions will make helicopter more susceptible to pilot-induced oscillations.

b. Check breakout forces in all controls. When checking lateral and longitudinal forces ensure collective is at mid travel. Estimate all break out forces in the following conditions:

(1) AFCS Servos OFF, AFCS OFF, Trim OFF

(a) Pitch — 3.5 to 6.5 pounds

(b) Roll — 1.5 to 4.5 pounds

(c) Collective — 20 pounds

(d) Yaw — 30 pounds

(2) AFCS Servos ON, AFCS ON, Trim OFF

(a) Pitch — .5 to .75 pounds

(b) Roll — .5 to 1.0 pounds

(c) Collective — 3 to 4 pounds

(d) Yaw — 8 pounds

(3) AFCS Servos ON, AFCS ON, Trim ON

(a) Pitch — 1.5 to 2.0 pounds

(b) Roll — 1.5 to 2.0 pounds

(c) Collective — 9 pounds

(d) Yaw — 16 pounds

Note

When checking for primary and secondary stops, use minimum force. Move control in individual axis and allow other control to move to coupled positions as required.

c. Locate Primary and Secondary Stops — To find stick or pedal stops, move control as described in the procedure to maximum allowed movement using minimum force. When control will no longer move with minimum force, this is the primary stop. Once primary stop is located, using approximately double the force required to find primary stop, push through in the same direction. Spring pressure should be felt. When stick no longer moves while feeling the relief, this is the secondary stop.

(1) Pitch Primary and Secondary Stops/Limiters - Control limiter checks:

(a) Move cyclic forward until contacting forward pitch limiter while holding pedals and collective centered.

CAUTION

Do not use excessive force at limiter, possible damage to flight control could result.

(b) With slight pressure against cyclic stick, press left pedal. Cyclic stick should roll off limiter onto forward cyclic primary stop. Locate forward primary and secondary stops. Cyclic stick should not contact instrument panel at either stop.

(c) With hands off cyclic and collective stick, press right pedal forward. Cyclic should return to near center, checking the forward pitch limiter.

Note

If during limiter checks cyclic stick goes directly to primary stops, make sure pedals are centered and collective is at mid travel.

(d) Center controls. Hold pedals and collective stick centered.

(e) Pull cyclic aft to limiter.

(f) Put slight pressure against cyclic stick and press right pedal. Cyclic should roll off limiter on to aft cyclic primary stop. Locate aft primary and secondary stops. Cyclic should not contact pilot or copilots seats at either stop.

(2) Roll Primary and Secondary Stops

(a) Center flight controls.

(b) Move cyclic left and locate primary and secondary stops.

(c) Move cyclic right and locate primary and secondary stops.

(d) Center flight controls.

(3) Collective Primary and Secondary Stops

PROFILE

(a) With right pedal full forward and collective full up locate upper primary and secondary stops.

(b) With left pedal full forward, locate collective stick lower primary and secondary stops.

(4) Yaw Primary and Secondary Stops

(a) Center cyclic stick and release all flight controls. Engage SERVO 1.

(b) With collective full up, gently and repeatedly press right pedal until pedal does not return to foot and stays at full throw. When pedal no longer springs back, this is the secondary stop.

(c) When SERVO 1 is secured, pedal will return to primary stop. Maintain slight pressure on pedal and secure SERVO 1. Note pedal to return to primary stop.

(d) Center cyclic stick and release all flight controls. Engage SERVO 1.

(e) With collective full down, gently and repeatedly press left pedal until pedal does not return to foot and stays at full throw. When pedal no longer springs back, this is the secondary stop.

(f) When SERVO 1 is secured, pedal will return to primary stop. Maintain slight pressure on pedal and secure SERVO 1. Note pedal to return to primary stop.

(5) Collective and Yaw Coupling

(a) AFCS OFF, center pedals and lower collective full down. Press right pedal fully with hand off collective. Look for collective to rise. Press left pedal and look for collective to lower.

d. AFCS control response

(a) Engage SERVO 1 and slowly operate flight controls (cyclic, collective, and rudder pedals) through their limits. Check for freedom of movement and binding. Feel for momentary restrictions.

(b) Repeat process with SERVO 2.

(c) Repeat process with SERVO 1, SERVO 2, AFCS, and TRIM engaged.

7. Resume PCL at **Console** checklist AFCS servos engage, release, and transfer, until after AFCS check.

AB

8. Barometric/Radar Altimeter Hold check

a. BAR ALT push button — PRESS. BAR ALT light should illuminate with no fail advisories.

b. RAD ALT pushbutton — PRESS. RAD ALT light should not illuminate.

c. CLTV TRIM REL button — PRESS. BAR ALT light should flash.

d. BAR ALT pushbutton — PRESS. BAR ALT light should go out.

e. RAD ALT knob set to zero.

f. RAD ALT pushbutton — PRESS. RAD ALT light should illuminate with no fail advisories.

g. RAD ALT knob — INCREASE. Collective should rise slightly.

h. RAD ALT knob set to zero.

i. CLTV TRIM REL button — PRESS. RAD ALT light should go out. Engage RAD ALT again and disengage with copilots CLTV TRIM REL button.

j. RAD ALT pushbutton — PRESS. RAD ALT light illuminated. Press RAD ALT BIT button on indicator. RAD ALT should not self-test.

k. RAD ALT light illuminated. Secure both pilot and copilot radar altimeters and note RAD ALT light to go out, BAR ALT light illuminates, and ALT failed advisory light illuminates. Press MODE RESET and note ALT failed advisory light to go out.

l. BAR ALT pushbutton — PRESS. Note light to go out.

m. Reset pilot and copilot radar altimeters as desired. Press RAD ALT BIT button on indicator. Note indicator to 100 ±15 feet.

AB

9. Trim System Checks

a. Cyclic beeper Trim — Check SERVO 1, AFCS, and Trim ON. Operate pilots cyclic stick beeper trim button full forward, full aft, full right, and full left. Repeat check on copilots side. Note that movement is instantaneous and smooth.

Note

- Actuate pedals for one minute while pressing pedal micro-switches prior to pedal trim checks to ensure yaw channel is fully ready for check.
- Pushing pedals to their full forward limit during trim checks will cause a heading mode failure.
- Moving of flight controls with trim engaged, but trim release not pressed, is moving control against its force gradient.
- Do not attempt trim checks unless AFCS has warmed for at least 3 minutes after initial powering up or recycle.

b. With TRIM ON, center cyclic and pull collective full up with collective trim release pressed. Release collective trim and note collective to stay in the full up position. Against force gradient, push collective full down and release. Note collective to return to full up position. Against force gradient, move cyclic forward, aft, left and right and note in each case its return to the trimmed center position. Press cyclic trim release and reposition cyclic one or more inches from center. After releasing cyclic trim release; note cyclic to stay in trimmed position. Against force gradient in yaw, without pressing pedal switches, individually push rudder pedals 2 to 3 inches and remove feet. Note pedals to return to trimmed position. Repeat all checks on copilots side.

PROFILE

c. Heading Trim — Press both pedal trim switches while centering pedals and center HDG TRIM knob. Release pedal trim switches and wait 30 seconds. Turn HDG TRIM knob to clockwise and note right pedal advances. Press right pedal trim switch and note motion stops. Turn pedal counterclockwise and note left pedal advances. Press left pedal trim switch and note motion stops.

10. Resume PCL at **Console** checklist single- and two-point cargo hooks - as required, until after **STARTING ENGINES/ROTORS** checklist.

10.3.4 Starting Engines/Rotors

A D 1. Ignition — Place #1 engine anti-ice switch to ON and have crewman report hearing ignitions from engine. Repeat for #2 and #3 engines.

A D 2. Engine Speed Trim — Using Pilots collective grip, beep engine speed control levers from SHUT OFF to GRD IDLE. Manually position speed control levers out of ground idle detent. Beep speed control levers from MIN GOV to MAX GOV (full forward) and back to MIN GOV. Note position of levers automatic stopping point. Levers should be at MIN GOV position. Repeat procedure on copilot's collective grip. While actuating speed control levers from MIN GOV to MAX GOV with copilot's grip, check that pilot's grip has override capability.

A D 3. Engine Starter Interlocks — Set initial conditions as follows:

Speed Control Levers — SHUTOFF
Blade Fold Control Panel — Blade Spread/Flight Ready
Rotor Brake — On, rotor brake caution/advisory lights illuminated
Gust Lock — Disengaged

a. Pitch Locks Engaged, Safety Valve Closed — Using pilot's pocket checklist, engage pitch locks but do not fold rotor. With PITCH LOCKS ENGAGED light illuminated, secure MASTER POWER. Position rotor for engine start. Check for ENG START HEAD POS advisory light and release switch. Attempt to start each engine. None should start because pitch locks are advanced.

b. Head Not in Start Position — Using pilot's pocket checklist, disengage pitch locks to BLADE SPREAD/FLIGHT READY. With BLADE SPREAD and FLIGHT READY lights illuminated and rotor brake engaged, attempt to start engines. None should start because head is not in start position.

c. Gust Lock On — Position rotor to engine start and verify caution lights. Engage gust locks and check for ROTOR LOCKED/BLADE PYLON FOLD lights. Attempt to start engines. None should start because gust lock is engaged.

d. Rotor Brake Off — Disengage gust lock and check for BLADE SPREAD/FLIGHT READY lights. Release rotor brake and attempt to start engines. None should start because rotor brake is disengaged.

e. Safety Valve Open — Engage rotor brake in EMER and check for caution/advisory lights. Check for Blade Spread/Flight Ready lights and head in start position. Place Master Power switch to POWER. Check for SAFETY VALVE OPEN light. Attempt to start engines. None should start because Safety Valve is Open. Place emergency start switch to EMER and attempt to start engines. Engines should motorize. Abort starts and return switch to NORM. Secure Safety Valve and check for BLADE SPREAD/FLIGHT READY lights.

PROFILE

A D

4. Rotor Brake Interlocks

   a. Place speed control levers to SHUT OFF and rotor brake switch to EMER. Check ROTOR BRAKE PRESS and ROTOR BRAKE ON lights are illuminated.

   b. Place rotor brake switch to RELEASE and note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights out.

   c. Hard Brake

      (1) Place rotor brake switch to EMER and note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights illuminated.

      (2) Place rotor brake switch to OFF. Note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights illuminated.

   d. Manual Release

      (1) Have crewman release rotor brake from cabin. Note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights out.

      (2) Secure manual release handle in cabin and place rotor brake switch to EMER. Note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights illuminated. Release rotor brake and note ROTOR BRAKE PRESS and ROTOR BRAKE ON lights out.

   e. Soft Brake — Place soft brake switch to NORM and hold for five (5) seconds. Check for one (1) minute time delay relay to trip and then note ROTOR BRAKE PRESS light illuminates. Release rotor brake press with rotor brake switch. Note ROTOR BRAKE PRESS light out.

   f. #1 Engine — Move #1 speed control lever full forward. Attempt to set soft brake and hard brake. Note that neither brake sets.

   g. Place rotor brake switch to EMER. Slowly retard #1 speed control lever to GRD IDLE. Ensure rotor brake does not engage prior to GRD IDLE.

   h. #2 and #3 Engine — Release rotor brake pressure. Repeat checks for #2 and #3 speed control levers.

5. Fuel Selector Levers — move to 2-1-2.

A D

6. Maximum N_g Check, APP/Engine Starter Checks, Start and Abort Microswitches — Hold #1 speed control lever to shut off. Press starter button until starter energizes with ENGINE STARTER ON light is illuminated. Then release button and speed control lever. Starter should stay engaged and N_g should accelerate to 26% to 32%. Abort starter and annotate maximum N_g. Repeat process for #2 and #3 engine. On #3 engine, while starter is accelerating pull APP HIGH EXH TEMP and LOW OIL PRESS circuit breakers to check APP/Engine Starter Bypass. APP should continue to operate and starters should continue to accelerate. Reset circuit breakers and disengage engine starter.

7. Area — Clear/fireguard posted.

8. Flight Controls — Start Position.

PROFILE

A D

9. OAT — Record outside air temperature in °C and use chart to identify target N_g.

T_2 -°C	N_g Min - Max
-30	60.5 - 63
-20	61.0 - 63.5
-10	61.5 - 64.5
0	62.5 - 65.5
+10	63.5 - 66.5
+20	64.5 - 68
+30	65.5 - 69
+40	66.5 - 70

46 clicks = 1 1/4 turns = 1% N_g

A D

10. Ground Idle Checks

a. #3 engine starter button pressed.

b. #3 Speed control lever to GRD IDLE at 20% N_g indicated. Look for acceleration and N_g to pass through 30%. Follow engine parameters to ground idle.

(1) Maximum T_5 during start — Record maximum attained T_5 for engine during start cycle.

(2) Starter Dropout — Record engine starter drop out N_g. Starter drop out limits for Vickers and Dynapower starters is 51% to 58% N_g. On Vickers starters, adjust drop out switch and reattempt start if time permits. On Dynapower starters, no adjustment is available and starter replacement is required to solve discrepancy. If starter continues to run beyond 60% N_g, secure starter using speed control lever.

(3) Start time — Record time in seconds from starter engagement to stable ground idle N_g. Start time for ambient conditions above -15 °C is 60 seconds or less.

(4) Ground idle readings after engine has stabilized — Ground idle reading is required to be recorded prior to advancing speed control lever beyond ground idle. Due to hysteresis in the engine control system, adjustments made to engine after speed control is advanced are unreliable and may cause improper starting parameters for engine. Ensure that all readings and adjustments are made between SHUT OFF and GRD IDLE only.

(a) N_g — Record ground idle N_g. Compare indicated N_g to target N_g for ambient conditions recorded above. If adjustment is necessary, secure engine and have crewman adjust engine using procedures in Aircrew Pocket Checklist A1-H53BE-NFM-900.

(b) W_f — Record fuel flow when correct N_g is attained. Target fuel flow is 200 to 350 pounds per hour (PPH).

(c) Engine Instruments — Check all engine parameters for unusual indications in the ground idle regime.

c. Repeat process for #2 and #1 engine.

11. Resume PCL at **STARTING ENGINES/ROTORS** checklist fuel selector levers crossfeed 3-3-1, until after MGB OIL PRESS, BLADES SPREAD, and FLIGHT READY lights off.

WARNING

- There are no interlocks to prevent turning off pressure to either hydraulic stage when a servo in the other stage is in bypass. Enough force can be generated by a bypassed stage to drive a servo to its extreme if pressure is unavailable to the nonbypassed stage.
- Do not attempt flight if hydraulic pressure fails to transfer or both systems can be secured at the same time.

Note

- Improper servo timing, excessive air, or incorrect primary servo input rigging can result in fluctuations or control jumps.
- While doing interlock checks and/or securing individual servo stages, blinking first or second stage servo pressure lights can occur.

A C

12. Control Reponses at GRD IDLE:

a. With AFCS, TRIM, and SERVO 1 on; place pilot's flight control SERVO OFF switch to 2 STG. Check that 2 STG M/R SERVO BYPASS, 2 STG PRESS M/R, 2 STG T/R SERVO BYPASS and UTILITY T/R PRESS lights illuminate and second stage pressure indicator to read zero. Although a slight displacement is permissible, there should not be large or cycling fluctuations in the tip path plane or jump in controls when switching servo positions. With pilot's switch in 2 STG, copilot place copilot's SERVO OFF switch to 1 STG. First stage should not secure. If first stage secures immediately return switch to center.

b. Move cyclic then collective slightly and cautiously while watching tip path. Note corresponding tip path movement with control input. Center cyclic and collective and repeat process in yaw noting slight nose movement corresponding to pedal inputs. Center control and have copilot repeat process in same condition. Lack of corresponding movement or reverse movement in any axis is an indication of mechanical flight control malfunction.

c. Place pilot's flight control SERVO OFF switch to 1 STG. Check that 1 STG M/R SERVO BYPASS, 1 STG PRESS M/R T/R, and 1 STG T/R SERVO BYPASS lights illuminate and first stage pressure indicator to read zero. Although a slight displacement is permissible, there should not be large or cycling fluctuations in the tip path plane or jump in controls when switching servo positions. With pilot's switch in 1 STG, copilot place copilot's SERVO OFF switch to 2 STG. Second stage should not secure. If second stage secures immediately return switch to center. Move flight controls and check as described in step b.

d. Repeat steps a. through c. on copilot's controls.

e. Center both SERVO OFF switches and engage SERVO 1 leaving SERVO 2 armed.

PROFILE

13. Resume PCL at **STARTING ENGINES/ROTORS** checklist rotor 100%, N_r, until after No. 2 generator on.

A

14. APP

a. Place APP emergency start switch to EMER. Individually pull and reset HIGH EXH TEMP and LOW OIL PRESS circuit breakers. APP should continue to operate. Pull both HIGH EXH TEMP and LOW OIL PRESS at same time. APP should continue to operate.

b. Pull overspeed circuit breaker. APP should flame out and N_g should decrease immediately. Move APP handle to SHUT OFF to prevent post shut down fire.

c. Note coast down time from flame out to 0% N_g. Time should be 45 seconds ±10 seconds.

15. Purge pushbutton — AS DESIRED.

10.3.5 Pre-Taxi

A D

1. Engine Overspeed — At 100% N_r, individually position overspeed switches to TEST. Note fluctuations in N_r, N_g, W_f, and T_5.

A D

2. Flat Pitch — Position all three speed control levers full forward. Check N_r 104 to 107%. Retard #2 and #3 speed control levers to ground idle.

Note

Pilot's quad tach and triple torque indicator shall be used for all checks except copilots two per cent torque.

A D

3. Maximum N_r/N_f Governing Check and Torque Calibration — Check N_f to read 102.5% ±0.5%. Have crewman adjust as required using Aircrew Pocket Checklist A1-H53BE-NFM-900. Check/adjust #2 and #3 low side torque to read 2%. Advance #2 engine and retard #1. Check #2 N_f and #1 low side torque. Do not attempt to adjust #2 N_f with rotor engaged. Advance #3 and retard #2. Repeat checks and adjustments as required for #3 engine. Maximum difference among all engines shall not exceed 1/2% N_r. Match torques and set rotor at 100% N_r.

A D

4. Acceleration Check — With all three-speed control levers at full forward, retard #1 engine speed control lever to ground idle. Allow engine to stabilize at ground idle for minimum of one minute to allow for turbine shroud cooling. Advance #1 speed control lever to full forward within one (1) second. Note amount of time engine takes to spool up to 80% N_g and immediately retard lever to ground idle. Time to 80% N_g should not exceed 10 seconds and engine shall not flame out or compressor stall throughout acceleration or deceleration. Repeat process on #2 and #3 engine.

CAUTION

Whenever accelerating an engine to rematch N_f/N_r, carefully advance speed control lever to avoid abrupt reengagement of free wheeling units, which leads to free wheeling unit failures.

A CD

5. Vibrations — If during rotor engagement and engine acceleration, look for ground shuffles, ground rolls, 1 per, and/or high frequency vibrations. If noteworthy vibrations are felt and initial

PROFILE

main rotor or tail rotor track and balance is not required, stop functional check flight here and troubleshoot aircraft with maintenance department.

A 6. Electrical Power Supply Checks

a. Generator Drop Out and Pick Up — ACFS SERVO 1 ON, SERVO 2 UNARMED, AFCS OFF, and TRIM OFF. Reduce N_r slowly until generators caution lights illuminate. Note N_r and increase speed control levers to 100% N_r. Generator drop out and pick up should occur from 91% to 96% N_r. Reengage AFCS and TRIM.

b. Generator Checks — Turn on either pilot's anti-exposure suit blower and note air blowing from hose. Turn #1 generator OFF. Note #1 generator caution light goes on and air no longer blows from hose. Turn #1 generator ON and note caution light goes off and air blows from hose. Repeat process on #2 and #3 generators. Secure blower after completion of checks.

Note

With AFC 490, the #2 GEN, #3 GEN, #2 RECT, BIM, COMPASS FAIL, and CG HOOK INOP caution lights and the AFCS DEGRADED advisory light should come on and the AFCS control panel should indicate a simplex failure.

c. Rectifiers — Turn on copilot's spotlight and beep beam to where it is visible from cockpit. Pull CONVERTER NO. 1 circuit breaker on No. 1 primary AC bus panel in cabin. Note #1 RECT caution light illuminates and copilot's spot goes out. Reset circuit breaker and note caution light out and spotlight on. Pull CONVERTER NO. 2 on No. 3 primary AC bus. Note #2 RECT caution light and spotlight goes out. Reset circuit breaker and secure/stow spotlight.

d. Single Generator Operation — Turn No. 1 and No. 2 generators off and check for the #1 GEN, #2 GEN, and #1 RECT caution lights. Turn the No. 2 generator on and the No. 3 generator off and check for the #1 GEN and #3 GEN caution lights. Turn the No. 1 generator on and the No. 2 generator off and check for the #2 GEN, #3 GEN, #2 RECT, and BIM caution lights. Turn the No. 2 and No. 3 generators on and check that all generators, rectifiers, and BIM caution lights extinguish. Aircraft with AFC 490 incorporated check for #2 GEN, #3 GEN, #2 RECT, BIM, COMPASS FAIL, C/G HOOK INOP caution lights and the AFCS control panel will display a simplex failure.

7. Resume PCL at **PRE-TAXI** checklist anti-ice as required, until the **TAXI** checklist.

10.3.6 Taxi

A 1. Wheel Brakes — Each pilot check first left the right brake pedals. Press both pedals and set brakes. Release brakes at end of check.

AB 2. Heading Indicator/Turn Needles Check

a. Check that heading indicators turn appropriately while aircraft taxis.

b. Turn Rate Transfer While Taxiing — Pull copilot's VGI circuit breaker on emergency dc bus circuit breaker panel in the cockpit. Copilot's turn needle should be inoperative. Press copilot's TURN RATE switch to light ALT. There should be a slight jump in the rate needle, indicating a switch over. Turn rate indicator should become operative. Press switch to light NORM and reset circuit breaker. Repeat procedure using PILOT VGI circuit breaker

PROFILE

on emergency dc bus breaker panel in cockpit. Press pilot's TURN RATE switch to light ALT. There should be a slight jump in the rate needle, indicating a switch over. Turn rate indicator should become operative. Press switch to light NORM and reset circuit breaker.

A C 3. Flight Control Response (Taxiing) — While taxiing, check operation of tail rotor controls by making slight taxiing turns to right and left without using wheel brakes.

A C 4. 100% N_r Servo Check — At 100% N_r, recheck servo timing by turning off first stage. Check for tip path plane response. Move pedals a slight amount both left and right to check for proper operation of tail rotor servo. Repeat checks for second stage.

Note

When switching AFCS servo systems, slight displacement is permissible. However, there should not be large or cycling fluctuations in the tip path plane or jump in controls when switching servo positions in excess of 4 inches.

10.3.7 Pre-takeoff. Complete the **PRE-TAKEOFF** checklist.

10.3.8 Flight

A C 1. Hover Controllability — Ensure that AFCS SERVO 1 is ON, AFCS SERVO 2 is ARMED, and the AFCS and TRIM pushbuttons are ON. Slowly lift to a 10- to 15-foot hover to ensure proper operation of the system and that there are no pronounced vibrations. Observe all engine and transmission instruments for proper operating range. Check tail rotor control by making left and right turns on the spot of at least 10°, short right and left/forward and aft slide. Note proper flight control response. Ascend to a 25- to 50-foot hover into the wind. Make a 360° right pedal turn stopping every 90°. When right pedal turn is complete, repeat pedal turn to left. Ensure BDHIs follow aircraft through turn.

A C 2. Lateral Flight — With AFCS and TRIM on, enter right sideward flight into the wind at 35 knots airspeed. At 35 knots, helicopter should maintain heading and there should be enough left pedal remaining to yaw helicopter to the left. Reposition aircraft and with AFCS and TRIM on, enter right sideward flight into the wind at 35 knots airspeed. At 35 knots, helicopter should maintain heading and there should be enough left pedal remaining to yaw helicopter to the left.

Note

- This check should be made at 50 feet with helicopter going into wind sideward.
- To obtain 35 knots airspeed, subtract wind component to get ground speed.

A 3. Generator Underfrequency — While hovering reduce N_r to 91% for at least 5 seconds. Generators should not drop out. Reestablish 100% N_r.

AB 4. AFCS in a hover:

a. Power change/Heading Hold — Make a quick ±20% torque change with feet off pedals. Helicopter transient heading error should not exceed 5° either side of original heading.

Note

A properly rigged yaw system will have left pedal about 1 inch forward of right pedal in a hover motionless, into the wind.

PROFILE

b. Push/Pull Release — AFCS and TRIM on and helicopter trimmed for a hands-off hover into the wind, push cyclic forward 1/2 inch against the stick trim for 1 second and release. Helicopter should return to original attitude with no more than one overshoot. Repeat procedure for aft, left, and right.

c. Hover Stability — Trim helicopter for a hands-off hover into the wind. Helicopter should maintain attitude to within ±1°, and heading within ±3°. Additional tolerance must be added under gusty conditions. Repeat with SERVO 2.

d. RAD ALT Hover — Set ALT SET knob to a known altitude that will be referenced during this check. Establish a hover at that known altitude and engage RAD ALT. Helicopter should hover at that altitude ±7 feet, as indicated on the radar altimeter.

A

5. Cargo Ramp/Door/Tail Skid Operation — While hovering, place ramp master switch to PILOT. ISOLATION VALVE OPEN advisory light should illuminate. Place ramp position switch to CLOSE. Ramp should remain in position and door should close if not already closed. Place ramp position switch to level. Ramp should open to level position and ramp door should open and lock. RAMP OPEN advisory light and crew's ramp UNLOCKED light should go on. Place ramp position switch to close. Ramp and door should close. Place ramp master switch to CREW and repeat all checks. Place ramp master switch to OFF. ISOLATION VALVE OPEN advisory light should extinguish. During this check, Tail skid should remain extended because landing gear is down.

CAUTION

Prior to ramp being moved, ensure ramp flippers are secured or removed from ramp and upper ramp door is not pinned in place. Actuator should be installed on ramp door and functional.

A

6. Landing Gear/COMM 2 Antenna — Raise and lower landing gear. Time required from handle movement to up indication should be 15 seconds or less. Note that red light in landing gear handle is on any time gear is in transit. During down cycle, handle light will go off when gear is down and locked. After up cycle, handle light will go off about two seconds after gear is up and locked. Note that tail skid extends and retracts with landing gear. Check COMM 2 antenna is in AUTO. Note that antenna extends when gear goes up and antenna retracts when gear goes down. AFC 455 removes this function.

A D

7. Collective Bias — Check that aircraft weight is 56,000 pounds or greater. On ground, reduce N_r below 99%. To prevent hysteresis, increase only the speed control levers to adjust N_r to 100%. Ensure torques are matched on triple torque indicator. Smoothly pull in power until safely off the deck and, without stopping, increase collective to 100% torque. While in a climb, N_r should read 100 ±2% with a maximum allowable torque split of 8% between any two engines. If torque split is greater than 8%, land helicopter and adjust collective bias using Figure 10-1. Do not adjust collective bias in a hover.

Note

Do not adjust collective bias while in flight or in a hover. Adjustments made in a hover will not account for hysteresis and will give erroneous reading after collective is lowered.

8. Refer to PCL **FLIGHT** checklist as required.

PROFILE

AB — 9. Heading Hold Take Off — Lift helicopter into a stable hover and note torque. With feet off pedals, take off by increasing torque 20% greater than indicated hover torque. Transient heading should not be over ±5°.

A — 10. Flight Instruments — Check that pilot and copilot airspeed indicators are within 5 KIAS of each other and the altimeters are within 75 feet of each other.

11. Autorotation

A C — a. Auto Turn Check — Set altimeter to 29.92 and lower landing gear if over land. Climb to altitude, where N_r is to be recorded and cruise until OAT has stabilized. Compute density altitude then refer to Figure 10-2 to determine rpm for conditions. Climb an additional 700 to 1000 feet for start of autorotation. Level off, establish 95 KIAS, and select a heading that provides an approach to a suitable landing area if a problem occurs on recovery. Slowly reduce collective to full low pitch, holding 95 KIAS. At some combinations of gross weight and density altitude, it will be necessary to retard the speed control levers slightly to separate N_f from N_r. After noting N_r, return speed levers to a position that will maintain 100% N_r during the recovery. Make no control inputs at least 100 feet before rpm check altitude. Record rpm. N_r should be within ±2.5% of the rpm obtained from Figure 10-2. If correct rpm not achieved, adjust all pitch control rods between the rotating swashplate and the blades. Lengthen rods to lower rpm. Shorten rods to increase rpm. One full turn changes RPM 3% N_r.

ABC — b. BAR ALT Autorotation — Enter a 95-knot autorotation with collective on bottom stop and let N_r stabilize. Hold collective down, engage BAR ALT, and descend another 200 feet. The N_r should remain the same. Disengage BAR ALT. If a tip path plane jump is experienced, terminate the flight and have collective rigging checked.

A C — c. Yaw Control Check — Autorotate and yaw helicopter left and right. Adequate tail rotor control should be available. Check tail rotor rigging if control is not available.

A C — 12. In-flight Track and Balance — As required by helicopter maintenance, perform an in-flight track and balance using authorized vibration analysis equipment. Continue track and balance until acceptable limitations are achieved for main rotor system. If track and balance adjustments are made, verification autorotation is required to ensure track and balance adjustments did not push auto turns out of specification.

A C — 13. Vibrations — Fly helicopter at 150 KIAS. Listen and feel for abnormal vibrations. Reduce airspeed to 130 KIAS and commence 30° level turns, climbs and descents noting unusual vibrations and beats. Objectionable vibrations should be troubleshot using authorized vibration analysis equipment and procedures.

A C — 14. Flight Control Position — With helicopter trimmed for straight and level flight at 150 KIAS and 2000 feet density altitude, cyclic should be approximately 3 inches from forward stop longitudinally, centered in roll; collective 2 inches from upper stop; and pedals approximately centered within one inch.

Note

Ensure that, prior to checking fuel transfer system, main fuel cells have burned down sufficiently to allow increase in main fuel indications to be noted and that transfer checks will not be interrupted by high-level shutoff valves. During transfer checks, as main fuel cells near full, have crewman look for fuel to dump overboard from fuel vents indicating inoperative fuel shutoff valves.

A

15. Fuel Transfer System — Ensure refuel power is secured and probe is in STOW.

a. Left Aux. to No. 1 and No. 2 Left — Place the left auxiliary transfer/refuel switch to XFR. Place No. 1 and No. 2 left transfer/refuel switch to XFR. Observe L MAIN FLOW light to illuminate. Note that main fuel indications increase and left auxiliary indicator decreases. Secure transfer to main tanks.

b. Left Aux. to No. 3 and No. 2 Right — Keep the left auxiliary transfer/refuel switch to XFR. Place No. 3 and No. 2 right transfer/refuel switch to XFR. Observe R MAIN FLOW light to illuminate. Note that main fuel indications increase and left auxiliary indicator decreases. Secure main and auxiliary transfer switches.

c. Right Aux. to No. 1 and No. 2 Left — Place the right auxiliary transfer/refuel switch to XFR. Place No. 1 and No. 2 left transfer/refuel switch to XFR. Observe L MAIN FLOW light to illuminate. Note that main fuel indications increase and left auxiliary indicator decreases. Secure transfer to main fuel tanks.

d. Right Aux. to No. 3 and No. 2 Right — Keep the right auxiliary transfer/refuel switch to XFR. Place No. 3 and No. 2 right transfer/refuel switch to XFR. Observe R MAIN FLOW light to illuminate. Note that main fuel indications increase and left auxiliary indicator decreases. Secure main and auxiliary transfer switches.

e. Turn on both main and auxiliary transfer. As tanks near full, check for main fuel tank vents for overboard spills. When main fuel tanks are full, secure transfer and purge fuel lines. Time purge cycle to take 8.5 minutes.

A

16. Fuel Dump — Climb to a minimum altitude of 6000 feet and maintain straight and level flight. Position aircrewman where dump tube discharge can be witnessed. Actuate, individually, each fuel dump switch and have aircrewman report fuel discharge with corresponding drop in quantity gage.

A D

17. Engine Anti Ice — Individually actuate each anti ice switch. Note an increase in T_5 with switch actuation and IGV ANTI ICE ON advisory light illuminates. If engine inlet removable section is below 37°C, note ENG ANTI ICE caution light to illuminate. If caution light illuminates, system should generate enough heat to extinguish light in three minutes or less unless outside air temperature is below freezing.

A D

18. Four-point Performance Check — The four-point performance check determines minimum acceptable power for existing ambient conditions and pressure altitude.

a. Establish airspeed at 90 to 120 knots, wings level with EAPS open.

Note

Perform performance checks with EAPS doors open only due to inconsistent pressure loss across EAPS.

b. Ensure cabin heater, APP, engine anti ice, BAR ALT HOLD, fuel transfer and purge are secured.

c. Set barometric altimeter to 29.92 and select a pressure altitude.

Note

- Target pressure altitude must be maintained within ±100 feet.
- N_r must be maintained at 100% ±1%.
- Upper T_5, N_g, and torque limit, whichever is achieved first, is checked first to make sure topping is properly set. Incorrectly adjusted topping mechanically limits engine performance.
- The fuel control mechanically limits N_g to 102.5% if operating properly.
- If temperature is below 5°C, pressure altitudes below 1000 feet may result in an inability to reach maximum performance. If this happens, increase altitude and repeat check.
- At pressure altitudes above 1000 feet, anticipate the following conditions:

  1. If temperature is below -5°C, expect to reach 100% N_g before reaching 773°C T_5 on the -416 or 792°C T_5 on -416A.
  2. If temperature is -5°C to +5°C, N_g or T_5 becomes the limiting factor of performance.
  3. If temperature is above +5°C, T_5 should be the limiting factor.

- If maximum N_g or torque is reached prior to the target T_5, the performance plot shall be based on the indicated T_5 at that performance limitation.

d. Maintain 100% N_r, target airspeed, and target altitude. Adjust speed control lever/collective pitch to obtain maximum T_5 (773°C for -416 or 792°C for -416A), 100% N_g, or 137% torque.

Note

During performance check, allow engine to stabilize for a minimum of 1 minute. Recording any parameter prior to stabilization will provide inaccurate and erratic performance data.

e. After engine has stabilized record directed parameters.

f. Adjust collective and speed control levers to achieve next three reporting thresholds.

g. Repeat procedures for the next two engines.

A 19. Heater — Check heater rheostat OFF and VENT off. Aircrew check that all diffusers in cabin are open. Cockpit diffusers and circular vents open. Blower should not be running. Place VENT switch ON and check for airflow at all vents and diffusers, then secure vent blower. Turn rheostat to middle position. Both vent fan and combustion blower should start and heater should light off in 45 seconds. If heater does not ignite is 45 seconds, heater should secure automatically. Check for heat at all vents and diffusers. Turn heat to HI and check for an increase in air temperature. Turn rheostat to OFF. Heater should secure and the vent and combustion blower should continue to operate until plenum chamber is cool.

AB 20. AFCS

PROFILE

a. Collective Drop — Be sure SERVO 1, AFCS, and TRIM are engaged. While in forward flight at 130 knots, with feet off rudder pedals, lower collective to flat pitch within 6 to 8 seconds. Transient heading error should not be over ±10°.

b. Flight Stability — Trim helicopter for straight and level flight at 130 knots. When trimmed, engage BAR ALT. Fly hands-off for about 2 minutes. Helicopter should maintain attitude within 3° in pitch, roll and yaw, during calm air conditions. Altitude should be maintained at ±25 feet, or 1% of altitude, whichever is greater.

c. Push/Pull and Release — Transfer to SERVO 2, AFCS, and TRIM engaged, trim helicopter for straight and level flight at 130 knots. When trimmed, engage BAR ALT. Push cyclic forward 1 inch for 1 second and release. Helicopter should return to original attitude with no more than one overshoot and to 130 ±5 knots. Repeat test, pulling cyclic 1 inch aft for 1 second. Repeat check with left and right cyclic inputs. Repeat check with SERVO 1 on.

d. BAR ALT Beep Trim/Longitudinal Trim Check — With SERVO 1 on, AFCS, TRIM, and BAR ALT engaged, trim helicopter for straight and level flight at 130 knots. Beep cyclic aft to attain airspeed of 110 knots. Helicopter should maintain altitude within 40 feet and new airspeed without excessive oscillation or overshoots. Look for smoothness in cyclic travel and total control of beeper. Retrim by beeping to 130 knots and check previous tolerance.

e. Auto Bank — With SERVO 1 on, AFCS, TRIM, and BAR ALT engaged; trim helicopter for straight and level flight at 130 knots and engage AUTO BANK. Apply lateral cyclic force to roll slowly into a 20° left bank without use of beeper trim or trim release. The pedals may move to maintain a coordinated turn. Stop roll rate and release cyclic. The helicopter should maintain a 20° left bank. Ball in turn and bank indicator should hold to within ±1/2 ball width. After 180° of turn with the ball trimmed to the center of the race, slowly roll back to within 2° of wings level, arrest the roll and yaw rates and release the cyclic. The helicopter should return to a zero bank angle. Repeat check in 20° right bank.

f. Trimmed Turn — With AUTO BANK disengaged and SERVO 1 on, AFCS and TRIM engaged, trim helicopter for straight and level flight at 130 knots. Beep cyclic to obtain 20° of bank. Fly hands-off through at least 180° of turn. Helicopter should remain in trimmed flight and there should be no undesirable pitching or rolling. Pedals may move to maintain a coordinated turn. Ball in the turn-and-bank indicator should hold to within ±1/2 ball width of center. After 180° of turn, leave feet on pedals and roll out. Repeat above in opposite direction.

g. FAS Checks — Establish trimmed level flight at 120 KIAS. BAR ALT hold off.

(1) Gently push cyclic forward against the trim. Note the increase in force required to move the cyclic over the forces required in the hover for "push/pull and release checks". Allow aircraft to return to trimmed level flight.

(2) Trim aircraft to a level 20° angle-of-bank at 120 KIAS. Against trim, increase angle-of-bank to 45°, apply aft cyclic pressure to maintain airspeed, collective to maintain altitude. Note the increasing stick forces and discernible forward stick drive resisting the aft cyclic pressure. Allow helicopter to return to 20° angle-of-bank trim position.

(3) Trim the helicopter into a level 20° angle-of-bank at 120 KIAS. Against trim, increase angle-of-bank to 35° to 40°, adjust collective to maintain altitude. As the

helicopter rolls through 35° angle-of-bank, airspeed hold should disengage. When airspeed increases more than 5 knots, allow cyclic to return to 20° angle-of-bank trim position. Airspeed should return to 120 KIAS.

h. Pedal Check — At 120 KIAS with ball within ±1/2 ball width of center, kick ball out of center no more than 1 — 1/2 ball width. Forces should not be over 24 pounds. Press pedal release switch on collective and forces should disappear. Release the pedal release switch and allow pedals to move, note helicopter returns to coordinated trimmed flight.

A

21. HF Radio — Turn on radio and channelize at 29.000 or 29.999 depending on radio installation. Ensure that side tone is heard as radio channelizes. Select an appropriate "Mainsail" frequency and set. Channelize frequency and ensure side tone is heard. Attempt to transmit to selected station. Have other crewman check for appropriate side tone. Have crewman attempt to transmit from helo team leaders station. If responding station hears transmission, set radio to 29.000 or 29.999 (depending on installation) and channelize. Secure radio after shutdown frequency is set. If no station responds, turn international time hack frequency and listen for time hack. If time hack can be heard, set shutdown frequency and secure radio.

A

22. Navigation Sets

a. UHF-DF

(1) (ARC 182) Fly over a known geographical point with a known radial/DME from tower. Using COMM 1 set to tower frequency, turn mode to DF. When tower transmits note NO 1 needle to point at radial that the tower resides on selected BDHI. If possible turn aircraft and note needle locked to radial. Repeat procedure in VHF and for COMM 2 UHF and VHF.

(2) (ARC 210) Fly over a known geographical point with a known radial/DME from tower. Using COMM 1 set to tower frequency, turn operational mode to ADF. When tower transmits note NO 1 needle to point at radial, which the tower resides on selected BDHI. If possible turn aircraft and note needle locked to radial. Repeat procedure in VHF and for COMM 2 UHF and VHF.

b. LF/ADF — Fly over a known geographical point with a known radial/DME from transmitter. Select frequency and note #1 pointer on selected BDHI should indicate known bearing ±5°. Repeat on headings of ±45°. With CW and ANT selected a beat note should be heard in headset. Select VOICE and check ADF receiver operation with mode selector to ANT. Check for audible reception on middle and high bands.

c. TACAN — Fly over a known geographical point with a known radial/DME from transmitter. Select desired channel and note No. 2 needle in selected BDHI to lock to known bearing of station ±2°. Turn helicopter until nose is centered on NAVAID. Turn CDI course select until CDIs are centered and ambiguity window reads TO. The course selected window should read the known heading ±2.5° and No. 2 needle on selected BDHI should have head of needle pointing at station ±2°. Maintain heading toward station and turn course selector knob until CDIs are on second dot and note course selected. Turn knob opposite direction until CDIs are on second dot on other side of indicator and note heading. There should be a 10 ±3° difference between to annotated courses. Turn course selector knob to reciprocal heading of known radial. Note ambiguity window to read FROM.

d. VOR — Fly over a known geographical point with a known radial/DME from transmitter. Select desired frequency and note No. 2 needle in selected BDHI to lock to known bearing of station ±2°. Turn helicopter until nose is centered on NAVAID. Turn CDI course select until CDIs are centered and ambiguity window reads TO. The course selected window should read the known heading ±2.5° and No. 2 needle on selected BDHI should have head of needle pointing at station ±2°. Maintain heading toward station and turn course selector knob until CDIs are on second dot and note course selected. Turn knob opposite direction until CDIs are on second dot on other side of indicator and note heading. There should be a 10 ±3° difference between to annotated courses. Turn course selector knob to reciprocal heading of known radial. Note ambiguity window to read FROM.

e. ILS — If possible, contact approach and execute an ILS approach. Note during approach that localizer and glideslope indicators react to ILS signals and that glideslope warning flags retract when glideslope is intercepted.

f. IFF/SIF — Contact local approach agency and check all functions of IFF/SIF, if possible.

g. GPS — The CDNU ON switch is a two-position switch providing electrical power to the CDNU. Perform GPS initialization procedures and note any discrepancies, then press STAT and check the system GO/NOGO status. To clear any flashing check sign, press CLR. Press IDX and confirm the correct LAT LONG, month, day, year, WGS - 84 and 47 are displayed. If not correct, enter correct data. Press the line select (L/S) to left of data position, and the data will transfer from scratchpad to the display. Ensure GPS initializes. Fly over a known geographical point with a known radial/DME to desired LAT/LONG. Enter correct LAT/LONG and note No. 2 needle in selected BDHI to lock to known bearing of station ±2°. Turn helicopter until nose is centered on LAT LONG. Check all ancillary functions of GPS and note that all subsystems are operational.

A D 23. EAPS — Above 150 feet, slow helicopter to 50 KIAS, gear up. Note EAPS DOOR CLOSED advisory light illuminates between 100 and 60 KIAS.

Note

Prior to performing this check, be sure that radar altimeter is on and operating.

A 24. Landing Gear — Descend through 150 feet and note the LDG GEAR UP warning light flashes and a pulse tone is heard in the headset at 150 ±10 feet. Slow helicopter to a hover. Press LDG GEAR UP warning light and note light to extinguish and tone to stop. Lower collective and note light and tone to return. Below 150 feet, accelerate helicopter until landing gear warning system secures. Airspeed should be 60 ±5 knots. Ascend above 150 feet and decelerate to 50 KIAS with gear up, gear warning should not sound. Secure radar altimeter and note landing gear warning.

Note

Prior to performing this check, be sure that radar altimeter is on and operating.

10.3.8.3 Descent to Landing. Refer to PCL.

10.3.8.4 Prelanding. Refer to PCL.

10.3.9 Shutdown

A 1. Probe Extension and Retraction — Execute extension and retraction of fuel probe in accordance with the Pilots Pocket Checklist. Note that extension time does not exceed 1 minute and retraction time does not exceed 2 minutes with at least 1 minute between cycles.

PROFILE

2. Refer to PCL until after **SHUTDOWN** checklist flight controls position for shutdown.

A D

3. Engine Fuel Selector Shutdown checks the ability to shut down the engine with the fuel selector lever.

Note

After fuel selector lever shutdown, check fuel filter button normal.

a. Match torques at 100% N_r.

b. Place No. 1 engine speed control lever to GRD IDLE. Place No. 1 engine fuel selector lever to SHUT OFF. When flameout occurs, immediately place No. 1 speed control lever to SHUT OFF and return the No. 1 fuel selector lever to direct until after coastdown.

c. Restart No. 1 engine. If topping has been adjusted, recheck ground idle and make adjustments as necessary.

d. Repeat steps a. and b. for No. 2 engine.

e. No. 2 engine — SHUTDOWN.

f. Repeat steps a. and b. for No. 3 engine.

g. No. 3 engine — SHUTDOWN.

4. Refer to PCL until after **SHUTDOWN** checklist No. 1 and No. 3 generators off.

A

5. APP — Place APP circuit breaker (switch) to OFF. APP should flameout and decelerate to zero in 45 $\pm$10 seconds. Place control lever to SHUTOFF.

6. Complete PCL **SHUTDOWN** checklist.

ROTOR SPEED	#1 TORQUE	CORRECTIVE ACTION TO INPUT LEVER ADJUSTING SCREWS (SEE NOTE)
Remains at 100%	Equals #3	None
Remains at 100%	Less than #3	Turn #1 CCW; #3 CW same amount
Remains at 100%	Greater than #3	Turn #1 CW; #3 CCW same amount
Exceeds 100%	Equals #3	Turn both #1 and #3 CW same amount
Exceeds 100%	Less than #3	Turn #3 CW
Exceeds 100%	Greater than #3	Turn #1 CW
Decreases below 100%	Equals #3	Turn both #1 and #3 CCW same amount
Decreases below 100%	Less than #3	Turn #1 CCW
Decreases below 100%	Greater than #3	Turn #3 CCW

ROTOR SPEED	#1 AND #3 TORQUE	CORRECTIVE ACTION TO INPUT LEVER ADJUSTING SCREWS (SEE NOTE)
Remains at 100%	Equals #2	None
Remains at 100%	Less than #2	Turn #1 and #3 CCW, turn #2 CW twice as much
Remains at 100%	Greater than #2	Turn #1 and #3 CW, turn #2 CCW twice as much
Exceeds 100%	Equals #2	Turn #1, #2, and #3 CW same amount
Exceeds 100%	Less than #2	Turn #2 CW
Exceeds 100%	Greater than #2	Turn #1 and #3 CW
Decreases below 100%	Equals #2	Turn #1, #2, and #3 CCW same amount
Decreases below 100%	Less than #2	Turn #1 and #3 CCW
Decreases below 100%	Greater than #2	Turn #2 CCW

Rotor Speed Adjustment

INITIAL CONDITION: Flat Pitch, 100% N_r
FINAL CONDITION: OGE Hover

NOTE

- CW adjustments decrease torque/N_f/N_r and CCW adjustments increase. CW/CCW pertains to the direction of the knurled adjusting nut, as viewed from below, on the No. 1 and No. 3 engine bias blocks, and as viewed from above on the No. 2 engine bias block.

- If adjusted one engine at a time, one turn will change the torque split by approximately 2%. Adjusting two engines at a time will change the torque split approximately 4% per turn. Once all engines are married, adjusting all three engines, one turn each, will cause N_f/N_r to change approximately 1%.

Figure 10-1. Torque Split Beyond Allowable Limits

AUTOROTATION RPM (% Nr)
95 KIAS

MODEL: CH-53E
DATA AS OF: 17 NOV 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

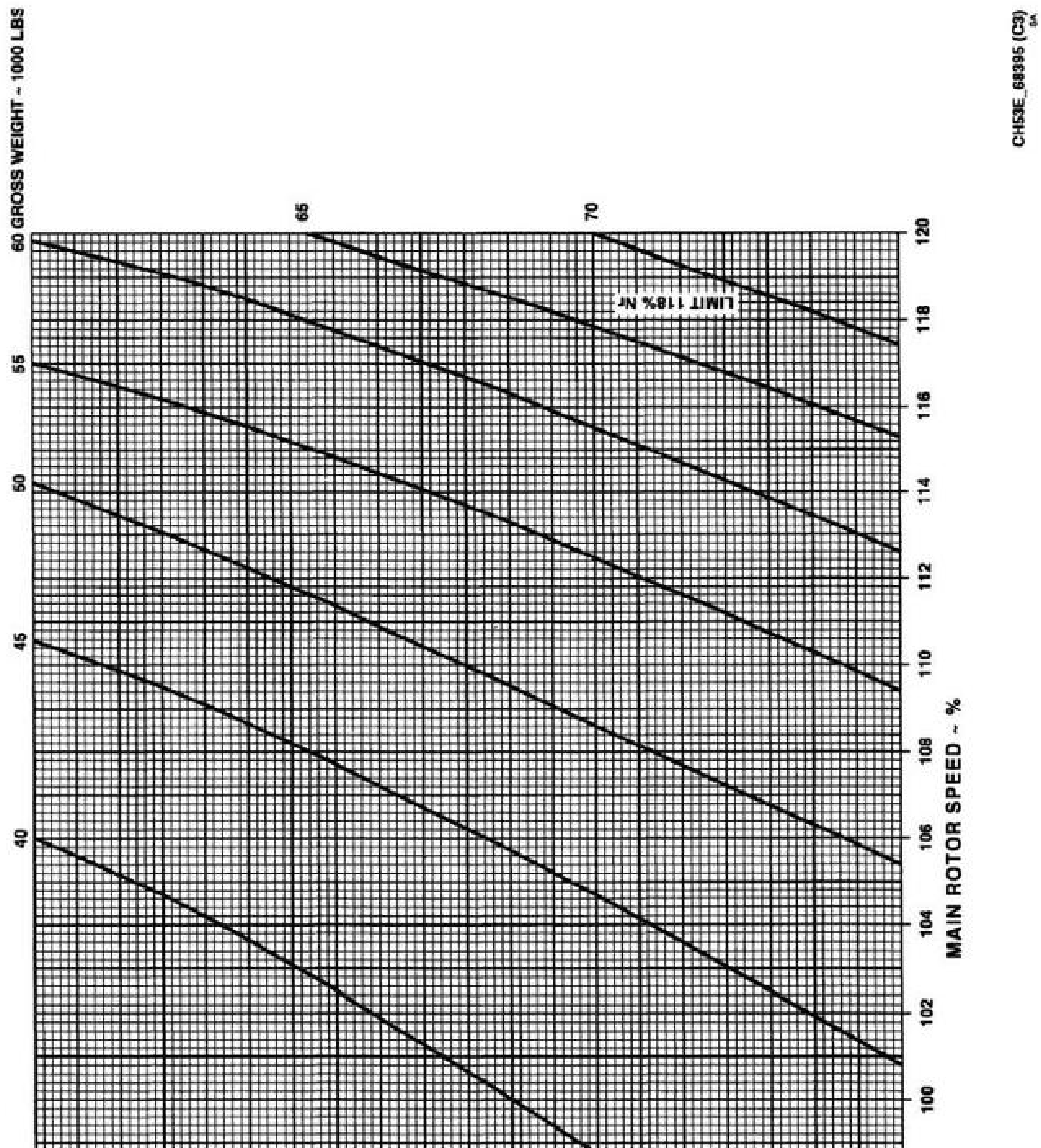


Figure 10-2. Autorotation RPM

PART IV

FLIGHT CHARACTERISTICS

CHAPTER 11
Flight Characteristics

11.1 INTRODUCTION

The unlimited freedom of movement at low speed and normal fuselage attitude, the ability to take off and land vertically, and the ability to hover over one spot comprise the advantageous flight characteristics of the helicopter. The normal speed range extends from a rearward speed of 30 knots to a forward speed of 150 KIAS, which includes sideward flight up to 35 knots. The helicopter is equipped with an automatic flight control system (AFCS) for stabilization.

11.2 SETTLING WITH POWER

Settling with power is a phenomenon which occurs when the power required to maintain level hovering or forward flight exceeds the power available. This may occur at high density altitude, high gross weights, or when operating with degraded engine performance. Careful preflight analysis of performance capabilities in Part XI, and in-flight awareness of ambient conditions, helicopter gross weight, and engine operational power performance will aid in avoiding settling with power. To recover from this condition:

1. Speed Control Levers — FULL FORWARD.

2. Maintain N_r.

3 Increase forward airspeed.

4 Reduce weight by releasing external loads, jettisoning auxiliary fuel tanks, or dumping fuel.

11.3 POWER SETTLING

Power settling is the incapability to stop a rate-of-descent when the helicopter begins to settle into a vortex ring state. A vortex ring state occurs when the velocity of the downwash from the rotor is approximately equal to the rate of descent of the helicopter causing the air to recirculate up, around and back down through the rotor disc. The decreased rotor efficiency that results will cause a loss of lift, increased roughness, and poor control response. Settling may not be recognized as power settling, and a recovery may not be effected until considerable altitude has been lost. Recovery is best made by increasing forward speed and decreasing collective pitch. Increased collective pitch may further worsen the condition. Power settling is most likely to occur during conditions of high gross weight, high density altitude, low airspeed, downwind landing, and descending powered flight.

CAUTION

Flight conditions causing power settling should be avoided at low altitudes because of the loss of altitude necessary for recovery.

11.4 GROUND EFFECT

Ground effect is experienced when hovering at less than approximately 80 feet. When hovering close to a large surface, the surface restrains the rotor downwash permitting an increased hovering capability. This is done by reducing the induced velocity required to produce a given amount of thrust, which correspondingly decreases the amount of power required to hover. The decreased power requirements, when operating in ground effect, enables underpowered or heavily-loaded helicopters to hover, then obtain translational lift.

11.5 TRANSLATIONAL LIFT

Translational lift is the additional lift developed as the helicopter accelerates into forward flight. It is obtained by introducing the rotor to airspeed, thus changing the relationship between power required and power available. As airspeed increases, power required will correspondingly decrease until airspeeds are attained where an increase in drag will require an increase in power.

11.6 GROUND RESONANCE

Ground resonance is a self-excited vibration caused by unfavorable dynamic coupling between lead-lag motions of the rotor blades on their hinges and motions at the main rotor head in the plane of the rotor.

Ground resonance vibration in the fuselage would be at a sub-harmonic frequency of about 2/3 per main rotor revolution.

Analysis, testing, and experience with this aircraft have not revealed any normal flight or ground conditions or likely malservice or failure modes which are subject to ground resonance.

Ground resonance could conceivably be caused by an unlikely combination of multiple failures involving landing gear stiffness or damping or blade lead-lag dampers. In such a case, amplitude buildup would probably be initiated by cyclic motions or a hard one-wheel landing.

If there is reason to believe ground resonance is occurring, recover by becoming airborne. Subsequent attempts at landing should be smoothly executed.

WARNING

If it is necessary to engage the rotor while the helicopter is tied down, it is mandatory that the tiedown chains be loose, relieving any tension in the chains attached above the oleos. Engagement of the rotor while the helicopter is tied down tightly will result in ground resonance.

11.7 ROLLOVER CHARACTERISTICS

11.7.1 Definition of Terms. Static rollover angle, critical rollover angle, and dynamic rollover define the rollover characteristics of any helicopter. Static rollover angle is the angle at which the helicopter will tip over on its side if it is parked on a very steep embankment. The minimum angle is about 27°. It occurs when the helicopter is tilted about an axis passing through the nose gear and either main gear ground contact points. Critical rollover angle is the maximum angle of slope that can be negotiated in a cross-hill landing or takeoff. At this angle, full lateral cyclic input is required to trim the wheels level with the slope without sliding. With the left wheel uphill and brakes on, this angle is about 13°. Dynamic rollover is an insidious dynamic condition that can occur during takeoff or landing with one wheel on the ground. It can result in almost certain destruction of the helicopter. It is not definable by a single number, nor is it simply a function of slope angle or lateral control authority. These will aggravate it, but the main contributor to dynamic rollover is buildup of angular velocity of the helicopter's center of gravity about the wheel touching the ground. When the resulting angular momentum of the helicopter about that wheel is greater than can be countered with full opposite lateral cyclic, the helicopter will roll over. This can occur within 2 seconds. The insidious aspect of dynamic rollover is that the roll rates which precipitate it are within the range the pilot would normally allow in flight. A detailed explanation of dynamic rollover follows, in conjunction with a discussion of slope landing, in order to develop a single set of logical control responses.

11.7.2 Slope Landing and Takeoff. There are three major forces involved in slope landings and takeoffs (Figure 11-1). These are: helicopter weight, rotor lift, and ground reaction (normal and friction forces). In general, the helicopter is controlled by using collective pitch to balance weight with rotor lift and by tilting rotor lift (into the slope) with lateral cyclic, which adds to wheel friction and prevents sliding.

Slope landings should be made by descending slowly and placing the upslope wheel on the ground first. Then, coordinately lower the collective and move the cyclic into the slope until the downslope wheel is also on the ground. The controls should always be positioned to keep the helicopter from drifting. Continue coordinated movement of collective and lateral cyclic until all of the helicopter weight is resting firmly on the ground. If lateral cyclic control contacts its stop, or if rotor-to-ground clearance becomes marginal before the downslope wheel is firmly on the ground, return to a hover by slowly raising

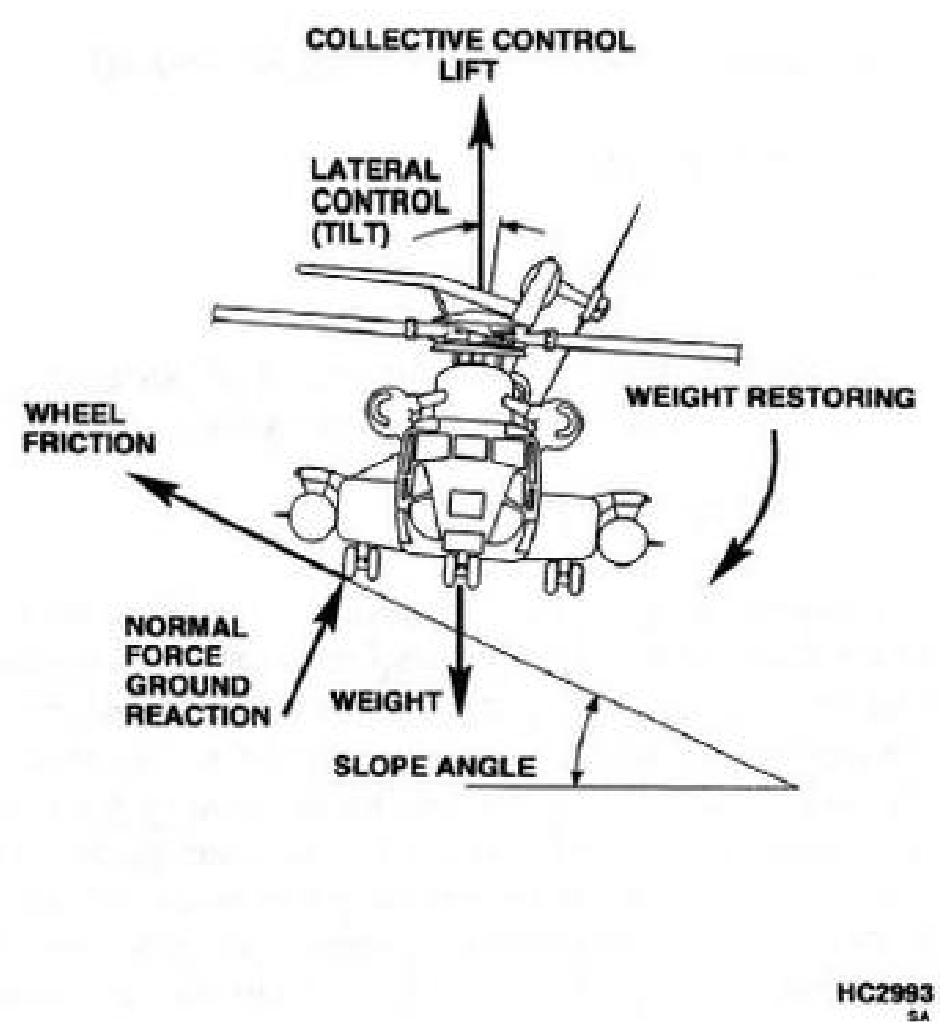


Figure 11-1. Slope Landing and Takeoff

collective and centering cyclic. Select another landing site with a shallower slope. After the slope landing is completed, be sure that the helicopter will not slide downhill, then center lateral cyclic. In a cross-slope landing with one wheel on the slope, collective provides a significant contribution to roll control. Lateral cyclic still provides a hub moment, but control power (roll acceleration per inch of cyclic) about the wheel is substantially reduced. In this landing condition, the roll center is transferred from the center of gravity to the touchdown wheel, which results in a higher roll inertia. The roll inertia about the ground-contact wheel can be five times greater than the roll inertia about the center of gravity. Therefore, the corresponding control power is about 1/5 of the fully-airborne value. Thus, lateral control will feel sluggish. Cross-slope landings (or takeoffs) should not be attempted on slopes steeper than the critical rollover angle (13°). As explained previously, lateral cyclic is on its stop and the downhill wheel is just touching the ground at this angle.

Cross-slope takeoffs should be made by first moving cyclic into the slope to prevent drift. Coordinately raise collective and adjust lateral cyclic to raise the downhill wheel first until the helicopter becomes level and lifts off the ground. Avoid large lateral cyclic displacements when the helicopter becomes airborne, because the roll center will now shift back to the center of gravity and lateral control power will increase five-fold to its flight value. If the helicopter rolls past level (into the slope) during the takeoff, lower collective rapidly but smoothly to avoid dynamic rollover. Set the helicopter back down on the slope and check for a blocked or hung-up wheel.

11.7.3 Dynamic Rollover. Dynamic rollover is the result of the helicopter developing too much angular momentum about a wheel in contact with the ground. It can occur during takeoff and landing on slopes, on corrugated steel matting or macadam, or during a deck launch with one gear still chained. The helicopter can roll over from a level attitude if a high sideward velocity (drift) occurs at touchdown and the wheel is prevented from sliding. This is illustrated in Figure 11-2. In this condition the upsetting rolling moment is caused by the momentum of the helicopter acting about the wheel ground-contact point. Thus, the wheel restraint converts the linear translation (drift) into an angular motion (roll rate) or angular momentum. The roll rate can be very large, depending on the sink and drift speeds, and the degree of wheel restraint. The resulting roll rate may be checked with opposite lateral cyclic, but lateral control will be sluggish (as described above) and will be limited by control range (stops). As in slope landing, and in all cases, smooth reduction of collective is the most effective corrective action the pilot can take to prevent dynamic rollover. If lateral cyclic cannot be displaced far enough to tilt the rotor lift line-of-action outside the wheel tread, then rotor lift adds to the upsetting moment (Figure 11-2). Since rotor lift opposes the only restoring force, helicopter weight, lift should be reduced. Thus, collective should be lowered if it appears that lateral control is ineffective, even though it has not yet contacted the stop. Since the AFCS is limited in authority (±10%) and subject to the same reduction in control power, its effectiveness in countering dynamic rollover is severely limited. For this reason, the pilot must observe the following procedures with caution.

11.7.4 Dynamic Rollover Avoidance Procedures

1. Do all landing, takeoff, and ground maneuvers smoothly, and maintain low roll rates.

2. Avoid rapid takeoffs.

3. Maintain wheels-level during takeoff and landing.

4. On sloping terrain, always lift the downhill wheel first during lift-off.

5. Keep the helicopter trimmed laterally during ground contact. Do not permit it to drift.

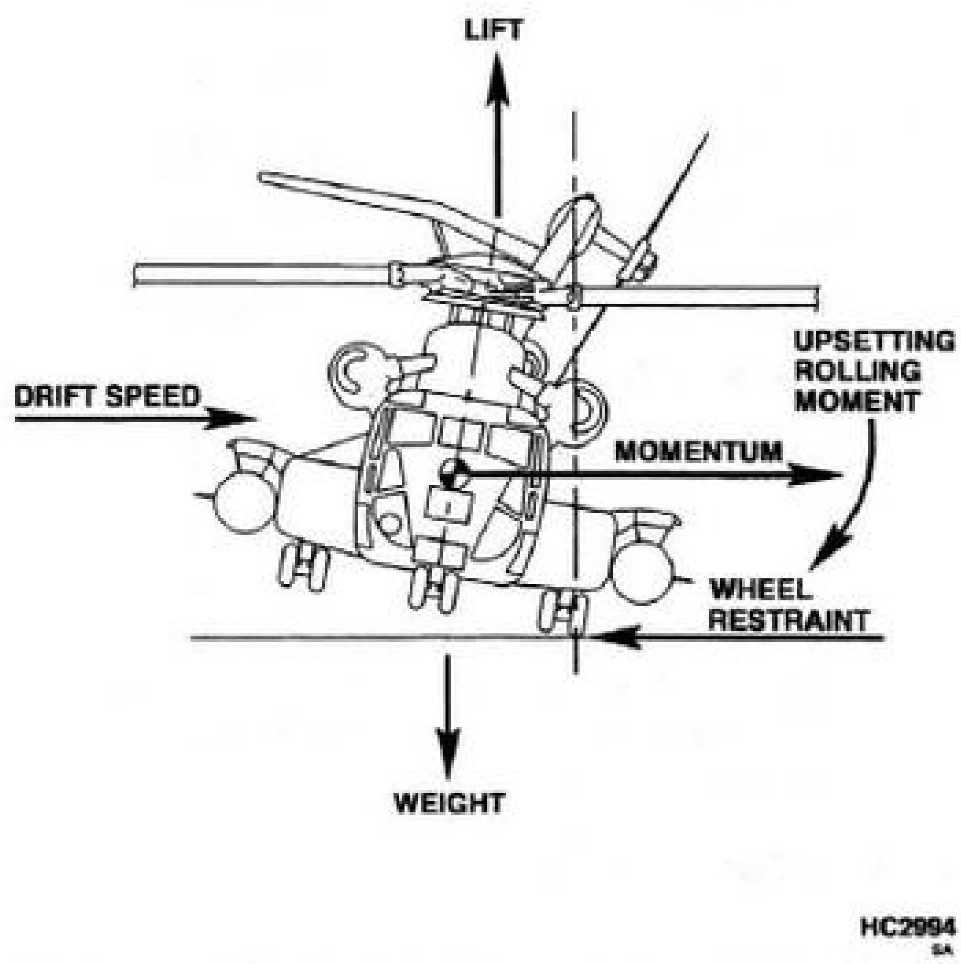


Figure 11-2. Dynamic Rollover Diagram

6. If lateral control feels sluggish, reduce collective and check for obstructions.

7. To correct roll rate, reduce collective smoothly. Avoid fast collective-drop to prevent blade strike or fuselage bounce.

8. Check cross-winds and lateral center-of-gravity offsets.

WARNING

When taking off or landing on a sloping or rough surface, the helicopter can be subjected to conditions which, with the slightest inattention by the pilot to developing roll rates, can result in almost certain destruction by dynamic rollover. Keep the helicopter under control at all times. When landing or taking off with one wheel touching the ground, use smooth collective motion to maintain low roll rates. Do not allow the helicopter to drift during ground maneuvers.

11.8 AIRSPEED INFORMATION

The following airspeeds are recommended for normal flights without external loads:

MANEUVER	AIRSPEED
Climb	100 KIAS
Slow Cruise	115 KIAS
Normal Cruise	135 KIAS
Descent	As required
GCA or CCA	115 KIAS
'Copter Inst. Approach	90 KIAS

Note

Precision approach radar blind speeds may occur during final radar approaches. If so, increase or decrease airspeed within the cruise range.

11.9 DOWNWASH

Downwash is the term applied to the accelerated mass of air under a hovering helicopter. Downwash generated by the helicopter, under certain conditions, may create a hazard for personnel required to work underneath the helicopter during hover operations (HIFR, external cargo operations, hoisting, etc.). Downwash velocity will vary with hover altitude, aircraft gross weight, distance from the aircraft, and height AGL of the velocity measurement. See figures 11-3 through 11-5. Downwash characteristics (pattern, peak gust velocities, etc.) will vary due to all of the above considerations in addition to wind direction and velocity. Directly underneath the helicopter is an area of relative calm (Figure 11-6). Ambient winds will have striking effects on downwash characteristics by reducing effects upwind and increasing effects downwind. This will certainly be a factor in shipboard operations. Ambient winds will cause downwash effects to be experienced in the normally calm area under the helicopter. Personnel movement under the helicopter at lower gross weights is comparable to the CH/RH-53D at a similar disc loading value. All downwash is characterized by great differences between average sustained velocities and peak velocities. Personnel must continually compensate for the changing forces. Control inputs cause large fluctuations in downwash which come as random gusts. This unpredictable nature and higher downwash velocities require a more cautious approach to CH-53E operations. Ability to function under the helicopter also varies with the size, weight and strength of the individual. The following is a general guideline for ground crew operations at various aircraft gross weights when attempting to move about at the point of the greatest downwash velocity.

1. Less than 50,000 pounds — Cautious, unrestricted operation of well-briefed personnel with optimum traction for footing.

2. 50,000 pounds — Limit that most personnel may be expected to tolerate without great difficulty.

3. 50,000 pounds to 56,000 pounds — Some personnel will begin to experience marginal or complete instability.

4. 56,000 pounds — All personnel will experience at least momentary loss of stability.

5. Above 60,000 pounds — Movement of personnel should not be attempted.

Note

- For zero wind, maximum average velocities occur at 49 feet from the rotor center (1.25 rotor radii). Maximum peak velocities occur from 59 feet to 69 feet from the rotor center (1.5 to 1.75 rotor radii).

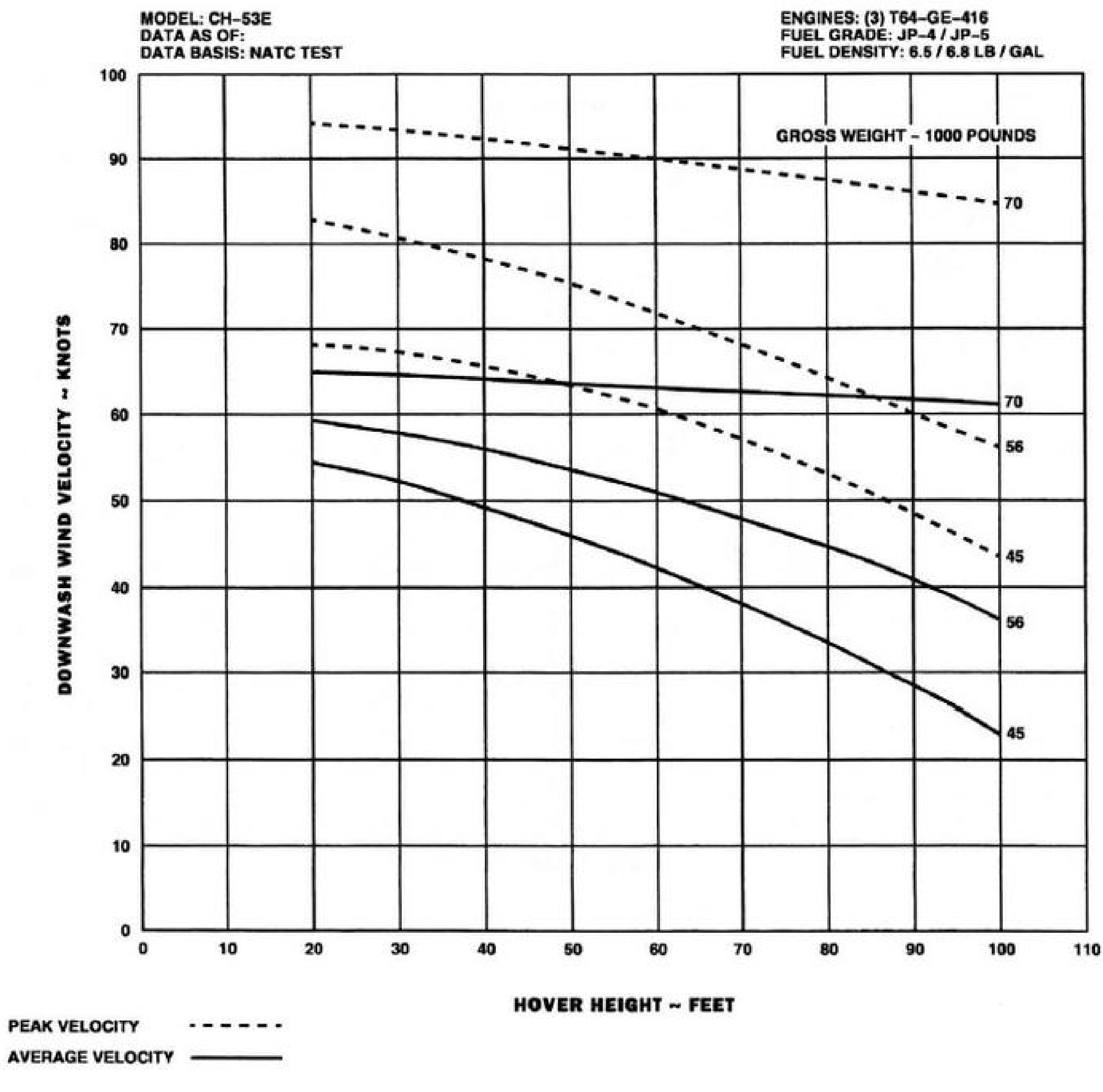


Figure 11-3. Maximum Downwash Wind Velocity as a Function of Wheel Hover Height AGL

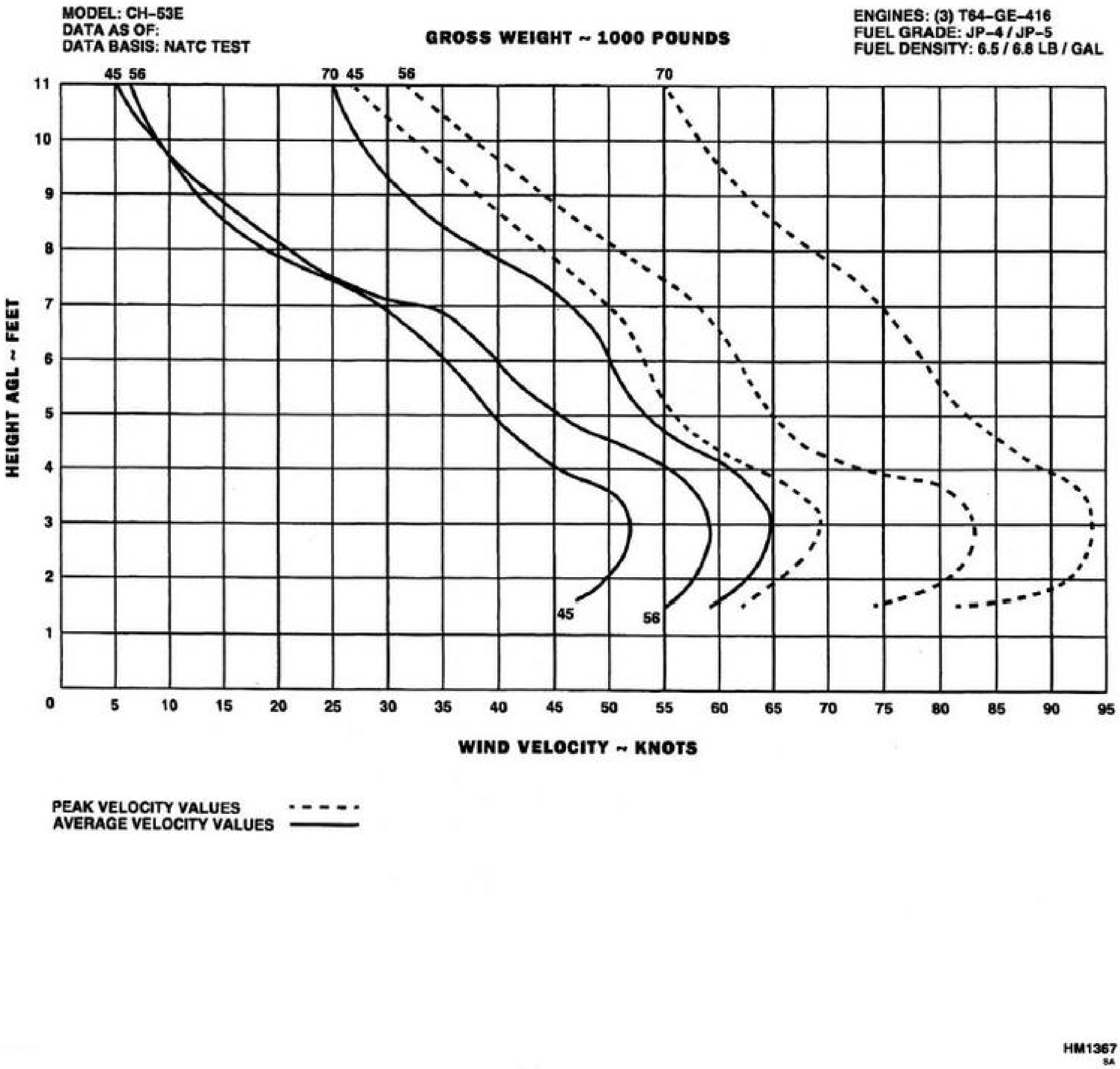


Figure 11-4. Maximum Velocity - Height Profiles of Helicopter Downwash Wind Velocity Measured During a 20 Foot Hover

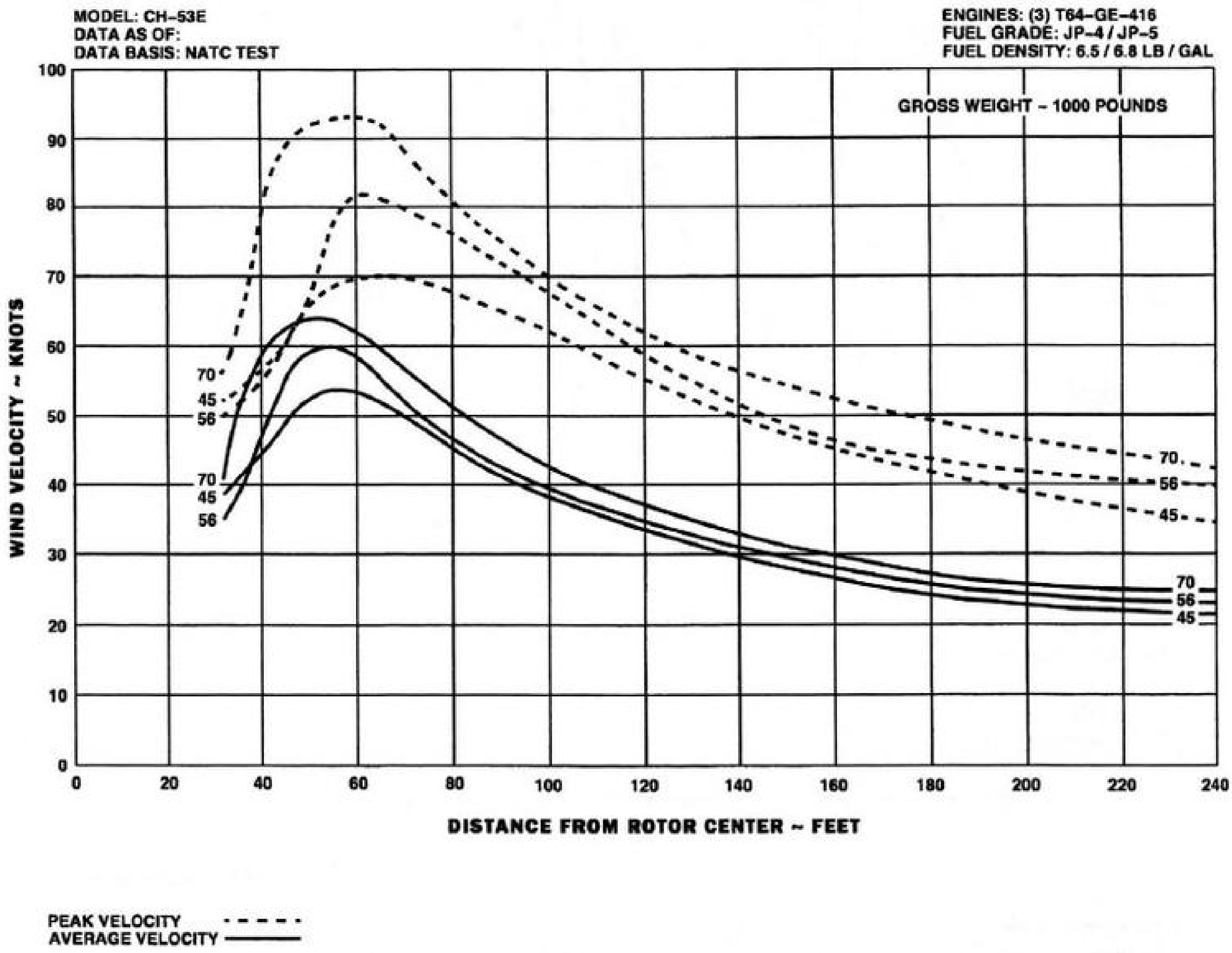


Figure 11-5. Helicopter Downwash Wind Velocity as a Function of Distance from the Rotor Center — Data Measured at a Height of Three Feet

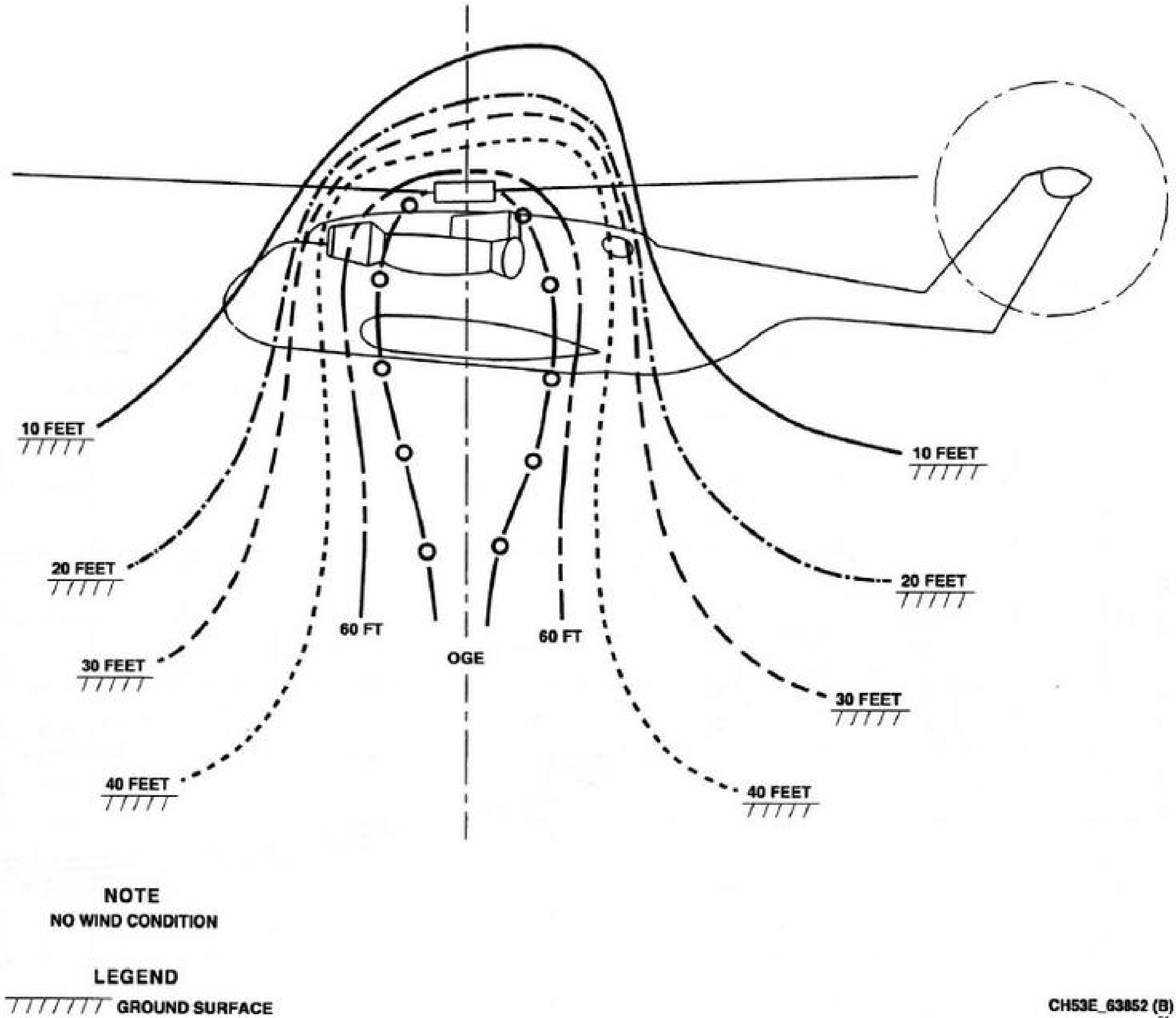


Figure 11-6. Zones of Relative Calm for Various Wheel Heights

- Personnel working underneath a hovering helicopter should have full body impact protection from projectiles (sand, etc.), goggles, and protective helmet with sound attenuation features.
- During external load operations, the pilot should hover without picking up the load until the hookup crew is well clear of the area.
- Recommended action for ground crewmen who are inadvertently engulfed in high velocity downwash is to drop to the ground in a sitting or prone position.

11.10 BLADE STALL

The retreating main rotor blades (the blades moving aft) have a tendency to stall which limits helicopter operating conditions and could cause structural damage. The tendency to stall is a result of reduced retreating blade relative air velocity (rotational speed minus forward speed) and the requirement to retain rotor rolling moment balance on the helicopter. The rolling moment balance requirement is met by increasing angle of attack on the retreating blade and decreasing it on the advancing blade, through a combination of cyclic pitch and blade flapping velocity. For normal flight conditions this angle of attack variation is able to provide rolling moment balance even though the relative air velocity is smaller on the retreating blade. As flight conditions grow more severe, aerodynamic stalling of blade sections will begin to occur on the retreating blades, limiting the amount of lift that can be obtained. Blade stall is most likely to occur when operating at high values of airspeed, gross weight, density altitude, and power, and especially with low rotor rpm. Maneuvers, acceleration, or turbulent air, all of which increase G-load factors, will induce blade stall by reducing the airspeed at which it will occur. The roughness which accompanies it is not pronounced in this model helicopter and is not hazardous. However, operation at high gross weights (50,000 lbs. and greater) and high forward airspeeds will result in excessive fatigue damage rates on rotor system components during flight regimes in which incipient blade stall (Figure 23-11) occurs.

11.10.1 Method of Decreasing Blade Stall. Blade stall may be decreased as follows:

1. Gradually decrease collective pitch.

2. Gradually decrease the severity of the maneuver.

3. Gradually decrease airspeed.

4. Increase N_r. (When possible.)

11.10.2 Incipient Blade Stall Chart. This chart (Figure 23-11) gives the pilot and copilot a rapid means of finding the indicated airspeed at which blade stall occurs for various altitudes, rpm, gross weights, and angles of bank.

11.11 COORDINATION OF FLIGHT CONTROLS

Helicopter control is attained through the conventional use of the cyclic, collective, and rudder pedals. Flight control coordination is further enhanced by a mixing unit that integrates collective with pitch, yaw, and roll to provide essentially a vertical response with collective inputs. In addition to the conventional yaw to roll coupling provided in the mixing unit, yaw is also coupled to pitch, to compensate for the effect of the canted tail rotor. Turn coordination is automatically coupled into the yaw axis above 60 KIAS when entering into a bank turn. Longitudinal forces derived from the FAS actuator are appropriately shaped to provide a cyclic force proportional to the G forces developed in the maneuver.

11.12 LEVEL FLIGHT AND MANEUVERING CHARACTERISTICS

Level flight characteristics are very good at all speed conditions and operational altitudes. Fuselage attitude is dependent on the aircraft's center-of-gravity and airspeed. This is shown in Figure 11-7. The airspeeds in Figure 11-7 are steady airspeeds, not accelerating airspeeds. With accelerating airspeed, such as transition from a hover to forward flight, the aircraft attitude would tend to nose-down instead of nose-up as shown for the low steady airspeeds shown in Figure 11-7. Rearward and sideward flight can be accomplished without difficulty. Rearward flight can be flown up to 30 knots and sideward flight up to 35 knots. With the AFCS engaged, the helicopter is stable about all axes. Heading hold is provided at all airspeeds. Attitude hold is provided from 0 to 60 knots. Airspeed hold is provided above 60 knots. The inherent high control power makes the helicopter highly maneuverable at all airspeeds. Because of this, longitudinal cyclic forces have been introduced, through the AFCS FAS system, to help prevent the pilot from overstressing the airframe and dynamic system. During maneuvering flight above 60 knots, the pilot can expect to feel longitudinal forces commensurate with the G level imposed on the helicopter.

11.13 STRUCTURAL ASPECTS OF MANEUVERING FLIGHT

Maneuvering flight produces stresses in both the airframe and dynamic systems which are of a higher magnitude than level flight stresses at comparable conditions of airspeed and altitude. Exceeding the design limit in the magnitude of the load factor can cause immediate airframe damage. Damage resulting from exceeding the load factor would typically be popped rivets, wrinkled fuselage skin, or deformed fuselage frames. Exceeding the design limit regarding frequency of high load occurrence can result in a shortening of dynamic system component lives. In general, increasing collective pitch during maneuvers results in increased dynamic system stresses, and conversely, decreasing collective pitch, all other factors equal, usually results in lower stresses. High bank angle and high pitch or roll rate maneuvers also usually result in elevated dynamic system stress levels. For the same flight condition, 105% rotor speed will result in lower dynamic system stresses than the use of 100% rotor speed. Maneuvering at high altitude usually results in higher system stresses because the main rotor blades operate closer to the stall point. Maneuvering in uncoordinated flight tends to increase tail rotor system stresses approximately proportional to the amount of sideslip developed.

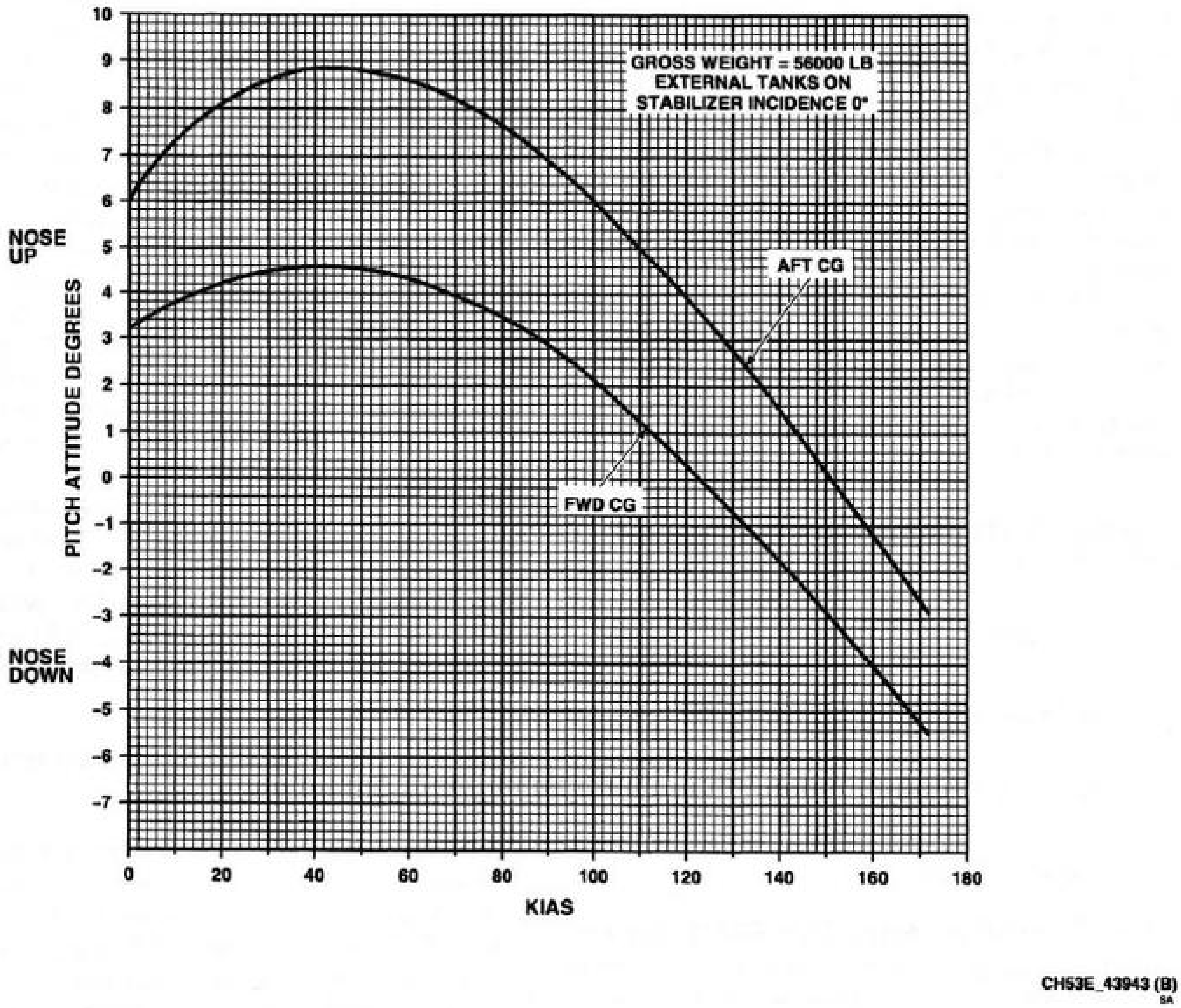


Figure 11-7. Pitch Attitude vs. Airspeeds

11.14 VERTICAL BENDING MODE

The vertical bending mode is an airframe phenomenon in which the aircraft structure, when driven by a forcing function, flexes in an oscillating manner at its natural frequency, resulting in possible structural damage. Once excited, the airframe oscillations are slow to dampen out, and unless the cause (forcing function) is removed, the oscillations will be sustained and may diverge. The following factors may act as a forcing function: the aircraft's natural frequency which is very close to the main rotor frequency (1 per), the vertical oscillating frequency of external loads, and/or moderate oscillating flight control inputs. Although special features have been added to the flight control system to isolate pilot input as a forcing function, main rotor imbalance, pilot input under degraded AFCS conditions, or external load oscillations can excite the bending mode. These 3 primary forcing functions, although individually maintained below excitation level, can be cumulative and when combined may excite the mode.

11.15 FLIGHT WITH EXTERNAL LOADS

It is very important for the pilot to know the riding characteristics of certain loads and the associated flight control applications. All maneuvers made with external cargo loads should be gradual and well coordinated.

Care must be taken when flying with external loads that have aerodynamic characteristics (i.e., light aircraft, wings, tail sections, sheet metal, plywood, etc.). The aerodynamic lift of these loads may amplify any oscillation and cause the load to contact the helicopter. Hovering and turns while hovering present no unusual problems. However, some helicopter oscillation may be noticed with low density bulky cargo when in level flight. This oscillation can be lessened with smooth control movements. When making turns at higher airspeeds, more than the normal opposite lateral cyclic displacement is necessary to prevent excessive rolling motion into the direction of turn. This tendency increases with airspeed and requires a slightly larger turning radius than would be required at the same gross weight with an internal cargo load. More than normal amounts of cyclic displacement are necessary to overcome the external cargo inertia when initiating or stopping sideward flight. However, slow steady sideward flight presents no problems. Experience has shown that for any type of external cargo load, there is an airspeed best suited for that particular load, from very low speeds to cruise speeds. There is no single rule for flying external loads, since the combination of weight, dimension, and shape all have a direct bearing on the action of the load during flight. In general, more power will be required to hover with large flat loads that create a large vertical drag, than compact loads of the same weight. External cargo can be satisfactorily flown if control movements are smoothly applied and airspeed is slowly increased to determine both the riding characteristics of the load and the best airspeed for it to be flown. If high airspeeds or turbulence should cause the load to oscillate, this can be reduced by decreasing airspeed and using the flight controls smoothly.

11.16 COLLECTIVE BOUNCE

Abrupt control inputs at high gross weight or with external loads may result in vertical oscillations known as "collective bounce". An abrupt collective control input will produce a vertical jump in the airframe. Another abrupt movement of the pilot's arm in reaction to this initial jump in the airframe will again move the collective involuntarily so that another bounce will be transmitted to the airframe. This sequence can repeat itself with increasing amplitude and is aggravated if the pilot continues to hold the collective whether or not the trim is engaged. When transporting external loads, the helicopter reaction can be transmitted to the load through the springing action of the pendant. Abrupt flight maneuvers, gusting winds, turbulence, and shifting or failure of external load slings can initiate similar vertical oscillations in the airframe. Smooth, coordinated control inputs with the collective trim release switch temporarily pressed should prevent entry into pilot induced or pilot-assisted oscillations (PIO/PAO).

WARNING

Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight.

11.17 PILOT INDUCED/ASSISTED OSCILLATIONS (PIO/PAO)

Oscillations caused by or sustained by pilot actuation of cyclic, collective, or rudder pedals can be eliminated by releasing the appropriate flight control for several seconds. If doubt exists as to which axis the oscillation is in, the pilot should release both collective and cyclic, and the oscillation should stop within several seconds. The fuselage bending mode is felt as a 3.25 Hz vertical oscillation or bounce. Fuselage-to-external load coupled bending is felt as a vertical oscillation of 2.5 to 4.0 Hz, dependent upon external load weight. These oscillations might be confused with 1P (See 1.a. under VIBRATION). These PIO and PAO vibrations are conditions in which the natural movement of the pilot's body, in reaction to aircraft oscillations, causes the flight controls to react dynamically in such a way as to amplify the motion.

WARNING

Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight. If encountered, releasing the flight controls (HAND REMOVED FROM COLLECTIVE) for several seconds should eliminate the condition. During external load operations, if PIO/PAO is encountered and the oscillations do not dampen following release of the flight controls for several seconds, JETTISON THE LOAD.

Cyclic and pedal desensitizers have been added to the AFCS to reduce the probability of encountering this phenomenon by decoupling the pilot from the airframe to varying degrees across the susceptible frequency band during rapid control reversals.

The following conditions may indicate an inoperative desensitizer for the -109 computer configuration:

1. DSEN fail advisory light on the AFCS control panel.

2. AFCS is off.

3. AFCS duplex failure.

4. FAS shear pin is sheared.

WARNING

Recycling computer power while carrying an external load should only be attempted while in stable, nonmaneuvering flight. If a desensitizer failure occurs, and does not clear after a mode reset or recycling computer power, the following precautions must be observed.

1. Avoid rapid control inputs.

2. Minimize hover time.

3. Do not pick up an external load. If flying with an external load, continue to the destination and gently set the load down. Do not attempt to relift the load.

11.18 VIBRATION

The inherent vibration in any helicopter is created by the mechanical functions of the engines and transmission systems, aerodynamic and dynamic action of the main rotor and tail rotor blades, and aerodynamic impingement on the fuselage. The predominant vibration felt in the occupied areas of the helicopter is generally at NP of the main rotor, where N equals the number of blades and P equals per revolution. This is for a helicopter which has been "tuned" to track and balance the rotors. Sometimes two or more frequencies are superimposed to create a third frequency called a beat. Generally, vibrations are divided into three categories: (1) low, (2) medium, and (3) high frequencies. Through experience the pilot can judge which vibrations are normal and react especially to vibration changes which indicate adjustments are required. It is most helpful to identify the frequency range of the vibration to expedite troubleshooting.

WARNING

Excessive vibrations should be considered as sufficient cause for termination of routine flight operations.

1. Low-frequency vibrations.

   a. One-per-revolution (2.98 cycles per second) at 100% N_r.

   A one-per-revolution vibration originates from the main rotor system and is caused by an imbalance or out-of-track condition. The rotor could be somewhat out-of-track without causing an objectionable one-per-revolution (1P) vibration.

   Note that the fuselage natural bending frequencies are close to the main rotor one-per-revolution vibration frequency. Transient short term excitation of these frequencies may be confused with 1P. These vibrations can be induced by large amplitude (1-inch or greater) rapid control reversals or stirs (see pilot induced/assisted oscillations, PIO/PAO).

   b. Ground roll.

   This is a one-per-revolution vibration felt about the roll axis. It occurs with the rotor turning at 100% N_r. If it is present at 100% N_r on the ground, but disappears when the helicopter is lifted into a hover, check the servicing of the main landing gear tires and struts or main rotor balance.

   c. Vertical bounce on the deck.

   This vibration may appear to the pilot as a mild vertical oscillation at a one-per-revolution frequency, and occurs while stopped or taxiing at 100% N_r. It can easily be eliminated by a slight change in either the cyclic or collective position.

   d. Tail shake.

   Tail shake is a random oscillation of relatively small amplitude and is felt in the cockpit as lateral motion. It is most likely to occur at 100 to 140 KIAS level flight and at slightly lower speeds during descent. This vibration is caused by the empennage being placed in the turbulent airflow behind the main rotor head pylon. The frequency of occurrence is random and is slightly greater than once-per-revolution. This model helicopter is generally insensitive to tail shake.

2. Medium-frequency vibrations.

a. Seven-per-revolution (20.9 cycles-per-second at 100% N_r).

These vibrations are most perceptible at a forward CG loading, high speed, and during a steep approach. The manner in which a load is distributed within the cabin may also have an effect on the magnitude of the seven-per-revolution vibrations.

b. Tail rotor one-per-revolution (11.7 cycles-per-second at 100% N_r).

The frequency (11.7 cycles-per-second) of tail rotor one-per-revolution is about one-half of the seven-per-revolution of the main rotor. If this frequency roughness of the helicopter increases, check the tail rotor balance and track.

3. High-frequency vibrations.

These vibrations may be felt as a tingling sensation in the soles of the feet or a tickling in the nose. In extreme cases, the instrument needles will appear to be fuzzy. High-frequency vibrations will normally come from the engine, main gear box input section, or tail rotor drive system, and are often equally apparent in a ground run as in flight. The most important cues to high frequency vibration are the associated sounds.

a. Main gear box vibrations.

The main gear box has many possible sources of high frequency vibrations, such as the various gear box mounted accessories, the accessory gear train, the APP drive shaft, and APP clutch, oil cooler blower, vent fan blower, input drive shafts from the engines, bevel gear, and freewheeling units. These vibrations are generally heard rather than felt in the airframe.

Combinations of these vibrations, in extreme cases, could result in the pilot sensing low or medium beat frequency vibrations or modulation of sounds. These would be detected as vibrations which are affected only by variation in main rotor speed, and may be just as apparent in a ground run as in flight. There are also numerous gear clash sounds that occur under various conditions, the acceptability of which can only be determined by experience, or measurements by instrumentation.

b. Engine vibrations.

To the pilot, excess engine vibrations will greatly increase noise levels. A tingling or buzzing of the airframe near the engine mounts may be sensed in the cabin by the crewman and indicate engine or engine mount problems. If the noise level of one engine seems too high compared with the other engines at the same power condition, and if the excessive noise varies with N_g or N_f changes and is possibly accompanied by a tingling vibration in the engine speed lever, then there may be a bad engine bearing or rubbing compressor blades may be indicated. Listen carefully to the engine during normal shutdown and look for discoloration (hot spots).

11.19 OPERATION IN SALT SPRAY ENVIRONMENT

If hovering is necessary in a salt spray environment, a significant engine performance degradation should be anticipated due to a salt deposit buildup in the engine compressor section. The best indication of this power loss is the relationship between T_5 and torque, where increases in T_5 at a constant torque setting signify engine performance degradation. To minimize salt ingestion, utilize the highest hover altitude consistent with the mission and avoid abrupt control movements. In case of a significant increase in T_5 (40°C or approaching maximum T_5 limits, whichever comes first), subsequent engine operation in clean air at higher altitudes may dissipate some of the salt buildup. Flight through rain may also reduce salt buildup. After operating in a salt spray environment, make an applicable entry on the maintenance action forms (MAF), requiring a fresh water wash/Rustlick application in accordance with current instructions.

11.20 NO. 2 ENGINE COMPARTMENT BACKFLOW

With the main rotor at 100% N_r, a negative pressure differential exists between the No. 2 engine cowling forward cooling scoops and the engine tail pipe. The negative pressure attempts to push the hot exhaust gases backwards into the aft engine compartment. During normal or unlocked engine starts, as well as forward flight with the torque of all three engines matched, the venturi effect created by the engine exhaust flow across the ejector gap creates a net positive pressure and positive airflow which ensures that hot exhaust gases are evacuated out of the engine compartment and through the tail pipe.

Operating the No. 2 engine at ground idle above 85 KIAS may result in a backflow of hot exhaust gas into the aft portion of the engine compartment area. During engine starts in any flight condition, some backflow will occur, however temperature levels quickly drop as the engine reaches ground idle speed and drop further as the engine is accelerated to a matched-torque condition. The most serious backflow condition occurs during a No. 2 engine stall at all ground and flight conditions. In the stalled condition, N_g may decay below ground idle levels and the T_5 will rapidly increase. The engine cannot develop sufficient positive pressure due to the low N_g speed. This allows the hot exhaust gas to backflow into the engine compartment. If this condition persists, thermal damage could occur leading to a fire in the aft portion of the engine compartment area.

WARNING

An engine fire in the aft portion of the compartment may not be detected by the fire detecting system. In a backflow condition, the fire extinguishing agent may not reach the aft portion of the engine compartment to extinguish the fire.

CAUTION

No. 2 engine backflow is most prevalent under the following conditions:

1. No. 2 engine in a stalled condition.

2. No. 2 engine at ground idle at airspeeds above 85 KIAS.

3. Engine starts with the rotor at 100% N_r and port winds greater than 15 knots.

PART V

EMERGENCY PROCEDURES

CHAPTER 12
Emergency Procedures

12.1 INTRODUCTION

The terms IMMEDIATELY, POSSIBLE, and PRACTICAL as used in this manual refer to the degree of urgency with which a landing must be made.

1. Land Immediately — Self-explanatory.

2. Land as Soon as Possible — Means land at the first site at which a safe landing can be made.

3. Land as Soon as Practical — Means extended flight is not recommended. The landing site and duration of flight is at the discretion of the pilot-in-command.

Any helicopter experiencing trouble in flight shall immediately notify the flight leader by radio or by visual signals, as the situation dictates. If the nature of the emergency warrants an immediate return to base, a radio call shall be made to enable the base to prepare for an emergency landing. In any case, the following information shall be transmitted:

1. Side number of the helicopter.

2. Position.

3. Difficulty.

4. Intentions.

5. Fuel state.

If the helicopter with the emergency does not have radio communications, all possible information is relayed visually to the wingman who makes the necessary radio transmission.

Weight Reduction — Any emergency situation discussed in this section assumes that jettisoning of external cargo is an acceptable step in any procedure.

Note

If time permits, get the attention of the passengers in case of an emergency.

12.2 MEMORY ITEMS

Checklist items indicated with an * shall be completed without reference to the checklist.

12.3 PRECAUTIONARY LANDINGS

A precautionary landing is described as a landing when further flight is possible but inadvisable. Such landings will be governed by the following:

1. When an indication is received by the warning lights or instruments that continued flight would jeopardize the safety of the helicopter or crew.

2. When control function is questionable or instruments fail that are essential for continued flight.

3. Any condition of uncertainty or distress.

Further flight will not be attempted until the trouble has been determined and/or corrected, as appropriate. It must be emphasized that most precautionary landing instances require an inspection by qualified maintenance personnel before further flight is attempted.

12.4 LOSS OF VISUAL REFERENCE DURING LANDING

To initiate a wave-off following loss of visual reference during landing, proceed as follows:

*1. Collective — INCREASE TO CLIMB.

WARNING

- Not only must descent be stopped to prevent impact with the surface, but also a positive rapid climb is necessary to regain visual flight conditions. Any delay may allow drift to develop which could cause impact with ground/obstacles.

- Consideration should be given to external cargo jettison.

*2. Cyclic — HOVER ATTITUDE (ON INSTRUMENTS).

*3. Selected Heading — MAINTAIN.

12.5 EXTERNAL CARGO JETTISON

*1. Area — CLEARED IF POSSIBLE.

*2. Cargo release — ACTIVATED.

WARNING

Prior to jettison of external cargo alert the crew to prevent injury.

12.6 TWO-POINT CARGO SUSPENSION SYSTEM HOOK OPEN ADVISORY LIGHTS

FWD or AFT hook open advisory lights indicate the respective hook latch mechanism is not fully overcenter and the load is susceptible to inadvertent release. If the FWD HOOK OPEN or AFT HOOK OPEN advisory lights illuminate while carrying an external load, proceed as follows:

1. Avoid abrupt control movements and attitude changes.

2. Land as soon as practical.

WARNING

Do not attempt to move hook linkage or troubleshoot the systems until the load is safely on deck.

12.7 SINGLE- OR DUAL-ENGINE LANDING

Safe emergency single- or dual-engine landings (Figure 12-1) can be made provided they are initiated within reasonable airspeed and altitude combinations. Refer to the Ability to Maintain Level Flight chart in Chapter 24. When possible, a landing site should be selected that provides a smooth hard surface, and be approached at a safe single- or dual-engine airspeed.

1. Prelanding and landing checklists — COMPLETED.

2. Arrive at 90° position at about 350 feet AGL, 60 to 80 KIAS, with maximum N_r.

3. At about 1000 feet straightaway into the wind, continue descent so as to arrive at 150 to 200 feet AGL with 40 to 60 KIAS.

4. At 150 to 200 feet AGL, initiate a nose-up flare. Maintain flare until about 30 feet is noted on radar altimeter. Apply collective to avoid a high rate-of-descent.

Note

Single- or dual-engine landings to confined areas or unprepared terrain may require a slight modification of final approach flare and airspeed to clear obstacles and/or lessen ground roll at touchdown.

5. At 30 feet AGL, reduce nose attitude to a maximum of 8° nose-up and increase collective to cushion landing.

6. Upon ground contact, slowly lower collective pitch lever to minimum and simultaneously move cyclic slightly forward of neutral position.

7. Apply wheel brakes to minimize ground roll.

12.8 SINGLE- OR DUAL-ENGINE WAVE-OFF

Any time the pilot feels that an approach is not within the desired parameters, a wave-off shall be executed. If the helicopter is in a nose high attitude and low airspeed, level the nose and use just enough collective to stop the rate of descent. As this is completed, best forward single- or dual-engine airspeed should be regained. Before beginning any approach, whether to a confined area or to a designated landing pad, a determination must be made as to the best route of exit if a wave-off must be made.

12.9 SINGLE- OR DUAL-ENGINE TAKEOFF

Emergency single- or dual-engine takeoffs are allowed. However, in all cases the takeoff gross weight shall be reduced to be sure of single- or dual-engine hover capability as appropriate. Takeoff without single- or dual-engine hover capability is not recommended.

The gross weight, density altitude, and wind conditions are the factors to be considered when determining whether a safe single- or dual-engine takeoff can be

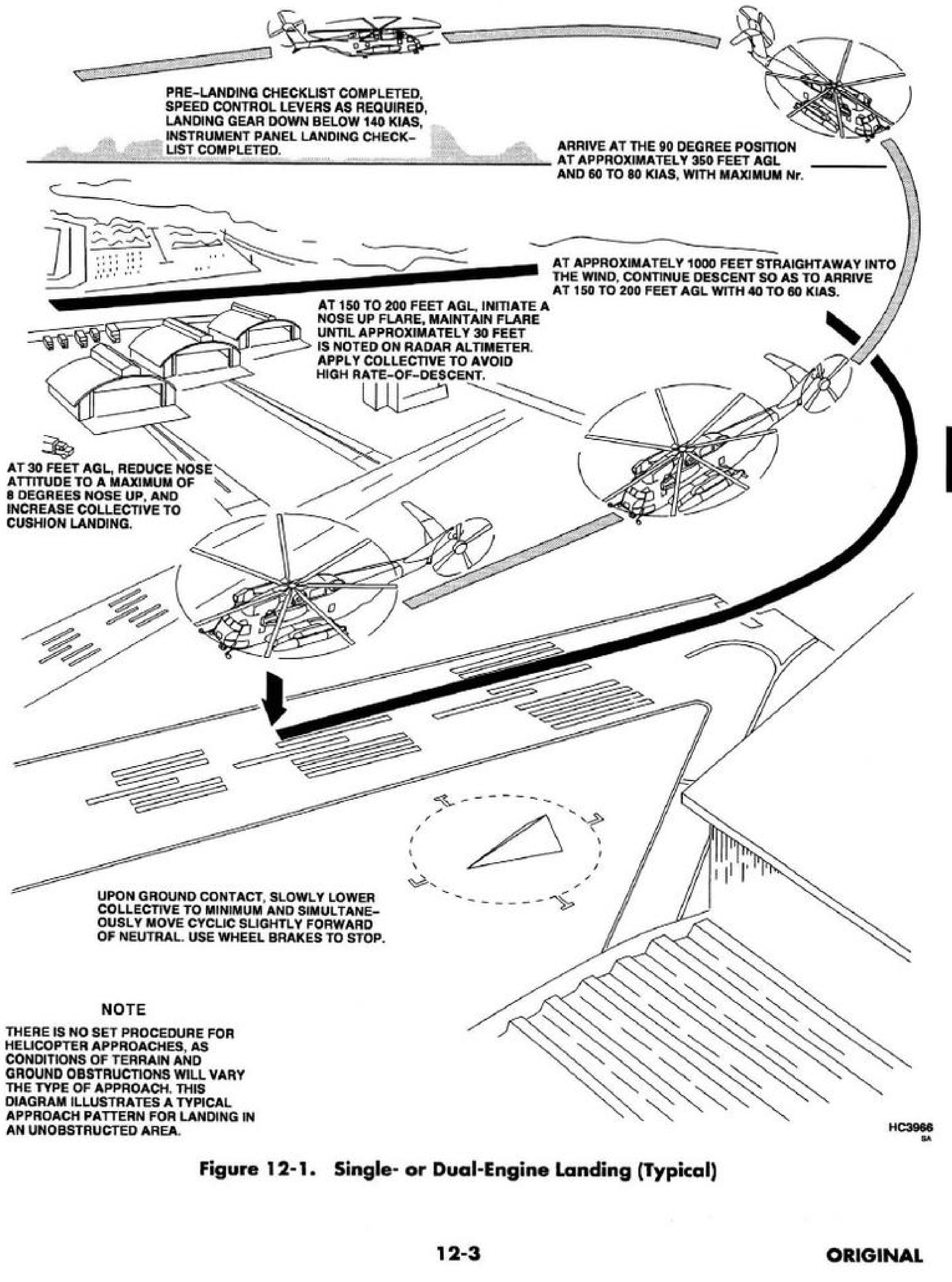


Figure 12-1. Single- or Dual-Engine Landing (Typical)

accomplished and safe single- or dual-engine airspeed can be maintained. Refer to the Climb-Single- and Dual-Engine charts and the Ability to Maintain Flight — Single- and Dual-Engine charts in Part XI. A single- or dual-engine takeoff is made in the same manner as a three-engine takeoff, except the engine speed control lever(s) is advanced full forward and retained until a safe single- or dual-engine airspeed is reached. Power is then adjusted to stay within safe single- or dual-engine airspeed envelope.

12.10 SINGLE- OR DUAL-ENGINE FAILURE

WARNING

- Pilot response to single- or dual-engine failure is dictated by gross weight, ambient conditions, relative wind, and height above the surface. These factors will determine whether an immediate landing or a flyaway recovery should be attempted. Based on the pilot's knowledge of aircraft single- or dual-engine power available and power required, the pilot should decide which procedure he intends to follow before the emergency occurs. Indecision following the single- or dual-engine failure may prevent the success of either procedure.

- If the altitude hold feature of AFCS is engaged, it will increase collective pitch in an attempt to hold altitude. The collective must be positively controlled by the pilot to prevent excessive loss of rotor speed.

CAUTION

Nose high attitudes shall be avoided near the surface or the tail rotor blades may strike the ground or water. Tail rotor contact may occur with nose attitudes above 5° when on the water. The altitude, airspeed, and gross weight at which a single- or dual-engine failure occurs will dictate the action to be followed to effect a safe landing. Refer to the height-velocity diagram-one or two engine failure. During mission planning, the engine torque available can be determined from the maximum and military power-available charts. The minimum and maximum indicated airspeed at which level flight can be maintained is determined from the Ability to Maintain Level Flight Chart. The maximum gross weight at which a hover or level flight can be maintained decreases as density altitude increases. Therefore, mission planning should include a thorough analysis of the performance data in Part XI.

Note

- If altitude cannot be maintained or a safe single- or dual-engine landing is not feasible, decrease gross weight by releasing external cargo, dumping fuel, or jettisoning auxiliary fuel tanks if required. Stop dumping before landing.

- Careful monitoring of main fuel tank quantities is required on flights where fuel transfer from range extension fuel tanks is being conducted, and fuel is not being depleted from all main tanks. Main fuel tank expansion volume can diminish and ultimately result in overboard vent spillage, due to constant flow of fuel through helicopter fuel system precheck lines.

*1. Collective — MAINTAIN N_r.

*2. Airspeed — AS REQUIRED.

*3. Pickle — AS DESIRED.

*4. Speed control levers — AS REQUIRED (SHUT OFF AFFECTED ENGINE, CONDITIONS PERMITTING).

5. Land as soon as practical.

WARNING

Refer to Height-Velocity Diagram, Dual-Engine Failure and Height-Velocity Diagram, Single-Engine Failure in Part XI.

Note

- A roll on landing will normally decrease power required. Minimize drift and yaw on landing.

- Determine which engine has failed by reference to engine torquemeters, T_5 indicators, N_f or N_g tachometers, and proceed as instructed in ENGINE SHUTDOWN IN FLIGHT in this section. If a restart is advisable, refer to ENGINE RESTART DURING FLIGHT in this chapter.

12.11 POWER MALFUNCTIONS

(Figures 12-2 through 12-8.)

Note

- The shaded indicators on the gages for Figures 12-2 through 12-8 show the indicators for the affected engine. The indicators that are not shaded show the indicators for normal engines.
- If N_f/N_r increases when a torque split occurs, high torque engine is probably attempting to overspeed. If N_f/N_r decreases when torque split occurs, low torque engine probably has had a power loss.
- In case of single-, dual-, or three-engine failure, consider starting the APP so that electrical power will be available to the AFCS, rotor brake, fire extinguisher, and lighting systems, if N_r should be dropped below 91% to 96% on touchdown.

The altitude and airspeed at which engine failure occurs will dictate the action to be taken for a safe landing. It should be noted that the engine instruments often provide indications of fuel control system failure before actual engine failure. Air starts can often be made, but should not be attempted if there is evidence of mechanical failure within the engine.

12.12 ENGINE CHIP LOCATOR LIGHT

An engine chip locator light accompanied by unusual vibrations and/or low oil pressure/high oil temperature, or an engine chip locator light returning after resetting circuit breaker without the above indications, is cause to suspect probable engine failure. If an engine chip detector light goes on, do this:

*1. Instruments/Caution Lights — CHECK.

If malfunction verified:

*2. Perform SINGLE- OR DUAL-ENGINE FAILURE procedures.

3. If chip locator light is not accompanied by other indications of a malfunction, pull and reset engine chip circuit breaker.

4. If chip locator light returns after circuit breaker is reset, perform SINGLE- OR DUAL-ENGINE FAILURE procedures.

5. If chip locator light remains off, continue mission, monitoring engine performance closely.

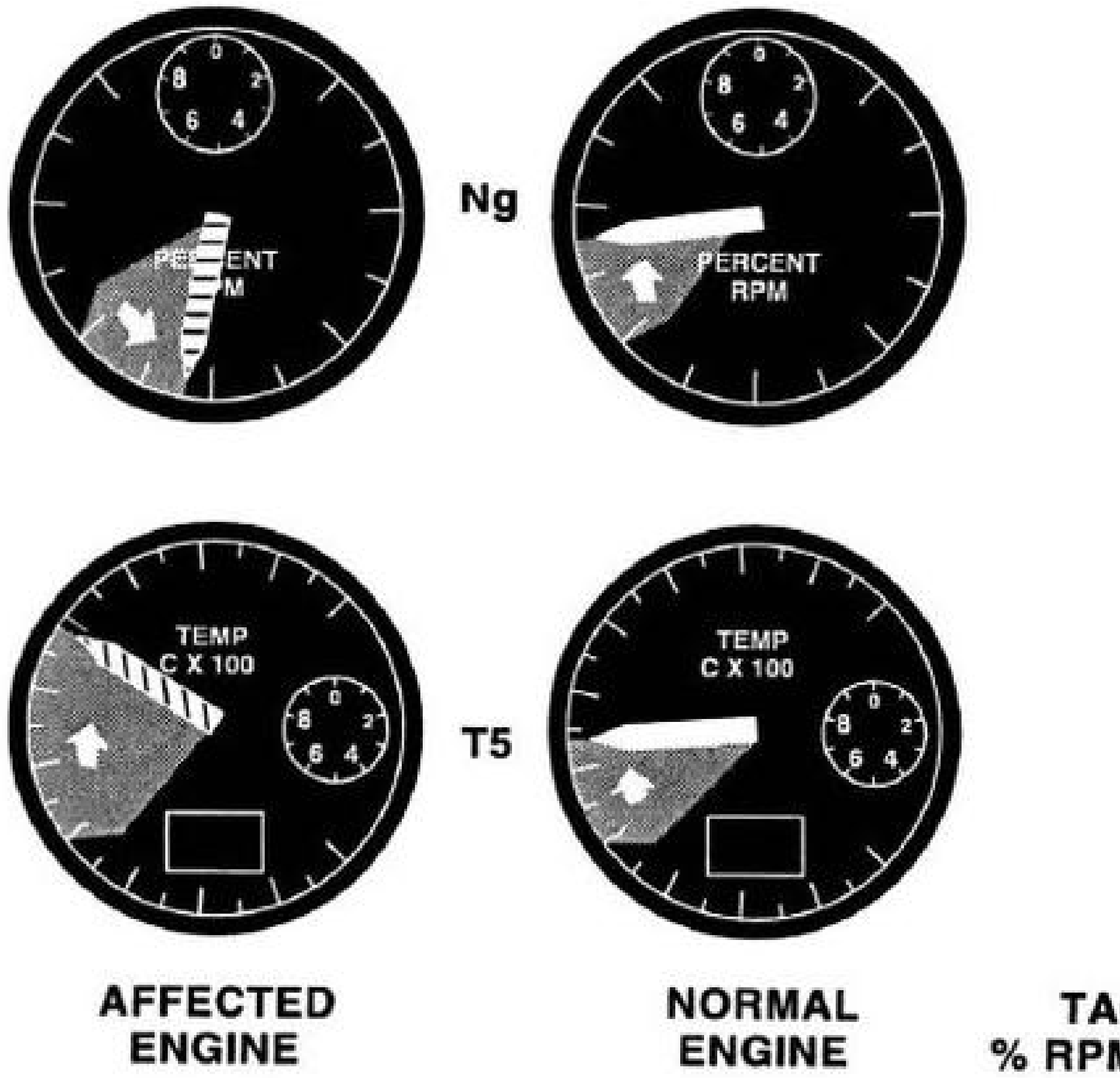
WARNING

Level single- or dual-engine flight and/or safe single or dual-engine hover landings may not be possible at certain combinations of helicopter gross weight and density altitude. Flight conditions may require that the decision to establish single- or dual-engine flight be deferred until a safe descent is possible. Select landing site suitable for running landing if available.

SYMPTOMS	CORRECTIVE ACTION
See Gages Affected engine(s): T_5 increase — all other parameters decrease. As long as the affected engine is producing any usable torque, it's N_f will remain matched with the normal N_f/N_r. If torque drops to zero, N_f will likely split off and decay.	*1. Collective — MAINTAIN N_r. *2. Airspeed — AS REQUIRED. *3. Pickle — AS REQUIRED. *4. Speed control levers — AS REQUIRED (If compressor stall of No. 2 eng is indicated, reduce airspeed to 85 KIAS and immediately secure SCL and continue with Engine Shutdown In Flight procedures. If No. 1 or No. 3 engs, affected SCL below MIN GOV).
Normal Engine(s): All parameters increase except for steady N_f/N_r. If the normal engine's power available is not sufficient for the affected engine's power loss, (i.e., the total torque requirement cannot be met), N_f/N_r may droop/decay excessively depending on the degree of power deficit. Also, if the normal engines have sufficient power available to compensate for the affected engine's power loss, (i.e., the total torque requirement can be met), it is normal for N_f/N_r to droop about 1% to 2% as the normal engines are forced to assume the additional load. **NOTE** Compressor stall is normally accompanied by unusual engine sounds/slight yaw kick. Illumination of ENGINE FUEL BOOST and FUEL FILTER CAUTION LIGHTS is possible due to decay of N_g.	5. If T_5 continues to rise, position speed control of affected engine to SHUT OFF; secure engine as instructed under ENGINE SHUT DOWN IN FLIGHT in this chapter. **WARNING** With a compressor stall in the No. 2 engine, any delay in shutdown of the engine can result in hot exhaust gas backflow into the engine compartment creating a fire hazard. If a No. 2 engine stall is suspected, reduce airspeed to less than 85 KIAS to reduce backflow and shutdown the engine. 6. If T_5 decreases and stall clears, slowly advance speed control lever to reestablish matched torques. 7. If stall recurs, secure affected engine as instructed under ENGINE SHUTDOWN IN FLIGHT in this chapter.

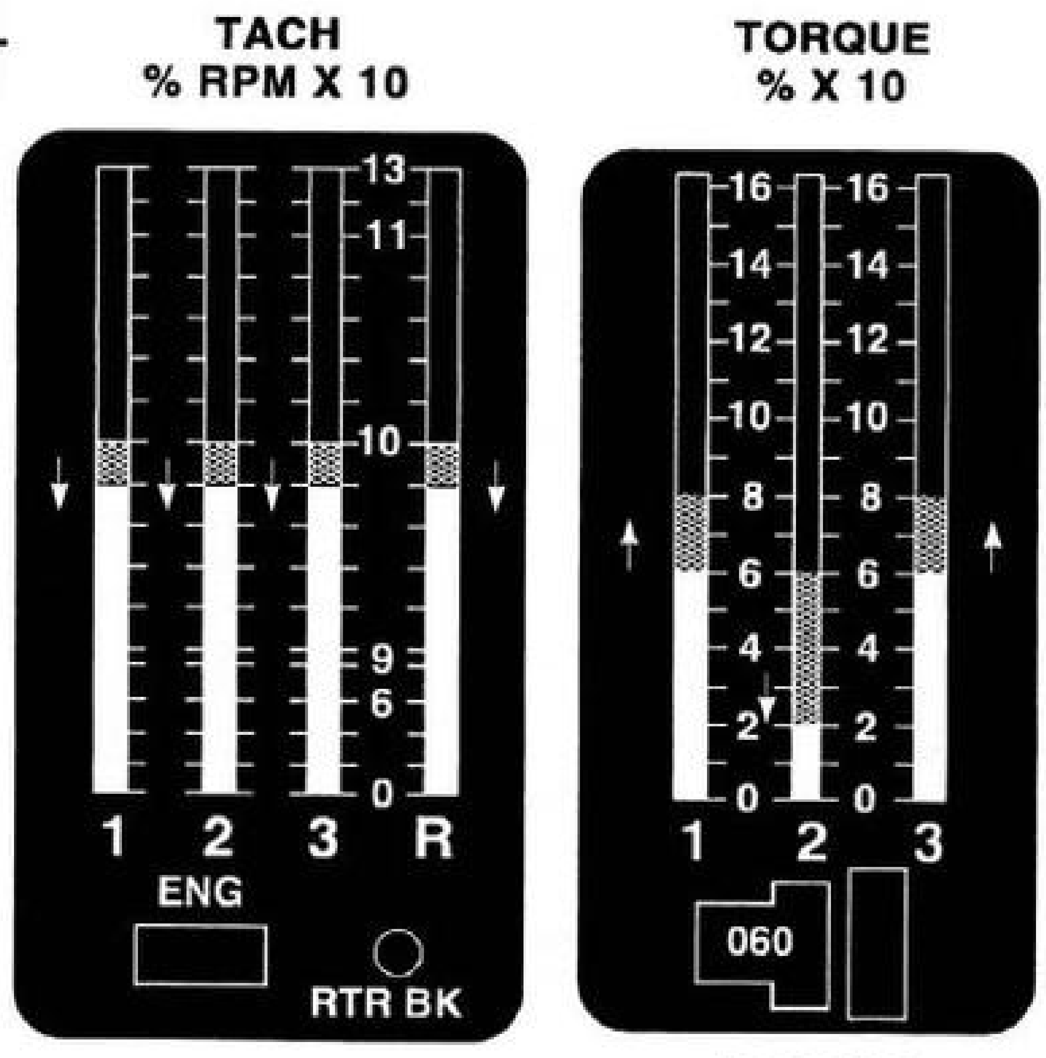
Figure 12-2. Compressor Stall (Sheet 1 of 2)

COMPRESSOR STALL



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE-TO-ENGINE-TO-ROTOR SYSTEM RELATIONSHIPS UPON OUTSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.



NOTE

IN THIS EXAMPLE, THE NORMAL ENIGINES HAVE SUFFICENT POWER AVAILABLE TO COMPENSATE FOR THE AFFECTED ENGINE'S POWER LOSS.

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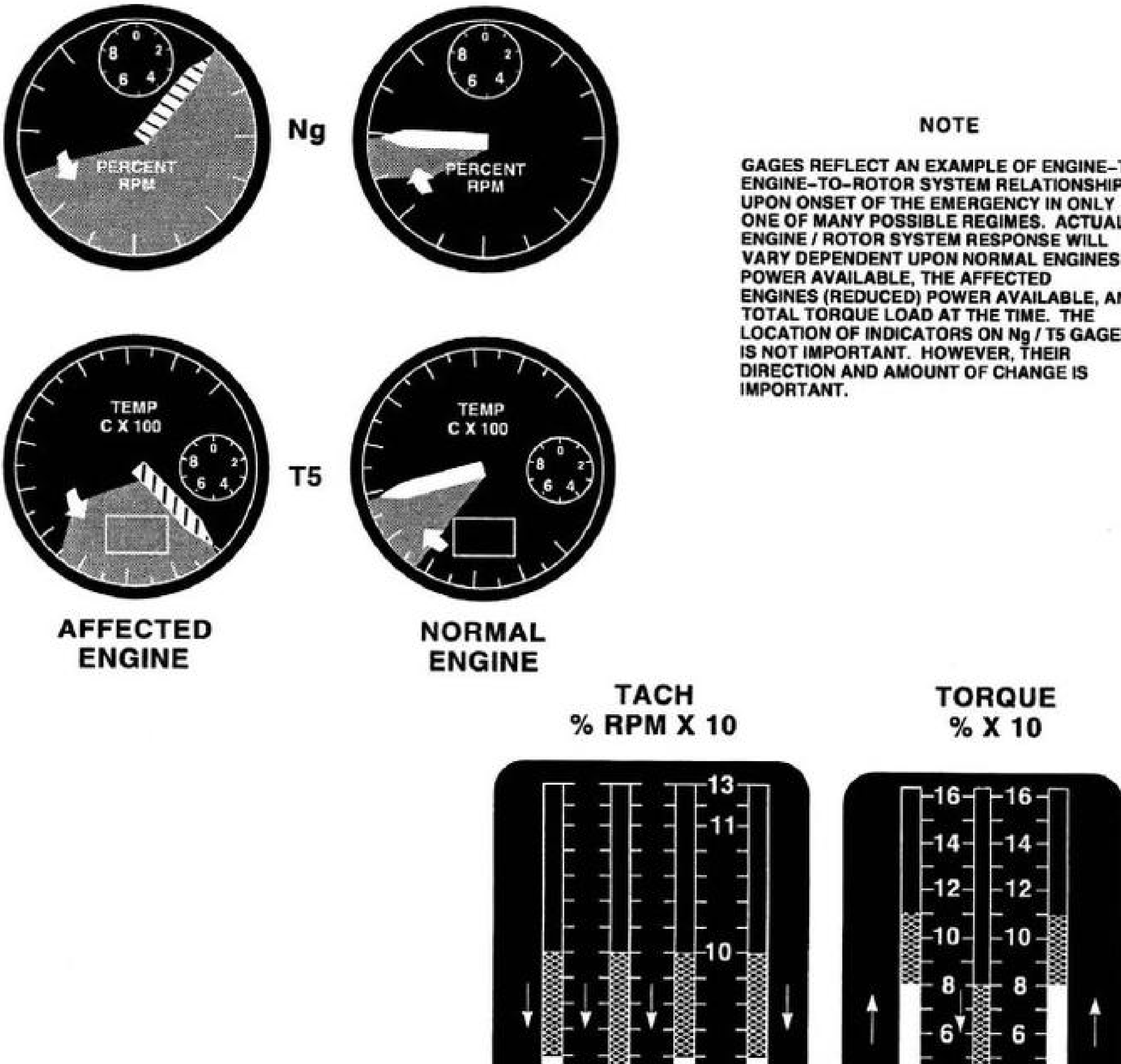
Figure 12-2. Compressor Stall (Sheet 2 of 2)

SYMPTOMS	CORRECTIVE ACTION
1. Power loss caused by control/accessory malfunction; no stall, no flameout. Under certain conditions an N_f flex shaft failure will cause the affected engine to stabilize at ground idle with no control available through the speed control lever. Affected engine(s): All engine parameters decreasing. As long as the affected engine is producing any usable torque, it's N_f will remain matched with the normal N_f/N_r. If torque drops to zero, N_f will likely split off and decay. Normal engine(s): All engine parameters increasing except N_f/N_r. If the normal engine's power available is not sufficient for the affected engine's power loss, (i.e., the total torque requirement cannot be met), N_f/N_r may droop/decay excessively depending on the degree of power deficit. Also, if the normal engines have sufficient power available to compensate for the affected engine's power loss, (i.e., the total torque requirement can be met), it is normal for N_f/N_r to droop about 1% to 2% as the normal engines are forced to assume the additional load. 2. Power loss caused by fuel contamination/fuel starvation (engine flameout) See Gages Affected engine(s): All parameters decreasing. Normal engine(s): All engine parameters increasing except N_f/N_r. If the normal engine's power available is not sufficient for the affected engine's power loss, (i.e., the total torque requirement cannot be met), N_f/N_r may droop/decay excessively depending on the degree of power deficit. Also, if the normal engines have sufficient power available to compensate for the affected engine's power loss, (i.e., the total torque requirement can be met), it is normal for N_f/N_r to droop about 1% to 2% as the normal engines are forced to assume the additional load.	*1. Collective — MAINTAIN N_r. *2. Airspeed — AS REQUIRED. *3. Pickle — AS DESIRED. *4. Speed control levers — AS REQUIRED. 5. Continue to use affected engine if engine is producing some torque and all engine parameters are within limits. **WARNING** If the No. 2 engine is operating at a low power condition and the N_g is less than 75%, hot exhaust gas may backflow into the engine compartment creating a fire hazard. Limit airspeed to less than 85 KIAS to reduce backflow. If dual-engine flight can be maintained, consideration should be given to securing the No. 2 engine. 6. Carefully monitor all engine parameters. 7. Secure affected engine as instructed under ENGINE SHUTDOWN IN FLIGHT in this chapter if any further engine malfunction is indicated, or if affected engine is not producing torque. **NOTE** If engine power loss takes place following fuel system transfer, selected fuel source is suspect for contamination or insufficient fuel.

Figure 12-3. Engine Power Loss (Sheet 1 of 2)

ENGINE POWER LOSS
(ENGINE FLAMEOUT)



NOTE

IN THIS EXAMPLE, THE NORMAL ENGINES HAVE DEVELOPED TOPPING POWER WHICH IS NOT SUFFICIENT TO COMPENSATE FOR THE POWER LOSS. SINCE TOTAL POWER REQUIREMENTS CANNOT BE MET, Nf / Nr BEGINS TO DECAY.

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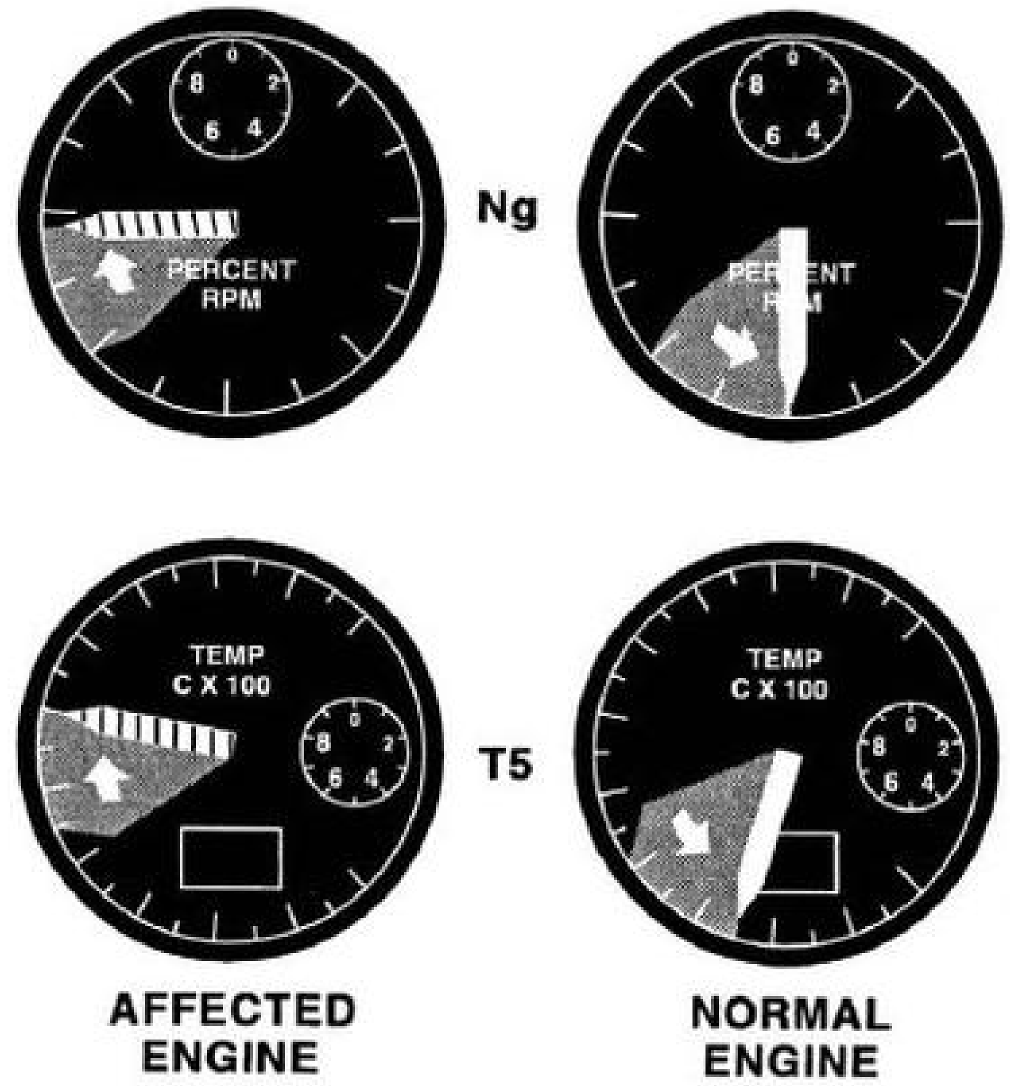
Figure 12-3. Engine Power Loss (Sheet 2 of 2)

SYMPTOMS	CORRECTIVE ACTION
1. Engine fuel system malfunction/N_f flex shaft failure. See Gages Affected engine(s): All parameters increasing, fuel flow may jump to 1700 lbs or more. **NOTE** Engine may accelerate to maximum power. If engine attempts to deliver uncommanded power exceeding the total torque requirements, N_f/N_r will increase/overspeed depending on the degree of power surplus. Also, if the engine attempts to deliver uncommanded power less than the total torque requirements, N_f/N_r can be expected to increase slightly, about 1% to 2%. Normal engine(s): All parameters decreasing except N_f which will remain the same or possibly increase with affected engine.	*1. Collective — MAINTAIN N_r. *2. Airspeed — AS REQUIRED. *3. Pickle — AS DESIRED. *4. Speed control levers — AS REQUIRED. Attempt to regain control of affected engine power by retarding affected engine's speed control lever below MIN GOV. **WARNING** If the No. 2 engine speed control lever is at or below MIN GOV and the N_g is less than 75%, hot exhaust gas may backflow into the engine compartment creating a fire hazard. Limit airspeed to less than 85 KIAS to reduce backflow. If dual-engine flight can be maintained, consideration should be given to securing the No. 2 engine. 5. If affected engine cannot be controlled manually without exceeding operating limits, secure engine as instructed under ENGINE SHUTDOWN IN FLIGHT. 6. If speed control lever can be used to control affected engine power without exceeding operating limitations, use it to match engine torques. Make all collective adjustments slowly to facilitate maintaining torques matched. **NOTE** Following an N_f flex shaft failure, the speed control lever will act as a direct throttle in the transition range, providing full control of engine power. Control may or may not be regained with a fuel control malfunction. 7. Make a normal landing in accordance with NORMAL LANDING procedures in Chapter 7, except copilot will do as follows, as directed by pilot: a. Control N_r throughout descent and approach by adjusting speed control lever of malfunctioning engine. b. While reducing collective on landing, retard speed control lever on malfunctioning engine to prevent rotor overspeed.
2. Power train failure.	1. See power train failure.

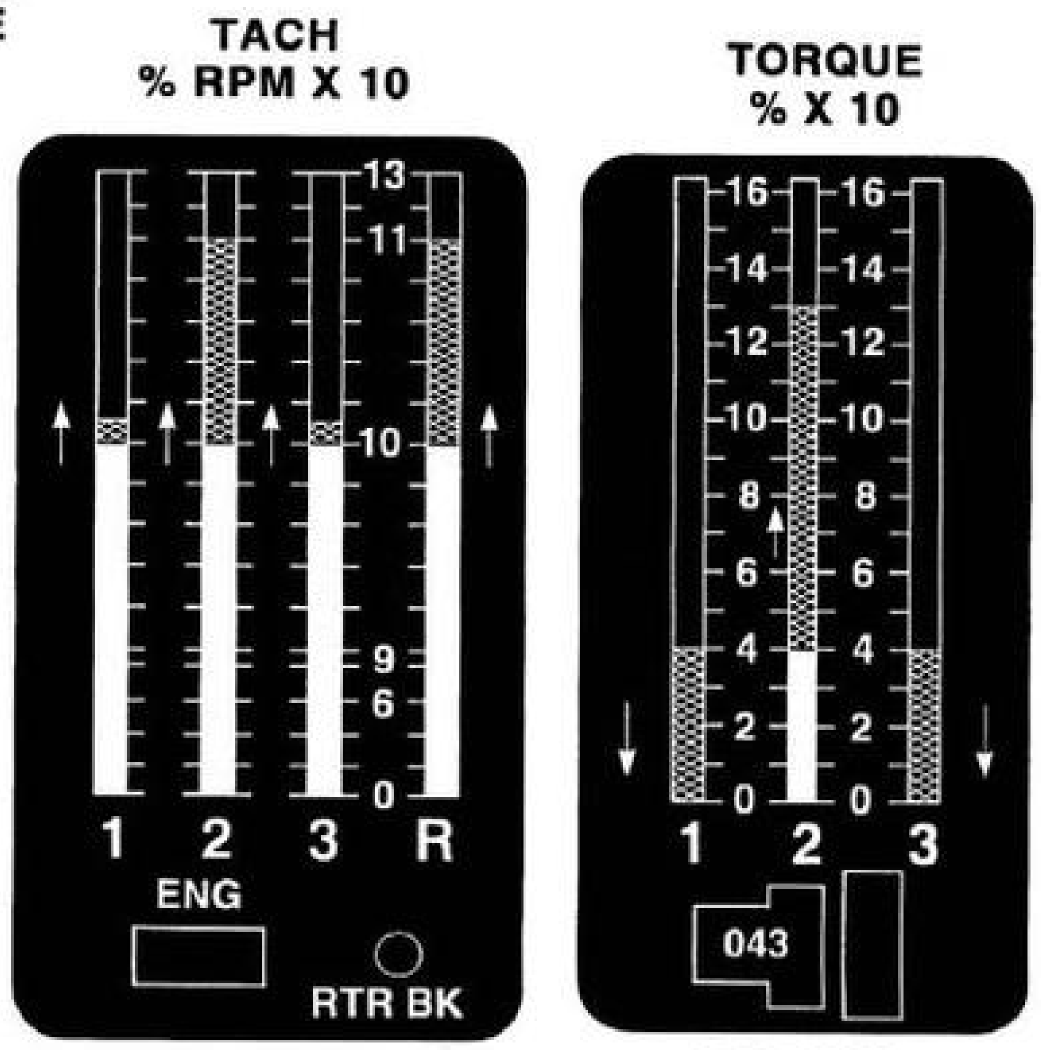
Figure 12-4. Engine Overspeed (Sheet 1 of 3)

ENGINE OVERSPEED
(Nf FLEX SHAFT FAILURE)



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE–TO–ENGINE–TO–ROTOR SYSTEM RELATIONSHIPS UPON ONSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.



NOTE

IN THIS EXAMPLE, Nf FLEX SHAFT FAILURE HAS CAUSED AFFECTED ENGINE TO DELIVER MAXIMUM POWER, WHICH IS IN EXCESS OF TOTAL TORQUE REQUIREMENTS, AND THE AFFECTED ENGINE Nf / Nr INCREASE ABOVE SELECTED SPEED.

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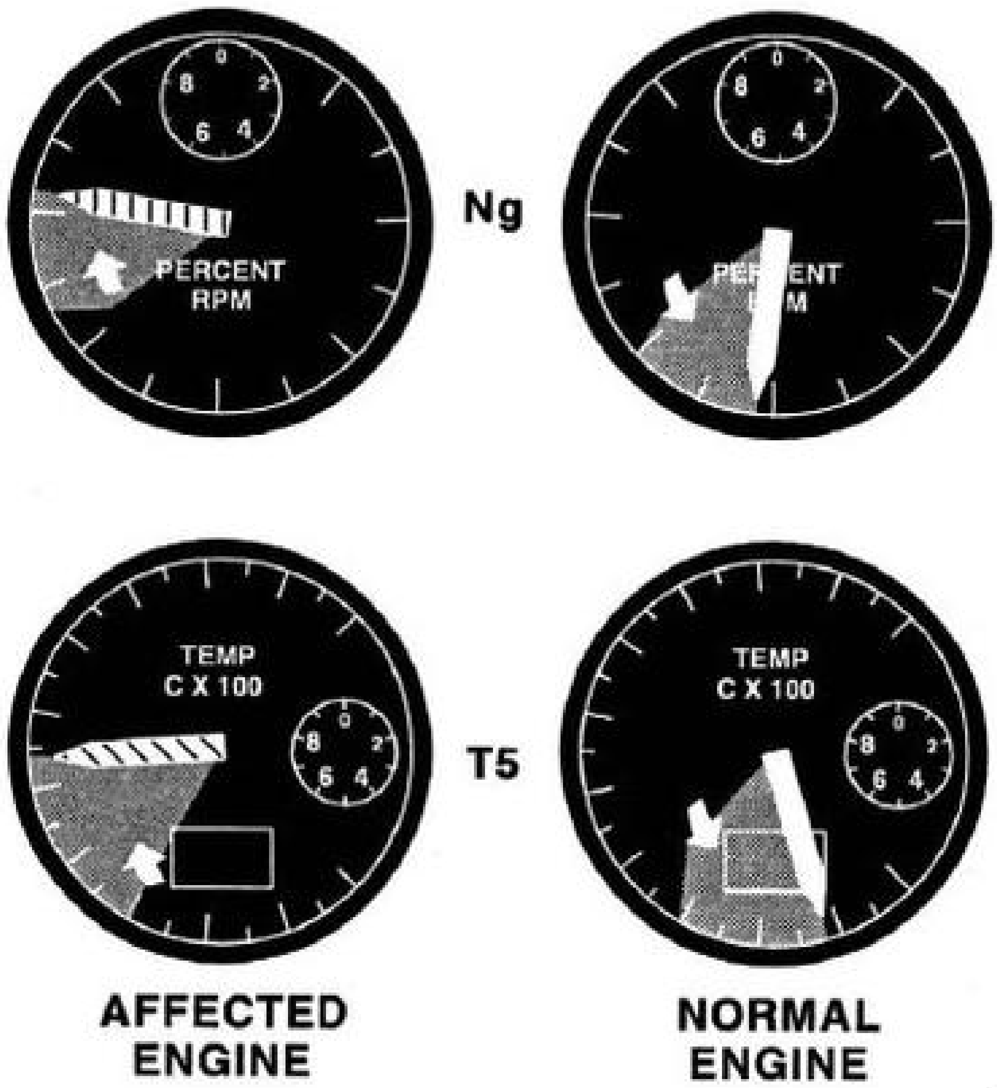
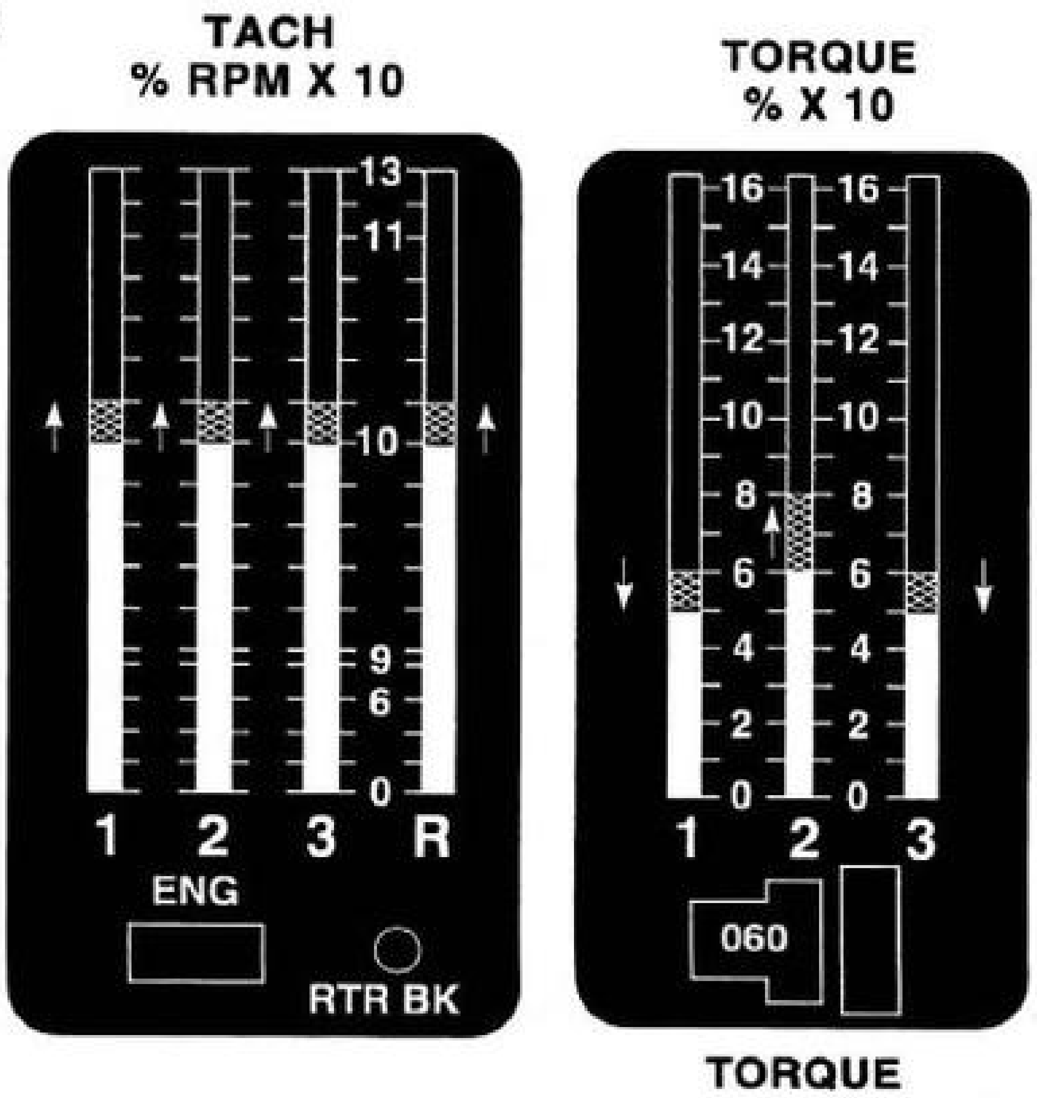
Figure 12-4. Engine Overspeed (Sheet 2 of 3)

ENGINE OVERSPEED
(FUEL REGULATING SYSTEM MALFUNCTION SHOWN)



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE–TO–ENGINE–TO–ROTOR SYSTEM RELATIONSHIPS UPON ONSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.



NOTE

IN THIS EXAMPLE, THE MALFUNCTIONING ENGINE EXHIBITS AN UNCOMMANDED INCREASE IN POWER WHICH IS NOT IN EXCESS OF TOTAL TORQUE REQUIREMENTS. ALL ENGINES CONTINUE TO SHARE THE LOAD.

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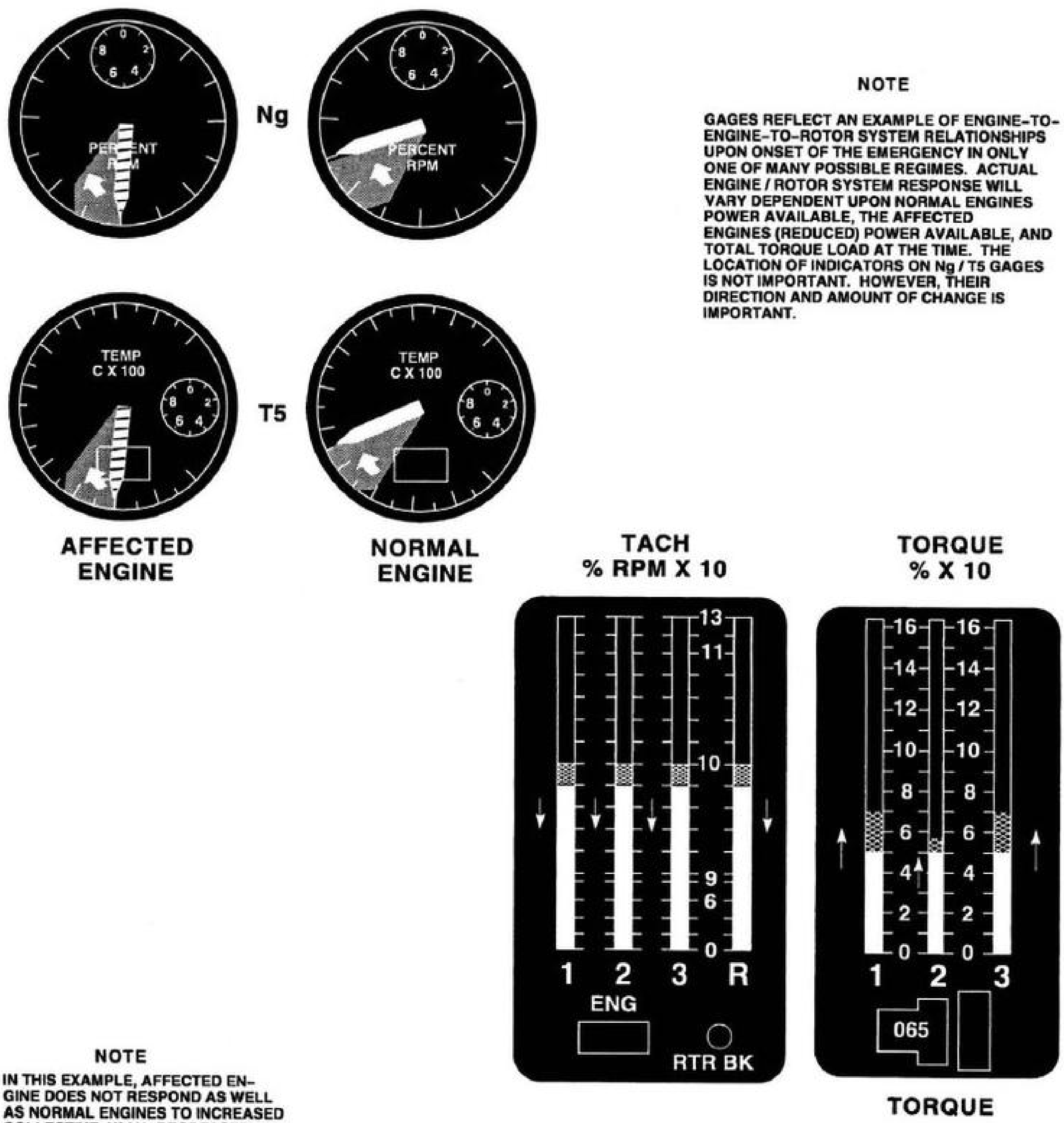
Figure 12-4. Engine Overspeed (Sheet 3 of 3)

SYMPTOMS	CORRECTIVE ACTION
1. Speed control lever linkage disengaged. Engine response: a. When all speed control levers are advanced simultaneously, affected engine parameters (T_5, N_g, Q) will decrease as normal engine(s) parameters increase. b. When all speed control levers are retarded simultaneously, affected engine parameters (T_5, N_g, Q) will increase as normal engine(s) parameters decrease.	1. Match torques using normal engine's speed control levers. 2. If N_r exceeds desired limits, reduce speed control lever position on normal engine(s) to decrease N_f/N_r. 3. Use fuel control lever of affected engine(s) to secure engine.
1. Collective compensation linkage (collective bias) disengaged. See Gages a. Reduced torque response on affected engine with change in collective position. b. Noticeable torque split with change in collective position. c. Rotor droop with increased collective input.	1. Trim engine speed control levers to maintain N_f/N_r. 2. Retrim, with load change, as necessary. **NOTE** Expect unusually large torque splits at high load conditions.

Figure 12-5. Control Linkage Failure (Sheet 1 of 2)

CONTROL LINKAGE FAILURE
(INCREASE OF COLLECTIVE SHOWN)



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE-TO-ENGINE-TO-ROTOR SYSTEM RELATIONSHIPS UPON ONSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.

NOTE

IN THIS EXAMPLE, AFFECTED ENGINE DOES NOT RESPOND AS WELL AS NORMAL ENGINES TO INCREASED COLLECTIVE. Nf / Nr DECREASED ONLY SLIGHTLY.

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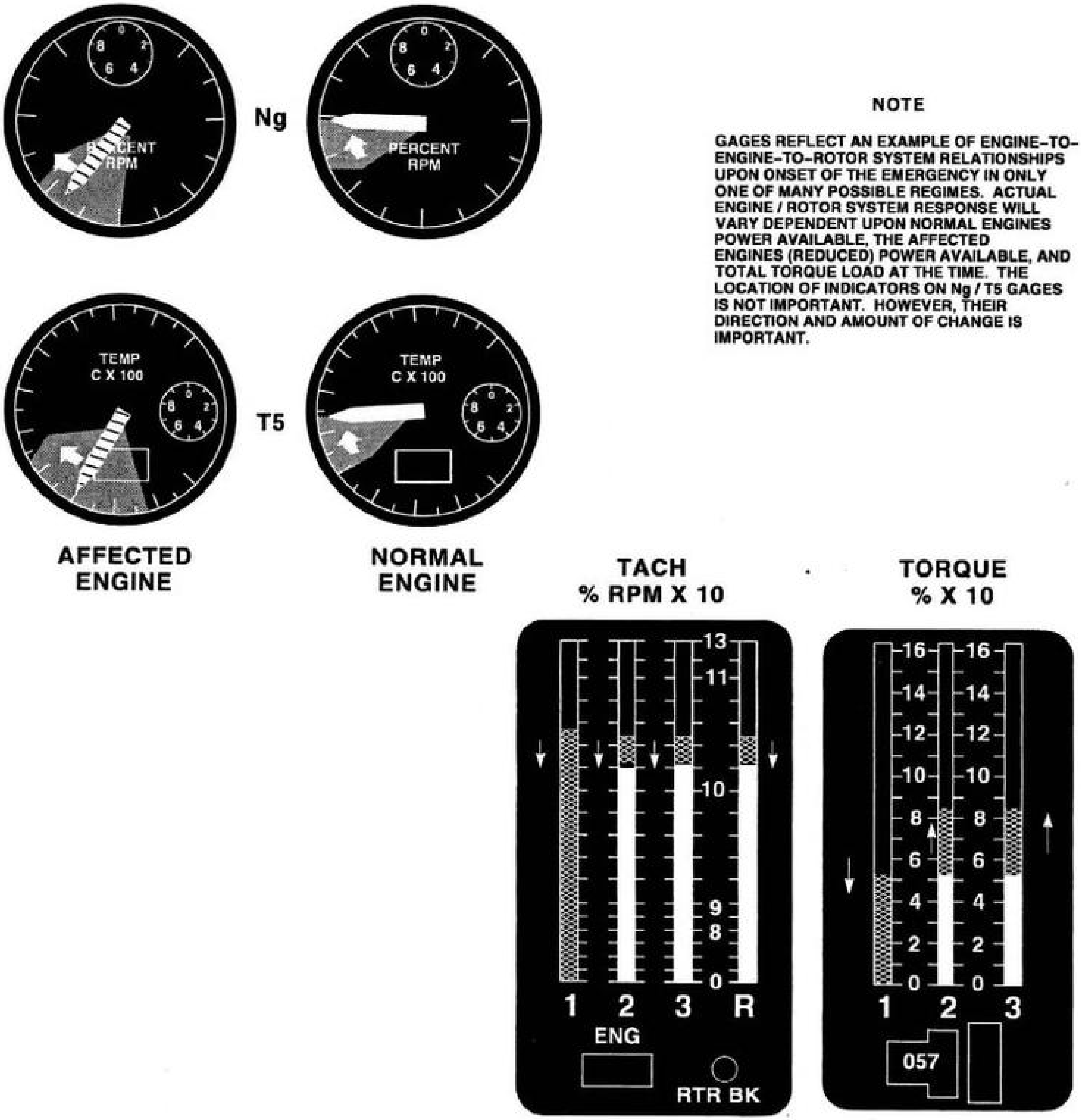
Figure 12-5. Control Linkage Failure (Sheet 2 of 2)

SYMPTOMS	CORRECTIVE ACTION
1. Failure between power turbine and nose gear box. See Gages Affected engine(s): a. Sudden decrease to zero on N_f and torque indicators. b. N_g and T_5 increasing until overspeed system actuation, then T_5 decreasing and N_g decreasing to flight idle. c. Grinding/howling noise may be heard. Normal engine(s): All engine parameters increasing to except N_f/N_r. If the normal engine's power available is not sufficient to offset the affected engine's power loss, (i.e., the total torque requirement cannot be met), N_f/N_r may droop/decay excessively, depending on the degree of power deficit. Also, if the normal engines' power available is sufficient to offset the affected engine's power loss, (i.e., the total torque requirement an be met), it is normal for N_f/N_r to droop about 1% to 2% as the normal engines are forced to assume the additional load.	*1. Collective — MAINTAIN N_r. *2. Airspeed — AS REQUIRED. *3. Pickle — AS DESIRED. *4. Speed control levers — AS REQUIRED (SECURE AFFECTED ENGINE(S)). **CAUTION** Do not attempt to restart affected engine.
2. Failure in helicopter transmission system. Affected engine(s): N_g, T_5 — decrease. N_f — may increase to overspeed cut in (110% ±2%), then decrease with N_g stabilizing at flight idle speed. Torque — decrease to zero. Refer to Normal engine(s) in symptom 1.	

Figure 12-6. Power Train Failure (Sheet 1 of 2)

POWER TRAIN FAILURE
(FAILURE BETWEEN NO.1 ENGINE TURBINE AND NOSE GEAR BOX)



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE-TO-ENGINE-TO-ROTOR SYSTEM RELATIONSHIPS UPON ONSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.

NOTE

OPERATING AT 105 PERCENT Nf / Nr AT THE ONSET OF THE EMERGENCY.

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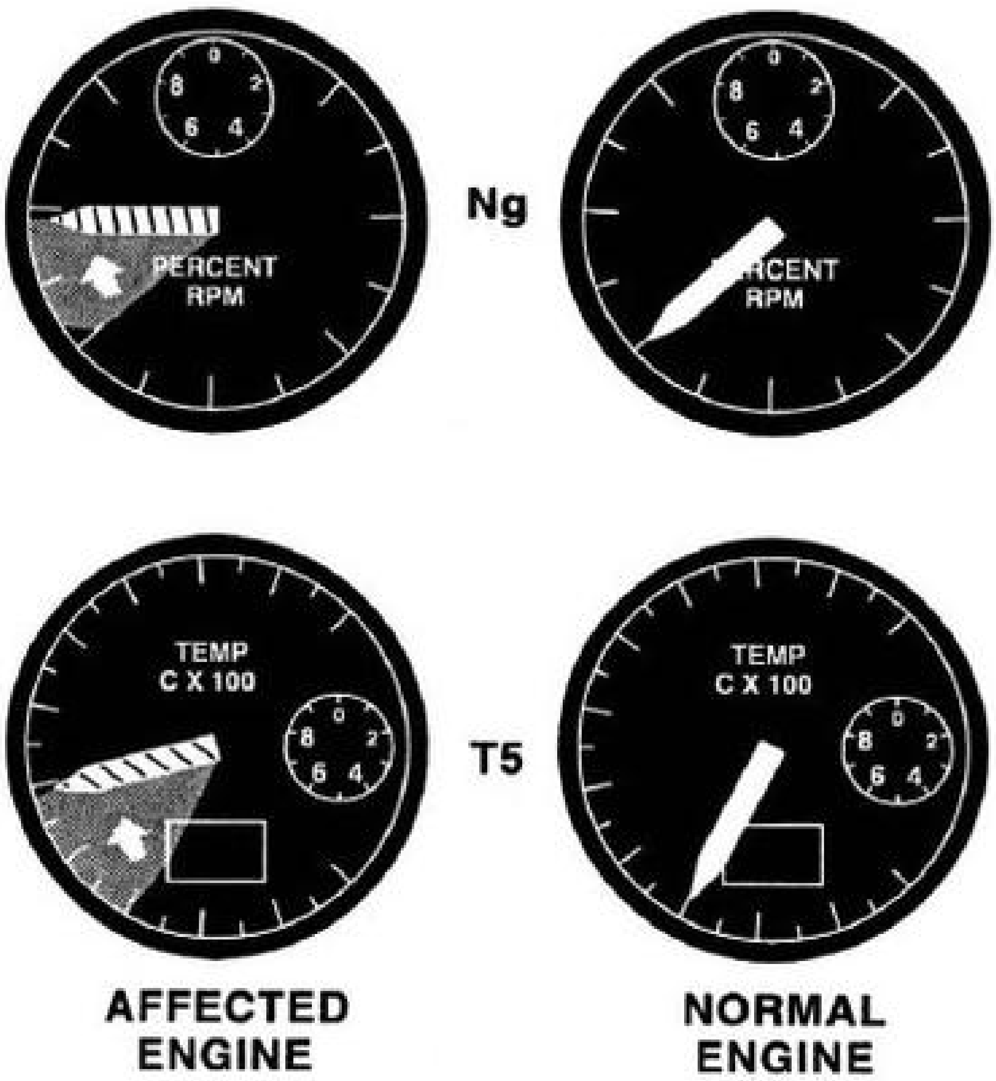
Figure 12-6. Power Train Failure (Sheet 2 of 2)

SYMPTOMS	CORRECTIVE ACTION
See Gages 1. Extended hover over salt water. a. T_5 and N_g slowly increasing, torque setting, N_f and N_r remain constant, all engines. b. Power can decrease below limits of single-point performance check.	1. Record low power indications for maintenance action. 2. Increase hover altitude to reduce salt buildup/power reduction rate. 3. Abort mission if power deterioration is excessive. **NOTE** A T_5 increase of 40°C at a constant Q is equal to a power loss of about 10%.
2. Compressor fouling. a. Reduced power output at any N_g/T_5 condition. b. Power can decrease below limits of single-point performance check. See Figure 7-5.	1. Record low power information for maintenance action. 2. Abort mission if power deterioration is excessive.
3. Compressor and turbine erosion/FOD. a. Reduced power output at any N_g/T_5 condition. b. Engine may fail to pass single-point performance check. See Figure 7-5. c. In serious instances of FOD, compressor stall/power loss may occur (see Compressor Stall, Figure 12-2).	1. Record unusual symptoms and power data for maintenance action. 2. Abort mission if power deterioration is excessive.
4. Stator vane schedule shift. a. Unusual N_g/T_5 relationship on low power engine. b. Low power engine may stall during overspeed check, deceleration or acceleration. c. Low-power engine ground idle speed may shift to or below minimum ground idle limit.	1. Record unusual symptoms and power data for maintenance action. 2. Abort mission if power deterioration is excessive.
5. Excessive engine air bleed/leakage. a. High T_5 for given N_g on low-power engine.	1. Record unusual symptoms and power data for maintenance action. 2. Turn anti-icing system of low-power engine ON; look for slight increase in T_5. Turn system OFF; look for slight decrease in T_5. If T_5 remains steady, anti-ice system is inoperative. 3. Abort mission if power deterioration is excessive.

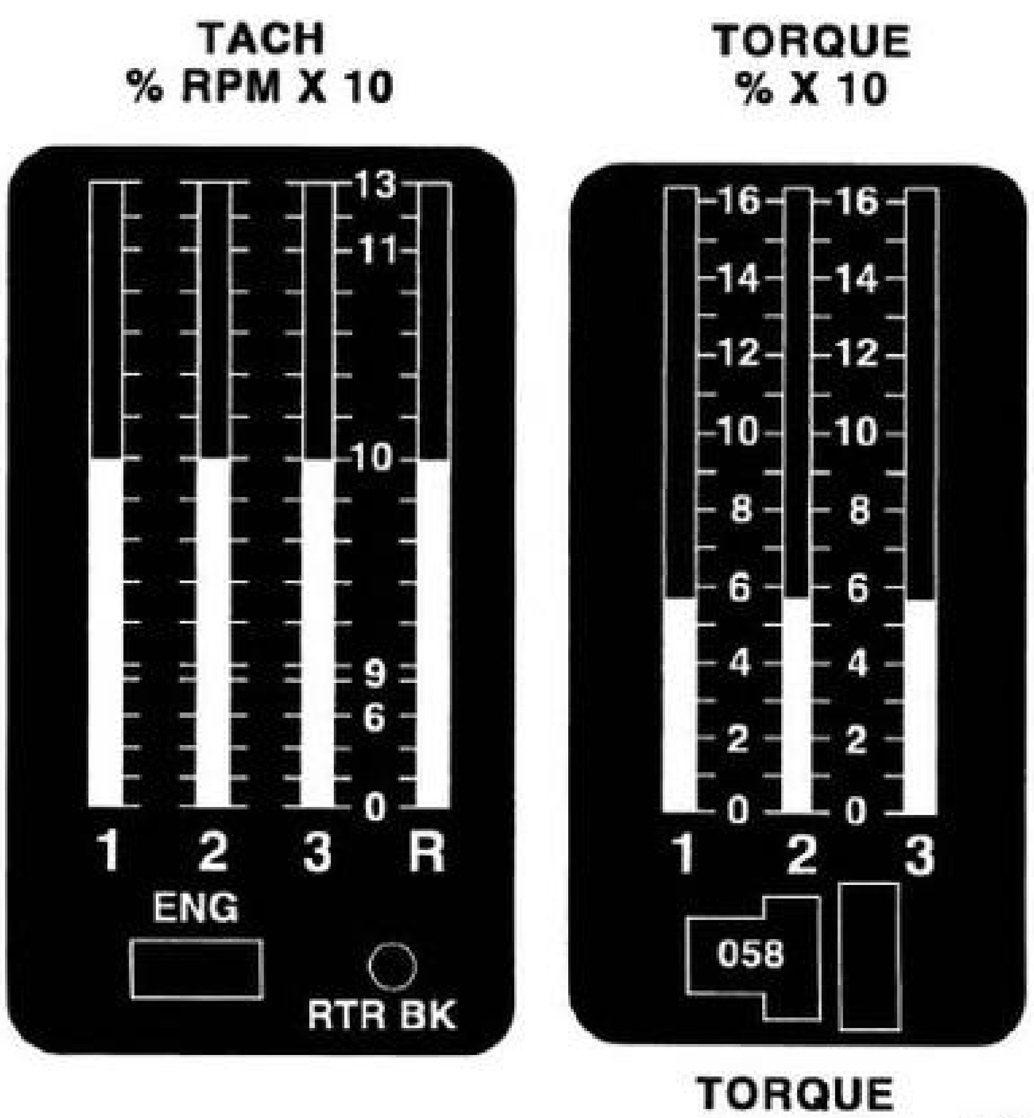
Figure 12-7. Power Deterioration (Sheet 1 of 2)

POWER DETERIORATION
(LOW ALTITUDE SALT WATER HOVER CONDITION SHOWN)



NOTE

GAGES REFLECT AN EXAMPLE OF ENGINE-TO-ENGINE-TO-ROTOR SYSTEM RELATIONSHIPS UPON ONSET OF THE EMERGENCY IN ONLY ONE OF MANY POSSIBLE REGIMES. ACTUAL ENGINE / ROTOR SYSTEM RESPONSE WILL VARY DEPENDENT UPON NORMAL ENGINES POWER AVAILABLE, THE AFFECTED ENGINES (REDUCED) POWER AVAILABLE, AND TOTAL TORQUE LOAD AT THE TIME. THE LOCATION OF INDICATORS ON Ng / T5 GAGES IS NOT IMPORTANT. HOWEVER, THEIR DIRECTION AND AMOUNT OF CHANGE IS IMPORTANT.



NOTE

POWER DEGRADATION MAY NOT DEVELOP AT A RATE READILY NOTICEABLE BY SUDDEN CHANGES IN PERFORMANCE GAGES.

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Figure 12-7. Power Deterioration (Sheet 2 of 2)

SYMPTOMS	CORRECTIVE ACTION
1. ENG OIL PRESS HIGH caution light on	
(a) Cold oil	(a) 1. Maintain reduced speed/power on affected engine until engine oil temperature is within normal operating range.
(b) Plugged lube jet	(b) 1. If critical power requirements exist, reduce power of affected engine to minimum needed for immediate requirements. 2. Transition to single- or dual-engine operating procedures as quickly as possible, and secure affected engine as instructed under ENGINE SHUTDOWN IN FLIGHT in this chapter.
2. ENG OIL PRESS LOW caution light on **NOTE** Low pressure light may come on at ground idle if N_g is at or near minimum limit.	1. If critical power requirements exist, reduce power of affected engine to minimum needed for immediate requirements. 2. Transition to single- or dual-engine operating procedures as quickly as possible, and secure affected engine as instructed under ENGINE SHUTDOWN IN FLIGHT in this chapter.
3. High oil temperature **NOTE** Oil temperature may approach maximum limit during sustained high load condition at high ambient temperatures.	1. Reduce power of affected engine to minimum needed for immediate requirements. 2. If engine oil temperature decreases to within maximum limit, continue to operate affected engine at reduced power. 3. If engine oil temperature continues to exceed maximum operating limits, transition to single- or dual-engine operating procedures as quickly as possible, and secure engine as instructed under ENGINE SHUTDOWN IN FLIGHT in this section.
4. Engine oil low level caution light on.	1. Replenish from auxiliary oil tank.

WARNING

- Level single- or dual-engine flight and/or safe single- or dual-engine hover landing may not be possible at certain combinations of helicopter gross weight and density altitude. Flight conditions may require that the decision to establish single- or dual-engine flight be deferred until a safe descent is possible. Select landing site suitable for running landing if available.
- If the No. 2 engine must be operated at less than 75% N_g, hot exhaust gas may backflow into the engine compartment creating a fire hazard. Limit airspeed to less than 85 KIAS to reduce backflow. If dual-engine flight can be maintained, consideration should be given to securing the No. 2 engine.

Figure 12-8. Engine Lubrication System Malfunction

12.13 EMERGENCY SHUTDOWN

If an emergency situation dictates immediate discontinuation of engine or rotor system operation, such as fire, control failure, transmission failure, etc.; stop the aircraft if moving, request assistance as necessary, and proceed as follows:

*1. High pressure rotor brake switch — EMERGENCY.

*2. All engine speed control levers — SHUTOFF.

*3. APP — AS REQUIRED.

*4. Fuel selector levers — SHUTOFF.

WARNING

- A fire hazard exists during emergency brake application due to the heat generated and the presence of debris and oil in the rotor brake area.
- Personnel should not exit the cabin section during emergency shutdown until the rotor head has stopped.

Note

Underfrequency protection may cause loss of electrical power due to rapid N_r decay prior to complete pressurization of the emergency rotor brake.

12.14 ENGINE SHUTDOWN IN FLIGHT

*1. Speed control lever — SHUT OFF.

WARNING

- If an operating engine and a failed or secured engine have the same tank selected, the operating engine may flame out if the failed or secured engine's fuel selector lever was not placed to SHUT OFF.
- If the No. 2 engine is shut down and/or subsequently restarted, reduce airspeed to less than 85 KIAS during the shutdown and start sequence to reduce the possibility of a fire hazard caused by hot exhaust gas backflow into the aft engine compartment.

*2. Fuel selector lever — SHUT OFF.

CAUTION

If an engine postshutdown fire should occur as indicated by a continuous T_5 above 320°C, motor engine with starter to extinguish fire.

3. Adjust power on operating engines.

4. EAPS door — CLOSED.

12.15 ENGINE RESTART DURING FLIGHT

WARNING

The No. 2 engine in-flight restart should be determined by critical power requirements. If the No. 2 engine is restarted, reduce airspeed to less than 85 KIAS during the start sequence to reduce the possibility of a fire hazard caused by hot exhaust gas backflow into the aft engine compartment.

CAUTION

A failed engine should not be restored in flight unless it can be determined that it is reasonably safe to do so. Before restarting engine in flight, allow 30 seconds of gas generator windmilling with engine speed control lever at SHUT-OFF, to purge engine of fumes and fuel.

Note

With AFC 483, a #2 ENGINE OVERHEAT caution light lets the pilots know when the No. 2 engine compartment temperature is above critical limits.

1. Emergency start switch — EMER.

2. EAPS — CLOSED.

3. Engine speed control lever — SHUT OFF. Inoperative engine.

4. Fuel selector lever — AS REQUIRED.

CAUTION

Due to probability of damaging the starting system, if time permits, the gas generator speed should be at zero before engaging the starter.

5. Starter button — PRESS.

6. Speed control lever — GRD IDLE AT 20% N_g.

7. Engine instruments — CHECKED.

While engine is accelerating, check N_g tachometer, T_5 indicator, and engine fuel flow, as during normal start.

8. Speed control lever — 100% N_f. Match engine torques.

9. EAPS — AS DESIRED.

12.16 THREE-ENGINE FAILURE

Should all engines fail, a safe autorotative landing probably can be made except when flying at low altitude-airspeed combinations. Refer to Height-Velocity Diagram — Three Engine Failure chart in Chapter 24. The altitude-airspeed combination for a safe autorotative landing is dependent upon many variables such as density altitude, gross weight, proximity of a suitable landing area, and wind direction and velocity. Main rotor rpm will decay as soon as all engines fail, and the helicopter will yaw and roll to the left due to a loss in power and corresponding reduction in torque. Heading can be maintained by depressing the right rudder pedal to decrease the tail rotor thrust. Except when all engines fail in close proximity to the ground, it is mandatory that autorotation be established by immediately lowering the collective pitch to minimum. If collective pitch is not reduced enough to effect a safe recovery, control will be lost due to a decay in N_r.

WARNING

- After three-engine failure, corrective action has to be completed immediately or control will be lost due to N_r decay. Although the corrective action has to be done quickly, it must also be done smoothly to avoid rotor blade to fuselage contact.

- With a three-engine failure the option of jettisoning external auxiliary fuel tanks exists. The maximum jettisoning speed for descent is 120 KIAS, and the maximum rate of descent is 1500 fpm. Since this rate of descent will be reached and exceeded rapidly, the decision to jettison should be made and executed immediately.

Note

- Flare effectiveness at airspeeds for minimum rate-of-descent will be marginal in arresting descent rate.

- The maximum glide distance airspeed provides improved flare effectiveness.

12.16.1 Autorotative Landing. (Figure 12-9) Autorotative RPM will vary with different ambient temperatures, airspeeds, pressure altitudes, G-load factors, and gross weights. Optimum rotor speed (N_r), in the descent, is 95% to 100%. For autorotative descent, select an autorotative glide airspeed as required (Figure 12-10). Perform landing checklist with landing gear as desired (gear up for water landings). The recommended entry airspeed for the cyclic flare should be no less than the minimum rate-of-descent airspeed as determined by figure 12-10. At or above 150 ft AGL (avoiding continuous flight in the shaded area of the height-velocity diagram, Figure 24-1), initiate a smooth, progressive flare by adjusting nose-up pitch attitude as necessary to reduce ground speed and rate-of-descent. At an altitude of about 50 to 75 ft AGL, lower the nose to the landing attitude (8° nose-up maximum) and raise the collective to cushion the landing.

WARNING

- Allowing airspeed to decrease below 40 KIAS will cause a rapid increase in rate-of-descent.

- N_r will decay rapidly when collective is applied to recover. Allowing N_r to decay prematurely may result in insufficient lift for recovery.

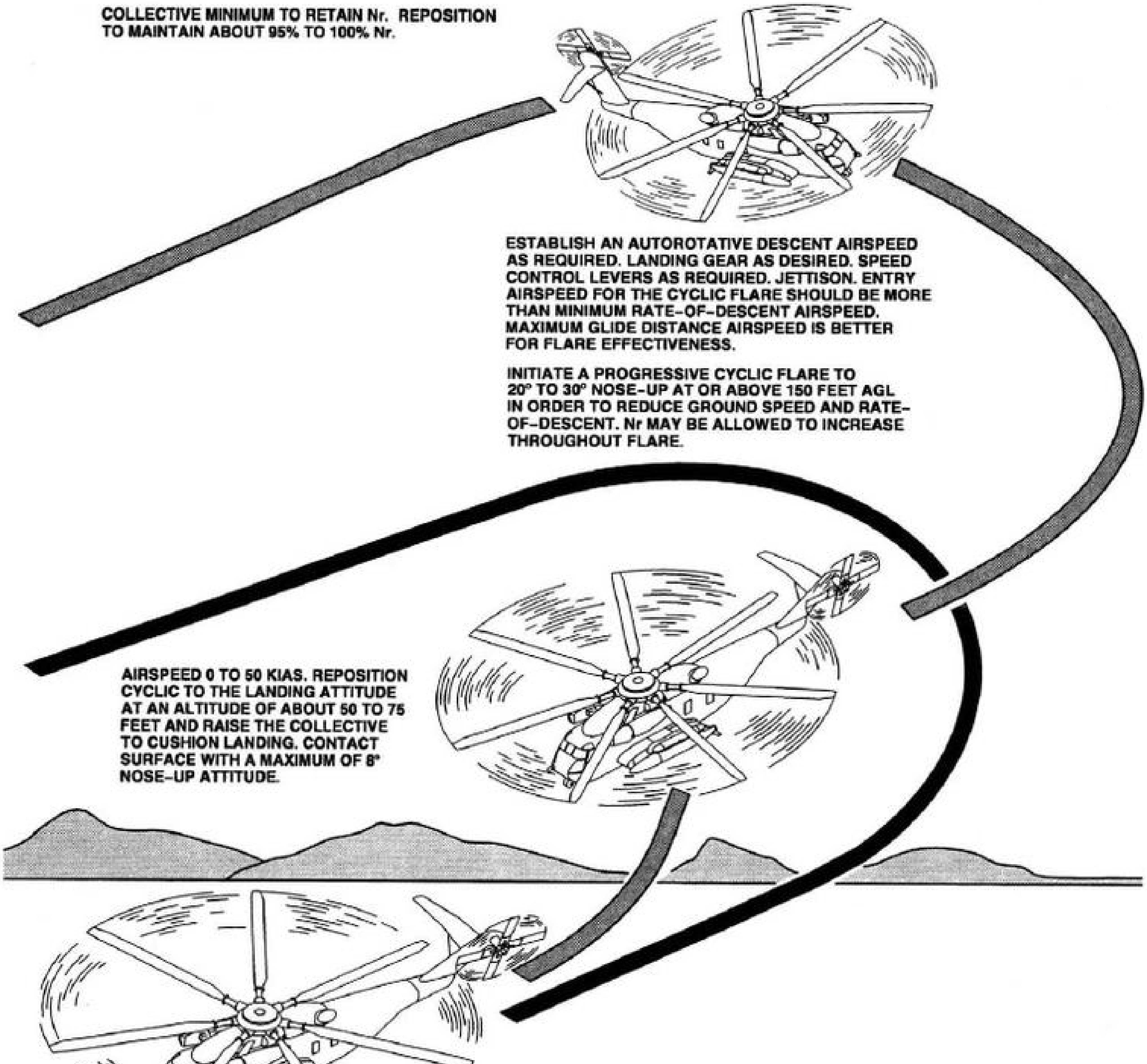


Figure 12-9. Autorotative Landing (Typical)

12.16.2 Three-Engine Failure While Hovering at Low Altitude (0 to 50 Feet). If all engines should fail while hovering at low altitude, settling will be rapid, and immediate application of right rudder pedal will be necessary to maintain heading. The landing can be cushioned by increasing collective pitch as the helicopter settles to the ground. Do not reduce collective pitch, as a reduction in pitch will cause the helicopter to settle more rapidly. The helicopter should be held in a hover attitude until contact is made with the ground, where the cyclic should be moved to the neutral position and the collective pitch lever slowly lowered to minimum. After contact with the ground is made, apply wheel brakes, start the APP, and apply the rotor brake.

12.16.3 Three-Engine Failure (Hover and Takeoff)

*1. Collective — REDUCE (IF ALTITUDE PERMITS, TO MAINTAIN N_r).

*2. Airspeed — AS REQUIRED.

*3. Pickle — AS DESIRED

*4. Speed control levers — AS REQUIRED.

*5. Collective — INCREASE (CUSHION LANDING).

12.16.4 Three-Engine Failure (Cruise)

*1. Collective — REDUCE (TO MAINTAIN N_r AT 95% TO 100%).

*2. Airspeed — AS REQUIRED (MAXIMUM GLIDE DISTANCE AIRSPEED PROVIDES IMPROVED FLARE EFFECTIVENESS).

*3. Pickle — AS DESIRED.

*4. Speed control levers — AS REQUIRED.

*5. Execute autorotative landing (Figure 12-9).

12.16.5 Three-Engine Failure at High Power and Low Speed. Lower the collective to the full-down position while moving the cyclic forward to regain airspeed. Establish a glide at the airspeed for minimum rate-of-descent. This action normally requires several hundred feet of altitude if the recovery is started at zero airspeed. If there is enough altitude, the minimum rate-of-descent airspeed may be increased to the maximum glide distance airspeed for improved flare effectiveness. Land as outlined in THREE-ENGINE FAILURE (Autorotative Landing), in this chapter.

12.16.6 Three-Engine Failure at High Power and High Speed. If a constant airspeed is maintained while normal recovery procedures are being used, a loss of several hundred feet of altitude will be realized. This altitude loss may be reduced by applying aft cyclic and adjusting collective pitch as necessary to maintain sufficient N_r. The rate that aft cyclic is applied and the duration of the corresponding nose-high attitude determines the rate of deceleration and/or loss of altitude. Judicious use of collective pitch during the flare to keep N_r from building up also reduces the rate-of-descent. Land as outlined in THREE-ENGINE FAILURE (Autorotative Landing); in this chapter.

12.16.7 Three-Engine Failure at High Speed and Low Altitude. If three-engine failure is encountered at high speed and low altitude, immediately but smoothly apply aft cyclic to hold the helicopter off the surface and adjust collective pitch to maintain N_r. Land as outlined in THREE-ENGINE FAILURE (Hover/Take-off), in this chapter.

12.16.8 Autorotation Charts. The autorotation charts (Figure 12-10) are provided for conditions of both sea level standard day and 5000 ft standard temperature (standard temperature lapse rate applied to sea level standard day condition). They provide the best airspeed for either maximum glide distance (glide ratio) or minimum rate-of-descent for different gross weights. The glide ratio section shows the distance traveled in nautical miles per 1000 ft of altitude loss under zero wind conditions. The rate-of-descent section shows the vertical descent rate in hundreds of feet per minute. The best values for each section are shown by dashed curves. Maximum glide distance or minimum rate-of-descent is achieved by adjusting the cyclic and collective to control and maintain 100% N_r at the airspeed shown where these dashed curves cross an appropriate gross weight arc.

For example, to find the maximum glide distance (glide ratio), choose an appropriate gross weight arc on the right side of the upper section (50,000 lbs). Follow this contour to where it is crossed by the dashed curve. From that point, drop straight down to read the airspeed required for maximum glide distance (104 KIAS). From the same point where the gross weight arc is crossed by the dashed curve, trace left to read a maximum glide ratio of 0.52 nm per 1000 ft altitude loss. The rate-of-descent

AUTOROTATION

100% Nr   SEA LEVEL   STANDARD DAY
GEAR DOWN

MODEL: CH-53E
DATA AS OF: MARCH 1997
DATA BASIS: FLIGHT TEST

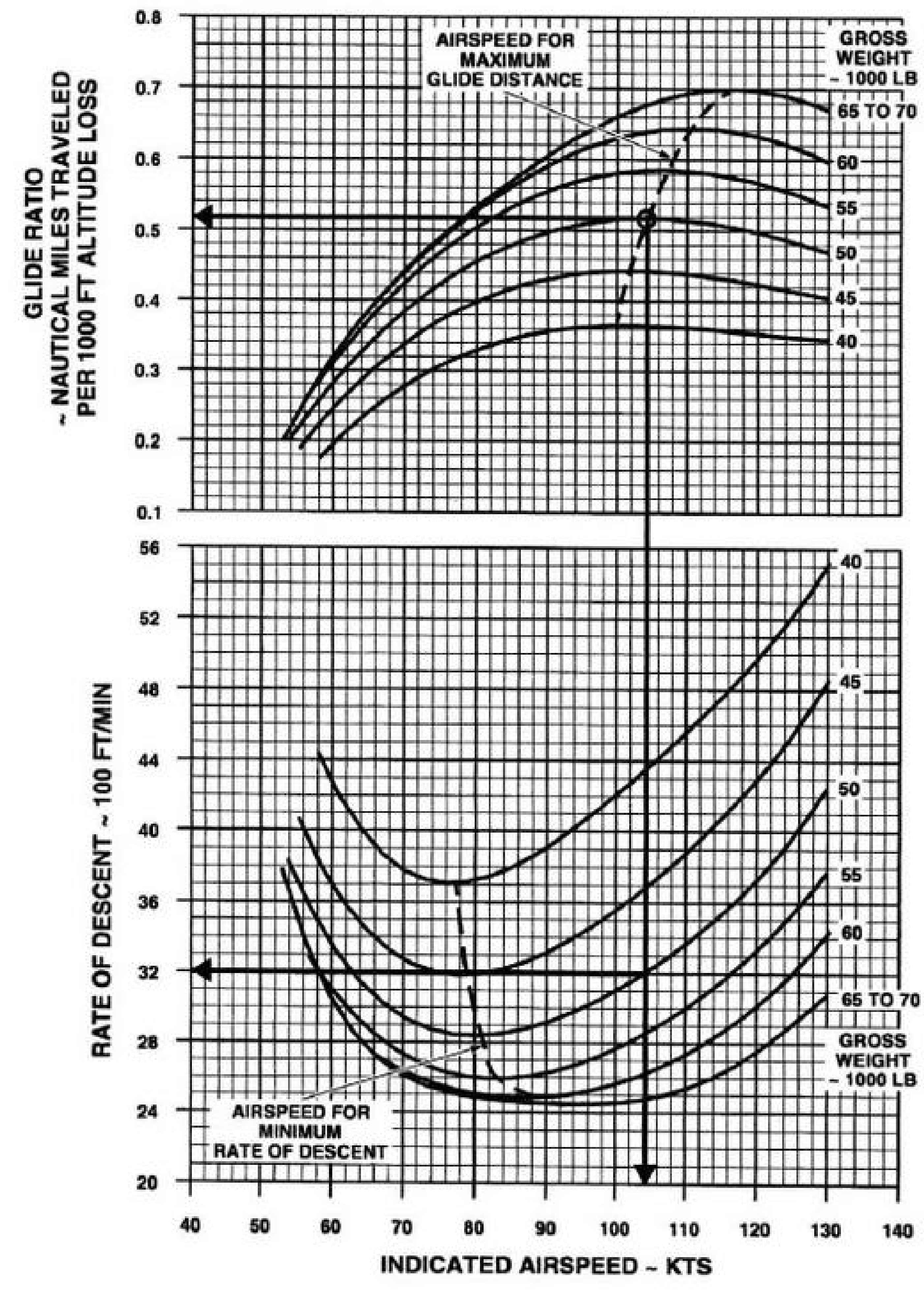
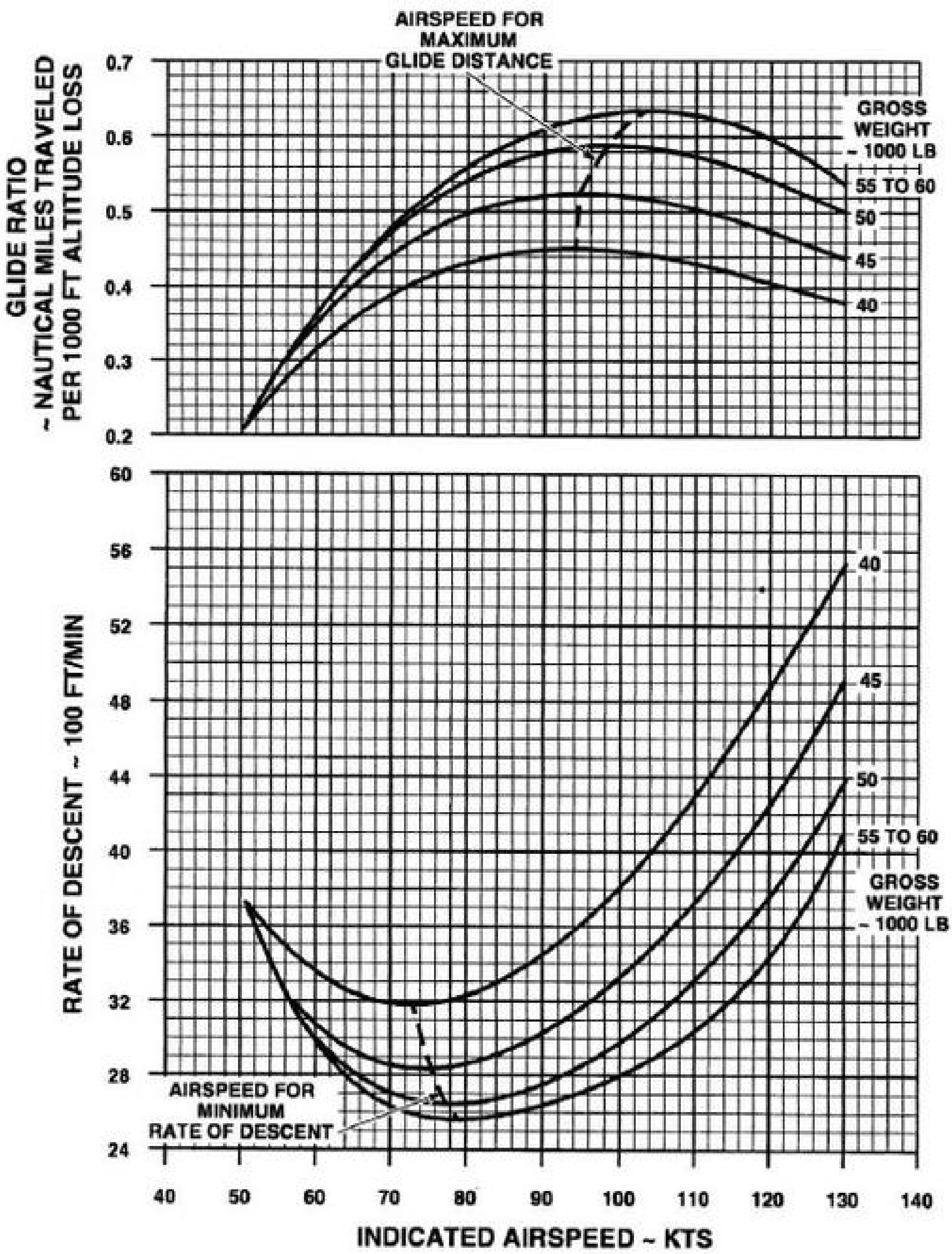


Figure 12-10. Autorotation Chart (Sheet 1 of 3)

AUTOROTATION

100% Nr 5000 FT STD TEMP
GEAR DOWN

MODEL: CH-53E
DATA AS OF: MARCH 1997
DATA BASIS: FLIGHT TEST



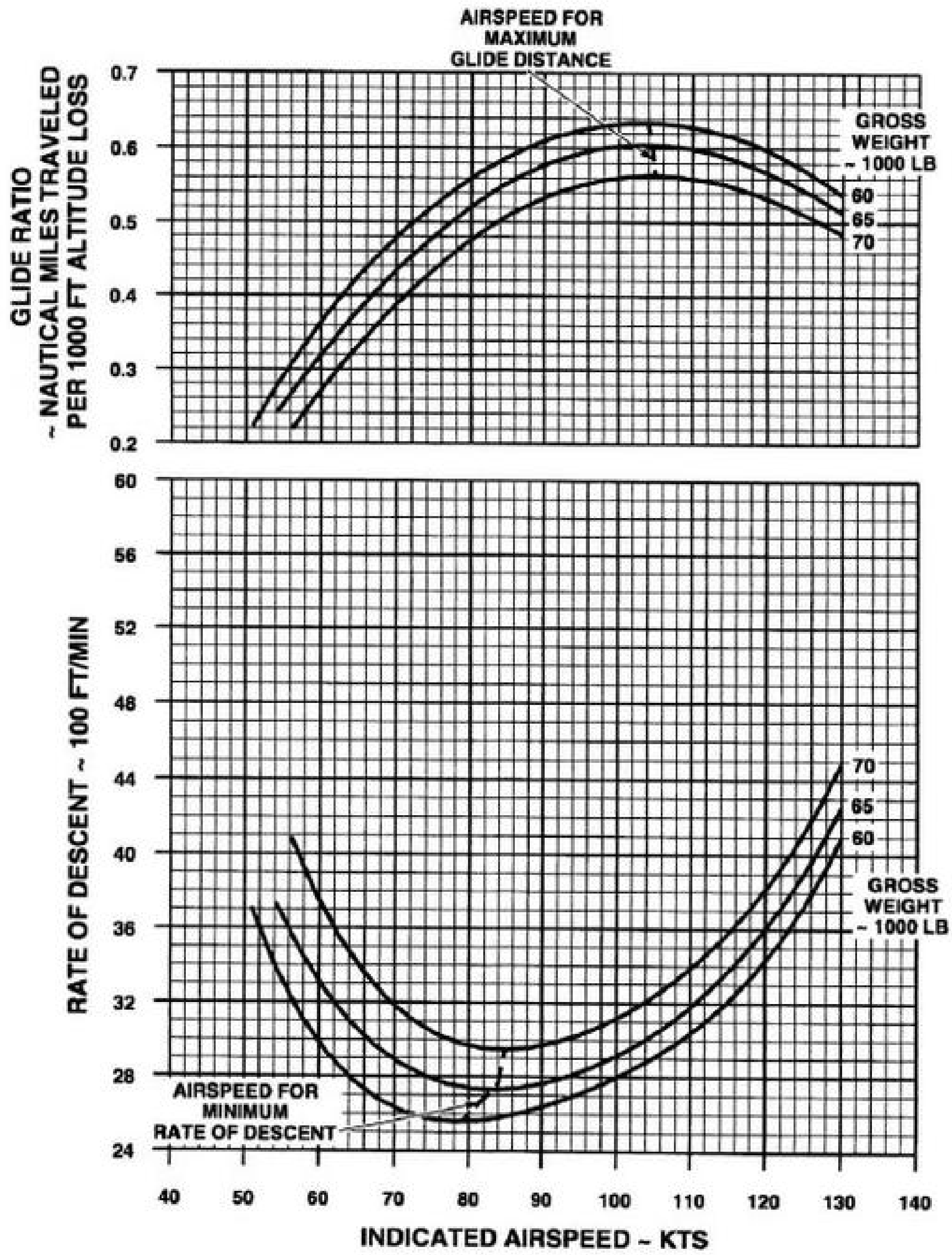
HC3712_1

Figure 12-10. Autorotation Chart (Sheet 2 of 3)

AUTOROTATION

100% Nr 5000 FT STD TEMP
GEAR DOWN

MODEL: CH-53E
DATA AS OF: MARCH 1997
DATA BASIS: FLIGHT TEST



HC3712_2
SAF

Figure 12-10. Autorotation Chart (Sheet 3 of 3)

under these conditions can then be found by tracing left from where the previously-defined airspeed line crosses an appropriate gross weight arc in the lower section (3200 ft per minute).

Airspeed for minimum rate-of-descent can be found in a similar manner, providing glide ratio information.

12.17 TAIL ROTOR SYSTEM FAILURE

Tail rotor system failures can generally be classified as drive system failure or control system failure.

12.17.1 Tail Rotor Drive System Failure

WARNING

Tail rotor drive system failure, in all regimes of flight, can produce violent helicopter response, therefore recognition of impending failure is extremely important. Extended flight at moderate airspeed is theoretically possible following tail rotor drive system failure in forward flight. Extend hovering flight is not possible following a tail rotor drive system failure.

Tail Rotor Drive System failure, where RPM and thrust are lost, may be caused by any one of a multitude of structural failures. A drive system failure, either in hover or forward flight, may be difficult to cope with because the stabilizing effect of rotating disk area and/or tail rotor thrust will be lost. Tail rotor drive system failure is usually preceded by excessive vibration or noise in the tail section, followed by a right yawing acceleration which will be proportional to the amount of torque which is being used at that time. If the failure occurs in forward flight, it will result in a right yaw acceleration that probably would be somewhat lower than loss of drive in a hover. However, in either case, the right yaw acceleration can be reduced by an immediate reduction in power. Landing from forward flight without the tail rotor operating is hazardous due to the high possibility that the helicopter may touch down in an excessive skid and roll over. Following a tail drive failure in flight, if the right yaw acceleration is arrested after initial collective reduction and extended powered flight is achieved, a running landing may afford the best touchdown control, terrain permitting. The final approach should be made into the wind at approximately 80 KIAS. As airspeed is decreased below 100 to 120 KIAS on final, the reduced slip stream can be expected to result in somewhat greater skid; however, this tendency should be offset by the lesser amount of torque required to fly 80 KIAS and descend, resulting in a tolerable in-flight skid. Approaching the intended point of touchdown, at approximately 50 to 75 feet AGL, coordinated collective power reduction and aft cyclic to minimize, if not eliminate, the torque load should produce acceptable nose alignment while further reducing ground speed prior to touchdown. In order to maintain nose alignment, all operating engines should be secured and rudder pedals centered before increasing collective to cushion the touchdown. However, if acceptable nose alignment is achieved at a low collective setting which can be maintained until ground contact, all engines should be secured soon after touchdown. In any case, judicious lateral cyclic should be applied to ensure the helicopter track over the ground follows the nose at/after ground contact. After touchdown differential braking should be used to help maintain directional control.

If extended flight is possible, however rough terrain/water precludes a running landing or nose alignment is not achieved as described above, a moderate side flare approaching the intended point of landing should be used to minimize ground speed and drift prior to touchdown. All operating engines should be secured during the flare, prior to increasing collective to cushion the landing. Touching down tail first may aid in cushioning both forward and vertical deceleration on ground contact, and may even assist in maintaining a straight ground track.

If extended flight is not achievable, an immediate autorotative descent and landing should be made as outlined under Three-Engine Failure (Autorotative Landing), in this chapter.

Landing from a hover with an inoperable tail rotor is hazardous because of fuselage rotation. Fuselage rotation can be stopped or greatly reduced by retarding all engine speed selectors to the shut off position. However, the engines should not be shut down until the helicopter is clear of the height-velocity avoid area.

WARNING

Loss of tail rotor thrust will result in exaggerated pitch and roll responses to collective and/or rudder inputs due to mechanical coupling.

12.17.1.1 Tail Rotor Drive System Failure (Hover and Take-Off)

*1. Collective — REDUCE (IF ALTITUDE PERMITS) TO INITIATE A MODERATE RATE-OF-DESCENT AND RETARD ROTATION.

*2. Airspeed — AS REQUIRED (LAND IN LEVEL ATTITUDE).

*3. Pickle — AS DESIRED.

*4. Speed control levers — SHUT OFF AT 5 TO 20 FEET AGL.

*5. Collective — INCREASE (CUSHION LANDING).

12.17.1.2 Tail Rotor Drive System Failure (Cruise)

*1. Collective — REDUCE (ENOUGH TO STOP FUSELAGE ROTATION).

*2. Airspeed — 100 to 120 KIAS.

*3. Pickle — AS DESIRED.

*4. Rudder pedals — CENTERED.

*5. If directional control is not regained — AUTOROTATE.

WARNING

- If steps 1 through 4 are unsuccessful in regaining directional control of the helicopter, the pilot should immediately enter autorotation and perform an autorotative descent and landing as outlined under Three-Engine Failure (Autorotative Landing), in this chapter. Secure all engines before increasing collective to cushion landing.

- If the tail rotor/tail rotor gearbox/tail section has (have) departed the aircraft, absence of the autorotating tail rotor will necessitate an autorotative descent and landing. However, due to the forward shift of C. G. under such conditions, the pilot should use extreme caution during the flare recovery to avoid excessive forward pitch rates which may become uncontrollable.

6. If directional control is regained, proceed with steps a. and b.

a. Alter bank angle and collective as required to maintain controllable flight. The magnitude of bank angle required for straight ground track will vary with airspeed and collective setting. As airspeed is reduced below 100 to 120 KIAS, a larger angle of bank or reduction in torque will be required to compensate for increased right yaw.

b. Land as soon as possible.

(1) If over suitable flat terrain, attempt a running landing. Consideration should be given to landing with the landing gear up if the surface is soft/uneven and possibility of shearing the landing gear or rolling over is judged to exist. Establish 80 KIAS on final and approaching 50 to 75 feet AGL, a combination of collective reduction/aft cyclic will minimize torque and slow groundspeed to assist in aligning the nose for touchdown. Secure all engines before increasing collective to cushion landing.

(2) If nose will not align or terrain is too rough for running landing, accomplish landing using a moderate side flare to minimize ground speed and drift, secure all engines in the flare and contact ground tail first on flare and flare recovery.

12.17.1.3 Tail Rotor Drive System Failure During Landing. If the tail rotor drive system fails during the landing approach, the proper corrective action will depend upon the airspeed and altitude the helicopter has at the time of failure. The pilot should land the helicopter utilizing either the Tail Rotor System Failure (Cruise) landing procedure or the Tail Rotor Drive System Failure (Hover and Take Off) landing procedure, in this chapter. It is, therefore, incumbent upon the pilot to select the proper procedure based upon where the helicopter is in the landing profile.

12.17.2 Tail Rotor Control System Failure. The self-centering spring installation provides the capability of continued flight to a landing site with tail rotor control system failure. At a gross weight of 46,500 pounds the helicopter flies in a right sideslip (left yaw) below 135

KIAS, trims to balanced level flight at about 135 KIAS, and flies in a left sideslip (right yaw) at speeds above 135 KIAS. Balanced flight at gross weights above 46,500 pounds is achieved at lower airspeeds, and below 46,500 pounds at higher airspeeds.

12.17.2.1 Approach and Landing with Tail Rotor Control System Failure. If an approach and landing is to be made, airspeed can be reduced while maintaining a reasonable trimmed flight condition by slowly reducing power and entering a left turn with cyclic. Balanced flight can be maintained during power and airspeed changes by increasing or decreasing the roll angle until about 35% to 40% torque and 50 to 60 KIAS is attained. Level flight can then be maintained with a small amount of right sideslip at 35% to 40% torque and 50 to 60 KIAS. Increasing collective too rapidly or too much will cause a sideslip to the left and decreasing collective too rapidly or too much will cause a sideslip to the right. It is recommended that a roll-on landing be made on a prepared surface. If the landing has to be made to an unprepared surface, consideration should be given to a wheels-up slide-on landing. It is important during the final phase of the landing to (1) retain attitude by referencing the VGI, (2) slightly apply collective just before touchdown to provide a nonslip condition for touchdown, and (3) immediately apply wheel brakes while slowly lowering the collective. A wave-off may be made any time before a small flare is initiated for final touchdown by accelerating into forward flight. While accelerating, the helicopter will enter a left sideslip condition that will decrease as airspeed is increased.

1. Flight path — 180° LEFT APPROACH.

2. Downwind leg — 200 FEET ALTITUDE AND 45 to 50 KIAS.

Note

Airspeed can be reduced during the turn on to final approach or when rolling out of the turn to final approach.

3. Start — APP.

Note

N_r above 103% may result in APP shutdown.

4. Final approach — 6° TO 8° NOSE-UP ATTITUDE, AND ENOUGH TORQUE TO MAINTAIN 35 TO 45 KIAS AND 200 TO 300 FEET-PER-MINUTE RATE-OF-DESCENT.

WARNING

Rapid or too large increased collective application will cause the helicopter to sideslip to the left. Rapid or too large decreased collective application will cause the helicopter to sideslip to the right.

5. Collective — INCREASE SLIGHTLY TO REDUCE SIDESLIP AND MAINTAIN ALL CONDITIONS TO TOUCHDOWN.

6. Touchdown — IMMEDIATELY APPLY WHEEL BRAKES AND SLOWLY LOWER COLLECTIVE.

7. Speed control levers — GROUND IDLE.

12.17.2.2 Tail Rotor Control Failure in a Hover. Loss of tail rotor control in hover will be characterized by unresponsive pedals. Aircraft response will depend on hover power required, wind speed, and aircraft heading relative to the wind. Collective increases will increase the right yawing moment. Collective decreases will decrease the right yawing moment. If the aircraft is yawing right, slowly reduce collective and touch down with minimum drift as tail yaws into the wind. If aircraft is yawing left, start the APP if possible, and slowly decrease N_r at 5 to 10 feet AGL to reduce tail rotor thrust and left yaw rate. Touch down with minimum drift as tail yaws into wind and left yaw rate stops.

12.17.3 PYLON UNSAFE FOR FLIGHT Light. Illumination of the PYLON UNSAFE FOR FLIGHT light while operating at 100% N_r may provide warning of a malfunctioning tail rotor disconnect fitting. Total failure of the tail rotor disconnect fitting will result in loss of tail rotor drive. Failure to retract or premature extension of the tail rotor actuator could result in damage to the tail rotor head or tail rotor gear box. Extension or cycling of the tail rotor disconnect disengage flag may also indicate a malfunctioning tail rotor disconnect fitting.

Illumination of the PYLON UNSAFE FOR FLIGHT light or extension/cycling of the tail rotor disengage flag occurs, execute the following procedures:

*1. If accompanied by abnormal vibration, noise in the tail section, or yaw kicks — LAND IMMEDIATELY.

2. If not accompanied by these indications — LAND AS SOON AS POSSIBLE, MINIMIZE TAIL ROTOR STRESS, EXECUTE RUNNING LANDING IF POSSIBLE.

Note

A PYLON UNSAFE FOR FLIGHT caution light may be accompanied by loss of AFCS servos.

12.18 BEARING VIB LIMIT, BEARING TEMP DETECT, and BEARING TEMP LIMIT Caution Lights (AFC 491)

The BEARING VIB LIMIT, BEARING TEMP DETECT, and BEARING TEMP LIMIT caution lights are part of the bearing monitor system (BMS). Refer to Chapter 2 for additional BMS details.

Note

A VIB DETECT light on the BMP indicates that the BMS has sensed bearing vibration level(s) which are higher than normal. A 10-hour limitation (for SP-1 and/or SP-2 sensors) or a 50-hour limitation (for the DISC sensor) will be imposed and will require maintenance action.

12.18.1 BEARING VIB LIMIT Caution Light. If the BEARING VIB LIMIT caution light comes on:

1. Aircrew — ALERT.

2. Land as soon as practical.

12.18.2 BEARING TEMP DETECT Caution Light. If the BEARING TEMP DETECT caution light comes on:

1. Aircrew — ALERT.

*2. Land as soon as possible.

Aircrew:

1. Emergency landing checklist — EXECUTE.

12.18.3 BEARING TEMP LIMIT Caution Light. If the BEARING TEMP LIMIT caution light comes on:

1. Aircrew — ALERT.

*2. Land immediately.

Aircrew:

1. Emergency landing checklist — EXECUTE.

12.18.4 Bearing Monitor System Fault Isolation. The bearing monitor panel (BMP) shows bearing monitor system (BMS) fault indications to the aircrew. If a fault indication shows more than a maintenance condition, the pilots have to know immediately. This is normally done by the BEARING VIB LIMIT, BEARING TEMP DETECT, or BEARING TEMP LIMIT lights on the caution/advisory panel. If the aircrew sees a system or bearing fault condition on the BMP:

1. Tell the pilots about the indication and the sensor location shown on the BMP display.

2. If the BMP display shows a plus sign (+) next to the fault, press PREV or NEXT as necessary to identify all faults.

3. Tell the pilots about any other bearings or sensors which give fault indications.

Note

If the location shown on the BMP display has a fault, an applicable BEARING STATUS or SYSTEM STATUS annunciator light comes on.

4. BMP system reset (IF REQUIRED):

Note

Do not perform system reset after a PNL NG failure.

a. BMP display — ALL OK.

b. Press PREV button — RESET DISPLAYED.

c. Press SELECT button — RESET COMPLETE.

*5. Land as soon as practical if a system fault occurs which precludes monitoring of swashplate vibrations/temperatures as indicated by any of the following conditions:

a. Illumination of a TEMP or VIB system status light, and SP1 and SP2 fault indications appearing in the BMP alphanumeric display.

b. Illumination of the PANEL system status light and PNL NG fault indication appearing in the BMP alphanumeric display.

c. Failure of the BMP display or loss of system power.

Note

Failure of both the SP1 and SP2 sensors or failure of the bearing monitor panel (BMP) will result in loss of swashplate monitoring capabilities.

12.19 BIM® CAUTION LIGHT

If BIM caution light goes on, have a crewmember check if BIM circuit breaker is in (on right cabin circuit breaker panel). Due to the sensitivity of the system, the caution light may go on due to Electromagnetic Interference (EMI), giving the pilot a false indication of impending spar failure. If the caution light remains on with the circuit breaker in, and EMI is not verified:

12.19.1 In-Flight

*1. Airspeed — 80 KIAS, MINIMIZE MANEUVERING.

*2. Altitude — MINIMUM SAFE.

3. No. 3 primary ac BIM circuit breaker — CHECK IN.

4. Land as soon as practical. Do not exceed 2 flight hours unless necessary to reach a safe landing site.

Aircrew (at pilot's discretion)

1. Reset circuit breaker.

2. Perform IBIS BIT check.

12.19.2 On the Ground. If all spar indicators are white, but the BIM caution light remains on or the IBIS BIT is unsatisfactory, a malfunction in the radiation detector or signal processor is indicated. The helicopter may be flown for 2 hours at 80 KIAS at minimum safe altitude (minimizing maneuvering). The helicopter must then be landed and reinspected before continuing on additional 2-hour legs. If a spar indicator shows black at any time, further flight shall not be attempted until qualified maintenance personnel check the integrity of the spar.

12.20 FIRE

When possible, confirm presence of fire by sight or smell; then do as follows:

12.20.1 Engine Compartment Fire on the Ground. If an engine compartment fire occurs while on the ground, do this:

*1. Speed control lever — SHUT OFF.

*2. Emergency T-handle (for engine on fire) — PULL AFT.

This shuts off fuel and selects engine compartment for fire extinguisher.

*3. Main engine fire extinguisher switch — MAIN, RESERVE, IF NECESSARY.

4. Ground crew — ALERTED.

Aircrew:

*1. Notify pilot of location and extent of fire.

*2. Discharge fire extinguisher into compartment access.

12.20.2 Single- or Dual-Engine Compartment Fire(s) in Flight. Engine fires are usually the result of an engine malfunction or failure of one of its component systems. Ruptured fuel and oil lines will usually be detected by engine instrument indications. To be sure the engine fire detection system is not being activated by the sun's rays, turn the helicopter 90° to its flight path. When possible, confirm presence of fire by sight or smell; then do this:

*1. Collective — MAINTAIN N_r.

*2. Airspeed — AS REQUIRED.

*3. Pickle — AS DESIRED.

*4. Speed control levers — AS REQUIRED (AFFECTED ENGINE(S) SHUT OFF).

*5. Fire T-handles — PULL AFT (AFFECTED ENGINE(S)).

*6. Main engine fire extinguisher switch — MAIN, RESERVE IF NECESSARY.

Note

If two bottles were discharged into one engine compartment, the remaining bottle can be discharged into either of the remaining compartments. The last bottle will be discharged by either the MAIN or RESERVE selection, depending on which two bottles have already been discharged, and which compartment has been selected. In this case, the most expeditious thing to do is to select MAIN and then RESERVE.

*7. If fire continues, land immediately.

8. If fire extinguished, refer to SINGLE- OR DUAL-ENGINE FAILURE in this chapter.

12.20.3 Engine Postshutdown Fire. An engine postshutdown fire in the combustion chamber after shutdown may continue to feed itself unless it is blown out by compressor air. Indications would be a rise in T_5 above 320°C after shutdown and/or excessive smoke from the engine exhaust outlet.

*1. Speed control lever — SHUTOFF.

*2. Fuel selector lever — SHUTOFF.

*3. Emergency start switch — EMER.

*4. Starter button — PRESS.

Motorize engine until fire is put out, and observe T_5.

Note

If all engines have been shut down, APP should be operating.

5. If fire continues, be sure EAPS doors are open and have fire extinguisher discharged into air inlet duct while motoring engine.

6. Pull down on handle of speed control lever to stop starter.

7. If an engine fire warning light goes on:

Emergency T-handle — PULL AFT.

To select engine compartment for fire extinguisher.

8. Engine fire extinguisher switch — MAIN. RESERVE, IF NECESSARY.

Aircrew:

*1. Notify pilot of location and extent of fire.

*2. If fire continues, at pilot's command, discharge fire extinguisher through open EAPS doors.

12.20.4 Three Simultaneous Engine Compartment Fires in Flight

*1. Land immediately.

12.20.5 APP Or Cabin Heater Fire. A fire in either the APP or cabin heater will be indicated by the fire warning master lights and the fire warning lights in the APP emergency T-handle. Whenever the APP and cabin heater fire warning light is on, do this:

*1. APP emergency T-handle — PULL AFT (TO DISCHARGE FIRE EXTINGUISHER AND SHUTOFF APP AND HEATER FUEL).

*2. If fire persists — LAND IMMEDIATELY.

3. APP circuit breaker control switch — OFF. If APP operating.

4. Cabin heater rheostat control — OFF. If cabin heater operating.

5. Alert ground crew (if on the ground).

Aircrew:

*1. Notify pilot of location and extent of fire.

*2. Discharge fire extinguisher into compartment access.

12.20.6 Fuselage Fire

*1. Cockpit circular vents — CLOSED.

*2. Vent fan switch — OFF.

*3. If fire persists — LAND IMMEDIATELY.

Aircrew:

*1. Notify pilot of extent and location of fire.

*2. Fight fire with fire extinguisher.

*3. Pull circuit breaker(s) for affected system at pilot's command.

*4. Emergency Landing Checklist — EXECUTE.

12.20.7 Electrical Fire. In case of an electrical fire, attempt to isolate the affected circuits by selectively securing electrical equipment or pulling circuit breakers. If fire persists, land immediately; while in flight, do as follows:

WARNING

Turning all generators off will result in immediate loss of all electrical instruments, warning systems, ICS, and AFCS, except servo 1. Helicopter response to total electrical loss may be violent. Landing gear may only be extended by the emergency method, and a positive gear down check will not be possible. Consideration should be given to all problems before turning all generators off.

*1. Circuit breaker (for affected circuit) — PULL.

*2. Fight fire with portable fire extinguisher.

*3. If fire persists — LAND IMMEDIATELY.

Aircrew:

*1. Notify pilot of extent and location of fire.

*2. Fight fire with fire extinguisher.

*3. Pull circuit breaker(s) for affected system at pilot's command.

*4. Emergency Landing Checklist — EXECUTE.

12.20.8 Hydraulic Fire in Main Rotor Pylon. Hydraulic fire in the main rotor pylon area is most likely to occur during taxi, hover, or low airspeed operations. Hydraulic fire may be indicated by white smoke and/or flames in the vicinity of the main transmission and/or by illumination of a number of unassociated caution lights. Because of the intense heat generated, flight control components may disintegrate rapidly, causing the aircraft to become uncontrollable. If a hydraulic fire is detected/suspected:

*1. Land immediately.

Note

If feasible, accomplish a running landing at 40 knots ground speed to maintain airflow through the rotary wing pylon.

*2. Secure helicopter — IMMEDIATELY.

WARNING

Delay in shutting down the helicopter may give the fire time to burn through a flight control component, causing the helicopter to roll over.

3. Portable fire extinguisher — USE.

12.20.9 Smoke and Fume Elimination

Pilot:

1. Vent fan — ON.

2. Registers and diffusers — OPEN.

Crewman:

1. Diffusers — OPEN.

2. Upper half of personnel door — OPEN.

3. Emergency escape hatch (gunner window) — OPEN.

4. Cargo ramp door — OPEN.

CAUTION

Do not push out cabin windows or escape hatches while helicopter is in flight, as they may damage helicopter.

12.20.10 Fire During Rapid Ground Refueling (RGR) Operations

Aircrew:

*1. RGR personnel — ALERTED.

*2. Refueling operations — CEASE.

*3. Emergency shutdown — AS REQUIRED.

*4. Evacuate helicopter.

*5. Fight fire with portable fire extinguisher.

Ground Crew:

*1. Refueling switch — OFF.

*2. Fuel line — DISCONNECT.

*3. Alert aircraft/vehicle personnel.

*4. Fight fire with portable fire extinguisher.

12.20.11 #2 ENGINE OVERHEAT Caution Light (AFC 483) When the temperature inside the No. 2 engine compartment rises above approximately 575°F, a signal is sent to illuminate the #2 ENGINE OVERHEAT caution light. Check engine instruments and proceed as follows:

*1. Collective — MAINTAIN N_R.

*2. Airspeed — AS REQUIRED.

*3. Pickle — AS DESIRED.

*4. Speed control levers — NO. 2 ENG SHUTOFF.

5. Perform single- or dual-engine procedures.

6. If subsequent fire is detected/suspected, perform single- or dual-engine compartment fire(s) in flight procedure.

CAUTION

Do not attempt to restart affected engine.

12.21 EMERGENCY DESCENT

There is no set procedure for an emergency descent. Damage to the helicopter or engines must be considered secondary to getting the helicopter on the ground. During an extreme emergency, the condition or type of landing may be the determining factor in the type of emergency descent to be made. If a long distance must be covered to a selected landing site, a dive with power would be most feasible. A normal power-on vertical landing may be made when the landing site is reached. A circling autorotation, at higher airspeeds, will provide a higher rate-of-descent and view of the landing site.

12.22 SYSTEM EMERGENCIES

12.22.1 Fuel Supply System Failure

12.22.1.1 Fuel Filter Bypass Light. One or two engine's fuel filter being bypassed.

1. Engine instruments — MONITOR.

2. Land — AS SOON AS PRACTICAL.

Three engines' fuel filters being bypassed.

1. Engine instruments — MONITOR.

2. Land — AS SOON AS POSSIBLE.

12.22.1.2 Engine-Driven Fuel Pump Failure. If an engine-driven fuel pump should fail, the engine will shut down due to fuel starvation. Refer to ENGINE SHUTDOWN IN FLIGHT in this chapter.

12.22.1.3 Fuel Boost Pump Failure. If a fuel boost pump should fail (as evidenced by an ENG FUEL BOOST caution light and its associated ENG FLTR BY-PASS caution light), the engine-driven fuel pump will supply enough fuel for normal engine operation. Check engine operation and fuel flow. Land as soon as practical.

12.22.1.4 Fuel Control System Failure. Power loss resulting from complete fuel control system failure can be determined by an immediate reference to the indication of the torquemeter, accompanied by a large decrease in T_5, and further verified by a drop of power turbine speed to zero. Engine stall is usually recognized by a rapid rise in T_5 and a hang-up of N_g, possibly accompanied by an audible rumble or vibration, or a popping noise. Flameouts are recognized by an immediate decrease in T_5, N_g, fuel flow, torque, and N_f on the affected engine. If no engine malfunction was observed before the flameout, a restart may be attempted. If the fuel control has malfunctioned in a manner that has caused the engine to overspeed, retard the speed control lever to reduce the N_f to 100%. The entire overspeed protection system will normally control the overspeed when it reaches 110% ±2% N_f. If the overspeed protection system does not control the overspeed, and N_f cannot be reduced to 100% by retarding the speed control lever, or raising the collective to droop the rotor, shut down the affected engine. It should be noted that the engine instruments often provide indications of fuel control system failure before actual engine failure. If engine failure is due to momentary malfunction of the fuel control system or to improper operating technique, an air start can usually be made to restore engine operation, when time and altitude permit.

12.22.1.5 Fuel Transfer Failure. If one auxiliary fuel tank fails to transfer into any main fuel tank, the following procedure is recommended to reduce asymmetrical fuel loading as much as possible: Operate two engines from the main tank (No. 1 or No. 3) on the non-transferring side. Transfer fuel from the operating auxiliary tank to the main tank on the non-transferring side. When the transferring auxiliary tank is empty, the pilot may elect to jettison or retain the auxiliary tanks. If the pilot elects to retain the auxiliary tanks and asymmetrical fuel loading is still present, continue to operate two engines from the selected main tank until that tank's FUEL LOW caution light goes on. If asymmetrical fuel loading is still present, operate two engines from the No. 2 tank.

WARNING

Fuel quantities should be watched closely during this procedure to prevent flameout.

Note

- Fuel consumption from the tanks can be increased or decreased selectively by varying engine power.
- When operating with one empty auxiliary fuel tank and one full one, aircraft handling characteristics remain satisfactory.

12.22.2 External Fuel Tank Jettison. External auxiliary fuel tank jettison may be required in case of single- or dual-engine operation. If tank jettison is to be done, do this:

*1. Airspeed — 0 TO 150 KNOTS. (Maximum airspeed in descent: 120 KNOTS).

*2. Rate-of-descent — LESS THAN 1500 FEET-PER-MINUTE.

*3. Bank angle — ZERO DEGREES.

*4. Area — CLEARED IF POSSIBLE.

*5. Place desired AUX TANK JTSN switch — ON.

12.22.3 Fuel Dump. Fuel dumping may be required in case of single- or dual-engine operation, or to adjust fuel loading in case of fuel system malfunction. Fuel shall not be dumped below 90 KIAS or above 130 KIAS. Fuel shall not be dumped if the rate-of-descent is greater than 1500 feet-per-minute. The desired minimum altitude for fuel dump is 6000 feet.

1. Airspeed — BETWEEN 90 AND 130 KIAS.
2. Rate-of-descent less than 1500 feet-per-minute.
3. Avoid populated areas.
4. Determine desired fuel to remain after dumping.
5. Fuel dump switches — AS REQUIRED.
6. Fuel quantity — MONITOR.
7. Fuel dump switches — SECURE WHEN DESIRED TANK LEVEL REACHED.

If fuel dump is not secured, it will dump down to the level that turns the fuel low-level caution lights on, at which time fuel dump shuts off automatically.

CAUTION

After securing fuel dump switches, allow 2 minutes for fuel dump lines to drain. Securing fuel dump immediately before overflying a ship or landing area will result in fuel draining onto that ship or area, creating a personnel or a fire hazard.

8. Dump tubes — CHECK.

12.22.4 AFCS System Failures

12.22.4.1 AFCS Computer Malfunction. A malfunction in the AFCS computer can cause low to high random inputs into the main rotor or tail rotor controls, possibly resulting in helicopter vibration.

The CMPTR POWER pushbutton on the AFCS CONTROL panel should be turned off if the following happens:

1. An increase in aircraft motion, vibration, or tip path plane movement accompanied by the AFCS

DEGRADED advisory light and all FAIL ADVISORY lights except DESEN and SAS indicates a single computer (SIMPLEX) failure and the AFCS is only partially functional. If this happens, secure trim and AFCS, then recycle computer power.

2. An increase in aircraft motion, vibration, or tip path plane movement accompanied by the AFCS CAUTION light indicates a dual-computer (DUPLEX) failure and no AFCS functions are available. If this happens, recycle computer power OFF and then ON.

An AFCS caution light means both computers are off and no AFCS functions are being performed. If recycling computer power OFF and then ON does not make the AFCS caution light go out, do the following:

*1. Instrument meteorological conditions (IMC) — LAND AS SOON AS POSSIBLE.

2. Visual meteorological conditions (VMC) — LAND AS SOON AS PRACTICAL.

12.22.4.2 Desensitizer Failure. Any of the following conditions may indicate an inoperative desensitizer:

1. DSEN fail advisory light on the AFCS control panel is lit.

2. AFCS is off.

3. AFCS duplex failure.

4. FAS shearpin is sheared.

WARNING

Loss of a control desensitizer will, under certain circumstances, allow the pilot to interact with the fuselage bending modes to create a pilot-induced oscillation (PIO). This interaction can result in divergent helicopter oscillations. Delayed pilot response in eliminating these oscillations may result in helicopter damage and/or uncontrolled flight. If this happens, releasing the flight controls for several seconds should eliminate the condition. During external cargo operations, if PIO/PAO happens and cannot be controlled, immediately jettison the load.

If a desensitizer failure happens, do the following:

1. MODE RESET pushbutton — RESET.

If the desensitizer failure does not clear after mode reset, the following precautions must be taken:

1. Avoid abrupt control inputs.

2. Minimize hover time.

3. Do not pick up an external load. If flying with an external load, continue to the destination and gently set the load down. Do not attempt to relift the load.

12.22.4.3 AFCS Malfunction. An automatic flight control system (AFCS) malfunction could happen as a result of a stability augmentation system (inner loop, SAS) failure; autopilot (outer loop, trim) failure, or an AFCS servo hardover. The cues are distinctly different for each failure mode. An inner loop failure will be noted by an unusual uncommanded attitude change with no associated movement in the flight controls. Due to the limited authority (about 10%) of the inner loop functions of the AFCS, this failure mode is generally benign and easily controlled by the pilot.

An autopilot failure, on the other hand, is characterized by an uncommanded movement of the flight control. The rate of movement of the flight control is limited to 10% per second, which gives the pilot adequate time to control the autopilot failure (trim drive). Recovery is made by pressing the trim release of the flight control in question and manually repositioning the control.

12.22.4.4 AFCS Servo Hardover. An AFCS servo hardover is an uncommanded movement of the flight controls which cannot be easily overridden by the pilot. The rate at which the control moves may vary from a relatively slow rate (about 1-inch per second) to full travel in less than one second (100% per second). When potentially high rates of control change are experienced, and pressing the trim release does not override the drive, suspect an AFCS servo hardover. A rapid response to this emergency will be required to retain control. If a hardover is experienced, do the following:

*1. Transfer to other AFCS servo. If servo hardover condition goes away — PROCEED AND LAND AS SOON AS PRACTICABLE.

CAUTION

High control forces may change to normal at AFCS servo changeover.

*2. If servo hardover condition continues — SECURE AFCS SERVOS.

*3. VMC — LAND AS SOON AS PRACTICAL.

*4. IMC — LAND AS SOON AS POSSIBLE.

12.22.5 Electrical Power Supply System Malfunction

12.22.5.1 Alternating Current System Failure

1. Affected generator — RESET/OFF, THEN ON.

2. If one or two generators fail — LAND AS SOON AS PRACTICAL.

3. If all generators fail or if two generators fail during night, instruments, or icing conditions — LAND AS SOON AS POSSIBLE.

4. Failure of any generator with a simultaneous supervisory panel failure will result in loss of the associated primary ac bus. If this occurs during night or IMC — LAND AS SOON AS POSSIBLE.

Note

(AFC 490) When operating the aircraft with the No. 1 generator on, and the No. 2 and No. 3 generators off or failed; the No. 3 primary ac bus will be lost failing the No. 2 AFCS computer, AHRS, TACAN, VOR, all three BDHIs, and the radar altimeter.

12.22.5.2 Direct Current System Failure

1. If either rectifier fails — LAND AS SOON AS PRACTICAL.

2. Extend landing gear.

3. If both rectifiers should fail, or if either rectifier fails at night or during instrument conditions, land as soon as possible.

12.22.6 Hydraulic Power Supply System Failure. A display of very low hydraulic fluid quantity by the hydraulic fluid status gage or the caution panel dictates the following action:

1. First and second stage hydraulic systems fluid quantity low — LAND AS SOON AS POSSIBLE.

2. First stage and utility hydraulic systems fluid low — LAND AS SOON AS POSSIBLE.

3. First or second stage hydraulic system fluid low — LAND AS SOON AS PRACTICAL.

4. Second stage and utility systems fluid quantity low — LAND AS SOON AS PRACTICAL.

5. Utility hydraulic system fluid quantity low — LAND AS SOON AS PRACTICAL.

12.22.6.1 Utility Hydraulic System Failure. The primary visual indications of system malfunctions are: (1) The UTIL HYD PRESS gage on the instrument panel, redlined at 2600 psi minimum or 3300 maximum, (2) the UTILITY PRESS caution light that goes on when hydraulic pressure drops below 2000 psi, (3) the UTILITY OIL HOT caution light that goes on when the hydraulic fluid temperature rises to 107°C, and (4) the UTILITY QTY T/R caution light that goes on when reservoir quantity drops to an unsatisfactory level.

The utility hydraulic system receives pressure from a pump driven by the accessory gear box, and failure will be indicated by the pressure gage or temperature caution light. The engine starting system, APP starting system, landing gear system, cargo ramp and door system, main wheel power brake system, blade/pylon fold systems, rotor head positioning for engine start, second stage side of tail rotor servo, AFCS SERVO 2 pitch, altitude, roll, and yaw servos, utility hoist, and cargo winch will be inoperative if the utility hydraulic system pump should fail, or if pressure is lost from the system.

If utility hydraulic system failure is indicated by either the UTILITY PRESS caution light or the pressure gage is at zero or fluctuating near or below 1000 psi, proceed as follows:

WARNING

Extended flight with utility hydraulic system failure is not recommended, due to possible loss of first stage hydraulic system and subsequent loss of tail rotor control.

*1. Landing gear — EXTEND.

CAUTION

Should utility hydraulic failure occur with ramp at or below level position, ramp to ground contact may occur during landing.

2. Land as soon as possible.

12.22.6.1.1 Utility Hydraulic Fluid Hot. A UTILITY OIL HOT light will illuminate when either the utility hydraulic fluid or blower motor has become overheated. When a UTILITY OIL HOT light is observed and overheated fluid is suspected, operation of utility subsystems such as the ramp, overhead door, and landing gear provide increased fluid distribution which aids in lowering fluid temperature. Should the UTILITY OIL HOT light illuminate, proceed as follows:

1. Hydraulic pressure and quantity gages — CHECK.

2. HEAT EXCH UTIL (NO 1 PRI DC BUS) and HEAT EXCHANGE UTILITY PWR (NO 1 PRI AC BUS) CBs — CHECK.

a. If either CB is out, attempt to reset only once. Go to step 3.

b. If both CBs are in when first checked, pull the UTIL OIL HOT (NO 3 PRI DC BUS) CB.

(1) If the caution light extinguishes, the fluid has overheated.

(a) Reset CB.

(b) Ramp and overhead door — CYCLE SEVERAL TIMES.

(c) Landing gear — CYCLE SEVERAL TIMES.

(d) Go to step 3.

Note

Ramp shall not be lowered below the level position at airspeeds in excess of 120 knots.

(2) If the caution light remains illuminated, the blower has overheated and shut down. Reset the UTIL OIL HOT CB. Then, pull the HEAT EXCH UTIL CB for 1-2 minutes to allow blower to cool and be restored.

(a) If the caution light extinguishes while the HEAT EXCH UTIL CB is out, the fluid is not overheated. Restored blower operation is verified by the caution light remaining off when the CB is reset.

(b) If the caution light remains illuminated, the fluid is overheated (in addition to the blower). After resetting the HEAT EXCH UTIL CB, the caution light will not go out until the fluid has cooled. If the caution light is on, proper blower operation can be verified by pulling and resetting the UTIL OIL HOT CB and noting the caution light momentarily goes off.

3. If pressure and quantity remain normal, yet the light remains illuminated — LAND AS SOON AS PRACTICAL.

12.22.6.2 Flight Control Hydraulic System Failure. The primary visual indications of system malfunctions are: (1) 1ST and 2ND STAGE HYD PRESS gages on the instrument panel redlined at 2600 psi minimum or 3300 psi maximum, (2) the 1 STG PRESS M/R T/R and 2 STG PRESS M/R caution lights that go on when pressure drops below 2000 psi, (3) the 1 STG QTY M/R T/R and 2 STG QTY M/R caution lights that go on when reservoir fluid quantity drops to an unsatisfactory low level, and (4) on helicopters modified by AFC 308 the 2 STG OIL HOT caution light that goes on when the second stage hydraulic fluid temperature rises to 107°C.

WARNING

- Failure of first and second stages of flight control system will result in loss of control of helicopter.

- Rapid or abrupt movement of flight controls with only one primary flight control hydraulic system operating can result in control restrictions due to a reduction of pressure in operating system.

Note

- Do not turn a flight control system off if a constant abnormally high pressure is indicated. Land as soon as practical.

- In case of loss of pressure in first or second stage hydraulic system, check that both collective flight control servo switches are ON.

- In the event of a pending 2nd stage failure (pressure fluctuations), consideration should be given to securing AFCS SERVO 1 to allow smooth operation of AFCS servo functions.

*1. Reduce airspeed to 80 to 100 knots.

*2. Land as soon as possible.

Control of the helicopter can be maintained by either the first stage or second stage hydraulic system if one or the other fails. Either system may be turned off by actuating either collective flight control servo switch, provided there is at least 2000 psi hydraulic pressure in the remaining system. When one servo system fails, it should not be shut off unless there is a definite restriction of controls; airspeed should be decreased to 80 to 100 KIAS. Flight should be terminated as soon as possible due to the possibility of failure of the remaining servo system. Loss of pressure in either servo system will be indicated by an appropriate low pressure caution light and lower than normal operating pressure on the corresponding hydraulic pressure gage. A pressure switch interlock makes it impossible to turn off one servo system while the pressure in the other servo system is below 2000 psi. When the second stage hydraulic system is inoperative due to a loss of pressure, these systems or related components will also be inoperative:

1. The half of each primary tandem servo that is powered by the second stage hydraulic system; and when the second stage hydraulic system is turned off, the half of the tail rotor tandem servo that is powered by the utility hydraulic system.

2. Pitch, altitude, roll, and yaw channels of SERVO 1.

12.22.6.2.1 Second Stage Hydraulic Fluid Hot. Should the 2ND STG OIL HOT caution light illuminate, proceed as follows:

1. Hydraulic pressure and quantity gages — CHECK.

2. HEAT EXCH NO 2 (NO 2 PRI DC BUS) and HEAT EXCHANGE 2ND STAGE PWR (NO 2B PRI AC BUS) CBs — CHECK.

   a. If either CB is out, attempt to reset only once. Go to step 3.

   b. If both CBs are in when first checked, pull the 2-STG OIL HOT (NO 1 PRI DC BUS) CB.

      (1) If the caution light extinguishes, the fluid has overheated. Reset the CB and go to step 3.

      (2) If the caution light remains illuminated, the blower has overheated and shut down. Reset the 2-STG OIL HOT CB. Then, pull the HEAT EXCH NO 2 CB for 1-2 minutes to allow blower to cool and be restored.

         (a) If the caution light extinguishes while the HEAT EXCH NO 2 CB is out, the fluid is not overheated. Restored blower operation is verified by the caution light remaining off when the CB is reset.

         (b) If the caution light remains illuminated, the fluid is overheated (in addition to the blower). After resetting the HEAT EXCH NO 2 CB, the caution light will not go out until the fluid has cooled. If the caution light is on, proper blower operation can be verified by pulling and resetting the 2-STG OIL HOT CB and noting the caution light momentarily goes off.

3. If pressure and quantity remain normal, yet the light remains illuminated — LAND AS SOON AS PRACTICAL.

12.22.6.3 Restriction or Binding in the Flight Controls

1. Check for any cockpit obstructions to the flight controls.

2. Reduce airspeed to 80-100 KIAS.

3. Minimize flight control inputs.

4. Land as soon as possible.

12.22.6.4 Primary Tandem Servo Malfunction. The primary visual indications of a primary tandem servo malfunction are the 1 STG M/R SERVO BYPAS or 2 STG M/R SERVO BYPAS caution lights that go on when a servo has malfunctioned in such a manner to cause it to bypass hydraulic pressure or it has lost system pressure.

WARNING

When the 1 STG M/R SERVO BYPAS caution light is observed after a utility hydraulic system failure, securing first stage flight control system will result in loss of tail rotor control. There are no interlocks to prevent turning off pressure to first or second stage hydraulic systems, when a servo in the other stage is in bypass. Turning off pressure to the non-bypassed stage results in loss of control of the servo.

An individual primary tandem servo malfunction will be indicated by a servo bypass caution light that indicates which flight control hydraulic system has the failed servo. The caution light does not indicate the individual servo that has failed. The servo bypass caution light will indicate a servo has failed in a manner that has subjected it to a loss of hydraulic pressure. The servo bypass caution light may go off with certain positions of the servo piston, even though the malfunction still exists. In this case, check the appropriate flight control hydraulic system pressure gage to determine if the system has failed or the failure is within the servo.

When a servo bypass caution light is observed, do not turn off the corresponding servo system unless there is a definite restriction of controls and do the following:

*1. Airspeed — REDUCE.

*2. Land as soon as possible.

12.22.6.5 Tail Rotor Hydraulic System Failure. The first stage flight control hydraulic system furnishes the necessary pressure to operate the first stage side of the tail rotor tandem servo. The first stage hydraulic quantity indicator and the caution light are the primary visual indication of loss of hydraulic fluid to the first stage system. The first stage hydraulic pressure gage and caution lights are an immediate indication of a loss of operating hydraulic pressure to the first stage side of the tail rotor tandem servo. The utility hydraulic system furnishes the necessary pressure to operate the second stage side of the tail rotor tandem servo. The utility hydraulic quantity indicator and the caution light are the primary visual indications of loss of hydraulic fluid to the utility system. The utility pressure gage and caution lights are an immediate indication of loss of operating hydraulic pressure to the second stage side of the tail rotor tandem servo. The UTILITY T/R PRESS caution light goes on when utility pressure downstream of the second stage servo shutoff valve in the utility module, drops below 2000 psi.

WARNING

Do not shut off first stage flight control hydraulic pressure when there is no utility hydraulic pressure being furnished to the tail rotor tandem servo. Tail rotor control will be lost.

12.22.6.6 Tail Rotor Tandem Servo Malfunction. The primary visual indications of tail rotor tandem servo malfunction are the 1 STG T/R SERVO BYPAS and 2 STG T/R SERVO BYPAS caution lights that go on when the servo has malfunctioned in such a manner to cause it to bypass hydraulic pressure or it has lost system pressure.

When a tail rotor servo bypass caution light is observed, do not turn off the corresponding servo system unless there is a definite restriction of controls and perform the following:

*1. Airspeed — REDUCE.

*2. Land as soon as possible.

12.22.7 Utility Hoist

12.22.7.1 Jammed Hoist. If the hoist jams, do not attempt to hoist or lower it any further; this could shear the cable. The aircrewman shall inform the pilot of the jam. If a load is on the end of the cable, the helicopter will have to set the load down.

12.22.7.2 Hoist Cable Shear

For cockpit shear:

1. Hoist control master switch — PILOT or CREW.

2. Emergency panel shear switch — SHEAR.

For cabin shear:

1. Hoist control master switch — CREW.

2. Crewman's cable shear switch — SHEAR.

12.22.8 Landing Gear System Failure

Note

Aural ("GEAR, GEAR")/visual (GPWS ALERT) warning occurs when helicopter is less than 150 feet AGL, IAS is less than 60 knots, and landing gear is up.

If the utility hydraulic system should fail or the landing gear electrical system should fail, the landing gear cannot be retracted; however, the landing gear can be lowered by the landing gear emergency system. This system will lower the landing gear in a hover in about 10 seconds. However, with forward airspeed, which causes an airload on the nose gear door, the emergency landing gear system may take from 1 to 2 minutes. The system lowers the landing gear by compressed nitrogen from a 3000 psi capacity nitrogen bottle. To lower the landing gear, do this:

CONDITION:

Utility pressure up, landing gear control handle down, all gear unlocked but not extended.

CAUTION

Leave landing gear control handle in down position.

Note

- Do not actuate landing gear emergency release handle.

- If LANDING GEAR CONT circuit breaker is pulled, there will be no down and locked indication in cockpit.

1. Pull LANDING GEAR CONT circuit breaker, to cut hydraulic pressure to landing gear.

2. After 5 seconds, reset circuit breaker.

3. Repeat procedure if gear does not extend.

4. If gear fails to fully extend and lock, at 80 to 100 KIAS execute a steady state turn, maximum bank 60°, to exert G forces on helicopter.

5. Retract VHF-FM antenna.

6. Check for dual point hooks in stowed position.

7. If gear still does not extend, leave circuit breaker out, and have ground personnel move gear to down and locked position.

WARNING

Be sure helicopter is properly grounded before maintenance personnel attempt to lower gear.

CONDITION:

Utility pressure not available to lower gear, or gear fails to unlock with landing gear control handle down, regardless of pressure indication.

CAUTION

Leave landing gear control handle in down position.

1. Activate landing gear emergency release handle.

If all gear unlock but one fails to fully extend, do this:

2. Pull LANDING GEAR CONT circuit breaker to deactivate four-way valve for landing gear control.

3. Reset landing gear emergency release handle.

4. Retract VHF-FM antenna.

WARNING

Be sure helicopter is properly grounded before maintenance personnel attempt to lower gear.

5. Check for dual point hooks in stowed position.

6. At 80 to 100 KIAS, execute a steady state turn, maximum bank 60°, to exert G forces on helicopter; or hover and have ground personnel move gear to down and locked position.

WARNING

Do not attempt to execute the G-force maneuver in step 5 with loss of utility system pressure.

CAUTION

Pitch attitudes of over 5° to 7° nose-up should not be exceeded when landing with wheels up. If the landing gear system experienced an electrical malfunction and the landing gear has been lowered by the emergency system, the tail skid will not be extended.

Proper selection of a landing site and care during hovering or touchdown will permit a landing with a minimum of danger to personnel and damage to the helicopter. If attempts to lower the landing gear by the emergency system are unsuccessful, it may be possible to jar the landing gear loose by an abrupt increase in collective pitch after a shallow dive. It is also possible to hover at an altitude that will permit ground personnel to exercise all possible means to lower the landing gear and insert the landing gear lockpins.

Note

Landings with all wheels retracted or with any one or any two wheels down may be made by placing soft objects, such as mattresses, under the malfunctioning landing gear and the bottom of the fuselage. Ground personnel should place the soft objects before touchdown, and then direct pilot from a hover to a vertical landing on objects. The force of the rotor downwash should be considered during this evolution.

12.22.8.1 Landing with All Gear Retracted or Improperly Lowered. If a landing must be made with all wheels retracted or improperly lowered, choose a level spot with no obstructions and preferably with a soft surface, such as sand, grass, or bushes.

1. APP — START.

2. From a hover, let down slowly and smoothly with no forward or sideward motion.

3. If landing gear is not fully retracted, it may push forward as in partial retraction, and helicopter will settle on lower fuselage and sponsons.

4. Speed control levers — SLOWLY REDUCE POWER ON ALL ENGINES TO GRD IDLE.

Note

Note which way helicopter will tilt as rotor speed decays. Greatest damage will occur to the main rotor blades if the helicopter tips to one side and the blades strike the ground.

5. Cyclic — MAINTAIN CONTROL AS LONG AS POSSIBLE.

6. Shut down engines.

7. Rotor brake — APPLY IF HELICOPTER TIPS OR AFTER ROTOR HAS COASTED TO A STOP.

8. Install auxiliary fuel tank safety pins.

12.22.8.2 Landing with One Main Gear Retracted or Not Locked Down. If only one main gear and the nose gear are down and locked and all attempts fail to lower and/or lock the malfunctioning main gear, retract the other main gear to provide a symmetrical configuration for a safer landing, and to lessen damage to the helicopter. If the other landing gear will not retract, use this procedure to make a landing:

1. When one main gear and the nose gear are down and locked, it is possible to use shoring or soft padding under the malfunctioning main gear, to prevent the helicopter from tipping over.

2. APP — START.

3. From a hover, let down slowly and smoothly with no forward or sideward motion.

4. Speed control levers — SLOWLY REDUCE POWER ON ALL ENGINES TO GRD IDLE.

Note

Helicopter will tilt to the side that has the retracted main gear, as rotor speed decays. Greatest damage will be to main rotor blades.

5. Cyclic — MAINTAIN CONTROL AS LONG AS POSSIBLE.

6. Shut down engines.

7. Rotor brake — APPLY IF HELICOPTER TIPS OR AFTER ROTOR HAS COASTED TO A STOP.

8. Install auxiliary fuel tank safety pins.

12.22.8.3 Landing with Both Main Gear Retracted or Not Locked Down. If only the nose gear is down and locked and all attempts fail to lower and lock both malfunctioning main gear, attempt to retract the nose gear to provide a symmetrical configuration to lessen damage to the helicopter. If the main landing gear will not retract and the nose gear does, use this procedure to make a landing:

1. When only the nose gear is down and locked, it is possible to use soft padding under the fuselage to lessen the tipping action.

2. APP — START.

3. From a hover, let down slowly and smoothly with no forward or sideward motion.

4. Speed control levers — SLOWLY REDUCE POWER ON ALL ENGINES TO GRD IDLE.

5. Cyclic — MAINTAIN CONTROL AS LONG AS POSSIBLE.

6. Shut down engines.

7. Rotor brake — APPLY WHEN CONTROL IS LOST OR ROTOR HAS COASTED TO A STOP.

8. Install auxiliary fuel tank safety pins.

12.22.8.4 Landing with Nose Gear Retracted or Not Locked Down. If only the main gears are down and locked and all attempts fail to lower the nose gear, land with this configuration and do not attempt to retract the main gear, to provide a symmetrical configuration, as the helicopter will not tip with both main gear extended. When only the main gears are down and locked, it is possible to use padding under the malfunctioning nose gear, or if padding is not available, the helicopter may be landed by using this procedure:

1. APP — START.

2. From a hover, let down smoothly and slowly with no forward or sideward motion.

3. Wheel brakes — LOCKED.

4. Collective — LOWER SLOWLY AS MAIN LANDING GEAR CONTACTS GROUND, AND EASE CYCLIC BACK AS HELICOPTER SETTLES NOSE-DOWN.

Do not bring cyclic back far enough to allow main rotor blades to hit droop stops.

5. Wheel chocks — IN PLACE.

6. Shut down engines when nose is firmly on ground.

7. Rotor brake — APPLY AFTER ROTOR HAS COASTED TO A STOP.

8. Install auxiliary fuel tank safety pins.

12.22.9 Main Gear Box Failure. Main gear box failure may be indicated by any abnormal noise. At that time, check all instruments, and monitor for adverse indications. If the instruments should show any unusual indications, make an emergency landing. Main gear box failure may also be indicated by an unusual yaw kick accompanied by fluctuations in the torquemeters. If indications of main gear box failure are noted, do this:

*1. Land immediately.

WARNING

An increase in torque for a given flight condition is an indication of a main gear box impending failure.

12.22.9.1 Main Gear Box Chip Locator Light. When the CHIP DETECTED caution light is accompanied by the MAIN GB chip locator light on the chip locator panel, progressive failure of the main gear box may be occurring.

*1. Instruments and caution lights — CHECK.

*2. If malfunction verified — PERFORM MAIN GEAR BOX FAILURE PROCEDURES.

3. If malfunction is not verified, have the aircrewman isolate which source chip is coming from by using the MAIN XMSN CHIP LOCATOR panel.

4. Pull and reset main gear box chip detector circuit breaker. If chip locator light returns after circuit breaker is reset — LAND AS SOON AS POSSIBLE.

5. If chip light remains off when circuit breaker is reset, continue with mission and closely monitor all main gear box instruments and caution lights.

12.22.9.2 Main Gear Box Oil System Failure. MGB AUX lube pump caution light illuminates:

1. Land as soon as practical.

Note

It is not necessary to abort a flight as a result of losing the main gear box auxiliary oil pump as indicated by the MGB AUX LUBE PUMP caution light going on. Continue mission monitoring all other main gear box gages, chip detector, and caution lights. Be sure condition is corrected before next flight.

Loss of the main gear box primary oil pump is indicated by a decrease in oil pressure. If the MGB OIL PRESS caution light goes on and a complete loss of oil pressure is indicated, the gear box has lost all primary means of lubrication. In this case reduce airspeed to minimum power required for flight, descend to minimum altitude, duration of flight not to be over 30 minutes, land as soon as possible.

If the MGB oil press and the MGB AUX lube pump caution lights both illuminate and the MGB oil pressure drops rapidly or decreases below minimum, the main gear box has lost all means of lubrication and an immediate landing shall be made. In this case:

*1. Land immediately.

If transition from level flight is required, perform the following:

1. Airspeed — 80 to 100 KIAS.

2. Retard No. 2 engine to GRD idle.

CAUTION

Excessive temperatures within the No. 2 engine compartment may occur in flight with the No. 2 engine at ground idle.

3. Commence a power-on descent.

4. Land immediately using No. 2 engine if necessary during the landing.

WARNING

Loss of MGB oil pressure accompanied by an increase in noise, vibrations, yaw kicks, or power surges indicate MGB seizure is imminent.

A malfunction of the main gear box or the oil cooling system that would cause improper or insufficient lubrication will be indicated by one or more of these symptoms:

Note

If any one of the following symptoms are noted when flying over land, land as soon as possible. If the symptoms are noted when flying over water, return to nearest ship or shore at reduced airspeed and low altitude. The altitude should be sufficient to permit a quick flare if an enroute emergency water landing is necessary.

1. MGB OIL PRESS caution light goes on.

2. MGB OIL HOT caution light goes on.

3. MAIN GB chip locator light goes on and cannot be reset.

4. Maximum or minimum indications on the main gear box oil pressure and temperature gages.

12.22.9.3 A Main Gear Box Oil Cooler Blower Failure. A main gear box oil cooler blower failure may be indicated by an abnormal noise or thump and short duration medium frequency vibration/buffet felt through the flight controls and airframe. Damage to the system components in the vicinity of the oil cooler blower may occur. An oil cooler blower failure will be accompanied by one or more of the following indications:

1. Main gear box oil temperature and pressure caution lights and abnormal gage indications.

2. No. 2 engine oil temperature gage and pressure caution lights for abnormal indications.

Components or systems susceptible to secondary damage include 1st stage hydraulic system, tail rotor drive shaft, tail rotor control linkage, utility tail rotor control pressure and return lines, and the No. 2 engine.

If indication of a main gear box oil cooler blower failure exist:

1. Check appropriate instruments and caution lights.

2. Shut down No. 2 engine (conditions permitting).

3. Land as soon as possible.

12.22.9.4 Free Wheeling Unit (FWU) Failure. A FWU failure is a slippage condition which allows the N_f to exceed N_r with no usable torque transmitted to the MGB. This condition, usually caused by FWU bearing spitout, may be momentary (sometimes repeatedly) or permanent and may also result in breakup of the FWU. Slippage is indicated by any/all of the following symptoms: N_f exceeding N_r torque dropping to zero, and a slight to moderate left yaw kick as the FWU slips. Sudden FWU reengagement causes a jolt in the airframe. If momentary slippage and reengagement occur to rapidly, symptoms may not be fully reflected in the cockpit quad tach and torque indicator; therefore, pilots should carefully monitor their instruments if FWU malfunction is suspected. In addition, a FWU may lock up following a momentary slippage, wherein the MGB can backdrive the engine. This will be indicated by N_f not splitting off from N_r upon retarding the affected engine SCL to MIN GOV.

If a momentary slippage is indicated:

*1. Collective — MAINTAIN N_r.

*2. Airspeed — ESTABLISH DUAL- OR SINGLE-ENGINE AIRSPEED.

*3. Pickle — AS DESIRED.

*4. SCL — AFFECTED ENGINE TO MIN GOV.

WARNING

If the No. 2 engine speed control lever is at or below MIN GOV and the N_g is less than 75%, hot exhaust gas may backflow into the engine compartment creating a fire hazard. Limit airspeed to less than 85 KIAS to reduce backflow. If a FWU slippage has occurred and dual-engine flight can be maintained, consideration should be given to securing the No. 2 engine. If a FWU lockup is suspected, maintain No. 2 engine at no less than 75% N_g to reduce possibility of backflow and to ensure engine lubrication.

CAUTION

In the event of a No. 1 or No. 3 FWU lockup, maintain the affected engine at or above ground idle to ensure lubrication of the power turbine shaft bearings.

5. Land as soon as practical.

6. Affected engine if locked up — SHUTDOWN LAST.

Permanent FWU slippage (in which the FWU slips without reengaging) is a form of power train failure. Refer to procedure for "Failure in helicopter transmission system" under "POWER TRAIN FAILURE" in this section.

12.22.10 Nose Gear Box Failure. Nose gear box failure may be indicated by an abnormal noise or change in noise frequency. A malfunction that would cause a binding or restriction within the gear box will cause a high engine torque reading to be observed. A malfunction that would cause a no-load condition on the engine should produce a tendency for the engine to overspeed. If indications of nose gear box failure are noted, do this:

*1. Instruments and caution lights — CHECK.

*2. Collective — MAINTAIN N_r.

*3. Airspeed — AS REQUIRED.

*4. Pickle — AS DESIRED.

*5. Speed control levers — AS REQUIRED (Shutoff affected engine, conditions permitting).

6. Land as soon as practical.

12.22.10.1 Nose Gear Box Chip Locator Light. When the CHIP DETECTED caution light is accompanied by either of the nose gear box chip locator lights, check all other nose gear box caution lights and gages and engines torquemeters to verify malfunction.

*1. Instruments and caution lights — CHECK.

*2. If malfunction verified — PERFORM NOSE GEAR BOX FAILURE PROCEDURES.

3. If nose gear box malfunction cannot be verified by other instruments, temperatures, or pressures, pull and reset the chip detector circuit breaker for the affected nose gear box.

4. If chip light returns after circuit breaker is reset, perform NOSE GEAR BOX FAILURE procedures.

5. If chip locator light remains off when circuit breaker is reset, continue mission and closely monitor nose gear box instruments and associated caution lights.

Note

An increase in torque for a given flight condition is a positive sign of nose gear box internal binding or restriction.

12.22.10.2 Nose Gear Box Oil System Failure. Loss of nose gear box lubrication will be indicated by the nose gear box oil temperature gage and oil temperature and pressure caution lights. If indications of a nose gear box oil system failure are noted, do this:

*1. Instruments and caution lights — CHECK.

*2. Perform NOSE GEAR BOX FAILURE procedures.

12.22.11 Accessory Gear Box Failure. Accessory gear box failure may be indicated by any abnormal noise. If any abnormal noise is heard, check all instruments and electrically operated equipment for adverse indications. Systems that operate from the accessory gear box may also give adverse indications. If indications of accessory gear box failure are noted, do this:

1. Instruments and caution lights — CHECK.

2. Land as soon as possible.

12.22.11.1 Accessory Gear Box Chip Locator Light

1. Instruments and caution lights — CHECK.

2. If malfunction verified — LAND AS SOON AS POSSIBLE.

3. If malfunction is not verified, pull and reset circuit breaker marked ACCESS INT/TAIL, under heading CHIP DETECTOR, on the emergency dc bus circuit breaker panel. If, after resetting circuit breaker, chip locator light returns, land as soon as possible.

4. If chip locator light remains off when circuit breaker is reset, continue mission and closely monitor all accessory gear box and caution lights and gages for accessory gear box driven systems.

Note

Accessory gear box failure will result in the loss of second stage, utility, and engine start pumps, AFCS and other associated systems, and the No. 1 and No. 3 generators.

12.22.11.2 Accessory Gear Box Oil System Failure. Loss of accessory gear box lubrication will be indicated by the accessory gear box oil temperature and pressure caution lights. If loss of accessory gear box lubrication is indicated, do this:

1. Instruments and caution lights — CHECK.

2. Land as soon as possible.

12.22.11.3 Intermediate or Tail Gear Box Failure and Chip Light. Other than the chip light and the TGB/IGB OIL PRESS caution lights, there are no other instruments or caution lights with which to verify impending failures. A combination of chip light and corresponding OIL PRESS caution light confirms an impending failure. Additional flight indications of impending failure may include heading control difficulty, yaw kick, high frequency vibrations, and unusual or loud grinding noises from the tail section.

If impending failure is imminent as noted by combination of chip and corresponding OIL PRESS light, illumination of any caution light with additional flight indications discussed above, or any of the flight indications discussed above, proceed as follows:

*1. Land immediately.

If only a single caution light illuminates without any additional indication of failure, proceed as follows:

1. Appropriate circuit breaker — CYCLE.

2. If caution light returns — LAND AS SOON AS POSSIBLE.

3. If caution light does not return — CONTINUE FLIGHT AND MONITOR CLOSELY.

12.22.12 Windshield Failure. When a glass covered windshield breaks, the entire surface crazes. Visibility through the crazed windshield is severely limited. If the inner surface of a failed windshield remains intact:

1. Reduce airspeed to 80 knots.

2. Manually close EAPS doors.

3. Land as soon as practical.

If a complete failure of the windshield occurs:

1. Reduce airspeed as necessary for comfort within the cockpit.

2. Manually close EAPS doors.

3. Monitor engine instruments for indications of possible FOD.

4. Land as soon as practical.

12.23 LIGHTNING STRIKE

Lightning strike can occur while flying in the vicinity of thunderstorms. Damage to main and tail rotor blades in the form of arcing, erosion and heat annealing will result. Engineering analysis of blades subjected to an actual inflight lightning strike concluded that the damage to the blades can be so severe that the fatigue life would be reduced to a few hours or even minutes. If a lightning strike is suspected, the helicopter should be landed and inspected. In past cases, major hidden damage was inflicted and was associated with minor appearing visible/external damage to the spot or pockets. However, no hidden damage was found without visible/external indications of some kind.

If lightning strike suspected.

*1. Airspeed — 80 KIAS.

*2. Land as soon as possible.

12.24 GROUND RESONANCE

Characteristics and the tendency for development of ground resonance are discussed in Chapter 11. Immediate corrective action at the onset of ground resonance is imperative to prevent structural damage. Proceed as follows:

*1. If able — TAKE OFF.

*2. If unable to takeoff — EMERGENCY SHUTDOWN.

12.25 OSCILLATIONS

Chapter 11 describes the aircraft's flight characteristics, tendencies, and types of oscillations which are most likely to be encountered. If the conditions discussed in Chapter 11 are encountered, proceed as follows:

*1. Flight control — RELEASE.

If oscillations do not dampen within several seconds:

*2. External cargo — JETTISON.

12.26 SUSPECTED ROTOR DAMPER FAILURE

When the rotor damper fails, an unbalanced rotor condition may be felt as a low-frequency beat or lateral vibration. Rotor blades will normally stay in track. If a rotor damper is suspected of failing, do this:

1. Make small, smooth control inputs.

2. Slowly increase main rotor rpm.

3. Slowly reduce airspeed to 80 KIAS.

4. Use small bank angles.

5. Land as soon as practical.

If vibrations become excessive:

6. Land as soon as possible.

Note

A shallow approach to a running landing is preferable. However, if conditions do not permit, then an approach to a touchdown (no hover) landing should be made.

7. After helicopter has come to a stop, accomplish an engine shutdown without use of rotor brake.

WARNING

A rotor damper failure could lead to ground resonance.

12.27 LOST PLANE PROCEDURES

The primary requirements when lost are:

1. CONFESS.

2. CLIMB.

3. COMMUNICATE.

4. CONSERVE.

5. CONFORM.

6. Know any peculiar local area/ship procedures.

12.28 INADVERTENT ENTRY INTO IFR CONDITIONS

(Figure 12-11.) Formation flights into IFR conditions should be avoided at all times. If the lead elements of a formation enter IFR conditions, follow on elements should attempt to remain VFR or land if possible. If the flight or portions of the flight enter inadvertent IFR condition, the following procedures are recommended:

1. Helicopter No. 4 will climb to the minimum safe altitude (MSA) + 1500 feet and commence a turn for 180° away from helicopter No. 3, reporting passing the 90° position.

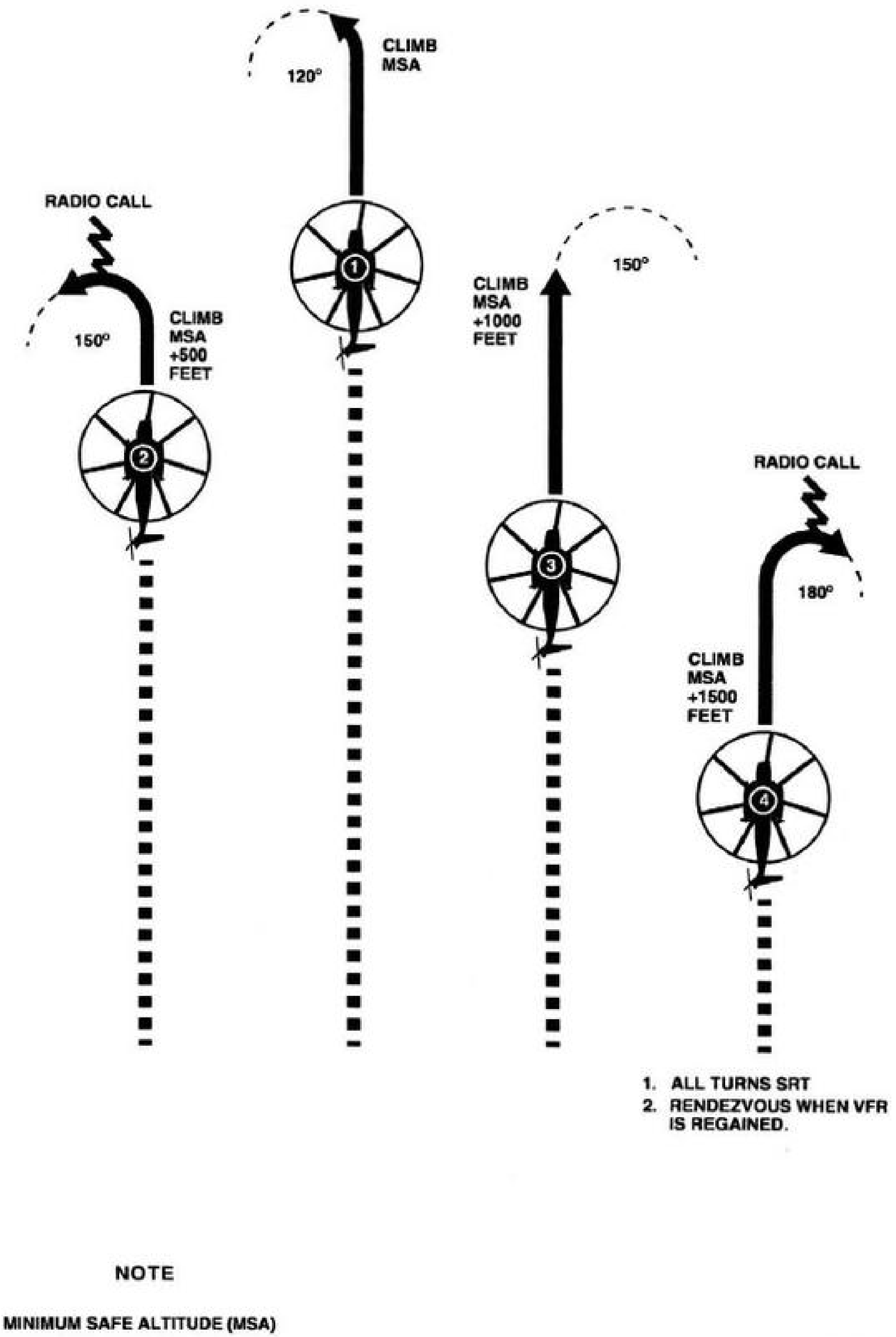


Figure 12-11. Lost Sight During IFR Flight Procedures

2. Helicopter No. 3 will climb to the minimum safe altitude (MSA) + 1000 feet and commence a turn for 150° away from helicopter No. 2, after receiving the radio call from helicopter No. 4.

3. Helicopter No. 2 will climb to the minimum safe altitude (MSA) + 500 feet and commence a turn for 150° away from the lead helicopter, reporting passing the 90° position.

4. Helicopter No. 1 will climb to the minimum safe altitude (MSA) and commence a turn for 120° away from helicopter No. 3, upon receiving the radio call from helicopter No. 2.

Airspeeds may be adjusted in the course of executing these procedures. At no time should airspeed exceed the briefed flight cruise speed. If helicopters regain VFR flight conditions, they may execute a join-up and proceed as briefed. If VFR conditions cannot be regained each helicopter will individually contact the local IFR controlling agency for instructions. Base altitude, airspeed and heading should be called by the flight leader upon execution of these procedures. Terrain avoidance should be the primary concern when executing inadvertent IFR procedures.

12.29 UNUSUAL ATTITUDE RECOVERY

Unusual attitudes are considered to be attitudes of over 30° pitch and 60° bank. There are three general unusual attitudes, nose-low, nose-high, and high bank angles. During all unusual attitude recoveries, the nose-low attitude is the desired condition from which to complete all recoveries. Under flight conditions with less than +1 G-force on the helicopter, there is a substantial reduction in the longitudinal and lateral flight control effectiveness. The reduction in flight control effectiveness requires a larger cyclic displacement to achieve the desired control response, which can result in rotor/fuselage contact. The tail rotor maintains the most control effectiveness during flight conditions with less than +1 G-force, and should be used as the primary recovery control. The following general techniques should be used for unusual attitude recovery:

12.29.1 Nose-Low. This is the easiest recovery to effect. The ball should be centered with the pedals, the wings leveled by smooth application of lateral cyclic, and then a smooth cyclic pullout should be begun.

12.29.2 Nose-High. Nose-high recoveries are made by applying rudder and a minimum of lateral cyclic to establish a coordinated turn toward the nearest horizon. The collective should be maintained initially and then adjusted as necessary to maintain N_r as the helicopter goes into a nose-low attitude. Longitudinal cyclic should be neutralized until a nose-low attitude is reached, then recover as in nose-low procedures. This procedure will reduce the possibility of rotor/fuselage contact resulting from a forward cyclic input to effect recovery.

12.29.3 High Bank Angles. High bank angle unusual attitudes are recovered from by applying appropriate lateral cyclic, being careful not to inadvertently apply longitudinal cyclic. High bank angles in combination with nose high attitudes should be recovered from by applying the nose-high recovery procedures first and correcting the high bank angle when a nose-low attitude has been attained. Final recovery is made by using the nose-low procedures.

Note

> If the unusual attitude is accompanied by loss of rotor rpm, all recoveries can be made as specified above, while moving collective as necessary to recover rpm.

12.30 EMERGENCY AIR REFUELING PROCEDURES

12.30.1 Breakaway Procedures. When a crewmember aboard either the tanker or the receiver determines that an emergency exists, he will transmit, on air refueling frequency, the tanker's call sign and the word "Breakaway" three times. This call is used to notify the tanker and receiver that an emergency condition exists, such as excessive rate of closure, receiver overrunning, etc. The aircraft do not necessarily have to be in contact-made to call a breakaway. Relative position of both aircraft must be monitored closely by the tanker and receiver crewmembers during all phases of air refueling. If the tanker desires a breakaway while operating with loss of interplane communications, the crewmember will state on interphone, "(Tanker call sign), breakaway, breakaway, breakaway," and observer will flash the Aldis lamp ON and OFF rapidly from the paratroop door window. If the receiver initiates a breakaway during loss of interphone communications, the tanker crewmember observing the breakaway will state so on the interphone, and the pilot will initiate the breakaway procedure.

During breakaway, the receiving pilot reduces airspeed slightly and maneuvers to the normal disconnect position (about 5 to 10 feet above the contact position). This causes the tanker to gradually pull away from the receiver and the refueling hose to extend. A normal disconnect occurs when the refueling hose reaches its maximum extension.

CAUTION

Extreme care shall be used by the receiver pilot to avoid descending during the operation. Maintaining altitude assures maximum rotor blade to drogue separation during and after disconnect.

12.30.2 Systems Malfunctions

12.30.2.1 Fuel Siphoning. At any time fuel siphoning is noticed, stop fuel transfer and notify the tanker. The requirement to continue fuel transfer is at the discretion of the receiver pilot.

If fuel siphoning begins upon executing a disconnect under normal circumstances; consideration should be given to reengaging to reset the nozzle. If siphoning continues, Land as Soon as Practical. Make a running landing to preclude recirculation of fuel spray due to rotor wash during hover operations.

WARNING

- If a large amount of fuel spray is coming from the probe, a serious fire hazard exists, as the entire outside of the helicopter could be sprayed with fuel. Radio transmission and electrical actuation of systems shall be held to those absolutely necessary.
- Purging with a damaged or malfunctioning probe may cause fuel under pressure to be sprayed on the nose of the helicopter.

Note

- A small amount of fuel spray from the nozzle and receptacle during fuel transfer does not require fuel transfer to be terminated. Notify the tanker and receiver pilots if this condition exists. The air refueling operations will be continued or discontinued at the discretion of the receiver pilot.
- If a probe head leaks and the probe is retracted, greatly increased fuel spray may be expected during the retraction process. When the retraction is completed, fuel spray should diminish to what was originally experienced before probe retraction or a lesser fuel spray condition.

12.30.3 Refueling with a Non-Extended Probe. Aerial refueling with a non-extended probe is possible in emergency fuel situations. Extreme caution and cyclic smoothness are necessary due to the close proximity of the rotor blade tips and the refueling hose and drogue.

12.30.3.1 Emergency Air Refueling Hose Guillotine. If a receiver helicopter is unable to disconnect from the tanker during air refueling, the hose may be jettisoned as follows:

CAUTION

The receiver helicopter must be in the correct position, before hose jettison, to be sure that the hose will fall down and below the helicopter.

1. The receiver moves to a high refueling position with the refueling probe above the tanker hose pod. The hose should be pushed in to the minimum A/R range.

CAUTION

The receiver helicopter will experience a slight pitch down when the hose is jettisoned.

2. The receiver pilot calls for "hose jettison."

3. The tanker guillotines the hose.

4. The receiver initiates a slow breakaway from the tanker and slows to an airspeed commensurate with stability and flight characteristics of the hose.

5. The receiver completes the post air refueling checklist. If the probe fails to retract, do not attempt to recycle, as damage to the probe may result.

6. The receiver performs an approach and vertical landing from a high hover.

12.31 EMERGENCY EGRESS

12.31.1 Emergency Ground Egress

WARNING

During any emergency egress, particular care must be taken to avoid being struck by the rotor blades.

Pilot/Copilot

1. Execute emergency shutdown.

2. When rotors stop turning — ORDER ABANDON AIRCRAFT.

3. Seat — FULL BACK.

WARNING

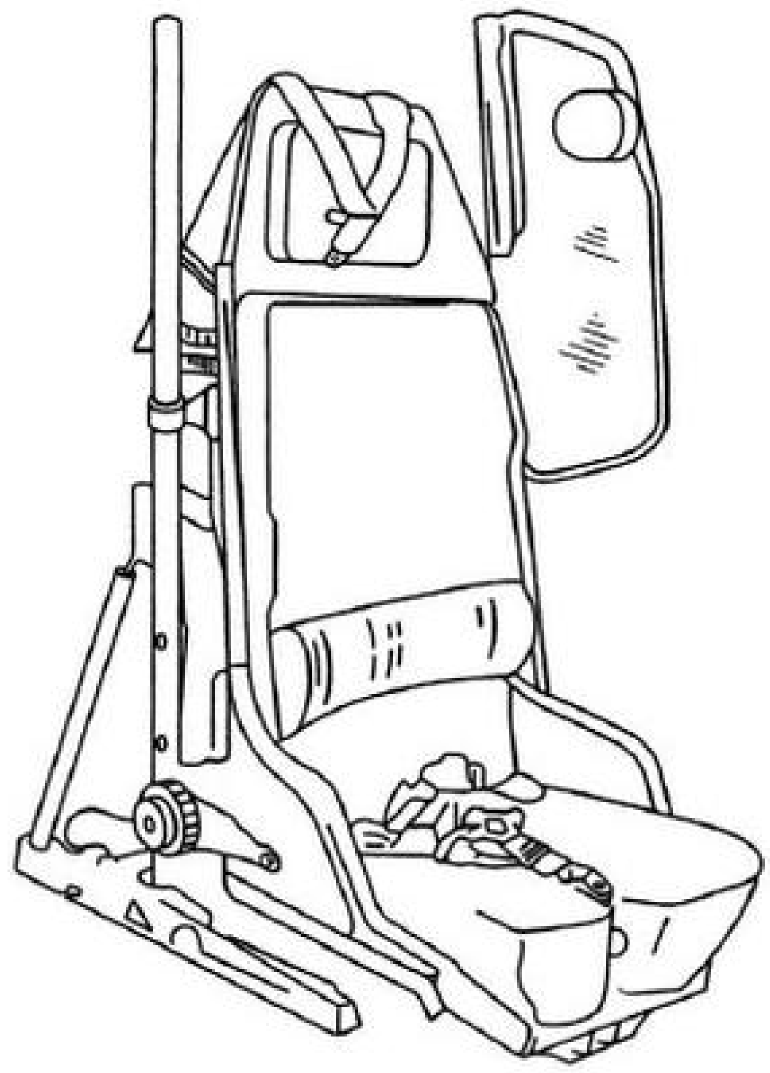
If seat strokes, occupant and seat may shift downward 18 inches and move forward. Windows, hatches, doors, and handles may not be located in the same familiar place.

4. ICS — DISCONNECT.

5. Armor plate wing to rear (if applicable).

6. Appropriate window — EMERGENCY RELEASE (IF DETERMINED EXIT).

7. Release seat harness.



CRASH–ATTENUATING SEAT IN STROKED POSITION HC0750 SA

8. Exit helicopter through appropriate exit.

WARNING

If exiting through copilot's window, copilot must ensure that collective does not block exit path.

Aircrewman

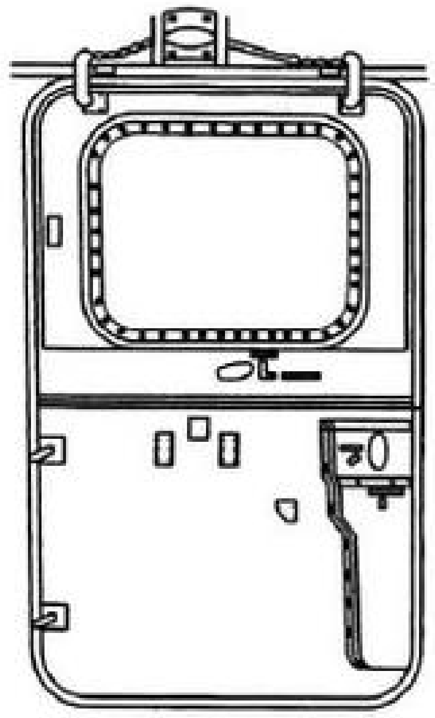
1. Signal passengers to unstrap.

2. Assist and control passengers with egressing helicopter.

3. Ensure all passengers are out.

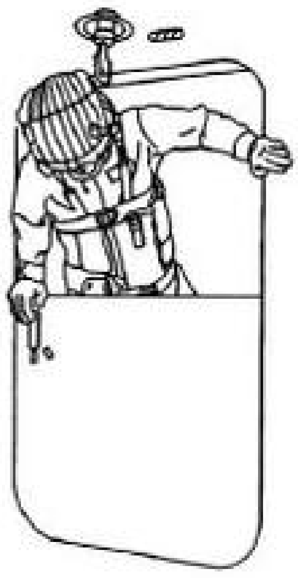
4. Abandon helicopter.

12.31.2 Personnel Door



HC2995
SA

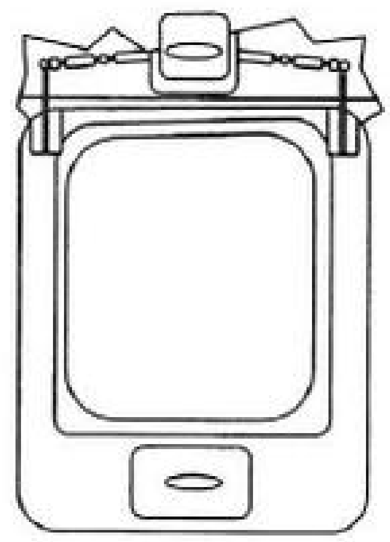
1. Remove upper half of personnel door by turning both upper and lower handles clockwise and pulling inward.



HM1402
SA

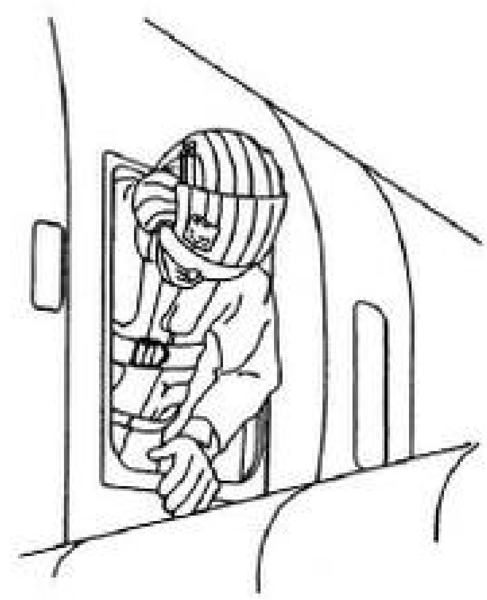
2. Exit aircraft over top of lower door.

12.31.3 Cabin Emergency Escape Hatch



HM1403
SA

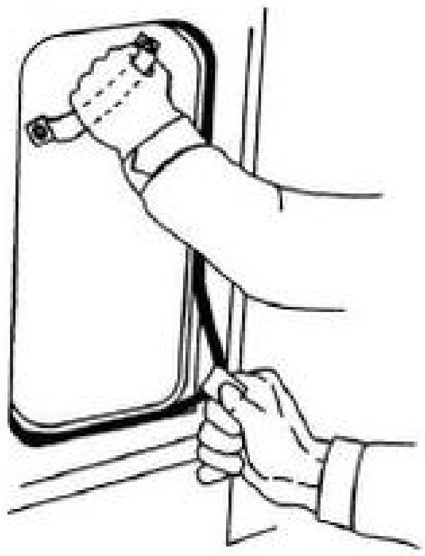
1. Grasp both upper and lower handles and turn clockwise. Remove hatch by pulling inboard.



HM1405
SA

2. Exit aircraft through hatch.

12.31.4 Cabin Window

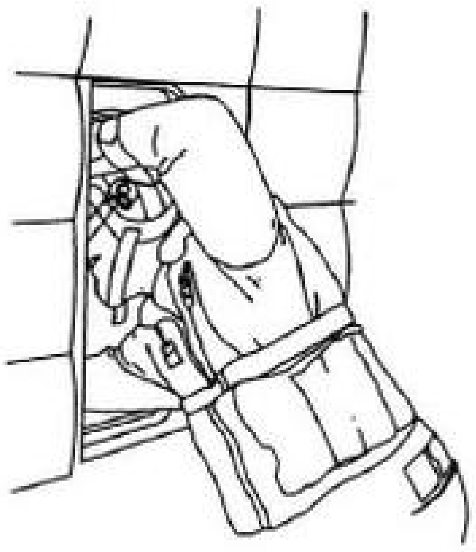


HM1406
SA

1. Locate and grasp handle and pull tab on lower right of window. Pull tab to release window from rubber seal.

HM1407
SA

2. Pull window inboard.



HM1408
SA

3. Exit helicopter through window.

12.31.5 Cargo Ramp and Door

WARNING

When the helicopter is floating on the surface with power on, do not exit the helicopter through the cargo ramp or door, because of the chance of being struck by the operating tail rotor blade.

12.31.6 A/P22P-9(V) CBR Protective Assembly. The A/P22P-9(V) chemical, biological, and radioactive protective assembly is worn by all crew members and passengers when considered appropriate for protection against the elements of chemical, biological, or radioactive warfare. For general information, normal donning and doffing, and routine usage, refer to Aviation Crew Systems Manual, NAVAIR 13-1-6.10, Special Mission Aircrew Equipment.

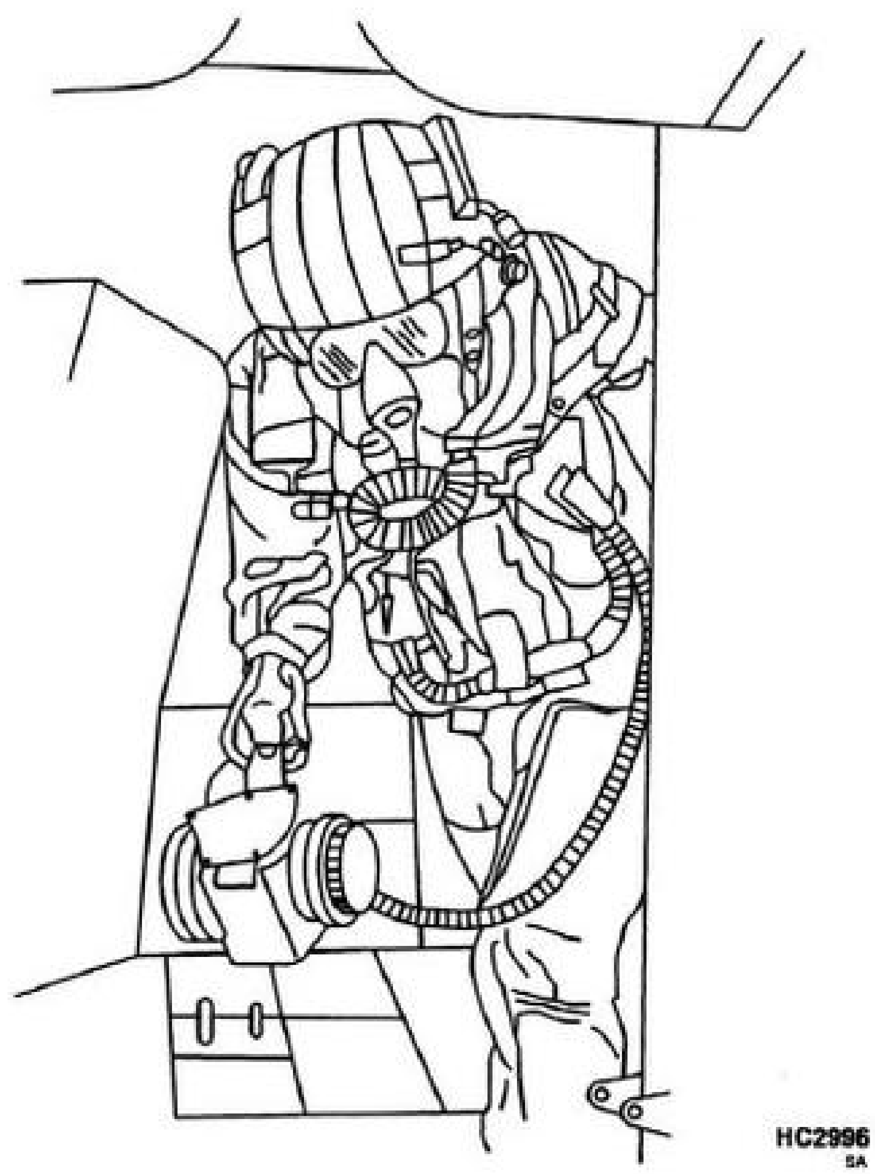
WARNING

- Thorough familiarization with procedures and operation during emergency situations is essential. Exposure to harmful elements or suffocation may result from improper use.

- Suffocation may result if the CBR protective assembly is exposed to smoke or direct flames. The CBR mask will afford some protection against fire and fumes although the mask is made of a combustible material and will not provide oxygen in an oxygen-deficient environment.

While egressing helicopter over land as previously described and while wearing the CBR protective assembly, the following additional steps must be performed.

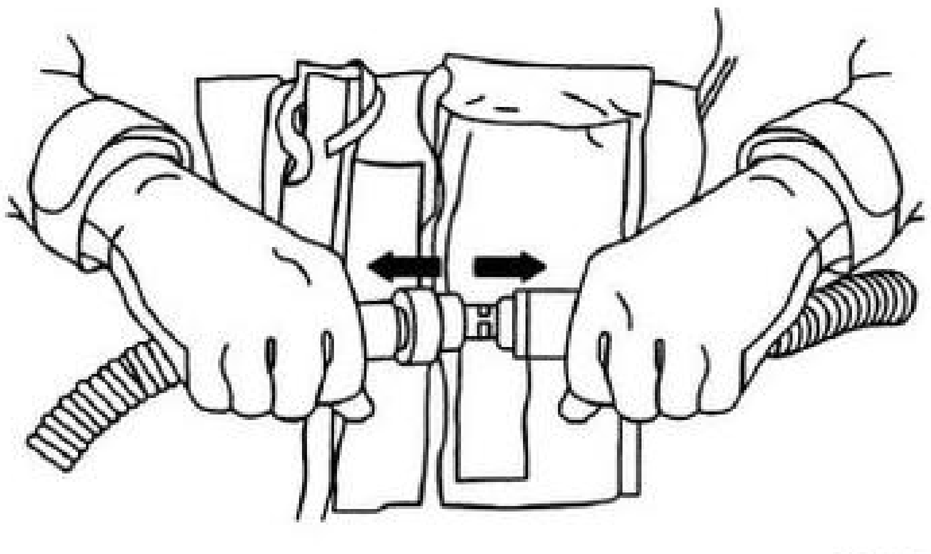
12.31.6.1 Aircrewman Emergency Egress



1. After releasing seat harness and if time permits, disengage the ventilator from aircraft mounting bracket and carry the ventilator by the web strap handle while egressing helicopter.

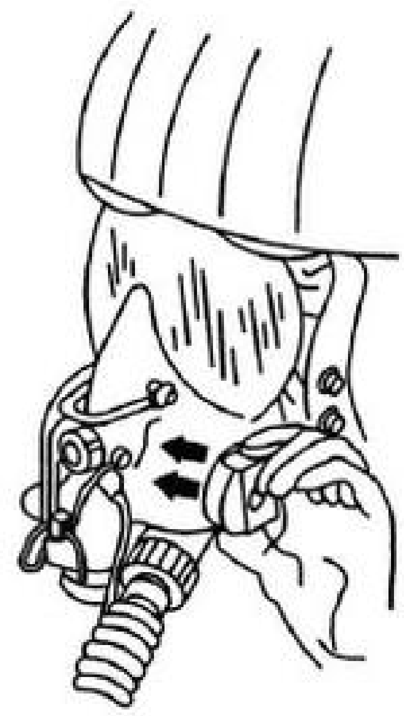
Note

An axial pull of 25 pounds at the RIED valve is required to disconnect the ventilator hose from the manifold inlet hose. When the hoses are disconnected, the optical area of the face plate will mist over rapidly.



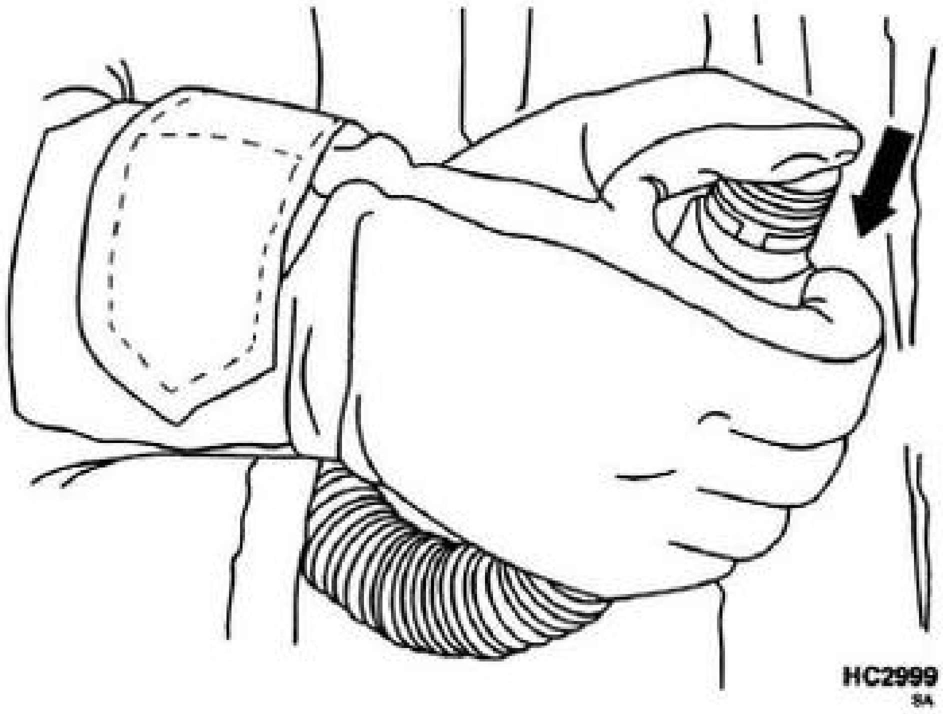
HC2997
SA

2. If time and circumstance necessitate egress without the ventilator, quickly disconnect the ventilator hose from the manifold inlet hose and leave ventilator in aircraft mounting bracket.



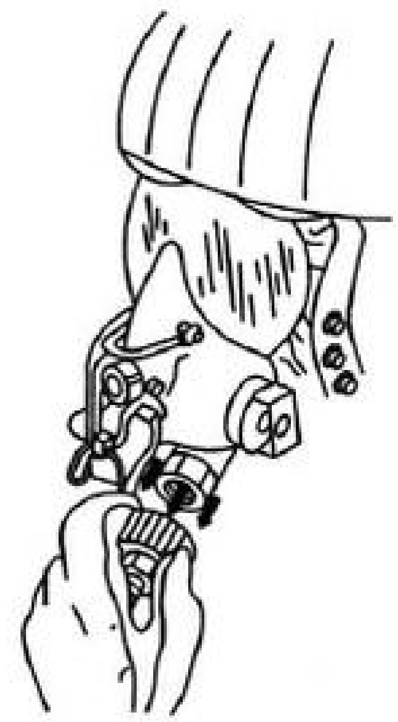
HC2998
SA

3. Close the hood outlet valve, and quickly egress the helicopter.



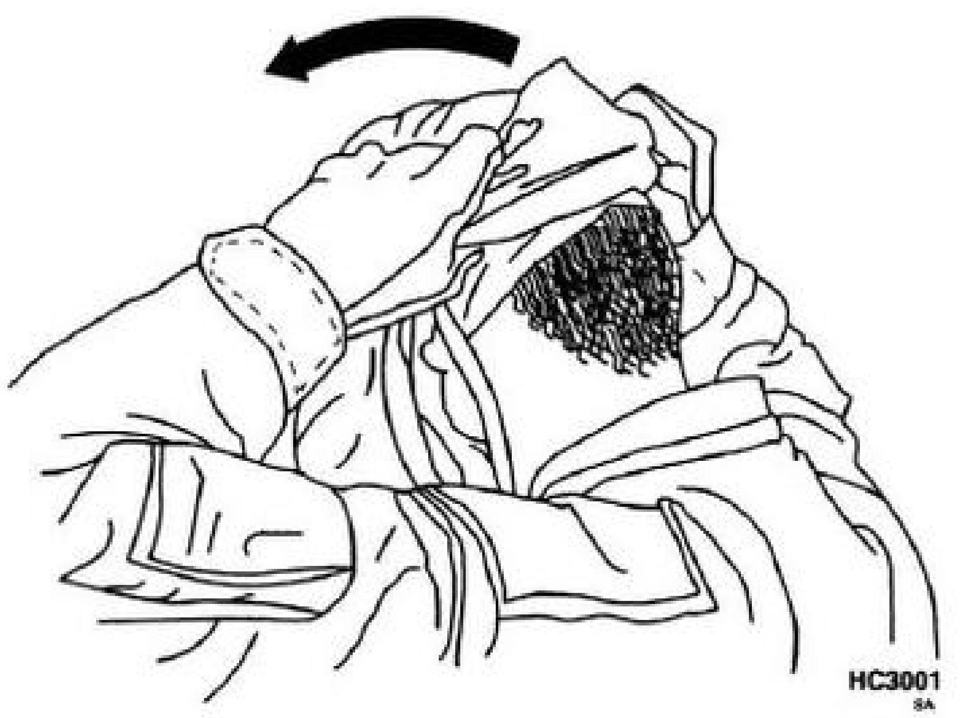
HC2999
SA

4. Upon egress without the ventilator, depress the perforated snorkel portion of the RIED valve to breathe unfiltered air temporarily.



HC3000
SA

5. Shear the anti-suffocation valve on the mask for direct breathing of unfiltered air.



HC3001
SA

6. Remove the respirator assembly.

12.31.6.2 Pilot/Copilot Emergency Water Egress

1. To prevent water entry into the mask, close the hood outlet valve prior to impact. Take a deep breath just prior to the ventilator submerging.

2. Disconnect the ventilator hose from the manifold inlet hose.

Note

With the hood outlet valve closed and with the respirator hose disconnected from the manifold inlet hose, the mask should be sealed off from air and water entry.

HC3002
SA

3. Maintain a reference point with one hand and release seat harness. Egress and swim clear of helicopter.

4. Inflate LPU when clear of helicopter.

HC3003
SA

5. Hold the REID valve above water level and depress perforated portion to breathe unfiltered air temporarily.

Note

The CBR protective mask provides good visibility and the manifold hose can be used as a snorkel in rough water.

6. If flooding of the face mask occurs, clear mask immediately upon surfacing by using the following procedure:

WARNING

Do not attempt to breathe through the inlet hose enroute to the surface or with water in either the mask or manifold tube as drowning may occur.

a. Locate and shear the anti-drown connector.

b. Ensure that mask exhalation valve is above water and mask is upright. Forcibly exhale. The mask will rapidly drain.

c. To draw water from hood, open hood outlet valve and tilt hood to left.

12.31.6.3 Ventilator Malfunction. Ventilator malfunction may be caused by electrical power or ventilator motor failure. This will result in the loss of the positive overpressure feature of the mask and the cooling air used to prevent mask misting.

1. Change controls to unimpaired pilot.

2. Close hood outlet valve.

3. Check ventilator power switch on, circuit breaker in.

4. Check integrity of ventilator power cord.

5. Install spare battery.

6. If ventilator still fails to function, it may be necessary to exchange ventilators with an aircrewman.

WARNING

Disconnecting the ventilator in a contaminated environment may allow a CBR agent to enter the mask.

12.31.6.4 Airsickness in Contaminated Area

1. Disconnect both mask toggle harness leads from helmet.

2. Disconnect helmet chin strap.

3. Lift bottom of mask from face to allow vomitus to drain from mask area to neck.

4. Replace mask on face and reconnect the chin strap and mask toggle harness.

12.31.7 FLIR Malfunctions. Refer to FLIR Malfunction table for indications and corrective actions.

INDICATION	MALFUNCTION	ACTION
CHOT flashes	Cryogenic cooler exceeds 100°K operating limit	At system start up, wait 10 minutes. If still visible after 18 minutes, turn cryogenic cooler (CRYO) off. When CRYO off, turret is in stow position and FLIR image not displayed.
PBIT	Periodic BIT failure	Run BIT.
PHOT	Power Supply Hot	Indicates SDC power supply failure. Shot off HNVS system.
CAL	Calibration	Indicates need for HNVS calibration. Avionics symbology degraded. Turn SYM BRT to center to remove display symbols.
THOT	FLIR Unit Hot	Turn off HNVS system.
FLIR/RNS LEDs not lit during LAMP TEST	If LEDS not lit, power not supplied to HNVS or FLIR/RNS Control Panel failure	Turn off HNVS system.
SYS POWER or PROC LED lit 5 seconds after LAMP TEST	SYS POWER (System Power) or PROC (Processor) LED lit, SDc failure	Turn off HNVS system.
DIS PWR lit 5 seconds after LAMP TEST	DIS PWR (Display Power) power supply failure or PDU failure	Turn off HNVS system.
RNS FAIL LED lit or lit 90 seconds after BIT	Doppler data degraded, or BIT failure, or Doppler system failure	Turn RNS OFF. Doppler symbology will not display.

12.32 EMERGENCY WATER OPERATION

CAUTION

For watertight integrity, all doors, hatches, and the cargo ramp must be closed during all water operations.

The helicopter is configured with watertight hull and sponsons to permit emergency water landings with the ability to stay afloat for about 2 hours in 1- to 3-foot waves with a wind of 7 to 16 knots. If the helicopter becomes capable of further flight, a normal water takeoff may be made. If a takeoff is prevented due to excessive gross weights, but allowable at lower gross weights, consideration should be given to lightening the helicopter by removing cargo and nonessential equipment. If the helicopter cannot be flown from the water, it may be possible to taxi to a shoreline or salvage area. When operating on or near the surface of salt water, the turbine compressor blades will acquire salt encrustation which could eventually cause compressor stall. The rate of salt water ingestion increases with power; therefore, hovering close to the water or operations with increased collective while on the surface should be held to an absolute minimum. The stability of the helicopter on the water must be maintained by the pilot at all times when the engines and rotors are operating. Increased collective will have a leveling effect on choppy seas, but will also increase the spray effect which will correspondingly increase the amount of salt ingested into the engines. A static helicopter can right itself from a roll of 10°, but high wave and wind conditions could cause excessive rolling and subsequent capsizing. Care must be taken not to increase lateral unbalance, since this will reduce the stability of a static helicopter on the water. In higher sea states, the helicopter will ride more comfortably with the bow angled about 30° to the existing sea. It is desirable to keep the rotor system operating unless it is determined that the helicopter is to be abandoned. If the decision is made to abandon the helicopter, the APP should be continued in operation until after the engines are shut down and the rotors have stopped.

As rotor brake application will cause the helicopter to turn in the water, it is desirable to let the rotors coast down, unless rotor decay without brake application would be more hazardous. If time permits, secure all power and shut off all fuel before abandoning the helicopter (Figure 12-12).

12.32.1 Ditching Preparation. Ditching preparation will vary with the system failure/emergency procedure experienced. There will be more time for preparation in a controlled ditching scenario than an uncontrolled (i.e., autorotation or power loss with uncontrolled sink rate).

In a controlled situation, consideration should be given to establishing a low hover/taxi for egressing passengers/crew prior to actual ditching of the helicopter. Time permitting, consideration should also be given to jettisoning pilot/copilot windows prior to water entry.

In an uncontrolled situation, the main consideration is making sure passengers/crew are alerted and braced for impact/water entry.

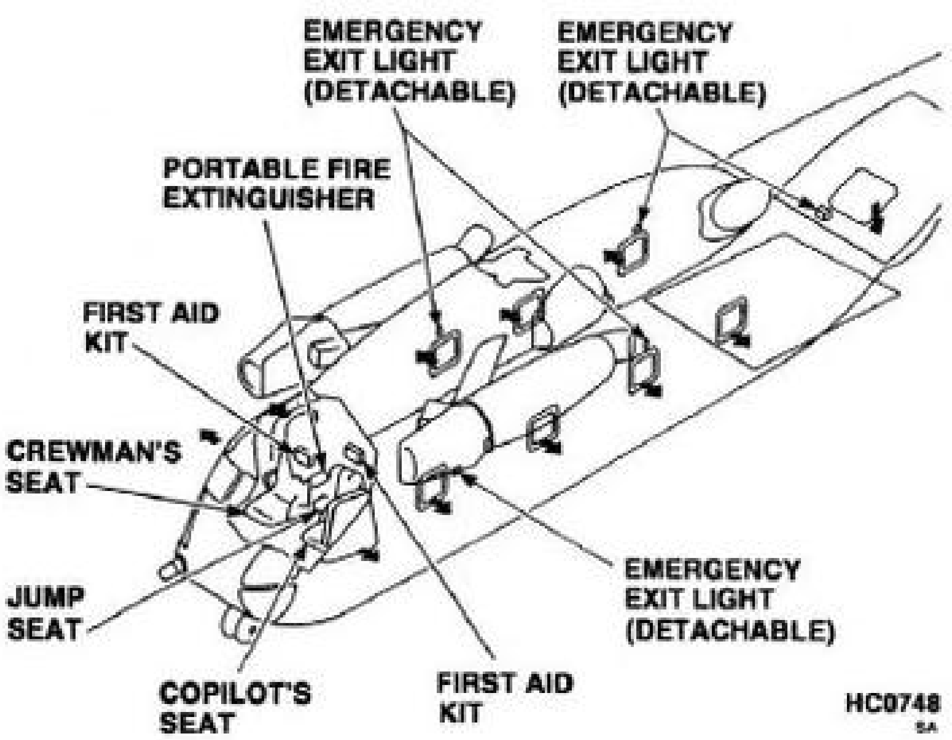


Figure 12-12. Emergency Exits

Pilot/Copilot:

Time permitting, perform the following procedures:

1. Alert crewmembers.

2. Order doors/hatches secure as required. Cargo ramp/door secured. Pilot/copilot windows as desired.

3. Lock seat harness.

4. Auxiliary fuel tanks — AS DESIRED.

5. Follow emergency radio procedures.

WARNING

Careful consideration should be given to the jettison of internal cargo. Movement of heavy loads may cause unacceptable CG shifts, which may jeopardize controllability of the aircraft.

Aircrewman:

1. Jettison cargo — AS REQUIRED.

2. Notify cabin occupants and ensure their seat belts are fastened and to keep their legs from under the seat.

3. Ensure doors/hatches as required, cargo ramp/door secured.

4. Emergency equipment — READIED.

5. Crewman — FASTEN SEAT BELT.

6. Notify pilot that cabin occupants are prepared for water landing.

WARNING

Do not inflate flotation equipment inside aircraft.

Note

Ensure that cabin occupants wearing LPP-1 have them released from container and properly donned.

12.32.2 Three-Engine Water Landing

CAUTION

Nose-up attitudes greater than 5° may cause the tail rotor blades to strike the water.

A water landing with all engines operating should be approached in the same manner as a vertical landing ashore, except the landing gear should be retracted. If the landing gear cannot be retracted, care must be taken to minimize the forward contact speed. Care should be taken to establish a hover before descent with all sideward and rearward motion stopped. Any visual reference to objects in the water will aid in maintaining position during the descent. As the helicopter comes to rest on the water, the collective should be lowered smoothly while simultaneously moving the cyclic to the neutral position. At this point, the forward inclination of the rotor mast will cause the helicopter to have a tendency to move forward in the water.

12.32.3 Single- Or Dual-Engine Water Landing. A single- or dual-engine landing on the water differs only slightly from that on a hard surface. However, it is necessary that touchdown speed be somewhat slower, especially over rough water, and that the rate-of-descent be held to a minimum. When possible, the pilot should pick out an object such as a buoy, boat, or shoreline in the path of the intended landing, to provide a ready reference. The use of instruments, especially the radar altimeter, and visual reference to rotor downwash will assist the pilot in maintaining a reference.

1. Crew — ALERTED.

2. Landing checklist — GEAR UP.

3. Cyclic — MODERATE FLARE AT 150 TO 200 FEET.

4. Collective — INCREASE TO CONTROL RATE-OF-DESCENT.

5. At 30 feet, assume landing attitude and smoothly apply maximum collective to cushion landing.

CAUTION

Nose-up attitudes greater than 5° may cause the tail rotor blades to strike the water.

6. Contact water as slowly as possible.

12.32.4 Water Autorotative Landings. Autorotative landings on water differ from land, in that touchdown speed must be held to a minimum. The helicopter should enter the water with a near vertical descent if possible. Refer to THREE-ENGINE FAILURE (Autorotative Landing), in this chapter.

*1. Autorotate as described under Three-Engine Failure.

*2. Enter water tail rotor first.

12.32.5 Three-Engine Water Takeoff

WARNING

If damage to the tail rotor is suspected, do not take off. Tail rotor damage may be accompanied by heavy medium-frequency vibrations. See VIBRATION in Chapter 11. Rapidly increasing severity of vibrations may indicate impending tail rotor failure. Consideration should be given to shutting down rotor system.

The procedures for a three-engine takeoff from water is the same as those outlined for a normal three-engine takeoff from land. However, excessive spray will be encountered as the collective is increased, and use of the windshield wiper system is recommended. The helicopter should be lifted vertically until clear of the surface before transitioning into forward flight. Premature application of forward cyclic as the collective is being increased may result in a severe tuck if the helicopter is not clear of the water surface. Standard climbout procedures should be used, to attain a safe single-engine operating speed as soon as possible.

12.32.6 Single- or Dual-Engine Water Takeoff. A single- or dual-engine water takeoff may be made if conditions permit a near vertical lift-off. Normally all takeoffs will be made into the wind, but high sea states may make it desirable to take off slightly off the windline, in order to lessen wave impact. Takeoffs will become increasingly difficult with calm winds and higher gross weights. Consideration must also be given to the possibility of power loss as a result of salt ingestion. The speed control lever(s) should be advanced full forward to obtain the power to lift the helicopter until it sits high in the water. This power should be maintained as forward speed is increased. Forward speed should not exceed the maximum taxi speed of about 8 knots. Once clear of the surface, the helicopter should be accelerated forward to gain airspeed, before establishing a safe climb airspeed and altitude.

12.32.7 Water Taxiing

CAUTION

Extreme caution must be taken when taxiing downwind in winds of over 25 knots.

Water taxiing procedures are basically the same as those outlined for taxi operations ashore. Forward speed is attained by applying slight forward cyclic while simultaneously slightly increasing collective. Additional forward speed may be obtained by increasing either cyclic or collective; however, increased collective will increase the amount of salt ingested by the engines. The helicopter can be taxied in calm water at a speed of about 8 knots. In higher sea states it may be necessary to reduce taxi speeds and maintain some increased collective, to minimize the wave impact. The wave impact may be further minimized by taxiing from 30° to 90° to the waves. The helicopter should be kept level at all times and turns should be made by moving the cyclic in the direction of the turn and simultaneously using the rudder pedals. If excessive taxi speeds or wave action should cause the helicopter to tuck, the collective should be immediately lowered to minimum and forward movement stopped. Sideward and rearward taxiing may be done with cyclic and collective, but are not recommended.

12.32.8 After Landing Checklist

12.32.8.1 Helicopter Upright, Rotors Engaged. If the helicopter is upright with power on and it is necessary to abandon it, do this:

Pilot:

1. Order — ABANDON HELICOPTER.

WARNING

If egressed personnel become inadvertently dispersed once in the water, and/or wind/sea conditions are such that further water taxi will increase hazard to personnel, consideration should be given to holding position and shutting down once all visible personnel are well clear of the rotors.

2. When copilot and occupants have egressed — TAXI DOWNWIND FROM PERSONNEL AT LEAST 100 YARDS.
3. APP — ON.
4. Landing gear — DOWN.
5. Engines — SHUTDOWN.
6. Cyclic — MAINTAIN ATTITUDE.
7. Rotor brake — DO NOT APPLY.
8. HAC — ABANDON HELICOPTER.

Aircrew:

*1. At pilot's command, abandon aircraft.

*2. Signal passengers — UNSTRAP.

*3. Notify pilot — PASSENGERS OUT AND CLEAR.

*4. Crew — ABANDON HELICOPTER AND DEPLOY LIFE RAFT (if required).

WARNING

Consideration should be given to inflating multiplace rafts only after rotor shutdown or when rafts are well clear of the rotor system, due to minimal clearance between the ditched helicopter's rotor and the water's surface. This will also prevent personnel from prematurely boarding a raft and possibly being struck by the rotor system.

*5. Assist passengers into raft (if required).

12.32.8.2 Helicopter Rolls Over or Does Not Float. All personnel shall remain strapped in until rotors stop. Passengers shall not inflate life vest while in helicopter.

*1. When rotors stop — ABANDON HELICOPTER.

*2. Check — ALL PASSENGERS OUT.

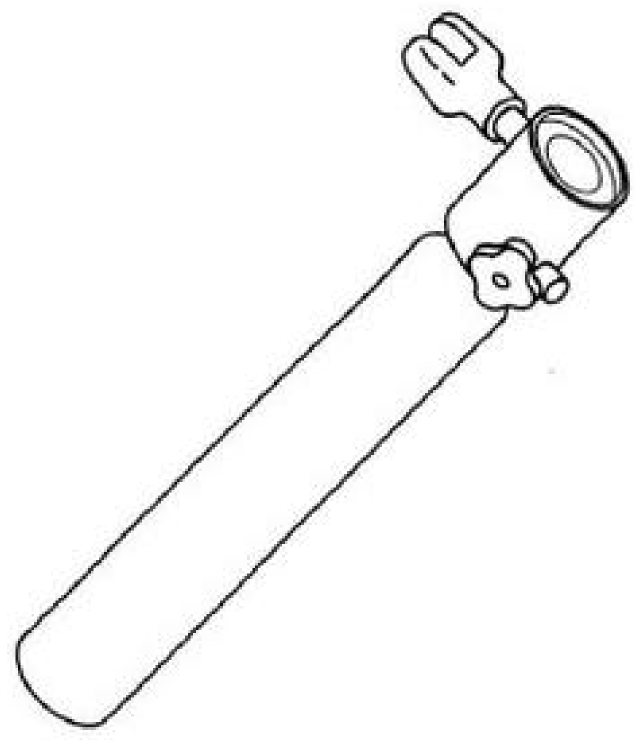
*3. Flotation devices — INFLATE WHEN CLEAR OF OBSTRUCTIONS.

*4. Assist passengers into raft (if required).

Note

- If time permits, launch rafts through any escape point.
- If the helicopter is inverted, use of the single-point suspension hatch should be considered for exit.

12.32.9 Helicopter Emergency Egress Device (HEED)



1. Prior to submerging, if time does not permit placing the HEED in your mouth, make a normal egress.

2. If you become entangled, disoriented, or for whatever reason your egress is delayed, hold onto a reference point with one hand, remove HEED, place in your mouth, clear water from mouth piece, and continue with normal egress procedures.

3. If you cannot reach the surface, inflate LPU when you are sure you are free of the helicopter.

WARNING

As you are ascending to the surface breathing off the HEED, you must continually exhale to vent the expanding air from your lungs to prevent injury.

12.32.10 Pilot/Copilot Emergency Water Egress

WARNING

Copilot must ensure that the collective lever does not block egress through window.

1. Emergency rotor brake — EMERGENCY (IF APPLICABLE).

2. Seat — FULL BACK.

WARNING

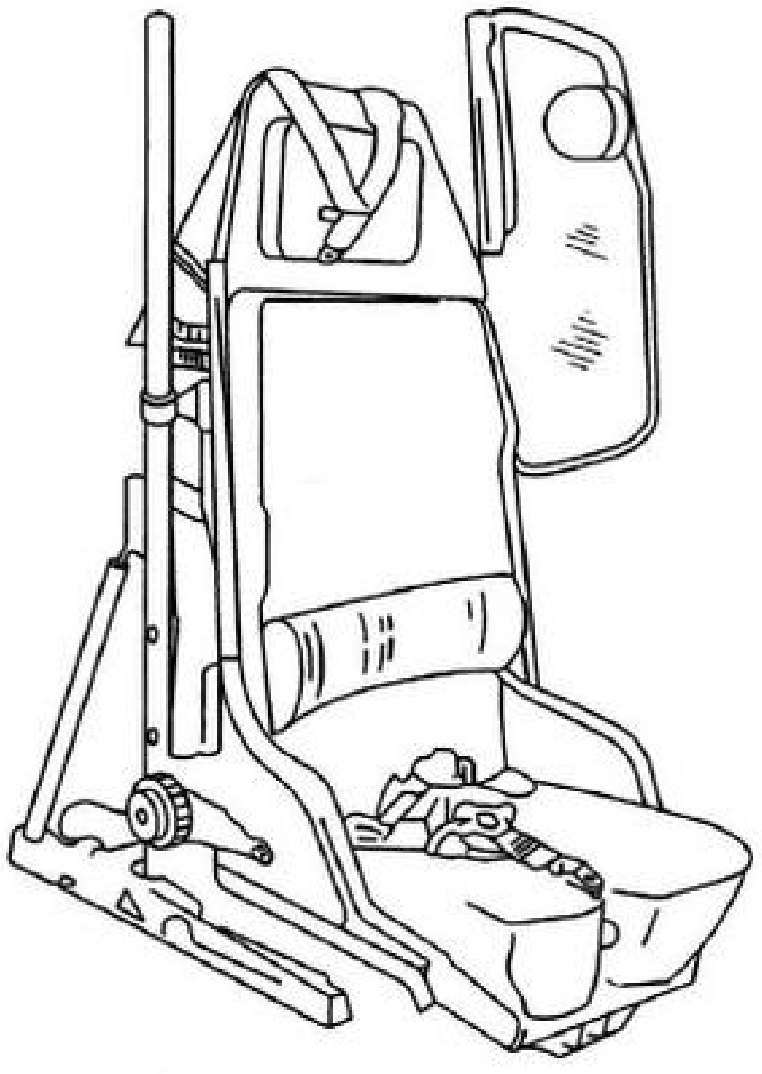
If seat strokes, occupant and seat may shift downward 18 inches and move forward. Windows, hatches, doors, and handles may not be located in the same familiar places.

3. Disconnect ICS.
4. Armorplate wing to rear (if applicable).
5. Appropriate window — EMERGENCY RELEASE.

WARNING

If helicopter begins to overturn after impact:

a. Place the HEED in your mouth.



CRASH–ATTENUATING SEAT IN STROKED POSITION

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b. Place one hand on seat harness release.

c. Place other hand on known reference point.

d. Remain strapped in 5 to 8 seconds after impact or until water is no longer rushing into cockpit.

6. Release seat harness.

WARNING

Do not inflate LPU until outside helicopter.

7. Exit helicopter, grasp sides of window frame pulling body through, use feet to push off on any available surface.

8. Once in water outside helicopter, inflate LPU and swim well away from the helicopter.

12.32.11 Aircrewman Emergency Water Egress

1. Signal passengers to unstrap once aircraft has settled and all violent motion has stopped.

2. Deploy all life rafts.

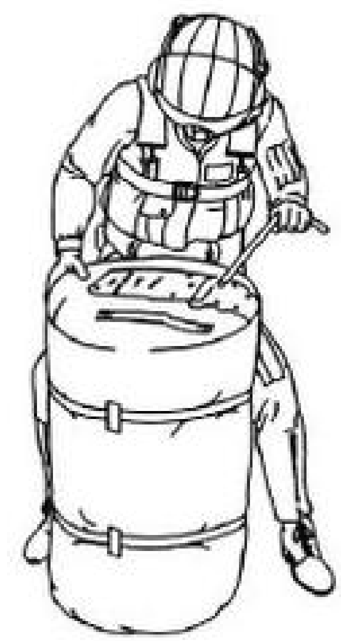
CAUTION

In order to avoid loss of the raft, retain control of the raft retention lanyard after deployment. Uninflated, the raft package will float from 10 to 20 minutes, depending on sea state.

a. Grasp raft and move to personnel door or ramp area.

b. Open and remove upper half of personnel door.

c. Locate raft retention lanyard.



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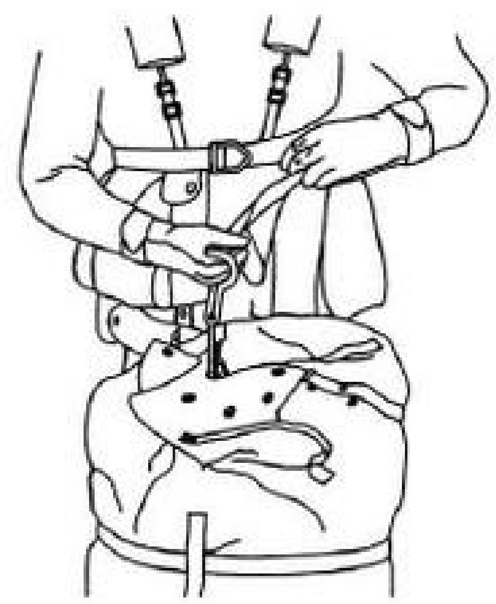
d. Locate raft inflation handle (continuation of retention lanyard).



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e. Push raft through upper half of ramp door or over top of lower personnel door. Pull sharply on inflation handle.

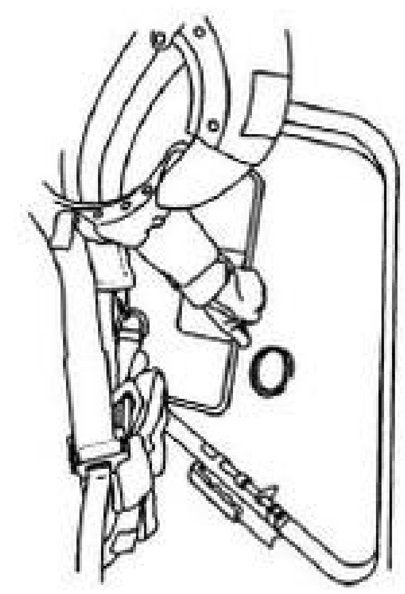
3. Control and assist passengers.

   a. Brief passengers to remain seated until all violent motion has stopped.

   b. Assist passengers with unstrapping and exist-ing helicopter.

4. Check all passengers out of helicopter.

5. Abandon helicopter through appropriate exit.



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PART VI

ALL-WEATHER OPERATION

CHAPTER 13
All-Weather Operation

13.1 INSTRUMENT FLIGHT PROCEDURES

The CH-53E is capable of instrument flight concurrent with minimums established for conventional dual-piloted aircraft. The installed navigation equipment can supply the pilot with range and bearing information to a preselected destination. With the automatic flight control and trim systems engaged, the flight characteristics are stabilized in altitude, pitch, roll, and yaw. A selected altitude can be automatically maintained by engaging the BAR ALT feature of AFCS. As with all instrument flying, careful preflight planning is necessary. Except for some repetition necessary for continuity, the procedures and techniques here are only those that differ from, or are in addition to, the normal operating procedures covered elsewhere in the manual. Refer to the NATOPS Instrument Flight Manual for detailed instrument flight procedures.

13.1.1 Simulated Instrument Flight. Safety precautions and procedures for conducting simulated instrument flights are in OPNAVINST 3710.7.

13.1.2 Taxi Checklist

1. Vertical gyro indicators — CHECK TURN AND SLIP INDICATORS.

2. Heading Indicator/Standby compass — TRACKING.

3. Turn indicators — TRANSFER/CHECK.

4. VGI — SET ON INDEX DOT/ERECT.

13.1.3 Instrument Takeoff. When conditions, meteorological or otherwise, prevent execution of normal takeoff and acceleration to climb speed, prior to loss of adequate visual reference, an instrument takeoff may be performed as follows:

1. Checklist — COMPLETE.

2. Parking brakes — AS REQUIRED.

3. Collective — Increase smoothly to desired power.

4. Rudder pedals — as helicopter becomes light on landing gear, adjust pedals as required to maintain heading. (Recommend feet off pedal micro switches.)

5. Cyclic — Maintain hover attitude (normally 5° to 8° nose-up, 2° to 3° left wing down).

WARNING

Do not lower nose below hover attitude until immediate obstacle clearance assured. Inadvertent descent or drift may cause impact during takeoff.

Note

- Attitude indicator will give dependable attitude indications at all speeds. However, until about 40 knots of forward airspeed is indicated, pilot cannot definitely ascertain helicopter's direction of motion.
- Turns should not normally be made below 200 feet above terrain.

6. Once desired transition altitude is reached, smoothly lower nose (no lower than 5° nose down) to accelerate to desired climb airspeed. Maintain positive rate of climb during transition.

7. Establish best rate of climb airspeed.

13.1.4 Climb. Climb under instrument conditions is similar to the climb technique and procedure described for a normal climb. Consult the climb charts in Part XI for the best climb speed at various gross weights and altitudes. The AFCS will maintain the heading and attitude established by the pilot. Limit climbing turns should not exceed standard rate.

13.1.5 Cruise. After leveling off, stabilize airspeed and power and engage the BAR ALT channel of AFCS, if desired. Pay particular attention to navigation as a slow airspeed results in large drift angles. Speed limitations for various weights, altitudes, and N_r are outlined in Chapter 4. Under instrument flight conditions, these upper limits should be approached with caution. A minimum speed of 40 knots should be observed to maintain the normal flight characteristics associated with forward flight. The airspeed indicator system is less reliable below 40 knots. The coordinated turn features of AFCS will be inoperative below 60 KIAS.

Note

There will be slightly increased fuel consumption with continued use of BAR ALT.

13.1.6 Holding. If extended holding is expected or fuel requirement dictates, consideration should be given to transitioning to maximum endurance airspeed. Any cruising airspeed can be easily maintained in the normal holding pattern.

13.1.7 Descent. Normal descents are made by reducing power until the desired rate-of-descent is accomplished. Enroute descents are normally made at cruising airspeed.

13.1.8 Instrument Approaches. Instrument approaches are made by using standard instrument approach procedures. By using cruising speed during the entire approach, the pilot can reduce the effect of wind on the track and ground speed and a more precise approach can be flown. See Figures 13-1 and 13-2 for typical GCA and ADF approaches, respectively. Refer to NATOPS Instrument Flight Manual for typical ILS approach.

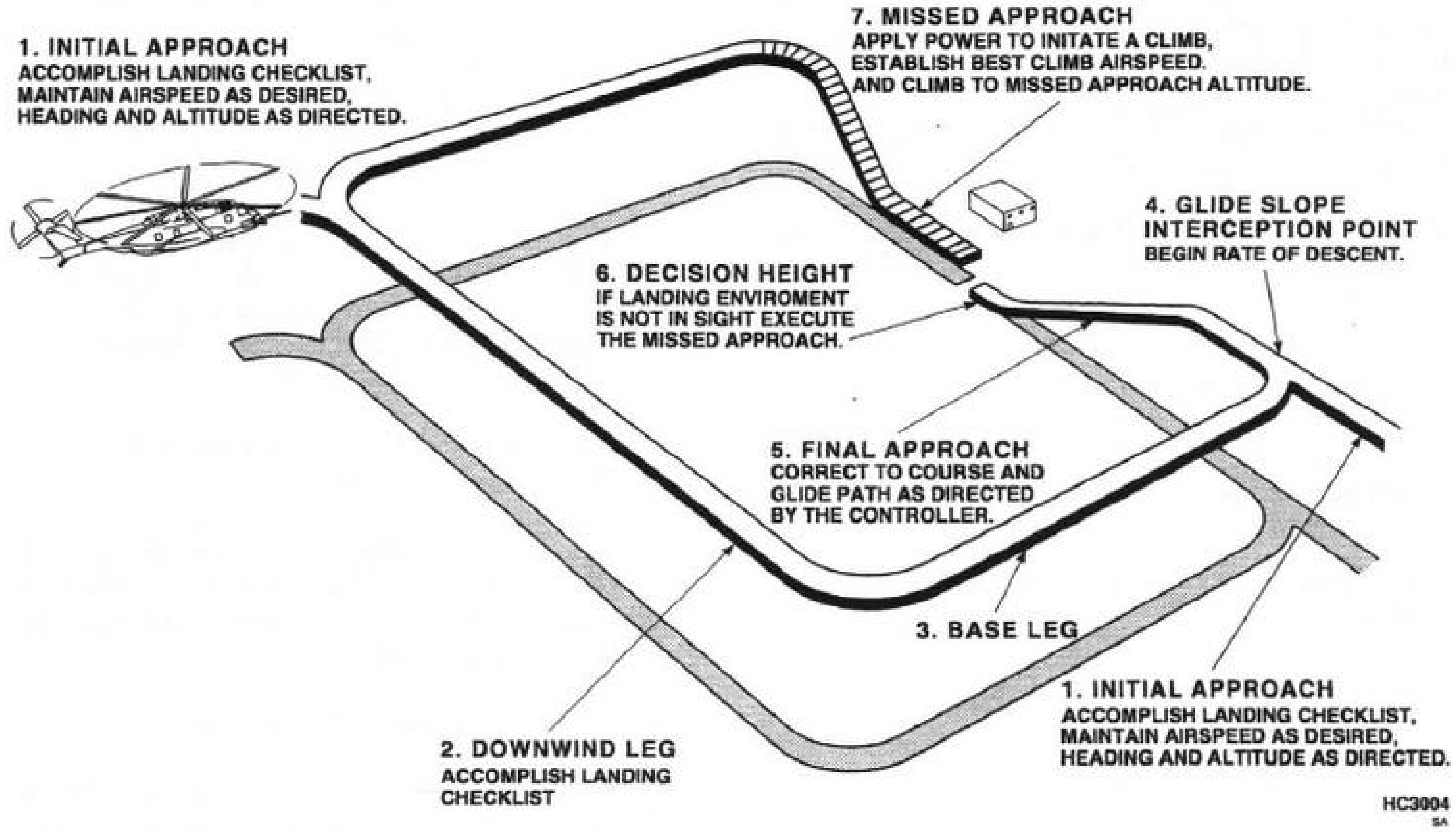


Figure 13-1. Ground Controlled Approach (Typical)

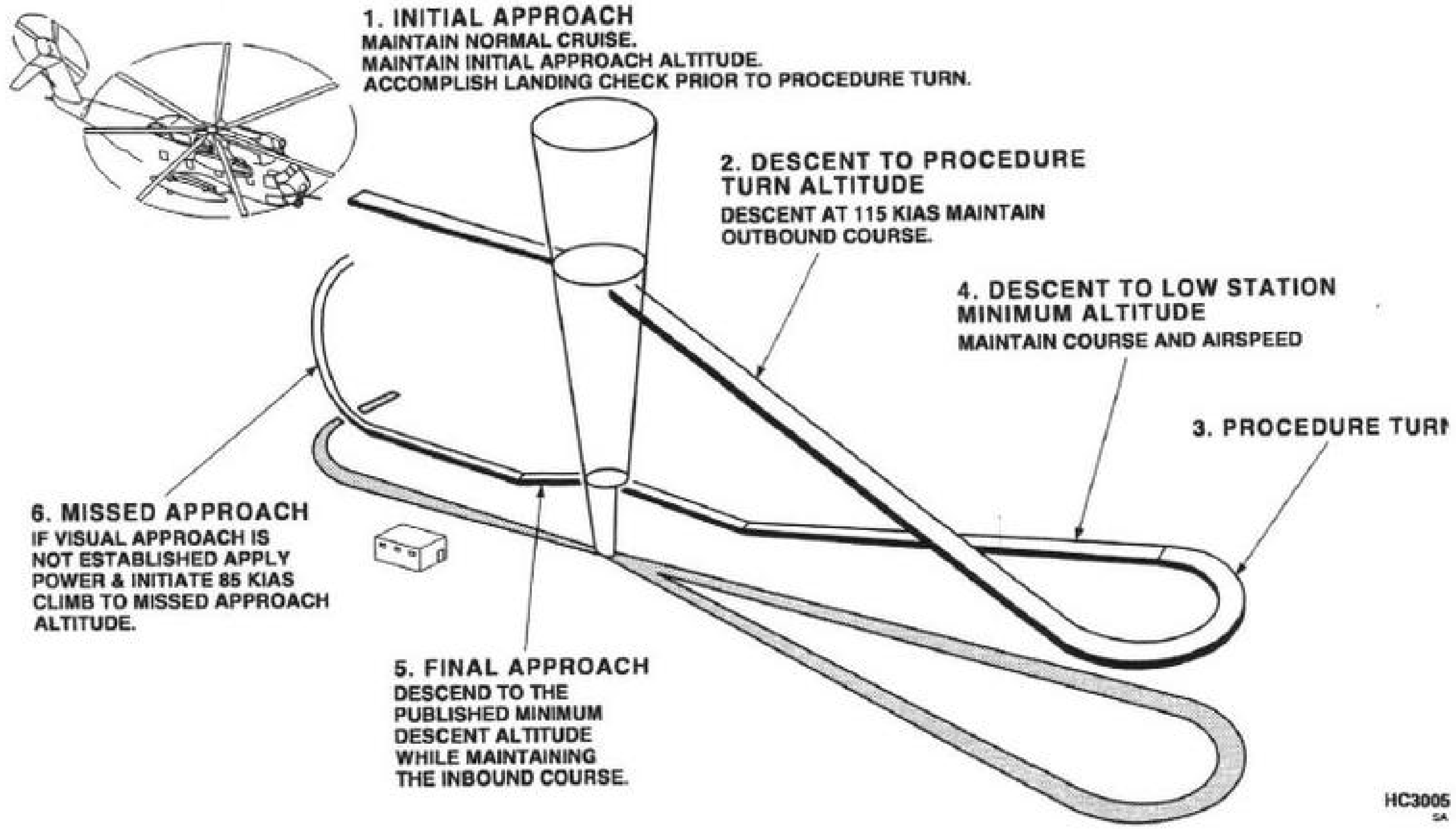


Figure 13-2. ADF Approach (Typical)

CHAPTER 14
Extreme Weather Operations

14.1 COLD WEATHER PROCEDURES

The major problems in cold weather operations are the preparation for flight, restricted visibility from blowing snow, and the adverse effects on helicopter materials. Moisture, usually from condensation or melted ice, may freeze in critical areas. Tire, landing gear strut, fire extinguisher bottle, and accumulator air pressures will decrease as temperatures decrease. Extreme diligence on the part of both ground and flight crews is required for successful cold weather operation.

Moderate or severe icing conditions shall be avoided. Trace and light icing should be avoided but can be flown in if the time limits in Figure 14-1 are not exceeded. The greatest dangers caused by ice accumulation are lowered main rotor blade efficiency and possible damage to the tail rotor blades. Icing of the engine air inlet area is an ever-present possibility when operating in weather with temperatures near or below 0°C. When any form of icing is anticipated or encountered, the EAPS doors shall be manually closed and remain closed until after engine shutdown, for engine anti-icing and to prevent shedding ice from entering the engines. In addition, the engine anti-icing systems shall be turned on by placing the engine anti-ice switches to ON/CONT IGN, with or without EAPS installed.

When operating on an unknown snow surface, the danger of breaking through snow crust is lessened by maintaining power. Pilots should be aware of the fact that the horizon may be lost when flying over large unbroken expanses of snow. In this condition, the helicopter should be flown entirely by instruments at a safe instrument altitude. To prevent snow blindness, colored glasses should be worn in snow areas.

CONFIGURATION	ICING INTENSITY	FLIGHT DURATION IN ICING CONDITION
Three EAPS doors manually closed until after engine shutdown and three engine anti-icing systems operating.	Trace Light	Unlimited 30 Minutes
No. 1 and No. 3 EAPS not installed. No. 2 EAPS door manually closed until after engine shutdown. Three engine anti-icing systems operating.	Trace Light	Unlimited 30 Minutes

WARNING

The helicopter is restricted from flying into known or forecast moderate or severe icing conditions.

Figure 14-1. Anti-icing Summary

WARNING

Human efficiency is reduced sharply as temperature drops below -18°C. In arctic and subarctic operations, rotor wash is known to have a supercooling effect that is hazardous to personnel. Consequently, exposure of personnel being evacuated or of ground personnel to rotor wash should be held to a minimum. Absolutely no part of a person's skin shall be exposed for any length of time under the rotor downwash when in an arctic climate. Exposed skin may freeze in as little as 30 seconds.

Note

Following exposure to temperatures of -5°C or colder for 1 hour, full pressurization of the rotor brake may not occur. This will result in increased stopping time for the rotor. The electrical rotor brake release may not function as well. The manual rotor brake release may be used as required.

14.1.1 Anti-Icing Systems. In visible moisture below 4°C, the EAPS doors shall be manually closed and remain closed until after engine shutdown. In addition, the engine, windshield, pitot heat, and FLIR anti-ice systems shall be turned on. If there is dry snow at an OAT of -4°C or lower, engine anti-ice should be turned off, and the use of windshield anti-ice is optional. Helicopters operating in icing conditions shall be in accordance with Figure 14-1.

CAUTION

Damage of the cockpit windshields may occur any time the windshield anti-ice is activated without visible moisture; consideration should be given to activating low position prior to high position.

14.1.2 Preflight Inspection. In addition to doing a normal preflight inspection, the main rotor head and blades, tail rotor, and flight controls should be thoroughly inspected and made free of all ice and snow accumulations. Failure to remove accumulations while on the ground can result in serious aerodynamic and structural effects when flight is attempted. Check that the helicopter surfaces, controls, ducts, blades, IBIS detector, IBIS spar pressure indicators, oleo shock struts, fuel tank vents, static ports, pitot tubes, turret FLIR unit and support assembly are free from accumulations. Check that the landing gear struts, tires, and hydraulic accumulators are properly inflated.

Check the lower section of the engine air inlet and the lower portion of the EAPS barrel for evidence of ice and snow accumulations. Moisture collected on the previous flight can accumulate in the lower section and freeze. An attempted engine start could cause damage. If ice is suspected, check the engine to be sure it is free to rotate. If not, apply external heat to the forward engine section to permit thawing. Start the engine as soon as possible after thawing, to remove all moisture before it freezes again.

CAUTION

Remove all ice and snow accumulation before flight. Do not attempt to chip or scrape accumulations from any surface or controls. Portable ground heaters or deicing fluid may be used to remove any accumulation that cannot be swept off.

14.1.3 APP/Engine Starting. For APP start, a longer start interval may be obtained by using both APP accumulators simultaneously. This can be accomplished by pulling the T-handle in the cabin section down prior to commencing APP start. Be sure that ground heater ducts have been removed and EAPS doors are manually closed, then make normal engine start.

CAUTION

- High engine oil pressure will exist until the oil has warmed. Should engine ENG OIL PRESS HIGH light stay on for over 3 minutes, secure the engine. Do not exceed GRD IDLE until oil pressure is within normal operating limits.
- When engaging rotor on ice, use the alternate start procedures, to prevent sliding from abrupt rotor torque input.

14.1.4 Post Engine Start. Immediately after engine start and rotor engagement, turn on the cabin heater, engine anti-icing systems, pitot heat, windshield anti-icing systems, and FLIR anti-icing function.

Note

- Allow a longer warmup period during cold weather, due to the time required to bring engine and transmission oil temperatures up to desired operating range.
- The FLIR system anti-ice heaters are used to prevent the build up of ice by heating the turret gimbals. It will not remove ice that is already present. Turn on ICE only if ambient temperature is below 40°F (5°C) and prior to encountering icing conditions.

14.1.5 Taxi. In cold weather, make sure all instruments have warmed up enough for normal operation. Check for sluggish instruments during taxiing.

Note

The nose gear may not swivel at temperatures below -37°C because the fluid in the nose gear viscous damper may become solid at these temperatures.

The helicopter can be taxied in soft snow. The deeper the snow, the more difficult taxiing and directional control may become, and increased collective pitch may be necessary. Helicopters should not be taxied on a snow-covered surface that is suspected or known to contain hidden obstructions or hazards. Normally, the rotor wash at taxiing power will not obstruct visibility from blowing snow. Ground handling characteristics of the helicopter on loose or compacted snow at temperatures below -18°C are good, and wheel braking action is fair to good. However, as temperatures rise toward freezing, snow-covered surfaces become more slippery and increasing caution must be taken.

When it is necessary to taxi on ice-covered surfaces, use slow ground speeds so that cyclic displacement may be used as the primary braking force.

14.1.6 Takeoff. The pilot must be certain that the helicopter wheels are not frozen to the surface. A slight yawing motion, induced by light rudder pedal motion, should break the wheels free when they are frozen to the surface. Takeoffs into fog or low clouds when the temperature is at or near freezing could result in engine air inlet icing. Select an area devoid of loose or powdery snow, to lessen the restriction to visibility from blowing snow.

14.1.7 Cruise. During cruise, use the cabin heater, engine anti-ice systems, pitot heat, and windshield anti-ice protective systems as required. After takeoff from water, wet snow, or slush-covered field, operate the landing gear through several complete cycles to prevent their freezing in the retracted position. Expect slower operation of the landing gear in cold weather due to stiffening of all lubricants.

If icing conditions are encountered, close the EAPS doors manually and keep them closed until after engine shutdown on the ground. Although the EAPS HIGH PRESS LOSS caution light may go on, indicating excessive clogging of the strata tubes, keep the EAPS closed. Cycling the EAPS with ice on the doors could FOD the engine as the broken ice pieces are ingested. During icing conditions, the main rotor assembly and blades will collect ice. After a certain amount has collected, vibration may be noted in the controls and the airframe. When icing is present during low altitude flights or approach, additional power will be necessary for safe flight. Also, do not lower the landing gear until in the landing pattern, to avoid too much ice accumulation on the landing gear and exposed components.

WARNING

To prevent engines from ingesting ice when icing is anticipated or encountered, manually close the EAPS doors and keep the doors closed until engines are shut down after landing.

Note

As ice accumulates upon the rotor system, increased power may be required to maintain level flight. While changing altitude to avoid icing conditions, adjust torque setting and airspeed to maintain power turbine inlet temperatures and torques within operating limits.

14.1.8 Landing. Make a normal landing; but, if icing is present, increased power may be necessary for a safe landing. If power requirements become critical and terrain permits, a running landing may be made. Be sure EAPS doors are manually closed and remain closed until after engine shutdown.

Landing in snow can be hazardous because of unknown hazards beneath the snow, and reduced visibility due to blowing snow. Landings in unprepared areas are especially hazardous. The slope of the terrain may be masked by snow drifts, and obstacles beneath the snow can damage the landing gear, ramp, and underside of the helicopter. Unlike sandy conditions where a no hover landing is usually the best, landings conducted on unprepared surfaces of heavy snow should be made by coming into a high hover and blowing the loose snow clear of the landing zone. Several approaches may be necessary to reach an acceptable level of visibility. A no hover landing can be made to prepared surfaces where the slope and obstacles are known. Damage to the helicopter can occur if a no hover landing is done in deep snow and the helicopter settles onto obstacles or uneven terrain. In deep snow the helicopter may never settle to the ground and the isolation valve will not open. Clearance of both the tail rotor and main rotor will be lower depending on the depth of the snow and the amount the helicopter settles. After performing a higher hover to blow away loose snow, keep a visual reference on an object forward of the helicopter, and slowly lower the helicopter to the ground. If no object is available, consideration should be given to dropping an object (tire, stake, etc.) from the single-point cargo door to provide a visual reference. Landing without a visual reference on an all white surface can result in helicopter drift and possible roll over. As the helicopter touches down, slowly lower the collective, as the helicopter settles. Power may have to be kept on the helicopter to provide safe clearances for the tail rotor and main rotor and passengers embarking or debarking. Attempts to fully lower the ramp can cause damage to the ramp hinges. Operate the ramp incrementally and visually check the hinge area. Passengers may have to embark or debark from a level ramp position or from the personnel door. If power is kept on the helicopter to prevent settling, the embarking and debarking of passengers will be more time consuming and difficult due to the increased rotor wash, and blowing snow.

WARNING

Main rotor and tail rotor blade ground clearances are reduced with the helicopter resting on the fuselage. Therefore, personnel entering or leaving the helicopter should use extreme caution to prevent being struck by the blades.

CAUTION

If the smoke grenade (or the object being used as a reference) should become completely obscured during the approach and/or landing, accomplish a waveoff.

14.1.9 Engine Shutdown. Make a normal engine shutdown as outlined in Chapter 7. As soon as the helicopter is parked, chock the wheels and release the brakes.

CAUTION

When shutting down engines on ice, allow rotors to coast to a stop, then apply rotor brake.

14.1.10 Postflight Inspection. Whenever possible, leave the helicopter parked with full fuel tanks. Make every effort during servicing to prevent moisture from entering the fuel system. Drain condensation from the fuel and oil sumps and drains, and remove all ice and snow from vents, drains, and breathers. Close all doors and hatches, and clean landing gear oleo struts of dirt, snow, and ice with a clean cloth soaked in hydraulic fluid. Check that protective covers have been installed. Engine exhaust and air inlet (without EAPS) protective covers should not be installed until after engines have cooled down.

14.2 HOT HUMID WEATHER OPERATIONS

High humidity usually results in the condensation of moisture throughout the helicopter. Possible results include malfunctioning of electrical equipment, fogging of instruments, rusting of steel parts, and the growth of fungi in vital areas of the helicopter. Further results may be pollution of lubricants and fluids and deterioration of nonmetallic materials. Normal procedures outlined in Part III will be followed for all phases of operation, with emphasis placed on the data contained herein. More power will be required to hover during hot weather than on a standard day. Hovering ceilings will be lower for the same gross weight and power settings on a hot day. Plan the flight thoroughly, to compensate for existing conditions, by using the charts in Part XI. Check for the presence of corrosion or fungus at joints, hinge points, and similar locations. Remove any fungus or corrosion. If instruments, equipment, and controls are moisture-coated, wipe them dry with a clean, soft cloth. When weather conditions permit, leave windows and doors open on the ground, to ventilate the helicopter.

Note

Fuel densities will decrease as the ambient temperature rises, resulting in a decrease in operating range.

14.3 DESERT OPERATIONS

Desert operation generally means operation in a very dry, dusty, often-windy atmosphere. Under such conditions, sand and dust will often be found in vital areas of the helicopter. Severe damage may be caused by sand and dust. Tow the helicopter into takeoff position which, if possible, should be on a hard, clean, surface free from sand and dust. EAPS should be installed and fully operational for all operations.

CAUTION

Dust and/or sand laden air can extend upward for several thousands of feet. EAPS doors shall be manually closed when operating under these conditions.

14.3.1 Preflight Inspection. Plan the flight thoroughly to compensate for existing conditions, by using the performance charts in Part XI. Check for sand and dust in control hinges and actuating linkages, and inspect tires for proper inflation. High temperatures may cause over-inflation. Check oleo struts for sand and dust, especially in the area next to the cylinder seal, and remove any accumulation with a clean, dry cloth. Inspect for and remove any sand and dust deposits on instrument panel and switches and on and around flight and engine controls. Expect higher fail rates on items such as main gear oleos, dampers, blade fold pins, and actuating cylinders, etc.

14.3.2 Engine Starting. If possible, engine starting and ground operation should be made from a hard, clean surface. Prior to engine start with EAPS doors closed, the MAIN TR INT GB PRESS (14 psi) circuit breaker (EMERGENCY DC BUS) should be pulled and left out for thirty seconds once APP is on line. This procedure will activate the EAPS blower motors and clear the EAPS of any accumulated dust and sand prior to engine start. Do the normal engine start, warmup, and ground tests, but limit ground operation to a minimum, as the downwash from the main rotor may stir up clouds of sand. Make every effort to lessen the sand from being blown up around the main rotor and engines. Consideration should be given to doing an unlocked start to alleviate APP overtemp if extended delays in the engine start sequence are encountered. Additionally, unlocked starts allow engine and NGB oil coolers to function.

14.3.3 Taxi. When it is absolutely necessary to taxi in sand and dust, get the helicopter airborne as quickly as possible, to lessen sand/dust intake by the engines and erosion of the rotor blades.

CAUTION

Turning in loose sand or soil could result in the nosewheel cocking 90°, and the nosewheel tires being rolled off the rims.

14.3.4 Takeoff. Execute a normal takeoff and climb as rapidly as possible. Takeoff in heavy sand/dust may result in disorienting IFR conditions. The non-flying pilot should furnish the pilot at the controls with a constant flow of flight information during this period.

14.3.5 Cruise. Avoid flying through sand/dust storms when possible. Dust and grit in the air causes considerable damage to the internal engine parts and erosion of the rotor blades. The EAPS doors shall be manually closed, the vent blower off, and the windows closed when operating in a sand/dust environment.

14.3.6 Landing. The best procedure for landing, to reduce blowing sand/dust, is a rolling landing, if conditions permit. If conditions do not permit a rolling landing, fly a minimum power approach with a no hover landing. The EAPS doors shall be manually closed, the vent blower off, and the windows closed when operating in a sand/dust environment.

14.3.6.1 Ground Operations. During extended ground operations (e.g., hot refueling in a hot desert environment), the No. 1 and No. 3 nose gear box and engine oil temperatures may exceed normal operating limits. Retarding No. 1 and/or No. 3 ENG SCL to ground idle/min governing may allow NGB/ENG oil temperatures to return to normal operating temperatures. If an NGB OIL HOT caution light illuminates, refer to Chapter 12 (emergency procedures). Considerations should be given to planning minimum ground operations and facing the aircraft into the wind.

14.3.7 Engine Shutdown. Shut down the engine as soon as practical after landing, to reduce the intake of sand/dust. Consideration should be given to performing a no rotor brake shutdown to reduce wear on dynamic components.

14.3.8 Postflight Inspection. Install all protective covers and shields. When operating in high ambient temperatures leave the windows, doors, and hatches open to ventilate the helicopter, except when sand/dust is blowing or is forecast to blow.

14.4 TURBULENCE AND THUNDERSTORMS

14.4.1 Turbulent Air Operation. Avoid flying under conditions of severe turbulence. When operating in turbulent air, use pilot discomfort as a guide to determine the extent of roughness that is acceptable. Decreasing airspeed and/or increasing N_r during cruise conditions will improve handling characteristics and decrease the possibility of blade stall. Make descents with a low rate-of-descent and a comfortable airspeed. Refer to MOUNTAIN AND ROUGH TERRAIN FLYING in this chapter.

14.4.2 Thunderstorms. Avoid flights through or near thunderstorms. If thunderstorms are encountered during flight, close the EAPS doors to prevent engine damage and land as soon as practical. Violent turbulence and restricted visibility may be encountered in thunderstorms. When lightning is encountered at night, turn the cockpit white light and instrument lights to full intensity, to prevent temporary blindness. Lightning striking the main or tail rotor can damage the blades so severely that the fatigue life could be reduced to a few minutes.

14.4.3 Lightning Strike. Lightning strike can occur while flying in the vicinity of thunderstorms. Damage to main and tail rotor blades in the form of arcing, erosion and heat annealing will result. Engineering analysis of blades subjected to an actual in-flight lightning strike concluded that the damage to the blades can be so severe that the fatigue life would be reduced to a few hours or even minutes. If a lightning strike is suspected, the helicopter should be landed and inspected. In past cases, major hidden damage was inflicted and was associated with minor appearing visible/external damage to the spot. However, no hidden damage was found without visible/external indications of some kind.

14.5 MOUNTAIN AND ROUGH TERRAIN FLYING

Many helicopter missions require flight and landings in rough and mountainous terrain. Refined flying techniques, along with complete and precise knowledge of the individual problems to be encountered, are required. Landing site condition, wind direction and velocity, gross weight limitations, and effects of obstacles are but a few of the considerations for each landing or takeoff. In a great many cases, meteorology facilities and information are not available at the site of intended operation. The effects of mountains and vegetation can greatly vary wind conditions and temperatures. For this reason, each landing site must be evaluated at the time of intended operation. Altitude and temperature are major factors in determining helicopter power performance. Gross weight limitations under specific conditions can be computed from the performance data in Part XI. A major factor improving helicopter lifting performance is wind. Weight carrying capability increases rapidly when increases in wind velocity are related to the rotor system. However, accurate wind information is more difficult to obtain and more variable than other planning data. It is therefore not advisable to include wind in advanced planning data, except to note that any wind encountered in the operating area may improve helicopter performance. In a few cases, operational necessity will require landing on a prepared surface at an altitude above the hovering capability of the helicopter. In these cases, a roll-on landing and takeoff will be necessary for the mission. Data for these conditions can be computed from the charts in Part XI.

14.5.1 Wind Direction and Velocity. There are several methods of determining the wind direction and velocity in rough areas, the most reliable being by the use of smoke. However, it must be noted that the hand-held day night distress signal and the standard ordnance issue smoke hand grenade, while satisfactory for wind indication, constitute a fire hazard when used in areas covered with combustible vegetation. Observation of foliage will indicate to some degree the direction of the wind, but is of limited value in estimating wind velocity. Helicopter drift, determined by eyesight without the use of navigational aids is the first method generally used by experienced pilots. The accuracy with which wind direction may be determined through the drift method becomes a function of wind velocity. The greater the wind value, the more closely the direction may be defined.

14.5.2 Landing Wind Line Estimate. When over the landing zone (Figure 14-2), start a 360° standard rate turn to the right or left. After completing the turn, the helicopter will be on the wind line downwind from the landing zone. Execute a turn into the wind that will provide adequate distance for a normal approach.

14.5.3 Landing Site Evaluation. Five major considerations in evaluating the landing area are: (1) height of obstacles which determine approach angle, (2) size

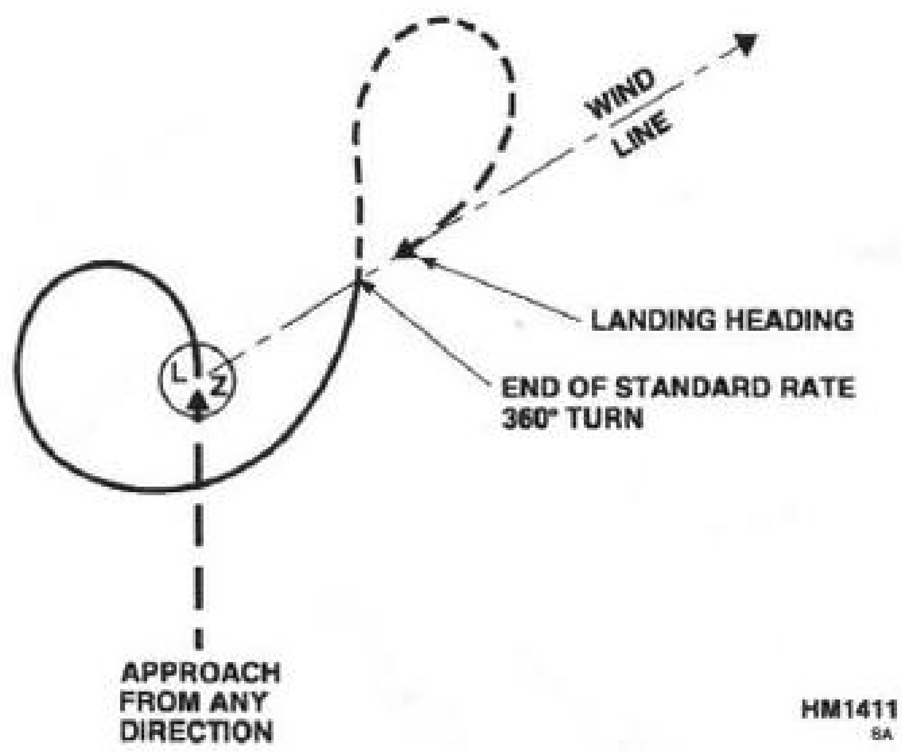


Figure 14-2. Landing Wind Line Estimate

and topography of the landing zone, (3) possible loss of wind effect, (4) power available, and (5) departure route. The transition period is the most difficult part of any approach. As helicopter performance decreases, the transition period becomes more critical, and of necessity approaches must be shallower, and transition more gradual. Therefore, as the height of the obstacle increases, larger areas will be required. As wind velocity increases, so does helicopter performance. However, when the helicopter drops below an obstacle, a loss of wind generally occurs as a result of the airflow being unable to immediately negotiate the change prevalent at the upwind side of the landing zone, where a virtual null area exists. This null area (Figure 14-3) extends toward the downwind side of the clearing and will become larger as the height of the obstacle and wind velocity increases. It is therefore important in the landing phase that this null area be avoided if marginal performance capabilities are anticipated. The null area is of particular concern in making a takeoff from a confined area. Under heavy load or limited power conditions, it is desired to achieve a significant value of forward velocity and translational lift before transitioning to a climb, so that the overall climb performance of the helicopter will be improved. If the takeoff cycle is not begun from the most downwind portion of the area, and the translational velocity is not achieved before arrival in the null area, a significant loss in lift may occur at the most critical portion of the takeoff. Also, in the vicinity of the null area, nearly vertical downdraft of air may be encountered, which will further reduce the actual climb rate of the helicopter. It is feasible that, under certain combinations of limited area, high obstacles upwind, and limited power available, the best takeoff route would be either crosswind or downwind, terrain permitting. The effects of detrimental wind flow and the requirement to climb may thus be minimized or circumvented. Even though this is a departure from the cardinal rule of takeoff into the wind, it may well be the proper solution when all factors are weighed in their true perspective. Never plan an approach to a confined area wherein there is no reasonable route of departure.

CAUTION

Turret FLIR unit clearance should be considered when landing in rough terrain or when landing is sites with obstacles.

The terrain within a site is considered from an evaluation of vegetation, surface characteristics, and slope. Take care to avoid placing the rotors in low brush or branches. Obstacles covered by grass may be located by flattening the grass with rotor wash before landing. Power should be maintained so that an immediate takeoff may be made should the helicopter start tipping from soft earth or a gear dropping into a hole. Cross-slope, upslope, or downslope landing can be made. Landing upslope affords maximum ramp and tail rotor clearance.

Note

Landing downslope affords an easier wave-off, but greatly reduces the ramp and tail rotor clearance to the ground, and should be avoided whenever possible. See Slope Landings in Chapter 7.

14.5.4 Effects of High Altitude. Decreased hover performance, decreased forward airspeed limits, and increased susceptibility to blade stall are associated with high altitude operations. Operating limitations and performance data should be carefully reviewed before operating at high altitudes. Maneuverability is generally decreased and shallower turns at slower airspeeds are required to avoid blade stall than at lower altitudes. Smooth and timely control application and anticipation of power requirements are of prime importance in fully using the performance capabilities of the helicopter at high altitude.

14.5.5 Turbulent Air Flight Techniques. Helicopter pilots must be constantly alert to evaluate and avoid areas of severe turbulence; however, if encountered, immediate steps must be taken to avoid continued flight through it to prevent exceeding the structural limits of the helicopter. An increase in N_r will improve the helicopter's gust response, providing a smoother ride and de-

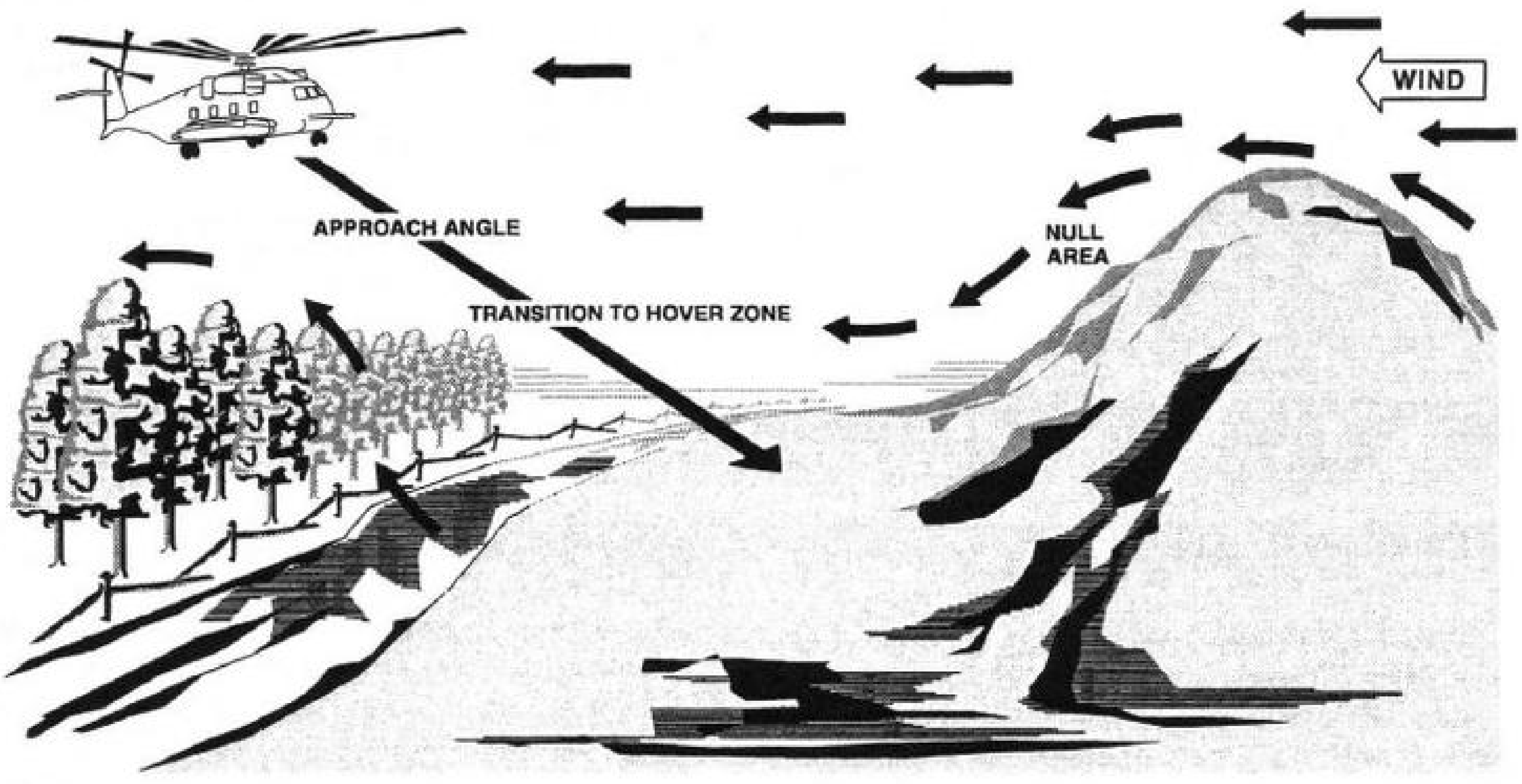
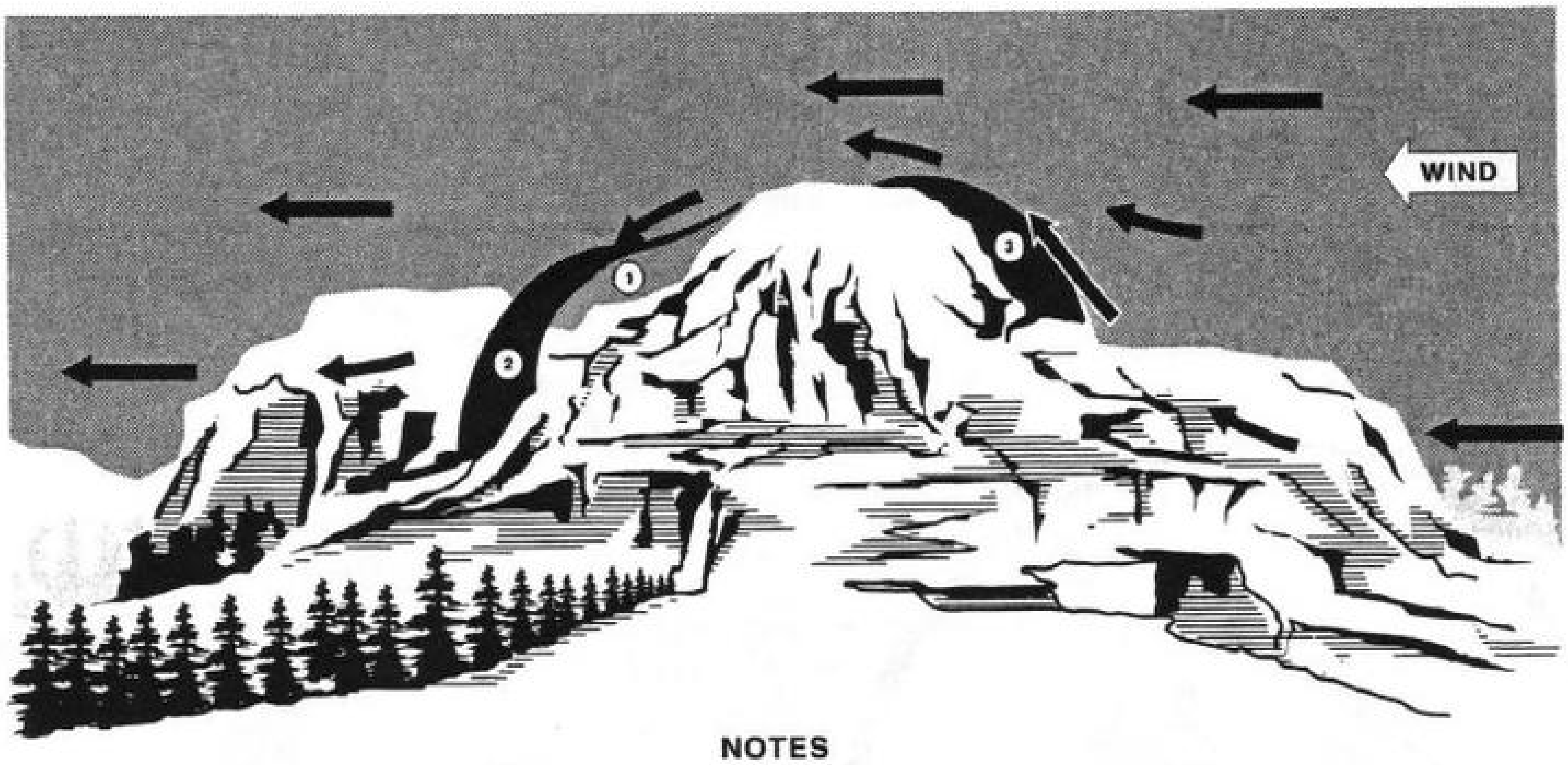


Figure 14-3. Wind Effect in a Confined Area

crease susceptibility to blade stall. Severe turbulence is often found in thunderstorms, and helicopter operations should not be conducted in their vicinity. The most frequently encountered type of turbulence is orographic turbulence. It can be dangerous, if severe, and is normally associated with updrafts and downdrafts. It is created by moving air being lifted by natural or man-made obstructions. It is most prevalent in mountainous regions and is always present in mountains if there is a surface wind.

Orographic turbulence is directly proportional to the wind velocity. It is found on the upwind side of slopes and ridges near the tops and extending down the downwind slope (Figure 14-4). It will always be found on the tops of ridges associated with updrafts on the upwind side and downdrafts on the downwind side. Its extent on the downwind slope depends on the strength of the wind and the steepness of the slope. If the wind is fairly strong (15 to 20 knots) and the slope is steep, the wind will have a tendency to blow off the slope and not follow it down. However, there will still be some tendency to follow the slope. In this situation there will probably be severe turbulence several hundred yards downwind of the ridge at a level just below the top. Under certain atmospheric conditions a cloud may be observed at this point. On more gentle slopes the turbulence will follow down the slope but will be more severe near the top. Orographic turbulence will be affected by other factors. The intensity will not be as great when climbing a smooth surface as when climbing a rough surface. It will not follow sharp contours as readily as gentle contours.

Man-made obstructions and vegetation will also cause turbulence. Extreme care should be taken when hovering near buildings, hangers, and similar obstructions. The best method to overfly ridgelines from any direction is to acquire sufficient altitude before crossing, to avoid leeward downdrafts. If landing on ridgelines (Figure 14-5), the approach should be made along the ridge in the updraft, or select an approach angle into the wind that is above the leeward turbulence. When the wind blows across a narrow canyon or gorge (Figure 14-6), it will often veer down into the canyon. Turbulence will be found near the middle and downwind side of the canyon or gorge. When a helicopter is being operated at or near its service ceiling and a downdraft of more than 100 feet-per-minute is encountered, the helicopter will descend. Although the downdraft does not continue to the ground, a rate-of-descent may be established of such magnitude that the helicopter will continue descending and crash even though it is no longer affected by the downdraft. Therefore, the procedure for transiting a mountain pass



NOTES

1. NULL AREA USUALLY FOUND ON LEEWARD SIDE AT CREST OF SLOPE.
2. IN VERY STRONG WIND CONDITIONS, AND / OR ON VERY STEEP SLOPES, TURBULENCE WILL BE FOUND ON THE LEEWARD SIDE OF THE SLOPE IN CLEAR AIR.
3. UP-DRAFTS WILL EXTEND ABOVE THE SURFACE FURTHER THAN THE TURBULENCE, DEPENDING ON WIND SPEED.

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Figure 14-4. Wind Flow Over and Around Peaks

shall be to fly close aboard that side of the pass or canyon which affords an upslope wind. This procedure not only provides additional lift, but also a means of exit in case of emergency. Maximum turning space is available and a turn into the wind is also a turn to lower terrain. The often used procedure of flying through the middle of a pass to avoid mountains invites disaster. This is frequently the area of greatest turbulence (Figure 14-7), and in case of emergency the pilot has little or no opportunity to turn back due to insufficient turning space. Rising air currents created by surface heating cause convective turbulence. This is most prevalent over bare areas. Convective turbulence is normally found at a relatively low height above the terrain, generally below 2000 feet. It may, however, under certain conditions and in certain areas, reach as high as 8000 feet above the terrain. Attempting to fly over convective turbulence should be carefully considered, depending on the mission assigned. The best method is to fly at the lowest altitude consistent with safety. Attempt to keep your flight path over areas covered with vegetation. Turbulence can be anticipated when transitioning from bare areas covered by vegetation or snow. Convective turbulence seldom gets severe enough to cause structural damage.

Note

> A rotor speed above 100% N_r is recommended during flight through turbulence to reduce the susceptibility to blade stall.

14.5.6 Adverse Weather Conditions. When flying in and around mountainous terrain under adverse weather conditions, it should be remembered that the possibility of inadvertent entry into clouds is everpresent. Air currents are unpredictable and may cause cloud formations to shift rapidly. Since depth perception with relation to distance from cloud formations and cloud movement is poor, low hanging clouds and scud should be given a wide berth at all times. In addition to being briefed, the pilot should carefully study the route to be flown. A careful check on the helicopter compass should be maintained in order to fly a true heading if the occasion demands.

14.5.7 Summary. The following guide lines are considered to be most important for mountain and rough terrain flying:

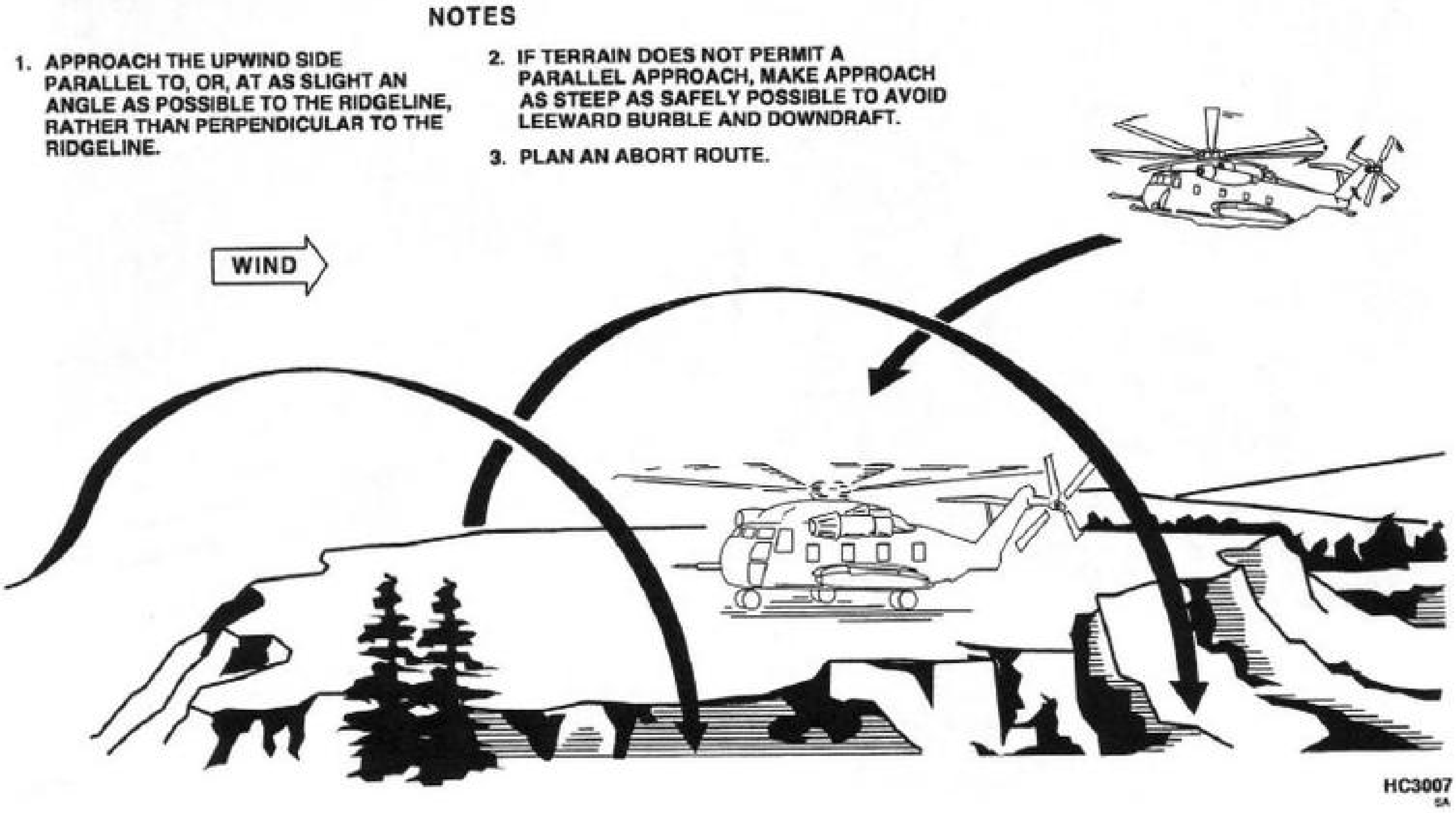


Figure 14-5. Wind Effect on Ridgeline Approach

1. Make a continuous check of wind direction and estimated velocity.

2. Plan your approach so that an abort can be made downhill and/or into the wind without climbing.

3. If wind is relatively calm, try to select a hill or knoll for landing, to take full advantage of any possible wind effect.

4. When evaluating a landing site in noncombat operations, execute as many fly-bys as necessary with at least one high and one low pass, before conducting operations into a strange landing area.

5. Evaluate the obstacles in the landing site and consider possible null areas and routes of departure.

6. Do not base landing site selection solely on convenience. Give consideration to all relevant factors.

7. Determine ability to hover out of ground effect before attempting a landing.

8. It is recommended that BAR ALT and RDR ALT be disengaged when flying in turbulence.

9. Avoid flight in or near thunderstorms.

10. Give all cloud formations a wide berth.

11. Fly as smoothly as possible and avoid steep turns.

12. Cross mountain peaks and ridges high enough to stay out of downdrafts on the leeward of the crest.

13. Avoid downdrafts prevalent on leeward slopes.

14. Plan your flight to take advantage of the updrafts on the windward slopes.

15. Whenever possible, make approaches to ridges along the ridge, rather than perpendicular to it.

16. Avoid high rates-of-decent when approaching landing sites.

17. Know your route and brief well for flying in these areas.

18. When operating below ridgelines, be alerted for power and telephone lines.

Figure 14-6. Wind Flow Over Gorge or Canyon

14.6 EXTENDED OVERWATER FLIGHT

Overwater flights may require extended time and distance away from land. Proper mission planning is essential to the safe and successful conduct of extended overwater flight. The following planning items should be used to determine the limiting criteria for extended range flights.

14.6.1 Equal Time Point (ETP). The ETP is located at a point along the route that is equidistant, in time, from the departure point to the destination.

ETP (in miles) = GSr Total Distance/(GSr + GSc)

Total Distance = the total distance from takeoff to destination.

GSr = Ground speed to return, based on TAS and wind average from takeoff point to midpoint of flight.

GSc = Ground speed to continue, based on TAS and wind average from midpoint of flight to continue on to destination.

14.6.2 Point of Safe Return (PSR). The PSR is the farthest point along the route to which the aircraft can fly and still return safely to the point of departure.

PSR (in time) = GSr Time/(GSo + GSr)

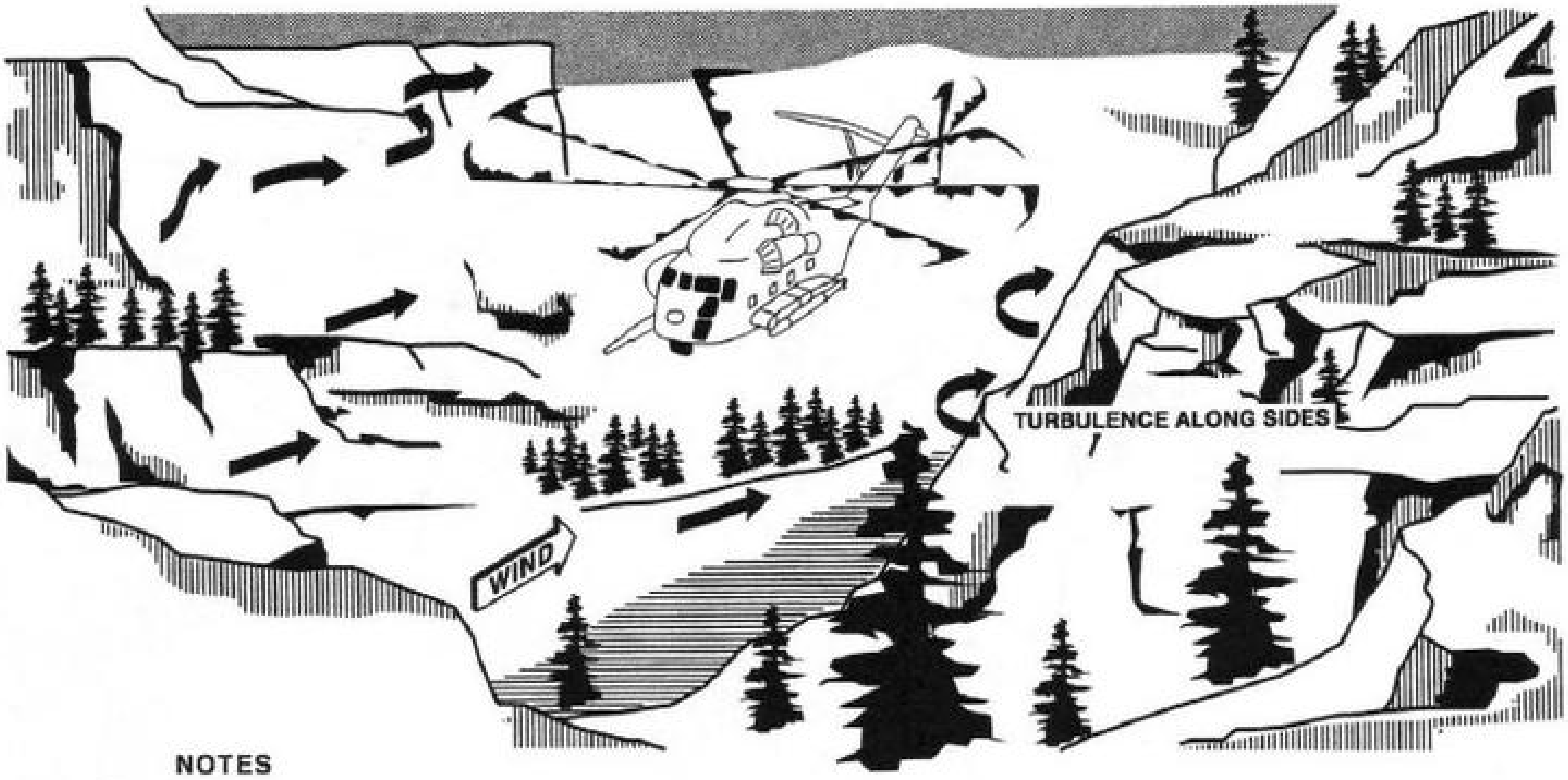
PSR (in distance) = PSR (in time) × GSo

GSr = Ground speed to return, based on TAS and wind average from point of return to the takeoff point.

GSo = Ground speed out, based on TAS and wind average from takeoff point to point of return.

Time = Flight time of usable fuel (in hours) less required reserves.

14.6.3 Average Unit Range. Average maximum range TAS × usable fuel, less reserve in lbs.



NOTES

1. INCREASED WIND VELOCITIES MAY BE FOUND IN THIS AREA DUE TO VENTURI EFFECT.
2. EXCESSIVE TURBULENCE NEAR BOTTOM.

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Figure 14-7. Wind Flow in Valley or Canyon

PART VII

AVIONICS

CHAPTER 15
Communication Systems

15.1 COMMUNICATION EQUIPMENT

Radio communication equipment (Figure 15-1) is operated through individual control panels on the center console and overhead control panels (FO-1, FO-3, and FO-8). Interphone and radio integration is made with the intercommunication system (ICS) control panels at the crewmember stations. The emergency dc bus circuit breaker panel in the cockpit furnishes power to the ICS through two circuit breakers under the general heading ICS. The circuit breaker marked LHS furnishes power to the copilot, left gunner, aft left cabin, and external pylon stations. The circuit breaker marked RHS furnishes power to the pilot, jump seat, aircrewman, aft right cabin, and external stations. The external nose station is beneath the pilot's window, and the external pylon station is on the right side of the main rotor pylon near the work platform. Spring-loaded three-position microphone trigger switches, marked ICS and RADIO, on the pilot's and copilot's cyclic grips, connect their respective microphones to the interphone transmission circuit when held at ICS, and to the radio transmission circuit when held at RADIO. The jump seat station has a telephone-type handset; a special cable may be connected to allow use of a protective helmet with headset/microphone. The aircrewman microphone circuit is connected to the interphone transmission circuit by pressing a button on the key cord. An additional transmission switch is on the utility hoist grip and is used in conjunction with the aircrewman's ICS. The AN/AIC-14 ICS (FO-8 and FO-10) is controlled through ICS master and ICS radio control panels at the pilots',

TYPE	DESCRIPTION	FUNCTION	PRIMARY OPERATOR	APPROXIMATE RANGE	CONTROL LOCATION
ICS	AN/AIC-14	Interphone and radio integration	All		Cabin and cockpit
HF/COMM	AN/ARC-94	Communication	Pilots	Depends on conditions	Cockpit
HF/COMM	AN/ARC-174	Communication	Pilots	Depends on conditions	Cockpit
VHF-FM/COMM	AN/ARC-114A	Communication	Pilots	* LOS	Cockpit
FM/VHF/UHF COMM	AN/ARC-182	Communication	Pilots	* LOS	Cockpit
AM/FM/VHF/UHF COMM (AFC 455)	AN/ARC-210(V)	Communication	Pilots	* LOS	Cockpit
Speech Security	KY-28 (VHF-FM)	Communication	Pilots	LOS	Cockpit
Speech Security	KY-28 (UHF)	Communications	Pilots	LOS	Cockpit
Speech Security	KY-58 (VHF-UHF AM/FM)	Communications	Pilots	LOS	Cockpit
UHF-AM/COMM	AN/ARC-159	Communication	Pilots	LOS 55 miles	Cockpit
IFF/Transponder	AN/APX-72	Identification	Pilots	LOS	Cockpit

Figure 15-1. Communication Equipment

jump seat, aircrewman's, aft right, aft left, and gunner's stations. External ICS control panels are on the right side of the nose and the right side of the main rotor pylon for ground personnel.

15.1.1 ICS Master Control Panels. The pilot, copilot, jump seat, aircrewman, gunner, aft left, and aft right ICS master control panels are marked and operated in the same manner. The ICS master control panels, marked ICS, contain an amplifier selector switch marked AMPL SEL, a microphone selector switch marked MIC SEL, and an interphone volume control knob marked INTPH VOL. The AMPL SEL switch is a four-position rotary-type switch with positions marked EMERG, NORM, ALT 1, and ALT 2. The NORM position is used for normal operation. Failure of the receiver amplifier disables some of the ICS functions. Full operation can be regained by selecting ALT 1, which routes all signals through the interphone amplifier. Failure of the interphone amplifier disables some of the ICS functions. Full operation can be regained by selecting ALT 2, which routes all signals through the receiver amplifier. When the AMPL SEL switch is at EMERG, the ADF circuit is inoperative. However, if both the receiver isolation and interphone amplifiers should fail, placing the AMPL SEL switch to EMERG will connect the applicable ICS station directly to the UHF, HF, and VHF FM radio sets, to permit transmitting and receiving at the cockpit stations, but receiving only at the cabin stations. The microphone selector switch has three positions: COLD, which is used in normal operation and requires the use of the microphone trigger switch; HOT, which gives the operator continuous microphone hands-off operation; and CALL, a spring-loaded override position which is inoperative. The knob marked VOX SENS is right of the AMPL SEL rotary switch, with a marked position OFF and an arrow pointing in a counterclockwise direction. The VOX SENS function operates as follows: The system is energized by turning the knob clockwise out of the OFF detent. The ICS station should be keyed either with the applicable key switch or by placing the MIC SEL switch to HOT. The VOX SENS knob should now be adjusted so that the microphone is energized when the operator talks in a normal tone, and deenergized when the operator stops talking. Turning the knob clockwise decreases the sound level necessary to key the microphone.

15.1.2 ICS Radio Control Panels. The pilot's and copilot's ICS radio control panels marked RAD contain a rotary-type transmitter selector switch marked TRAN SEL, five two-position toggle switches marked UHF, FM, HF, ADF, and VHF (inoperative), and a rotary volume control marked RAD VOL. The TRAN SEL switch, with marked positions U, F, H, and V (inoperative), is used to connect the audio and keying circuits of the ICS to the selected radio transmitter. The five two-position toggle switches are used to select the desired receiver operation. The jump seat station's radio control panel marked ICS RAD is marked and operated in the same manner as the pilot's and copilot's, with the exception of the rotary-type transmitter selector switch marked ICS TRAN. The ICS TRAN switch has marked positions I (for ICS key), F, and H. The crew chief, aft right, aft left, and gunner radio control panels contain five two-position toggle switches marked UHF, HF, VHF FM, ADF, and VHF AM (inoperative) that provide only receiver operation.

15.1.3 External ICS Stations. The external ICS stations (FO-10 and FO-11) are for ground support personnel. Both station controls are identical and consist of a plug marked MIKE, a plug marked PHONE, and a volume control knob marked INTPH VOL. The nose station is equipped with a telephone-type handset, but a headset-microphone will have to be plugged into the main rotor pylon station.

15.2 HF/COMM SET

15.2.1 AN/ARC-94 HF Radio. The AN/ARC-94 set provides airborne voice communication. It receives on a frequency range of 2.000 to 29.999 MHz and transmits on a frequency range of 2.000 to 24.000 MHz. The set is remotely controlled from a control panel marked HF on the cockpit console (FO-8). The control panel contains a mode selector switch marked OFF, USB, LSB, AM, DATA, and CW, four frequency selector knobs, and an rf gain control knob marked RF SENS. When the mode selector switch is placed in USB, a mechanical filter is selected that allows only upper sideband frequencies to pass through the filter. Placing the switch to LSB selects a mechanical filter that allows only the lower sideband frequencies to pass through the filter. Placing the switch to AM allows the upper sideband, lower sideband, and carrier frequencies to pass. The DATA position of the mode selector switch is inoperative, and there are only provisions for the CW position. The set is tuned by dialing in the desired frequency, keying the transmitter button, and waiting for the one MHz tune tone (present while the antenna coupler is tuning) to disappear. The No. 2B primary ac bus circuit breaker panel in the cabin furnishes power to the set through a circuit breaker marked HF, under the general heading RADIO. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes power to the set through a circuit breaker marked HF, under the general heading RADIO.

To turn the set on, select HF and H on the ICS radio control panel. Select an operating mode and frequency, and adjust the rf gain. Key the transmitter and wait for the tune tone to disappear.

WARNING

During ground operation of the set, be sure that personnel are clear of the antenna. Serious burns may result if the antenna is contacted during ground operation.

CAUTION

To lessen possibility of coil damage, tune set to a frequency of 29.000 MHz before securing equipment, or when not in use on ground.

15.2.2 AN/ARC-174(V) HF Radio. The AN/ARC-174(V) HF radio provides airborne voice communication in the frequency range of 2 to 29.9999 MHz (280,000 channels). The HF radio, as installed in this helicopter, has the capability of transmitting and receiving on upper side band (USB), lower sideband (LSB), and amplitude modulation (AM). The set is remotely controlled from the control panel marked HF on the cockpit console (FO-8). The No. 1 primary dc bus circuit breaker panel provides power through circuit breakers marked HF CPLR under the general heading RADIO.

15.2.3 Control Panel. The control panel marked HF contains a mode control switch marked OFF-USB-LSB-AM-CW-SVU-SVL-RF TEST, four frequency control knobs, a SQL knob, RF TEST lamp, and a frequency readout window. OFF removes power from the set. USB, LSB, and AM select the respective voice modes of radio transmission and reception. CW, SVU, and SVL are not used in this installation. RF test position allows isolation of HF radio fault to an individual unit by selecting an HF frequency and keying the system. The status of the HF TEST lamp will indicate which unit is faulty: light out indicates normal, and light on steady or blinking gives malfunction indications useful to maintenance personnel. The four rotary selector controls change the drum frequency display in the readout window marked MHz to select the usable HF frequencies in the range from 2.0000 to 29.9999 MHz in increments of 100 HZ. The squelch (SQL) control provides a selection of eight squelch threshold-level settings which reduce the background noise level between transmissions.

To operate the HF/COMM set:

1. Select USB, LSB, or AM mode of operation using the mode select switch.

2. Select desired frequency by adjusting the four frequency rotary switches and observing the frequency readout scale.

3. If monitoring only is desired, place the HF switch on the transmitter/receiver selector to R.

WARNING

Do not operate HF transmitter on deck when personnel are within 50 feet of the antennas. A radiation hazard exists.

4. To transmit, position the HF switch on the radio transmitter/receiver selector panel to R/T.

5. Key transmitter to tune selected frequency. A constant tone will be heard during the tune cycle for approximately 3 seconds. Once the tune cycle has been completed, the radio is tuned.

6. Key the transmitter to transmit.

CAUTION

To lessen the probability of coil damage, tune set to frequency 29.9999 MHz before securing equipment or when not in use on the ground.

15.3 VHF-FM/COMM SET (WITHOUT AFC 455)

15.3.1 AN/ARC-114A Radio. The AN/ARC-114A set provides two-way voice communication with a 150 Hz tone included in the transmitted carrier wave. The set contains a tunable multi-channel main transmitter-receiver that operates on any one of 920 channels spaced in .05 MHz units in the 30.00 to 75.95 MHz frequency range. The set also includes a fix tuned guard receiver that permits continuous monitoring of the guard frequency whenever the main transmitter-receiver is tuned to another frequency. The No. 2 primary dc bus circuit breaker panel in the cabin furnishes power to the set through a circuit breaker marked VHF, under the general headings FM and RADIO.

15.3.2 Control Panel. The panel, marked VHF FM COMM, is on the cockpit console (FO-8). The tuning knob on the left tunes the main transmitter-receiver in 10 MHz and 1 MHz steps as indicated by the first two digits of the MEGAHERTZ indicator, and the knob on the right tunes in 0.1 and .05 MHz steps, as indicated by the last two digits. The RCVR TEST pushbutton, when pressed, injects an 800 Hz tone into the main receiver, to give an audible indication of proper receiver performance. The function control determines the operating mode of the set. The OFF position turns power off. The T/R position allows operation of the main transmitter-receiver. The T/R GUARD position allows operation on the main transmitter-receiver and the guard receiver. The HOMING and RETRAN positions do not operate. The SQUELCH knob NOISE position allows the receiver to be sensitive to a predetermined level of incoming radio frequency, and the OFF position turns squelch off. When the received signal on the carrier includes a 150 Hz tone, selecting TONE/X provides a more positive squelch operation and improved weak signal reception. The AUDIO knob adjusts receiver volume. The RETRAN zone of the knob is not applicable for this installation.

To turn the set on, select FM and F on the ICS radio control panel. Select function, frequency, and appropriate squelch.

Note

Plain text communications transmissions are not possible when KY-28 mode switch is at C and associated KY-28 is installed.

15.3.3 Retractable Antenna. On aircraft without AFC 455, the system has a retractable antenna that is controlled by a switch marked ANTENNA, under the general heading FM, with marked positions RETRACT, AUTO, and EXTEND, on the copilot's miscellaneous switch panel. The switch is normally left at AUTO, which permits the antenna to automatically extend when the landing gear is retracted and automatically retract when the landing gear is extended. Placing the switch to EXTEND or RETRACT will cause the antenna to extend or retract, regardless of landing gear position. The No. 2 primary dc bus circuit breaker panel in the cabin furnishes power to the antenna through a circuit breaker marked ANT under the general headings FM and RADIO.

CAUTION

Do not place the switch to EXTEND while on the ground. This may cause damage to the antenna and extending mechanism.

15.4 FM/VHF/UHF COMM SETS (WITHOUT AFC 455)

15.4.1 AN/ARC-182(V) Radio. Two AN/ARC-182(V) sets provide frequency modulated and amplitude modulated spectrum coverage to give communication frequencies for FM, VHF, and UHF between 30.00 MHz and 399.975 MHz. The left and right panels are designated COMM 1 and COMM 2, respectively. Tuneable frequencies are available in .025 MHz increments. FM receiver and transmitter frequencies are in the 30.000 to 87.975 MHz frequency range. VHF receiver only frequencies are available in the 108.000 to 117.975 MHz frequency range. VHF receiver and transmitter frequencies are available in the 118.000 to 155.975 MHz frequency range. UHF tuneable receiver and transmitter frequencies are available in the 225.000 to 399.975 MHz frequency range.

The set includes guard receivers that permit continuous monitoring of guard frequencies whenever the main transmitter-receiver is tuned to another frequency. The guard channels are normally set at 40.5 FM, 121.5 and 156.8 VHF, and 243.0 UHF.

The set also provides automatic direction finding (ADF) in conjunction with the VHF/UHF direction finder. Relative bearing to the radio transmission source will be shown by the No. 1 pointer on the selected pilot BDHI.

The emergency dc bus circuit breaker panel provides power for the COMM 1 system through a circuit breaker marked COMM 1 under the general heading RADIO. The No. 2 primary dc bus circuit breaker panel provides power to the COMM 2 system through a circuit breaker marked COMM 2 under the general heading RADIO.

15.4.2 Control Panel. The panels marked V/UHF are on the cockpit console (FO-8). The VOL switch adjusts the audio output. The squelch toggle switch at OFF disables the receiver squelch, and at SQL enables the receiver's squelch. The UHF toggle switch selects the FM or

AM operating mode when tuned to a frequency in the UHF band. The BRT switch controls brightness of FREQ/(CHAN) lighting intensity. The four frequency selectors set the frequency shown in the readout window marked FREQ/(CHAN). From left to right the four frequency selectors set hundred and tens, units, tenths, and hundredths respectively during manual operation.

The MODE switch has marked positions OFF-T/R-T/R + G-DF-TEST. OFF removes power from the set. T/R enables the main transmitter and receiver. TR + G has the same function as T/R, plus the guard receiver. The guard receiver is tuned to the proper frequency for the selected operating band of the main receiver. DF permits operation of homing indicator when radio is tuned to frequency in low VHF (FM) band. Test is used for maintenance functions.

The CHAN SEL switch has an inner and outer selector. The inner switch permits selection of preset frequencies (channels) when outer selector is set to PRESET. The outer selector is marked 243-MAN-G-PRESET-READ-LOAD. 243 turns main receiver and transmitter to UHF guard (243.0). All panel functions except VOL, SQL, and BRT are disabled. MAN permits manual frequency change using frequency control switches. G tunes receiver-transmitter to guard frequency of the band to which the radio was last tuned. PRESET permits selection of any one of 30 preset operating frequencies. Selected channel number is displayed in the FREQ/(CHAN) window at the units and tenths positions. READ permits display of frequency of preset operating channel instead of channel number. Displayed frequency may be altered by use of frequency control switches, but stored frequency will not change. LOAD loads frequency selected in READ mode into memory to alter preset channel frequency. No change to stored preset frequency unless frequency has been changed while frequency mode selector has been set to READ.

Note

> Flashing or blanking of the FREQ/(CHAN) windows on COMM 1 and COMM 2 control panels may occur during shipboard operations due to shipboard electromagnetic emissions.

To operate the FM/VHF/UHF COMM set:

1. Select T/R, TR + G, or DF mode of operation using the mode select switch.

2. Select desired preset frequency by placing outer channel selector switch to PRESET and adjust the center two frequency rotary switches and observe the frequency readout scale.

3. Select desired manual frequency by placing outer channel selector switch to MAN and adjust the four frequency rotary switches and observe the frequency readout scale.

4. When the COMM 1 transmitter/receiver is to be used, ensure the COMM 1 antenna is extended.

5. When the COMM 2 transmitter is to be used:

   a. UHF only — Select FWD on COMM 2 pushbutton on pilot's miscellaneous switch panel.

   b. FM/VHF/UHF — Select AFT on COMM 2 pushbutton on pilot's miscellaneous switch panel.

6. When monitoring only is desired, place the desired selector (COMM 1 or COMM 2) transmitter/receiver switch to R.

7. To transmit, place the desired selector (COMM 1 or COMM 2) transmitter/receiver switch to R/T. Key the transmitter to transmit.

15.4.3 FM/VHF/UHF Antennas. Three antennas (Figure 15-2) are provided. The lower FM/VHF/UHF antenna is retractable and is used only with the COMM 1 transmitter/receiver. It is controlled by a switch marked COMM 1 ANTENNA, with positions EXTEND-AUTO-RETRACT. The switch is normally left in AUTO, which permits the antenna to automatically extend when the landing gear is retracted and automatically retract when the landing gear is retracted and automatically retract when the landing gear is extended. Placing the switch to EXTEND or RETRACT will cause the antenna to automatically extend or retract, regardless of landing gear position. With AFC 455, all three antennas are removed and are replaced by two tunable blade antennas. The COMM 1, COMM 2 antennas are located in place of the old antennas.

CAUTION

> Do not place the switch to EXTEND while on the ground. This may cause damage to the antenna and extending mechanism.

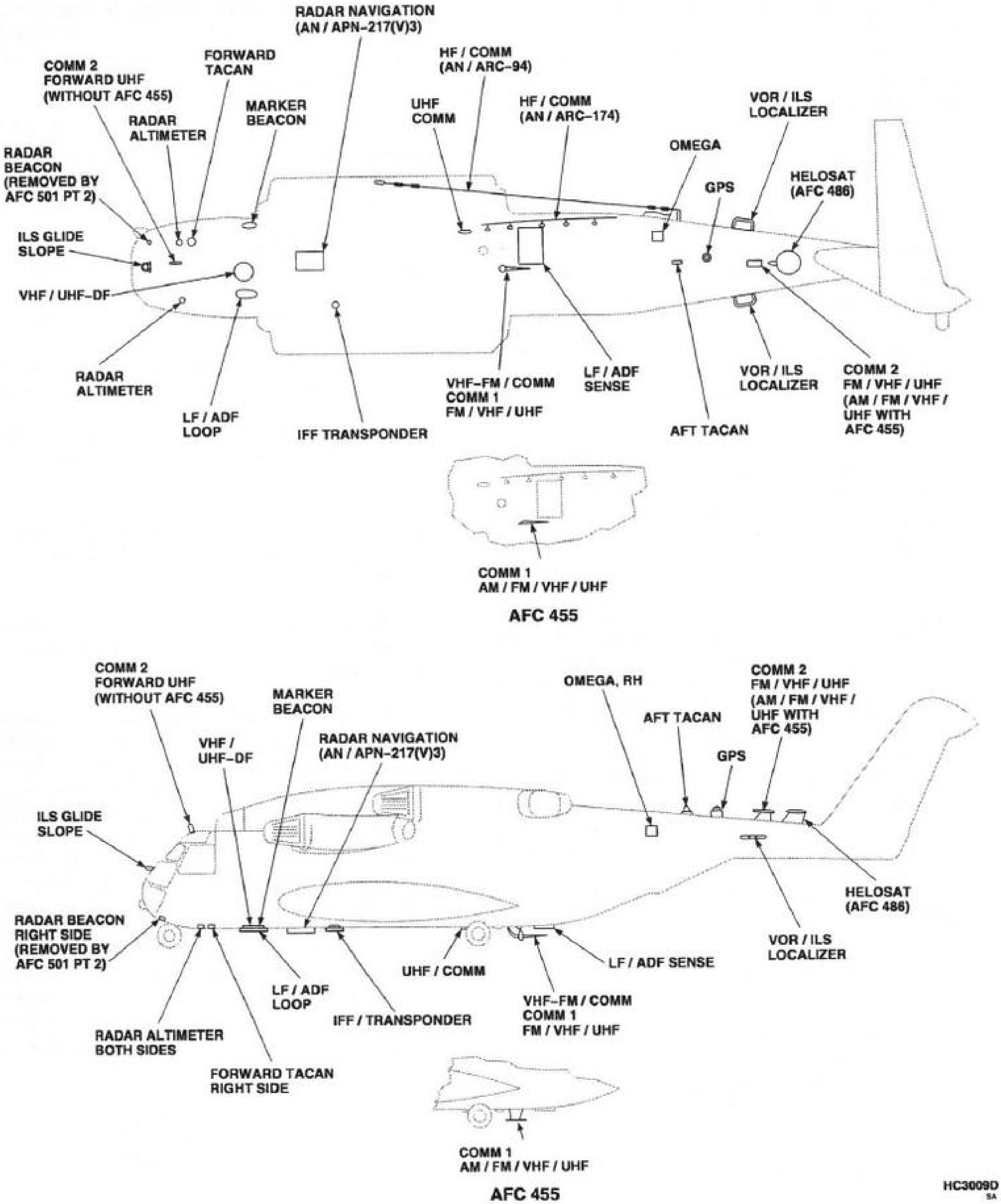


Figure 15-2. Antennas

The No. 2 primary dc bus circuit breaker furnishes power to the retractable antenna through a circuit breaker marked COMM 1 ANT under the general heading RADIO.

The upper forward UHF and upper aft FM/VHF/UHF antennas are used only with the COMM 2 transmitter/receiver. The UHF ANT selector switch on the pilot's miscellaneous switch panel, when pressed, will light to indicate which antenna has been selected (FWD or AFT). The forward (FWD) antenna is for UHF use only, and the aft (AFT) antenna is for FM/VHF/UHF use.

Note

COMM 1 and COMM 2 radios have identical functions. However, the COMM 1 antenna is more appropriate for FM use due to reduced range and antenna placement beneath the helicopter. The forward COMM 2 antenna is for UHF use only. The aft COMM 2 antenna is more appropriate for VHF use.

15.4.4 VHF/UHF Direction Finder. The purpose of the OA-8697/ARD direction finder is to receive signals in the VHF/UHF ranges of 100 to 400 MHz and provide relative bearing information with the BDHIs No. 1 pointers. Selecting DF with COMM 1 or COMM 2 mode switch activates the VHF/UHF direction finder.

Note

- If both pilots select ADF on their respective mode select panels and COMM 1 and COMM 2 both have DF selected, but different frequencies selected the COMM 2 direction finder takes priority. There is only one VHF/UHF-DF antenna.

- UHF/DF bearing information on the No. 1 needle of the BDHI using COMM 1 or COMM 2 may be unreliable while transmitting on the other ARC-182 radio.

A 100 Hz tone will be heard when a VHF/UHF signal is being received which will decrease in volume when the signal is acquired and the BDHIs No. 1 needle points toward the selected signal source. If the LF/ADF is on and homing on a station and the VHF/UHF-DF is activated, the VHF/UHF-DF will have priority, and BDHIs No. 1 needle will point to the VHF/UHF-DF signal source.

The No. 3 primary ac bus furnishes power through a circuit breaker marked UHF/DF under the general heading 26V RADIO.

To operate the VHF/UHF-DF:

1. Select desired manual or preset frequency in the appropriate COMM selector window. (Frequency range of 100 to 400 MHz only).

2. Select DF on the appropriate COMM mode switch.

3. Reference appropriate COMM BDHI No. 1 pointer for DF homing.

Note

Reduced reception and bearing accuracy may be experienced any time the station is not on the nose of the helicopter.

15.5 SPEECH SECURITY SYSTEMS

15.5.1 KY-28. The KY-28 systems are controlled by panels on the pilot's overhead control panel (FO-1). The copilot's panel is associated with the VHF-FM/COMM set, and the pilot's panel operates in conjunction with the UHF-AM/COMM set. The KY-28 installation and associated equipment comprise a speech security system; operating procedures and related support should be received from the facility security office. The control panels are marked KY-28, and each has three switches. When the function switch is placed from OFF to ON, power is applied to the system. A third position marked RLY is inoperative. The mode switch is used to select plain (P) or cipher (C) speech operation. When the switch is placed to P, normal operation of the appropriate radio is available, and only uncoded reception and transmission is possible. When the switch is at C, secure speech is available through the appropriate radio. If it becomes necessary to zero out (erase) the codes set into the system, place the zeroize switch to ZEROIZE. Nullify codes (zeroize) only when security compromise is imminent.

Note

- After codes are nullified, secure transmission cannot be made until system codes are reset.

- VHF-FM and UHF-AM/COMM sets are unusable for plain text communication when their associated KY-28 set's mode switch is at C, regardless of position of function switch.

- Transmission of classified or secure information is prohibited in plain (P) unsecured mode of operation.
- KY-28 mode switch should be left at plain (P) position when coder is not installed, or function switch is OFF.

The No. 2 primary dc bus circuit breaker panel in the cabin furnishes power to the KY-28 (UHF) through a circuit breaker marked UHF JULIET under the general heading RADIO. The emergency dc bus circuit breaker panel in the cockpit furnishes power to the KY-28 (VHF) through a circuit breaker marked FM JULIET under the general heading RADIO.

Operate as follows:

1. Function switch — ON.
2. Mode Switch — P.
3. Make test transmission to establish contact.
4. Mode Switch — C.
5. Key appropriate radio.
6. Listen for steady tone, then an alternating two-tone signal in headset, before releasing microphone key switch.

Note

- Step 5 necessary only on initial operation, after function switch is placed ON.
- Prolonged steady tone indicates a malfunction.
- If alternating two-tone signal does not stop, depress and hold microphone button to transmit position, then release. If trouble continues, switch to P mode, as C mode is inoperative.

7. System is now ready for use. Key appropriate transmitter, wait for a beep tone, and commence voice transmission.
8. Subsequent transmission requires that beep tone in step 7 be heard before speaking over appropriate radio.

Note

- Do not turn KY-28 off with mode switch in cipher position.
- Speech security system is unusable when receiving or transmitting in ADF position of UHF-AM/COMM set.

15.5.2 KY-58. The KY-58 system is controlled by a panel on the pilot's center console (FO-8). On aircraft without AFC 455, the panel is associated with the AM/FM/VHF/UHF COMM set (COMM 1 and COMM 2). The KY-58 installation and associated equipment comprise a speech security system. Operating procedures and related support should be received from the facility security office. Mounting provisions are provided for two T SEC/KY-58 main units in the cabin beneath the precise navigation operator's radio selector control panels. Controls on the main unit are selected by maintenance personnel at the time of installation. Secure speech capability is available with the COMM 1 and COMM 2 FM/VHF/UHF COMM sets. The emergency dc bus circuit breaker panel furnishes power to the KY-58 through a circuit breaker marked COMM JULIET under the general heading RADIO.

With AFC 455, the AN/ARC-210(V) COMM set is AM/FM/VHF/UHF capable. The COMM set utilizes HAVE QUICK and SINCGARS anti-jamming to enhance the secure speech capabilities. There are two TSEC/KY-58's located in the cabin equipment rack. The No. 2 primary dc bus circuit breaker provides electrical power to COMM 1 and COMM 2 KY-58 (aircraft serial No. 161179 through 162501). The emergency dc bus circuit breaker provides electrical power to COMM 1 and COMM 2 KY-58 (aircraft serial No. 16502 and subsequent).

Note

Transmission of classified or secure information is prohibited in uncoded mode of operation.

When the T SEC/KY-58 (main unit) is not installed, its attaching harness connectors should be connected to the jumper harness permanently installed near the mounting frame.

15.5.2.1 Control Panel. The KY-58 control panel is marked KY/RLY. Functions indicated as 1 and 2 apply to COMM 1 and COMM 2 radios respectively. A guarded toggle switch marked ZEROIZE is used to erase code in the secure voice T SEC/KY-58 unit in the cabin. Under KY 1 and KY 2 the DELAY toggle switches marked IN-OUT, when placed to IN, initiate a delay in the secure voice unit to allow the system to act as a retransmit (relay) station. OUT removes the relay capability. The MODE toggle switches provide secure voice on FM band frequencies at the BB position and AM band frequencies at the DP position. The operational mode selector switch has positions OFF-PLAIN RELAY-CRYPTO RELAY-CRYPTO 1-CRYPTO 2-CRYPTO 1 + 2. OFF allows COMM 1 and COMM 2 radios to operate normally in plain text voice. PLAIN RELAY allows two radios to operate in relay mode with plain text. The intercom system has take-command authority over either radio. CRYPTO RELAY performs the same functions as PLAIN RELAY, but in encrypted text. At CRYPTO 1 two radios operate independently: COMM 1 in cipher and COMM 2 in plain text. At CRYPTO 2 two radios operate independently: COMM 1 in plain text and COMM 2 in cipher. At CRYPTO 1 + 2, if two T SEC/KY-58 units are in the system, both radios operate independently in cipher text.

To operate the KY-58:

1. Place KY DELAY for desired COMM 1 or COMM 2 system to OUT for normal procedures or to DELAY for relay procedures (cipher or plain).

2. Place KY MODE for desired COMM 1 or COMM 2 system to BB for FM frequencies or DP for AM frequencies.

3. Place CRYPTO at 1 for COMM 1 in crypto, 2 for COMM 2 in crypto, or 1 + 2 for COMM 1 and COMM 2 in crypto. Place CRYPTO at PLAIN RELAY for plain use or RELAY for relay.

4. Transmit/receive using normal VHF/UHF radio procedures.

15.6 UHF-AM/COMM SET (WITHOUT AFC 455)

15.6.1 AN/ARC-159(V)1 Radio. An AN/ARC-159(V)1 set is installed that provides two-way voice communication. This is done on any one of 20 preset frequencies, or by manual selection of any one of 7000 frequencies, spaced .025 MHz apart within the set's frequency range of 225.000 to 399.975 MHz. The set includes a guard receiver that permits continuous monitoring of the guard frequency whenever the main transmitter-receiver is tuned to another frequency. The set also provides automatic direction finding (ADF) in conjunction with the UHF-DF group. Relative bearing to the radio transmission source will be shown by the No. 1 pointer on the BDHI's. The emergency dc bus circuit breaker panel in the cockpit furnishes power through a circuit breaker marked UHF RADIO under the general heading RADIO.

15.6.2 Control Panel. The panel, marked UHF, is on the cockpit console (FO-8).

The function selector control permits selection of the set's operational mode. OFF turns the set's power off. MAIN puts the set in a transceiver mode of operation. BOTH puts the set in a transceiver mode of operation and turns on the guard receiver. ADF engages the UHF-DF group to provide automatic direction finding and puts both the main and guard receivers in operation.

The mode selector switch determines frequency selection and indicates frequency or channel selection. GUARD shifts the transceiver to the guard channel frequency and displays the frequency on the readout indicator. In this position, neither preset nor manual frequency selections will work. MANUAL permits manual selection of any one of 7000 frequency channels by use of the manual frequency selectors. The frequency selected is displayed on the readout indicator. In this position, the PRESET channel selector control will not work. PRESET permits selecting one of 20 preset channels with the PRESET channel control. The channel selected will be displayed on the readout indicator in the third and/or fourth-digit positions. In this position the manual selectors will not work. READ permits the operator to read the frequency of the selected preset channel. In this position the preset frequency is displayed on the readout indicator. The PRESET knob selects any one of 20 preset frequency channels when the mode selector is at PRESET.

The first manual frequency selector knob selects and indicates on the readout indicator the 100 MHz and 10 MHz frequency steps during manual operation. The second knob selects and indicates steps of 1 MHz, the third knob selects and indicates steps of 0.1 MHz. The fourth knob selects and indicates steps of 0.000 MHz, 0.025 MHz, 0.050 MHz, and 0.075 MHz (steps of 00 kHz, 25 kHz, 50 kHz, and 75 kHz).

The VOL knob adjusts receiver volume. Pressing the TONE pushbutton causes the transceiver to transmit a 1020 Hz tone signal. The squelch toggle switch at OFF disables the main receiver squelch, and at SQ the main receiver's squelch is not affected. The DIM knob adjusts the light intensity of the readout lamps. Pressing the LAMP TEST pushbutton tests the readouts.

Two antennas (Figure 15-2) are provided. Either one can be selected for improved communications. The UHF ANT selector switch on the pilot's miscellaneous switch panel, when pressed, will indicate which antenna has been selected: FWD (top) or AFT (bottom).

To turn the set on, select UHF and U on the ICS radio control panel. Select function, mode, frequency, and antenna.

Note

> Plain text communications transmissions are not possible when KY-28 mode switch is at C and associated KY-28 is installed.

15.7 IFF/TRANSPONDER SYSTEM

The AN/APX-72 system provides automatic radar identification and altitude information of the helicopter to all suitably equipped challenging facilities. Mode 1, 2, 3/A, C, or 4 interrogation signals are received by the system and decoded. The received signals are checked for valid code and proper mode, and if the proper interrogating signal has been received, a coded reply is sent. In addition to these normal identification and altitude reply signals, specially coded identification of position (I/P) and emergency signals may be sent in response to interrogating signals. The I/P reply signal is used to distinguish between aircraft displaying identical coding, and the emergency reply signal indicates an emergency or distress condition of the helicopter in flight. Normal identification operation, as well as transmission of the I/P or emergency signals, is done in operating modes 1, 2, and 3/A. Altitude interrogations and replies are done in mode C operation. The code for mode C is determined by the pressure altitude of the helicopter and is encoded in 100-foot units. Mode 4 operation gives a secure (encrypted) IFF capability through the use of a transponder computer. The code for mode 4 must be set into the computer before flight. The IFF/transponder system includes a test set that provides for the go/no go self-testing of the system in modes 1, 2, 3/A, and C. System self testing for mode 4 operation is performed automatically by the transponder computer. The system consists of a receiver-transmitter, transponder control, transponder test set, antenna, altimeter encoder, and a transponder computer. The encoder is discussed under Barometric Altimeter/Encoder in Chapter 2.

The transponder computer, when installed, processes mode 4 interrogations and generates appropriate reply signals. These reply signals are then sent to the transponder for transmission. A caution light marked IFF on the instrument panel will go on and an audio signal be heard in the pilots' headsets when the IFF caution light circuit detects an inoperative mode 4 capability. Specific discrepancies monitored by the IFF caution light are mode 4 codes zeroized, transponder failure to reply to a proper mode 4 interrogation, or the automatic self-test function of the transponder computer revealing a faulty transponder computer.

The No. 2B primary ac bus circuit breaker panel in the cabin furnishes operating power through a circuit breaker marked IFF under the general heading RADIO. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes control and test power through circuit breakers marked PWR and TEST under the general headings IFF and RADIO.

15.7.1 IFF/Transponder Control Panel.

The control panel is on the cockpit console (FO-8).

The IDENT/OUT/MIC switch controls identification of position (I/P) operation. When momentarily placed to IDENT (spring-loaded return to OUT), transmission of specially coded I/P reply signals to mode 1, 2, and/or 3/A interrogations is possible. When the switch is placed to MIC, I/P reply signals are possible when the UHF-AM/COMM set is keyed. Either method allows the sending of I/P reply signals for about 20 seconds. The OUT position prevents triggering I/P signals.

The MASTER switch removes power from the transponder at OFF. At STBY, the receiver-transmitter is energized and kept in the standby condition. The LOW position permits transponder operation with reduced receiver sensitivity. The NORM position permits transponder operation at normal receiver sensitivity. At EMER, the transponder operates at normal receiver sensitivity and responds to mode 1, 2, 3/A, and C interrogations, regardless of the position of the mode control switches.

The mode control switches marked M-1, M-2, M/3A, and M-C each have marked positions ON, OUT, and TEST. The TEST (up) position allows the transponder test set to locally interrogate the receiver in that mode. The TEST light will go on to show that the system is working properly. Placing a mode control switch to OUT will deenergize that mode, providing the MASTER control selector is not at EMER. With the mode control switches in the ON (center) position, each switch will operate as follows:

1. The M-1 switch controls mode 1 transponder operation and allows a code from 00 to 73 to be selected.

2. The M-2 switch controls mode 2 transponder operation.

3. The M-3A switch controls mode 3/A transponder operation and allows a code from 0000 to 7777 to be selected.

4. The M-C switch controls mode C transponder operation for altitude replies.

The TEST LIGHT goes on when the transponder system responds properly to mode 1, 2, 3/A, and C self test signals.

The MODE 1 code selector switches select and indicate the mode 1 two-digit reply code number. Desired codes are selected from 00 through 73.

The MODE 3/A code selector switches select and indicate the mode 3/A four-digit reply code number. Desired codes are selected from 0000 through 7777.

The RAD TEST/OUT/MON switch at RAD TEST permits the transponder to be interrogated by selected mode signals from external test equipment. The MON position turns on test set monitoring circuits. At MON, the TEST light will go on to indicate replies are being sent in mode 1, 2, 3/A, or C. The OUT position disables the RAD TEST and MON functions.

The mode 4 ON/OUT switch controls transponder mode 4 operation. The ON position enables the transponder system to reply to mode 4 interrogations. The OUT position disables mode 4 operation.

The mode 4 REPLY light will go on to indicate valid mode 4 replies when the mode 4 AUDIO/OUT/LIGHT switch is at either AUDIO or LIGHT. The REPLY light will go on when pressed-to-test, providing the AUDIO/OUT/LIGHT switch is not at OUT.

The mode 4 AUDIO/OUT/LIGHT switch selects mode 4 monitoring methods. When placed to AUDIO, aural and REPLY light monitoring of valid mode 4 interrogations and replies are possible. An audio tone in the pilot's headset indicates valid mode 4 interrogations are being received, and lighting of the REPLY light indicates replies are being transmitted. When placed to LIGHT, the REPLY light goes on to indicate valid mode 4 replies. When placed to OUT, aural and REPLY light monitoring of mode 4 interrogations and replies are disabled. The OUT position disables the REPLY light press-to-test function.

The mode 4 CODE switch has marked positions ZERO, B, A, and HOLD. The switch must be lifted over a detent to select ZERO. It is spring-loaded to return from HOLD to the A position. A and B select separate preset mode 4 codes which enable the transponder system to reply to code A or B interrogations, respectively. Both codes are mechanically inserted with a code changing key. The codes are mechanically held in the transponder computer until the first time the helicopter becomes airborne. Thereafter mode 4 codes automatically cancel (zeroize) any time the master switch is turned off or power is removed from the transponder computer. The code setting can be mechanically retained with weight on the wheels by turning the code switch to HOLD (only momentary actuation is required) and releasing it at least 15 seconds before the master switch or helicopter power is turned off. The ZERO position zeroizes the transponder mode 4 codes.

15.7.2 Starting Procedure

1. Place transponder control MODE 1 and 3/A code select switches to the required operational codes.

2. Place receiver-transmitter mode 2 code select switches in the electronics compartment to the required operational code. This is done prior to flight.

3. Place transponder control mode enable switches M-1, M-2, M-3/A, and M-C to ON. (If operational requirements specify that only certain modes are to be used, place all other mode switches to OUT.)

4. Place the transponder control MODE 4 ON-OUT switch to ON and CODE switch to A or B (as required) when equipped with the transponder computer and flying into a known mode 4 interrogating environment.

5. Place transponder RAD TEST-OUT-MON switch to OUT, AUDIO-OUT-LIGHT switch to LIGHT, and IDENTOUT-MIC switch to OUT.

6. Place transponder control MASTER switch to STBY for 1 minute (normal ambient temperature) or 5 minutes (extremely low ambient temperatures). Then place to NORM.

15.7.3 Self-Test Procedure

1. Press to test REPLY and TEST lights. Lights should go on.

2. Press PRESS TO TEST switch on caution panel. IFF light should go on.

Note

If mode 4 codes are zeroized, IFF caution light will be on before and after this test.

3. Place transponder control mode enable switches M-1, M-2, M-3/A, and M-C in sequence to TEST. TEST indicator should go on when each switch is at TEST, indicating a system go condition for particular mode being tested. Reset mode enable switches to ON or OUT as required.

4. Transponder computer automatically self-tests mode 4 circuits. Observe that IFF caution light is off. IFF caution light will go on when a mode 4 no-go condition is detected.

15.7.4 Normal Operating Procedures

Note

If desired to retain mode 4 codes between flights, it is necessary to lock codes into transponder computer before turning MASTER control OFF. Turning the MASTER control to OFF or removing power from helicopter without first locking codes into transponder computer will zeroize mode 4 codes. To lock code, momentarily place CODE control to HOLD after landing, and then do normal locking procedure. When power is next applied, transponder computer will again operate normally. If it is again desired to lock code in transponder computer, repeat HOLD procedure. Transponder computer will zeroize any time power is applied and CODE control is turned to ZERO, even if HOLD function has been activated. Once code is zeroized, code is not available until reset.

15.7.4.1 Mode 4 Monitoring. Place transponder control AUDIO-OUT-LIGHT switch to AUDIO to provide aural and visual (REPLY light) monitoring of valid mode 4 interrogations and replies. Place AUDIO-OUT-LIGHT switch to LIGHT to allow REPLY light monitoring only, if desired.

15.7.4.2 Monitoring Modes 1, 2, 3/A, and C. Place transponder control RAD TEST-OUT-MON switch to MON, for monitoring replies to selected 1, 2, 3/A and/or C operating modes.

15.7.4.3 Identification of Position (I/P) Operation. Receiver-transmitter will transmit specially coded I/P reply signals to mode 1, 2, 3/A interrogations when IDENT-OUT-MIC switch on transponder control is energized. Transmission of I/P reply signals requires appropriate mode enable switches to be at ON. Use one of the following two methods to control transmission of I/P reply signals:

1. Momentarily hold IDENT-OUT-MIC switch at IDENT, and then release it. This action will cause the receiver-transmitter to transmit I/P reply signals for about 20 seconds in response to mode 1, 2, or 3/A interrogations. Repeat as required.

2. Place IDENT-OUT-MIC switch to MIC. I/P reply signals can now be transmitted by momentarily keying UHF command set. When there is no more need for transmitting I/P reply signals, return IDENT-OUT-MIC switch to OUT.

15.7.4.4 Emergency Operating Procedures. During a helicopter emergency or distress condition, the system may be used to send specially coded emergency reply signals to mode 1, 2, or 3/A interrogations. These emergency reply signals will be sent as long as the MASTER switch on the transponder control remains at EMER, regardless of the positions of the mode enable switches.

1. Lift MASTER switch knob and turn to EMER.

2. When emergency is over, return MASTER switch to NORM or LOW.

15.7.4.5 Inoperative Mode 4 Operation. When lit, IFF caution light shows that equipment will not respond to mode 4 interrogations, and that operation in a known mode 4 interrogation environment should be avoided. To attempt correction, place MASTER switch to NORM (if in STBY or LOW), check that mode 4 ON-OUT switch is ON, and that proper A or B code has been selected for current code time period. If IFF caution light remains on, use applicable flight procedures that are operationally directed for an inoperative mode 4 condition.

15.7.4.6 Stopping Procedure

1. Set transponder CODE switch to HOLD or ZERO as required.

2. Place transponder control MASTER switch OFF. Place IDENT-OUT-MIC, M-1, M-2, M-3/A, M-C, MODE 4, AUDIO-OUT LIGHT and RAD TEST-OUT-MON switches to OUT.

15.8 AN/ARC-210(V) RADIO (AFC 455)

Two AN/ARC-210(V) radios (Figure 15-3) provide communication frequencies in the AM/FM/VHF/UHF bands between 30.000 MHz and 400.000 MHz. The left and right panels are designated COMM 1 and COMM 2, respectively. Tuning frequencies are available in 25 KHz increments, 5 KHz or 10 KHz offset tuning is provided over the 30.000 MHz to 400.000 MHz frequency range. The radio receiver-transmitter provides simplex 2-way communication in normal and secure voice. The frequency bands include 30 through 80 MHz (FM normal/secure voice), 108 through 156 MHz (AM normal/secure voice), 108 through 156 MHz (AM normal/secure voice, 121.5 MHz guard channel, 108 through 118 MHz receive only), 136 through 174 MHz (FM normal/secure voice), 225 through 400 MHz (AM normal/secure voice; automatic direction finder (ADF); 243 MHz guard transmission; command activity sonobuoy system (CASS/DICASS) command), 225 through 400 MHz (FM normal/secure voice).

WARNING

- The receiver-transmitter contains a radio frequency transmitter which, when operated through an antenna, may produce electromagnetic fields in close proximity to the antenna that are in excess of Occupational Safety and Health Administration (OSHA) standards. Be sure all personnel are clear of antenna when performing radio checks.
- Do not exceed radio receiver duty cycle of 1 minute transmit followed by 5 minute receive.

The radio set includes a guard receiver that permits continuous monitoring of guard frequencies whenever the main transmitter-receiver is tuned to another frequency. The guard channels are normally set at 121.5 MHz and 243 MHz AM.

The radio set scanning consists of preset channels 22 through 25 and the command channel is 22. When the radio receiver-transmitter is keyed during scanning, transmit is on the command channel frequency. When activity is detected on a scanned channel, the channel number and frequency are displayed by the radio set control. The radio receiver-transmitter transmits on the active channel frequency. The channel remains active for 3 seconds after the last detected activity or transmission, where upon scanning resumes.

The radio set also provides automatic direction finding (ADF) in conjunction with the VHF/UHF direction finder. Relative bearing to the radio transmission source will be shown by the No. 1 pointer on the selected pilot BDHI.

The radio set has 30 preset channels, using the channel/frequency CRSR switch. The pilot may select up to 25 (channels 1 through 25) preset operating frequencies for simplex operation or channels 26 through 30 with dual frequencies for half-duplex operation. When the frequency mode is in MAR, it allows the pilot to select one of 57 preset Maritime channels (channels 1 through 28, and 60 through 88), using frequencies 156 to 173.975 MHz. The maritime channel and transmit frequency are displayed on the control panel.

15.8.1 Control Panel. The controls and indicators of the radio set are shown in Figures 15-3 and 15-4. The control panels are marked V/UHF and are located on the cockpit center console (FO-8). The panels control mode select, function, and display, and are described in Figure 15-85, Control/Indicator Function.

15.8.1.1 Control Panel Built-In Test (BIT). Set operational mode to TEST. While BIT is running, display will be blank except for decimal point. After 15 to 20 seconds, 888.888 and all functions of the display are illuminated, indicating that the system has successfully passed BIT. Refer to Figure 15-5 for BIT readout examples.

The Emergency dc bus circuit breaker panel provides power for the COMM 1 system through a circuit breaker marked COMM 1 under the general heading RADIO. The No. 2 Primary dc bus circuit breaker panel provides power to the COMM 2 system through a circuit breaker marked COMM 2 under the general heading RADIO.

The radio set interfaces and operates with the TSEC/KY-58 secure voice equipment with the Electronic Counter Countermeasure (ECCM) applique. The applique provides for appropriate transmission security/ communication security (TRANSEC/COMSEC) and privacy modes. In HAVE QUICK mode of operation, the radio set A8 applique interfaces a number with the KY-58 that is compatible with all hop rates.

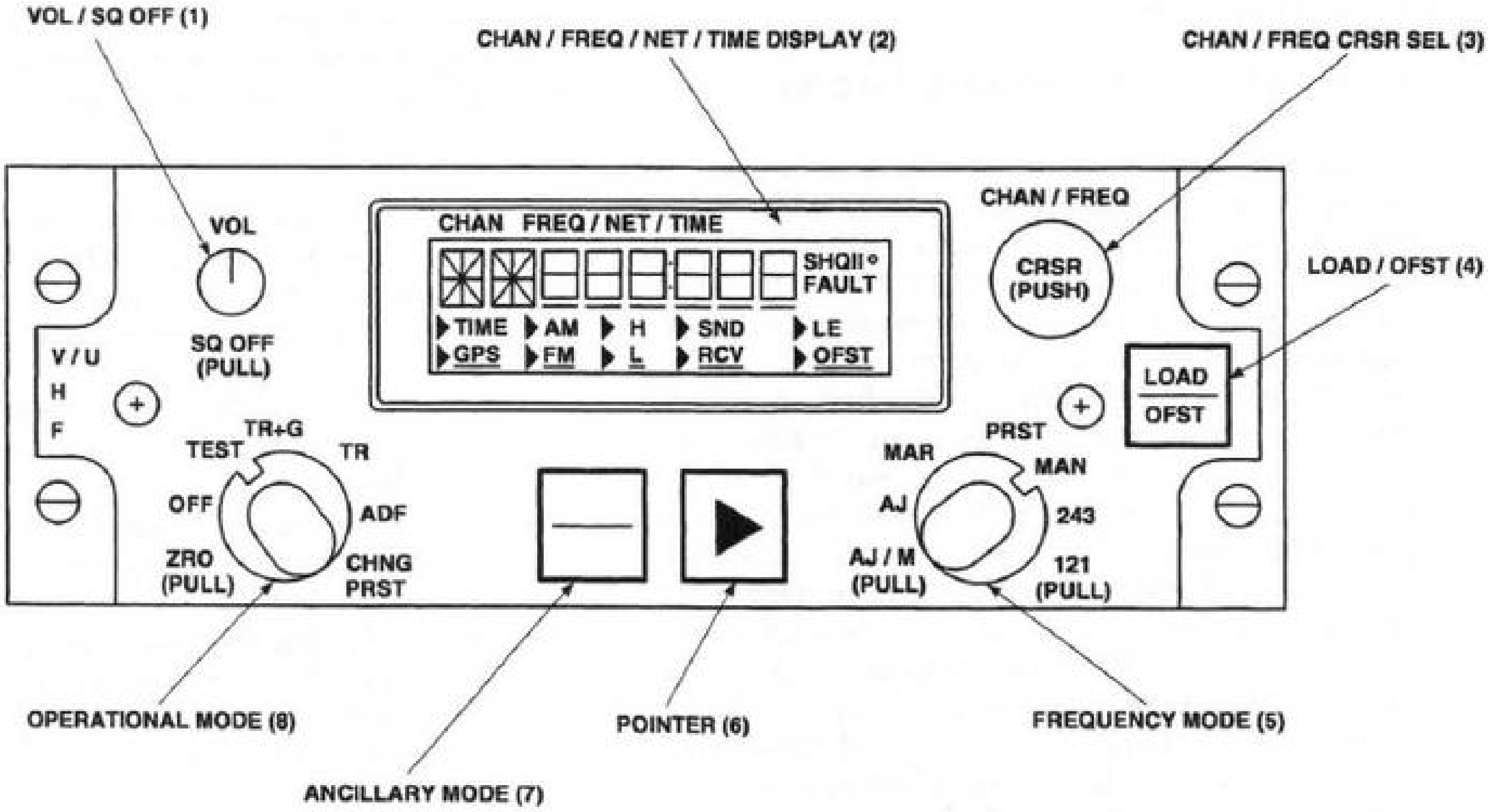


Figure 15-3. AN/ARC-210(V) Control Panel

15.8.2 Normal Operating Procedures. The following procedures are applicable for operating the AN/ARC-210(V) Radio Sets and Control Panels. The following information consists of predeparture instructions to prepare the system for normal and ECCM operation.

15.8.2.1 COMM 1 Radio Checkout

WARNING

Do not exceed RT-1556/ARC duty cycle of 1 minute transmit followed by 5 minutes receive.

1. SET COMM 1 C-11898/ARC control as follows:

Operational Mode Selector	T/R or T/R&G
Freq Mode Selector	MAN
VOL	MID-Range
SQL	Push-Pull Switch in

2. Built-In Test (BIT).

3. Radio Communications Test.

Select local authorized test frequencies and establish communications. Verify the station receives transmitted audio clearly. Verify presence of sidetone and received audio is heard clearly in headset. Repeat for UHF/AM/VHF/FM and GUARD RECEIVE.

4. Other Function Testing.

ADF Test: Enable ADF equipment by setting operational mode to ADF. Set frequency mode to proper frequency and verify proper ADF operation.

Squelch Disable: On VOL/SQ OFF switch, select squelch disable (pull). Noise should be heard in headset. Enable squelch and verify reduced noise is heard in headset.

Panel Lamps: Set panel illumination with console and panel control on the aircraft lighting panel. Verify faceplate lamps of C-11898 controls are variable in brilliance on both control boxes.

GPS Interface: Using the ancillary mode pushbutton, select GPS, then highlight with pointer button. Engage LOAD/OFFSET button. Time: Exits automatically and only GPS is displayed.

CONTROL/ INDICATOR	FUNCTION
VOL/SQ OFF	VOL Potentiometer/SQ OFF push-pull switch. Potentiometer adjusts audio output level. SQ OFF push-pull switch disables main receiver squelch in the out position and enables squelch in the in position.
CHAN/FREQ/ NET/TIME Display	Liquid crystal module display. Displays channel, frequency, net, time, mode, or built-in-test (BIT) results.
CHAN/FREQ CRSR Selector	CHAN (channel)/FREQ (frequency) CRSR (cursor) pushbutton rotary switch. Each time switch is depressed, the cursor position changes. Rotating the switch changes channel or frequency value depending upon mode selected and cursor position.
LOAD/OFST	Pushbutton switch. When depressed, enables the loading of various data depending upon the mode selected. Depressing this switch within 2 seconds after the operational mode selector has been placed to TEST causes the radio system to go into step self-test rather than end-to-end self-test.
Frequency Mode Selector	Isolated position rotary switch selects the following frequency modes: **NOTE** Knob must be pulled out to enter or exit positions marked PULL.
AJ/M (PULL)	With the frequency mode selector pulled and placed in the AJ/M position (pull-to-turn), AJ/M (antijam/master net) mode is selected. Provides same capabilities as AJ mode plus the added functions associated with a SINCGARS master net controller.
AJ	ECCM AJ (Anti-Jam) mode. Operator may select up to 25 AJ preset networks, either HAVE QUICK or SINCGARS ECCM nets, if all 25 channels are loaded with fill information, or the SINCGARS CUE channel and preset net number are displayed or AF presets and CS is displayed when the Cold Start channel is selected. Following operator selection, the CD-17/ARC applique supplies all frequency and control data for operation of the receiver-transmitter and antenna. The operator may define a HAVE QUICK channel by loading the WOD and type. In HAVE QUICK, the GPS and SND/RCV time ancillary modes are available. In SINCGARS, GPS SND/RCV, ERF (ECCM Remote Fill), H (Hop sets), L (Lockout Sets), and LE (Late Entry) modes are available and SINCGARS CUE channel is monitored.
MAR	Maritime mode. Operator may select any one of the 57 preset maritime channels (channels 1 through 28 and 60 through 88). Maritime channel and transmit frequency is displayed. Alternately depressing the LOAD/OFST pushbutton while in the MAR mode changes transmit frequency and station operation from ship to station and back.
PRST	Preset mode. Using the CHAN/FREQ switch, the operator may select up to 25 preset channels (1 through 25) for simplex operation, channels 26 through 30 with dual frequencies for half-duplex or Wide-Band Dedicated Channel UHF SATCOM (non-DAMA) operation, and channels 36 through 40 with dual frequencies for Demand Assigned Multiple Access (DAMA) UHF SATCOM operation. The selected channel, frequency, and modulation type (AM/FM) is displayed. SCAN mode is enabled when SCAN is displayed. Operator may also select SINCGARS CU (CUE) channel (31). When selected, CU and the frequency are displayed. Preset channels 22 through 25 are scanned. Channel 22 is the command channel and 23 through 25 are secondary channels. When a signal is detected on a scan channel, the channel number and frequency are displayed. Depressing LOAD/OFST during scanning will result in the selection of the last active channel being displayed and scanning to cease. Depressing LOAD/OFST a second and/or third time will tune the receiver/transmitter to the last active second and/or third channels. Depressing LOAD/OFST a fourth time will resume scanning operation. The same ancillary modes described for MAN mode are also available in the PRST mode.

Figure 15-4. Control Indicator Function (Sheet 1 of 3)

CONTROL/ INDICATOR	FUNCTION
MAN	Manual frequency select mode. Operator may select any of the radio operating frequencies. The following ancillary modes may also be selected: **NOTE** To select the ancillary modes, first remove the cursor from under the CHAN/FREQ digits by alternately depressing and then releasing the CRSR pushbutton. The ancillary mode pushbutton is used to position the cursor under the desired mode, and the pointer pushbutton is used to select or deselect the mode.
TIME/GPS	Global Positioning System (GPS) time mode. Enables the receipt of time from a GPS receiver when a CD-17/ARC Frequency Countermeasure Controller is attached to the receiver-transmitter.
AM/FM	AM/FM mode selection. Identifies modulation to be employed in the VHF band (136 to 155.985 MHz) and the UHF band (225 to 399.985 MHz).
SND/RCV	Send (SND) and receive (RCV) mode. Used for over-the-air transfers between radios on the same frequency when the LOAD/OFST pushbutton is depressed. HAVE QUICK TOD may be transferred with the radio operating frequency in the UHF range. SINCGARS ERF may be transferred if the radio operating frequency is in the VHF-FM (30 to 88 MHz) range. This switch is also used for Emergency Start time if time has not been loaded. This switch also changes display of SIMPLEX channel frequency; SND displays transmit frequency, and RCV displays receive frequency.
OFST	Offset mode. Enables the selection of any frequency in the valid operating bands from 30 to 400 MHz in 5 KHz steps. Offsets of 0 KHz, ±5KHz, and ±10 KHz can be selected after the pointer is placed in front of the OFST menu selection, and pressing the LOAD/OFST pushbutton switch to increment in ±5KHz steps. Display shows offset frequency pointer must be turned off to exit mode.
243	With the rotary switch pulled and placed in the 243 position (pull-to-turn), UHF guard mode is selected. The transmitter and main receiver are tuned to 243.000 MHz (AM). The preset and manual frequency selector controls become inoperative. Selection of this mode will also turn the radio on with the operational mode select in the OFF position with primary power present.
121 (PULL)	With the frequency mode selector pulled and placed in the 121 position (pull-to-turn), VHF guard mode is selected. The transmitter and main receiver are tuned to 121.500 MHz (AM). The preset and manual frequency selector controls become inoperative.
➧	Pointer pushbutton. Positions pointer to select or deselect ancillary mode select switch.
—	Ancillary mode pushbutton. Positions cursor under various ancillary mode options. Used with pointer pushbutton to select and deselect ancillary modes.
Operational Mode Selector	Isolated position rotary switch selects the following operational modes: **NOTE** Knob must be pulled out to enter or exit positions marked Pull.
ZRO (PULL)	With operational mode selector pulled and placed in the ZRO (zeroize) position, all ECCM fill data if zeroized by completely erasing it from memory. ZRO is displayed.
OFF	Selects OFF mode. Turns power off.

Figure 15-4. Control Indicator Function (Sheet 2 of 3)

CONTROL/ INDICATOR	FUNCTION
TEST	Selects Test mode. Initiates Built-in-Test (BIT) of the control unit, receiver-transmitter, CD-17/ARC applique, antenna converter unit, and antenna. Display is blanked, except for a momentary side pointer followed by the decimal point with the test in progress. Faults detected are displayed (refer to Figure 15-5, BIT Display Codes and Faulty Component). With no faults detected, the display illuminates all function indicators. The operator may single-step through each test and display the results by depressing the LOAD/OFST pushbutton within 2-seconds of selecting test mode. Test mode takes precedence over all operations except 243 MHz Guard.
TR+G	Selects main receiver-transmitter mode. The main receiver, transmitter, and guard receiver are on and able to perform all functions.
TR	Selects main receiver-transmitter mode. The main communications receiver and transmitter are on. Guard receiver is off.
ADF	Select automatic direction finding mode. Transmitter functions normally. The main receiver is connected to the ADF antenna port. The receiver will provide normal received audio in addition to providing the demodulated ADF signal. Guard receiver is on. In FM mode, degraded operation may be noted.
CHNG PRST	Selects change preset mode. Preset channels including COLD START and CUE channels, and corresponding operating frequencies and modulation can be loaded into receiver-transmitter memory and the HAVE QUICK ECCM net codes loaded into the ECCM controller memory. Presets may be loaded by the operator via the control unit, MIL-STD-1553B data bus, or data transfer device.

Figure 15-4. Control Indicator Function (Sheet 3 of 3)

15.8.2.2 Manual Loading of Preset Channels

1. Operational Mode selector — CHNG PRST.

2. Frequency Mode selector — PRST.

3. CHAN/FREQ knob — Select desired channel.

   a. Observe frequency indication on FREQ display.

   b. Change frequency by:

      (1) Pressing/releasing CHAN/FREQ knob to move the cursor under the desired digit(s).

      (2) Rotate CHAN/FREQ knob to increase/decrease the number.

      (3) To fine tune ±10 kHz steps:

         (a) Ancillary Mode cursor and pointer — Select OFST.

         (b) LOAD/OFST — PRESS.

4. If desired, change the default modulation for a given band by using the ancillary mode cursor and pointer to select AM of FM.

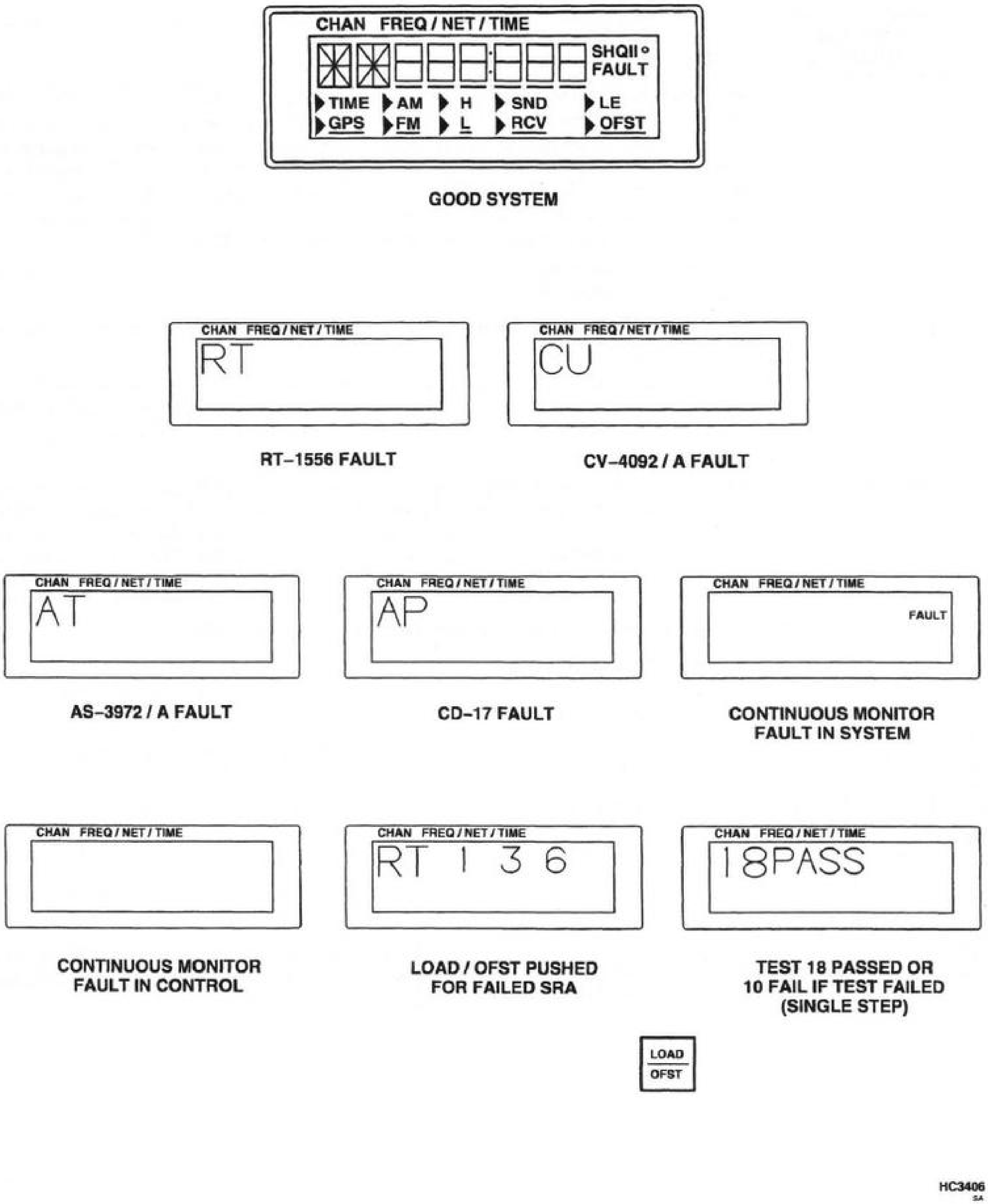


Figure 15-5. BIT Display Codes and Faulty Component

15.8.2.3 Scan Operation

Note

In SCAN mode, preset channel 22 is the Command Channel and channels 23 through 25 are secondary scanned channels. With SCAN displayed, keying the radio causes the transceiver to transmit on the Command Channel.1. Load channels 22 through 25 with desired frequencies.

2. Operational Mode selector — TR or TR+G.

3. Frequency Mode selector — PRST.

4. CHAN/FREQ knob — Rotate to select SCAN.

   a. Channel and frequency will be displayed whenever a signal is detected on a scanned channel.

   b. Transmit will occur on active channel if keyed within three seconds.

5. To transmit on the last active channel after radio returns to scan:

   a. LOAD/OFST — PRESS.

      (1) Returns receiver-transmitter to last active channel and ends scanning.

      (2) Radio is ready to communicate on the selected frequency.

   b. Pressing LOAD/OFST a second/third time will tune radio to second/third channel that was last active.

   c. Pressing LOAD/OFST a fourth time causes the radio to resume scanning.

15.8.2.4 Automatic Direction Finding (ADF) Transmitter continues to function normally. Receiver provides normal receive audio in addition to demodulated ADF signal to the ADF antenna port. Guard receiver remains on. In FM mode, degraded operation may occur.

1. Operational Mode selector — TR or TR+G.

2. Frequency Mode selector — PRST.

3. Operational Mode selector — ADF.

Note

#1 needle on BDHI will indicate direction of emitting radio whenever it transmits.

15.8.2.5 AN/ARC-210(V) ECCM Operating Procedures. By selecting AJ or AJ/M on the frequency mode selector, the operator may select up to 25 AJ preset channels containing HAVE QUICK I, HAVE QUICK II, or SINCGARS network data. An additional channel (channel 31) may be programmed with a SINCGARS cue frequency.

Note

AN/ARC-210(V) ECCM operation may only be activated if the CD-17/ARC Frequency Countermeasures Controller "applique" is attached to the RT-1556/ARC. SINCGARS data may be transferred into the applique utilizing the CYZ-10 Data Transfer Device (DTD), MIL-STD-1553B DATA BUS or via ECCM remote fill (ERF). HAVE QUICK data may be transferred utilizing the DTD, MIL-STD-1553B DATA BUS or loaded manually by the operator.

15.8.2.6 HAVE QUICK Operation

1. The following procedures will allow the operator to access many of the HAVE QUICK ancillary functions as well as operate the radio in the HAVE QUICK mode.

Note

Utilizing the CYZ-10 Data Transfer Device (DTD) to program HAVE QUICK operational data into the transceiver will normally negate the need to access most of the ancillary functions. It should be noted, however, that the CYZ-10 DOES NOT program Time-Of-Day (TOD) information into the transceiver. Therefore, provisions for TOD entry must be made.

2. A HAVE QUICK preset channel is represented by the symbols HQ I or HQ II in the upper right corner of the C-11898/ARC display. The applique stores preset channels containing HAVE QUICK Word-Of-Day (WOD), Multiple Words-Of-Day (MWOD), NET ID number, and Time-Of-Day (TOD). TOD will be the same for all HAVE QUICK operations, providing the time synchronization references are identical.

15.8.2.7 Operational Check HAVE QUICK I

1. Ensure that WOD/MWOD have been loaded either manually or with a data transfer device such as the CYZ-10, and TOD has been loaded via RF transfer or GPS receiver. Operational Day of Month (DOM) must be selected prior to HAVE QUICK operation.

   a. TOD Emergency-Start: The following procedure allows the operator to initialize the transceiver's internal clock for use as a TOD reference.

      (1) On the radio set control unit, select any frequency while in the normal or preset mode. The frequency selection is not band dependent. (AJ or AJ/M modes may NOT be used.)

      (2) Using the ancillary mode select and pointer pushbuttons, select both SND and RCV functions.

      (3) Push the LOAD/OFST pushbutton. This restarts the HAVE QUICK master clock to zero and restarts it to provide a timing reference.

Note

TOD is maintained for a minimum of 7 seconds during a power loss. If a power loss exceeds 7 seconds TOD must be reloaded.

   b. TOD Hardwired Transfer (GPS): The following procedure allows the operator to receive either random time or Universal Coordinated Time (UTC) from a GPS receiver hardwired to the transceiver. This action synchronizes the transceiver's internal clock to random time or UTC.

2. On the radio set control unit, select the GPS function using the ancillary mode and pointer pushbuttons.

3. Push the LOAD/OFST pushbutton. This updates the HAVE QUICK master clock with reception of the GPS timing reference.

4. TOD RF Transfer: The following procedure allows the operator to transmit or receive TOD utilizing an RF link. This action synchronizes the transceiver's internal clock to that of the transmitting radio.

   a. A communications link must be established between the two radios. If the transfer is done in manual or preset modes, the entire time is passed (days, hours, seconds, and fractions of seconds).

   b. To send TOD, the operator will use the ancillary mode and pointer pushbuttons to select SND.

   c. To receive TOD, the operator will use the ancillary mode and pointer pushbuttons to select RCV.

   d. The operator receiving TOD pushes the LOAD/OFST pushbutton.

   e. The operator sending TOD then has 60 seconds to push the LOAD/OFST pushbutton to initiate the TOD transfer.

   f. Ensure that WOD/MWOD have been loaded either manually or with a data transfer device such as the CYZ-10, and TOD has been loaded via RF transfer or GPS receiver. Operational Day of Month (DOM) must be selected prior to HAVE QUICK operation.

   g. Set the frequency mode to AJ.

   h. Using the CHAN/FREQ switch, select an authorized HQ I or HQ II net.

   i. Establish 2-way communications with another station on the selected net.

5. Verify WOD/MWOD Date: The following procedure allows the operator to verify WOD/MWOD date.

   a. Set the frequency mode to PRST and select channel 20 with CHAN/FREQ and operational mode to CHNG PRST.

   b. Select operating frequency of 220.000 by pushing CRSR switch until cursor is below desired frequency digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired operating frequency is selected. Press LOAD/OFST.

c. CHAN FREQ/NET/TIME display should display 00.

d. Enter day of month to be verified (00 for HQ, 01 through 31 for HAVE QUICK II) by rotating the CHAN/FREQ switch. Press LOAD/OFST. A double tone heard in the headset indicated a MWOD has been loaded for that day. No tone indicates MWOD for that day has not been loaded.

6. WOD/MWOD Load (Manual): The following procedure allows the operator to verify Manual loading of WOD/MWOD.

a. Set frequency mode to PRST and select channel 20 with CHAN/FREQ and operational mode to CHNG PRST.

b. Select operating frequency of 220.025 by pushing CRSR switch until cursor is below desired frequency digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired operating frequency is selected. Press LOAD/OFST.

c. CHAN FREQ/NET/TIME display should display 20 200.000.

d. Enter first segment of WOD. The segment consists of six digits. Select digit by pushing CRSR switch until cursor is below desired digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired WOD segment is selected. The last two digits of segment 20 determine the hop rate (00 for the slowest, 75 for the fastest). Press LOAD/OFST when entry is complete.

e. A short tone should be heard in the headset, and CHAN FREQ/NET/TIME display should display 19 300.000.

f. Enter second segment of WOD. Select digit by pushing CRSR switch until cursor is below desired digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired WOD segment is selected. In a multiple segment load, segment 19 designates if the WOD is in conference mode. For conference mode selection, enter 00 or 50 in the last two digits of the segment. Press LOAD/OFST when entry is complete.

g. A short tone should be heard in the headset, and CHAN FREQ/NET/TIME display should display 18 300.000.

h. Enter remaining segments (channels 18 through 15), pressing LOAD/OFST when each entry is completed.

i. CHAN FREQ/NET/TIME display should display two digits 00 through 31.

j. For HAVE QUICK II MWOD, rotate CHAN/FREQ switch to select two digit day of month (01 through 31). For HAVE QUICK WOD, display remains at 00. Press LOAD/OFST.

k. A double tone should be heard in the headset, and CHAN FREQ/NET/TIME display should display 20 220.025.

l. For HAVE QUICK II, repeat steps c through k for remaining five MWOD. For HAVE QUICK, the WOD load is completed.

7. MWOD Erase: The following procedure allows the operator to erase the MWOD.

a. Set frequency mode to PRST and select channel 20 with CHAN/FREQ and operational mode to CHNG/PRST.

b. Select operating frequency of 220.050 by pushing CRSR switch until cursor is below desired frequency digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired operating frequency is selected.

c. Press LOAD/OFST.

8. Operational Date (DOM) Load: The following procedure allows the operator to load DOM.

a. Set frequency mode to PRST and select channel 20 with CHAN/FREQ and operational mode to CHNG PRST.

b. Select operating frequency of 220.125 by pushing CRSR switch until cursor is below desired frequency digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired operating frequency is selected. Press LOAD/OFST.

c. CHAN FREQ/NET/TIME display should display 20 00.

d. Rotate CHAN/FREQ switch to select two-digit day of month (DOM) (01 through 31). Press LOAD/OFST. A short tone should be heard in the headset.

15.8.2.8 SINCGARS Operation

1. The following procedures will allow the operator to access many of the SINCGARS ancillary functions as well as operate the radio in SINCGARS mode.

Note

When using the CYZ-10 (DTD) to transfer SINCGARS operational data, it will normally negate the need to access most ancillary functions. Base Time is not part of the DTD transfer function.

2. A SINCGARS preset channel is represented by the symbol "s" (small s) in the upper right corner of the C-11898/ARC display. The preset channel identifies net data sorted in the applique containing the Net ID, Hopset, and TRANSEC Variable. This net data is sorted in nonvolatile memory and will be retained in the event of power loss. In addition, SINCGARS operation requires SINCGARS Base Time to synchronize the frequency hopping operations. SINCGARS Base Time (including the mission day) may be loaded using hardwired transfer via GPS receiver, over-the-air RF transfer from another radio or Emergency Time start. If hardwired transfer via GPS or over-the-air RF transfer is used, the SINCGARS Base Time shall be equal to the received time and the SINCGARS mission day shall be equal to the least significant two digits of the three digit day-of-year. SINCGARS Base Time may be viewed in the form of days, hours, and minutes (DD HH:MM). If the operator updates the SINCGARS Base Time manually, all NET TIME OFFSET will be zero.

3. In the AN/ARC-210(V), the internal clock is referenced to the HAVE QUICK TOD. Internal clock timing will be retained for a minimum of 7 seconds during a power loss. Beyond 7 seconds, the internal clock may need to be reloaded. The AN/ARC-210(V) has provisions for an external battery backup to maintain internal timing. If utilized, a loss of primary power will not effect the radio's internal timing as long as battery backup power is not interrupted.

15.8.2.9 Operational Check, SINCGARS

1. Ensure that SINCGARS data has been loaded by ECCM remote fill (ERF) or via a data transfer device such as the CYZ-10 Data Transfer Device (DTD).

2. Set the frequency mode to AJ or AJ/M.

3. Using the CHAN/FREQ switch, select an authorized SINCGARS channel.

4. Establish 2-way communications with another station on the selected net.

a. If communication is "scratchy", a late entry function should be performed to synchronize radios. It is performed as follows:

(1) Ensure COMM 1 and COMM 2 and local station are on the same preset SINCGARS channel.

(2) Both stations should enter wristwatch time by using ancillary mode cursor and pointer to select time. With FREQ/CHAN, enter new time in days, hours, minutes format. The time must be loaded to within one minute of net SINCGARS TIME to work.

(3) Return to the SINCGARS MENU on both radios by deselecting time.

(4) Enter LOAD/OFST on both radios.

(5) On COMM 1, select LE using cursor and pointer.

(6) Enter LOAD/OFST.

(7) Key local station to synchronize COMM 1.

(8) Repeat for COMM 2.

(9) Repeat operational SINCGARS testing to verify improved clarity.

5. <u>SYNC Time Chance (Manual):</u> The following procedure allows the operator to change time manually.

a. Set frequency mode to AJ or AJ/M.

b. Select a SINCGARS channel (indicated by an S displayed in the upper right corner of the display) using CHAN/FREQ.

c. Press ancillary mode cursor until cursor is under GPS. Press pointer pushbutton to select time.

d. CHAN FREQ/NET/TIME display displays days, hours, and minutes (DD HH:MM) 01 07:00.

e. Enter new time in days, hours, and minutes by pushing CRSR switch until cursor is below desired digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired time is selected. Press LOAD/OFST.

6. Late Net Entry: The following procedure allows the operator to make late entry into the receiver.

Note

Late net entry allows a radio set into a SINCGARS net without prior time synchronization. SINCGARS hopset, lockout set, and TRANSEC variable must be loaded prior to late net entry.

a. Set frequency mode to AJ. Load SYNC time (refer to paragraph 5, SYNC Time Change (Manual)). Sync time must be within 1 minute of net sync time.

b. Press ancillary mode cursor until cursor is under LE. Press pointer pushbutton to select LE. Press LOAD/OFST.

c. Establish communications with net radio sets. Late entry mode exits when the radio set becomes synchronized.

7. Electronic Protection (EP) Remote Fill: The following procedure allows the operator to fill the receiver.

a. Set frequency mode to AJ or AJ/M.

b. To receive ECCM Remote Fill (ERF), press ancillary mode select pushbutton until cursor is under RCV. Press pointer pushbutton to select RCV. Press LOAD/OFST. Perform steps d, e, f and g.

c. To transmit ERF, press ancillary mode select pushbutton until cursor is under SND. Press pointer pushbutton to select SND. Press LOAD/OFST. Perform steps d, e, f and g.

d. CHAN FREQ/NET/TIME display displays 01 (set number) in the CHAN position and an H (Hop set) or L (Lockout set) in the ancillary mode menu.

e. Select either H or L to select hopset or lockout set to be transferred.

f. Select desired set number to be transferred with CHAN/FREQ.

g. The receiving operator presses LOAD/OFST. CHAN FREQ/NET/TIME display returns to the state prior to ERF. The radio set operates normally and accepts ERF when it is sent.

h. The transmitting operator presses LOAD/OFST. CHAN FREQ/NET/TIME display sends the selected ERF and returns to the state prior to ERF.

8. Cold Start: The following procedure allows the operator to cold start SINCGARS operation.

Note

Valid SINCGARS TRANSEC variable must be loaded prior to cold start operation.

a. Set frequency mode selector to AJ.

b. Rotate CHAN/FREQ until CS is displayed on CHAN FREQ/NET/TIME display.

c. Set operational mode to CHNG PRST.

d. Select cold start operating frequency by pushing CRSR switch until cursor is below desired frequency digit. Rotate CHAN/FREQ switch until desired value is obtained. Repeat for each digit until desired operating frequency is selected. Press LOAD/OFST.

e. Set operational mode to TR+G. Establish 2-way communication with a similarly equipped transceiver to request ERF parameters.

f. Select RCV with ancillary mode selector and pointer pushbuttons to receive ERF (or SND to transmit ERF). Press LOAD/OFST.

g. CHAN FREQ/NET/TIME display displays an 01 in the channel position. Using the pointer, select H (Hop set) or L (Lockout set) to be transferred. Using CHAN/FREQ switch, select desired set number to be transferred.

h. Press LOAD/OFST. CHAN FREQ/NET/TIME display returns to the state that existed prior to ERF.

9. CUE Preset Load: The following procedure allows the operator to load CUE frequencies.

a. Set frequency mode to PRST.

b. Rotate CHAN/FREQ until CU is displayed on the CHAN FREQ/NET/TIME display.

c. Set operational mode to CHNG PRST.

d. Push CRSR switch until cursor is under desired frequency digit. Rotate CHAN/FREQ until desired value is obtained. Repeat for each digit until valid cue frequency is selected.

e. Press LOAD/OFST.

10. CUE Operation: The following procedure allows the operator to select antijam channels.

a. Set frequency mode to AJ or AJ/M.

b. Rotate CHAN/FREQ and select an antijam SINCGARS channel, indicated by an S displayed in the upper right corner of the display.

c. When a signal is received on the SINCGARS cue frequency, a short tone is heard in the headset and a "C" is displayed on the CHAN FREQ/NET/TIME display.

11. Zeroize: The following procedure allows the operator to zeroize fill data.

a. Pull operational mode selector and set to ZERO.

b. When data fill is deleted, ZRO is displayed.

15.8.3 AM/FM/VHF/UHF Antenna. Two antennas (Figure 15-2) are provided. The antennas are 9" tunable, that will receive and transmit in the 30 MHz to 400 MHz frequency range. Each antenna requires the use of a Digital Converter. The digital converter is an interface between the radio receiver output and the antenna control input. The No. 2 primary dc bus circuit breaker and emergency dc bus circuit breaker marked COMM 1 and COMM 2, under the general heading RADIO, provide electrical power to the antennas.

15.8.4 Digital Converter. The digital converter changes Manchester II encoded frequency information from the radio receiver, into a digital output for use by the tunable antenna. Built-in test (BIT) circuits within the digital converter provide a status output to the radio receiver-transmitter indicating the operational state of both the digital converter and tunable antenna. Interface with radio receiver and antenna control input is provided by three connectors located on the digital converter front panel. The No. 2 primary dc bus circuit breaker furnishes power to the digital converter through circuit breakers marked COMM 1 and COMM 2 under the general heading RADIO.

15.9 HELOSAT ANTENNA (AFC 486)

Helicopters with AFC 486 have provisions for mounting the HELOSAT antenna on the tail rotor drive shaft access cover (Figure 15-2). The system provides a means of satellite communication between ground troops and the on-board ground troop commander.

15.9.1 HELOSAT Installation. Requirements for installation of the HELOSAT antenna kit will be based upon operational priorities and equipment availability. The HELOSAT antenna kit is removed upon completion of SATCOM operations.

CHAPTER 16
Navigation Systems

16.1 NAVIGATION EQUIPMENT

Navigation equipment (Figure 16-1) is operated through individual control panels on the center console and overhead control panels (FO-1, FO-3, and FO-8).

16.2 UHF-DF GROUP

The AN/ARA-50 UHF direction finding group is used with the UHF-AM/COMM set to indicate, with the BDHI's No. 1 pointers, the bearing of radio signal sources. Selecting ADF with the UHF-AM/COMM set's function switch activates the UHF-DF group, and a 100 Hz tone will be heard when a UHF signal is being received. This tone will decrease in volume when the signal is acquired and the BDHI's No. 1 pointer points toward the UHF signal source. If the LF/ADF is on and homing on a station and the UHF-DF is activated, the UHF-DF will have priority, and the BDHI's No. 1 pointers will point to the UHF signal source. UHF-DF is never displayed by the No. 3 BDHI's No. 1 pointer. The No. 3 primary ac bus furnishes power through a circuit breaker in the cabin marked UHF DF, under the general heading RADIO. The No. 3 ac bus furnishes power through a circuit breaker in the cabin marked UHF DF, under the general heading 26V RADIO. The No. 3 primary dc bus furnishes power through a circuit breaker in the cabin marked UHF DF, under the general heading RADIO.

To turn the set on, switch operating UHF-AM/COMM set to ADF and select ADF for BDHI's No. 1 pointer.

Note

Reduced reception and bearing accuracy may be experienced any time the station is not on the nose of helicopter.

16.3 LF/ADF SET

The AN/ARN-89 LF/ADF (low frequency/automatic direction finding) radio compass set automatically indicates the direction from which an incoming radio frequency (rf) signal is received. The set operates in the frequency range of 100 to 3000 kilohertz (kHz). The No. 1 pointers of the BDHI's show the relative bearing of the transmitting station, in regard to the heading of the helicopter, when the UHF-DF set is not in use.

TYPE	DESCRIPTION	FUNCTION	PRIMARY OPERATOR	APPROXIMATE RANGE	CONTROL LOCATION
Doppler	AN/APN-217(V)3	Navigation	Pilots	N. A.	Cockpit
VHF/UHF-DF	OA-8697/ARD	VHF/UHF-ADF	Pilots	LOS 25 miles	Cockpit
UHF-DF	AN/ARA-50	UHF-ADF	Pilots	LOS 25 miles	Cockpit
LF/ADF	AN/ARN-89	Navigation and communication	Pilots	Transmitter power and weather	Cockpit
TACAN	AN/ARN-118(V)	Navigation	Pilots	LOS REC 390 miles A/A 200 miles	Cockpit
VOR/ILS	VIR-31A	Navigation	Pilots	LOS	Cockpit
Radar beacon (Without AFC 501 Part 2)	AN/APN-154	Extend identification range	Pilots	Depends on conditions	Cockpit
GPS	AN/ARN-151	Satellite Navigation	Pilots	Worldwide	Cockpit

Figure 16-1. Navigation Equipment

The No. 3 primary ac bus furnishes power through a circuit breaker marked LF ADF under the general heading 26V RADIO. The No. 1 primary dc bus furnishes power through a circuit breaker marked ADF under the general heading RADIO.

16.3.1 Control Panel. The panel, marked ADF RCVR, is on the cockpit console (FO-8).

16.3.1.1 Mode Selector Knob. The COMP position provides ADF operation. The ANT position allows the set to be used as an AM and CW receiver using the sense antenna. The LOOP position allows the set to be used as a manual direction finder using the loop antenna.

16.3.1.2 Loop Slew Knob. Permits the loop to be slewed L (left) or R (right). The knob is spring-loaded to the center position.

16.3.1.3 Audio Knob. Adjusts volume.

16.3.1.4 Coarse Tune Knob. Tunes receiver in 100 kHz steps as indicated by the first two digits in the frequency window.

16.3.1.5 Fine Tune Knob. Provides selection of 10 kHz digits (continuous tuning), as indicated by last two digits in frequency window.

16.3.1.6 CW-Voice-Test Switch. With CW and COMP mode selected, allows the tone oscillator to provide an audible tone for tuning to a CW station. With CW and ANT mode or LOOP mode selected, it enables the beat frequency oscillator to permit tuning to a CW station. With VOICE selected, it permits set to operate as an AM receiver with the mode switch at COMP, ANT, or LOOP. With TEST and COMP mode selected, it provides slewing of the loop through 180°, to check operation of the receiver.

16.3.1.7 Tune Meter. Indicates relative signal strength while tuning receiver to a specific radio signal.

16.3.1.8 Kilohertz Frequency Window. Indicates operating frequency to which receiver is tuned.

16.4 TACAN SET

The AN/ARN-118(V) TACAN set is a polar coordinate navigation system that is used to determine the magnetic bearing and slant line distance from the aircraft to a selected TACAN station. The selected TACAN station can be a ground, shipboard, or airborne TACAN station. The ground and shipboard TACAN stations are considered surface stations and supply both bearing and distance to the helicopter. An airborne station without a bearing transmitter only supplies distance information. An airborne station with a bearing transmitter supplies bearing and distance information.

The CH-53E's set is not capable of transmitting bearing information but does supply distance information when interrogated. Although maximum range of station reception is governed by line of sight considerations, the maximum operating range of the set is 390 nautical miles when the selected TACAN station is a surface station, and 200 nautical miles when the selected station is an airborne station. The TACAN navigation set has provisions for 126 X channels and 126 Y channels. The X channels are those presently in use by surface stations. The Y channels differ from the X channels in frequency assignment and pulse spacing.

Note

> The Y channels were developed to alleviate congestion of the X channels, but have not yet been implemented in ground stations. They are, however, available for use in the A/A modes. Use of the Y channels in the A/A mode is encouraged to eliminate possible interference with ground stations.

The magnetic bearing of a selected TACAN station is indicated by the BDHI's No. 2 pointer. The distance to the TACAN station is indicated by the BDHI's range indicator. A course to or from the TACAN station may be set in the pilot's course indicator COURSE selected window. The course indicator's ambiguity window shows whether the selected course is to or from the TACAN station. The course indicator's CDI and the BDHI's range indicator have warning flags that appear when unreliable signals below minimum usage are received. When correct bearing information cannot be determined, the BDHI's No. 2 pointer will search or turn in a manner that prevents the pilot from deriving improper information from it. See Bearing, Distance, Heading Indicator (BDHI) and Course Indicator in Chapter 2 for a detailed description of these indicators.

The No. 3 primary ac bus furnishes power to the set through a circuit breaker in the cabin marked TACAN PWR, under the general heading RADIO and through a circuit breaker marked TACAN under the general heading 26V RADIO. The No. 3 primary dc bus furnishes power to the set through a circuit breaker in the cabin marked TACAN, under the general heading RADIO.

16.4.1 TACAN Control Panel. The control panel marked TACAN is on the cockpit console (FO-8). The controls include a function selector switch, tens channel selector switch, units channel selector switch, X/Y channel selector, volume control knob, and self-test button. The control panel also contains a test indicator light and a channel digital display.

16.4.1.1 Function Selector Knob. A five-position (OFF, REC, T/R, A/A REC, AA T/R) function selector knob selects the mode of operation. OFF removes power from the set. The REC position allows only bearing information to be received from a surface station. The T/R position allows both bearing information and distance data to be received from a surface station. The A/A REC position allows only bearing information to be received from a suitably equipped cooperating aircraft. In the A/A T/R position, both bearing and distance information are received from another aircraft. If the cooperating aircraft is not equipped to transmit bearing signals, only the distance will be received in this mode.

Note

Operation in the air-to-air mode requires prearrangement with a cooperating aircraft. The second aircraft must be equipped with an air-to-air TACAN which is set to the air-to-air mode of operation and is set to a channel 63 channels away from the channel setting of the TACAN in the first aircraft. One aircraft may reply to as many as five others, but it will only display the distance to the nearest aircraft.

The TACAN navigation set requires a 90-second warmup period, regardless of the position selected by the function selector knob.

16.4.1.2 Channel Selector Knobs. The tens channel selector and units channel selector switches are rotary knobs that tune the TACAN navigation set to any of 126 TACAN channels. The X/Y channel selector, a movable ring around the units channel selector knob, selects either the X set of 126 channels or the Y set of 126 channels.

CAUTION

The units channel selector knob contains a built-in mechanical stop to prevent turning past the nine (9) position. Do not attempt to override this mechanical stop. Direction of knob must be reversed when the stop is reached.

16.4.1.3 Volume Control Knob. The volume control knob, marked VOL, varies the volume of the audio signals.

Note

TACAN audio is always present on ICS. The only audio level control is the VOL control on the TACAN control panel.

16.4.1.4 Self-Test Button. The manual self-test button, marked TEST, provides a test of the complete TACAN system, except for the antennas, when pressed.

16.4.1.5 Manual Self-Test. To initiate the self-test, select T/R and set a course of 180° in the pilot's course indicator window. Press the TEST button and observe that the test indicator light goes on for about 1 second, the BDHI and CDI flags come into view for about 7 seconds, and the No. 2 pointers of the pilot's BDHI indicates 270°. For the next 15 seconds, the flags go out of view, the range indicator displays 000.0 ($\pm$0.5), the No. 2 pointer indicates 180° ($\pm$3°), the CDI centers to within dot, and the ambiguity window indicates TO. When the self-test is complete, all indicators return to the indications displayed prior to the initiation of self-test. A failure is recorded if the test indicator light remains on during the test and/or the indicators are out of limits. The test can be done again in the REC mode, and if the indicator light does not go on, the malfunction is isolated to the transmitter section and the bearing information is valid.

16.4.1.6 Automatic Self-Test. To be sure that the TACAN system is operating properly, an automatic self-test occurs when the receiver signal becomes unreliable or the signal is lost. The results of the automatic self-test are the same as for the manual self-test except that the BDHI and CDI flags remain in view throughout the test.

CAUTION

Bearing and/or distance indications may still be present when the TEST lamp is on. Such indications could be either partially usable or grossly inaccurate. They should be cross-checked, using every available means. Be prepared for the possibility of TACAN equipment failure if the test indicator light goes on.

16.5 VOR/ILS SET

The VIR-31A VOR/ILS set receives signals transmitted by VOR and ILS stations. When a VOR frequency is selected, the signal output is applied to the BDHI's and course indicator's CDI. The BDHI's No. 2 pointer displays magnetic bearing to the VOR station. A course to or from the VOR station may be set in the copilot's course indicator COURSE selected window. The ambiguity window on the course indicator shows whether the selected course is to or from the VOR station. The course indicator's CDI has a warning flag that appears when unreliable signals below minimum usage are received. When correct bearing information cannot be determined, the BDHI's No. 2 pointer will turn to and remain at the 90° right position to prevent the pilot from deriving improper information from it.

When an ILS frequency is selected, the signal output is applied to the course indicator's CDI and GSI. The course indicator's CDI and GSI have warning flags that appear when unreliable signals below minimum usage are received. See Bearing, Distance, Heading Indicator (BDHI), and Course Indicator in Chapter 2 for a detailed description of these indicators.

The No. 3 primary ac bus furnishes power through a circuit breaker in the cabin marked VOR, under the general heading 26V RADIO. The No. 3 primary dc bus furnishes power through a circuit breaker in the cabin marked VOR LOC-GS, under the general heading RADIO.

16.5.1 VOR/ILS Control Panel. The control panel marked NAV is on the cockpit console (FO-8). The left knob selects frequency in 1 MHz steps, and the right knob selects frequency in 50 kHz steps. Frequency is displayed in an indicating window, and the frequency range is from 108.00 to 117.95 MHz. A movable ring control around the 50 kHz knob, marked VOL, adjusts volume.

Note

> VOR/ILS audio is always present on ICS. The only audio level control is the VOL control on the VOR/ILS control panel.

A movable ring function control around the 1 MHz knob removes power from the set when at OFF, turns the set on when at PWR, and checks system operation when at TEST.

On aircraft with the marker beacon installed the VOR/ILS control panel is modified. Frequency selection is the same. The left knob is marked MB VOL. The movable outer ring controls marker beacon volume. The right knob is marked NAV VOL. The movable outer ring controls VOR/ILS volume. A two position MB switch has positions HI and LO. LO provides a standard marker beacon width sensitivity. HI provides a longer period of marker beacon sensitivity. A three-position function selector switch is marked TEST, ON, and OFF. On provides power to the unit, OFF removes power, and TEST initiates the BIT.

16.5.1.1 VOR Test. Tune in and identify a VOR station, and then hold the function control at TEST. If a VOR signal is present, the CDI flag stays out of view, the CDI vertical bar deflects right, and TO appears in the ambiguity window. Release the function control to PWR or ON. The CDI flag comes into view in 1 second, and goes out of view in 5 seconds. Test is satisfactory.

If no VOR station is available, select any VOR frequency and hold the function at TEST. The CDI flag goes out of view after 3 seconds, the CDI vertical bar deflects right, and TO appears in the ambiguity window. Release the function control to PWR or ON, and the CDI flag comes into view in 1 second. Test is satisfactory.

16.5.1.2 ILS Test. Tune in and identify an ILS station, and then hold the function control at TEST. The CDI and GSI flags stay out of view, the CDI deflects to the right, and the GSI deflects down about 1 dot. Release the function control to PWR or ON. The CDI flag comes into view in 1 second, and goes out of view in 5 seconds. The GSI flag comes into view in 0.5 second, and goes out of view in 2.5 seconds. Test is satisfactory.

If no ILS station is available, select any ILS frequency and hold the function selector at TEST. The CDI flag goes out of view after 3 seconds, the GSI flag goes out of view after 1.5 seconds, the CDI deflects right, and the GSI deflects down about 1 dot. Release the function control to PWR or ON. The CDI flag comes into view in 1 second, and the GSI flag comes into view in 0.5 second. Test is satisfactory.

16.5.2 Marker Beacon Receiver. On aircraft with the marker beacon installed, next to the pilot and copilot's course indicators on the instrument panel (FO-5) are three lights (white, amber, and blue) that are used to indicate passage over the marker beacons when conducting an ILS/VOR approach. Passage over the outer marker (OM) is identified by the illumination of the white light in conjunction with the continuous dashes that are heard in the headset. Aurally, the dashes are comparatively low pitched (400 Hz). Passage over the middle marker (MM) is identified by the illumination of the amber light in conjunction with the alternating dots and dashes that are heard in the headset. Aurally, the alternating dots and dashes are high pitched (1300 Hz). Passage over the inner marker (IM) is identified by the illumination of the blue light in conjunction with dots keyed at a rate of six dots per second that are heard in the headset. Aurally, the continuous dots are modulated at 3000 Hz.

16.6 RADAR BEACON SET (Prior to AFC 501 Part 2)

The AN/APN-154 radar beacon set, operating in the frequency range of 8500 or 9600 megahertz (MHz), is an airborne radar beacon that extends the tracking range of a ground based system. When interrogated, the beacon provides an electrically-enhanced target. The set does not require visual or aural indications of operation. The set is controlled from a control panel marked RADAR BEACON, on the overhead control panel (FO-1), that contains a mode selector and, ACLS TEST light pushbutton, and power switch. The MODE selector switch has an ACLS position, a SINGLE position, plus marked positions 1, 2, 3, 4, and 5 under the general heading DOUBLE. The ACLS (automatic carrier landing system) is not used in this installation. The SINGLE position permits the set to respond to the single pulse of any code group received. The numbered positions, under the general heading DOUBLE, permit the set to respond to one of five double pulse interrogations. The ACLS TEST light pushbutton is not used in this installation. The power switch, with marked positions POWER, STDBY, and OFF, operates in the standard manner. The No. 3 primary dc bus circuit breaker panel in the cabin furnishes power through a circuit breaker marked RADAR BEACON under the general heading RADIO.

CAUTION

The set will warm up in about 5 minutes with the power switch at either STDBY or POWER. However, it is recommended that STDBY be used to prohibit the set from responding to a premature or unintentional interrogation signal that may cause equipment damage.

Operate radar beacon as follows:

1. Power switch — STDBY.

CAUTION

Allow 5 minutes of warmup time in standby power position, to prevent premature responses that might damage transmitter.

2. Power switch — POWER.
3. Mode selector switch — POSITION as follows:
   a. If set is to respond to a single-pulse interrogation — SINGLE.
   b. If set is to respond to double-pulse interrogations — DOUBLE, and select 1, 2, 3, 4, or 5 of double bracket.

16.7 OMEGA/VLF NAVIGATION SYSTEM (PRIOR TO INCORPORATION OF AFC 453)

The LTN-211 navigation system is a fully automatic computerized system designed for point-to-point area navigation. The system utilizes the OMEGA ground transmitter navigation network as its primary source to provide continuous position and navigational information on a world-wide basis. After initialization, any time adequate OMEGA signals are not available from the primary network the system will automatically continue navigation from the Very Low Frequency (VLF) Navy Worldwide Communication network. The VLF annunciator will illuminate any time VLF is providing the primary navigation signal. In the event that adequate signals are not available from at least three stations, the OMEGA system automatically goes into a dead reckoning (DR) mode of operation. As soon as adequate signals are again received, the OMEGA system automatically reverts to its normal mode of operation. The OMEGA system consists of the receiver-processor unit (RPU), control display unit (CDU) on the cockpit console, and antenna coupler unit (ACU). OMEGA waypoint navigation information is provided on the CDU and by the #2 needle of the #1 and #2 BDHI's, when selected. Selection is controlled by one pushbutton, TAC VOR/OMEGA (the other button, marked REL HDG/NO 2 PTR/DSR TK, is only a light indicator controlled by pilot side selection) switch near the #2 BDHI (copilot) and by three pushbutton switches near the #1 BDHI (pilot) (FO-5). The pushbutton switches illuminate when pushed to indicate the function selected. Both the pilot and copilot can select by the switch marked TACVOR/OMEGA either TACAN-VOR or OMEGA information for the #2 needle of the respective BDHI.

CAUTION

When the TAC-VOR/OMEGA switch is selected to the OMEGA position, the #1 needle bearing information is not reliable.

A second push button switch marked REL HDG/NO 2 PTR/DSR TK permits the selection of either relative heading or desired track information to be displayed by the #2 needle when OMEGA is selected by the pilot only. A third switch marked UTM/LAT-LONG by the pilot's BDHI permits selection of either UTM grid coordinates or latitude-longitude information for entry into the CDU. Power from the No. 3 primary ac bus is provided through two circuit breakers marked OMEGA NAV. The No. 3 primary dc bus provides power through a circuit breaker marked OMEGA NAV.

16.7.1 OMEGA Navigation Controls. The CDU (Figure 16-2) supplies data and instructions to the RPU via front panel keyboard controls and presents selected navigation information on the numeric displays. All operator controls, keyboard pushbuttons and displays are accessible at the CDU front panel. An operation status display consisting of a group of six annunciators is also provided on the front panel. Intensity of the displays is manually controlled by means of a front panel dimmer control. All operator-initiated tests and manual entry of navigation data are controlled from this unit.

16.7.1.1 Mode Selector Switch. The four-position mode selector switch provides power control, automatic and manual waypoint advance, and remote mode of operation. Switch positions and functions are:

1. OFF — Operating power is removed from system.

2. A (Automatic) — System is energized and provides an automatic waypoint advance mode in which equipment navigation between waypoints is performed sequentially, automatically changing indications in FROM-TO display. When the aircraft reaches a waypoint, the number in TO display shifts to FROM display, and the next waypoint number appears in TO display.

3. M (Manual) — System is energized and manual waypoint initialization is provided, enabling the operator to bypass or change waypoint manually to allow for flight plan alterations.

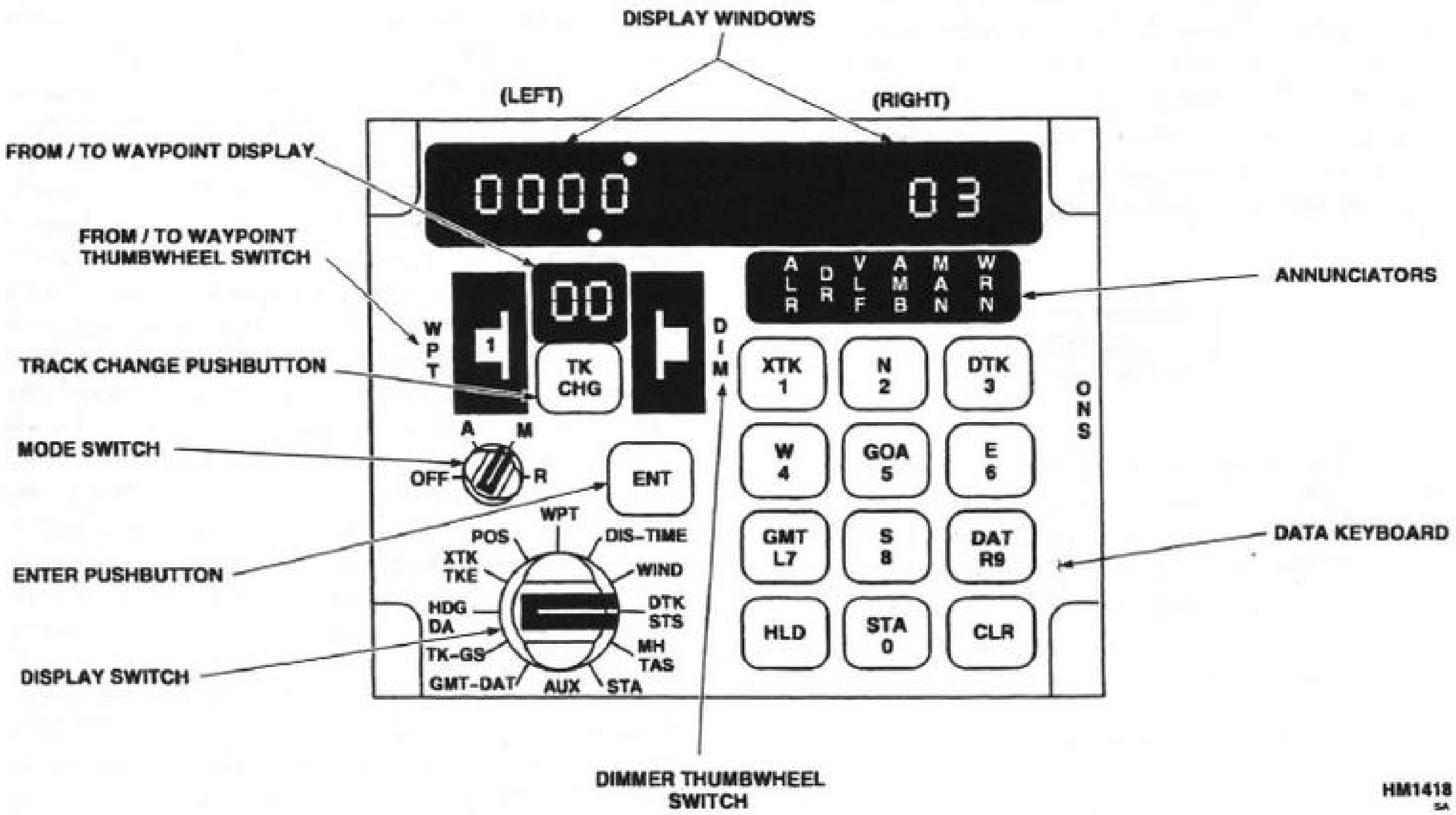


Figure 16-2. LTN-211 Control Display Unit

4. R (Remote) — Enables remote ranging features.

16.7.1.2 Display Selector Switch. The 12-position rotary display selector switch enables selection of navigation data and auxiliary functions for presentation on displays as follows:

1. GMT-DAT (Greenwich mean time and data) — Enables entry and presentation of current Greenwich mean time in left display and date (month, day, and year) in right display.

2. TK-GS (Track angle and ground speed) — Enables presentation of track angle with reference to north (0 to 359.9°) and ground speed (0 to 999 knots) in left and right displays, respectively. Ground speed indicates 0 until the landing gear scissors switch indicates weight off the wheels.

3. HDG DA (Heading and drift angle) — Enables presentation of aircraft true heading in left display and drift angle (L or R) from 0 to 39.9° in right display.

4. XTK TKE (Crosstrack distance and track angle error) — Enables presentation of crosstrack distance (L or R and 0 to 399.9 nm) in left display and track angle error (L or R and 0 to 180.0°) in right display. Crosstrack distance and track angle error read zero until a track leg has been inserted in the FROM-TO display.

5. POS (Present position) — Enables entry and presentation of the aircraft present position. The left display reads latitude and the right display reads longitude.

6. WPT (Waypoint positions) — Enables entry and presentation of coordinates of up to 9 waypoints corresponding to the digit on the WPT switch. In this position, the FROM-TO display will reflect WPT switch setting.

7. DIS-TIME (Distance and time to waypoint) — Enables presentation of distance from aircraft present position to next selected waypoint (from 0 to 999 nm) in the left display and time-to-go (from 0 to 999.9 minutes) in right display. Distance-to-go and time-to-go are blank unless a track change is entered. ETA in GMT is also available by pressing GMT on the data keyboard while at DIS-TIME.

8. WIND (Wind direction and speed) — Enables presentation of wind direction (from 0 to 359°) in left display and wind velocity in right display. If wind value exceeds 250 knots, a value of 999 will be displayed and malfunction code 05 will be present when display selector switch is set to DTK STS. Wind is not calculated for values of TAS below 100 knots or when the system is operating in the DR mode without manually entered ground speed and drift angle values.

9. DTK STS (Desired track angle and status/action codes) — Enables presentation of the computed desired track angle between the waypoints shown in the FROM-TO display in the left display when a track leg is inserted. If a track leg is not inserted, track angle will be zero. Also enables presentation of system status and action/malfunction codes in the right display.

10. MH TAS (Magnetic heading and true airspeed) — Enables entry and presentation of magnetic heading in left display and true airspeed in right display.

11. STA (Station status) — Enables presentation of the OMEGA transmitting stations which are in use and which have been deselected. A zero in any location, steady or flashing, is indication of deselection. Also enables presentation of station signal quality with manipulation of appropriate data pushbuttons.

12. AUX (Auxiliary functions) — Enables performance of various functions with selection of WPT switch settings:

0 - Relaning
Press 0 pushbutton
Press ENT pushbutton

1 - GS/DA entry

2 - Memory display

3 - Station frequencies being used (10.2, 13.6, 11.3 kHz)

4 - A number from 0 to 24 which is a quality index representing the system's estimate of position accuracy, 0 indicating best accuracy, 24 is displayed until navigation status 01 is reached. This function is used for test purposes only.

5 - VLF station status

6 - System operating on signals from two OMEGA stations. Designated by an R in left and right display. When more than two OMEGA stations are available, both left and right displays are blank.

7 - Spare

8 - Spare

9 - Display test

16.7.1.3 WPT Switch. With the display selector switch set to WPT, permits insertion of latitude and longitude data in waypoints 1 through 9 or selects display of coordinates of waypoints 0 through 9 for presentation on left and right numerical displays.

16.7.1.4 DIM Control. Controls light intensity of displays.

16.7.1.5 TK CHG Pushbutton. When pressed, allows entry of initial track leg and subsequent change of tract enroute.

16.7.1.6 ENT Pushbutton. Transfers data entered via the keyboard into the system computer.

16.7.1.7 Data Entry Pushbuttons. Standard keyboard (0 through 9 pushbuttons) allows manual entry of present position, waypoint coordinates, FROM-TO waypoints, time, date, track hold, crosstrack offset, wind, heading, true airspeed, and auxiliary functions.

16.7.1.8 HLD Pushbutton. A multifunction key that permits position check and update, display of action/malfunction codes, and waypoint editing.

16.7.1.9 CLR Pushbutton. Clears displayed data if not yet entered, and clears system if error is made in data entry routine.

16.7.1.10 Left and Right Numerical Displays. Display data selected by display selector switch.

16.7.1.11 FROM-TO and Waypoint Display (Located above TK CHG pushbutton). Displays FROM waypoint number and TO waypoint number of track leg being navigated. When display switch is set to WPT or AUX, the number selected by WPT switch is shown in the TO display.

16.7.1.12 Operation Status Display. Contains six individual annunciators which indicate operational status of the system as follows:

1. ALR (Alert) — Comes on when aircraft is 2 minutes from the selected TO waypoint. In automatic mode, goes out when a track leg change is made automatically. In manual mode, flashes 0.5 minute before reaching waypoint to indicate that track leg change must be made manually. The ALR annunciator will not come on below ground speeds of 100 knots.

Note

A corresponding OMEGA WPT ALERT light will illuminate on the Advisory Panel anytime the ALR annunciator illuminates on the CDU.

2. DR (Dead reckoning) — Comes on under the following conditions:

   a. At systems turn-on following entry of present position coordinates. Remains on until system NAV status (01) is achieved.

   b. Whenever OMEGA/VLF navigation capability is lost and remains on until NAV status is regained.

   c. During manually initiated relaning.

   d. The DR annunciator will not come on during power transfer when: the aircraft is on the ground, and NAV status is attained within 2 minutes after power transfer.

3. VLF (Very low frequency) — Comes on whenever the system is operating with signals from VLF stations as the primary navigation source.

4. AMB (Ambiguity) — Comes on whenever an OMEGA position ambiguity condition is detected and goes out when the ambiguity disappears.

5. MAN (Manual) — Comes on whenever a manual entry is made in true airspeed, magnetic heading, or crosstrack offset to indicate that the displayed values of these parameters have been manually entered. The annunciator remains on until the manual entries are set to zero.

6. WRN (Warn) — A steady WRN comes on to indicate that an OMEGA system failure has been detected by the integrity monitoring function. A flashing WRN annunciator occurs under the following conditions:

   a. Insufficient data input to system.

   b. Loss of true airspeed, magnetic heading, or both.

   c. Following a power interrupt of 7 seconds but less than seven minutes.

d. No synchronization within 3 minutes.

e. Failure of subassembly self-test.

Note

A corresponding OMEGA WARN light will illuminate on the Advisory Panel anytime the WRN annunciator illuminates on the CDU.

16.7.2 Normal Operation of the OMEGA Navigation System. The following procedures are applicable for operating the OMEGA navigation system (ONS) from the control display unit (CDU). The following information consists of pre-departure instructions to prepare the system for operation and inflight instructions for operation of the system in automatic, manual, and remote modes. Perform the operating procedures in accordance with these instructions and in the following sequence.

16.7.2.1 Pre-Departure Instructions. When activated, the system automatically initiates a self-test sequence, followed by automatic synchronization with the OMEGA station transmissions. Present position, time, and date must be entered and an initial track may be initiated by the operator prior to departure to obtain navigation data. True airspeed and heading inputs from the aircraft must also be provided for proper operation.

16.7.2.2 ONS Startup

1. Place the mode selector switch to the A or M position.

2. A 5-second automatic test display is provided. Verify that the left, right, and FROM-TO displays show 8s and that all six annunciators and the TK CHG, ENT, HLD, and CLR pushbuttons are lit.

3. Adjust DIM control for desired readout intensity.

16.7.2.3 Display Test. The display test enables the operator to verify that the CDU displays and computer controlled pushbuttons are operating correctly.

1. Place the display selector switch to the AUX position and the WPT switch to 9.

2. Verify that displays and pushbuttons are:

   a. Left display and FROM-TO display show 8s.

   b. Right display shows 8s except first character is an R.

   c. All decimal points in left and right displays are lit.

   d. All six annunciators in operation status display are lit.

   e. TK CHG, ENT, HLD, and CLR pushbuttons are lit.

   f. Verify DIM control varies lamp intensity of displays.

   g. Verify face plate is lit.

16.7.2.4 Present Position Entry. The aircraft's present position entry must be entered before omega navigation can be effected. In the following example, the aircraft's position is 33 degrees 54.6 minutes North latitude and 84 degrees 31.1 minutes West longitude.

Note

- The system is an alphanumeric system. All numeric entries must be preceded by a letter entry.
- If 1 OE or 2 OE, or flashing characters appear in data display, an operational error has been made. Press the CLR pushbutton and enter correct data.

Place the display selector switch to POS and the WPT switch to 0. Verify that left display reads 211 and right display reads 18 and the program dash number and the FROM-TO display reads 00. Enter present position as follows:

Press Push-button	Push-button Illumi-nated	Annun-ciator Illumi-nated	Left Display	Right Display
N2	ENT		N	
33546	ENT		33 54 6 N	18 04
ENT	ENT		33 54 6 N	000 00 0 E
W4	ENT		33 54 6 N	W
84311	ENT		33 54 6 N	84 31 1 W
ENT	ENT	DR	33 54 6 N	84 31 1 W

Note

The ENT pushbutton will remain illuminated until remaining initialization parameters (GMT and date) have been entered.

16.7.2.4.1 UTM Mode. Enter present position as follows:

Note

In the example, the aircraft position is at BKK ramp at north (northing) 1539.5 kilometers, grid zone 47 and east (easting) 674.5 kilometers.

1. Set display switch to POS and the aircraft UTM/LAT-LONG switch to UTM.

2. If previous stored position is accurate and aircraft has not moved, press ENT and proceed to TIME AND DATE ENTRY, otherwise proceed to step 3.

Note

- ENT remains on until remaining initialization parameters (GMT and date) are entered.

- A northing and easting entry of all zeros is not valid.

3. To start new northing entry procedure, press N or S (in this case, N).

4. Verify that left display blanks except for N and ENT is on.

5. Enter northing (1539.5 km) by pressing 1,5,3,9, and 5.

6. If northing display is correct, press ENT. If display is not correct, press CLR and repeat steps 3 through 6.

7. To start easting entry procedure, press E.

8. Verify that right display blanks except for E, and ENT is on.

9. Enter grid zone (47) by pressing 4 and 7.

10. Enter easting (674.5 km) by pressing 6, 7, 4, and 5. When 5 is pressed, the 4 of the grid zone (step 9) will not be displayed.

Note

The right display most significant digit will be blank or a 1 for the grid zones as follows:

GRID ZONES	DISPLAY
01-09	BLANK
10-19	1
20-29	BLANK
30-39	1
40-49	BLANK
50-59	1
60-	BLANK

11. If easting display is correct (7674.5E), press ENT. Verify that ENT goes off. If the easting is not correct, press CLR and repeat steps 6 through 10.

12. Verify grid zone entry by setting display switch to DTK STS and WPT switch to 0. Right display should display 47 as two most significant digits. If not, repeat steps 7 through 11.

16.7.2.5 Time and Date Entry. Greenwich mean time (GMT) must be entered into the receiver-processor unit (RPU) before propagation correction values can be calculated. In the following example the time is 0930 and the date is March 10, 1981.

Place the display selector switch to GMT-DAT and press the GMT L7 pushbutton. Verify that the left display blanks and that ENT pushbutton is still lit. Enter time and date as follows:

Press Push-button	Push-button Illumi-nated	Annun-ciator Illumi-nated	Left Display	Right Display
930	ENT	DR	930	000000
ENT	ENT	DR	930	000000
DAT R9	ENT	DR	930	
31081	ENT	DR	930	31081
ENT		DR	930	31081

Note

DR annunciator remains lit while the system transitions to the OMEGA mode (status 01). The RPU may update present position based on received omega station transmissions.

16.7.2.6 Waypoint Coordinates Entry. Coordinates for up to nine waypoints may be entered into the system, either while on the ground or in flight. Waypoints remain in the RPU until corrected or changed or are automatically cleared by placing the mode selector switch to OFF. Enter waypoint coordinates as follows:

Note

- The initial waypoint coordinates are entered into waypoint 1 unless a return to point of departure track is desired in which case the initial waypoint coordinates are entered into waypoint 2. Additional waypoint coordinates are then entered sequentially into subsequent waypoint storage locations.
- Unused waypoint storage locations may be used to enter alternate waypoint coordinates.

1. Place the display selector switch in the WPT position and set the WPT switch to 1. Verify FROM-TO display reads 1.

Note

Waypoint 0 is an automatic function that is reserved for establishing a track from the aircraft's present position and cannot be used to enter waypoint coordinates.

2. Enter initial waypoint coordinates per the instructions for entering present position entry except use initial waypoint latitude and longitude.

3. Verify that initial enroute waypoint latitude and longitude are displayed on left and right numerical displays, respectively.

4. Set WPT switch sequentially to remaining positions and enter corresponding enroute waypoint coordinates in the same manner as the initial enroute waypoint coordinates.

5. Position WPT switch to 1 through 9 and verify waypoint coordinates are correct.

Note

- An erroneous waypoint entry can be corrected, or an existing waypoint entry changed, by setting the WPT switch to the appropriate number and performing the entry procedures.
- The system also provides editing capability for inserting additional waypoints into the sequence. For example, an additional waypoint can be entered between existing waypoints 1 and 2 by entering it into waypoint 2, causing the existing waypoints 2 through 8 to shift automatically to become waypoints 3 through 9, and existing waypoint 9 to be deleted.

6. To insert an additional waypoint between two existing waypoints (for example between waypoints 1 and 2), proceed as follows:

a. Press HDL pushbutton; pushbutton lights.

b. Set WPT switch to desired number (in this case 2) and enter coordinates of new waypoint 2.

Note

ENT pushbutton comes on when N2 or S8 is pressed for latitude entry. Coordinates for both latitude and longitude must be entered.

c. Verify that entered coordinates are correct and press ENT pushbutton; pushbutton goes out.

d. Press HLD pushbutton; pushbutton goes out.

e. Rotate WPT switch sequentially to waypoints 3 through 9 and verify that waypoints have been resequenced.

7. A waypoint reversal feature is incorporated in the program allowing all or part of the route of waypoints to be reversed in sequence. This feature would be particularly useful, for example, in flying the round trip from the destination of the previous flight back to the point of origin. The waypoints previously entered will be recalled on power turn-on; waypoint reversal is accomplished as follows:

a. Set display switch to WPT and press HLD.

b. Press TK CHG and enter first and last waypoint numbers which are to be resequenced. If no numbers are entered, all contiguous waypoints beginning at WPT 1 will be resequenced.

c. Press ENT and then HLD.

d. Verify waypoint reversal by setting WPT switch to each position in which waypoints were entered.

Example: Enter TK CHG 1, 3

WPT Number	Normal Way-points	WPT Number	Reversed Way-points
1	N10°10.1′ W10°10.1′	1	N30°30.3′ W30°30.3′
2	N20°20.2′ W20°20.2′	2	N20°20.2′ W20°20.2′
3	N30°30.3′ W30°30.3′	3	N10°10.1′ W10°10.1′

16.7.2.7 Initial Track Selection. The initial track is the great-circle route between the aircraft's present position at the time the initial track is selected and the initial enroute waypoint. The operator must select and initiate the initial track as follows:

1. Press TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

2. Press STA 0 pushbutton, then the pushbutton representing the initial enroute waypoint.

3. Verify that FROM-TO display indicates 01 (the number of the waypoint selected).

4. Start initial track by pressing ENT pushbutton. Verify that ENT and TK CHG pushbuttons go out.

Note

Crosstrack distance and track-angle error (XTK TKE), distance and time to next waypoint (DIS TIME) and desired track angle (DTK) data are not available until a track leg is initiated. Also, flags controlled by ONS on aircraft instruments for ADI and HSI will not be pulled until an initial track is established.

16.7.2.8 System Status Check. The status of system operation is shown in the right numerical display when the display selector switch is placed in the DTK STS position. Action/malfunction codes, if present, are also displayed at this setting. System status is displayed as a two-digit code which starts at 90 when the system is turned on and decrements to 01 as follows:

STATUS CODE	SYSTEM STATUS
90	Self-test
80	Not up-to-temperature
60	Synchronization
30	Station Selection
03	Dead Reckoning
02	VLF NAV mode
01	OMEGA NAV mode

Note

DR annunciator will remain on during initial status countdown until status 01. Should the system fail to synchronize (not achieve 01 status), the problem may be due to local ground interference. Usually such interference is eliminated when the aircraft is moved. The NAV warning flag is in view until status 60 (synchronization) is achieved.

16.7.2.9 Error Detection. The system includes a complete program check on the operator. In the event the operator makes an error in data entry, the right display will show 1 OE and the CLR pushbutton will light. If data entry is incomplete, the right display will show 2 OE and the CLR pushbutton will light. A flashing display will indicate entry of unreasonable data. To correct the error, press CLR pushbutton and reenter the data.

16.7.2.10 Action/Malfunctions Codes. A solid WRN annunciator at any time, except during a display test, indicates that the system has failed and is no longer operative. A flashing WRN annunciator indicates failure of a subassembly, loss of aircraft inputs, or insufficient input data by the operator. With the display selector switch placed in the DTK-STS position, a system action code of 1, 2, or 3 will appear in the right numerical display to the left of the status code. Pressing the HLD pushbutton will result in the action code changing to a malfunction code associated with that action code. Repeated pressing of the HLD pushbutton will display any additional malfunction codes present. Action/malfunction codes are:

CODE	ACTION	MALF CODE	WARN
1-	Replace system	01 - Check summation failure 02 - Arithmetic, check failure 03 - Analog/digital converter failure 04 - Memory adder failure 05 - Data check failure 06 - Multiple inputs selected 07 - RF/Antenna failure	Flashes
2-	Manual data entry required	10 - Loss of TAS 11 - Loss of HDG 12 - Loss of TAS and HDG 13 - Power interruption >7 seconds 14 - No synchronization after 3 minutes (see NOTE 1) 15 - Initial data incomplete	Flashes
3-	Do not use for ADI or HSI	17 - No synchronization excitation for analog 18 - No steering excitation 19 - Synchronization No. 1 output failure 20 - Synchronization No. 2 output failure 21 - Synchronization No. 3 output failure 22 - Steering output failure 23 - Crosstrack DEV output failure	Off (see NOTE 2)

NOTE

1. No. manual entry required; system will automatically continue synchronizing.
2. Indication provided by aircraft instruments.

The flashing WRN annunciator can be eliminated and the action/malfunction codes blanked by pressing the CLR pushbutton after each code is displayed and then cycling through the codes a second time. For example, an action code of 2 and associated malfunction codes of 10 and 12 could be cleared as follows:

1. Set display selector switch to DTK STS to display action code 2.

2. Press HLD pushbutton to display malfunction code 10; then press CLR pushbutton.

3. Press HLD pushbutton to display malfunction code 12; then press CLR pushbutton.

4. Press HLD pushbutton to display 00.

5. Press HLD pushbutton to display action code 2.

6. Press HLD pushbutton repeatedly to recycle through the action/malfunction codes that were displayed.

7. Verify that the action/malfunction code positions on the right numerical display are blank each time the HLD pushbutton is pressed and that the flashing WRN annunciator has gone out.

To recall malfunction code, press the HLD pushbutton. 00 will appear. Press CLR pushbutton. Flashing WRN annunciator and action and malfunction codes will again be displayed by repeatedly pressing the HLD pushbutton.

16.7.2.11 OMEGA Station Status, Quality, and Deselection. The OMEGA station status display function shows the operator which stations are in use, which are available for use, which have been automatically deselected, and which have been manually deselected. Place the display selector switch in the STA position.

1. The display indicates the status of the received stations as follows:

DISPLAY	STATION STATUS
Steady station number	Station in use
Flashing station number	Available, not in use
Steady zero	Automatically deselected
Flashing zero	Manually deselected

2. The station identification displays from left to right are:

Left display:

1 - Norway, 2 - Liberia, 3 - Hawaii, USA,
4 - North Dakota, USA,

Right display:

5 - La Reunion, 6 - Argentina, 7 - Australia,
8 - Japan

3. Check station quality by pressing the pushbutton corresponding to the desired station. The quality (signal-to-noise ratio quality index) of each frequency for that station is displayed from left to right. Station No. 10.2 kHz, 13.6 kHz, 11.3 kHz.

4. Deselect a station as follows:

   a. Press STA 0 pushbutton. ENT pushbutton lights.

   b. Press the pushbutton(s) corresponding to the station(s) to be deselected. Verify that station(s) deselected indicates flashing 0.

   c. Press ENT pushbutton. Verify that ENT goes out and station(s) deselected indicates flashing 0.

5. Reselect a station as follows:

CAUTION

Pressing pushbuttons for stations which are not flashing zero will deselect those stations.

   a. Press STA 0 pushbutton. ENT pushbutton lights.

   b. Press the pushbutton(s) corresponding to station(s) to be reselected. Verify that station(s) reselected changes from flashing 0 to station number desired.

   c. Press ENT pushbutton. Verify that ENT goes out and station number reselected is lit.

Note

Stations which have been automatically deselected cannot be manually reselected.

16.7.2.12 VLF Station Status, Quality, and Deselection. The VLF station status function shows the operator the four stations available for use, stations which have been automatically deselected, and stations which have been manually deselected. Place the display selector switch in the AUX position and the WPT switch to 5.

1. The display indicates the status of the four received stations as follows:

Note

A change from flashing station number to a steady station number indicates acceptance of that station for navigation.

DISPLAY	STATION STATUS
Steady station number	Station selected for use
Flashing station number	Station interrogated for acceptance
Steady zero	Automatically deselected
Flashing zero	Manually deselected

2. The station identification displays from left to right are:

Left display:

1 - Helgeland, Norway, 2 - Rugby, England,
3 - Hawaii, USA, 4 - Washington, USA

Right display:

5 - Maryland, USA, 6 - Maine, USA,
7 - N. W. Cape, Australia, 8 - Yosami, Japan,
9 - Anthorne, England

3. Check station quality by pressing XTK 1 pushbutton. Signal quality (signal-to-noise ratio index) of each of the four nonzero stations are displayed in place of the station numbers. Press CLR pushbutton and the VLF station numbers will be restored.

4. Deselect a station as follows:

a. Press STA 0 pushbutton. ENT pushbutton lights.

b. Press the pushbutton(s) corresponding to the station(s) to be deselected. Verify that station(s) deselected indicates flashing 0.

c. Press ENT pushbutton. Verify that ENT goes out and stations(s) deselected indicates flashing 0.

5. Reselect a station as follows:

CAUTION

Pressing pushbuttons for stations which are not flashing zero will deselect those stations.

a. Press STA 0 pushbutton. ENT pushbutton lights.

b. Press the pushbutton(s) corresponding to the station(s) to be reselected. Verify that station(s) reselected changes from flashing 0 to a steady 0.

c. Press ENT pushbutton. Verify that ENT extinguishes and the reselected station(s) is indicated by steady 0.

Note

- Stations which have been automatically deselected cannot be manually reselected.
- Reselection of a VLF station does not mean it will necessarily be used for navigation (steady station number): if four stations are represented by steady digits, the reselected station(s) will remain steady zeroes. If the ONS computer is searching for available stations (flashing station numbers), it will eventually interrogate the reselected stations.

16.7.2.13 Inflight Instructions. Inflight operating instructions cover automatic and manual track leg change procedures, verification, and update of aircraft present position, bearing/distance checks between present position and waypoints, remote direct ranging between waypoints and from present position, remote ranging along flight plans, and manual entry of navigational parameters for manual and dead reckoning mode of navigation. During flight it is important to monitor the operation display to be aware of operational status of the system. In addition a periodic check of computed navigation information and aircraft input data should be performed.

16.7.2.14 Automatic Track Leg Change. In this mode of operation, the system sequentially navigates from waypoint to waypoint and automatically performs a track leg change when each waypoint is reached. As each track leg change is initiated, the system automatically calculates the true course between the two new waypoints. To operate in the automatic mode proceed as follows:

1. Place the mode selector switch in the A position. The FROM-TO display will indicate the waypoint being flown from and to respectively.

2. Two minutes before reaching the next waypoint, the ALR annunciator in the operation status display lights.

3. When the aircraft reaches the waypoint, the ALR annunciator extinguishes, the waypoint in the TO display shifts to FROM, and the next sequential waypoint automatically appears in the TO display.

16.7.2.15 Manual Track Leg Change. The manual mode enables track leg change procedures at any time to enable bypassing or changing waypoints manually to allow for flight plan alterations. In this mode the waypoints will remain in the FROM-TO display until a manual track leg change is performed. The operator may initiate a track leg change at waypoint bypass, and waypoint position changes as follows:

1. Track Leg Change at Waypoint:

   a. Place the mode selector switch in the M position. The FROM-TO display will indicate the waypoints being flown from and to, respectively (in this example, 0 1).

   b. Two minutes before reaching the waypoint, the ALR annunciator lights and 0.5 minutes before reaching the waypoint the ALR annunciator flashes.

   Note

   At this time the track change would have been made automatically if the CDU had been in the automatic mode of operation. If the track change is not made at this time, the ALR annunciator will continue to flash until a track change is made, and the aircraft will continue on the 0 1 track.

   c. Place the display selector switch in any position other than WPT or AUX.

   d. Press TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

   e. Press XKT 1, then N2 pushbuttons. Verify that FROM-TO display shows 1 2.

   f. Press ENT pushbutton. ENT and TK CHG pushbuttons and ALR annunciator go out and the FROM-TO display shows 1 2.

   Note

   The new desired track angle should be checked for reasonableness after the new track leg insertion is made.

2. Track Leg Change from Present Position:

   Note

   - In this example, the aircraft is enroute to waypoint 2 on track leg 1 2 and a decision is made to bypass waypoints 2 and 3 and go directly to waypoint 4.
   - When a track leg change from present position is inserted, a new WPT 0 (the present position of the aircraft when the insertion is made) is established.

   a. Place the mode selector switch in the A or M position.

   b. Place the display selector switch in any position other than WPT or AUX.

   c. Press the TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

   d. Press STA 0, then W4 pushbutton. Verify that FROM-TO display shows 0 4.

   e. Press ENT pushbutton. ENT and TK CHG pushbuttons go out and FROM-TO display shows 0 4.

Note

The new desired track angle should be checked for reasonableness after the new track leg insertion is made.

3. Waypoint Bypassing: The operator can bypass waypoints by initiating either a track leg change at a waypoint or a track leg change from present position.

4. Waypoint Position Change: The operator can change the coordinates of waypoints or use past waypoint storage locations for entering future waypoints. Enter waypoints as described in Waypoint Coordinates Entry, paragraph 16.7.2.7. Enter future waypoints sequentially starting with waypoint 1 storage location and continuing through last waypoint storage location used, since automatic track leg switching sequences from waypoint 9 back to waypoint 1.

CAUTION

Do not change coordinates of FROM or TO waypoints of track leg being flown.

16.7.2.16 Track Hold Mode. This mode of operation allows flight on a track referenced to north rather than on a track between waypoints. Perform track hold as follows:

1. Place the mode selector switch in the M position.

2. Place the display selector switch in the DTK STS position.

3. Press DTK 3 pushbutton. Verify that left display blanks and ENT pushbutton lights.

4. Press pushbuttons for desired track angle to the nearest tenth of a degree. Verify that left display is desired track entered.

5. Press ENT pushbutton to initiate track. Verify that ENT pushbutton extinguishes and FROM-TO display becomes 99. Check that DISTIME and XTK displays are all zeros.

6. To return to a waypoint-to-waypoint mode of navigation, initiate a track leg change from present position.

16.7.2.17 Position Check. The present position (POS) can be compared with an accurate position fix and updated in latitude and/or longitude at any time in flight or on the ground as follows:

1. Place the display selector switch in the POS position.

2. Press the HLD pushbutton. Verify that HLD pushbutton lights and present position and GMT displays are frozen.

Note

The system continues computing position changes resulting from aircraft movement during display freeze.

3. The display freeze allows for a comparison of the frozen position coordinates and the coordinates of the fix position and, since GMT is frozen, the time of the position check can be recorded.

4. To continue normal navigation, press the HLD pushbutton. Verify that the HLD pushbutton goes out.

16.7.2.18 Precision Position Update. If the present position displayed by the CDU is known to be incorrect and a known fix point (VOR, recognizable landmark, etc.) is available, the correct present position can be entered as follows:

1. On overflying a known fix point, press HLD pushbutton and compare position displayed on CDU to position of the fix point position.

2. If CDU displayed position agrees with the fix point position within 3 to 4 miles, press HLD pushbutton to continue normal navigation.

3. If CDU displayed position is in error by greater than 3 to 4 miles, perform the following:

   a. With mode selector switch set to M, and the display selector switch in the POS position, set the WPT switch in any position other than 0.

   b. Press pushbuttons to enter latitude of known fix point position. Verify that entered coordinates are displayed.

   c. Press ENT pushbutton. Unupdated latitude coordinates will reappear.

d. Press pushbuttons to enter longitude of known fix point position. Verify that entered coordinates are displayed.

e. Press ENT pushbutton. Unupdated longitude coordinates will reappear.

f. Press HLD pushbutton. Verify that HLD pushbutton goes out. The position displayed on the CDU will be updated to the currently derived position modified by the latitude and longitude difference between fix point coordinates and coordinates at the moment of overflight. Normal navigation will resume.

16.7.2.19 Nonprecision Position Update. If the present position displayed by the CDU is known to be incorrect and a precision position update cannot be performed because a known fix point is not available, a best-estimate present position can be entered if it is known to be within 60 nautical miles of actual present position. After the nonprecision position is entered, the system performs a relane operation using the OMEGA difference frequencies to determine present position. Perform the nonprecision position update as follows:

1. With the mode selector switch set to M, and the display selector switch in the POS position, record the present position.

2. Set WPT switch to 0, then press HLD pushbutton. Verify that HLD pushbutton lights.

3. Enter latitude and longitude of best-estimate present position. Verify that entered coordinates are displayed.

4. Press ENT pushbutton. Unupdated coordinates will reappear.

5. Press HLD pushbutton. HLD pushbutton goes out and updated present position will be displayed. Displayed position will change during relaning operation; final position display should be checked for reasonableness against position recorded in step 1.

16.7.2.20 Position Ambiguity. If the AMB annunciator on the operation status display lights, an OMEGA ambiguity (mislane) condition may exist with position errors resulting from it. Generally, such a condition will occur during sunrise or sunset periods or during abnormal signal disturbances caused by changing atmospheric conditions. No operator corrective action is recommended during these transition periods which usually last 15 to 20 minutes. During the ambiguity, the system enters the DR mode. Shortly after transition ends, the AMB and DR annunciators should extinguish and NAV status becomes 01. When ambiguity is not transition-related, proceed as follows:

1. To clear ambiguity, perform the following:

   a. With the mode selector switch set to M, place the display selector switch in AUX position and the WPT switch to 0. Verify that the FROM-TO display is 0 in TO position and most significant digit in right display is R.

   b. Press STA 0 then CLR pushbuttons. The AMB annunciator will extinguish in 15 seconds. If AMB annunciator goes out and remains out, ambiguity is cleared.

2. If ambiguity persists, perform the following in order:

   a. If known fix point is available, perform Precision Position Update, paragraph.

   b. If known fix point is not available but best-estimate present position (known to be within 60 nautical miles of actual present position) is available, perform Nonprecision Position Update, paragraph.

   c. If neither of the above is practical and present position displayed is known to be within 60 nautical miles of actual present position, perform a relane procedure as follows:

      (1) Place the display selector switch in AUX position and the WPT switch to 0. Verify that the FROM-TO display is 0 in TO position and most significant digit in right display is R.

      (2) Press STA 0 then ENT pushbuttons. The DR annunciator will light and the AMB annunciator will go out. The DR annunciator will go out when normal OMEGA/VLF navigation begins.

Note

VLF navigation is inhibited during relaning procedures and for 3 minutes after returning to NAV mode.

16.7.2.21 Cross-Track Offset Mode. To fly the aircraft on an offset track parallel to the present track, perform the following:

Note

The system must have an active track leg showing in the FROM-TO display.

1. Place the display selector switch in the XTK TKE position.

2. Press the XTK 1 pushbutton. Verify that left display blanks and ENT pushbutton lights.

3. Enter desired offset track to nearest tenth of a nautical mile. If L5.3NM is desired, for example, press GMT L7, GOA 5, and DTK 3 pushbuttons (or DAT R9, GOA 5, and DTK 3 for R5.3NM). Verify that left display is the desired offset track entered.

4. Press ENT pushbutton. Verify that left display returns to what it was prior to insertion of desired offset track and MAN annunciator lights. Turn in the direction of the offset track.

5. As the aircraft is turned, in the direction of the offset track, these events will occur:

a. As the turn progresses, track angle error in right display, steadily increases from value prior to offset track insertion and crosstrack distance in left display increments towards inserted offset distance.

b. As the offset distance is approached, the aircraft is turned to follow the desired offset track.

c. As this turn progresses, the track angle error in right display steadily decreases to zero and the left display shows desired offset distance from original track.

Note

The inserted offset track can be displayed by setting the mode selector switch to R with display selector switch in XTK TKE. The crosstrack offset remains in effect until removed by the operator.

6. To return to original track, place the display selector switch in the XTK TKE position and press XTK 1 pushbutton, then GMT L7 or DAT R9 and ENT pushbuttons.

Note

An entered offset track is automatically removed when an O-X track leg is entered.

16.7.2.22 Remote Direct Ranging Between Waypoints. The direct great-circle distance, time, and desired track angle between any two waypoints can be computed and displayed at any time after status 60 is attained as follows:

Note

Normal track calculations continue uninterrupted and the ALR annunciator and track leg change output functions as though the mode selector switch were set to A during the displays.

1. Place the display selector switch to DIS-TIME and the mode selector switch to R. Verify the FROM-TO display starts flashing.

2. Press the TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

3. Press pushbuttons corresponding to the two desired waypoints. Verify that FROM-TO display is the two selected waypoints.

4. Press the ENT pushbutton. Verify that ENT and TK CHG pushbuttons extinguish and FROM-TO display flashes.

5. The direct great-circle distance between the two selected waypoints is displayed on the left display and the time between the selected waypoints is displayed on the right display.

6. Place the display selector switch in the DTK STS position. The desired track angle between the two selected waypoints is displayed on the left display and system status is displayed on the right display.

7. Place the mode selector switch in the A or M position to return the system to normal operation.

16.7.2.23 Remote Ranging Along Flight Plan. The cumulative distance, time, and track angle along the flight plan from present position to any waypoint can be computed and displayed at any time after status 60 is attained as follows:

Note

Normal track calculations continue uninterrupted and the ALR annunciator functions as though the mode selector switch were set to A during the displays.

1. Place the display selector switch to DIS-TIME and the mode selector switch to R. Verify the FROM-TO display starts flashing.

2. Press TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

3. Press STA 0 pushbutton, then desired waypoint pushbutton. Verify that FROM-TO display is the two selected waypoints.

4. Press the ENT pushbutton. Verify that ENT and TK CHG pushbuttons go out and FROM-TO display flashes.

5. Total distance along the flight plan between the present position and the selected waypoint is displayed on the left display and the time from present position to selected waypoint (following flight plan) is displayed on the right display.

6. Press GMT L7 pushbutton and the time to go is replaced with the estimated time (GMT) of arrival (ETA) at selected waypoint (following flight plan). Press GMT L7 pushbutton again and time to go is restored.

Note

ETA is available only when either TO or FROM display is 0.

7. Place the display selector switch in the DTK STS position. The desired track angle based on the great-circle route to the selected waypoint from the present position will be displayed on the left display and the system status is displayed on the right display.

Note

With tracks O X or X O (where X is desired waypoint), distance and time will change as the flight progresses.

8. Place the mode selector switch in the A or M position to return the system to normal operation.

16.7.2.24 Remote Direct Ranging from Present Position. The direct great-circle distance, time and desired track angle from present position to any waypoint can be computed and displayed at any time after status 60 is attained as follows:

Note

Normal track calculations continue uninterrupted and the ALR annunciator functions as though the mode selector switch were set to A during the displays.

1. Place the display selector switch to DIS-TIME and the mode selector switch to R. Verify that FROM-TO display starts flashing.

2. Press TK CHG pushbutton. Verify that TK CHG and ENT pushbuttons light.

3. Press pushbuttons for desired waypoint, then STA 0 pushbutton. Verify that FROM-TO display is the two selected waypoints.

Note

Always press the number of the waypoint to which distance, time, and track angle are desired first, and then 0 for present positions to obtain direct great-circle distance between the two points.

4. Press ENT pushbutton. Verify that ENT and TK CHG pushbuttons go out and FROM-TO display flashes.

5. The direct great-circle distance between present position and the selected waypoint is displayed on the left display and the time from the present position to the selected waypoint is displayed on the right display.

6. Press GMT L7 pushbutton and the time to go is replaced with the estimated time (GMT) or arrival (ETA) at selected waypoint (flying direct). Press GMT L7 pushbutton again and time to go is restored.

Note

ETA is available only when either TO or FROM display is 0.

7. Place the display selector switch in the DTK STS position. The desired track angle from present position to selected waypoint will be displayed on the left display and the system status is displayed on the right display.

Note

With tracks O X or X O (where X is desired waypoint), distance and time will change as the flight progresses.

8. Place the mode selector switch in the A or M position to return the system to normal operation.

16.7.2.25 Manual Entry of Heading and True Airspeed (MH TAS). When a flashing WRN annunciator is displayed in the operation status display and interrogation of the system results in an action code of 2 and a malfunction code of 10, 11, or 12, true airspeed, true heading, or both must be manually entered as follows:

CAUTION

Failure to enter manual HDG and TAS after sensor data has been lost will affect navigation accuracy.

1. Manual True Airspeed Entry.

   a. With mode selector switch set to M, place the display selector switch in the MH TAS position.

   b. Press DAT R9 pushbutton. Verify that right display blanks and ENT pushbutton lights.

   c. Enter aircraft true airspeed (10 to 650 knots) to the nearest knot and press ENT pushbutton.

   d. Verify that entered data is correct, ENT pushbutton and flashing WRN annunciator extinguish, MAN annunciator lights, and right display flashes.

   e. Update as required for aircraft true airspeed changes.

   f. When manual true airspeed entry is no longer required (aircraft is providing input), repeat steps a, b, and c except enter zeroes. MAN annunciator will extinguish and system will resume using aircraft input.

2. Manual True Heading Entry.

   a. With mode selector switch set to M, place the display selector switch in the MH TAS position.

   b. Press GMT L7 pushbutton. Verify that left display blanks and ENT pushbutton lights.

   c. Enter aircraft heading (zero to 359.9°) to the nearest tenth of a degree and press ENT pushbutton.

   d. Verify that entered data is correct, ENT pushbutton and flashing WRN annunciator extinguish, MAN annunciator lights, and left display flashes.

   e. Update as required by changes in aircraft heading.

   f. When manual heading entry is no longer required (aircraft is providing input), repeat steps a, b, and c except enter zeroes. MAN annunciator will go out and system will resume using aircraft input.

16.7.2.26 Manual Entry of Wind (WIND). (Used in DR mode only.) The accuracy of DR navigation can be improved by manually entering wind direction and speed, which are not calculated in the DR mode. Manually enter wind direction and speed as follows:

CAUTION

Manual entry of wind parameters should not be made if the system is in the omega navigation mode (status 01) since navigation accuracy could be affected.

1. Verify that DR annunciator is on (system is in DR mode, status 03).

2. With mode selector switch set to M, place the display selector switch to WIND.

3. Press GMT L7 pushbutton. Verify that the left display blanks and ENT pushbutton lights.

4. Enter wind direction to the nearest degree.

5. Verify that left display shows entered value and press ENT pushbutton.

Note

Both wind direction and speed must be entered before ENT pushbutton will go out.

6. Press DAT R9 pushbutton and verify that right display blanks.

7. Enter wind speed to nearest knot.

8. Verify that right display shows entered value and press ENT pushbutton.

9. Verify that ENT pushbutton goes out and that displays indicate the entered values.

10. When OMEGA navigation is resumed, these values will be automatically updated based on received OMEGA data.

16.7.2.27 Manual Entry of Drift Angle and Ground Speed (DA and GS). (Used in DR mode only.) The accuracy of DR navigation can be maintained by periodically updating drift angle and ground speed. Manually enter drift angle and ground speed as follows:

1. Verify that DR annunciator is on (system is in DR mode, status 03).

2. With the mode selector switch set to M, place the display selector switch to AUX and the WPT switch to 1.

3. Press GMT L7 pushbutton. Verify that the left display blanks and the ENT pushbutton lights.

4. Press DAT R9 or GMT L7 pushbutton to indicate drift angle is right or left track.

5. Enter drift angle to nearest tenth of a degree. Verify that left display shows entered value and press ENT pushbutton.

Note

- Both drift angle and ground speed must be entered before ENT pushbutton will go out.
- Drift angle must be less than 39.9°.

6. Press DAT R9 pushbutton and verify that right display blanks.

7. Enter ground speed to nearest knot. Verify that right display shows entered value and press ENT pushbutton. ENT pushbutton will go out.

8. Verify that entered data is correct and that value of calculated wind is reasonable.

9. When OMEGA navigation is resumed, these values will be automatically updated based on received OMEGA data.

16.7.2.28 Power Interrupt. The system retains all data essential to resuming automatic operation after a power loss of up to 7 minutes. During a power interrupt, all displays will be blank. When power is restored, resume normal operation of the system in accordance with the following instructions:

1. When power is restored after a failure of less than 7 seconds:

   a. The DR annunciator will light.

   b. System status will be 60 or 30.

   c. System resumes operation in DR navigation mode using retained navigation data.

   d. Synchronization process automatically decrements to 01 status, navigation in the OMEGA mode is resumed, and the DR annunciator goes out.

2. When power is restored after a failure of more than 7 seconds and less than 7 minutes:

   a. The DR annunciator and HLD pushbutton will light.

   b. The action code will be 2 and the system status will be 60 to 30.

   c. System resumes operation in DR navigation mode using retained navigation data.

d. The system decrements to OMEGA station selection and remains in DR navigation mode.

e. The operator will:

(1) Update GMT (and date if required).

(2) Update present position if estimated present position has changed by more than 8 miles.

(3) Press HLD pushbutton.

3. When power is restored after a failure of more than 7 minutes:

a. The system is automatically put in the hold mode from the time power is restored.

b. The action code will be 2 and the system status will be 90, 80, or 60.

c. The operator will:

(1) Update GMT (and date if required).

(2) Update present position if estimated present position has changed by more than 8 miles.

(3) Press HLD pushbutton.

16.7.2.29 ONS Shutdown. To shut down the system, place the mode selector switch to OFF position.

16.8 GLOBAL POSITIONING SYSTEM (GPS) (AFTER INCORPORATION OF AFC 453)

WARNING

Use of GPS for approaches is not authorized at this time.

The CH-53E GPS Navigation Set is a world-wide, all-weather, navigation aid that receives and processes navigation information from NAVSTAR GPS satellites. GPS is a space-based radio positioning system that provides its user with highly accurate position, velocity, and time data. This service is provided globally, continuously, and under all weather conditions to users. GPS receivers operate passively, thus allowing an unlimited number of simultaneous users. The GPS has features which can deny accurate service to unauthorized users, prevent spoofing and reduce receiver susceptibility to jamming.

The GPS comprises three major segments, Space, Control, and User. The Space segment consists of a constellation of GPS satellites in semi-synchronous orbits around the earth. Each satellite broadcasts radio-frequency (RF) ranging codes and a navigation data message. The Control segment consists of a Master Control Station (MCS) and a number of monitor stations located around the world. The MCS is responsible for tracking, monitoring, and managing the satellite constellation and for updating the navigation data messages. The User segment consists of a variety of radio navigation receivers specifically designed to receive, encode, and process the GPS satellite ranging codes and navigation data messages.

The ranging codes broadcast by the satellites enables a GPS receiver to measure the transit time of the signals and thereby determine the range between a satellite and the user. The navigation data message enables a receiver to calculate the position of each satellite at the time of transmission of the signal. Four satellites are normally required to be simultaneously "in view" of the receiver for three-dimensional (3-D) positioning purposes. This allows the user 3-D position coordinates and position data. Treating the user clock offset as an unknown eliminates the requirements for users to be equipped with precision clocks. Less than four satellites can be used if the user altitude or system times are precisely known, or if altitude or time is not required to be determined. The CH-53E GPS system provides a 2-D solution and does not provide altitude.

The CH-53E GPS Navigation Set consists of the following components:

1. Satellite Signals Navigation Set.
2. Antenna Amplifier (AE-4).
3. Fixed Reception Pattern Antenna (FRPA-3).
4. GPS Signal Data Converter (SDC).
5. GPS Mission Data Loader (MDL).
6. Cryptographic Variable Loader (CVL) (Fill Port).
7. GPS Control Display Navigation Unit (CDNU).

16.8.1 Common GPS Equipment

16.8.1.1 Satellite Signals Navigation Set AN/ARN-151 GPS Receiver. The R2332E/AR, is a five channel GPS receiver capable of tracking the GPS signal in a high dynamic maneuvering environment. The receiver contains the receiver/signal processor, data processor, interface and power supply functions. The receiver tracks and processes the GPS signal from the antenna subsystem and provides position, velocity and is installed in the right equipment bay fuselage station (FS) 136. The receiver is powered by the number 3 primary 115VAC Bus and is protected by the GPS 3ARCVR circuit breaker located on the right cabin circuit breaker panel.

Four satellites with the proper geometric dilution of precision are required for the receiver to provide accurate navigation information in three dimensions. In addition to these satellites, the receiver's fifth channel is continually monitoring other satellites in the constellation in an effort to optimize the tracking geometry and to provide a backup for the loss of tracking of a satellite.

16.8.1.2 Antenna Amplifier (AE-4). The AM-7314/URN receives two satellite signals from the antenna. The signal is received as Link 1 (L1) and Link 2 (L2) radio frequency (RF) signals and supplies these signals to the navigation receiver. The amplifier amplifies and downconverts L1/L2-RF signals into separate L1 and L2 intermediate frequency (IF) signals. The L1 signal contains the coarse acquisition (C/A) code and the L2 signal contains the precision (P) code. When the P code is encrypted it becomes a Y code. Encryption is done by using the KYK-13 or by pilot inputs.

16.8.1.3 Fixed Reception Pattern Antenna (FRPA-3). The AS-3822/URN FRPA-3 is a low profile microstrip antenna that provides omnidirectional coverage to receive right-hand circularly polarized signals radiated from the NAVSTAR GPS satellites. It provides simultaneous reception of the L1 and L2 GPS navigation signals which are routed through a single coaxial cable to the receiver. The FRPA-3 relies on the aircraft to provide the essential ground plane for the antenna. The FRPA-3 is a non-repairable, passive unit requiring no power, adjustment or controls to function. The FRPA-3 antenna is installed at FS-689.

16.8.1.4 GPS Signal Data Converter (SDC). The CV-4138/A SDC is a digital-to-analog converter designed to drive analog flight instruments with navigation information derived from the GPS. The SDC receives digital range, bearing, course deviation information and flight mode status from the CDNU via an ARINC 429 digital data bus and converts the digital information to synchro, analog, and discrete signals. The GPS-driven flight installations in the CH-53 consist of the pilots and copilots number 2 needles, Distance Measuring Equipment (DME) window on the Bearing Distance Heading Indicator (BDHI), and the vertical bar on the Course Indicators (CI). The GPS, TACAN or other radio navigation information displayed on these instruments is selected using the switches on the pilot's and copilot's CI and BDHI select switch panels.

The SDC and mount are installed in place of the TACAN Data Analog Converter, FS 145. The SDC receives 115VAC from the number 1 primary AC bus, 26VAC from the number 3 primary AC bus and 28VDC from the number 1 primary DC bus. The circuit breakers are labeled GPS SDC and are located on the left and right cabin circuit breaker panels.

16.8.1.5 Mission Data Loader (MDL). The AN/ASQ-215 MDL is designed to provide nonvolatile bulk memory storage for military aircraft parameters, waypoints database, maintenance, and avionics initialization data. It consists of the CP-2092(P)/A Interface Receiver Unit (IRU) and a MU-1053/A data Transfer Module (DTM). The IRU interfaces with the CDNU as a receiver/transmitter on the MIL-STD-1553B bus and is fixed in the aircraft. The removable DTM contains the data which is accessed by the CDNU. The CDNU's Operational Flight Program (OFP) can be downloaded or verified from the MDL at the CDNU via the MIL-STD-1553B bus.

The MDL provides the aircrew with the ability to transfer flight plans, current GPS almanac data, and an extensive waypoint database to the aircraft to be used by the CDNU and GPS receiver. Information may be retrieved from the MDL prior to, or during flight. The MDL is designed to interface with a Tactical Aircraft Mission Planning Station (TAMPS) which is used by a variety of Naval aircraft. The MDL is installed in the equipment rack, left side FS 191. The MDL receives 28VDC from the number 1 primary DC bus. The circuit breaker is located on the left cabin circuit breaker panel.

16.8.1.6 Cryptographic Variable Loader/Control (CVL/CVC) (Fill Port). The C-12094/AR allows a cryptographic key from a KYK-13A to be loaded into the receiver. These keys are required to enable precision GPS navigation during times when SA and/or AS is enabled. The CVL is interfaced with the receiver cryptographic interface port and several discrete interfaces. The CVL consists of a load connector with dust cap, status light, and zeroization switch and is installed in the equipment rack.

16.8.1.7 Control Display Navigation Unit (CDNU). The C-12284/A CDNU control unit has two knobs and 67 keys. The knob to the right of the indicator screen is the power switch. It controls power to the CDNU. The BRT knob is to the left of the indicator and controls brightness of the indicator screen.

There are 67 keys on the control/display panel divided as follows (refer to Figure 16-3): There are four lines select (L/S) keys, on each side of the display. There are eight special function keys. There are 26 keys in the alphabetic keyboard, and they consist of three punctuation keys, seven standard function keys, a CLR (clear) key, four slew or cursor keys and 10 keys in the numeric keyboard.

1. The numeric and alphabetical keyboards, and the punctuation keys are used to formulate data for entry into the system. All values are presumed to be positive unless the negative (-) key, also called the delete key, is used to indicate otherwise. Some locations require that data contain a slash (/) or decimal point/period (.). The first key pressed is the character in the left position, with subsequent key presses sequentially taking successive positions toward the right. When more key presses are made than the number of spaces available, the latest key presses are ignored. When an attempt is made to input improperly formulated date (too long, improperly punctuated or signed, etc.), an error message appears. A single press of the clear key deletes the latest character added to the data formulation. A second press of the clear key deletes all the data formulation in the scratchpad.

2. The standard function keys are used to initiate the functions shown on the face of the key. See CDNU Page Tree (Figure 16-4).

a. The CLR function key allows the aircrew to eliminate certain information from the screen. When data is keyed into the scratchpad, one press will delete the latest character keyed; a second press will delete the entire block of data in the scratchpad. If there is data in the scratchpad that was not keyed in, but was generated there by other means (such as the Mark key), one press of the CLR function key will delete all of that data.

b. The IDX function key allows the aircrew to select one of eight control functions. The eight functions are start, zeroize, system text, MDL, mark list, hold, intercept and power.

c. The STAT function key allows the aircrew to perform a GO/NOGO self test of the CDNU system when there is no Operational Flight Program (OFP) installed. When the OFP is installed the STAT key allows the aircrew to view the status of the system units. These include the MDL, GPS, SDC, CDNUs and DAC.

d. The FPLN allows the aircrew to view the flight plan. Data available includes the title or location of the present point of navigation, desired inbound course, assigned altitude, planned time of arrival and operational selections of navigation controls.

e. The DIR function key is used to quickly insert a new immediate point of navigation into the flight plan. Any point keyed into the scratchpad or any waypoint presently in the flight plan may be entered into the brackets on the data line as the new To-waypoint.

f. The PROG function key is used to access the three progress pages. Page one displays an estimate of actual flight plan horizontal performance. Page two is not used. Page three displays raw aircraft flight data.

g. The MARK function key allows the aircrew to record the best estimate of aircraft position at an instant in time. Pressing the MARK key inserts the system present position estimate at that instant into the scratchpad of the page showing. The aircrew may then discard this information, they may insert it into the flight plan, or may insert it into the mark list or any of the Intercept pages.

h. The RNAV function key is used to access the latest RNAV page to be viewed. There are only two pages in the CDNU as delivered. This page allows the aircrew to view the present position estimates.

3. The Special function Keys access a display showing the function that is initiated by pressing each of the other special function (F1 through F7) and Menu Keys. The F1 through F6 keys are intended to initiate special functions that are not used at this time. At present only the F7 and Menu keys are implemented. The F7 key toggles between "Copy What?" and "Data For?". The Menu function key allows the aircrew to view the functions initiated by pressing the special function key and to gain access to the Model Aircraft page.

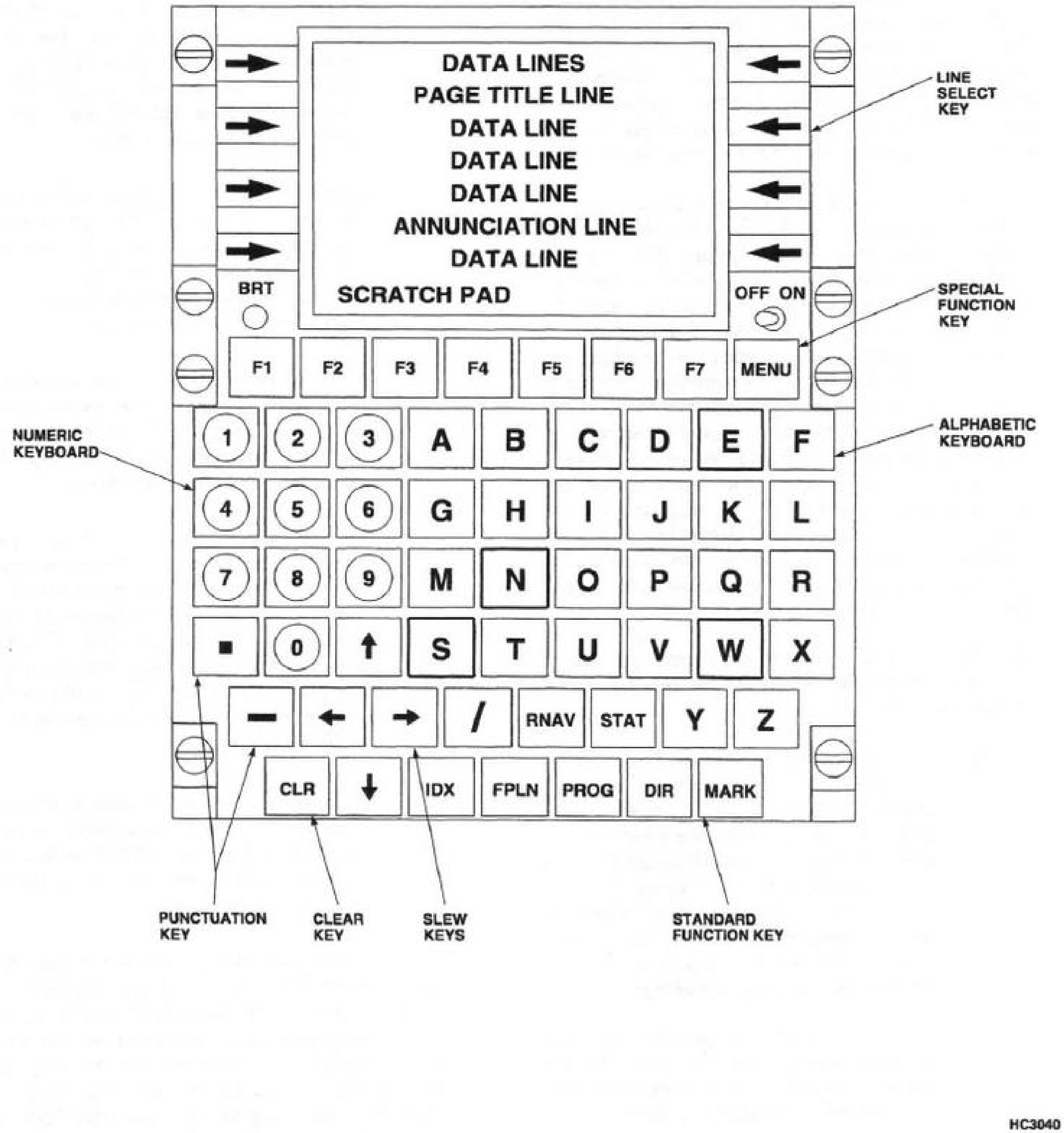


Figure 16-3. Global Positioning System Control Display Navigation Unit (CDNU)

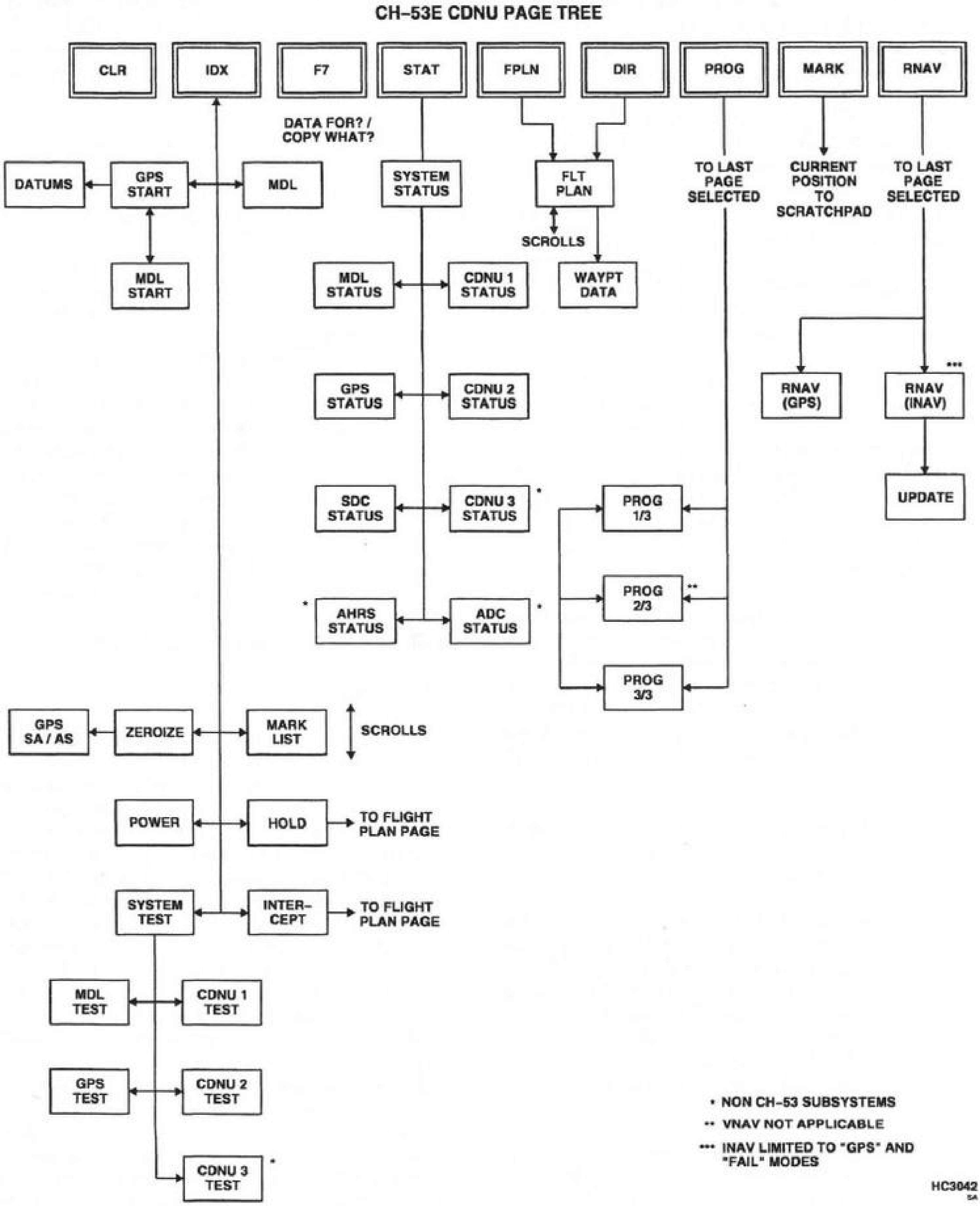


Figure 16-4. CDNU Page Tree

4. The Slew Keys (▲, ▼, ◀, and ▶) provide a means of scrolling through the lists and pages of data. The ▲ and ▼ keys cause data on certain lists to shift one data line at a time in the appropriate vertical direction. The intercept pages and the RNAV pages may be horizontally scrolled using the ◀ and ▶ keys. (When additional pages are available, an arrow will appear in the lower left corner of the screen.)

5. The Line Select Keys are numbered 1 through 4 on the left side of the display, and 5 through 8 on the right side of the display. Line select keys may be used to enter operator-formulated data, to toggle a mode that is displayed on the corresponding data line, or to access a subordinate page.

6. The CDNU Indicator Screen displays data in eight display lines. Display lines are numbered from the top to the bottom of the screen in ascending order and are 22 characters long. Each display line may be further divided into data fields of varying lengths. The CDNU has ten standard display symbols as shown in Figure 16-5. When the indicator screen displays a symbol it is prompting the operator to perform a function or is providing information.

a. The odd-numbered display lines are adjacent to the line select keys. The operator may use the line select keys (and the display lines adjacent to them) to enter data into the system. The odd-numbered display lines are also known as data lines and are numbered from top to bottom on the screen in descending order.

b. Data on the even-numbered display lines is used to communicate system information to the operator.

c. Display line 2 is called the Title Line. The operator may read the title of the page displayed at the center of the title line. If there is more than one page with that title, a page number will appear (example 8/12). Other symbols (▼ TO, ▼, ▲ INAV ▲, ▲ PRI ▲, TRK, MDR, etc.) that pertain to data on data line 1 or data line 2 may be displayed on the ends of the title line.

d. Display line 4 is called the information line. The information line displays symbols that pertain to data on data line 2 or data line 3, or miscellaneous information that does not belong on one of the other lines.

e. Display line 6 is called the Annunciation Line. Annunciations of a higher priority blink. The annunciation ENTER TIME is commonly seen after power-up and before the GPS begins supplying data.

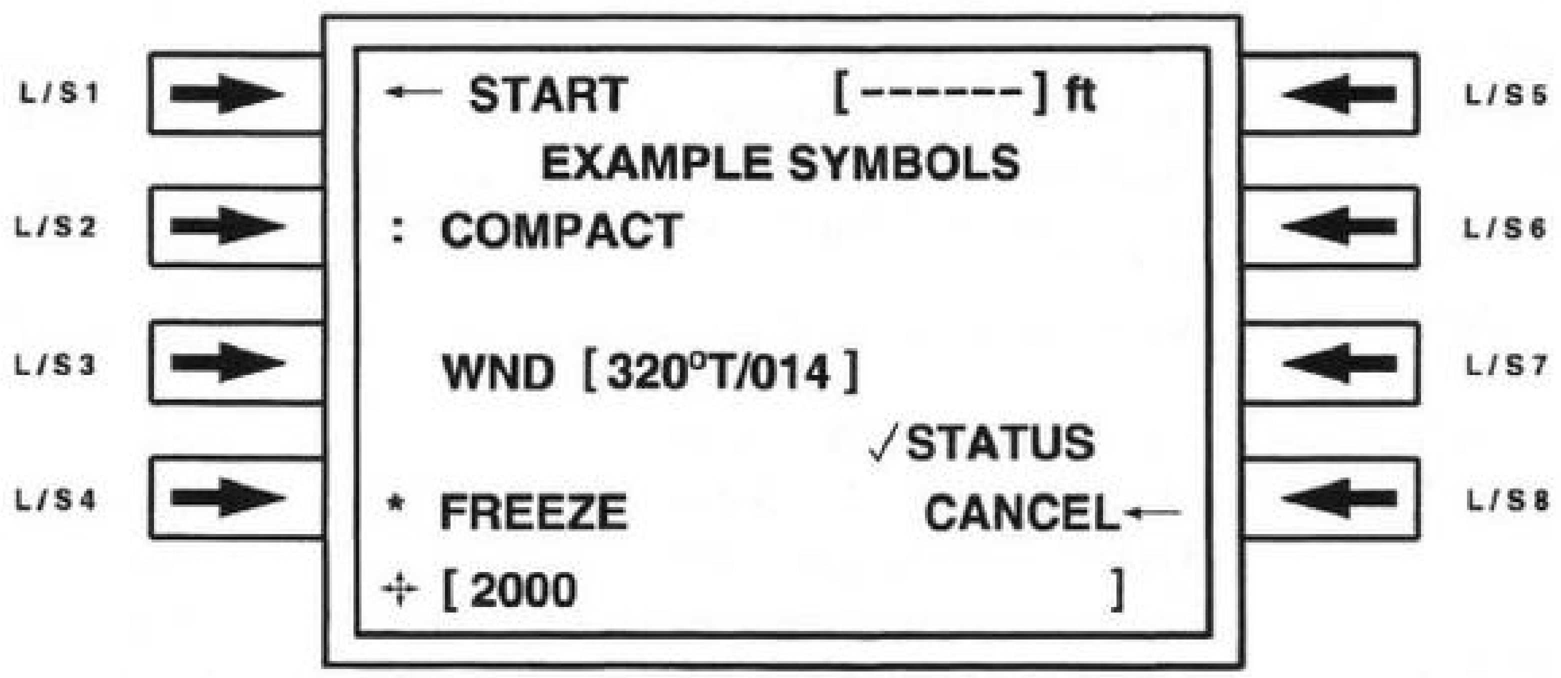
f. Display line 8 (at the bottom of the screen) is called the Scratchpad. The limits of the scratchpad are delineated by brackets [ ]. The scratchpad displays data being formulated by the operator and/or messages pertaining to it. Scratchpad messages are listed in the Alphanumeric List of Scratchpad Message table (Figure 16-6). Data keyed on the alphabetic keyboard, numeric keyboard, or any of the symbol keys appears in the scratchpad in the order of selection. Messages that assist the operator with normal operations are displayed during the part of the operations to which they apply. Messages of a higher priority blink. When the operator attempts to enter an out-of-tolerance value or quantity, the scratchpad displays a message indicating why it rejected the entry. This message alternates with the out-of-tolerance data in the scratchpad.

16.8.2 GPS Basic Operating Modes

1. Initialize.

The initialization process provides the information to the AN/ARN-151 that is the basis for satellite acquisition. The system must be initialized before it will function. Initialization occurs once power is applied to the system. The process is automatic with the necessary information coming from the critical memory, which is stored in the radio receiver. During operation, the GPS collects and stores the satellite almanac data in critical memory. The almanac data is normally available when the GPS is first turned on and provides information about location, time and date of the satellites. The batteries in the AN/ARN-151 provide electrical power to hold the almanac data in critical memory, when electrical power is removed from the aircraft. The GPS operator may input information about the GPS position, time and velocity to enhance the information in critical memory. With this information, the GPS determines which satellites are available and searches for the code sequence that identifies the appropriate number of satellites, it switches to the more accurate P code, collects the navigation data message and updates the critical memory. If critical memory is lost the GPS will search for satellite number 6 for 6 minutes. (Note:

CDNU STANDARD DISPLAY SYMBOLS



---- NO COMPUTED DATA IS AVAILABLE OR MEANINGFUL, OR POWER IS OFF

[ ] DATA ENTRY FROM SCRATCHPAD IS POSSIBLE / REQUIRED

↕ VERTICAL PAGE OR LINE SCROLLING POSSIBLE

✛ LATERAL OR VERTICAL PAGE SCROLLING IS POSSIBLE

→ PUSHING THE LINE SELECT L / S KEY WILL ACCESS A DIFFERENT PAGE (POINTING TO KEY)

← PUSHING THE LINE SELECT L / S KEY WILL SELECT THE ITEM OR ENABLE THE MODE (POINTING AWAY FROM KEY)

* FUNCTION IS ON OR ENABLED

: PUSHING APPROPRIATE L / S TOGGLES ALTERNATE SELECTION AMONG MODES

√ CHECK – √ STATUS FOR EQUIPMENT FAILURES

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Figure 16-5. CDNU Standard Display Symbols

MESSAGE	MEANING	RESET BY
✓GPS POWER (alternate)	Trying to operate GPS with power disabled on POWER page.	CLR key.
✓GPS STATUS (alternates)	GPS is on and has an internal failure.	CLR key.
✓MDL STATUS (alternates)	MDL is off, or MDL is on and has an internal failure.	CLR key.
CONFIRM ERASE FPLN (blinks)	Request to erase flight plan.	Reselect function, or CLR key.
CONFIRM ERASE WPTS (blinks)	Request to zeroize CDNU waypoints.	Reselect function, or CLR key.
CONFIRM LOAD ALM (blinks)	Request to load GPS almanac data.	Reselect function, or CLR key.
CONFIRM LOAD FPLN (blinks)	Request to load operational flight program.	Reselect function, or CLR key.
CONFIRM LOAD WPTS (blinks)	Request to load local waypoint data base.	Reselect function, or CLR key.
CONFIRM ZERO ALL (blinks)	Request to zeroize MDL, GPS SA/AS, and random access memory (RAM) and nonvolatile memory (NVM) in all CDNUs.	Reselect function, or CLR key.
CONFIRM ZERO CDNU (blinks)	Request to zeroize all RAM and NVM in all CDNUs.	Reselect function, or CLR key.
CONFIRM ZERO MDL (blinks)	Request to zeroize MDL cartridge data.	Reselect function, or CLR key.
CONFIRM ZERO KEYS (blinks)	Request to zeroize GPS SA/AS keys.	Reselect function, or CLR key.
COPY WHAT?	Request to copy waypoint data.	CLR key.
DATA FOR?	Request to access waypoint data.	CLR key.
ENTER MDL ADDRESS	Attempt to operate MDL before bus terminal address is entered.	CLR key.
ERROR (alternates)	Data in scratchpad does not meet the parameters for the data field in which entry was attempted.	Select a line select key for which data does meet parameters, or CLR key.
ERROR CRS CHG >90° (alternate)	Attempt to apply course edit greater than 90° from the current inbound course.	CLR key.
FLIGHT PLAN FULL (alternates)	Attempt to insert more than 50 points into the flight plan.	CLR key.
GROUND TEST ONLY (blinks)	Attempt to initiate prohibited test while in flight.	CLR key.
HOLD AT?	Holding pattern has been selected for insert into the flight plan.	CLR key.
INSERT INTERCEPT #	The intercept shown on the listed page (#) has been selected for insertion into the flight plan.	Valid insert or CLR key.
INTERCEPT IS ACTIVE (blinks)	Attempt to delete intercept which is active waypoint from the flight plan.	CLR key.
MDL IN USE (alternates)	Attempt to access MDL while in use by another CDNU.	CLR key.
NAME IN USE (blinks)	Attempt to attach an identical user-defined label to a second waypoint.	CLR key.
NO INTERCEPT SOLN (blinks)	Attempt to insert an intercept solution when no solution is possible.	Valid intercept, or CLR key.
NOT IN DATABASE (alternates)	Entry not found in database.	CLR key.

Figure 16-6. Alphanumeric List of Scratchpad Messages

Reinitialization may take up to two hours or longer.) If it does not find this satellite the GPS will sequentially look for the next one until it acquires an identifiable satellite. Once the GPS locks on to a satellite the almanac data is down loaded to the radio receiver and the initialization process then continues. Almanac data can also be loaded into the radio receiver by using the appropriate mission tape and the MDL.

2. MDL Downloading.

The Mission Data Loader (MDL) information may be downloaded into the CDNU to provide the GPS with the Operational Flight Program (OFP) along with three files of waypoint data (Primary Identifier Data Base, Reversionary Identifier Data Base and Flight Plan), Magnetic Variation and Satellite Almanac data (downloading of the OFP is not required if it has not been previously installed in the CDNU). The magnetic variation is automatically transferred from the MDL to the CDNU when the Data Transfer Module is inserted into the MDL. This automatic transfer takes place if the date corresponding with the MDL magnetic variation data is more current than what is stored in the CDNU. If MDL information is not downloaded during preflight, a flight plan of up to 50 waypoints may be manually created on the flight plan page of the CDNU using the line select, alphanumeric, and scroll keys.

3. Satellite Tracking.

Once initialized and operating, the GPS antenna acquires the Coarse Acquisition (C/A) code from the orbiting satellite. Based on information extracted from the C/A code the GPS acquires and tracks the Precision (P) code. The C/A code allows for quick acquisition, but the navigation data provides less than 100 meters of accuracy. The P code provides 10 meters or less of accuracy from the navigation data, but is more difficult to acquire. The C/A and P codes provide satellite data, such as clock, position, almanac and identification. This information is used to continuously track the satellite and update the critical memory. The crypto key (KYK-13 or KOI-18) enables the GPS receiver to receive and decode the GPS satellite P code transmission.

Note

Once the P code is encoded it is designated as a Y code.

Y code positioning data is needed when Selected Availability/Anti-Spoofing (SA/AS) conditions occur.

4. SA/AS Downloading.

The KYK-13 is required to download SA/AS data to the C-12094/AR Crypto Variable Control fill port. When the satellite broadcasts SA/AS data and the GPS SA/AS data is not loaded, the CDNU will indicate a GO system status on the Index and Status pages, but will display a high figure of merit (4 or greater) and high Estimated Horizontal Error (EHE) (16 or more meters) on the RNAV page. The SA/AS keys are downloaded by the ground crew personnel.

5. Navigation Data.

Once the navigation data is obtained from the satellite, the GPS becomes fully functional. It can now operate as a stand-alone system processing navigation data and providing position coordinates, altitude, speed and time information to the CDNUs. This information is used to optimize navigational data accuracy.

16.8.3 CDNU Operational Modes

1. Entering and Clearing Scratchpad Text.

   a. Press CLR key once, clears the last character in scratchpad.

   b. Press CLR key a second time, clears the scratchpad.

   c. Press the CLR key and holding it, clears characters one at a time from the right until released.

2. Inserting Scratchpad.

   a. Enter valid data in scratchpad.

   b. Press L/S key on the line you wish to change data.

3. Clearing Entries (Figure 16-7).

   a. Enter a dash "-" into the scratchpad.

   b. Press L/S key on the line you wish to change data. GPS Basic Operating Modes.

4. Clearing Scratchpad Error Messages (Figure 16-8).

   a. Enter "370/14" into Scratchpad.

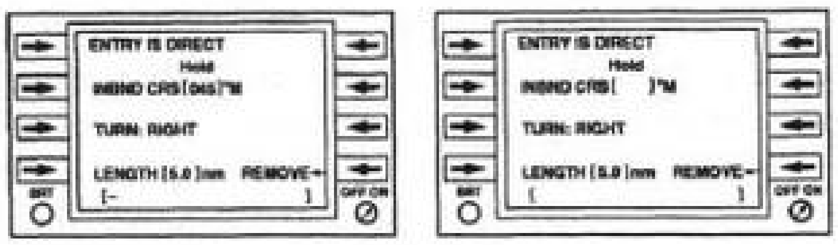

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Figure 16-7. Clearing Entries

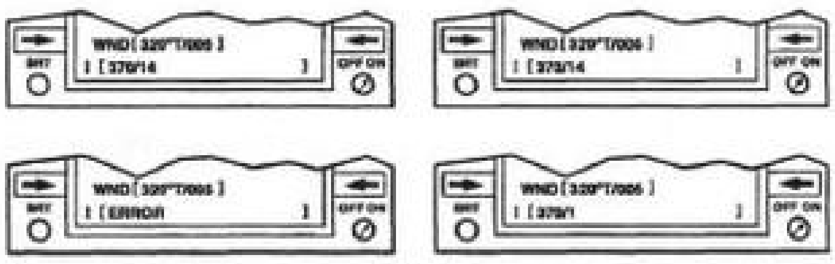

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Figure 16-8. Clearing Scratchpad Error Messages

b. Press L/S 4 key, "ERROR" flashes due to format incompatibility.

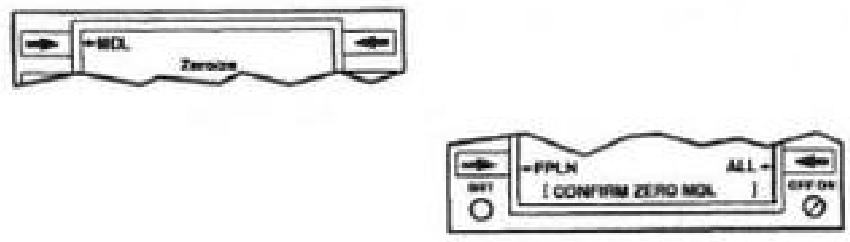
c. Press CLR key, "ERROR" message clears and last entry appears in Scratchpad.

d. Press CLR key again and last entry in Scratchpad is cleared.

5. Scratchpad Confirmation Messages/Zeroize Mode (Figure 16-9).

a. Pressing L/S key once, i.e. MDL, results in an advisory blinking in Scratchpad, i.e. "CONFIRM ZERO MDL".

b. Pressing the same line selected a second time proceeds to zeroize or erase the selected system data.



HC3157
SA

Figure 16-9. Scratchpad Configuration Messages/Zeroize Mode

(1) Advisory is cleared by pressing CLR to abort the operation.

6. Toggling Mode (Figure 16-10).

a. A colon ":" indicates toggling mode is available.

b. By pressing the appropriate L/S key the line will change, i.e. TRK[320]° M to TRK[320]°T. (Toggles "Mag" to "True")

7. Lateral Page Scrolling (Figure 16-11).

a. Press RNAV key.

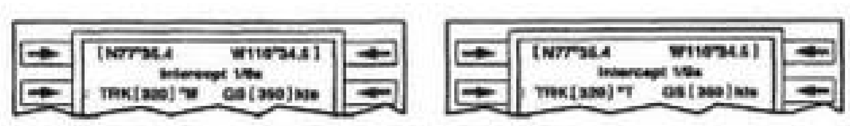


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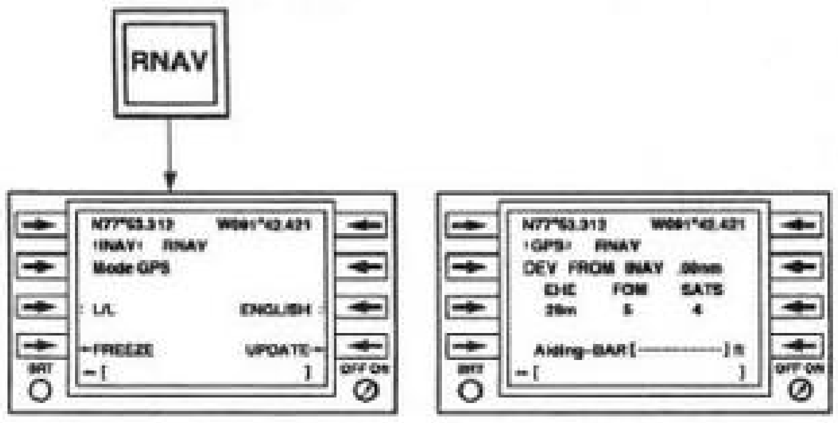
Figure 16-10. Toggling Mode



HC3159
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Figure 16-11. Lateral Page Scrolling

b. Press arrow key to scroll left or right.

c. Pressing arrow key in opposite direction will return to previous data page.

8. Vertical Page Scrolling (Figure 16-12).

a. Access Horizontal Datums, vertical two-headed arrow indicates that page scrolling is possible.

b. Horizontal Datums will display 1/12 pages.

c. There are a total of 12 Horizontal Datums pages. A list of the datums on these pages is detailed in the Horizontal Datum List (Figure 16-13).

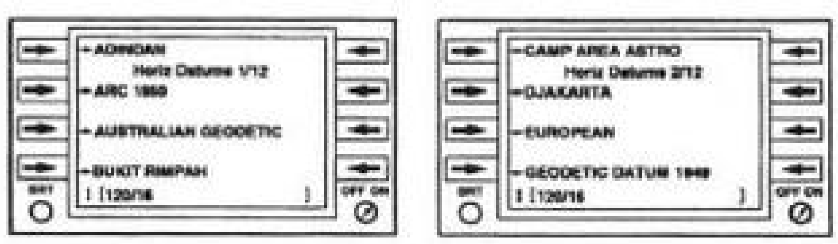

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Figure 16-12. Vertical Page Scrolling

d. Pressing the arrow key down once will select 2/12 page.

Note

Entry in Scratchpad is not affected by page scrolling.

e. Pressing down arrow key will display 3/12 page.

f. Pressing up arrow key will display 2/12 page.

g. Holding the arrow key up or down will cause continuous scrolling.

h. List will wrap back to page 1/12 when scrolling continues beyond the end of the list.

9. Line Scrolling (Figure 16-14).

a. Press DIR key.

b. Pressing down arrow key will display End of Flight Plan.

10. System Annunciators.

The left annunciation field has a maximum of 12 characters. The right annunciation field has a maximum of 9 characters.

a. Pressing the CLR key clears both left and right annunciator fields and displays the next lower priority annunciator.

b. Once the lowest priority annunciation is cleared, the highest priority non-clearable annunciation appears, i.e. FREEZE.

(1) Higher priority annunciations pre-empt display of lower priority annunciations. See CDNU System Annunciations (Figure 16-15).

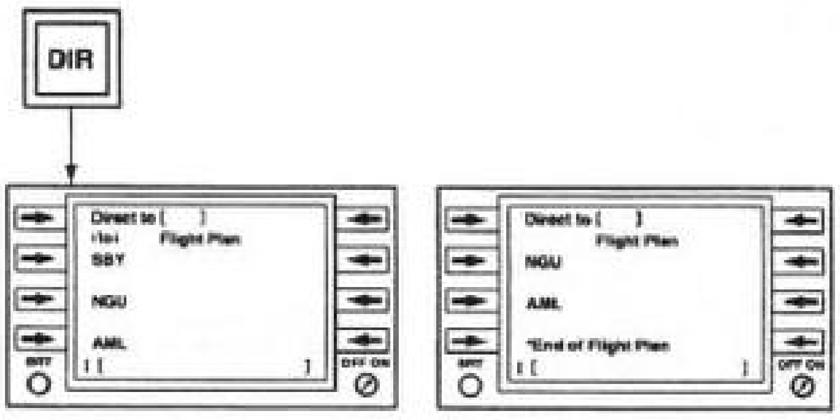
(2) Non-clearable annunciations cannot be cleared using the CLR key.

11. System Status Checks (Figure 16-16).

After the CDNU has been turned ON it will automatically perform a system check of all WRAs. When there is a faulty WRA, a "✓Status" will appear on the page. To identify the faulty WRA, press STAT key. The

MAP DATUM	ABBREVIATION	DATUM CODE
Adindan	ADINDAN	01
Arc 1950	ARC 1950	02
Australian Geodetic	AUSTRLN GEODETIC	03
Bukit Rimpah	BUKIT RIMPAH	04
Camp Area Astro	CAMP AREA ASTRO	05
Djakarta	DJAKARTA	06
European 1950	EUROPEAN 1950	07
Geodetic Datum 1949	GEODETIC 1949	08
Ghana	GHANA	09
Guam 1963	GUAM 1963	10
Gunung Segara	G. SEGARA	11
Gunung Serindung 1962	G. SERINDUNG	12
Herat North	HERAT NORTH	13
Hjorsey 1955	HJORSEY 1955	14
Hu-Tzu Shan	HU-TZU-SHAN	15
Indian	INDIAN	16
Ireland 1965 (Eire 1965)	IRELAND 1965	17
Kertau 1948 (Malayan Revised Triangulation)	KERTAU (MALAYAN)	18
Liberian 1964	LIBERIAN 1964	19
Luzon	LUZON	21
Merchich	MERCHICH	22
Montjong Lowe	MONTJONG LOWE	23
Nigeria	NIGERIA	24
North American 1927 CONUS	N AM 1927 CONUS	25
North American 1927 Alaska and Canada	N AM 1927 AL/CAN	26
Old Hawaiian, Maui	OLD HAWAII MAUI	27
Old Hawaiian, Oahu	OLD HAWAII OAHU	28
Old Hawaiian, Kauai	OLD HAWAII KAUAI	29
Ordinance Survey of Great Britain 1936	ORDNCE GB 1936	30
Qornoq	QORNOQ	31
Sierra Leone 1960	S. LEONE 1960	32
South America (Campo Inchauspe)	S AM CAMPO IN	33
South America (Chua Astro)	S AM CHUA ASTRO	34
South America (Corrego Alegre)	S AM COR. ALEGRE	35
South America (Provisional South America 1956)	S SM PROV 1956	36
South America (Yacare)	S AM YACARE	37
Tananarive Observation 1925	TANANARIVE 1925	38
Timbalai 1948	TIMBALAI 1948	39
Tokyo	TOKYO	40
Voirol	VOIROL	41
Special Datum, Indian Special	SPECIAL INDIAN	42
Special Datum, Luzon Special	SPECIAL LUZON	43
Special Datum, Tokyo Special	SPECIAL TOKYO	44
Special Datum, World Geodetic System 1984	SPECIAL WGS-84	45
World Geodetic System 1972	WGS-72	46
World Geodetic System 1984	WGS-84	47

Figure 16-13. Horizontal Datum List



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SA

Figure 16-14. Line Scrolling

GO/NOGO status page will identify which WRA is in a NOGO status and a "✓" symbol will appear to the left of the NOGO status. To identify the problem within the system, Press L/S 2 key.

a. L/S 1 key will allow user to toggle between "ENABLE" and "DISABLE", controls status reporting for this WRA.

b. On line 2 the overall GPS status will appear as GO, NOGO, Test or _____. The three ______ identifies, no computer data is available or meaningful, or power is off.

c. Line 3 shows the status of the MIL-STD-1553B Bus. It will indicate a GO status or identify a failure in BUS A, BUS B or a Terminal.

d. Line 4 will display a 16-bit data word that indicates the area of the fault. All bits set to 0 indicate an area where there are no faults. Any bit set to 1 indicates a fault has been detected in that area.

   Bits 15 (the bit closest to the left side of the display) through 7 indicate areas of the CDNU where faults have been detected. All other bits are reserved for future development.

e. Lines 5 and 7 identify the status of the GPS subsystems. Line 5 will indicate if the Receiver/Processor Unit (RPU) or Antenna Electronics are in a GO/NOGO Status. Line 7 identifies the status of the Battery System.

f. L/S 5 key line 1 will identify total number of failures since last reset of failure counter. Pressing L/S key resets failure counter to 0.

g. Press L/S 8 key, this will return system to status page. Note the "✓" has been removed from NOGO GPS.

16.8.3.1 Normal Operation of the GPS Navigation System. The following procedures are applicable for operating the GPS navigation system, from the Control Display Navigation Unit (CDNU). The following information consists of pre-departure instructions to prepare the system for operation and inflight instructions for the operator.

16.8.3.2 Pre-Flight Operation. After the aircraft is powered up the CDNU may be energized. Adjust bright control for desired readout intensity. The first CDNU to power up becomes the bus controller and will drive the flight instruments. The MDL and GPS are energized with application of aircraft power. The SDC is energized when power is applied to the TACAN. The CDNU performs internal Built In Test (BIT) on start up, then performs continuous BIT as long as the CDNU is energized. If the position reference is not available for internal memory or external aircraft system, the GPS will request position data be entered by the operator. If the almanac data is not available from memory or the data loader, the GPS will automatically perform a cold-start search of the sky to receive satellites.

16.8.3.3 Start-Up Procedures

1. GPS initialization.

   a. Press "IDX" key for Index Page.

   b. Press L/S 4 key, "System Test" will be displayed. Check the status of all the WRAs. The CDNU will display a GO or NOGO status of the system. The following should indicate a GO status; MDL, GPS, DAC (SDC), CDNU 1 and CDNU 2. The AHRS, ADC and CDNU 3 will display NOGO.

Note

To clear any flashing check sign; Press CLR key. AHRS and Wind are not sensed and will sometimes flash a check sign.

   c. Press "IDX" key for Index Page.

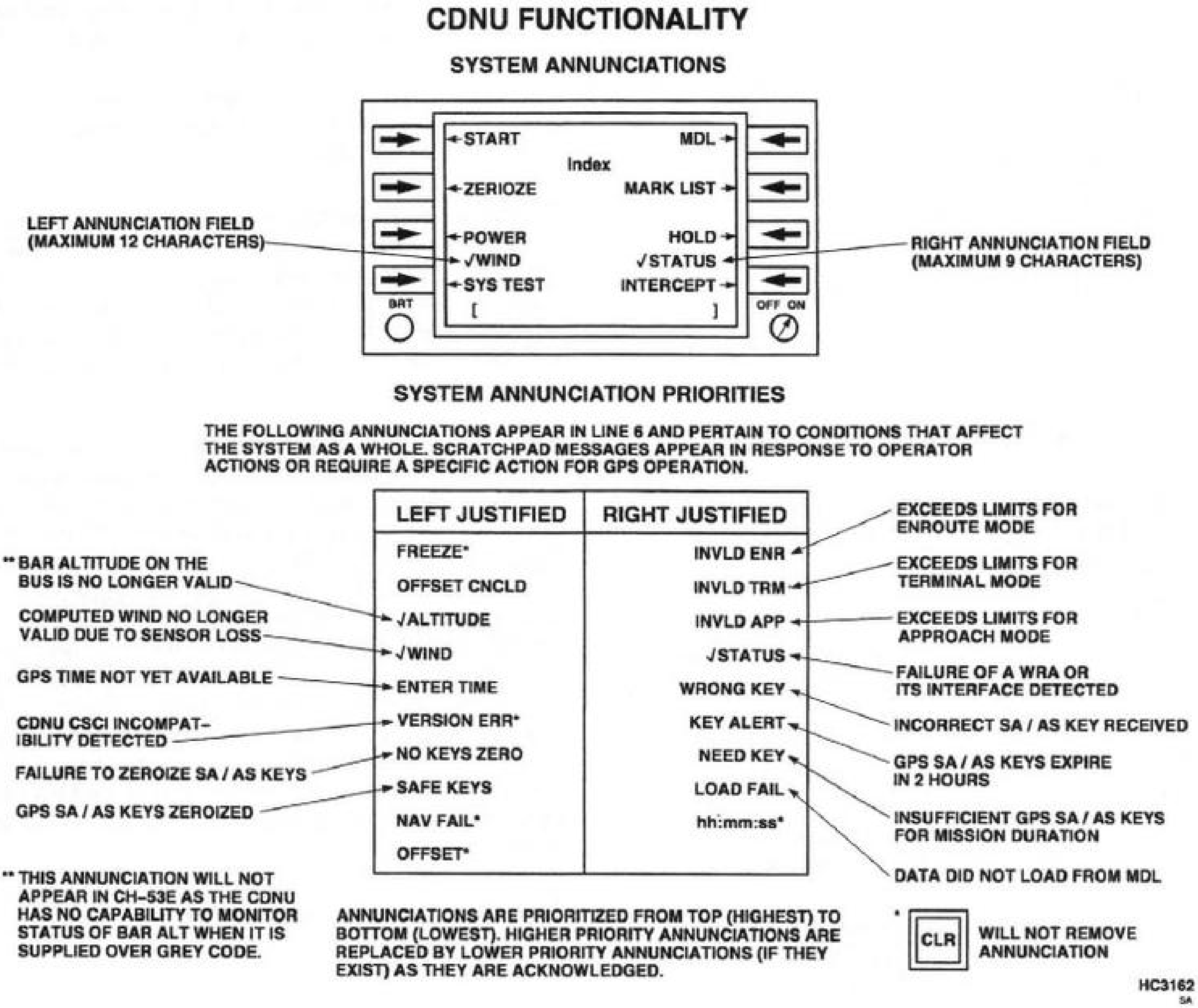

Figure 16-15. CDNU System Annunciations (Sheet 1 of 3)

d. Press L/S 1 key (Start) confirm correct.

(1) Ensure the proper DATUM is selected to correspond with the charts you are using for navigation. (WGS-84 and 47 for DMA charts in the U. S.)

(2) Verify Time, Date, and Location — change as necessary. Any entry will re-initialize GPS.

Note

Time is Universal Time Coordinate (UTC) Greenwich time and is updated at 1 HZ by the GPS receiver. Time can be entered manually if GPS fails.

(3) Press L/S 3 key it will set system time and display the time on line 6 in the right field.

Note

- If the bus controller fails in flight, the system time is lost and must be reentered on the backup bus controller.

Left Side Annunciations

ANNUNCIATION	MEANING	RESET BY
** ✓ ALTITUDE (blinks)	Barometric altitude from MADC is not valid.	CLR key, or barometric altitude becoming valid.
✓ WIND (blinks)	Wind no longer valid.	CLR key.
ENTER TIME	GPS time not valid or not available.	Entry of time, return of GPS valid time signal, or CLR key.
FREEZE * (blinks)	Freeze mode is engaged.	Deselection of FREEZE or expiration of FREEZE period.
NAV FAIL *	Selected navigation mode invalid.	Upgrade to valid navigation mode.
NO KEYS ZERO (blinks)	Failure to zeroize GPS SA/AS keys.	Successful clearing of GPS SA/AS keys, or CLR key.
OFFSET *	Parallel offset is engaged.	Parallel offset is disengaged.
OFFSET CNCLD (blinks)	Parallel offset cancelled by CDNU.	CLR key.
SAFE KEYS	GPS SA/AS keys zeroized.	CLR key.
VERSION ERR *	Incompatibility between CDNU software versions.	All versions of CDNU software are identical.

Right Side Annunciations

ANNUNCIATION	MEANING	RESET BY
✓ STATUS (blinks)	Detected failure of a WRA or its interface.	CLR key or STAT key (can also be disabled on appropriate unit status page).
hh:mm:ss *	System time clock selected.	Deselect system time clock.
INVLD APP (blinks)	EHE greater than allowed while APPROACH FLIGHT mode.	Decrease EHE to within limits or CLR key.
INVLD ENR (blinks)	EHE greater than allowed while in ENROUTE FLIGHT mode.	Decrease EHE to within limits or CLR key.
INVLD TRM (blinks)	EHE greater than allowed while in TERMINAL FLIGHT mode.	Decrease EHE to within limits or CLR key.
KEY ALERT (blinks)	GPS SA/AS keys will expire in two hours.	Entry of new SA/AS keys or CLR key.
LOAD FAIL	Data load from MDL not successful.	CLR key.
NEED KEY (blinks)	GPS SA/AS keys will expire before planned end of mission.	Shorten mission, install new GPS SA/AS keys, or CLR key.
WRONG KEY (blinks)	Incorrect GPS SA/AS key received.	Entry of correct GPS SA/AS key, or CLR key.

Annunciations in Priority Order

LEFT SIDE	RIGHT SIDE
FREEZE *	INVLD ENR
OFFSET CNCLD	INVLD TRM **
** ✓ ALTITUDE	INVLD APP
✓ WIND	✓ STATUS
ENTER TIME	WRONG KEY
VERSION ERR *	KEY ALERT
NO KEYS ZERO	NEED KEY
SAFE KEYS	LOAD FAIL
NAV FAIL *	LOAD FAIL
OFFSET *	hh:mm:ss *

* = Non-clearable; cannot be cleared by pressing CLR key (all others are "clearable").

** This annunciation will not appear in CH-53E as the CDNU has no capability to monitor status of BARO ALT.

Figure 16-15. CDNU System Annunciations (Sheet 2 of 3)

CDNU1 Status BITS and Meanings

BIT	DEFINITION
15	1553 Data Bus Status
14	1553 Data Terminal Status
13	Discrete I/O Card (A5a) Status
12	Discrete I/O Card (A7) Status
11	Graphics Generator Card (A2) Status
10	IOC 1553 Cards (A6, A8) Cards Status
9	Memory Card (A5) Status
8	Memory Card (A3) Status
7	CPU Card (A4) Status

Figure 16-15. CDNU System Annunciations (Sheet 3 of 3)

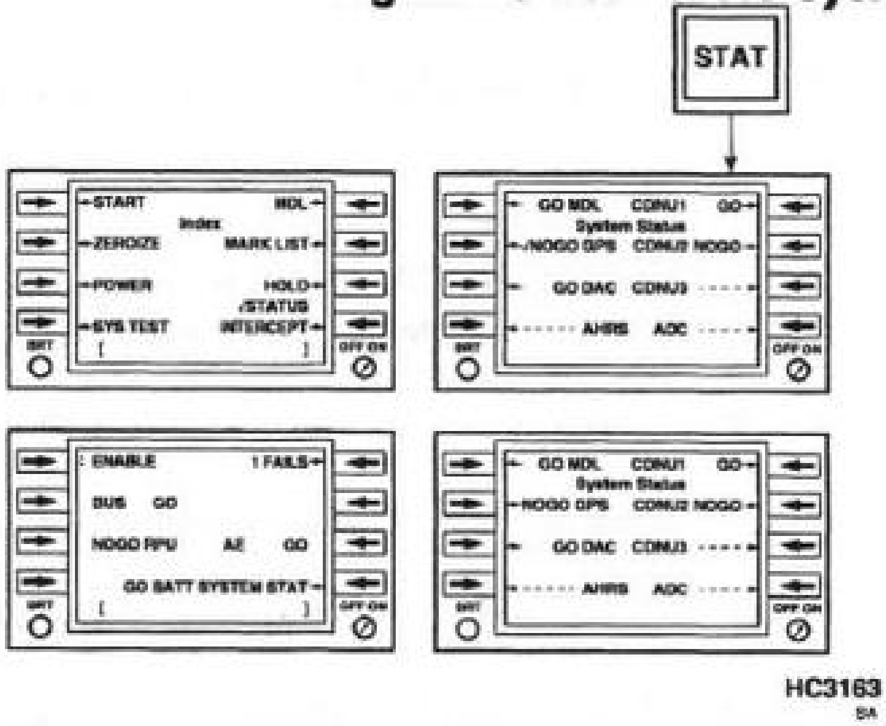

Figure 16-16. System Status Checks

- Anytime the aircraft is moved a great distance while the GPS is off, updating the GPS position on Line 1 will greatly reduce the time required for the system to initialize.

e. To change data, enter correct data into scratchpad. Press L/S key to left of data position. Data will transfer from scratchpad to display.

f. Press L/S 1 key (Lat/Long or MGRS) this accepts data as being correct and initializes GPS.

g. Scroll to MDL Start Page — Load Flight Plan from MDL.

or

h. Press "IDX" key for Index page.

i. Press MDL L/S key for MDL page — Load Flight Plan, OFP, Almanac or waypoint as necessary.

j. When GPS Course and Bearing have been selected, GPS is valid and there is an active waypoint in the Flight Plan.

(1) The BDHI OFF flag is removed from view.

(2) The GPS #2 needle points to the active waypoint.

(3) The black distance validity shutter flag is removed from view (otherwise needle will spin or CDI will not swing side-to-side).

2. GPS Crypto Loading of SA/AS Codes.

a. Use the Group Unique Key (GUK) code (AKAT A1105) with the KYK13 to load the codes into the GPS system.

(1) The fill panel is used to load the codes into the GPS system. See KYK-13 Key (Figure 16-17).

b. The Status of GPS keys can be observed in the GPS SA/AS page of the Zeroize page.

c. No CDNU input is required. Upon loading of the code, the ["STORAGE CODE"] prompt is displayed on Line 7 and the option is made

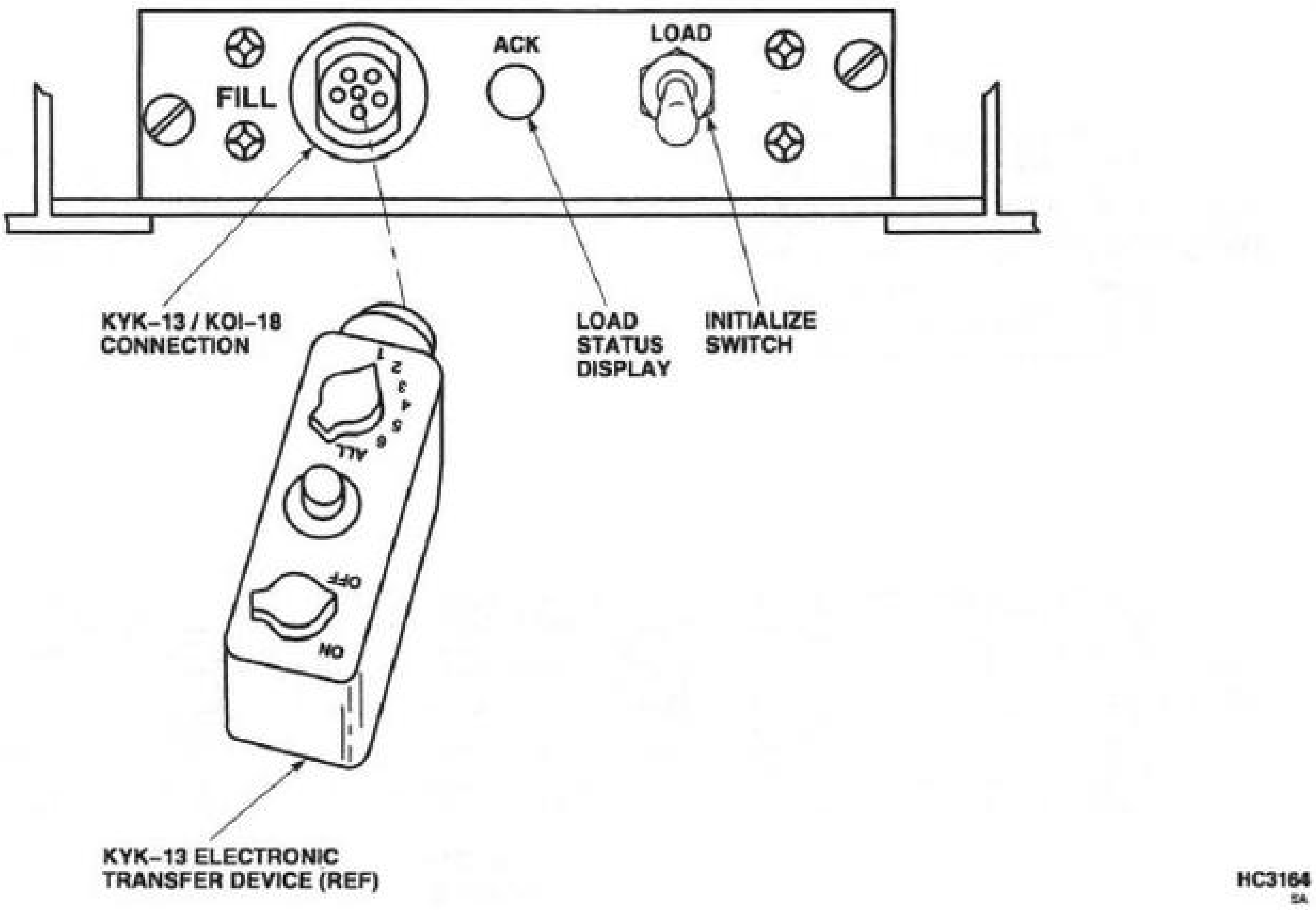

Figure 16-17. KYK-13 Key

available. If the GUK is loaded, a mission duration of "001" days will be displayed in the "Day" data field after several minutes.

Note

- If GPS conditions are not adequate for achieving precision code status, the mission during "Days" field will stay at "001". However, once a status of "001" is achieved it will remain displayed until the keys are zeroized.
- Shutting OFF power does not zeroize the keys.

3. System Status Checks.

   a. Press L/S 1 Start key, System Status page will be displayed. See System Status (Figure 16-18).

   b. When there is WRA in a ✔ NOGO status, press the L/S key corresponding to that system.

   c. The information on this page will identify the WRA status as a NOGO.

Note

The Status Page will only report back a GO or NOGO of the system.

4. System Test.

   a. Press "IDX" key, Index page will be displayed. See System Test (Figure 16-19).

   b. Press L/S 4 key System Test, System Test Page will be displayed. This page will report that a previous maintenance action NOGO status was performed on a WRA. The System Status Page will show the WRA is in a GO status.

5. MDL Overview.

The flight plan may be comprised of up to 50 waypoints loadable through the MDL or defined by the operator on the CDNU. Operator definable points do not allow for specification of MAGVAR/Declination, station elevation, TACAN channel, or frequency of

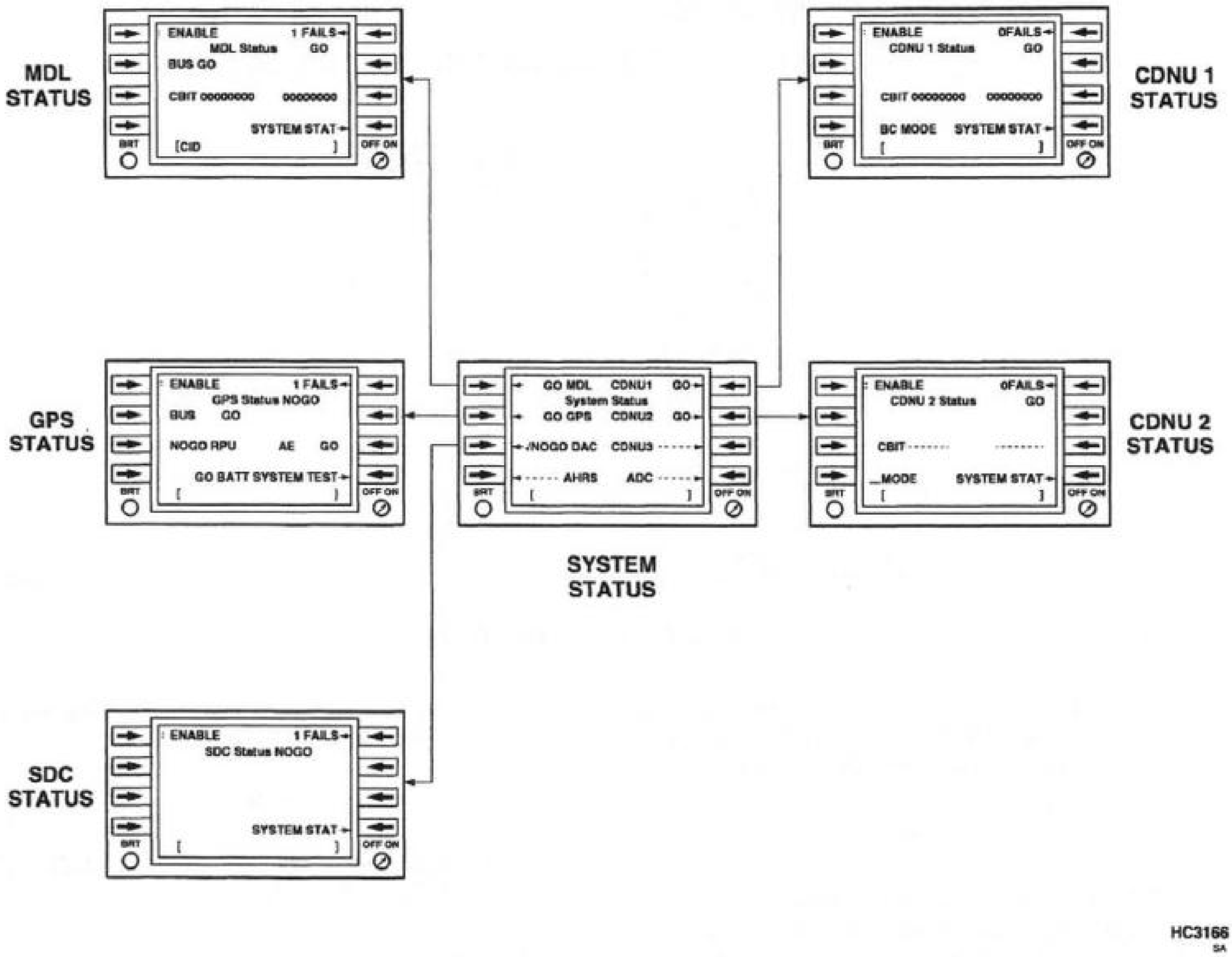

Figure 16-18. System Status

stations when waypoints are loaded from the MDL. The CDNU automatically assigns a MAGVAR to an operator-defined waypoint from the MAGNETIC VARIATION DATABASE lookup table for that point, a MAGVAR database is transferred automatically from the Data Transfer Module (DTM) through the MDL to the CDNU if it is more recent than the existing database.

Note

Production CDNUs received from supply will not be loaded with a MAGVAR database. Consequently, an MDL data cartridge (DTM), with a valid MAGVAR load, must be used the first time the CDNU is powered up.

6. Preflight MDL Operations/From MDL Start Page (Figure 16-20).

   a. Press IDX key.

   b. Press Start key, GPS start page is displayed.

   c. Press down arrow key, MDL Start page is displayed.

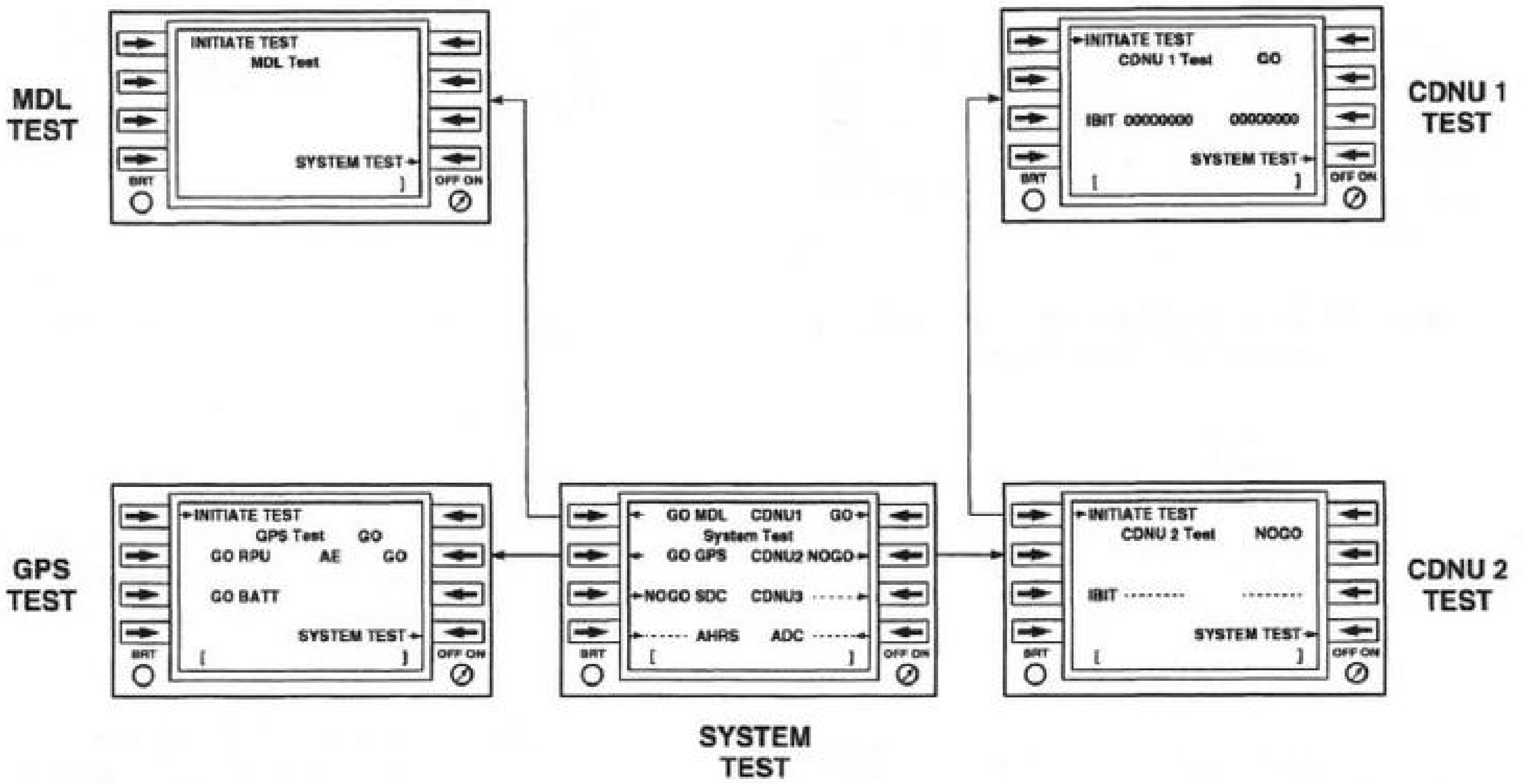

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Figure 16-19. System Test

(1) If primary database on MDL is available "PRI" table appears on line two. If reversionary database is being used, "REV" label appears.

(2) Verify MDL cartridge label and data stamp. This line is blank if no cartridge is installed.

(3) Verify MAGVAR data stamp on MDL cartridge database. It will be blank if the database does not exist.

d. Press L/S 4 key to erase flight plan in CDNU.

e. Press L/S 8 key to load new flight plan.

7. Preflight MDL Operations From MDL Page (Figure 16-21).

a. Press IDX key.

b. Press MDL key. MDL page is displayed.

c. To load waypoints, flight plan or ALM press the corresponding L/S key.

(1) The confirm message will appear in the scratchpad. The request is confirmed

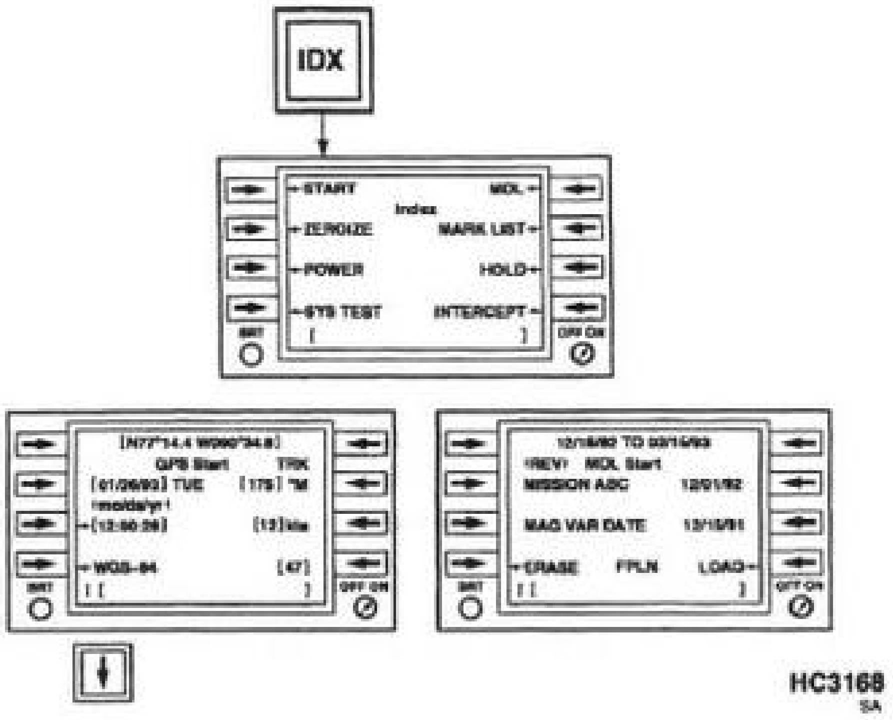

Figure 16-20. Preflight MDL Operations From MDL Start Page.

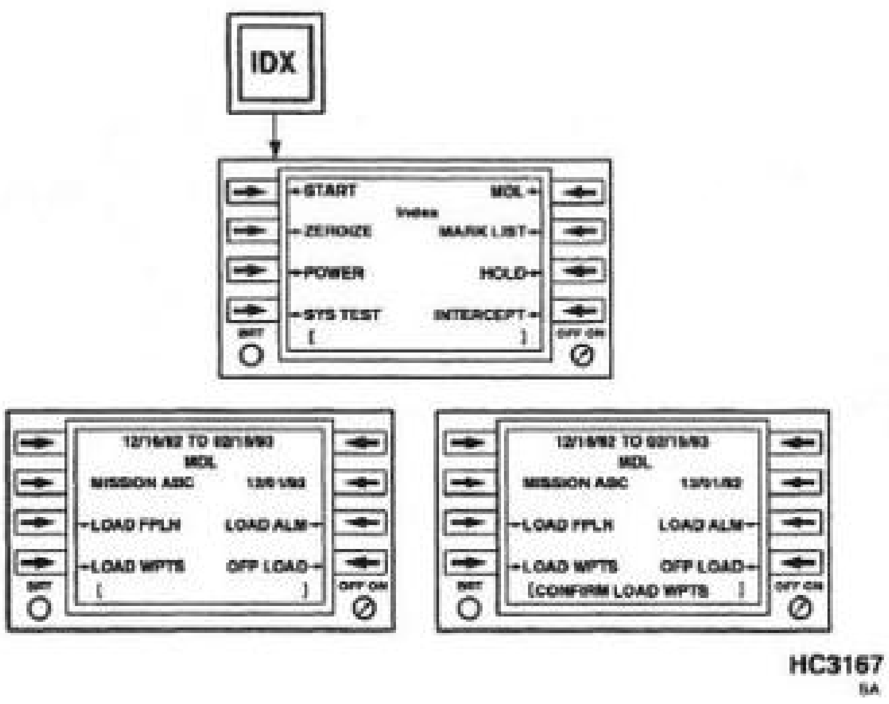

Figure 16-21. Preflight MDL Operations From MDL Page

and executed by depressing the same L/S key a second time.

16.8.3.4 Flight Plan Implementation. There is one flight plan that has up to 50 waypoints stored in the order to be flown. Waypoints move down the list as new waypoints are added above. The automatic leg sequencing is available at all times and the manual mode is available as a backup. The turn anticipation provides a 10 second alert prior to turn point for the next leg of flight plan to prevent-overshoots. The five most recently passed waypoints are stored in the memory and they cannot be edited or removed. They can be viewed, copied back into the flight plan or reused with Direct-To function.

1. Flight Plan Access (Figure 16-22).

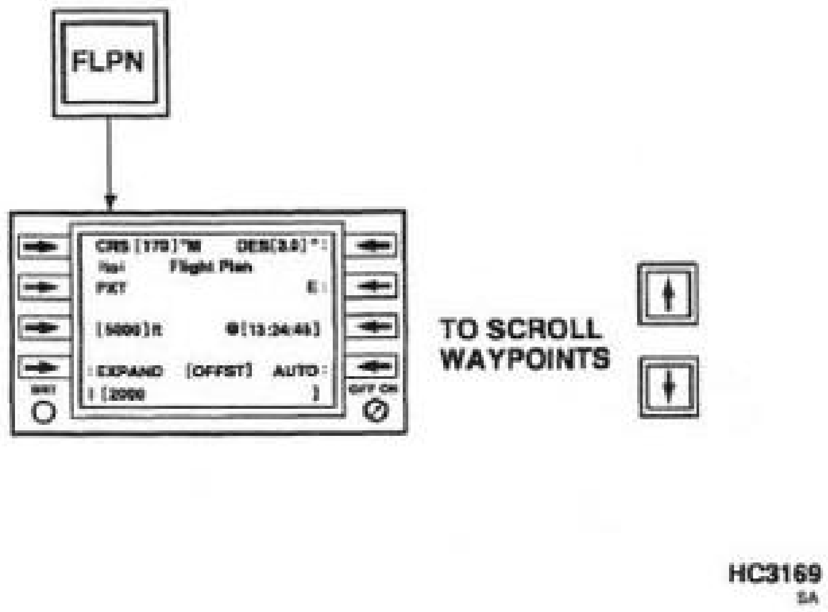

Figure 16-22. Flight Plan Access

a. Press FPLN key.

(1) Line 1 will display To-To state and calculate course to the active waypoint. It may also display To-From mode and select the desired course To or From the active waypoint.

(2) Line 2 left field will display ➡ to ⬅. This indicates the To waypoint is active. The arrows are removed when scrolled away from the active waypoint. Use up or down arrow keys to scroll to waypoints.

(3) Line 3 left field displays active waypoint. If scratchpad is empty, pressing a L/S key next to a waypoint calls up the "Waypoint Data" page with additional information on that waypoint.

(4) Line 3 right field displays flight mode. Using the L/S 6 key, the operator may toggle between approach (A), Terminal (T) and Enroute (E), Untoggled waypoints assume the mode of the last toggled waypoint. See GPS Flight Mode (Figure 16-23).

(5) Line 5 will display time of arrival.

(a) The time of arrival is optional and may be specified for any fixed waypoint.

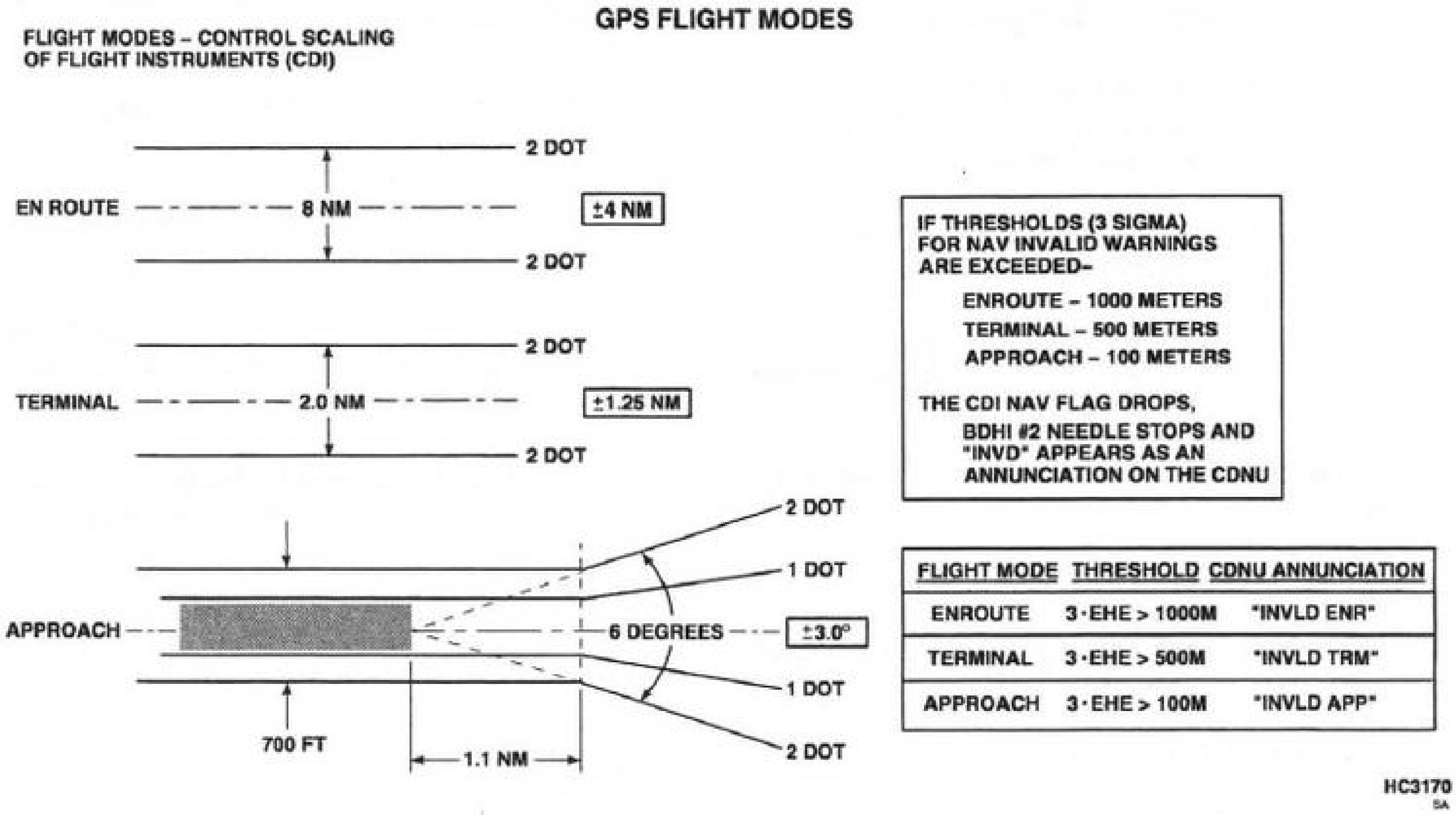

Figure 16-23. GPS Flight Mode

(b) This information is not applicable on "Intercept" waypoints.

Note

Ground speed required to meet the desired arrival time is generated and displayed on progress page 1/3.

(6) Line 7 left field, can be toggled between "Expanded" (2 waypoint/page) and "Compacted" (4 waypoint/page).

(a) Line 7 right field is used to toggle between Automatic (AUTO) and Manual (MAN) leg sequencing.

2. Erasing a Flight Plan/MDL Start Page (Figure 16-24).

a. Press IDX key.

b. Press L/S 1 key start, GPS start page will be displayed.

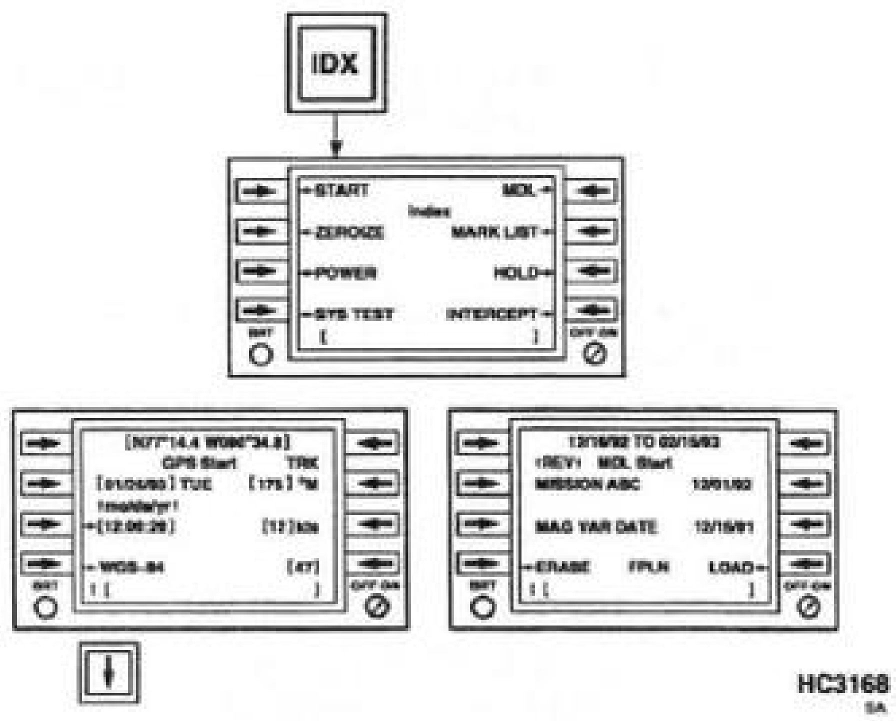

Figure 16-24. Erasing a Flight Plan/MDL Start Page

c. Press down arrow key to scroll to MDL start page.

(1) Line 3 will be blank if no MDL cartridge is installed. With MDL cartridge installed it will display cartridge label and date stamp.

(2) Line 5 will display active database.

(3) Using the L/S 4 key the operator may erase the old flight plan.

(4) First press of L/S 4 key will cause a flashing message in scratchpad, "Confirm Erase Flight Plan".

(5) Second press of L/S 4 key will erase the flight plan from the CDNU.

(6) Using the L/S 8 key the operator may install a copy of the flight plan from the MDL cartridge.

3. Erasing a Flight Plan/Zeroize Page (Figure 16-25).

a. Press IDX key.

b. Press L/S 2 key Zeroize, and Zeroize page will be displayed.

c. Press L/S 4 key FPLN.

(1) First press of L/S 4 key will cause a flashing message in scratchpad, "Confirm Erase FPLN".

(2) The second press erases the flight plan from the CDNU.

Note

This method of erasing a flight plan will not load a new flight plan.

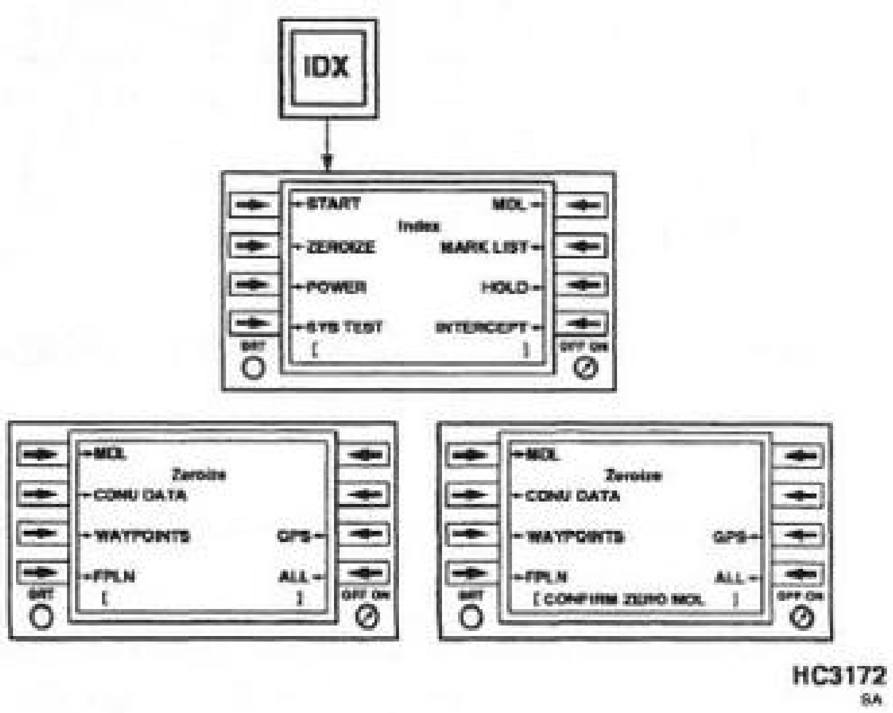

Figure 16-25. Erasing Flight Plan/Zeroize Page

4. Flight Plan Display Format/Expanded or Compacted (Figure 16-26).

a. Press FPLN key, flight plan page will be displayed.

b. Press L/S 4 key to toggle between Expanded or Compressed.

c. When Expanded is displayed on Line 7, pressing the down arrow key will display two waypoints.

d. When Compacted is displayed on Line 7, pressing the down arrow key will display four waypoints.

e. Further scrolling down will move waypoints up the display.

5. Creating a Flight Plan/Inserting the Initial Waypoint (Erase Old FPLN if necessary) (Figure 16-27).

a. Press FPLN key, flight plan page is displayed.

b. Enter first desired waypoint in scratchpad.

c. Press L/S 2 key, End of Flight Plan.

d. The waypoint inserted on Line 3 is placed above the current active waypoint and in turn becomes the active waypoint.

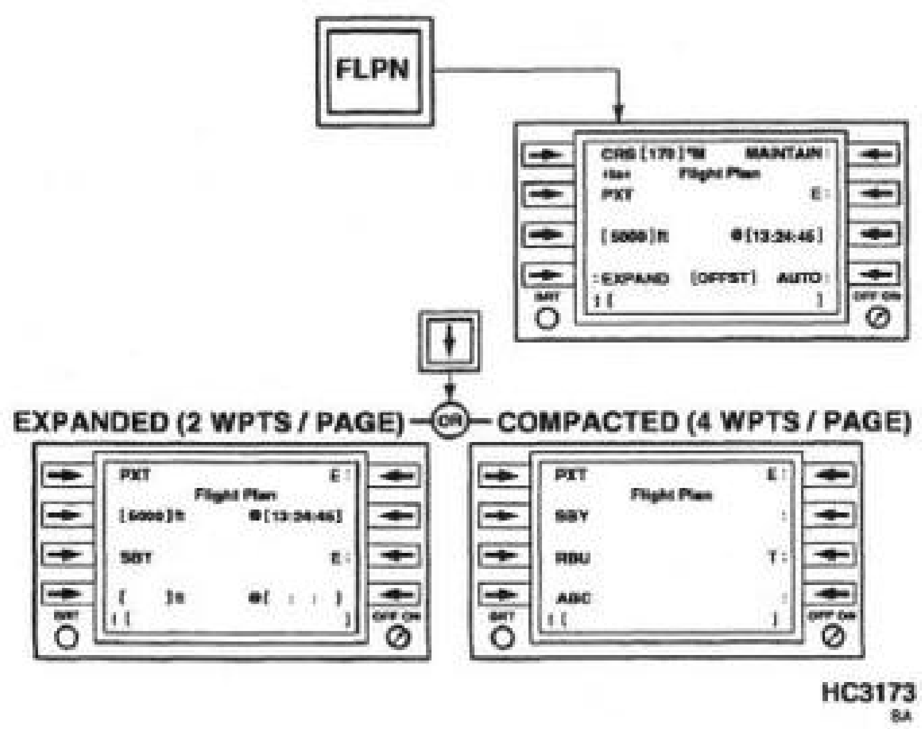

Figure 16-26. Flight Plan Display Format/Expanded or Compacted

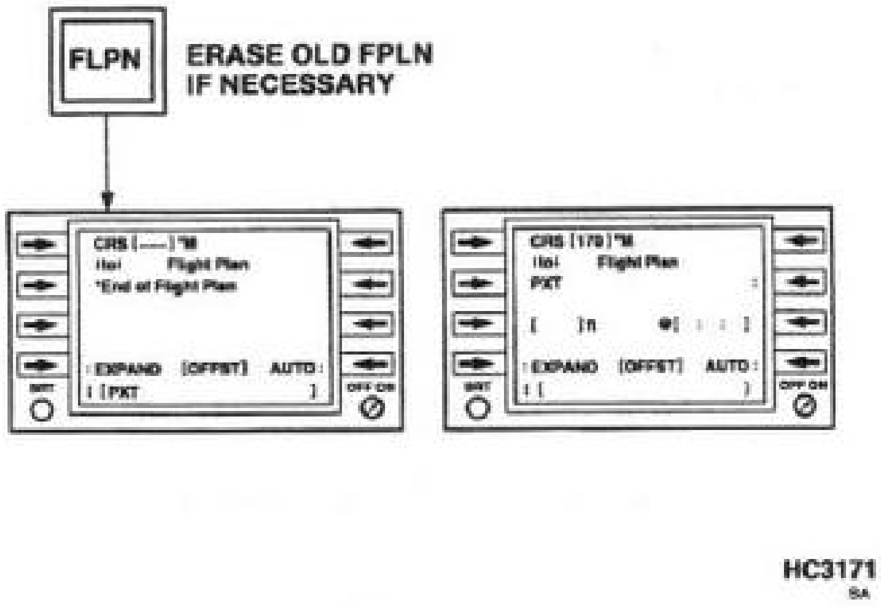

Figure 16-27. Creating a Flight Plan/Inserting the Initial Waypoint

(1) Enroute flight mode is automatically assigned to the initial waypoint. It can be modified if desired.

e. To add next waypoint, use down arrow key to move down the page. Waypoint will move to Line 1.

f. Enter next desired waypoint in scratchpad.

g. Press L/S 3 key, new waypoint will be displayed on Line 5.

(1) The flight mode of new waypoints defaults to blank. It can be toggled to other modes, by pressing L/S 6 key.

(2) Altitude and planned time of arrival on Line 7 are blank by default.

6. Creating a Flight Plan/Loading from the MDL (Figure 16-28).

a. Press IDX key, index page is displayed.

b. Press L/S 5 key, MDL page is displayed.

c. Press L/S 3 key, Load FPLN.

(1) The scratchpad will display message "Confirm Load FPLN". The message confirms request to load existing flight plan in the CDNU.

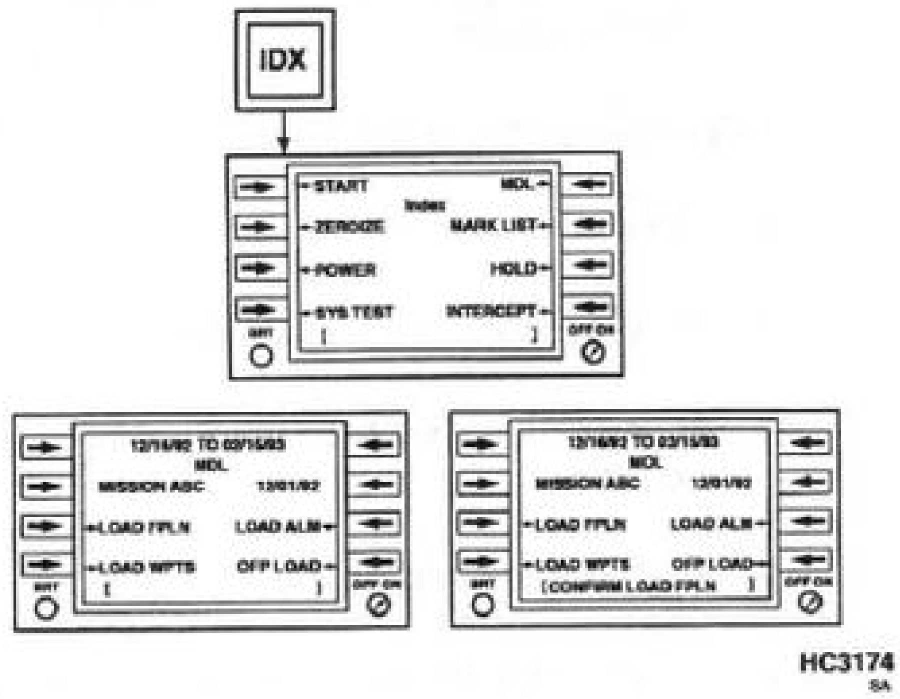

Figure 16-28. Creating a Flight Plan/Loading from the MDL

(2) Pressing L/S 3 key a second time loads the CDNU with a flight plan from the MDL cartridge.

7. Modifying a Flight Plan/Inserting Additional Waypoints (Figure 16-29).

a. Using down arrow key to scroll to desired waypoint.

b. Enter new waypoint into scratchpad.

c. Press the L/S key corresponding to the location for the new waypoint entry.

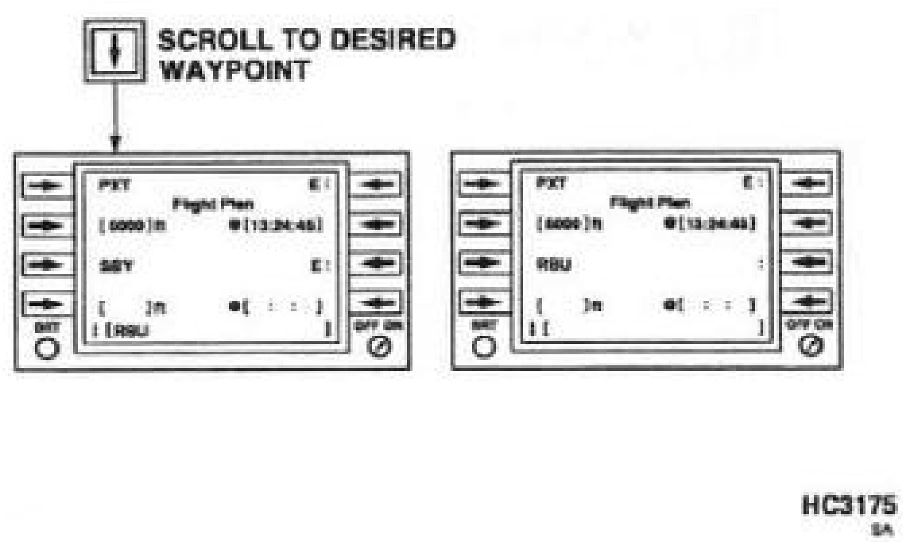

Figure 16-29. Modifying a Flight Plan/Inserting Additional Waypoints

d. The new waypoint will be inserted above the last waypoint.

8. Copying/inserting a waypoint.

a. Press FPLN button.

b. Press F7 key twice (Copy what?)

c. Press L/S key next to desired waypoint to be copied.

d. Scroll to new location.

e. Press L/S key to insert the selected waypoint to the new flight plan location. The copied waypoint will be inserted above the waypoint adjacent to the depressed L/S key.

9. Modifying a Flight Plan/Deleting Waypoints (Figure 16-30).

a. Using the down arrow key, scroll to the desired waypoint.

b. Enter "-" in the scratchpad.

c. Press the L/S key of the waypoint you want to delete from the flight plan.

Note

The active waypoint cannot be deleted with a dash.

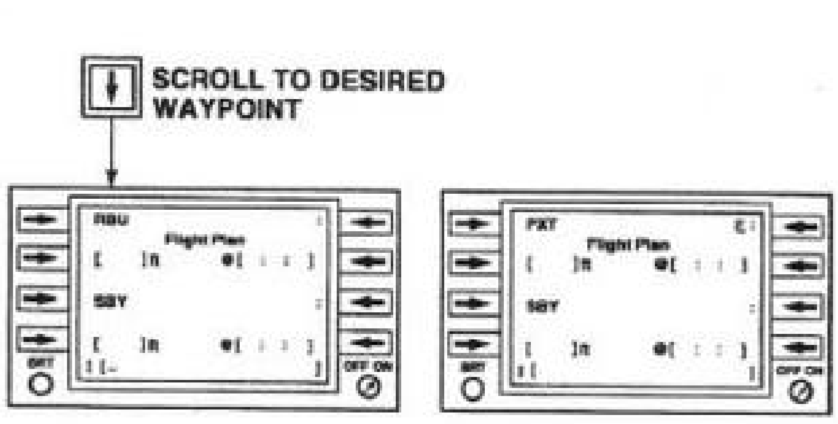

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Figure 16-30. Modifying a Flight Plan/Deleting Waypoints

d. When the waypoint is deleted the previous waypoint will fill the void.

10. Entering Waypoints/Identifier, Bearing, Distance (IBD) Waypoint (Figure 16-31).

a. Using down arrow key scroll to desired waypoint.

b. Enter the waypoint identifier, desired bearing and distance into the scratchpad.

c. Press L/S key of desired waypoint.

Note

Options are Bearing to 1 decimal place, Distance to 2 decimal places, True/ Magnetic "T" or "M" and English/Metric "N" or "K".

d. IBD waypoint will be inserted into the waypoint line and the previous waypoint will move down two lines.

11. Entering Waypoints/IBD Waypoint Alternate Method (Figure 16-32).

a. Using down arrow key to scroll to desired waypoint.

b. Enter desired bearing and distance into the scratchpad.

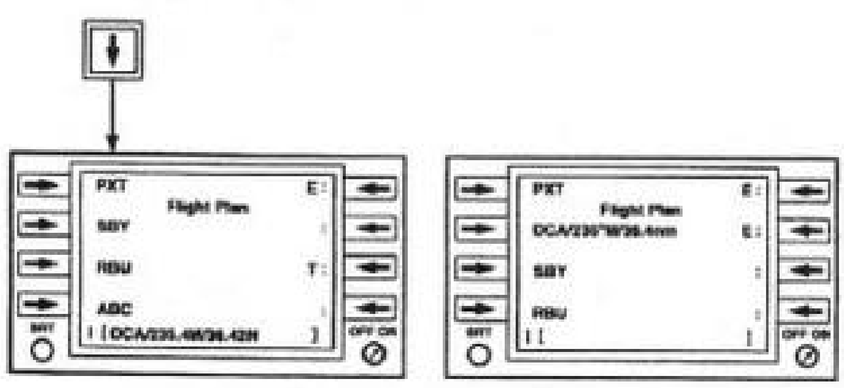

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Figure 16-31. Entering Waypoints/Identifier, Bearing, Distance (IBD) Waypoint

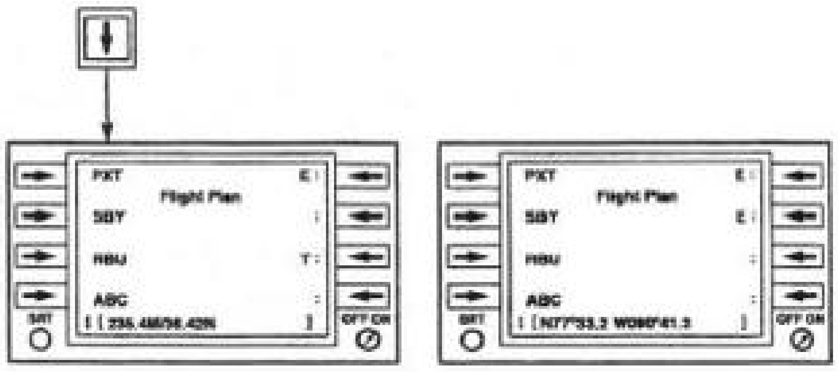

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Figure 16-32. Entering Waypoints/IBD Waypoint Alternate Method

c. Press L/S key of desired waypoint, this will become the Base waypoint. Base waypoint will remain unchanged.

(1) Lat/Long of new IBD waypoint is displayed in the scratchpad. It is now available for insertion into the flight plan at the desired position.

12. Entering Waypoints/Lat/Long or MGRS Waypoints (Figure 16-33).

a. Press FPLN key.

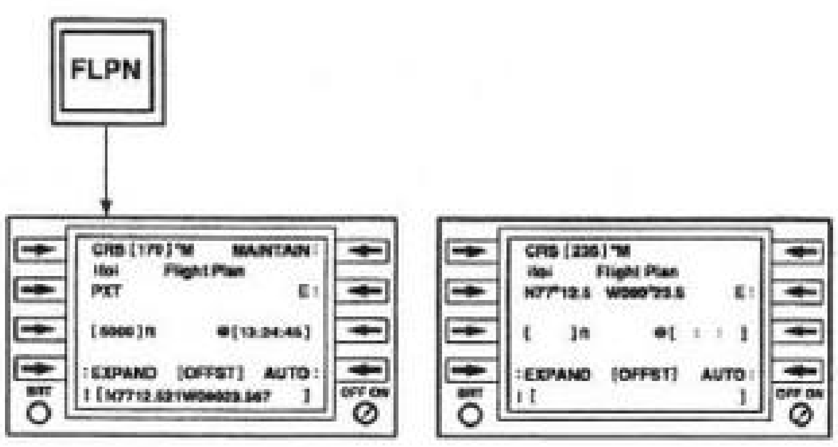

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Figure 16-33. Entering Waypoints/LAT/LONG or MGRS Waypoints

b. Enter Lat/Long or MGRS position in the scratchpad. Select the L/S key for the point in the flight plan where you want to insert the waypoint.

c. Press L/S 2 key, Lat/Long in scratchpad will be displayed on Line 3.

13. User Defined Labels/Adding or Removing Labels (Figure 16-34).

Note

A user defined label can be attached to any Lat/Long or MGRS waypoint in the Flight Plan or Mark List, i.e. "Tower". The table is preceded by "/" when entered in the scratchpad and is limited to a maximum of 5 characters. Duplicate names are not permitted. The label provides a name to a user defined waypoint, not found in the primary or reversionary database. Name is removed by typing "/" in the scratchpad and pressing the desired waypoint L/S key.

a. Press FPLN key.

b. Adding Label enter "/Label" into scratchpad.

c. Press L/S key of waypoint.

d. Removing Label, Enter "/" into scratchpad.

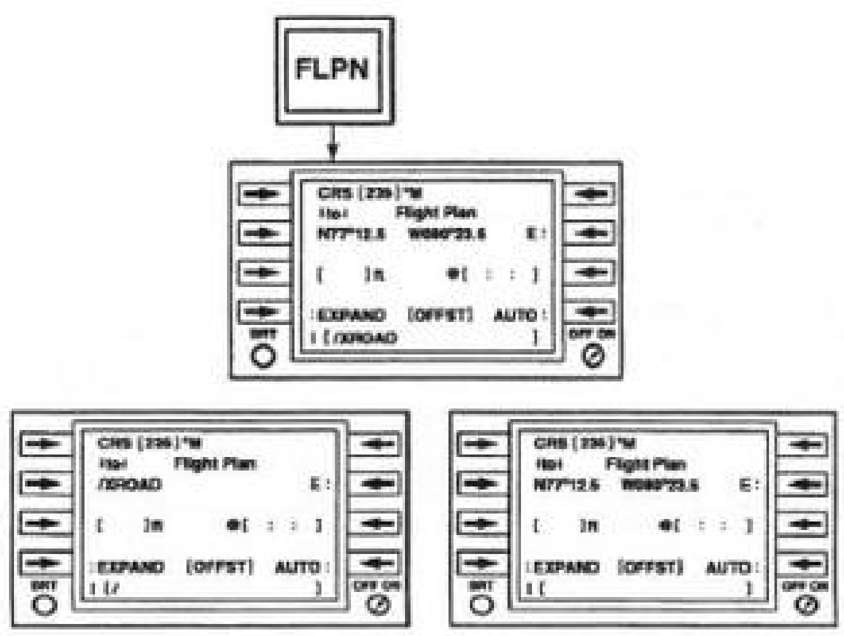

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Figure 16-34. User Defined Labels/Adding or Removing Labels

e. Pressing L/S key of User Defined Label will only remove label.

14. Assigning a time-on-target.

a. Press FPLN key.

b. Scroll to desired waypoint.

c. Enter desired TOT (Zulu) in scratchpad.

d. Press L/S 7 (@[: :]).

Note

A time-on-target will allow the use of the command ground speed (GScmd) on Progress Monitoring Page 1/3.

15. Auxiliary Data for Waypoints/from Flight Plan Page (Figure 16-35).

a. Using down arrow key, scroll to desired waypoint.

b. Press L/S key of the desired waypoint.

Note

For active or future waypoints the waypoint data page is accessed by pressing the L/S key of the desired waypoint with a blank scratchpad.

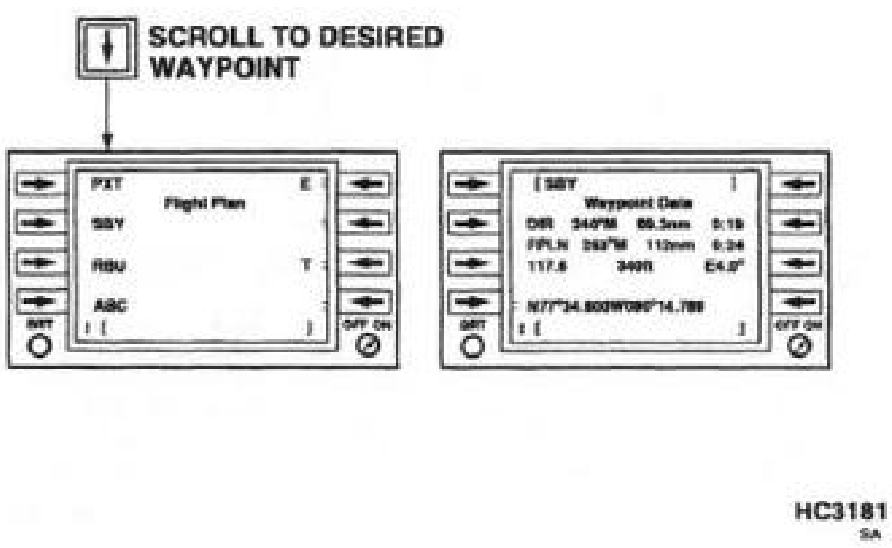


Figure 16-35. Auxiliary Data for Waypoints/from Flight Plan Page

c. The waypoint data page will be displayed.

(1) Line 1 will display waypoint.

(2) Line 3 will display Direct-To, To-To Course and Along Flight Plan (Inbound course/Distance to Go/Time to Go).

(3) Line 5 will display station frequency, elevation and declination.

(4) Line 7 will display waypoint location, toggles between Lat/Long and MGRS display for position.

d. To access waypoint from data page, enter auxiliary waypoint in scratchpad (3-5 letter identifier).

e. Press L/S 1 key, new waypoint will be displayed on Line 1.

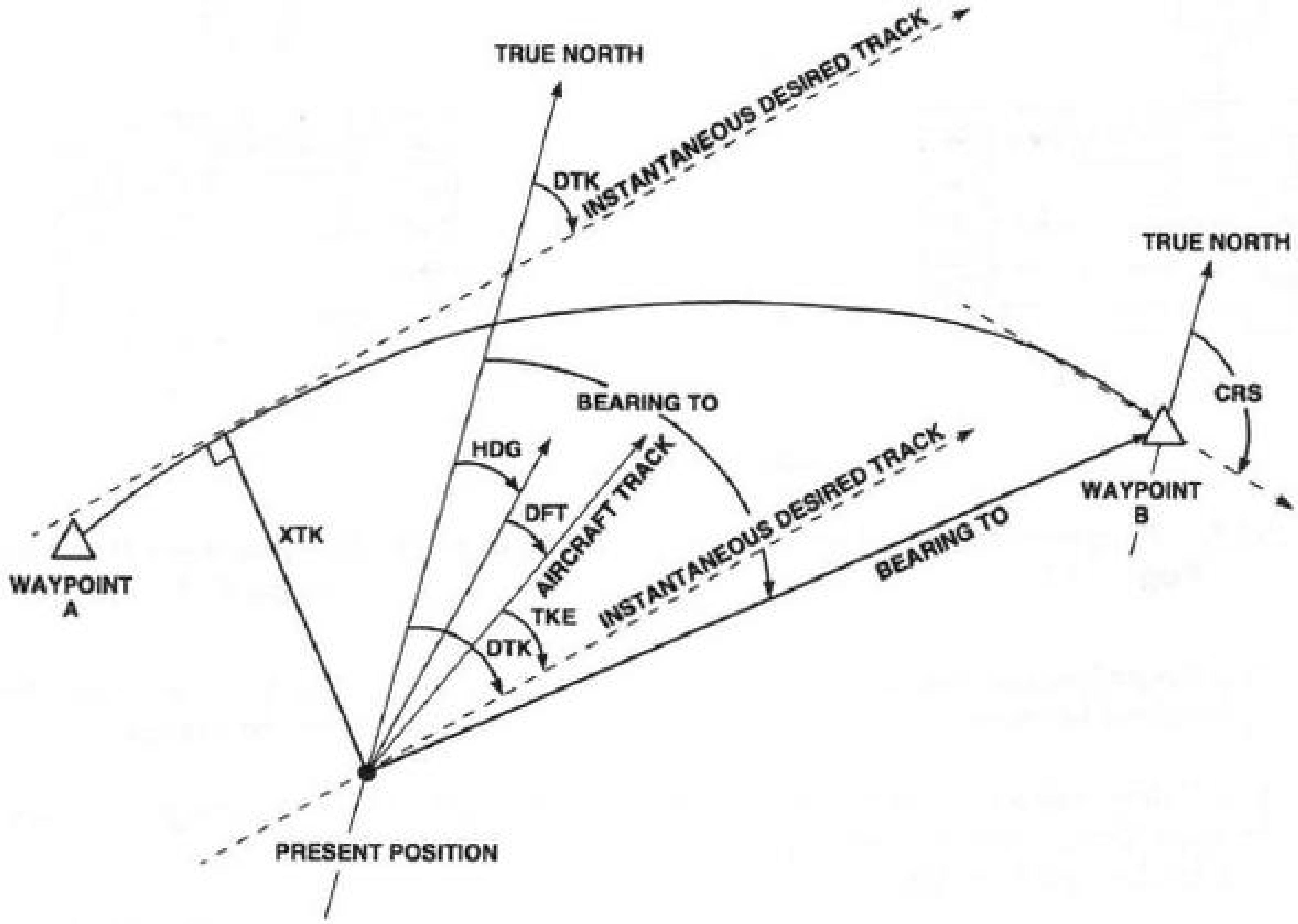
Note

- If waypoint is not currently in flight plan dashes will appear in the FPLN data line.
- If waypoint is not contained in the Reversionary or Preliminary Databases, the annunciation "Not In Database" will appear in the scratchpad.
- While on flight plan page the operator may use function key (F7) "Data For?" to enter waypoint. It can also be accessed from the Mark List page.

16. Progress Monitoring Procedures.

The "PROG" function key is used to access the latest Progress page viewed (Figure 16-36). The three Progress pages are page, scrollable, and wraparound. Any of the Progress pages may be exited by pressing any function key except MARK. Page (1/3) provides lateral guidance relative to the flight plan. Page (2/3) is not available for use in the CH-53E. Page (3/3) provides operating conditions independent from the flight plan.

a. Press PROG key, progress page 1/3 will be displayed. The Progress Monitoring Page 1/3 (Figure 16-37) displays the information



BEARING TO= TRUE BEARING TO THE WAYPOINT FROM PRESENT POSITION ± PRESENT POSITION MAGVAR

BEARING FROM= TRUE BEARING FROM THE WAYPOINT TO THE PRESENT POSITION± WAYPOINT MAGVAR (DECL IF AVAILABLE)

DRIFT ANGLE (DFT)= ANGULAR DIFFERENCE BETWEEN AIRCRAFT TRACK AND AIRCRAFT HEADING

COURSE (CRS)= DESIRED TRUE TRACK INTO THE WAYPOINT, AT THE WAYPOINT, ±WAYPOINT MAGVAR (DECL IF AVAILABLE)

TRACK ANGLE ERROR (TKE)= ANGULAR DIFFERENCE BETWEEN THE AIRCRAFT TRACK AND THE INSTANTANEOUS DESIRED TRACK

INSTANTANEOUS DESIRED TRACK (DTK)= DTK ± PRESENT POSITION MAGVAR

CROSS TRACK DEVIATION (XTK)= LATERAL DEVIATION FROM PRESENT POSITION TO A PERPENDICULAR TO THE INSTANTANEOUS DESIRED TRACK

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Figure 16-36. Progress Page Definition

required to gauge compliance with the Lateral Guidance Display parameters of the flight plan.

(1) Line 1 left field will display Desired Magnetic Course (DTK) and present position MAGVAR.

Note

DTK = Desired Great Circle true track ±present position MAGVAR.

(2) Line 1 right field will display ground speed required to achieve the current planned time of arrival.

(a) It is only present if planned time of arrival was entered for the waypoint.

(b) L/S 5 key when pressed allows operator to toggle between current ground speed and commanded.

(3) Line 4 indicates To or From bearing relative to active waypoint.

(4) Line 5 left field allows operator to toggle between position, To-Dist, From-Dist, To-Range and From-Range.

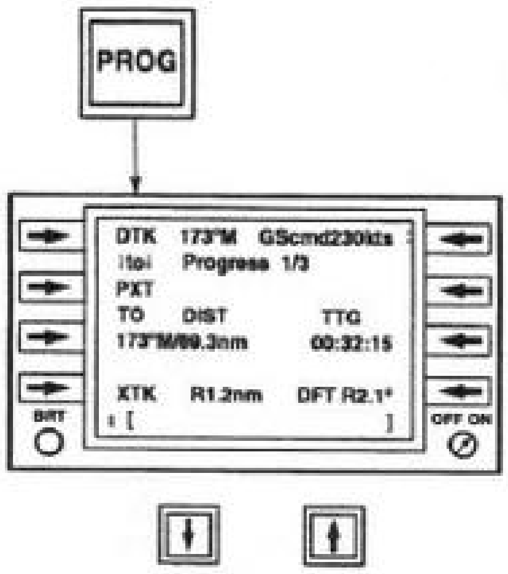

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Figure 16-37. Progress Monitoring Page 1/3

(5) Line 5 right field will display time to go to the active waypoint.

(6) Line 7 left field allows operator to toggle between Cross Track Deviation (XTK) and Track Angle Error (TKE)

(7) Pressing up or down arrow key will scroll to next progress page.

Note

Progress page 2/3 is not applicable to CH-53E.

b. Scroll to page 3/3 by using down arrow key. The Progress Monitoring Page 3/3 (Figure 16-38) displays information that is necessary to fly the aircraft, but does not directly affect compliance with the flight plan.

(1) Line 1 displays integrated NAV solution of present position.

(2) Line 3 left field displays current ground track.

(3) Line 3 right field allows operator to enter magnetic variation if required.

Note

If a MAGVAR table is not available, the computed MAGVAR will be periodically

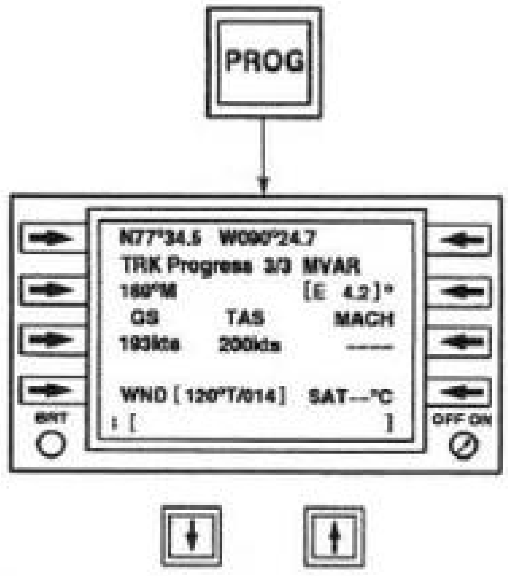

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Figure 16-38. Progress Monitoring Page 3/3

updated on Line 3. However, if the table is available, it cannot be changed.

(4) Line 5 indicates ground speed, TAS and Mach.

The TAS will be calculated based on ground speed and manual wind inputs only.

The Mach number will be displayed as a "_____".

(5) Line 7 indicates current wind, entered by operator.

(6) Pressing up or down arrow key will scroll to next progress page.

17. To-To Navigation (Figure 16-39).

a. To-To navigation is used in conjunction with Automatic Leg Sequencing.

b. Desired True Track is the calculated Great Circle Track between previous waypoints and the active waypoint.

c. The CDNU Computed Magnetic Course (CRS), displayed on line 1 of the Flight Plan Page, is the calculated Great Circle Track at the active waypoint location using the active waypoint MAGVAR or the active waypoint Magnetic Declination, if available.

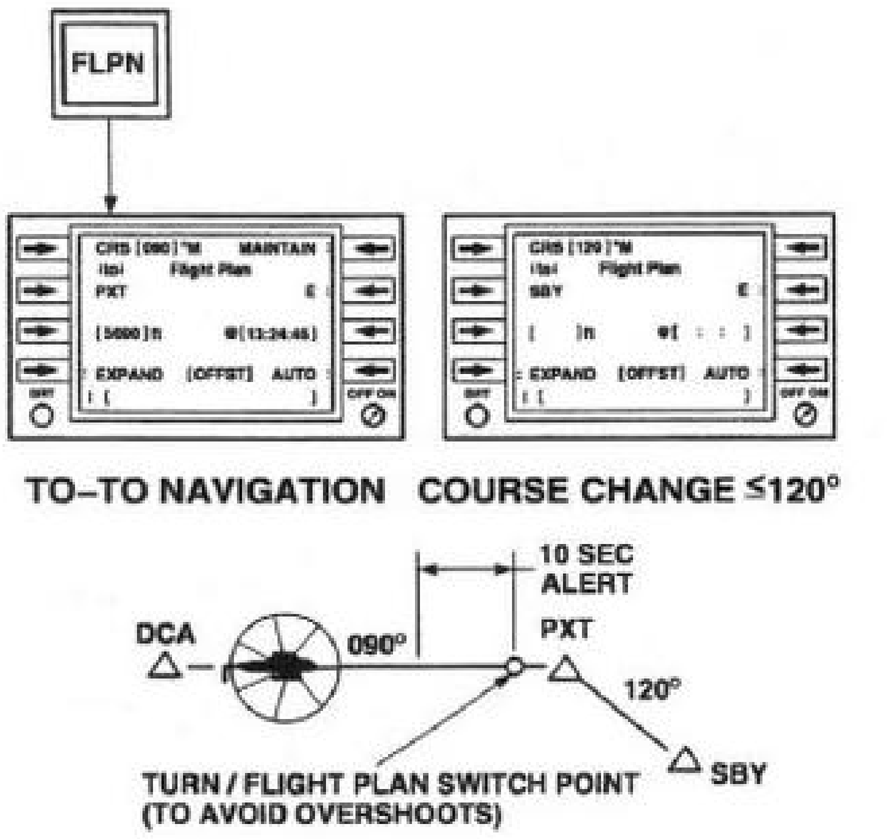

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Figure 16-39. To-To Navigation

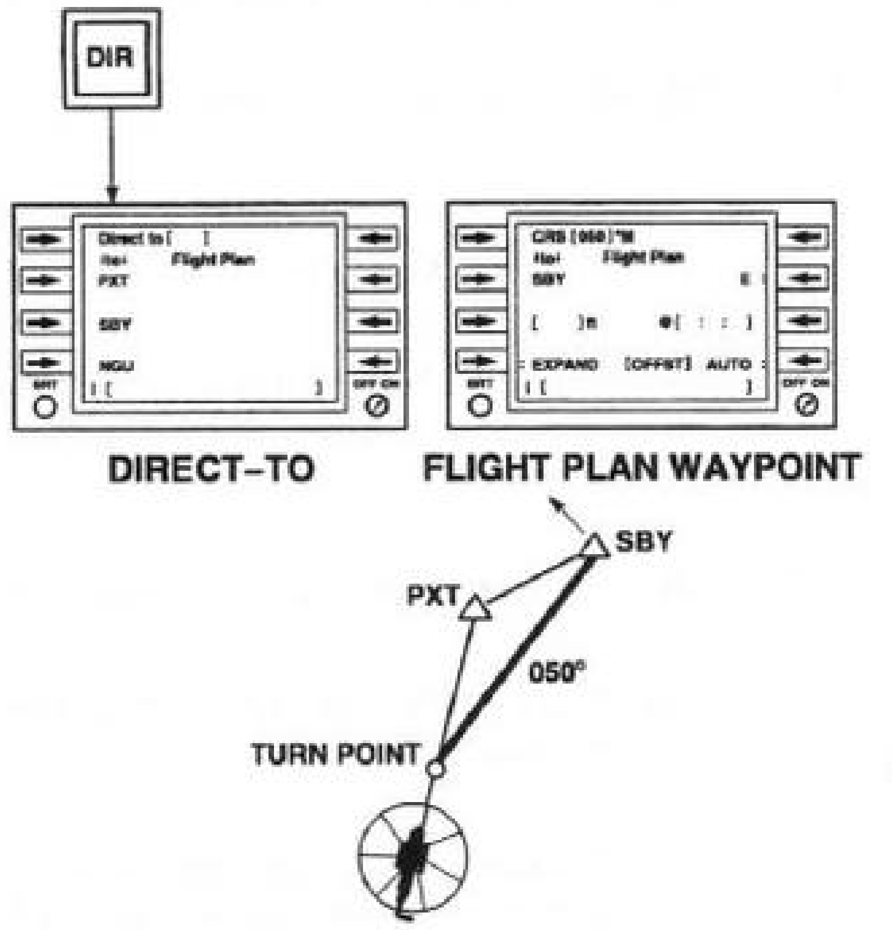

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Figure 16-40. Direct-To Navigation

d. Desired Magnetic Course (DTK), displayed to the BDHI and Progress Page 1/3, indicates the current required track along the Great Circle Track defined between the previous and active waypoints and displayed with aircraft position (Local) MAGVAR.

e. Course deviation is relative to deviation from the Great Circle Track.

f. Distance is the calculated Great Circle distance between the aircraft present position and the active waypoint.

g. CDNU displayed bearing "TO" is calculated using aircraft present position MAGVAR.

h. CDNU displayed bearing "FROM" is calculated using destination waypoint MAGVAR or Magnetic Declination, if assigned.

18. Direct-To Navigation (Figure 16-40).

a. Initiated by pressing "DIR" function key, displaying the Flight Plan Page.

b. Four Direct-To Possibilities.

(1) Direct-To a waypoint on the existing flight plan.

(2) Direct-To impromptu (on file) waypoint.

(3) Direct-To impromptu vector bearing/distance from present position.

(4) Via intermediate waypoint.

c. If necessary, scroll to desired Direct-To waypoints.

Note

Flight plan waypoints which are bypassed using Direct-To are deleted from the flight plan.

d. Press L/S 3 key, calculated course will be displayed on line 1.

e. Modifiable parameters associated with this waypoint can now be changed, if desired.

f. Impromptu Waypoint (Figure 16-41) may be entered into scratchpad. Press L/S 1 key, calculated course will be displayed on Line 1.

g. Impromptu vector from present position.

(1) Enter impromptu vector bearing/ distance in scratchpad.

(2) Press L/S key, calculated course direct to vector waypoint will be displayed on Line 1.

h. Alternate method for impromptu waypoint.

(1) Press FPLN key, enter waypoint to scratchpad.

(2) Press L/S 2 key, calculated course direct into intermediate waypoint will be displayed on Line 1.

i. Impromptu Vector from Present Position (Figure 16-42), press DIR.

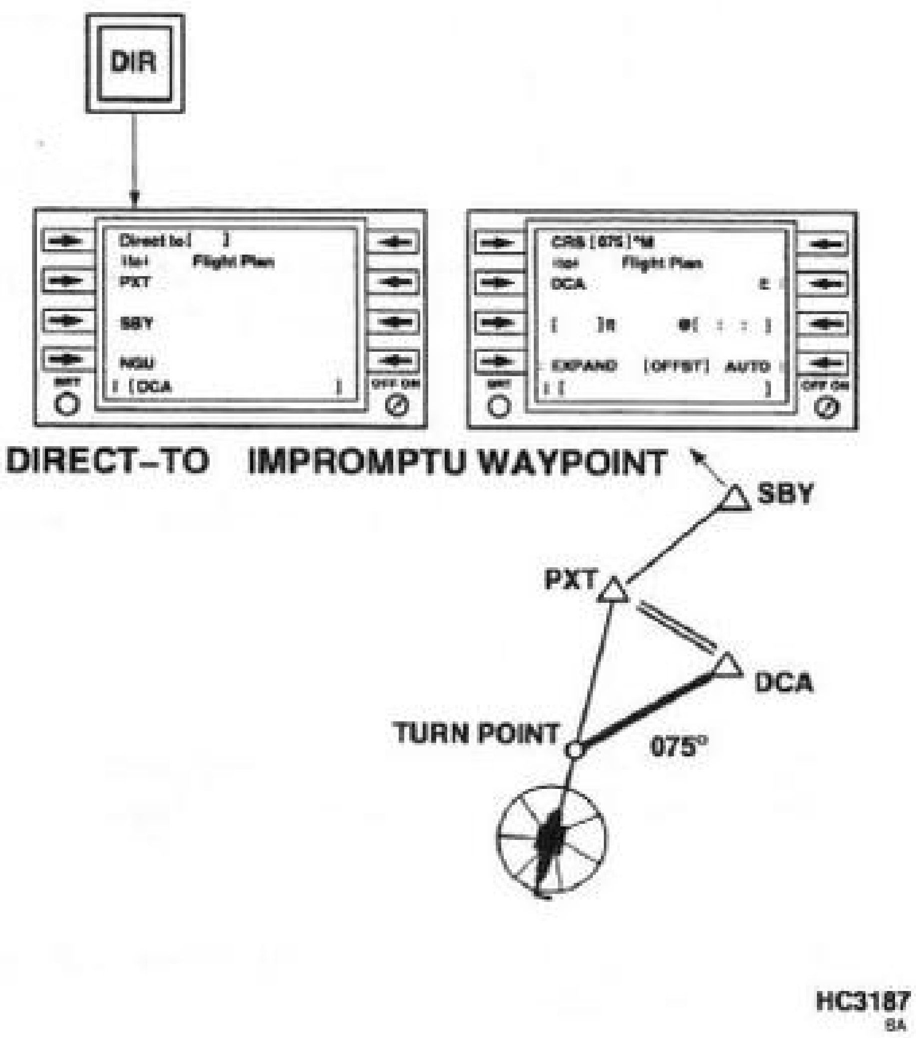

Figure 16-41. Impromptu Waypoint

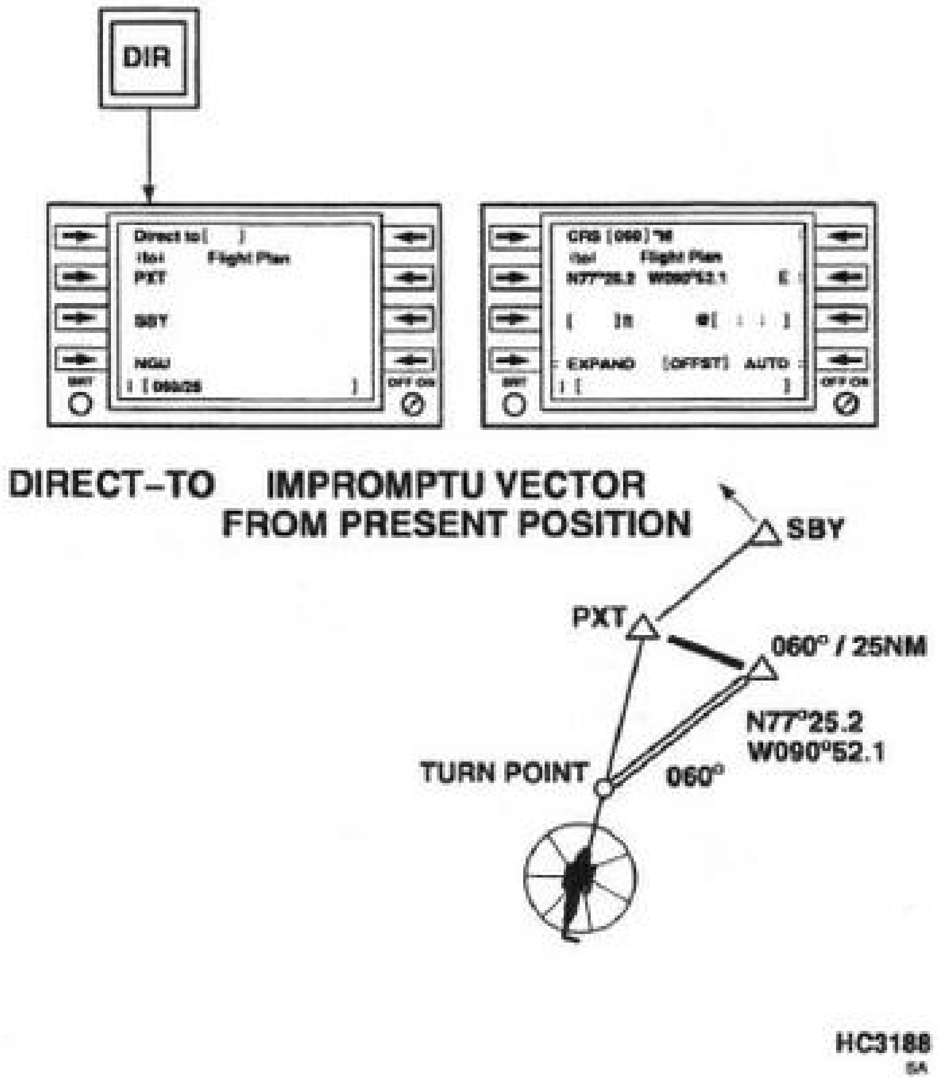

Figure 16-42. Impromptu Vector from Present Position

j. Enter impromptu vector bearing/ distance from present position.

(1) Press L/S 1 key.

(2) Calculated course direction, vector waypoint will be displayed on line 1.

k. Flight Plan Waypoint via Intermediate Waypoint (Figure 16-43), press DIR.

l. Enter intermediate Direct-To waypoint from reversionary or primary database.

(1) Press L/S key of desired flight plan waypoint.

(2) Calculated course direction, intermediate waypoint will be displayed on line 1.

19. To-From Navigation to a Waypoint (Figure 16-44).

a. To a waypoint, press FPLN key.

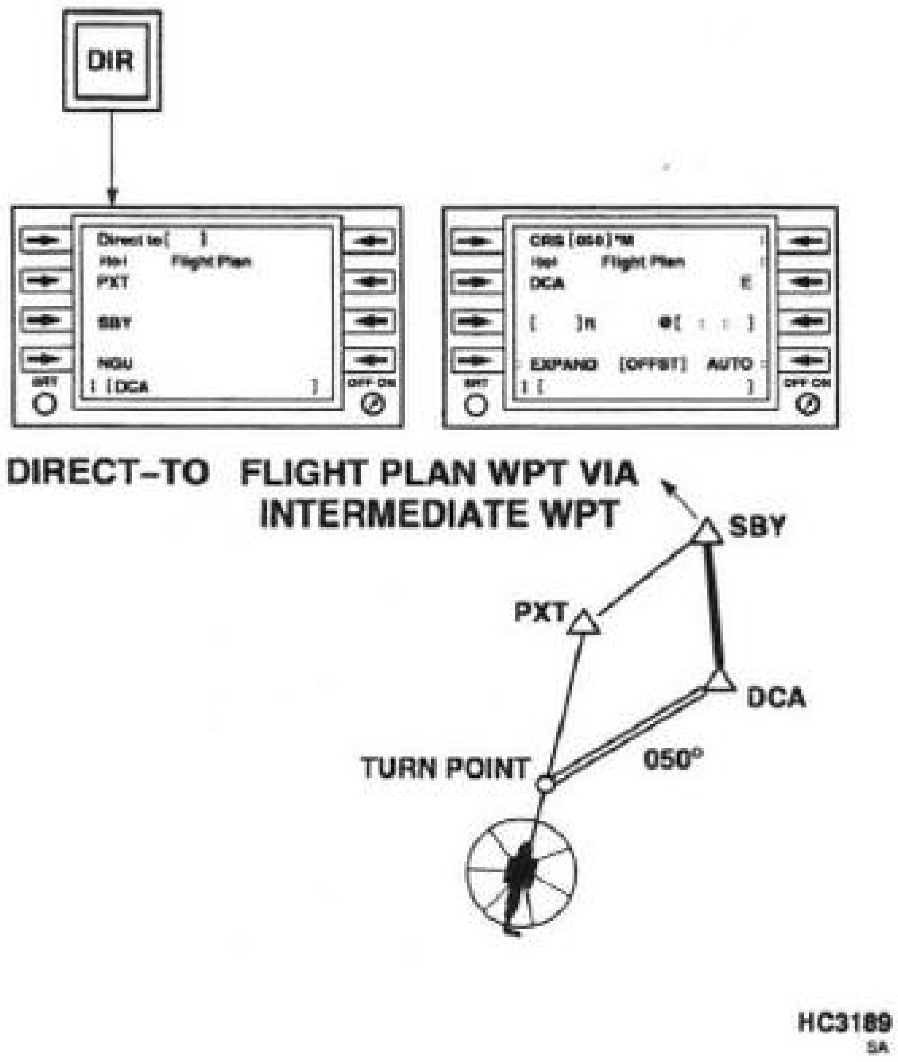

Figure 16-43. Flight Plan Waypoint Via Intermediate Waypoint

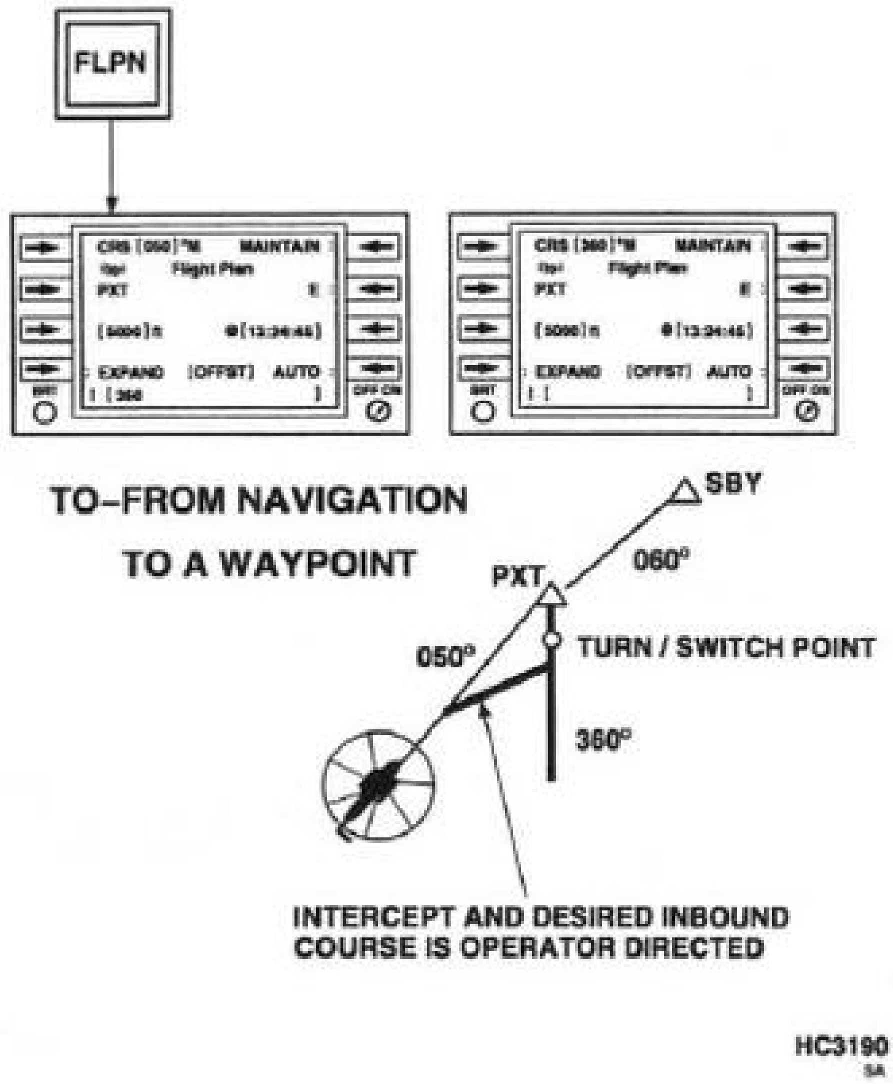

Figure 16-44. To-From Navigation to a Waypoint

b. Enter new desired course to the waypoint in scratchpad.

c. Press L/S 1 key, desired inbound course will be displayed on line 1.

Note

"TO" mode is defined as a course change less than 90° from currently displayed flight plan course. If exceeded, "ERROR CRS CHG > 90°" appears in the scratchpad.

d. From a waypoint press FPLN key (Figure 16-45).

e. Press L/S 8 key.

(1) Enter desired outbound course from the active waypoint into scratchpad.

(2) Press L/S 1 key, desired outboard course will be displayed on Line 1.

Note

- Must toggle to MAN prior to waypoint capture to realize "FROM" mode. The Manual mode will keep labels in flight plan.
- While in the "TO" mode, with manual waypoint sequencing selected, a course change greater than 90 degrees from currently displayed flight plan course activates "FROM" mode.

f. Desired Magnetic Course (CRS) is operator entered on the Flight Plan Page for the active waypoint.

g. Courses "TO" the active waypoint may use the AUTO or MANUAL sequencing mode (Manual Mode if it is desired to overfly the waypoint on the same course).

h. Manual sequencing mode must be used for a course "FROM" the active waypoint.

i. CDNU displayed Gearing "TO" or "FROM" is calculated the same as in the To-To mode.

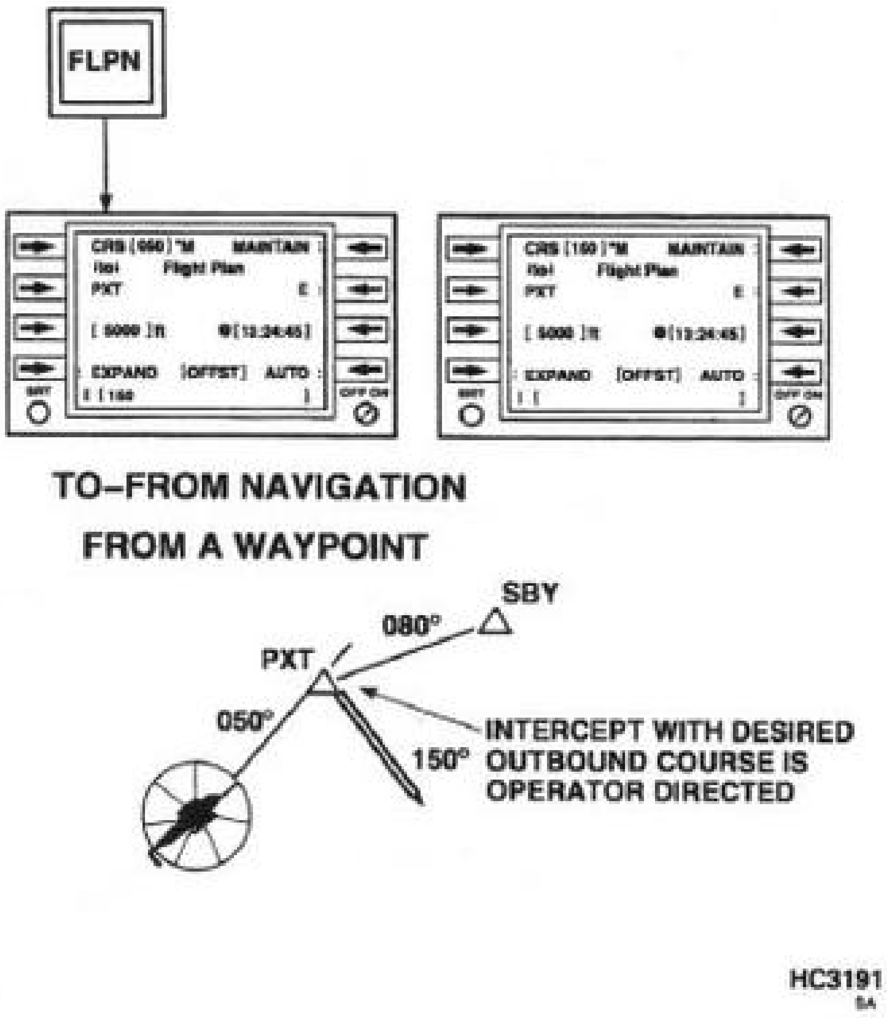

Figure 16-45. To-From Navigation from a Waypoint

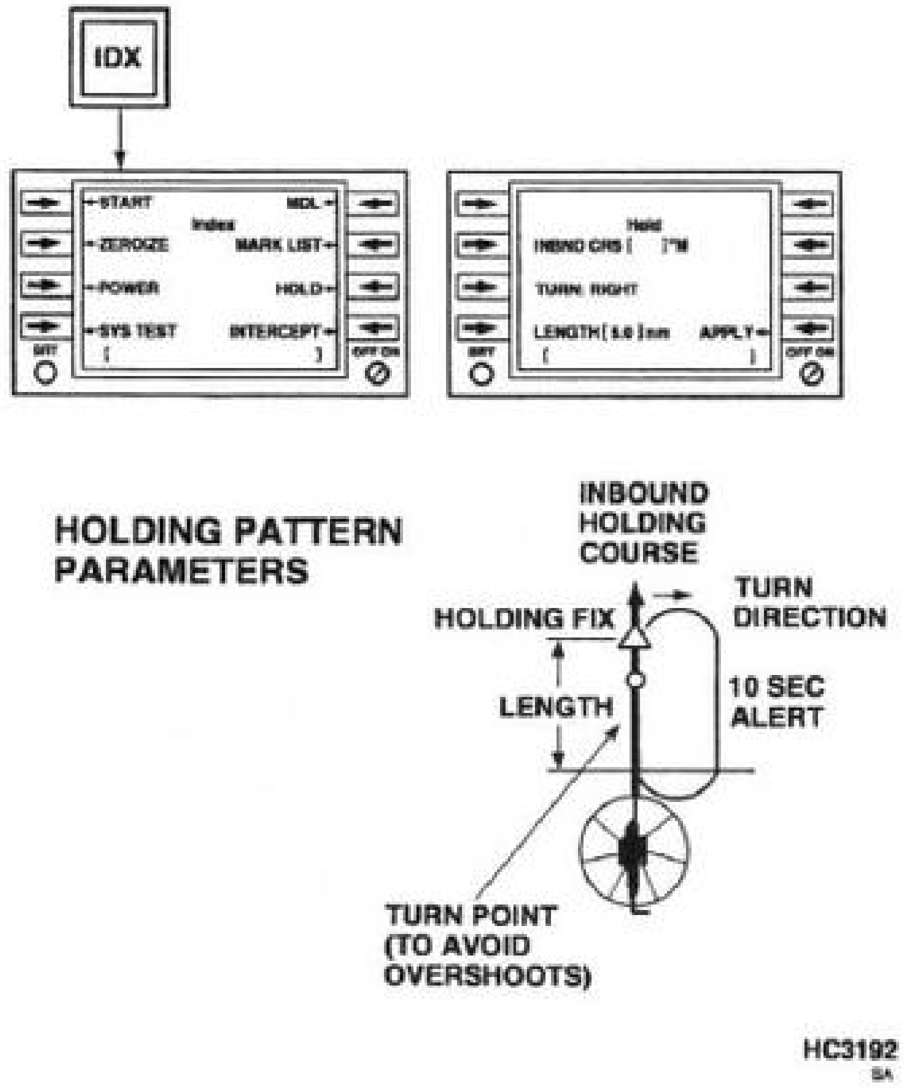

Figure 16-46. Holding Pattern Parameters

16.8.3.5 Holding Patterns

1. The CDNU computes the FAA method geometry for the holding entry. Line 7 of hold page reflects current holding definition which states: (1) Pattern Parameters (Figure 16-46) are defined, but the holding fix is not designated and "Apply" can be activated. (2) Pattern Parameters defined as, holding fix identified, but the holding guidance is not activated and "Remove" can be activated. (3) Holding guidance is active and "cancel" can be activated and holding is canceled. A holding pattern which is currently being executed can be canceled by selecting "Cancel" from the Hold page (thereby auto sequencing to the next waypoint) or calling the Direct page selecting a Direct-To waypoint.

   a. Press IDX key.

   b. Press L/S 7 key, Hold.

      (1) Enter inbound holding course if known in scratchpad (A blank display will default to the flight plan inbound course.)

   c. Press L/S 2 key, hold course will be displayed on Line 3.

   d. Toggle L/S 3 key "Right" or "Left" turns (defaults to Right).

   e. Enter pattern length in scratchpad. Press L/S 4 key (defaults to length of 5.0 nautical mile).

   f. Press L/S 8 key Apply, applies the parameters and calls the "Flight Plan" for selecting the Hold Fix.

2. Default Inbound Holding Course (Figure 16-47).

   a. From L/S 8 key "Hold" page, press L/S 8 key, Apply. "HOLD AT?" will appear in scratchpad.

   b. Press down arrow key, scroll to desired waypoint, and select desired Hold Fix.

   c. Hold icon indicates waypoint has been designated as a holding fix, opposite of desired waypoint on line 3.

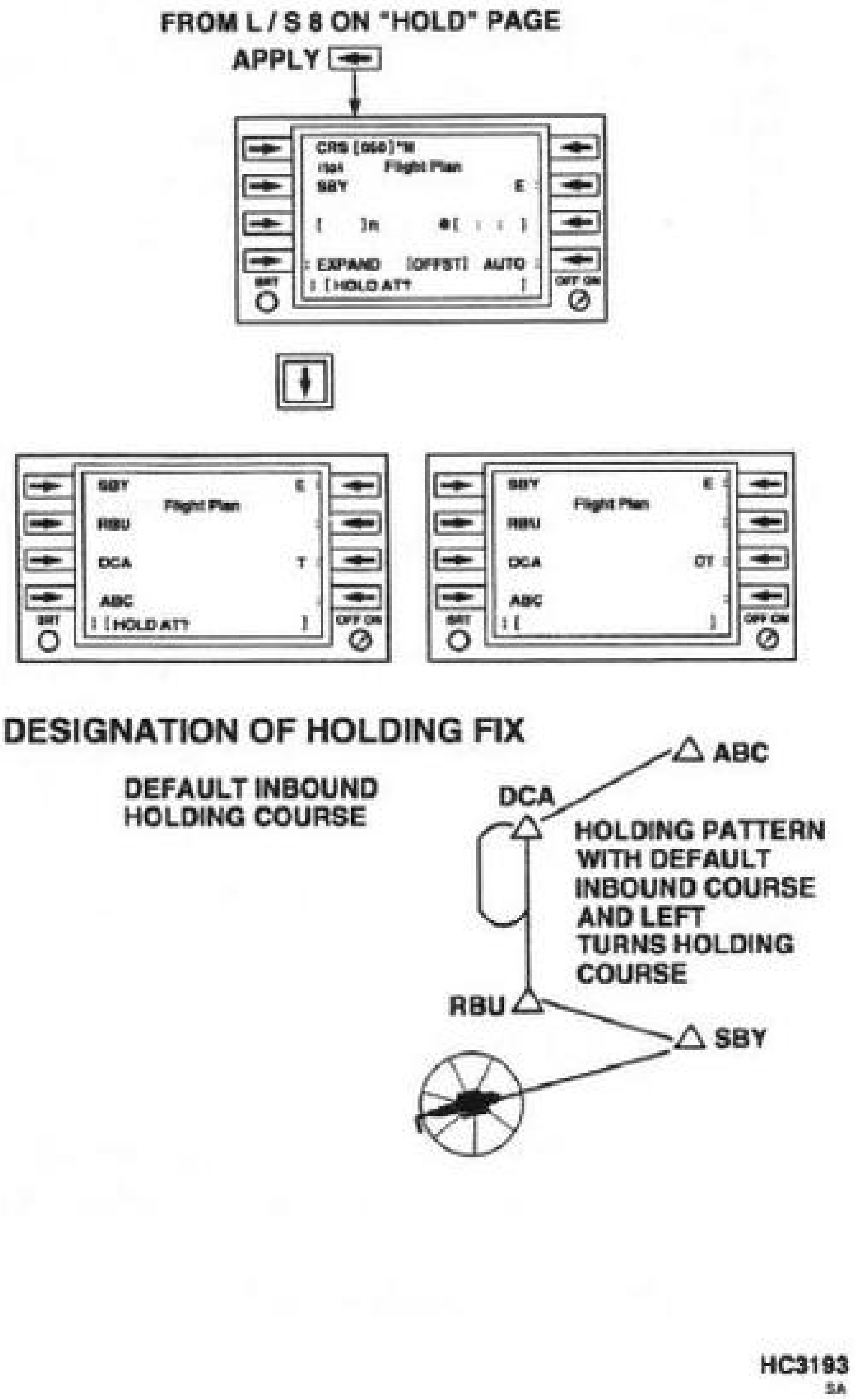

Figure 16-47. Default Inbound Holding Course

d. When a holding fix (Figure 16-48, defined with a defaulted inbound course) becomes the active waypoint, any course changes will affect the inbound holding course.

(1) Enter course change in scratchpad.

(2) Press L/S 1 key, new course will be displayed on Line 1.

3. Explicitly Defined Holding Course (Figure 16-49).

a. Enter desired holding course into scratchpad.

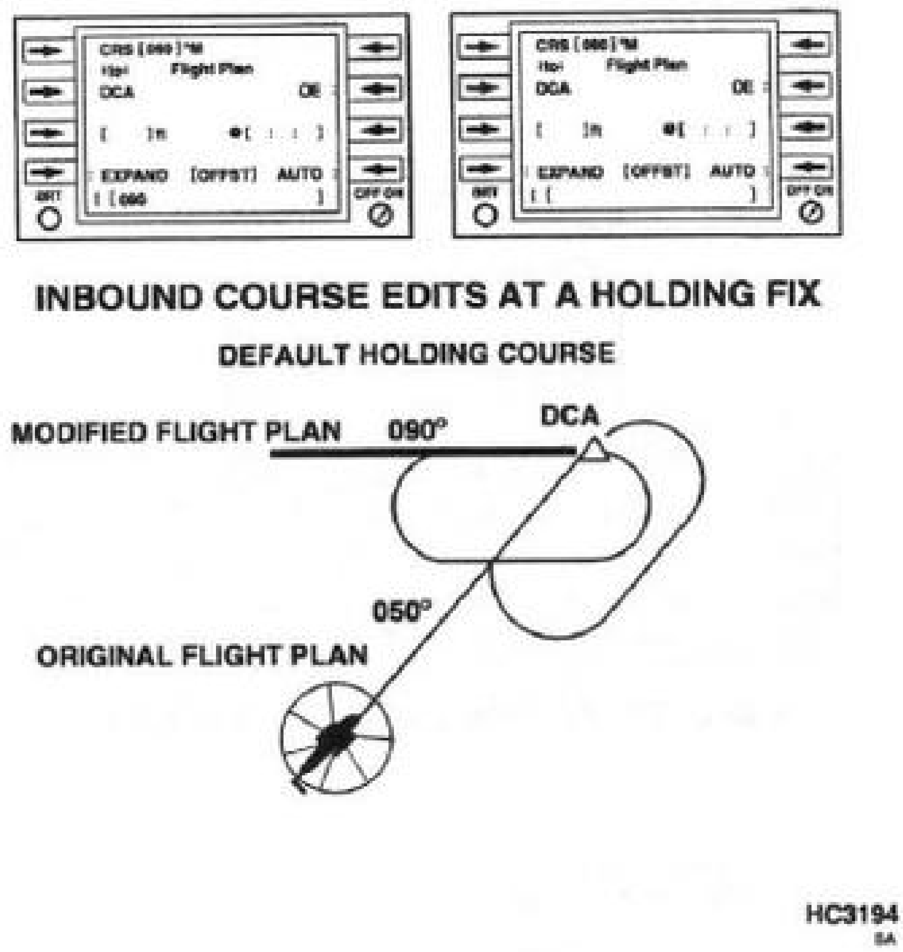

Figure 16-48. Inbound Course Edits at a Holding Fix

b. Press L/S 2 key, INBND CRS, new course will be displayed on Line 3. Inbound holding course is now explicitly defined and therefore fixed independent of the flight plan inbound course.

c. Press L/S 8 key APPLY.

d. Press L/S 2 key waypoint, "HOLD AT?" will appear in scratchpad.

4. Holding Fix Activation, Hold Page (Figure 16-50).

a. Before Passing Holding Fix.

(1) With hold fix selected, entry type is indicated on Line 1 (Direct in this case).

(2) Inbound course defaults to arrival course, Line 3 INBNDCRS [ ]°M, there will be no course indicated.

(3) Hold definition can still be removed and reapplied elsewhere, without losing parameter definitions Line 7.

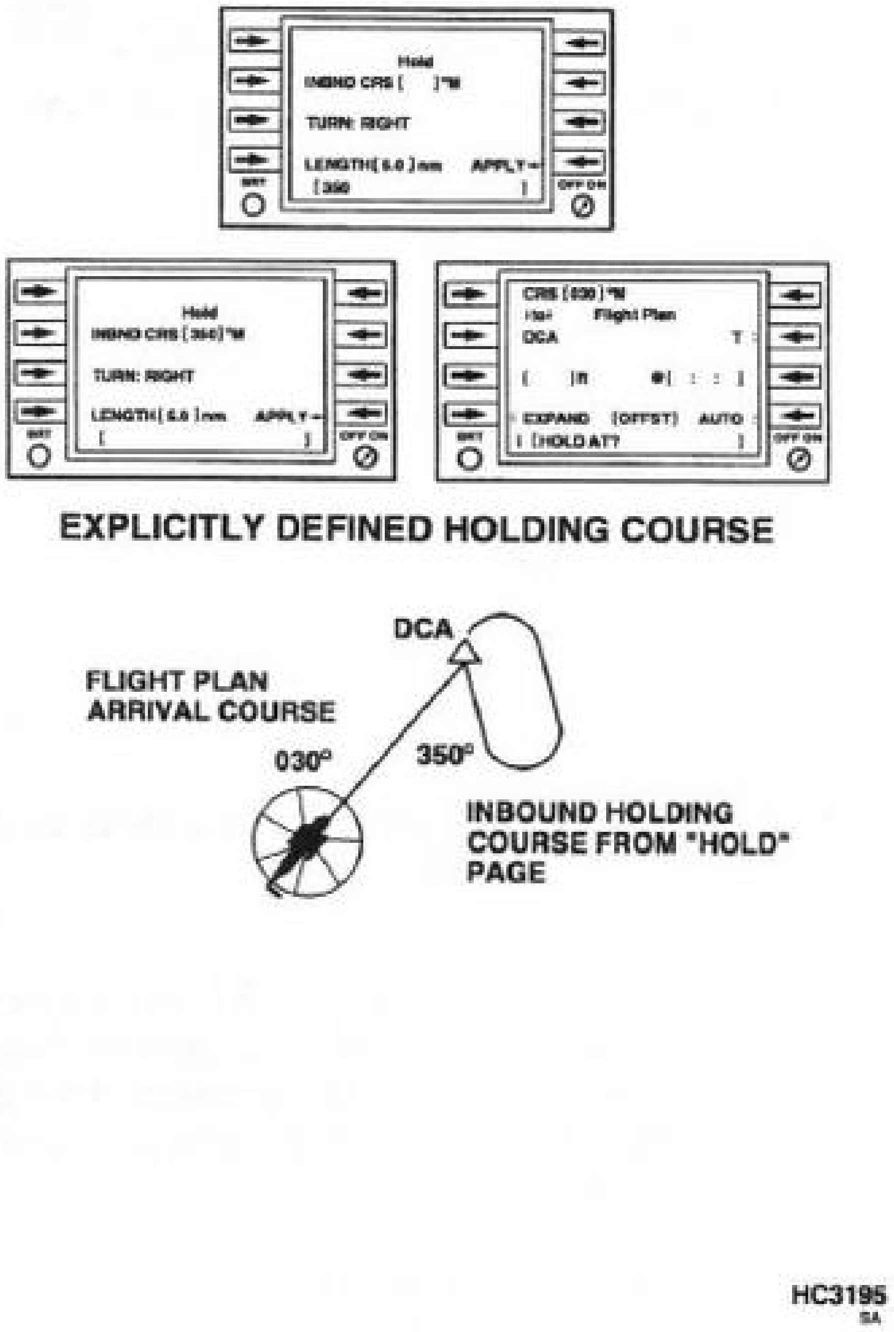

Figure 16-49. Explicitly Defined Holding Course

b. Remove After Passing Holding Fix.

(1) Holding becomes active on Line 1.

(2) Previous default inbound course now explicitly defined (remains the same, regardless of whether the aircraft is on inbound or outbound leg; does not negate the 10-sec. turn alert on either leg). Course edits can no longer be made when holding is active. Line 3 INBND CRS [030]°M, new course is displayed.

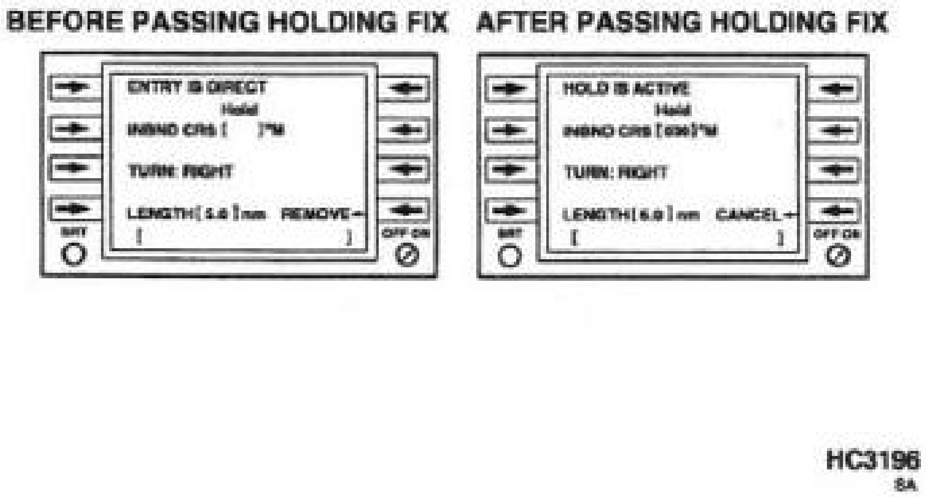

Figure 16-50. Holding Fix Activation, Hold Page

(3) Current pattern may be canceled: Holding pattern parameters may be reset if holding is canceled or when the current pattern is complete. Line 7 Cancel.

5. Holding Fix Activation, Flight Plan Display (Figure 16-51).

a. Before Passing Holding Fix.

(1) Hold icon on Line 3 indicates this waypoint is designated as a holding fix.

b. After Passing Holding Fix.

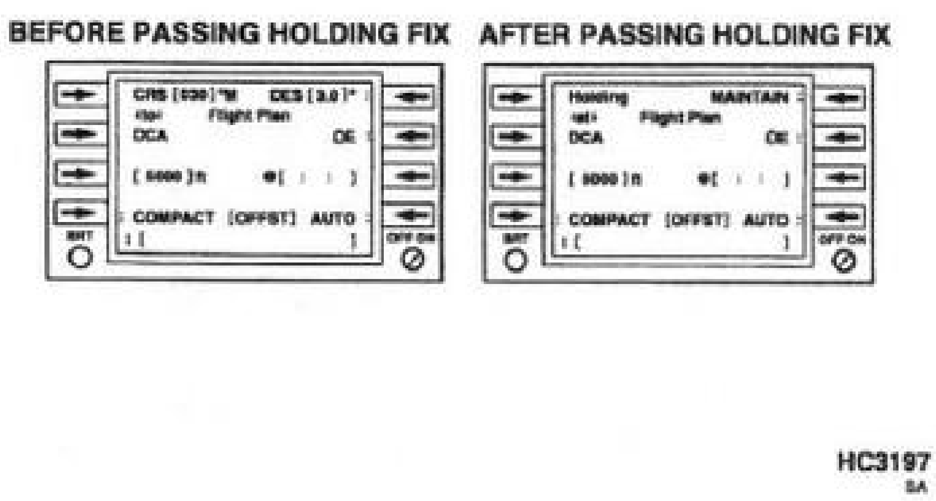

Figure 16-51. Holding Fix Activation, Flight Plan Display

(1) Line 1 indicates holding is active.

Note

Inbound holding course is now found on the "Hold" page in CRS [ ].

16.8.3.6 TACAN Arcing Approach

1. Entry using current TACAN procedures (Figure 16-52).

a. Press DIR key.

b. Press L/S 3 key, the new waypoint will be displayed on Line 3.

c. Enter desired inbound course to intercept Initial Approach Fix (IAF) into scratchpad.

d. Press L/S 1 key, CRS, new course will be displayed on Line 1.

e. Press L/S 8 key, prior to reaching the IAF, select MAN mode with CRS entry on Line 1.

f. During the arc, enter the Final Approach Course.

g. Enter desired Final Approach Course, to the active waypoint.

h. Press L/S 1 key, CRS, new course will appear.

i. After intercepting the Final Approach Course, enter the Missed Approach Course into scratchpad, but do not insert.

2. Missed Approach Procedure/Using Current TACAN Procedures (Figure 16-53).

a. While on the final approach, and prior to reaching the Missed Approach Point (MAP), enter the missed approach course.

b. Upon reaching the MAP, turn outbound. Enter the course from the scratchpad into CRS by pressing L/S 1 key.

c. Upon reaching the IAF, commence holding using standard TACAN procedures.

Note

This method reflects the current TACAN procedures and does not take advantage of the GPS and CDNU capabilities.

3. Recommended TACAN Arcing Approach RNAV Procedures (Figure 16-54).

a. Press DIR key.

b. Press L/S 3 key, the waypoint will appear on Line 5.

c. Press L/S 1 key, CRS (Execution) Upon reaching the IAF the CDNU will auto-sequence to

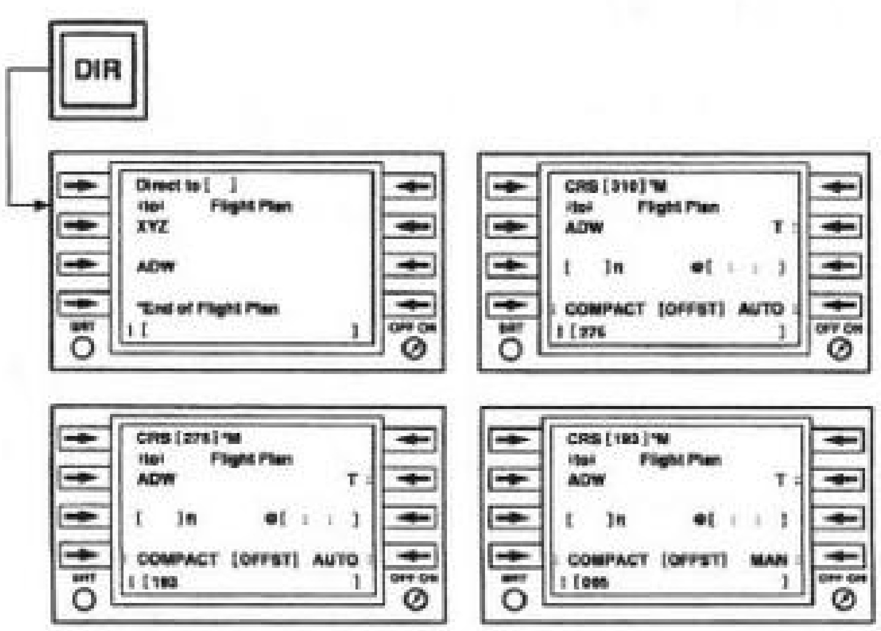

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Figure 16-52. TACAN Entry Procedures

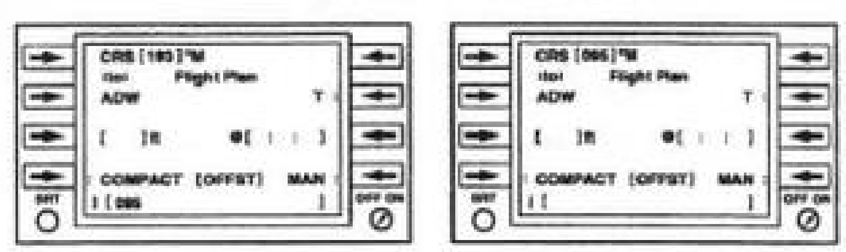

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Figure 16-53. Missed Approach Procedure Using Current TACAN Procedures

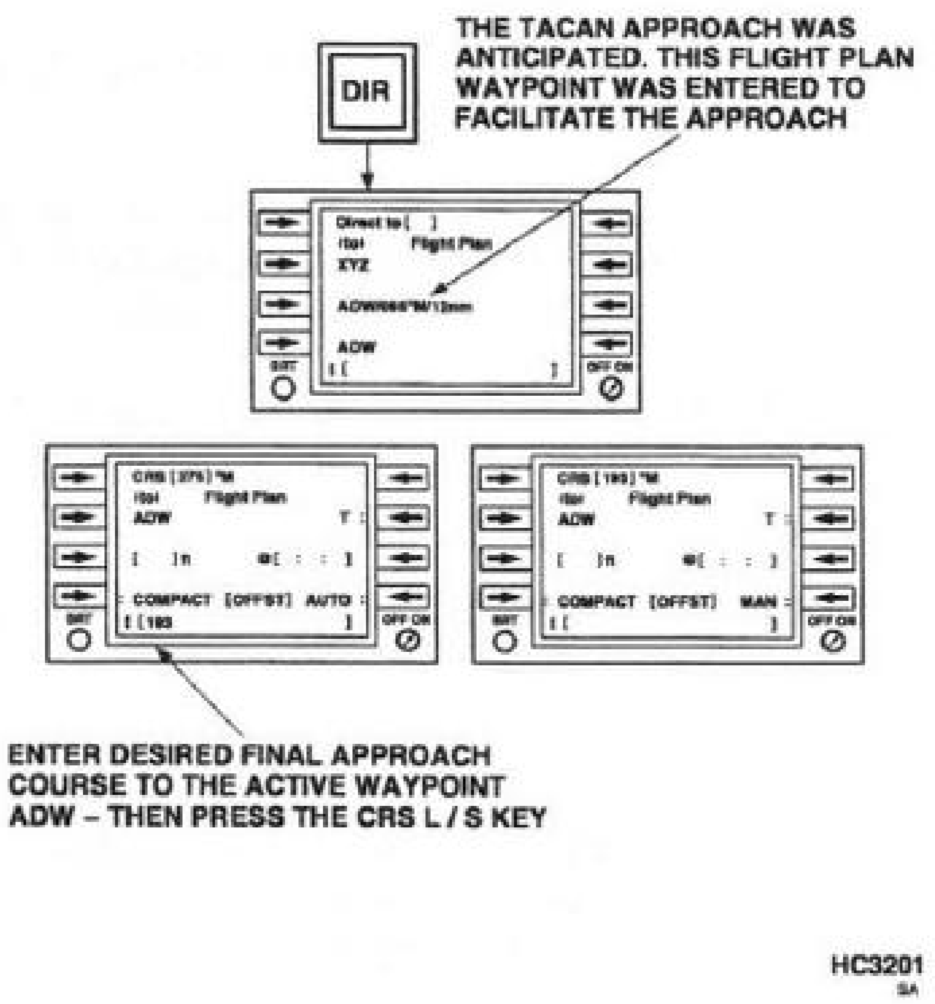


Figure 16-54. Recommended TACAN Arcing Approach RNAV Procedures

the next waypoint (ADW). Proceed with To-To mode inbound to the station until reaching 10 DME. Then commence arc.

d. During the arc MAN waypoint sequencing should be selected. Press L/S 8 key.

e. During the arc, the To-From mode must also be entered by selecting the desired final approach course to the To station.

f. Press L/S 1 key. The new course will be displayed on line 1.

4. RNAV Procedures Missed Approach Instructions (Figure 16-55).

a. Prior to commencing the approach, the missed approach instructions should be entered to the maximum extent possible.

b. The Holding Fix is the Initial Approach Fix (IAF) and should be added as the next waypoint (Identifier/Bearing/Distance Waypoint).

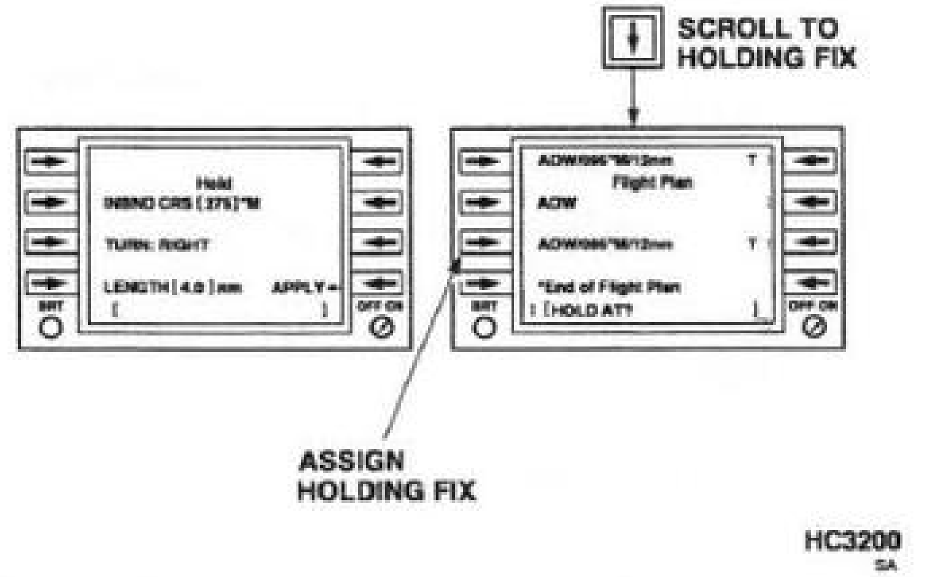


Figure 16-55. RNAV Procedures Missed Approach Instructions

c. The holding instructions should be entered on the "Hold" page, and press L/S 8 key, Apply.

d. The appropriate waypoint is selected for holding during the missed approach procedures.

e. Scroll down arrow key to holding fix, "Hold At?" will appear in scratchpad.

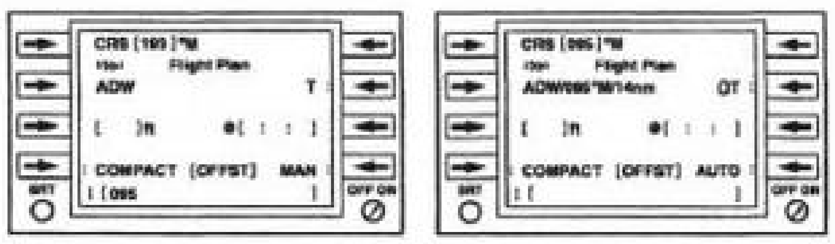
f. The Holding Fix will be assigned when the L/S 3 key is pressed. The IAF was added as the next waypoint after the destination. This will provide the necessary guidance for the missed approach.

5. RNAV Procedures Missed Approach Execution (Figure 16-56).

a. Prior to arrival at the Initial Approach Fix (IAF), the outbound course for the missed approach should be entered in the scratchpad.

b. To execute the Missed Approach Procedures (MAP), the required outbound radial should be entered from the scratchpad into CRS, press L/S l key.

c. As soon as the From flag is displayed on the course indicator, the Auto-sequencing mode should be toggled to Auto. (Activate holding and enter as described in the holding section.)



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SA

Figure 16-56. RNAV Procedures Missed Approach Execution

d. The next flight plan waypoint (IAF) is displayed after the Auto mode is executed and the previous waypoint (ADW) is passed (From), the course will be displayed on line 1.

16.8.3.7 Intercept Operations. The operator may keep track of nine moving waypoints. The intercept solution is a true intercept. It is calculated at the point where the paths of the aircraft and the waypoint cross. The CDNU recalculates the solution if changes in course and speed of parent aircraft occur. If the waypoint changes course or speed, the operator must provide corrections to the CDNU to remain accurate. Direct distance to intercept and Direct Time To Intercept (TTI) is computed for the To waypoint if it is moving. If intercept is not possible, the CDNU will compute the Point of Closest Approach (PCA) and the TTI to that point.

1. Moving Target Fix Definition (Figure 16-57).

   a. Press IDX key, IDX page will be displayed.

   b. Press L/S 8 key, Intercepts.

   c. Enter fix, track and time of fix for the intercept target with L/S 1, 2 and 3 keys respectively.

      (1) L/S 2 key also toggles the reference between True and Magnetic North when the scratchpad is blank.

   d. Line 2 indicates intercept number in use.

      (1) Number 1 of 9 possible intercepts.

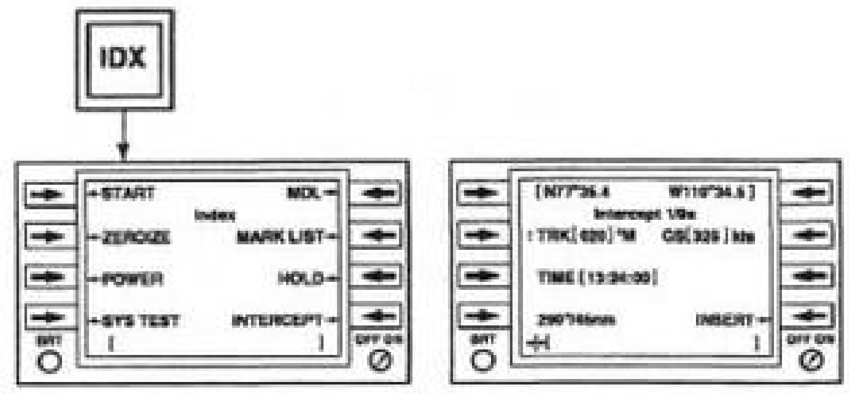

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Figure 16-57. Moving Target Fix Definition

      (2) The "a" indicates that lateral scrolling will produce a "b" page depicting the intercept solution.

   e. Line 7 will display bearing/distance to target's entered.

   f. Line 8 displays lateral and vertical scroll.

      (1) The vertical scroll key will access intercept pages 2/9a through 9/9a.

      (2) The lateral scroll will access intercept computation solution pages for each target 1/9b.

2. Executing Immediate (Direct-To) Intercepts (Figure 16-58).

   a. Press L/S 8 key, Insert.

   b. Scratchpad message will request insertion of the desired intercept, "Insert Intercept 1".

   c. Press L/S 2 key, insert intercept as new active waypoint.

   d. Intercept 1 is now active waypoint, displayed on line 3.

   e. Course to intercept will be displayed on line 1.

   f. Intercept 1 will appear on line 3, it indicates that a true intercept exists versus a Point of Closest Approach "PCA".

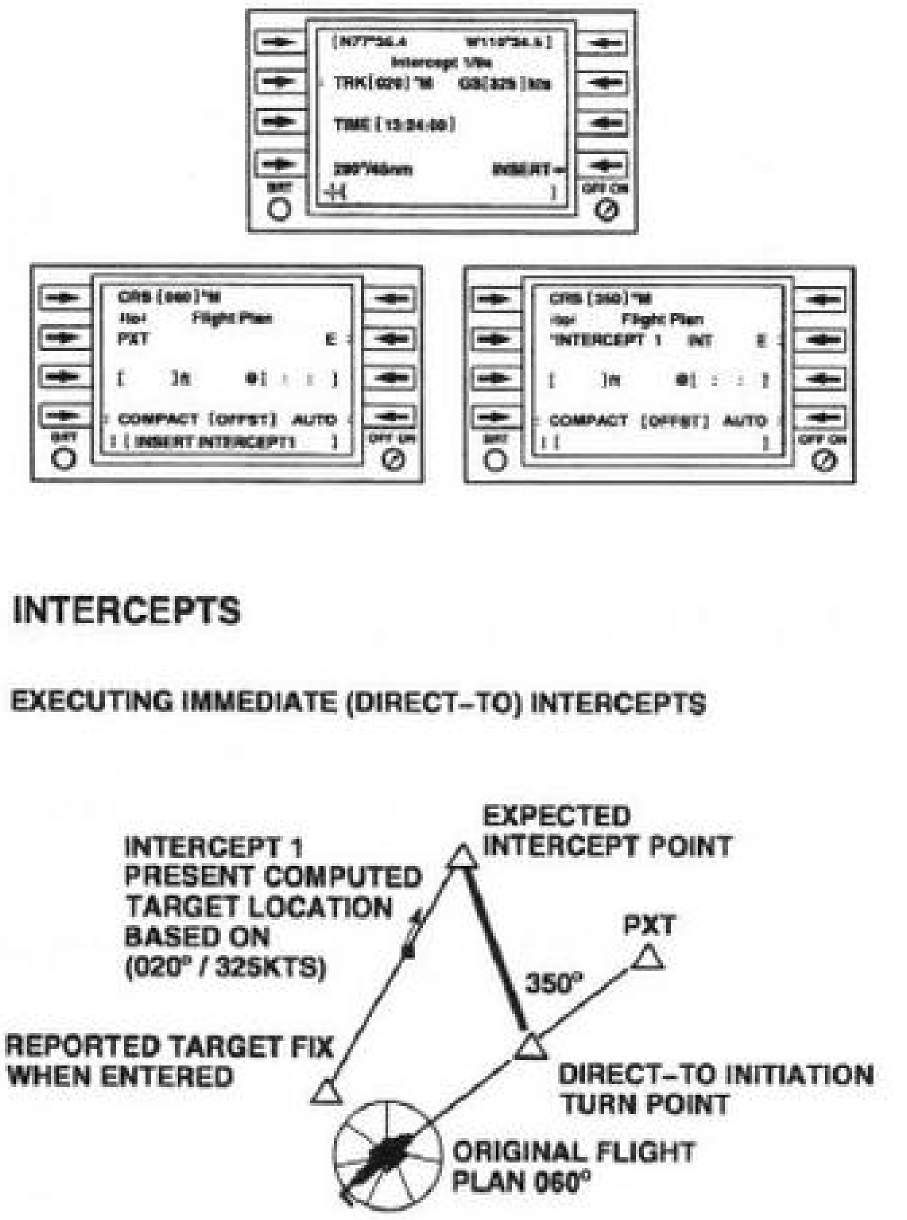

Figure 16-58. Executing Immediate (Direct-To) Intercepts

3. Displaying Immediate Intercept Solution (Figure 16-59).

a. Using down arrow key scroll to intercept page 5/9a.

b. View L/S 8 key Insert.

Note

Active intercepts can not be deleted (only future intercept may be deleted). If this line select is activated while the selected target intercept is "active" (i.e. the active waypoint), the message "Intercept Is Active" will be displayed in the scratchpad. If it is desired to abort the active intercept, use the Direct-To function to call the next desired waypoint.

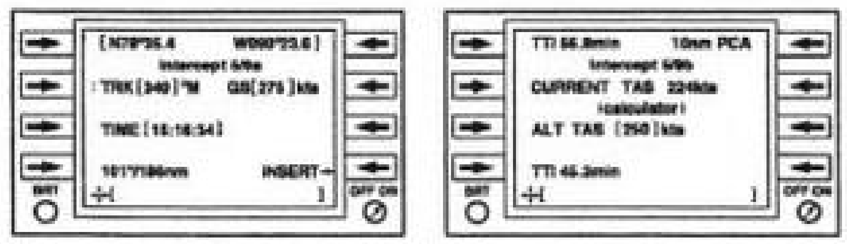

Figure 16-59. Displaying Immediate Intercept Solution

c. Using the right arrow scroll to display intercept page 5/9b.

(1) Line 1 will display current Time To Intercept (TTI).

(2) The right field of line 1 (PCA), indicates the current intercept solution, calculated by using the current TAS. This will not provide an intercept (a true intercept solution), but rather is the closest point of approach.

(3) Line 3 will display aircraft current true airspeed (TAS).

(4) Line 5 allows entry of an alternate airspeed for calculation of possible intercept solution.

(5) Line 7 displays alternate solution time to intercept in the right field of line 7. If it is blank it indicates that the alternate solution is a true intercept.

Note

For intercept targets that have not been inserted into the fight plan, the "calculator" function may be used to enter alternate true airspeeds to determine the effect on time to intercept and PCA miss distance. This function is available only if the intercept has not been executed as an immediate intercept.

16.8.3.8 Mark List. The Mark function key transfers the CDNU estimate of the present position into scratchpad at the instant the key is pressed. The position entered into the scratchpad in this manner remains in the scratchpad when other pages are accessed (Figure 16-60).

1. Recording and listing position and time.

   a. Press Mark key, it will record present location and time of mark in the scratchpad of whichever page is being displayed. Time will not be visible in the scratchpad.

Note

When on the flight plan page, if a Lat/Long is entered into the scratchpad by the Mark function and L/S key 1-4 pressed inadvertently, an unwanted waypoint will be entered into the flight plan.

   b. Press IDX key, IDX page will be displayed.

   c. Press L/S 6 key, Mark List.

2. Inserting the Mark List (Figure 16-61).

   a. Press down arrow key, scroll to desired Mark list waypoint A-1 (9 locations may be entered into the Mark list).

   b. Press L/S 3 key, the new mark may be entered sequentially in location A-1, or can overwrite existing mark if desired.

      (1) Lat/Long in scratchpad will now appear on line 5.

      (2) Time of mark is automatically transferred to line 7.

      (3) Line 2 indicates the waypoint data page for the mark location and can be viewed by pressing the appropriate L/S key (L/S 1 key or L/S 3 key).

      (4) Line 1 may be used by the operator to define a label of the waypoint using the same method as with the flight plan.

3. Adding to Flight Plan (Figure 16-62).

   a. Press down arrow key, scroll to desired Mark list waypoint.

   b. Press L/S 5 key, copy indicates the marked location may be copied to the scratchpad by selecting the appropriate L/S key (L/S 5 key or L/S 7 key).

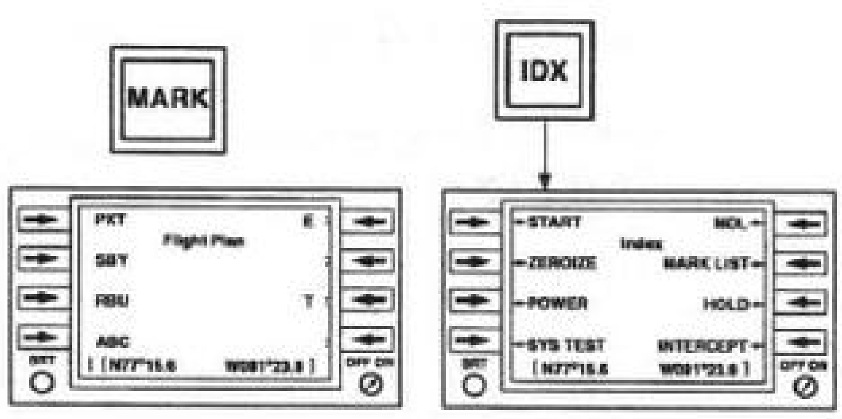

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Figure 16-60. Mark List

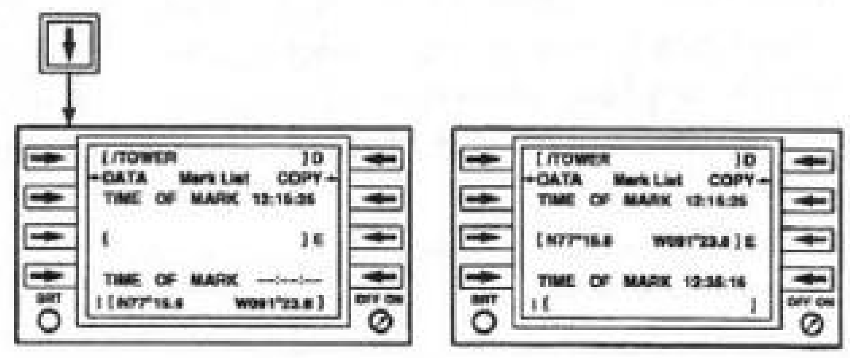

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Figure 16-61. Inserting the Mark List

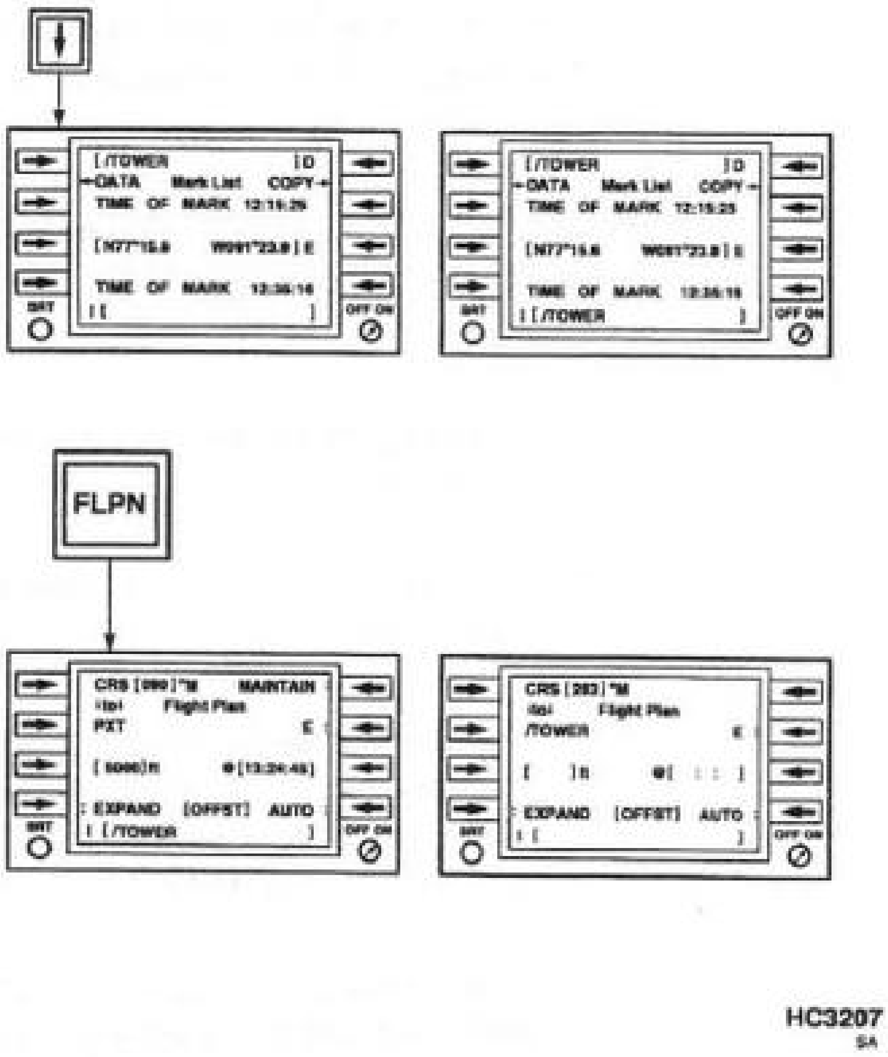

Figure 16-62. Adding to Flight Plan

c. Copying the desired location or user defined label to the scratchpad will automatically transfer the Lat/Long and other associated parameters.

d. To add a waypoint at a desired position in the flight plan, press "FPLN", then press L/S 2. The Direct-To function is automatically performed.

16.8.3.9 Parallel Course Offsets. The parallel course offset will display Time, Distance-To-Go, Leg Switch Point, Ten Second Alert, and Crosstrack Deviation. It is referenced to the new offset flight plan. Offset may be manually applied, deleted or changed at any time the active waypoint is not identified as a holding pattern.

1. Entering and deleting (Figure 16-63).

   a. Make entry into scratchpad (distance in kilometers or nautical miles to one decimal place).

      (1) Right "R" or Left "L" offset must be specified as first character.

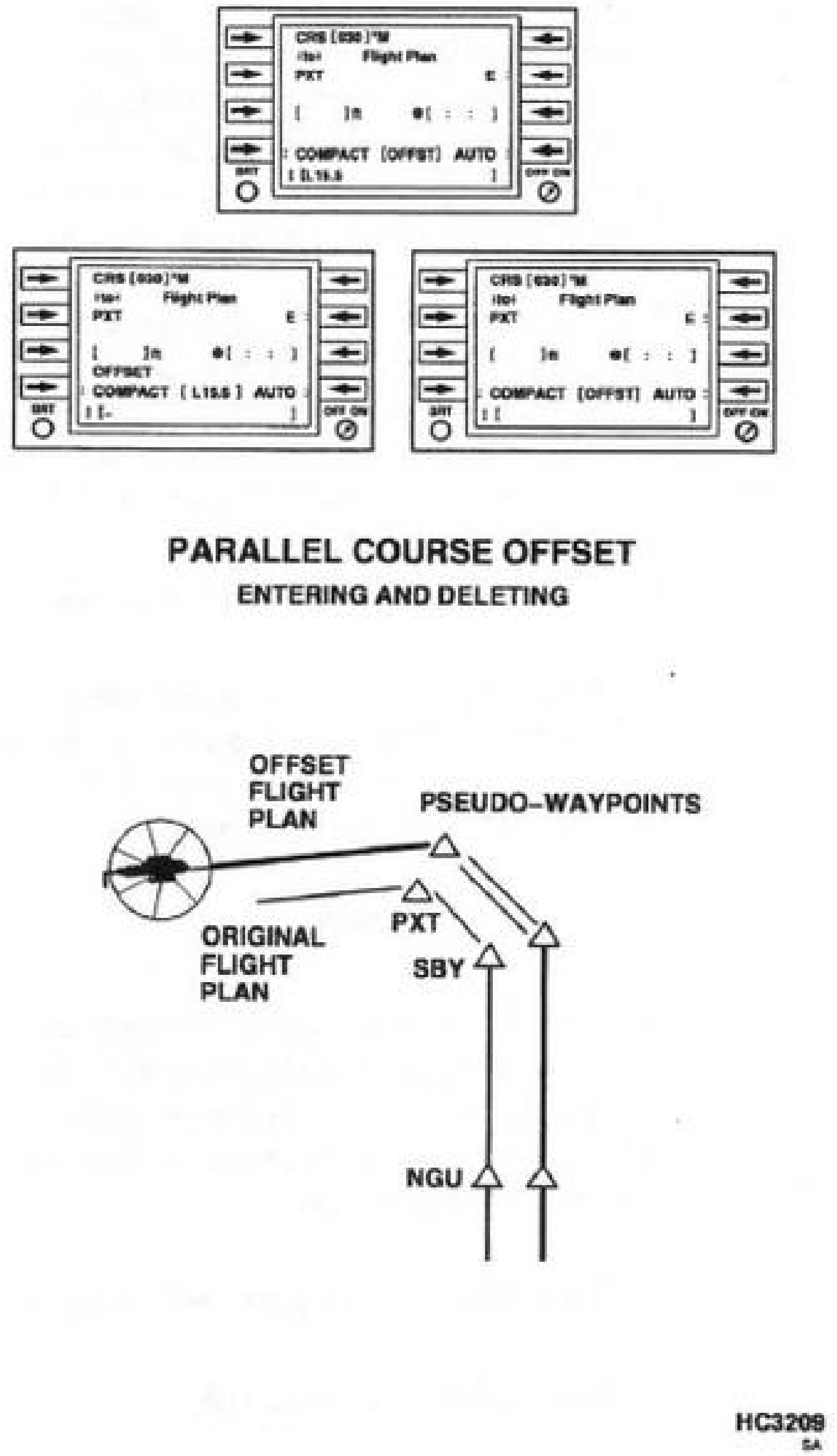

Figure 16-63. Entering and Deleting

      (2) Offset is displayed on line 7.

   b. Press L/S 8 key, the distance left or right will be displayed on line 7.

      (1) Offset is active.

   c. To deactivate distance enter "-" or "0" in scratchpad.

   d. Press L/S 8 key, distance will be removed from line 7.

2. Automatic Cancellation (Figure 16-64).

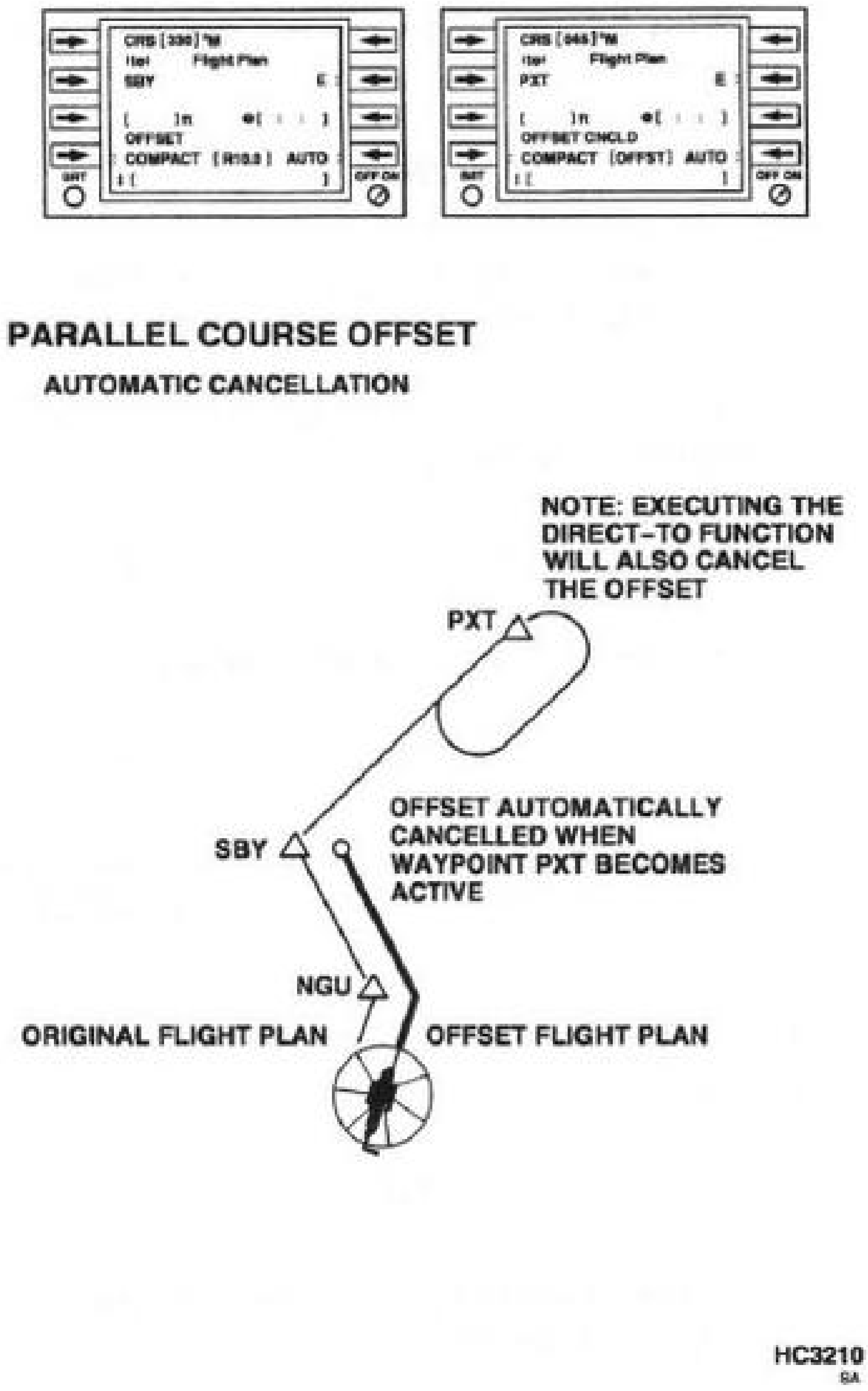

Figure 16-64. Automatic Cancellation

a. When active waypoint switches from waypoint to holding fix:

(1) Offset is canceled.

Note

Executing the Direct-To function will also cancel the offset.

16.8.3.10 Area Navigation. Area Navigation allows the operator to select the measurement systems used to display most navigation quantities used on RNAV, Start, Progress 3/3 page. These selections include choice of Lat/Long or Military Grid Reference System (MGRS) coordinates (Figure 16-65).

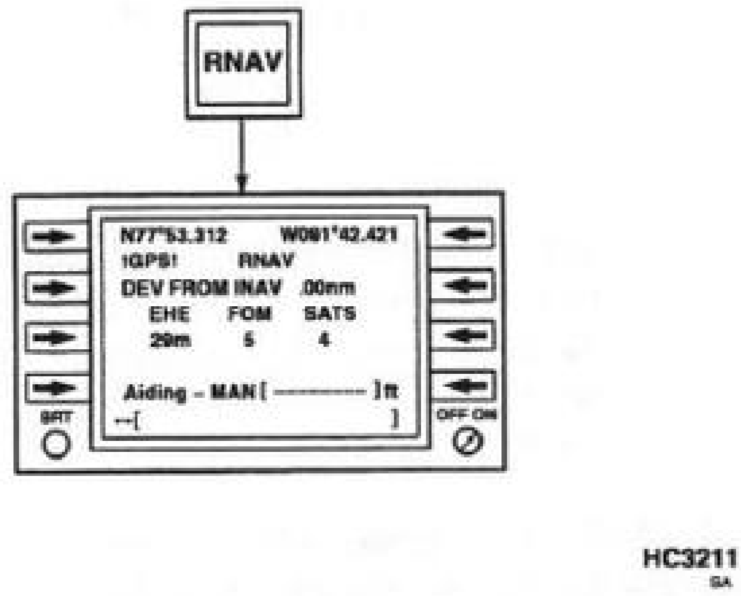

Figure 16-65. RNAV Menu

1. Press RNAV key, INAV RNAV page will be displayed.

   a. Line 1 will display integrated navigation (INAV) present position solution.

   b. Line 3 will display integrated navigation (INAV) mode. Only "GPS" and "FAIL" modes are applicable in the CH-53E.

   c. If GPS fails the NAV invalid flag is dropped in course indicator.

2. Press L/S 2 key to select GPS mode.

   a. Line 1 displays GPS present position solution.

   b. Line 2 right field will display "Invalid" when GPS solution is invalid.

   c. Line 3 will display deviation of GPS solution from INAV.

   d. Line 5 will display estimated horizontal error, GPS figure of merit and number of satellites currently being tracked.

   e. Line 7 will display Aiding-Man.

      (1) If barometric-altitude data is available on the MIL-STD-1553B bus to the CDNU, then the altitude data is updated automatically and Aiding-Bar is shown. Otherwise Aiding-Man will appear.

(2) The Nav invalid flag is dropped and CDNU annunciation raised if "EHE" exceeds the performance threshold for the current flight mode.

Note

Manual altitude entries in scratchpad will take precedence over grey code altitude. Since grey code altitude aiding is provided, no manual altitude value should be entered.

16.8.3.11 Freeze Mode. The freeze mode will freeze the display values existing at the moment the L/S 4 key is activated. The CDNU continues to navigate while in the freeze mode (Figure 16-66). A freeze condition will last for two minutes unless deselected by the operator. A flashing "Freeze" annunciation is the highest priority annunciation. When the annunciation on line 6 is flashing "Freeze", it is indicating that update is suspended.

Note

Activating the "Freeze" mode on the Progress, Start and RNAV page will not update navigation.

16.8.3.12 System Test. The subsystem Internal Built-In Test (IBIT) is executed through the CDNU system Test page. The system test will display GO/NOGO data results of the last IBIT, but it will not display current status. This test can only be performed while on the ground. The "Test" is displayed next to the WRA subsystem being tested to indicate IBIT in progress. A GO or NOGO is displayed next to the subsystem to report IBIT result (Figure 16-67).

1. Press IDX key, the IDX page will be displayed.

2. Press L/S 4 key, System Test page will be displayed.

Note

NO detailed IBIT Test page is available for the SDC, AHRS or ADC.

3. Press L/S 2 key GPS, GPS Test page will be displayed (Figure 16-68).

4. Press L/S key Initiate Test (Figure 16-69).

   a. Line 1 will indicate test is initiated.

   b. Line 2 will indicate IBIT test in progress.

   c. Line 2 will indicate when IBIT is complete and successful. A "GO or NOGO" will be displayed next to subsystem.

5. Subsystems may be tested by selecting appropriate L/S key.

Note

Dashes indicate GPS IBIT has not been performed since power up.

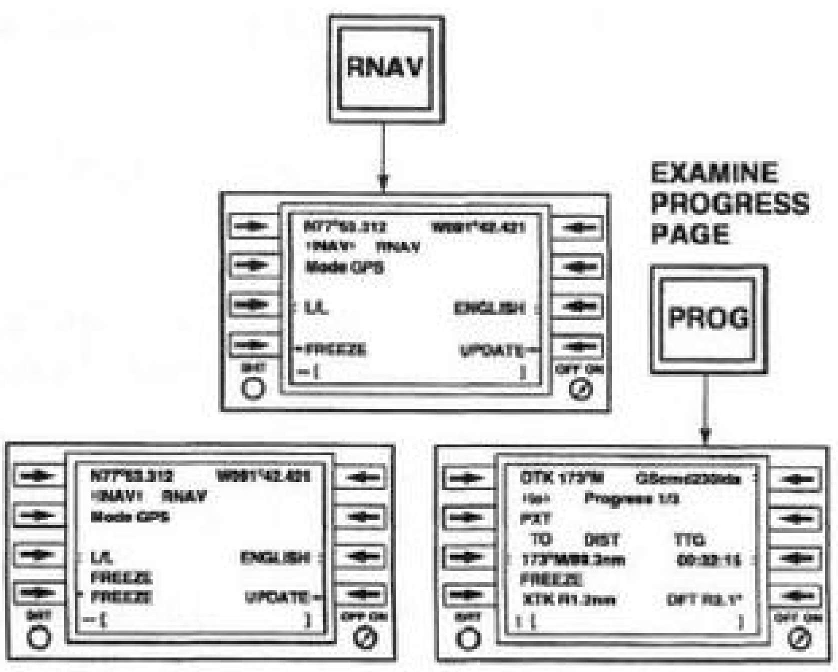

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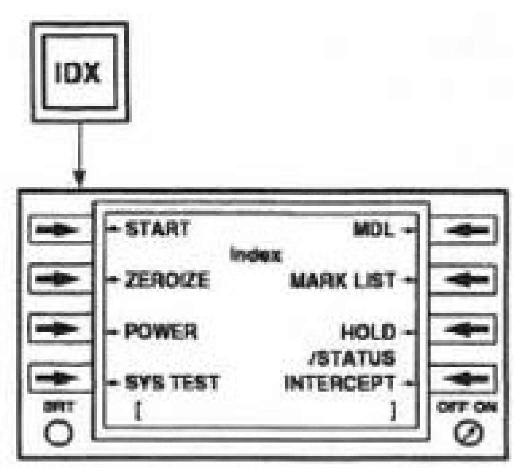
Figure 16-66. Freeze Mode



HC3214

Figure 16-67. CDNU System Test Page

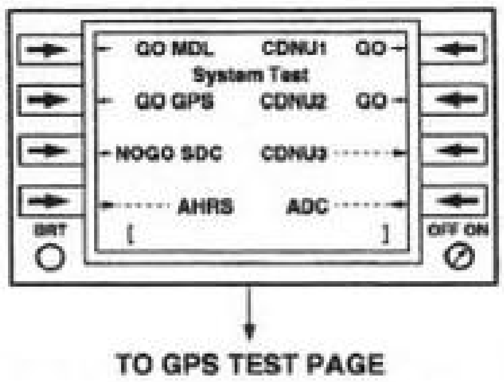


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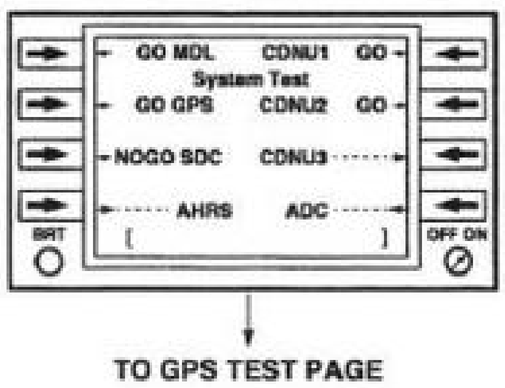
Figure 16-68. GPS Test Page



HC3218
SA

Figure 16-69. GPS IBIT Test

16.8.3.13 Zeroize Page. The Zeroize page is used whenever a need arises to zeroize flight or encrypt data (Figure 16-70).

1. Press IDX key, index page will be displayed.

2. Press L/S 2 key Zeroize, Zeroize page will be displayed.

   a. Pressing L/S 1 key will zeroize MDL cartridge data.

   b. Pressing L/S 2 key will zeroize CDNU local flight plan, intercept data and local reversionary waypoint database.

   c. Pressing L/S 3 key will zeroize waypoints.

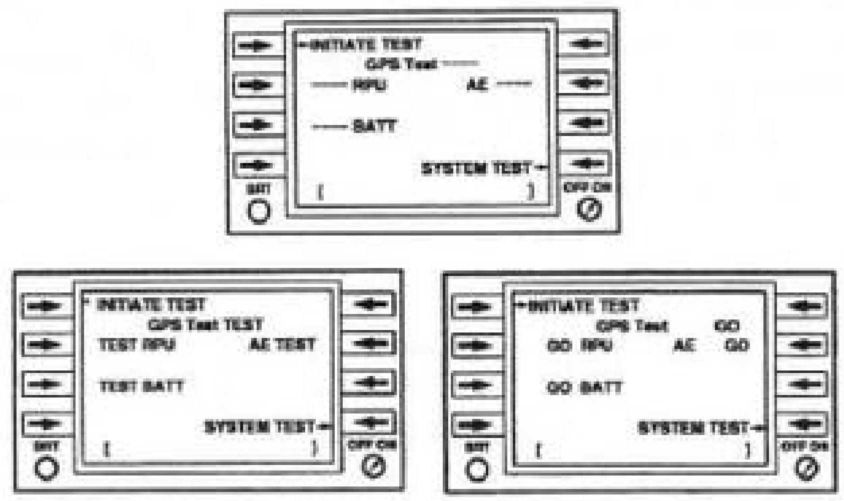


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Figure 16-70. Zeroize Page

   d. Pressing L/S 4 key will zeroize CDNU local flight plan.

   e. Pressing L/S 7 key will zeroize all GPS SA/AS page.

   f. Pressing L/S 8 key will zeroize all resident flight plan data, intercept data and local reversionary waypoint database in the CDNU, all data on MDL cartridge and all SA/AS keys stored in GPS.

Note

All zeroize commands require confirmation.

16.8.3.14 Postflight Operation Procedures. After completion of the mission, access the SA/AS page from the Zeroize page by selecting GPS. Then press the "Zero Key" line select on the SA/AS page. This declassifies the GPS receiver. This can be verified by the disappearance of "Zero Key" from the display on the SA/AS page.

16.9 RADAR NAVIGATION SET (DOPPLER)

The AN/APN-217(V)3 Radar Navigation Set (Doppler), consisting of a receiver/transmitter and control panel, provides helicopter ground speed; drift angle; and horizontal, vertical and lateral velocity information. It is a self-contained surface velocity sensor that uses continuous wave radar energy to automatically measure the heading, drift, and vertical velocity of the helicopter's motion. From these measurements, the heading, drift and velocity of the helicopter are calculated and displayed on the panel display units.

Power is provided by the No. 3 primary dc bus through a circuit breaker marked DOPPLER, under the general heading RADIO; and by the No. 3 primary ac bus through a circuit breaker marked DOPPLER, under the general heading RADIO. Temperature control for the set is provided by the Doppler fan, which receives power from the No. 1 primary ac circuit breaker marked DOPPLER FAN.

CAUTION

To prevent overheating the Doppler fan motor, do not block the Doppler fan intake located on the port side of the cabin.

16.9.1 Radar Control. The Doppler radar set is operated from the RNS/FLIR control panel on the center console. It has a three position switch marked OFF, PWR ON, and BIT. Moving the switch to any position requires the switch be pulled, moved to the new position, and released to lock in place. The BIT self-test will indicate whether the set is functioning by displaying test velocities on the panel display unit. A steady FAIL LED will also light to indicate a BIT failure, or an operational failure of the Doppler unit. If the aircraft is sitting motionless with power but rotors not turning, a "no Doppler signal" condition may exist. This "memory mode" condition is a normal expectation. The FLIR/RNS Control Panel FAIL light will not light. Doppler symbology will be removed from PDU display. Clear this condition by waving an object between Doppler antenna and the ground, or fly the aircraft to generate new data.

16.9.2 Radar Operational Environment. The radar will maintain a reliable track over sea state one at steady bank angles up to and beyond 45 degrees. However Doppler tracking is severely degraded by vertical acceleration, pitch and roll rate acceleration, especially in combination, and by an antenna covered with salt spray.

The radar set is wired in the land mode. Operating over water could result in a 1.8% error in navigational accuracy in forward flight. However the radar navigational accuracy will not be degraded when hovering over water.

CHAPTER 17
Mission Systems

17.1 NIGHT VISION DEVICES

The use of Night Vision Devices (NVDs) by qualified aircrew can significantly increase mission capability and safety (Figure 17-1). Refer to the CH-53 Tactical Manual (NWP 55-9-CH53) and MAWTS-1 Helicopter NVG Manual for a complete discussion of NVD flight and equipment considerations. Currency and training requirements for U. S. Marine Corps units are described in MCO 3500.16 (T and R Manual).

17.2 INFRARED DETECTING SET (FLIR)

The AN/AAQ-16B is a microprocessor controlled forward-looking infrared (FLIR) system. The system uses temperature to define an object, which assists the crew in navigating the helicopter at night or during low visibility, daylight operations. Avionics symbols, including flight, navigation, and status information are superimposed on the FLIR image. The FLIR system shall not be used exclusive of other flight instruments.

17.2.1 FLIR Controls and Indicators

17.2.1.1 FLIR/RNS Control Panel. Installed in the center console, the FLIR/RNS Control Panel (Figure 17-2) provides three control functions: power, lamp test, and built-in-test/fault isolation test (BIT/FIT). The panel also has three indicator lamps.

Power Switch:

1. Off — Operating power for the set is off. Turret is in stowed position.

2. COOL DOWN — Power is applied to the cryogenic cooler in TFU to cool down the detectors to the required operating temperature. Allow approximately 10 minutes for cool down procedure. Turret remains in stowed position.

3. PWR ON — Power is supplied to the set. Turret deploys to look-ahead position.

Test Switch:

1. BIT — Initiates BIT.

2. OFF — Detented neutral position prevents inadvertent engagement.

3. FIT — Displays fault isolation test pages. FIT pages enable operator to calibrate set and aid in-fault isolation.

Lamp Test Switch:

1. LAMP TEST — Illuminates DISP PWR, SYS PWR, PROC, and FAIL lamps when pressed.

2. DISP PWR — Indicates DEU and/or PDU power supply failure.

3. SYS PWR — Indicates SDC power supply failure.

4. PROC — Indicates failure in one of SDC system processors.

17.2.1.2 Multifunction Control Unit (MFCU). Four switches on the MFCU (Figure 17-3) centralize control of TFU operations.

TYPE	DESCRIPTION	FUNCTION	PRIMARY OPERATOR	APPROXIMATE RANGE	CONTROL LOCATION
Heads-up Display (HUD) System	AN/AVS-7	Heads-up data imaging	Pilots	N/A	Cockpit
Infrared Detecting Set (FLIR)	AN/AAQ-16B	Navigation	Pilots	LOS	Cockpit

Figure 17-1. Mission Equipment

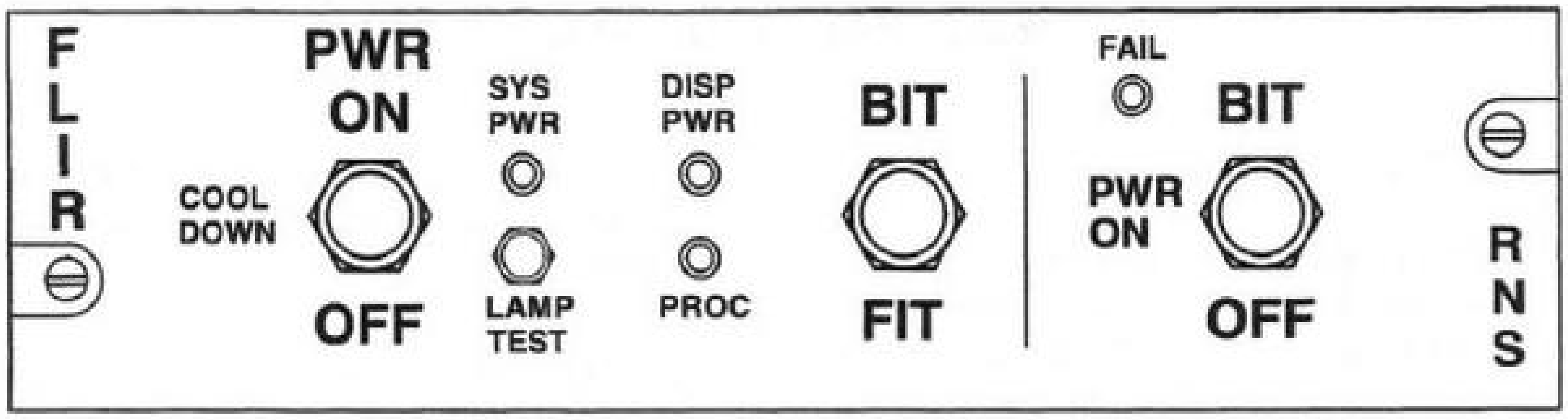


Figure 17-2. FLIR/RNS Control Panel

Note

Simultaneously pressing PDU softkeys and MFCU switches can cause erroneous signals to be transmitted to SDC.

17.2.1.3 Panel Display Unit (PDU). Day/ Night Brightness:

1. OFF — Turns off screen display.

2. DAY — FLIR image is displayed in DAY brightness range.

3. NT — FLIR image displayed in NIGHT (very low light level) brightness range. In this position an attenuated brightness range is available. NT range is compatible with night vision goggles.

Display Brightness:

1. BRT — Adjusts the degree of brightness for either day or night range.

Display Contrast:

1. CONT — Adjusts the degree of difference between the lightest and darkest parts of the image in day or night range.

Symbol Brightness:

1. (Center) — Turns display symbols off.

2. W — Adjusts symbols to the white-hot range.

3. B — Adjusts symbols to the black-hot range.

Panel Lighting Brightness:

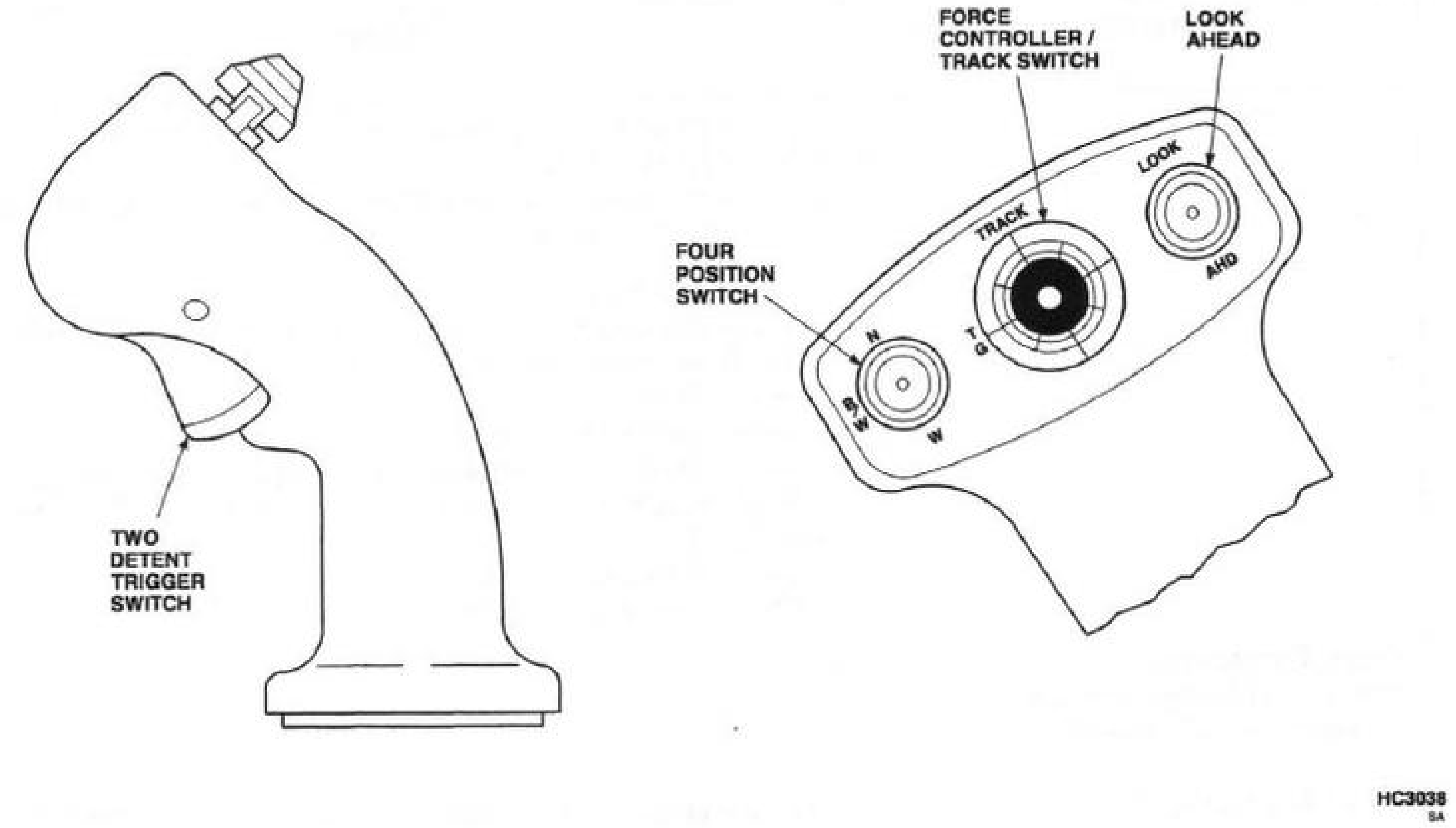
1. PNL — Adjusts softkey illumination.

17.2.2 System Start Up and Operational Readiness Test. System start up and operational readiness test procedures are described and listed by action, normal indication, and failure indication (Figure 17-4).

WARNING

All personnel should be clear of TFU during operational readiness test. The TFU will be moving and can cause severe bodily injury.

Do not attempt any repairs without turning power OFF. High voltages are present and can cause shock, injury or death.



CONTROL	FUNCTION
Trigger Switch (Mode dependent switch) First Detent	1. When flight page or menu pages displayed, star cursor * appears. 2. Locks in functions chosen with star cursor *. 3. When in Autotrack Enable (ATE) mode, initiates Autotrack (AT). 4. When in AT mode, redesignates secondary gate as primary gate. 5. When in FIT, locks selections, toggles through FIT pages, except during calibration.
Second Detent	1. When flight page or menu pages displayed, initiates functions chosen by star cursor * and returns system to normal operation. 2. When in BIT, exits BIT. 3. When in FIT, exits most FIT pages, except calibration.
Left Four-Position Switch (Mode dependent switch)	
N	1. When flight page, or menu pages displayed, selects narrow-field-of-view. 2. When in FIT, moves star cursor * up FIT menu pages.
W	1. When flight page, or menu pages displayed, selects wide-field-of-view. 2. When in FIT, moves start cursor * down FIT menu pages.

Figure 17-3. Multifunction Control Unit and Functions (Sheet 1 of 2)

CONTROL	FUNCTION
B/W	1. When flight, or menu pages displayed, changes polarity from black hot to white hot or vice versa. 2. When in FIT, moves star cursor * left on FIT menu pages, and changes avionics calibration data points.
TG	1. When in ATE mode, a. Toggle one time to adjust gate size using MFCU force controller. b. Toggle two times return MFCU control of turret. 2. When in AT mode, a. Toggle one time to adjust gate size. b. Toggle two times to enable aim point designate (APD) function. c. Toggle three times to return to secondary gate enable functions. 3. When in FIT, a. Moves star cursor * right on FIT menu page. b. Changes avionics calibration data points.
Force Controller/ **Track Pushbutton Switch** (Mode dependent switch)	
Force Controller (Unpressed, moved in directional pattern)	1. On flight page or menu pages moves star cursor * to desired function. 2. When in Autotrack mode, positions secondary gate, adjust gate size, offsets autotrack gate in APD mode. 3. When in FIT, adjust look-ahead angle and FLIR gain, adjusts scan width and scan rate. 4. Adjust calibration items: adjusts HORZ reference line up/down; adjusts MAN video gain up/down and left/right; sets BIN BIAS and video gain up/down and left/right G/L values.
Track Switch (Force Controller used as pushbutton)	1. When in any mode except AT and AHD, pressing track switch enables/disables ATE mode. 2. When in AT mode, pressing track switch once enables ATE, pressing a second time disenables ATE and brings system to RATE mode. 3. When in look-ahead mode, track switch will not function.
Look-Ahead Pushbutton Switch **LOOK AHD**	1. Positions and lock turret in predetermined look-ahead position. Pushing button a second time, or selecting AHD functions on flight page returns system to previous mode of operations. When turret is in look-ahead mode, autotrack enable, and scan mode cannot be initiated.

Figure 17-3. Multifunction Control Unit and Functions (Sheet 2 of 2)

ACTION	NORMAL INDICATION	FAILURE INDICATION
1. Turn on aircraft external power or internal power.	Power on.	
2. Set FLIR and Doppler circuit breakers.	Power is supplied to NHVS.	No indication until FLIR and Doppler power switch moved to ON.
3. Move FLIR power switch to COOL DOWN.	TFU cryogenic cooler starts to cool.	No indication on PDU until FLIR power switch moved to ON.
4. Move FLIR and RNS power switch to ON. Press and hold LAMP TEST on FLIR/RNS control panel.	FLIR and RNS LEDS are lit	If no lamps lit, power not supplied to HNVS/RNS control panel failure.
5. Release LAMP TEST and wait 5 seconds.	No lamps on FLIR/RNS are lit.	If SYS POWER or PROC lamp it, SDC fail.
		If DSP PWR lamp lit, DEU power supply failure or PDU failure, run BIT.
6. Turn both PDUs to NT or DAY, and adjust BRT and CONT fully clockwise.	Both PDUs illuminated.	PDU does not illuminate. Power not supplied to PDU OR PDU fail, run BIT.
7. Check both PDUs for presence of avionics symbols.	Avionic symbols present.	If no symbols present, adjust SYM BRT.
		If symbols not present, run BIT.
8. Check for presence of CHOT symbol.	No CHOT symbol.	If CHOT symbol visible wait for system to cool down.
		If CHOT symbol still visible after 18 minutes, RUN BIT.
9. Check for presence of FLIR image on both PDUs.	FLIR image visible.	If FLIR image not visible, adjust BRT and CONT.
		If FLIR image still not visible after performing steps 0 through 14, run BIT.
10. Select MENU function on flight page using PDU softkey.	Menu page 1 displays.	If menu page 1 does not display, run BIT.
11. Select GRSC function on menu page 1 using PDU softkey.	Gray scale brightness/contrast chart displays.	If gray scale brightness/contrast chart does not display, run BIT.
12. Adjust PDU contrast (CONT) and brightness (BRT) until 10 shades of gray scale are distinguishable.	Gray scale brightness/contrast chart is adjusted.	If gray scale function cannot be removed, run BIT.

Figure 17-4. System Start Up and Operational Readiness Test (Sheet 1 of 2)

ACTION	NORMAL INDICATION	FAILURE INDICATION
13. Perform ARE calibration:		
a. Point TFU to clear sky.		
b. Select NFOV.		
c. Select ARE on PDU.	Flashing "STOP"	
d. When STOP goes out, ARE complete.		STOP continues to flash without going out.
e. Select WFOV, slew TFU to desired position.		
14. Select MENU function two times.	Flight page displays.	If flight page does not display, run BIT.
15. Check if turret is in look-ahead position, indicated by AHD display in top left of PDU, system is in WFOV, and polarity is black hot (hot objects appear black).	Turret in look-ahead position, system is in WFOV, and polarity is black hot.	If turret not in look-ahead position, system not in WFOV and polarity is not black not, run BIT.
16. Press LOOK AHD button on MFCU or select AHD function on flight page to put system in NORM mode, indicated by NORM in top left of PDU.	Turret in NORM mode. When pressure is applied to MFCU force controller, turret and image move.	If NORM mode cannot be selected, run BIT. If turret does not move when pressure is applied to MFCU force controller, run BIT.
		If FLIR image will not stabilize, run BIT.
17. Press LOOK AHD button on MFCU or select AHD function on flight page.	Image and turret change to look-ahead position.	If turret does not change to look-ahead position, run BIT.
18. Check for presence of CAL in top right of PDU display.	CAL symbol not present.	If CAL symbol present, calibration required.
19. Check PDU values of avionics symbols; altitude, airspeed, torque and ground speed against appropriate cockpit indicators.	PDU values same as values on appropriate cockpit indicator.	If avionics symbols not same, calibrate altitude, airspeed, torque, or doppler.

Figure 17-4. System Start Up and Operational Readiness Test (Sheet 2 of 2)

17.2.3 Built In Test. Built in test (BIT) procedures are described and listed by action, normal indication and failure indication (Figure 17-5). The BIT is an operator-initiated test to further isolate a FLIR system failure.

WARNING

- All personnel should be clear of TFU during BIT. TFU will be moving and can cause severe bodily injury.
- Do not attempt any repairs of HNVS without first turning power OFF. High voltages are present and can cause shock, injury or death.

Note

To restart BIT at any point during BIT, toggle test switch on FLIR/RNS Control Panel to BIT and release.

17.2.4 Operating Procedures

WARNING

The HNVS system provides for increased situational awareness and aids navigation. The FLIR image and symbology shall not be used exclusive of other flight instruments.

The basic FLIR display incorporates several classes of data: flight page; menu page 1 and 2; flight data; FLIR data; navigation data; hover, transition or position mode data; turret servo mode data; operational mode data; and gain and level mode data. The flight symbols are superimposed on the FLIR image, which allows the operator to simultaneously view the image and important flight data. The flight page, menu pages, and flight data legends and their functions are displayed and described in Figures 17-6 through 17-13.

Functions may be selected with either the PDU softkey or the MFCU. To select any of the functions on the flight page or menu pages, press the PDU softkey adjacent to the label on the function legend. If the function is an on/off function, such as RCD, or an either/or function, such as BLK/WHT, pressing the softkey will change the current

ACTION	NORMAL INDICATION	FAILURE INDICATION
1. Toggle FLIR/RNS Control Panel to BIT and hold. Observe PDU display to pattern. If flight page is present after PDU test pattern, toggle FLIR/RNS Control Panel switch to BIT again.	Pattern visible.	If no pattern, DEU or PDU fails.
2. Release BIT switch.	BIT RESULTS page.	If no BIT RESULTS page, SDC fails.
3. Pull MDCU trigger to first detent and release. Test executes for approximately 90 seconds.	Turret and image move. INITIATED BIT in PROGRESS displays on BIT RESULTS page.	If no BIT RESULTS page, SDC fails.
4. Observe PDU display for BIT results.	BIT complete.	If PDU display reads SDU NOGO, SDC failed. If PDU display reads TFU NOGO, TFU failed.
5. To reinitiate BIT, pull MFCU trigger to first detent. To exit BIT pull MFCU trigger to second detent.	If MFCU trigger pulled to first detent, go to step 3, or if MFCU trigger pulled to second detent, system defaults to look ahead mode, WFOV, black hot polarity.	

Figure 17-5. Built In Test (BIT)

mode of operation. If the function requires analog adjustment, such as HORZ, use the MFCU force controller up, down, left, or right arrow softkey on menu page 2.

The MFCU can also be used to select functions on the flight or menu pages.

1. Pull MFCU trigger to first detent and release. A star cursor (*) displays in the middle of the PDU screen.

2. Using MFCU force controller, move star cursor (*) next to desired function until a line (__) appears adjacent to the desired function. Moving force controller up or down moves the star cursor (*) up or down. Moving force controller left or right moves the star cursor (*) left or right.

3. Lock in the function by pulling the MFCU trigger to the first detent and releasing. The function is locked in when a bracket () appears adjacent to the function.

4. Pull the MFCU trigger to the second detent to initiate the function.

17.2.4.1 Flight Data Items. Flight data items serve as a complete, integrated presentation of all data required for control of basic flight functions. Flight data items may

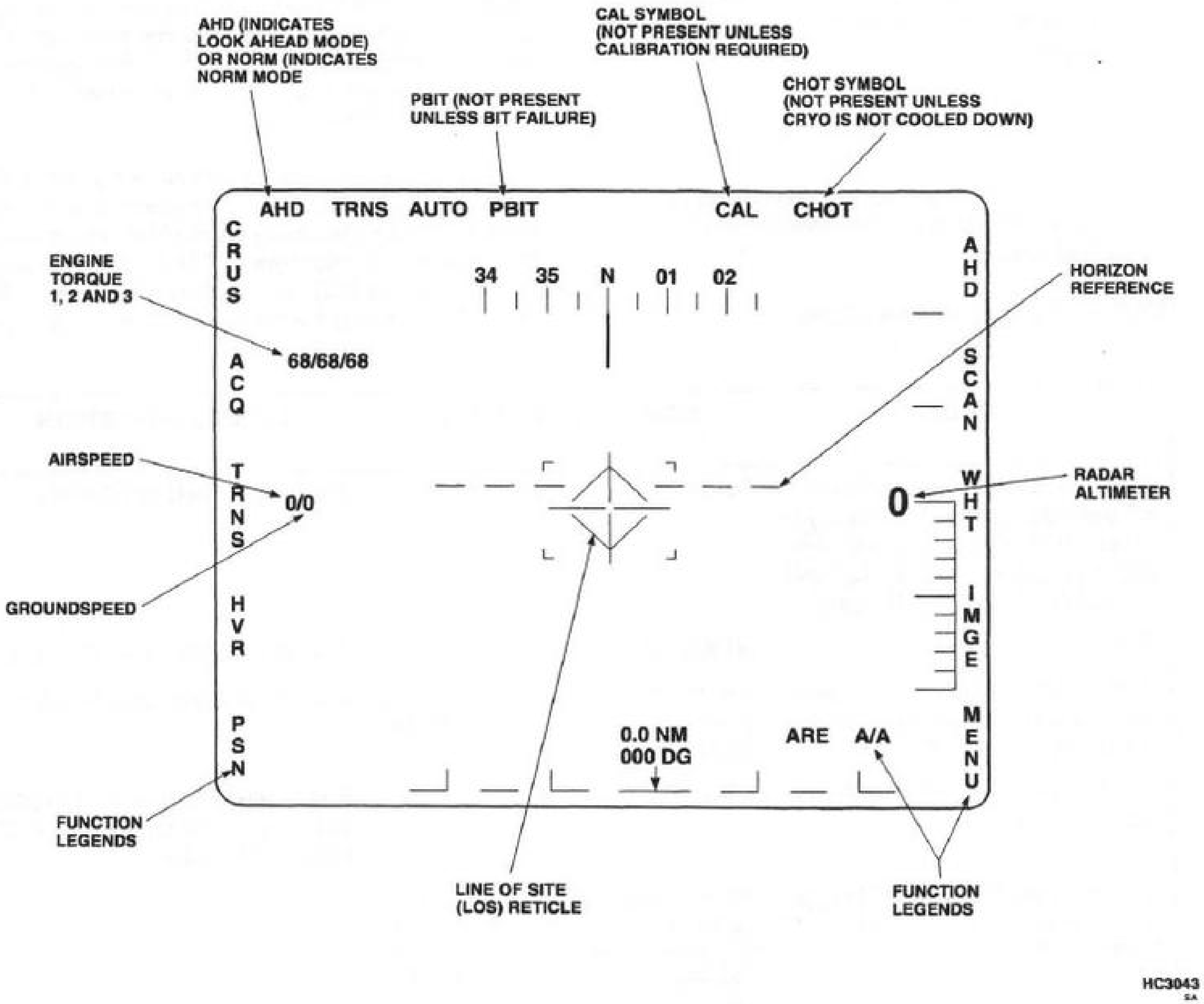
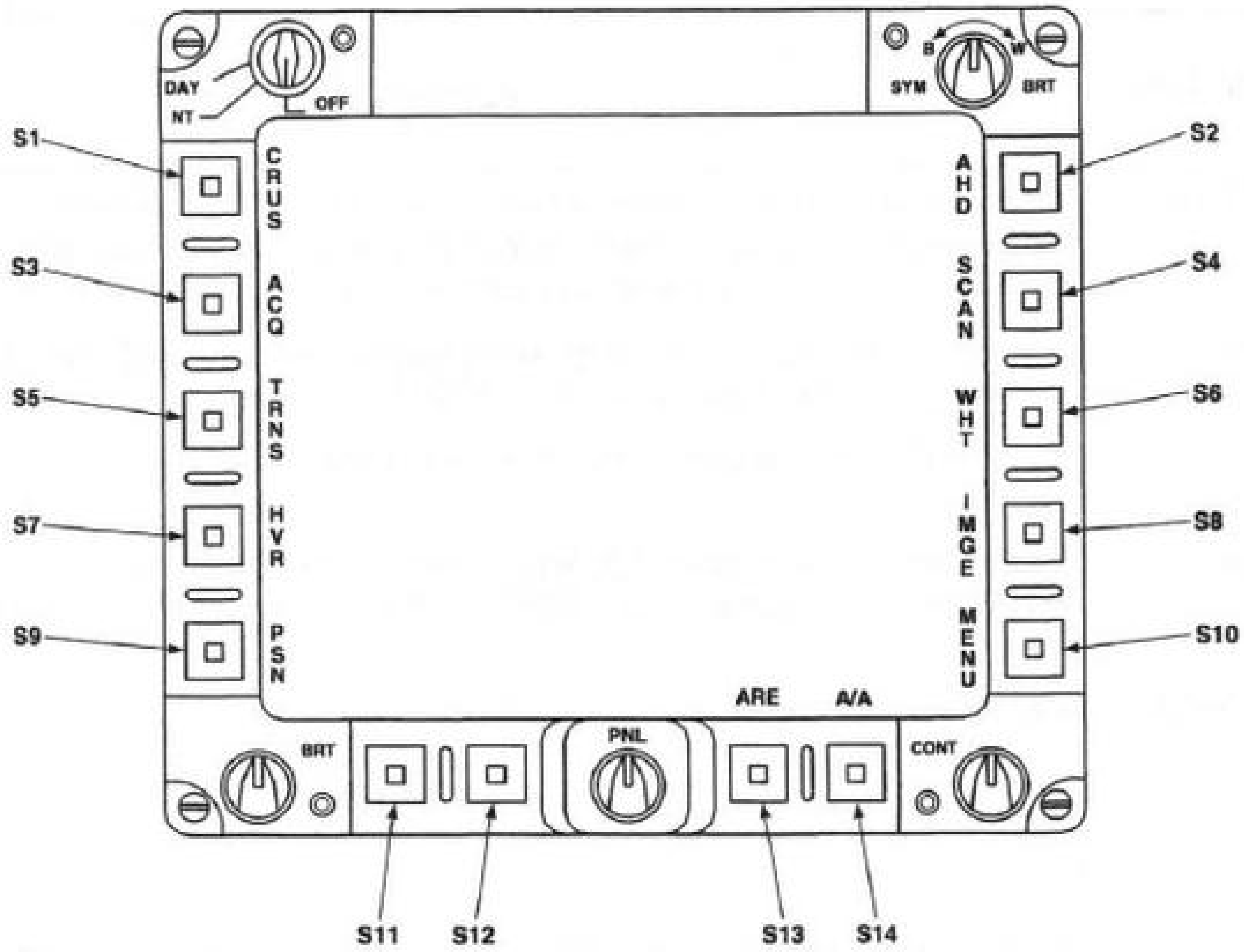


Figure 17-6. System Start Up



DISPLAY SYMBOL/ CONTROL	FUNCTION
CRUS (S1-Cruise)	Cruise operational mode. Navigational data from appropriate navigational system displayed. Turret servo mode defaults to NORM, unless AHD, ATE, AT, STOW, or SCAN mode displayed.
ACQ (S3-Acquisition)	Acquisition operational mode. Navigational data from appropriate navigational system displayed. Turret servo mode defaults to RATE mode unless AHD, ATE, AT, STOW, or SCAN mode displayed.
TRNS (S5-Transition)	Transition operational mode for flight involving transition to low altitudes and variable low speed at or below 60 knots indicated ground speed (KIG). Doppler navigational information used to generate velocity vector, acceleration cursor, and vertical velocity caret, Turret servo mode defaults to RATE mode unless AHD, ATE, AT, STOW, or SCAN mode displayed.
HVR (S7-Hover)	Hover operational mode for flight involving hover operations at or below 5 KIG. Doppler navigational information used to generate velocity vector, acceleration cursor, and vertical velocity caret. Turret servo mode defaults to RATE mode unless AHD, ATE, AT, STOW, or SCAN mode displayed.
PSN (S9-Position)	Position operational mode for flight requiring a precision hover capability at or below 5 KIG. Doppler navigational information is used to generate velocity vector, acceleration cursor, vertical velocity caret and position reference box. Position reference box is reference symbol for hover operations in relation to a selected position on ground. On entering PSN mode top of position reference box points to top of display. Box travels and rotates opposite and equal to subsequent aircraft position and heading changes. Digital altitude generated from radar altimeter displayed inside box. Turret servo mode defaults to RATE mode unless AHD, ATE, AT, STOW, or SCAN mode displayed.

Figure 17-7. Flight Page Functions (Sheet 1 of 2)

DISPLAY SYMBOL/CONTROL	FUNCTION
AHD (2-Look-Ahead)	Selecting AHD once selects look-ahead turret servo mode which positions and locks turret in predetermined look-ahead position. System defaults to WFOV. Selecting AHD a second time returns system to one of turret servo modes which allows turret movement.
SCAN (S4-Scan)	Scan turret servo mode. Turret will move in azimuth at the calibrated scan rate and width. The elevation angle can be varied by using MFCU force controller.
BLK, WHT (S6-Black/White)	Changes FLIR image polarity from black hot to white hot or white hot to black hot.
IMGE (S8-Image)	Selecting IMGE once removes FLIR image from display. Cryogenic cooler remains on. Turret remains at present gimbal angle. Selecting IMGE a second time replaces FLIR image on display.
MENU (S10-Menu page 1)	Selects first menu page.
(None) (S11)	No function.
(None) (S12)	No function.
ARE (S13-ARE calibration)	Initiates and performs calibration of pre-stored software — controlled Automatic Responsivity Equalization (ARE) values.
A/A or A/G (S14-Air-to-air or air-to-ground)	Air-to-air or air-to-ground mode. Air-to-air mode provides AC coupling system to reduce background cutter when viewing an airborne target or a target on water. Air-to-ground provides DC restoration to give better horizon definition when viewing a ground target.

Figure 17-7. Flight Page Functions (Sheet 2 of 2)

be utilized in conjunctions with conventional flight instruments. Flight data items are illustrated and described in Figure 17-8.

17.2.4.2 Navigational Data Items. Data items are provided to support navigation functions. These items are shown in Figure 17-9.

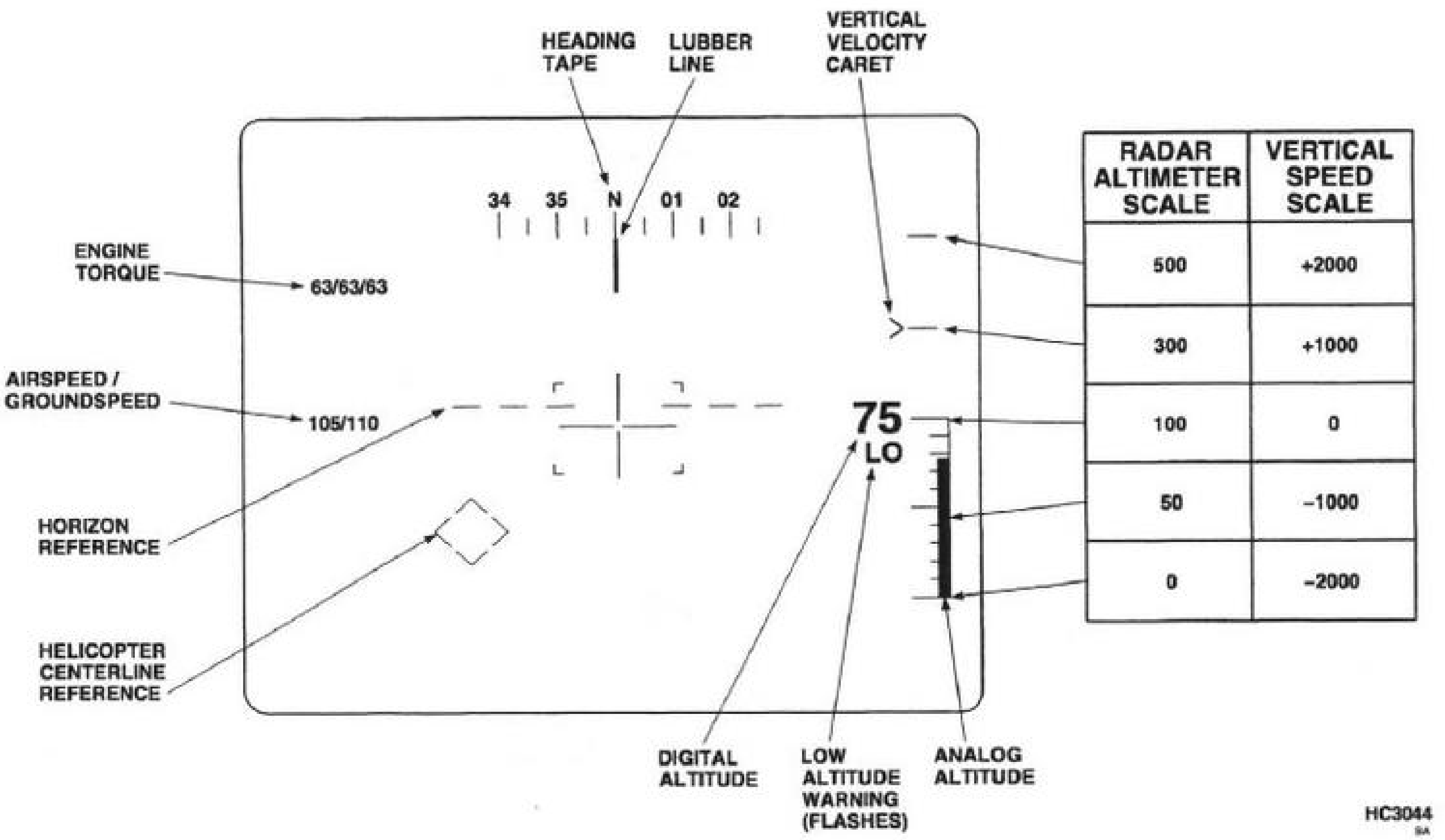
17.2.4.3 FLIR Data Items. Data items that support the operation and use of the FLIR are illustrated and described in Figure 17-10.

17.2.4.4 TRNS, PSN, and HVR Operational Mode Items. The five data items that support TRNS, PSN and HVR operational modes are shown and described in Figures 17-11 through 17-16.

17.2.4.5 Menu Page 1 Functions. Menu page 1 function legends are shown and discussed in Figure 17-15.

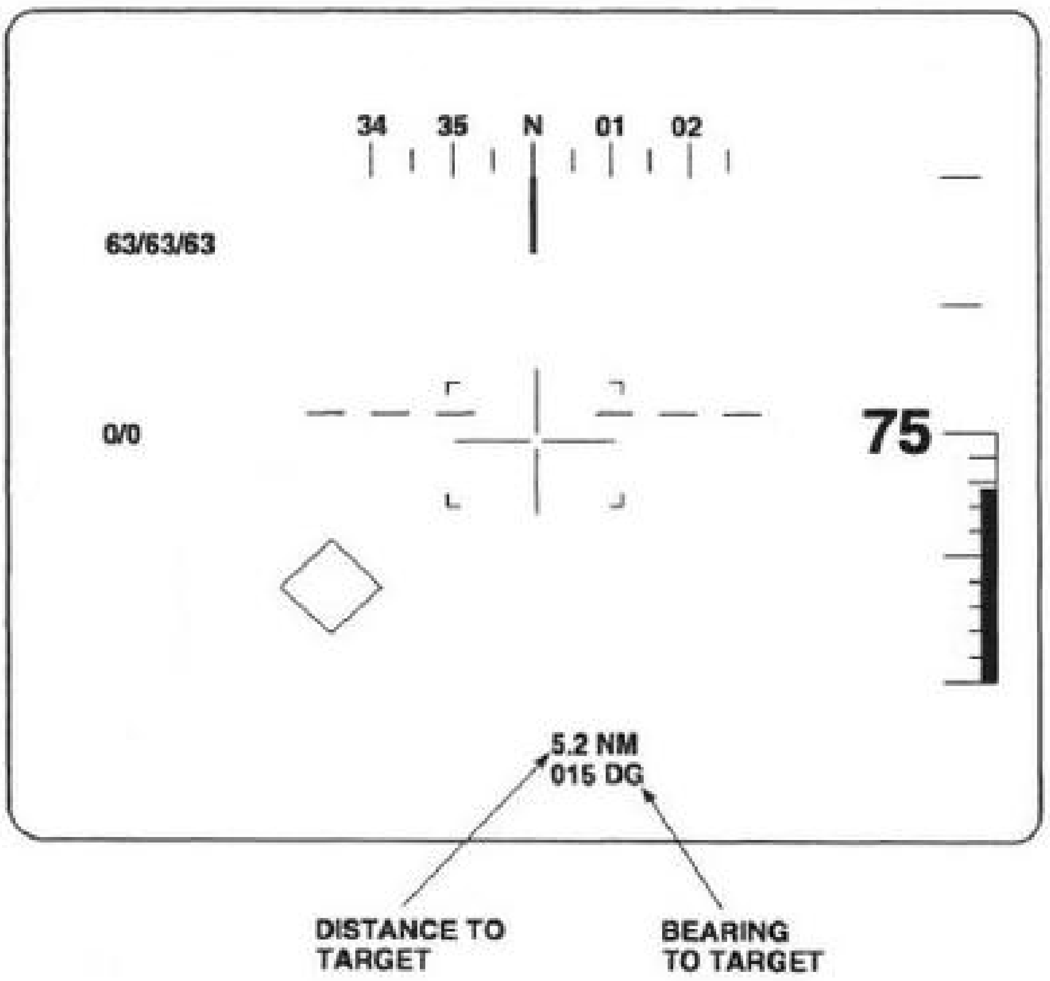
17.2.4.6 Menu Page 2 Functions. Menu page 2 functions legends are shown and discussed in Figure 17-16.

17.2.5 System Malfunctions. HNVS system malfunction indications, descriptions, and actions are described in Figure 17-17.



FLIGHT DATA ITEM	FUNCTION
Heading Tape and Lubber Line	Provides continuous indication of aircraft heading.
Horizon Reference	Indicates aircraft pitch and roll relative to horizon.
Vertical Velocity Caret	Provides a moving caret against the fixed analog altimeter. Vertical velocity caret indicates the rate of ascent/descent with the null point centered at the vertical center of the scale. Indices are located at +/- 1000 FPM and +/-2000 FPM.
Analog Altimeter	Provides AGL data from 0 to 500 ft. Analog altimeter displays 500 for any altitude between 500 and 5000 feet. At altitude above 5000 feet no analog altitude data is provided.
Low Altitude Warning	Flashes when aircraft is below the minimum altitude set on aircraft radar altimeter.
Digital Altitude	Digital readout of height above ground level (AGL) supplied from aircraft radar altimeter. Digital altitude is supplied up to 5000 ft. Above 5000 feet digital altitude will not be displayed.
Helicopter Centerline Reference	Helicopter centerline reference represents the nose of the aircraft. When turret moves to the left, the centerline reference will move to the right, and vice versa. When the turret moves up, the centerline reference will move down, and vice versa.
Airspeed/Groundspeed	Digital readout of indicated airspeed from airspeed transducer and ground speed supplied from appropriate navigational system. Ground speed is not present in TRNS, HVR or PSN mode.
Engine Torque or TGT	Provides engine torque percent of maximum torque allowed.

Figure 17-8. Flight Data Items



NAV DATA ITEM	FUNCTION
Bearing to Target	Bearing to target in degrees relative to present heading of the turret line-of-sight.
Distance to Target	Distance in nm to target in center of display. Distance to target is computed from turret pointing angles, aircraft attitude, and radar altimeter.

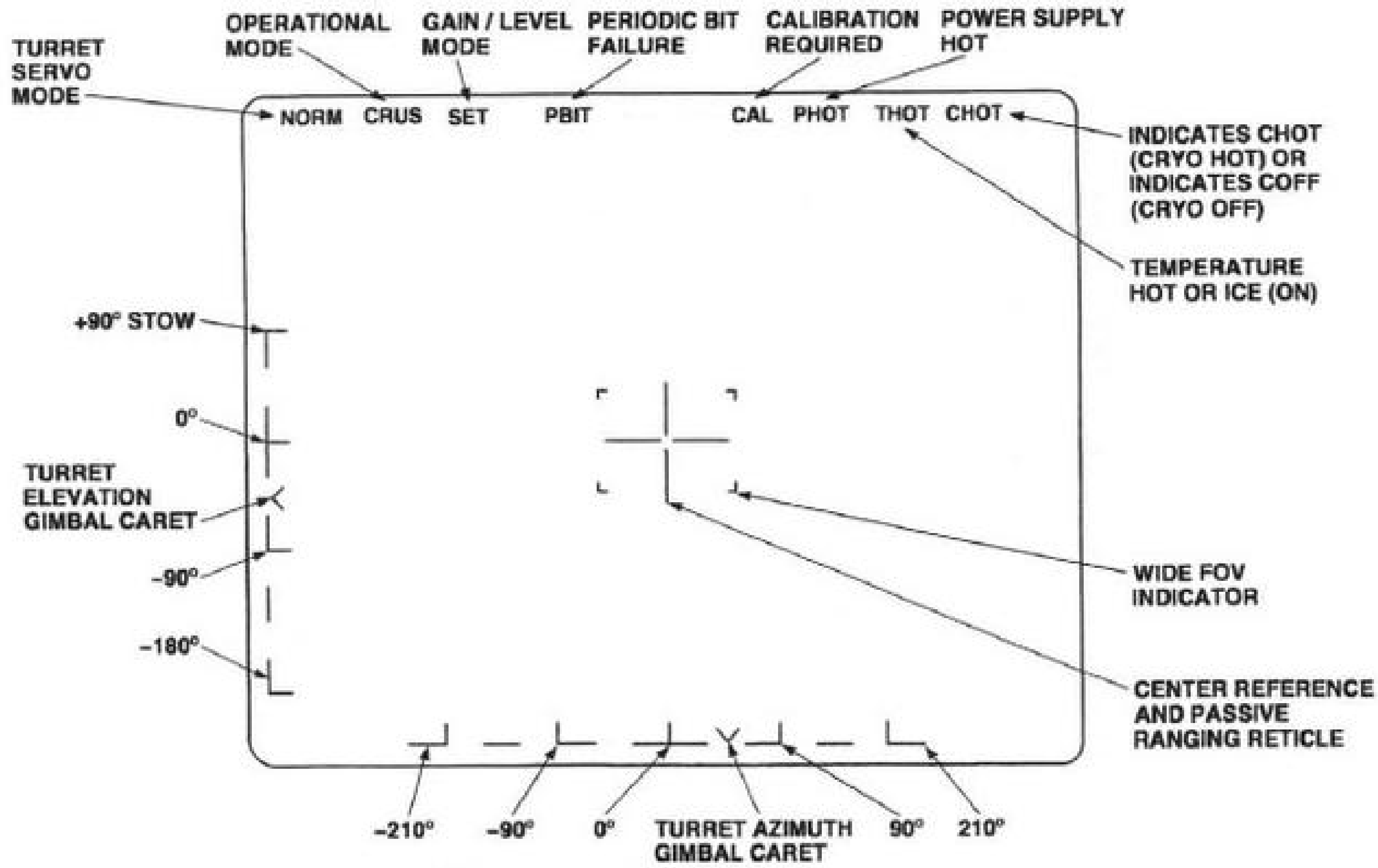
Figure 17-9. Navigation Data Items

17.2.6 Turret Servo Modes. There are seven turret servo modes: look-ahead (AHD), stow (STOW), normal (NORM), rate (RATE), autotrack (AT), autotrack enable (ATE), and scan (SCAN).

Note

- When flying with infrared detecting set, objects appear to be further away than they really are. The narrow-field-of-view (NFOV) is closer to the natural field-of-view than wide-field-of-view (WFOV). Since the distortion is more pronounced in WFOV, WFOV should be used for reference purposes. Once the desired object is located, switch to NFOV.
- When in NFOV and flying low, the helicopter appears to move much faster and much lower than it actually is. This condition is important when coming into the hover mode. The crew should check instrument air speed and other visual indicators to safeguard against the deceptive FLIR image.

17.2.6.1 Look-Ahead Mode. Look ahead moves the turret to a calibrated position in azimuth and elevation. The operator can adjust the look-ahead position of the turret +/-10 degrees in both azimuth and elevation.



FLIR DATA ITEM	FUNCTION
Turret Servo Mode	Turret servo mode indication is to the left of the heading tape. Turret Servo Mode will indicate AHD, RATE, NORM, SCAN, STOW, ATE or AT modes.
Operational Mode	Operational mode is indicated to the left of the heading tape. Operational mode will indicate CRUS, ACQ, HVR, PSN or TRNS modes.
Gain/Level Mode	SET, MAN or AUTO will display to show the gain and level mode.
PBIT (Periodic BIT Failure)	Indicates failure during periodic BIT.
CAL (Calibration Required)	Indicates need for system calibration.
COFF (Cryo Off)	Indicates cryogenic cooler is off.
PHOT (Power Supply Hot)	Indicates SDC power supply failure.
THOT (Temperature Hot)	Indicates TFU hot.
CHOT (Cryo Hot Indicator)	CHOT flashes when FLIR temperature exceeds operating limit (100 K)
NFOV Indicator	In WFOV, four corner indicators identify the FOV boundaries of the FLIR image if it were in NFOV. In NVOF the four corner indicators are not displayed.
Center Reference and Passive Ranging Reticle	Open cross symbol positioned at center of display indicating center of FLIR sensor. In NFOV, stadia marks on center reference and passive ranging reticle enable operator to estimate range to target of known dimensions.
Turret Azimuth and Elevation Gimbal Position	The turret pointing angle with respect to the aircraft reference is indicated by a caret on the vertical scale, representing elevation, and by a caret on the horizontal scale, representing azimuth. The scales are graduated in 30 degree segments with indices every 90 degrees. The scale limits are +/- 210 degrees in aximuth and +90 degrees and -180 degrees in elevation.

Figure 17-10. FLIR Data Items

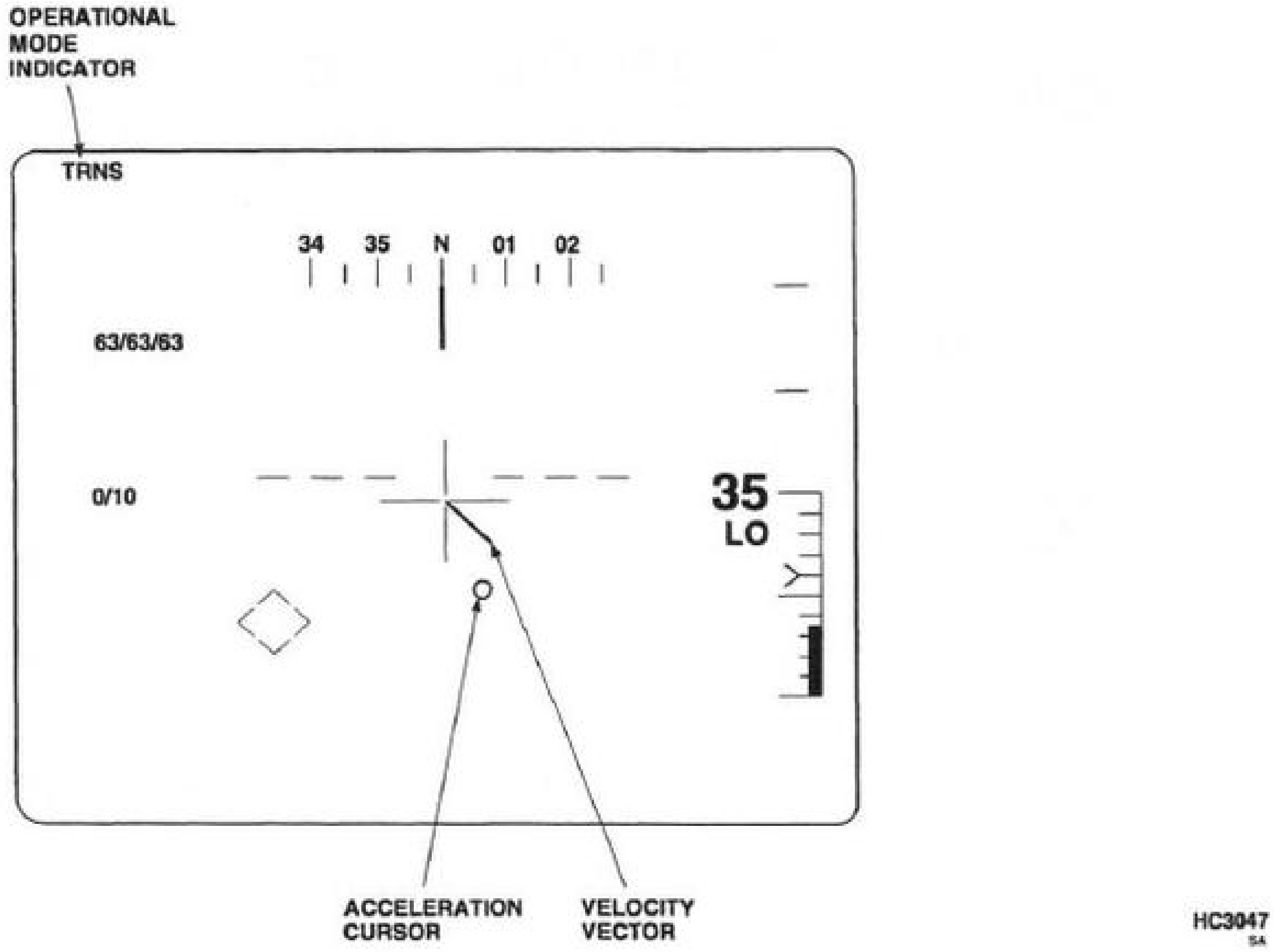


Figure 17-11. Transition, Mode Symbols

17.2.6.1.1 Look-Ahead Mode Operation and Adjustment. Initiate look-ahead mode by selecting AHD function on flight page or pressing LOOK AHD on the MFCU.

CAUTION

Change look-ahead position values in accordance with the provided procedures only. Do not adjust any values other than the ones outlined in the procedure. If any values other than the ones outlined in this procedure are adjusted, severe system malfunction may occur. If other values have been adjusted accidentally, do not store the values, reset system by toggling FLIR/RNS power switch to COOL DOWN or OFF and then back ON.

Note

- FIT pages are superimposed over FLIR image. When FIT pages are displayed, flight page and menu page function legends are not shown.
- To exit FIT, at any time, directly to flight page or menu pages, toggle the FLIR/RNS BIT/FIT switch to FIT and release. To re-enter FIT, toggle FLIR/RNS BIT/FIT switch to FIT. FIT page last displayed will display again. If EXIT is not an option on FIT page, pull MFCU trigger to second detent.

1. Toggle FLIR/RNS BIT/FIT switch to FIT and release. HNVS FIT page (Figure 17-18) will display.

2. Using MFCU four-position switch, move star cursor (*) to 12 CALIBRATION.

3. Pull MFCU trigger to first detent and release. CALIBRATION page (Figure 17-19) will display.

4. Using MFCU four-position switch, move star cursor (*) to SERVO.

5. Pull MFCU trigger to first detent and release. SERVO CALIBRATION page (figure 17-20) will display.

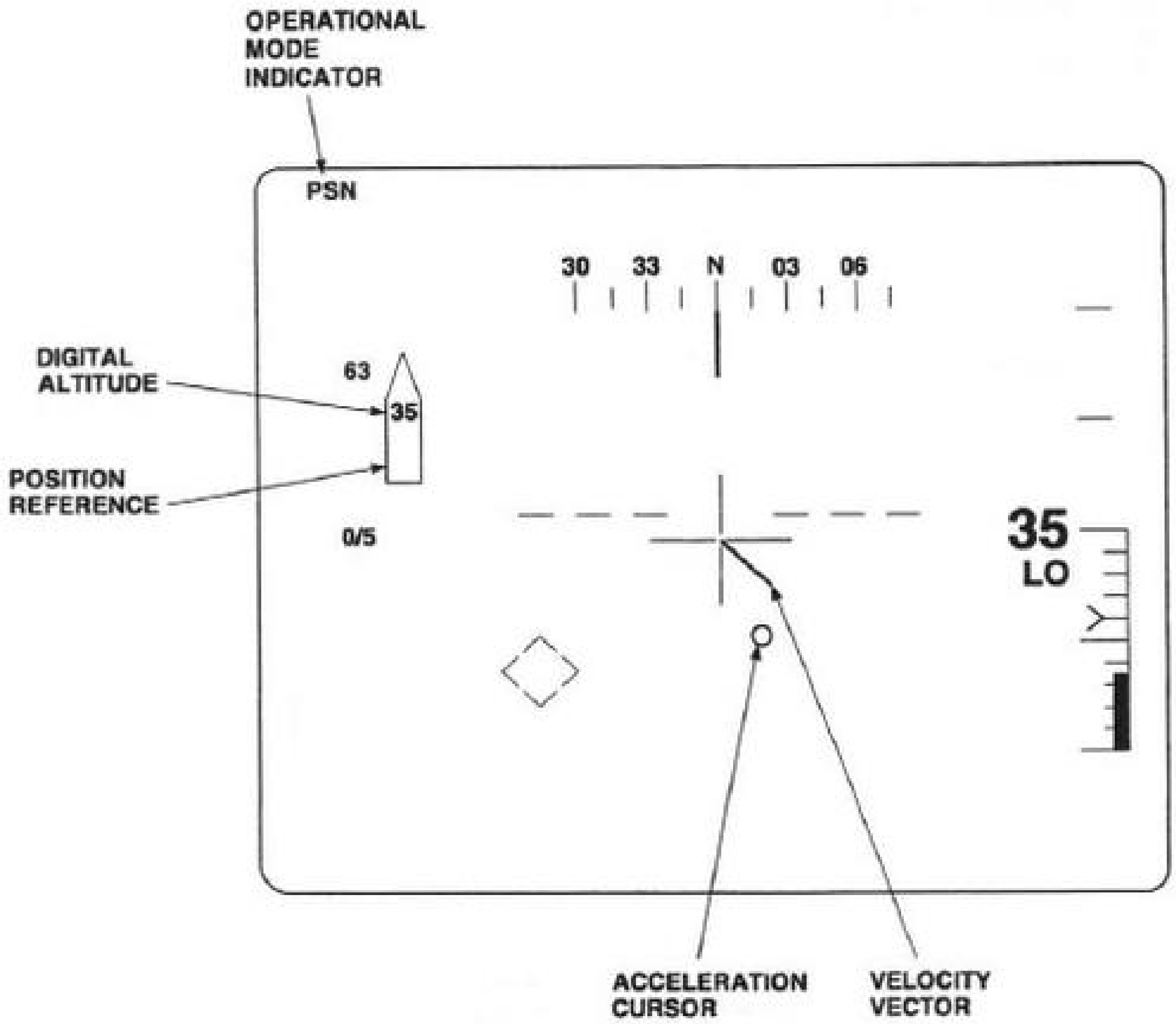


Figure 17-12. Position, Mode Symbols

6. Using MFCU four-position switch, move star cursor (*) to LKAHED.

7. Pull MFCU trigger to first detent and release. Star cursor (*) flashes.

Note

The limits of adjustment are +/-10 degrees in both azimuth and elevation. The recommended values for the look-ahead position are 0.0 degrees azimuth and elevation. Any values with the +/-10 degree limits in azimuth and elevation can be used.

8. While star cursor (*) is flashing, MFCU force controller can be used to adjust the azimuth and elevation values for the look-ahead position. Moving MFCU force controller up or down adjust elevation. Moving MFCU force controller left or right adjust azimuth.

9. After adjustments have been made, pull MFCU trigger to first detent and release. The start cursor (*) stops flashing.

10. Toggle FLIR/RNS BIT/FIT switch to FIT.

11. Select AHD function on flight page, or press LOOK AHD button on MFCU and observe look-ahead position. If look-ahead position is satisfactory, go to next step. If look-ahead position need further adjustment, toggle FLIR/RNS BIT/FIT switch to FIT and repeat steps 6 through 11.

Note

- New look-ahead position values are stored in volatile memory. New look-ahead position values will be used for the look-ahead position until system power is turned to OFF or COOL DOWN. When system power is turned to OFF or COOL DOWN, the new look-ahead position values are erased and default look-ahead position values will be used.

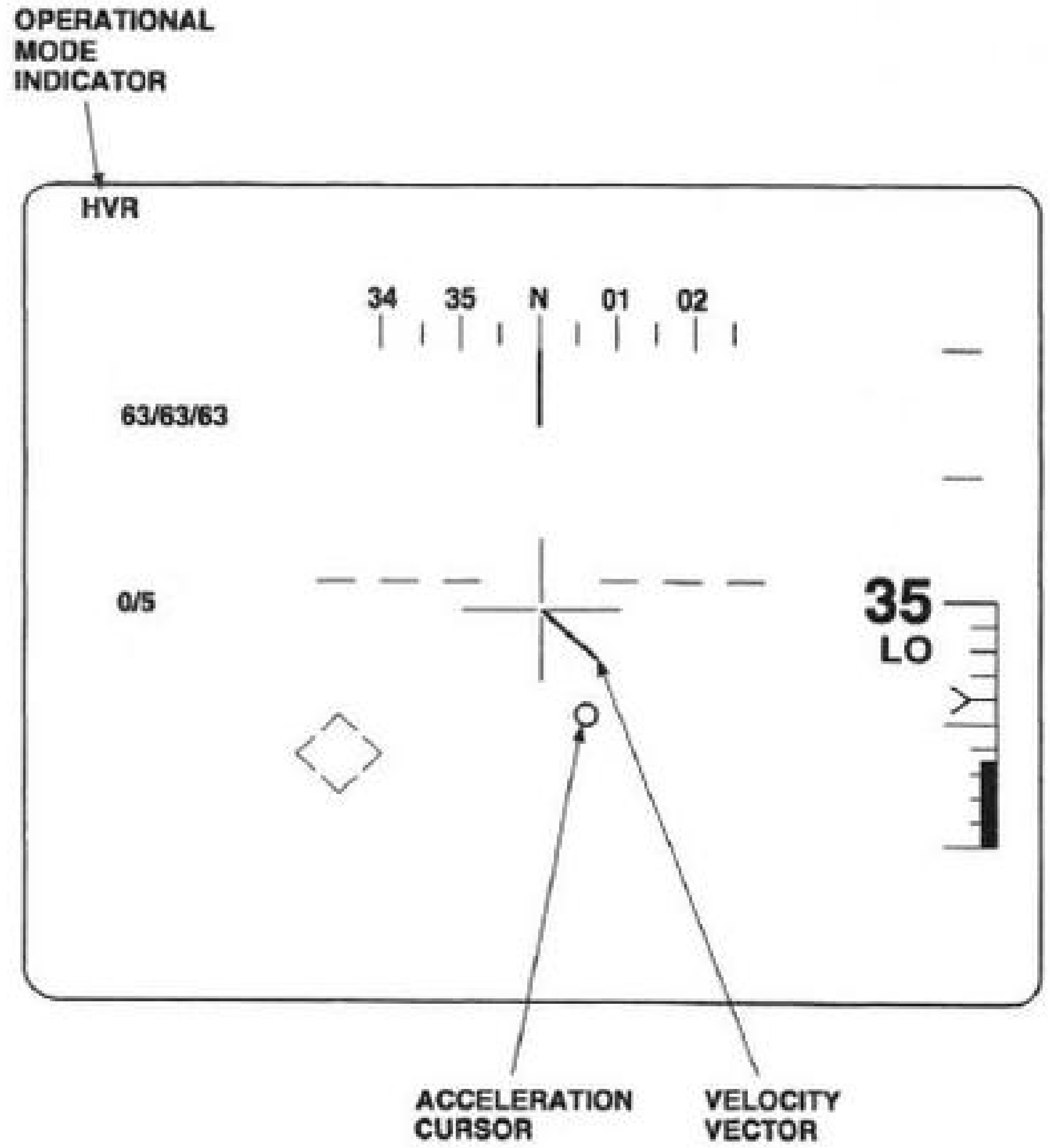
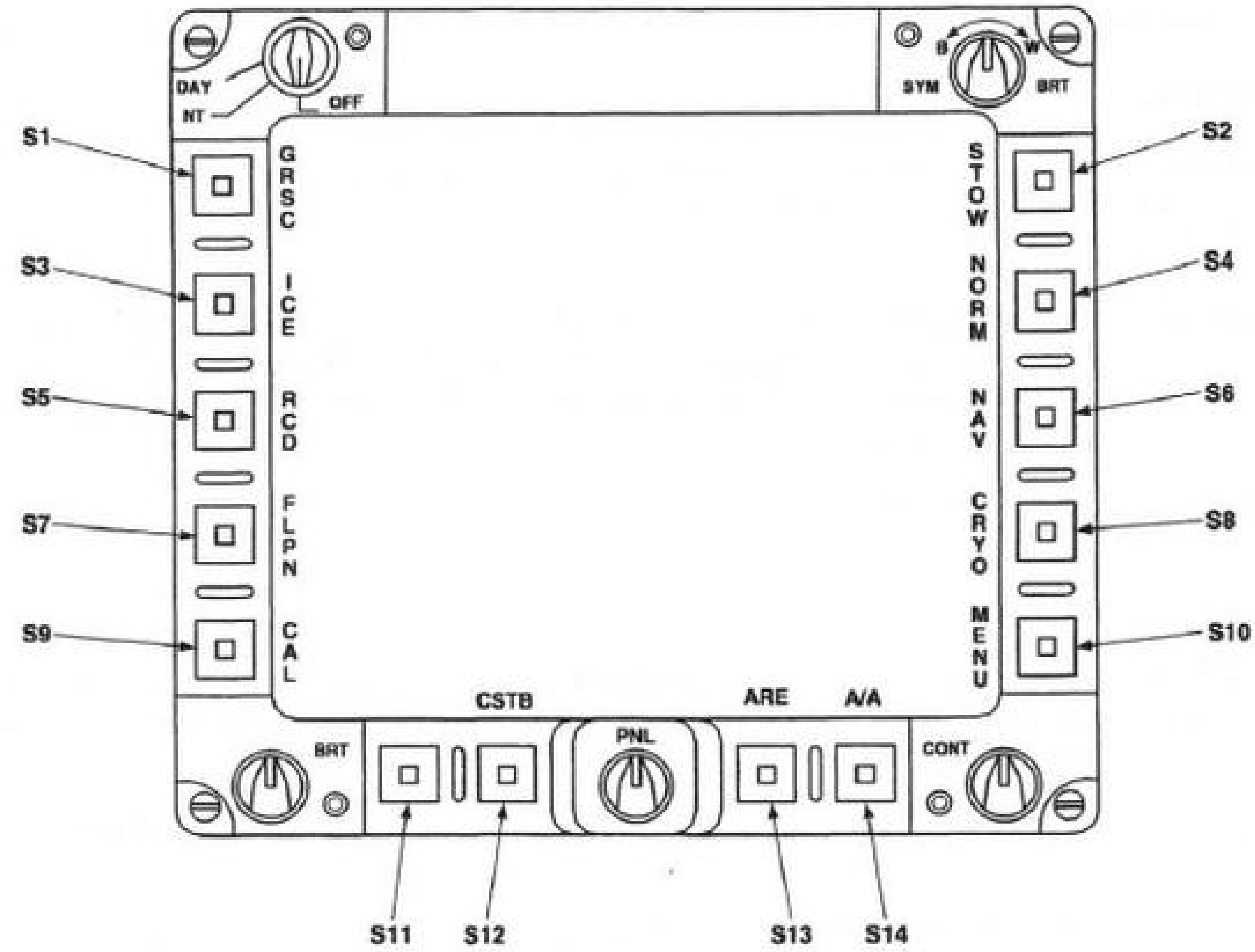


Figure 17-13. Hover Mode Symbols

TRNS, PSN, HVR ITEMS	FUNCTION
Operational Mode	Indicates current operational mode.
Velocity Vector	Represents the speed and direction in a horizontal plane. The length of the vector represents the speed of movement. The angular deflection represents the direction of movement. The origin of the velocity vector is the center of the display. Hover and position operational mode maximum scale deflection is 8 KIG. Transition operational mode maximum scale deflection is 108 KIG.
Acceleration Cursor	Aircraft acceleration in a horizontal plane. The spacing between the tip of the velocity vector and the acceleration cursor represents the magnitude of acceleration. The direction of displacement from this tip represents the direction of acceleration.
Position Reference Symbol (Doghouse)	Only displayed in PSN mode. Remains oriented to A/C heading when PSN mode initiated. Represents geographic position of A/C when PSN mode initiated. Digital indication of altitude in center of symbol.

Figure 17-14. TRNS, PSN, and HVR Mode Functions

- Steps 12-19 store new look-ahead position values in nonvolatile, permanent memory, replacing the default look-ahead position values. Store the new look-ahead position values only if the default values must be changed. If the default look-ahead values do not need to be permanently changed, exit FIT, step 16.



HC3049

DISPLAY SYMBOL/CONTROL	FUNCTION
GRSC (S1-Gray Scale)	Allows display of brightness and contrast adjustments to provide maximum gray scale resolution of FLIR image. Procedure for adjusting GRSC is: a. Select GRSC. Bar Graph replaces FLIR data. b. Adjust BRT and CONT until 10 distinct shades of gray are visible. c. Select GRSC again to remove bar graph.
ICE (S3-ICE)	Prevents build up of ice by heating TFU gimbals. Turn on only if ambient temperature below 40°F (5°C) prior to encountering conditions. Will not remove ice already present.
RCD (S5 — Record)	Function not active for this install.
FLPN (S7-Flight Plan)	Removes all symbology except airspeed/ground speed, engine torque, heading tape, altitude, and vertical velocity caret.
CAL (S9-Calibration)	If CAL symbol present, calbirate system.
STOW (S2-Stow)	Places turret in stow position and turns FLIR video off. Cryo remains on and avionics visible. Select AHD on flight page or press LOOK AHD on MFCU to remove turret from stow position and turn FLIR video on.
RATE or NORM (S4 - Rate Mode or Normal Mode)	RATE mode provides inertially reference LOS. Turret attempts to maintain the same pointing angle relative to ground. NORM provides aircraft referenced LOS. Turret attempts to maintain the same pointing angle relative to aircraft. If FLIR image drifts in RATE mode, calibrate manual rate.

Figure 17-15. Menu Page 1 Functions (Sheet 1 of 2)

DISPLAY SYMBOL/CONTROL	FUNCTION
NAV (S6-Navigation Data)	Function not active for this install.
CRYO (S8-Cryogenic)	Turns cryogenic cooler on/off. When CRYO off, turret is in stow position, and FLIR image not displayed. To restart cryogenic cooler, select AHD on flight page, CRYO on menu page 1, or press LOOK AHD on MFCU. After restart, FLIR image may be degraded for up to 10 minutes during cool down.
MENU (S10-Menu Page 2)	Selects menu page 2.
(None) (S11)	No function.
FSTB/CSTB (S12-Free Stabilization or Cage Stabilization)	Directs system to free stabilization (FSTB) during flight or on ground with engines running; compensates for aircraft vibration. CSTB cages the stabilization mirror. System should be left in FSTB at all times.
ARE (S13-ARE Calibration)	Initiates and performs calibration of pre-stored software-controlled ARE values.
A/A or A/G (S14-air-to-air or air-to-ground)	Directs either air-to-air or air-to-ground mode. Air-to-air provides AC coupling of system to reduce background clutter when viewing an airborne target, or a target on water. Air-to-ground provides DC restoration of system to give better horizon definition when viewing a ground target.

Figure 17-15. Menu Page 1 Functions (Sheet 2 of 2)

12. Toggle FLIR/RNS BIT/FIT switch to FIT. SERVO CALIBRATION page will display.

13. Using MFCU four-position switch, move star cursor (*) to STORE SERVO NV DATA.

14. Pull MFCU trigger to first detent and release to store new look-ahead position values in non-volatile memory. Star cursor (*) flashes.

15. When star cursor (*) stops flashing, new look-ahead position values have been stored.

16. Using MFCU four-position switch, move star cursor (*) to EXIT. Pull MFCU trigger to first detent to exit SERVO CALIBRATION page. CALIBRATION page will display.

17. Using MFCU four-position switch, move star cursor (*) to EXIT.

18. Pull MFCU trigger to first detent to exit CALIBRATION page. HNVS FIT page will display.

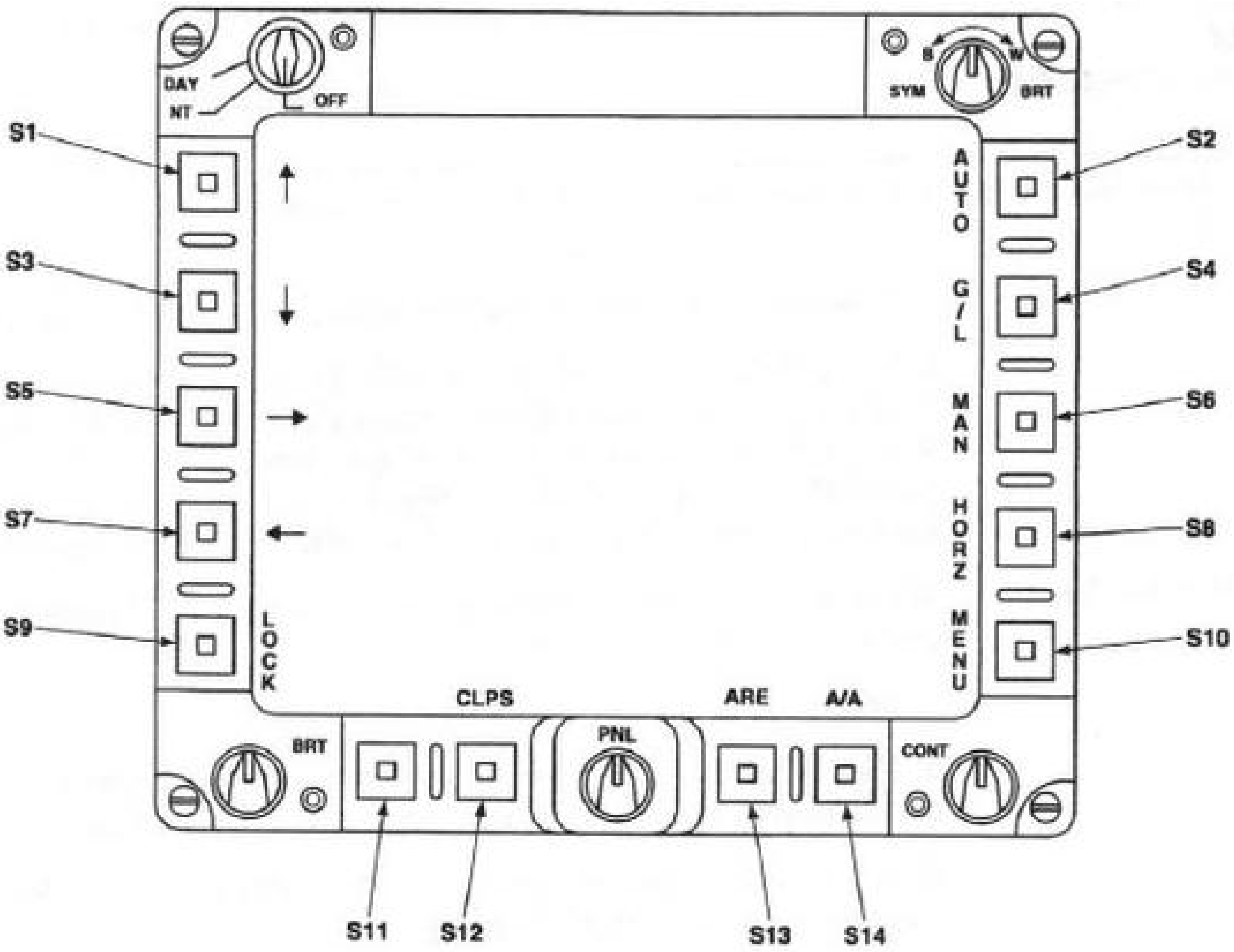
19. Pull MFCU trigger to second detent to exit HNVS FIT page.

17.2.6.2 Stow Mode. Stow mode moves the turret to the stowed position and turns FLIR image off. Initiate stow mode by selecting STOW function from menu page 1. STOW is visible on status line.

17.2.6.3 Normal Mode. The TFU maintains the same pointing angle relative to the aircraft unless the operator moves the TFU using the MFCU force controller. Initiate normal mode by selecting NORM function on menu page 1 or CRUS on flight page. NORM is visible on status line.

17.2.6.4 Rate Mode. Rate mode provides an inertially referenced line-of-sight. Initiate rate mode by selecting RATE function on menu page 1 or TRNS, HVR, PSN or ACQ on flight page. RATE is visible on status line.

17.2.6.5 Autotrack Enable (ATE) Mode. ATE mode is used to select a target to be automatically tracked using autotrack (AT) mode. When the target is selected in ATE mode, AT mode is initiated by pulling the MFCU trigger to the first detent. ATE mode is selected by pressing



HC3227

DISPLAY SYMBOL/CONTROL	FUNCTION
▲(S1-Up), ▼(S-Down) ◄(S5-Left), ►(S7-Right)	Arrow functions adjust G/L, MAN and HORZ functions. Pressing pushbuttons longer provides faster adjustment than MFCU Force Controller.
LOCK (S9-Adjustment Lock)	Locks adjustment to MAN, HORZ, or G/L.
AUTO (S2-Video Gain and Level Control)	Initiates automatic video gain and level control of FLIR image control algorithm.
G/L (S4-Video Gain and Level Control)	Adjusting constraints on AUTO function enhances FLIR definition of a specific target or overall FLIR image. a. Select G/L function. Gain/level scale displayed on PDU screen. b. Using MFCU force controller, or left/right/up/down arrow functions on menu page 2, adjust gain/level scale, which will adjust FLIR image. Up function decreases size of gain/level scale. Down increases the size of gain/level scale. Left shifts scale to hotter temperature range. Right shifts scale to colder temperature range. c. Select G/L a second time. BIN BIAS value displays. d. Adjust BIN BIAS value, which effects FLIR image. Up increases BIN BIAS value and lowers contrast. Down decreases BIN BIAS value and increases contrast. Default value is 5. Value ranges from 0 to 255 and rolls to 0 at 255. e. Select G/L a third time to return to gain/level scale adjust. f. Pull MFCU trigger to second detent, select LOCK or MENU functions to lock adjusted values and exit G/L function.

Figure 17-16. Menu Page 2 Functions (Sheet 1 of 2)

DISPLAY SYMBOL/CONTROL	FUNCTION
MAN (S6-Video Gain and Level Control)	Adjust gain and level of FLIR image manually.
	a. Select MAN function. Gain/level scale displays on PDU screen.
	b. Using MFCU force controller or left/right/up/down arrow functions on menu page 2 adjust gain/level scale. Up decreases size of gain/level scale. Down increases the scale. Left shift scale to hotter temperature range. Right shifts scale to colder temperature range. Pull MFCU trigger to second detent or select LOCK or MENU function on menu page 2 to lock in adjusted values and exit MAN function.
HORZ (S8-Horizon Adjust)	Vertically adjusts horizon symbol position using MFCU force controller or up/down arrow functions on menu page 2.
	a. Select HORZ.
	b. Using MFCU or up/down arrow function, adjust position of horizon symbol. Up moves horizon symbol up. Down moves horizon symbol down.
	d. Pull MFCU trigger to second detent or select LOCK or MENU function to lock adjustment and exit HORZ function.
MENU (S10-Flight Page)	Display flight page function legends.
None (S11)	No function.
CLPS (S12-Collapse Video)	Provides better vertical resolution of FLIR image. May cause objects to appear longer. Use CLPS to view antennas and support poles for wires. Select CLPS a second time to return to normal video.
ARE (S13-ARE Calibration)	Initiates and performs ARE value calibration. ARE calibration values are stored in volatile memory and erased when system power is turned to cool down or off. To permanently store ARE calibration values do ARE calibration.
A/A or A/G (S14-Air-to-air to air-to-ground)	Directs system to either air-to-air or air-to-ground mode. Air-to-air modes provides AC coupling of system to reduce background clutter when viewing an airborne target or a target on water. Air-to-ground provides DC restoration of system to give better horizon definition when viewing a ground target.

Figure 17-16. Menu Page 2 Functions (Sheet 2 of 2)

the track switch on the MFCU. when ATE mode is selected a dashed line track gate (Figure 17-21[A]) appears in the center of the display. The MFCU force controller is used to move the turret until the track gate is centered over the target. The size of the track gate can be adjusted using the gate size adjust function. Two operating functions are used to select a target and adjust the size of the track gate, MFCU function and gate size adjust function.

17.2.6.5.1 MFCU Function. MFCU function is used to move the turret to center the target in the dashed line track gate. MFCU function is the default function when entering ATE mode.

17.2.6.5.2 Gate Size Adjust Function. Gate size adjust function allows adjustment of the size of the dashed line track gate. When using gate size adjust function, the dashed line track gate will appear with lines through all four corners (Figure 17-21[B]). MFCU force controller adjust the size of the track gate. From default MFCU function, gate size adjust function is initiated by toggling the MFCU four position switch to the right (TG position) one time. When using gate size adjust function, toggling MFCU four-position switch to the right (TG position) one time returns to the default MFCU function.

INDICATION	MALFUNCTION	ACTION
CHOT flashes	Cryogenic cooler exceeds 100°K operating limit.	At system start up, wait 10 minutes. If still visible after 18 minutes, turn cryogenic cooler (CRYO) off. When CRYO off, turret is in stow position and FLIR image not displayed.
PBIT	Periodic BIT failure.	Run BIT.
PHOT	Power Supply Hot.	Indicates SDC power supply failure. Shut off HNVS system.
CAL	Calibration.	Indicates need for HNVS calibration. Avionics symbology degraded. Turn SYM BRT to center to remove display symbols.
THOT	FLIR Unit Hot.	Turn off HNVS system.
FLIR/RNS LEDs not lit during LAMP TEST	If LEDS not lit, power not supplied to HNVS or FLIR/RNS Control Panel failure	Turn off HNVS system.
SYS POWER or PROC LED lit 5 seconds after LAMP TEST	SYS POWER (System Power) or PROC (Processor) LED lit, SDC failure.	Turn off HNVS system.
DISP PWR lit 5 seconds after LAMP TEST	DISP PWR (Display Power) power supply failure or PDU failure.	Turn off HNVS system.
RNS FAIL LED lit or lit 90 seconds after BIT	Doppler data degraded, or BIT failure, or Doppler system failure.	Turn RNS OFF. Doppler symbology will not display.

Figure 17-17. HNVS SYSTEM MALFUNCTIONS

17.2.6.6 Autotrack Mode Description. AT mode is used when the operator wants HNVS to automatically track a target. In AT mode, the turret is locked on the target. The target is centered in the primary track gate. The turret will track the target until it is no longer in view or its IR signature significantly changes. ATE mode is used to initially select a target to be tracked by AT mode. The operating functions are: secondary gate enable function, gate size adjust function, and APD function.

17.2.6.6.1 Secondary Gate Enable Function. The secondary track gate appears as bold corners (Figure 17-21[C]) on the primary track gate. The secondary gate is used to select a secondary target or to center or redesignate a target within the existing FOV. The MFCU force controller is used to move the secondary track gate (Figure 17-21[D]) over a target for tracking. When the secondary track gate has been centered over the target, the secondary track gate can be redesignated as the primary track gate by pulling MFCU trigger to the first detent. The secondary track gate now appears as a solid box and the new target is now tracked. The size of the new primary track gate is adjusted using the gate size adjust function. Secondary gate enable is the default function in use when entering AT mode.

17.2.6.6.2 Gate Size Adjust Function. Gate size adjust allows adjustment of the size of the primary track gate. When using gate size adjust function the primary track gate will appear as a solid box with lines through the corners (Figure 17-21[E]). The MFCU force controller adjusts the size of the primary track gate. The default secondary gate enable function changes to the gate size adjust by toggling the MFCU four-position switch to the right (TG position) one time. When using gate size adjust, toggling MFCU four-position switch to the right (TG position) two times returns to the default secondary gate enable function.

17.2.6.6.3 APD Function. The APD function allows the operator to view an area outside the current FOV being tracked or to center the track gate after using the secondary gate enable function. The track gate is normally

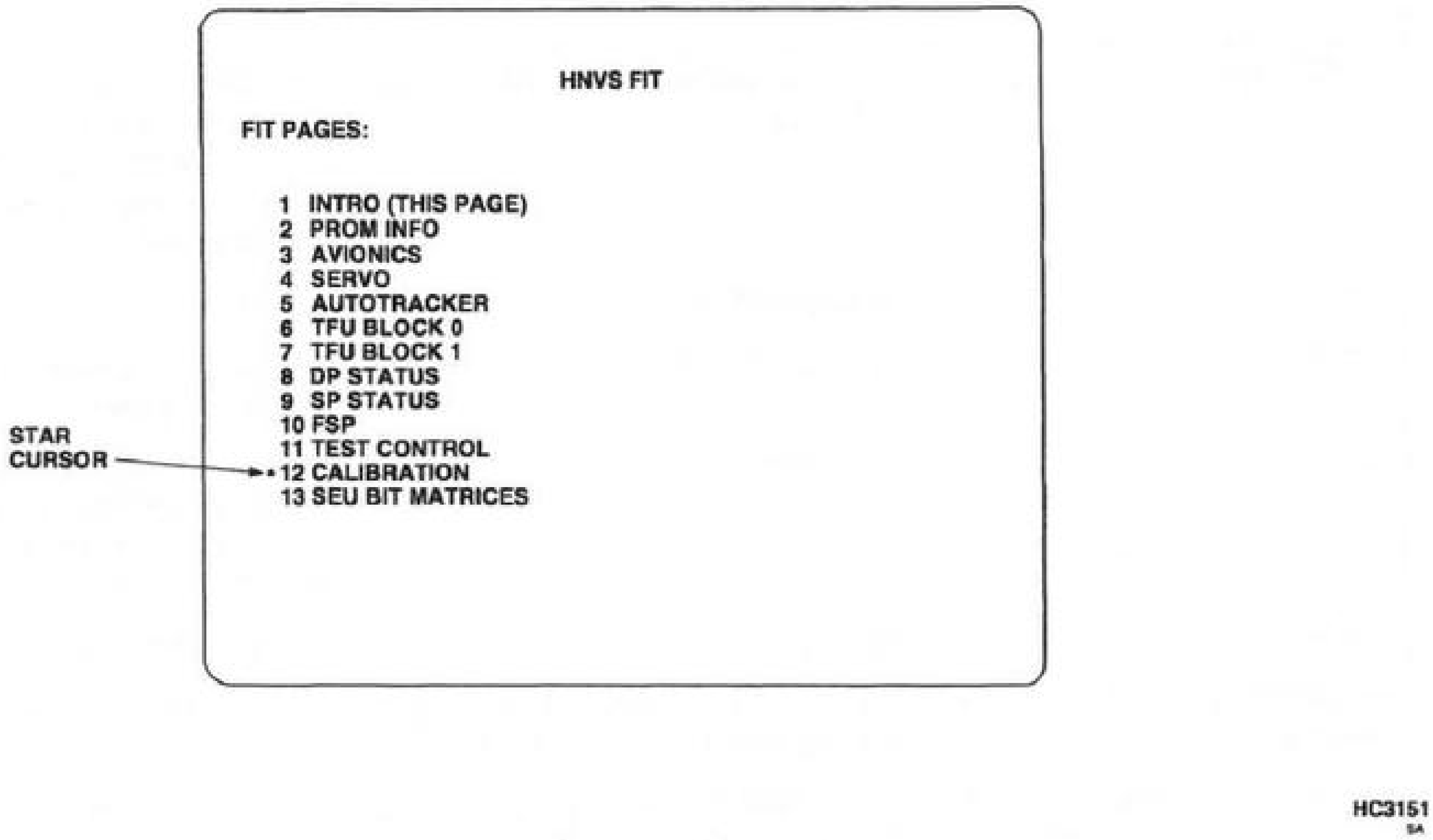


Figure 17-18. HNVS FIT Page

in the center of the display. To view an area outside the current FOV, APD (Figure 17-21[F]) is used. When using APD function, the MFCU force controller is used for limited turret movement. The default secondary gate enable function changes to the APD by toggling the MFCU four-position switch to the right (TG position) two times. When in APD function, toggling the MFCU four-position switch to the right (TG position) one time returns system to the default secondary gate enable function.

17.2.6.7 Autotrack Enable and Autotrack Mode Operation

Note

Ensure system is not in look-ahead before attempting to enter ATE mode.

1. Press the MFCU force controller track switch to enter ATE mode. ATE symbol is visible as turret servo mode. Dashed line track gate (Figure 17-21[A]) appears in center of display.

2. Adjust the track gate size to be as close to the size of the target as possible:

   a. Toggle MFCU four-position switch to the right (TG position) one time to enable gate size adjust. Track gate will appear as box with lines through corners (Figure 17-21[B]).

   b. Use MFCU force controller to adjust the size of the track gate. Make gate as close to size of target as possible. Move MFCU force controller up and down to adjust height of track gate. Move MFCU force controller left and right to adjust width of track gate.

   c. Toggle MFCU four-position switch to the right (TG position) once to set track gate size adjustments and disable gate size adjust function.

Note

MFCU force controller is used to move the turret. Track gate remains in center of display.

3. Using MFCU force controller center the target to be tracked within the dashed line track gate.

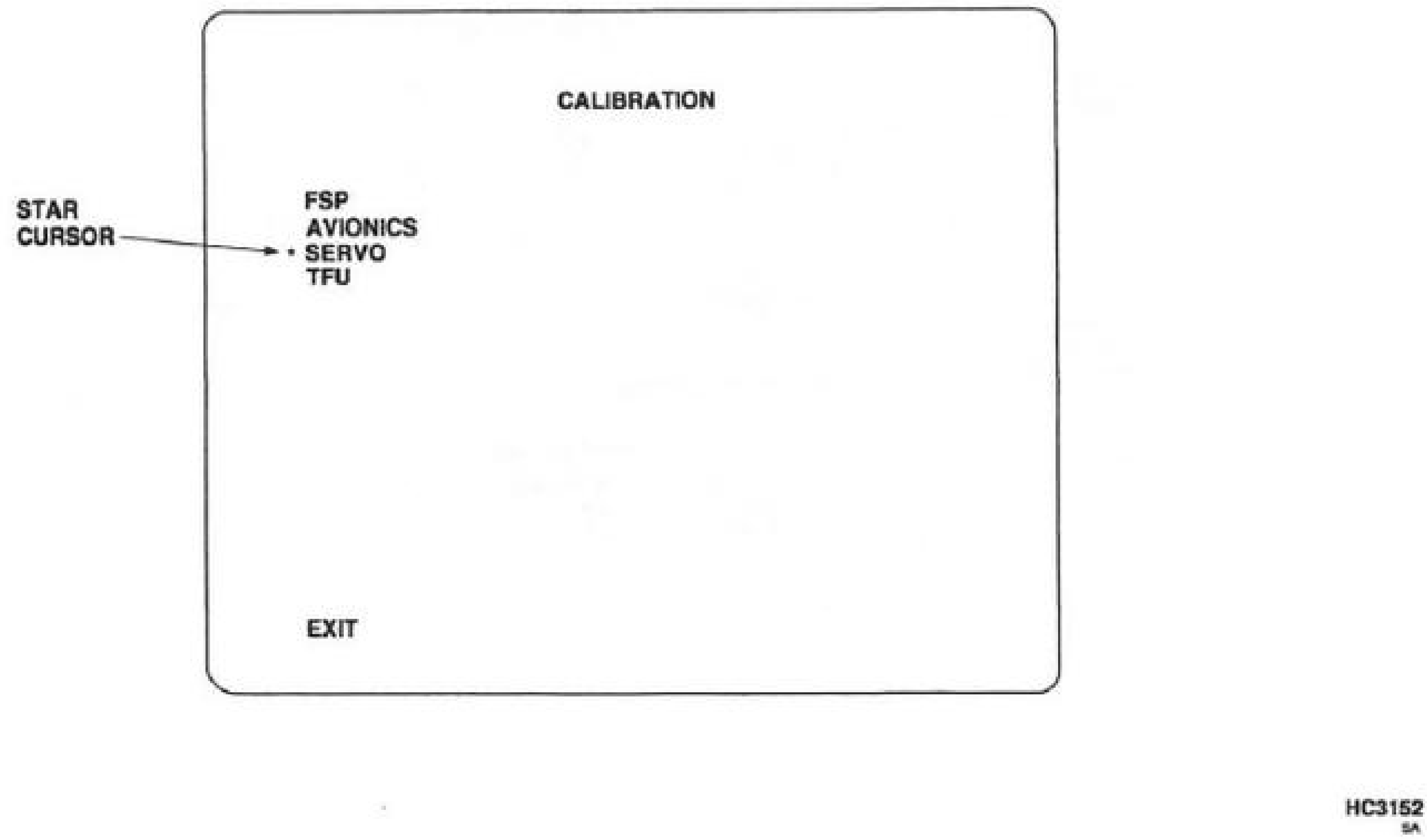


Figure 17-19. Calibration Page

4. Pull MFCU trigger to first detent to initiate AT mode. Mode symbol AT is visible as turret servo mode. Primary track gate is shown as solid box around the target being tracked. Secondary track gate is shown as bold corners (Figure 17-21[C]) of primary track gate.

17.2.6.7.1 Secondary Gate Enable Operation. Use secondary gate as follows:

1. Use MFCU force controller to move secondary track gate to desired target.

2. Pull MFCU trigger to first detent. Secondary track gate becomes primary track gate.

3. Adjust size of primary gate using gate size adjust function. Redesignate secondary gate as primary gate as often as necessary.

17.2.6.7.2 Gate Size Adjustment Operation. Readjust primary track gate size as follows:

1. In secondary gate enable, toggle MFCU four-position switch to the right (TG position) one time to enable gate size adjust function. Track gate will appear as box with lines through corners.

2. Use the MFCU force controller to adjust the size of the track gate. Make track gate size as close to size of target as possible. Move MFCU force controller up and down to adjust height of track gate. Move MFCU force controller left and right to adjust width of track gate.

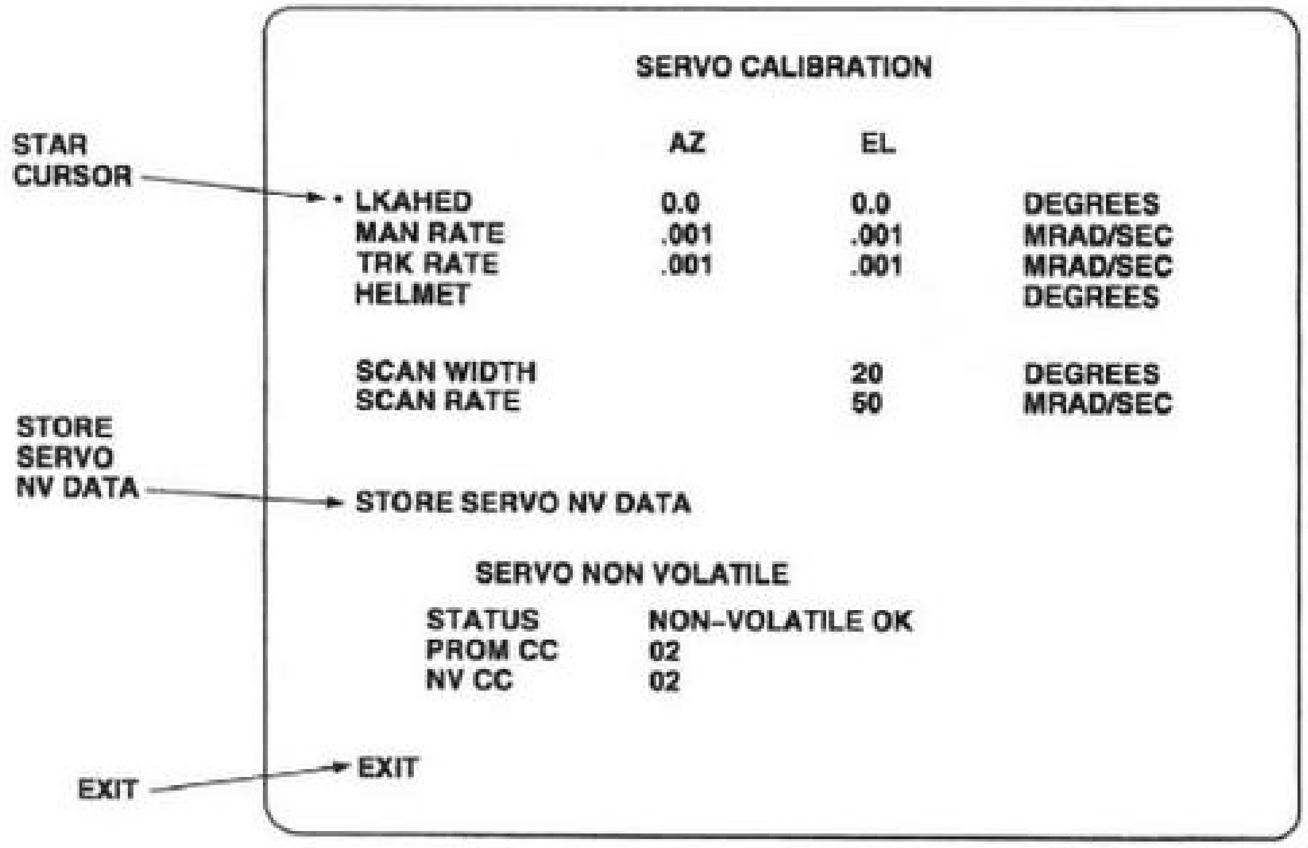
3. Toggle MFCU four-position switch to the right (TG position) two times to set new gate size adjustments and return to secondary gate enable function.

17.2.6.7.3 Aim Point Designate Operation. Initiate APD as follows:

1. In secondary gate enable mode, toggle MFCU four-position switch to the right (TG position) two times to change to APD mode. APD track gate appears as a solid box.

2. Use MFCU force controller to move turret to view other areas or to center the gate after using the secondary gate enable function. Turret has a limited range of motion. Track gate stays within FOV.

3. Toggle MFCU four-position switch to the right (TG position) one time to return to secondary gate enable function.



HC3153
6A

Figure 17-20. Servo Calibration Page

17.2.6.7.4 Change FOV in Autotrack Mode. FOV can be changed during AT mode, track gate should be centered on PDU display. Use the following guidelines for changing FOV:

Note

If in APD mode, before changing FOV, bring primary track gate back to center of display.

1. FOV should be changed from narrow to wide when the target can no longer be contained in track gate of maximum size.

2. FOV should be changed from wide to narrow when target size reaches approximately one half maximum gate size.

17.2.6.7.5 Breaking Autotrack Mode. When IR signature of target changes significantly, or background of overall FLIR image is too cluttered, AT mode may be broken. Before breaking AT mode, primary track gate flashes rapidly. Once AT mode is broken, system returns to ATE mode. Gate size does not change.

17.2.6.7.6 Exiting Autotrack Mode. To exit AT mode, press the MFCU force controller track switch once to return to ATE mode or press the MFCU force controller track switch two times to disable AT mode, and return to RATE mode. Pressing LOOK AHD on MFCU or selecting AHD function from flight page exits AT mode and returns the system to look-ahead mode. Pressing LOOK AHD on MFCU or selecting AHD function from the flight page a second time returns system to normal operation.

17.2.6.8 Scan Mode Description. The scan mode is used to repeatedly view a portion of the FOR. In scan mode, the turret moves horizontally across a calibrated scan width at a calibrated rate. The elevation angle of the scan can be varied using the MFCU force controller. Scan mode does not operate when the elevation angle is above +35°, between -80° and -100° (nadir), or below -170°. If FOV is changed, the turret continues to cover the same number of degrees of scan, however the rate is scaled for the FOV. The width (in degrees) of scan, and the rate (in mrad per second) at which the scan is made can be varied by the operator.

17.2.6.8.1 Scan Mode Operation. Initiate scan mode by selecting SCAN function from flight page. SCAN

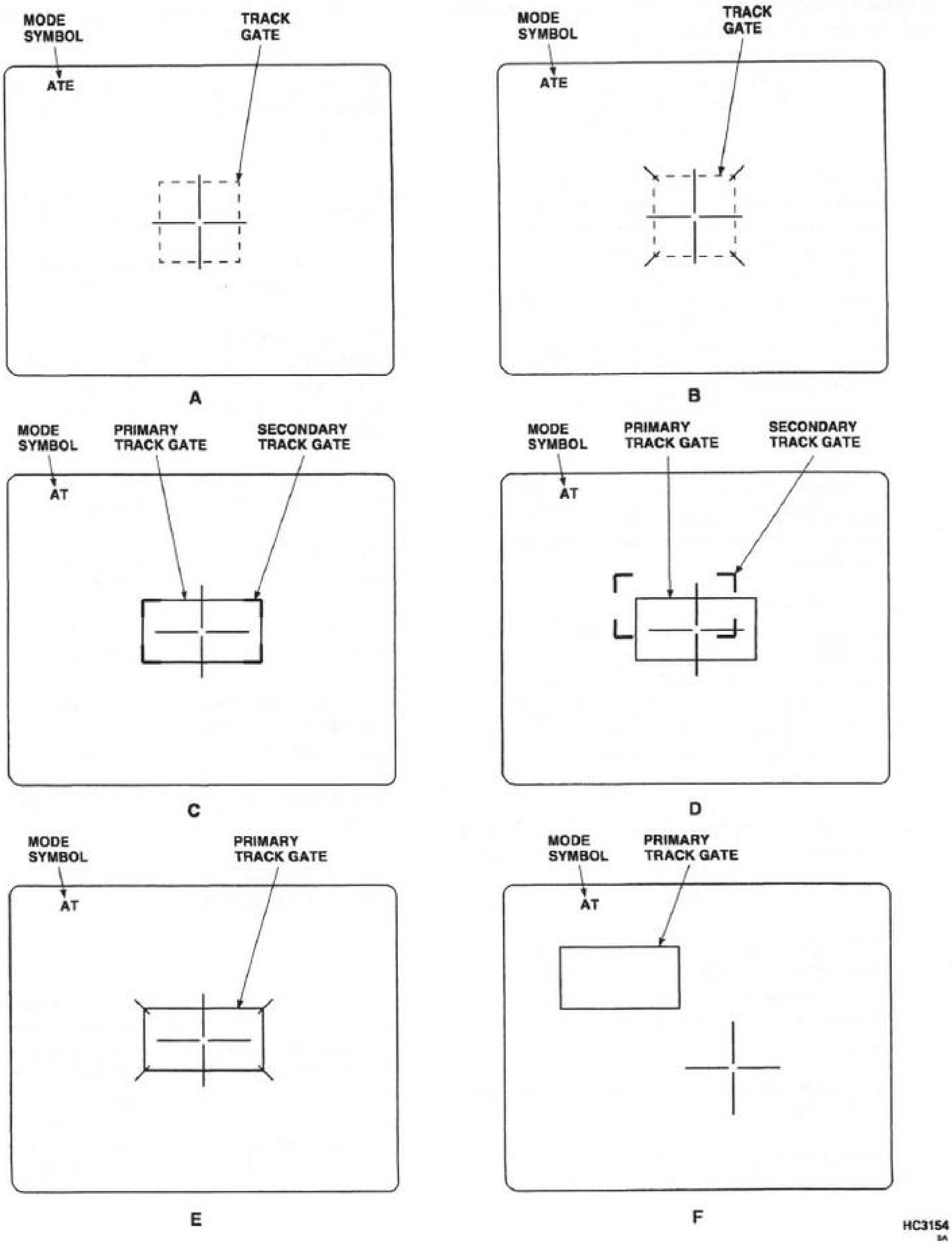


Figure 17-21. Autotrack Enable and Autotrack Track Gates

is visible for turret servo mode. To change the scan width and the scan rate, do the following:

CAUTION

Change scan width and scan rate values in accordance with the provided procedures only. Do not adjust any values other than the ones outlined in the procedure. If any values other than the ones outlined in this procedure are adjusted, severe system malfunction may occur. If other values have been adjusted accidentally, do not store the values. Reset system by switching power to COOL DOWN or OFF and then back ON.

Note

- FIT pages are superimposed over FLIR image. When FIT pages are displayed, flight page, and menu page function legends are not shown.
- To exit FIT at any time directly to flight page or menu pages, toggle the FLIR/RNS BIT/FIT switch to FIT and release. To re-enter FIT, toggle FLIR/RNS BIT/FIT switch to FIT. FIT page that was last displayed before exiting is displayed again. If EXIT is not an option on FIT page, pull MFCU trigger to second detent to exit.

1. Enter FIT by toggling FLIR/RNS BIT/FIT switch to FIT and releasing. The HNVS FIT page is displayed.

Note

MFCU four-position switch up position moves star cursor (*) up menu on FIT page. MFCU four-position switch down position moves star cursor (*) down menu on FIT page.

2. Using MFCU four-position switch, move star cursor (*) to 12 CALIBRATION.

3. Pull MFCU trigger to the first detent and release. CALIBRATION page (Figure 17-19) is displayed.

4. Using MFCU four-position switch move the star cursor (*) to SERVO.

5. Pull MFCU trigger to the first detent and release. SERVO CALIBRATION page (Figure 17-20) is displayed.

6. To adjust the width of scan, use MFCU four position switch to move star cursor (*) to SCAN WIDTH.

7. Pull MFCU trigger to first detent and release. This allows adjustment of the scan width.

8. Using MFCU force controller, adjust the value for SCAN WIDTH. The range of adjustment is 10 to 150 degrees in 1 degree increments. Up position increases value, down position decreases value. The default is whatever values were last stored.

9. When SCAN WIDTH value has been adjusted, pull MFCU trigger to first detent and release.

10. To adjust scan rate, use MFCU four-position switch to move star cursor (*) to SCAN RATE.

11. Pull MFCU trigger to the first detent and release. This allows adjustment of the scan rate.

12. Using MFCU force controller, adjust the value for SCAN RATE. The range of adjustment is 10 to 2500 MRAD/SEC in 10 mrad/sec increments (1 radian = 57°). Up position increases value, down position decreases value. The default is whatever values were last stored.

13. When SCAN RATE value has been adjusted, pull trigger to first detent and release.

Note

- New scan values are stored in temporary (volatile) memory. New scan values will be used for the scan mode settings until system power is turned to COOL DOWN or OFF. When system power is turned to COOL DOWN or OFF, the new scan mode settings are erased and default scan mode settings will be used when system power is turned on.

- Do steps 12 through 16 only to replace the default scan mode settings and to store new scan settings in non-volatile (permanent) memory. Storing the new scan mode settings, replaces the default scan mode settings with the new scan mode settings. Store the new scan mode settings only if the default scan mode settings must be changed. The recommended default settings for the scan mode are scan width of 20 degrees and scan rate of 100 mrad/sec. If the default scan mode settings do not need to be changed, exit FIT, go to step 17.

14. Using MFCU four-position switch, move star cursor (*) next to STORE SERVO NV DATA.

15. Pull MFCU trigger to first detent and release. Star cursor (*) flashes.

16. When star cursor (*) stops flashing, new scan value have been stored.

17. Using MFCU four-position switch, move star cursor (*) to EXIT and pull MFCU trigger to first detent. CALIBRATION page is displayed.

18. Using MFCU four-position switch, move star cursor (*) next to EXIT and pull the MFCU trigger to first detent. HNVS FIT page is displayed.

19. Pull MFCU trigger to second detent and release. Flight page or menu pages display.

17.2.7 Gain/Level FLIR Video Adjustment. The HNVS provides the operator with three options for enhancing the FLIR video definition by adjusting the FLIR gain and level. Adjusting the FLIR gain and level allows the operator to obtain the optimum FLIR video image for the scene or target being viewed. The three options are automatic FLIR gain/level control (AUTO), set FLIR gain/level control (G/L), and manual FLIR gain/level control (MAN).

17.2.7.1 Automatic Gain/Level Control. Automatic gain/level control (AUTO) is the system default. AUTO uses prestored parameters to automatically select the optimum video gain and level for the scene being viewed.

17.2.7.2 Set Gain/Level Control. Set gain level control enables the operator to control the FLIR video definition by changing the parameters used by the AUTO function. When using the G/L function the optimum video gain/level for the scene is automatically selected taking into account the changed parameters. When G/L function is selected, the GAIN/LEVEL scale is displayed. GAIN/LEVEL scale represents the current FLIR temperature range on the FLIR video that is enhanced with the available shades of gray. Objects with temperatures that fall outside the current FLIR temperature range are not enhanced on the FLIR video. If these objects have a higher temperature than the current FLIR temperature range, and the system is in black hot, these objects appear all black. If these objects have a lower temperature than the current FLIR temperature range, and the system is in black hot, all these objects appear all white. After the GAIN/LEVEL scale has been adjusted and G/L has been selected a second time, the BIN BIAS number is displayed. BIN BIAS controls the contrast of the FLIR image. Adjusting the size and position of the GAIN/LEVEL scale and adjusting the BIN BIAS value, if required, enables the operator to change the FLIR image of the scene being viewed until the optimum FLIR image is obtained.

To decrease the gain, increase the size of the GAIN/LEVEL scale, this increases the FLIR temperature range that is currently enhanced on the FLIR video. As the GAIN/LEVEL scale is adjusted, the effect on the FLIR image is shown. Increasing FLIR temperature range enables objects that had previously fallen outside the FLIR temperature range to be displayed. However, increasing the FLIR temperature range decreases the amount of detail of the objects in the overall FLIR image. The detail of the objects in the FLIR image decreases because the available shades of gray that enhance the video are now distributed over a greater temperature range. The operator should increase the size of the GAIN/LEVEL scale to view a greater number of objects with different temperatures on FLIR video.

To increase the gain, decrease the size of the GAIN/LEVEL scale, this decreases the FLIR temperature range that is currently enhanced on the FLIR video. As the GAIN/LEVEL scale is adjusted, the effect on the FLIR image is shown. Decreasing FLIR temperature range enables objects inside the current FLIR video range to be displayed in greater detail. However, decreasing the FLIR temperature range decreases the amount of objects with different temperatures that are displayed on the FLIR video. Fewer objects are displayed because the available shades of gray that enhance the FLIR video are now distributed over a smaller temperature range. The operator should decrease the size of the GAIN/LEVEL scale for viewing a specific target against a uniform background, or to enhance the definition of a specific object on the FLIR image.

Shifting the position of the GAIN/LEVEL scale shifts the FLIR temperature range that is enhanced on the FLIR video. Shifting the position of the GAIN/LEVEL scale to the left shifts the GAIN/LEVEL scale to the hotter end of the FLIR temperature scale. As the GAIN/LEVEL is shifted, the effect on the FLIR video is shown. Shifting the position of the GAIN/LEVEL scale to the right shifts the GAIN/LEVEL scale to the colder end of the FLIR temperature scale. Shifting the GAIN/LEVEL scale does not change the gain. The operator should shift the GAIN/LEVEL scale in conjunction with increasing/decreasing the gain until the optimum FLIR image is obtained.

Increasing the BIN BIAS value (maximum BIN BIAS value is 255) lowers the contrast of the FLIR image. Decreasing the BIN/BIAS value (minimum BIN BIAS value is O) increases the contrast of the FLIR image. As BIN BIAS is adjusted, the effect on the FLIR image is shown. The operator should increase the BIN BIAS value to identify targets against a uniform background. BIN BIAS value of 5 is the default when AUTO function is selected. For example, when viewing a point target against a uniform background, such as a ship on the water, the FLIR image shows that target's general shape, however, the specific details of the target are not clearly defined. The G/L function can enhance the definition of the target. Select G/L function. Decrease the size of the GAIN/LEVEL scale. Shift the position of the GAIN/LEVEL scale towards the temperature of the target, while observing the FLIR image. Continue to adjust the size and position of the GAIN/LEVEL scale until the optimum FLIR image of the target is displayed. To further enhance the FLIR image of the target, adjust the BIN BIAS value. Use similar methods for identifying specific targets in cluttered scenes.

17.2.7.3 Manual Gain/Level Control. Manual gain/level control (MAN) enables the operator to adjust the gain and level of the FLIR video manually. When using the MAN function, the optimum video gain and level for the scene being viewed is manually selected. The HNVS will not automatically enhance the scene with the new settings. Rather, the values manually selected will be used to enhance the scene. When MAN function is selected, the GAIN/LEVEL scale is displayed. The adjustments of the GAIN/LEVEL scale are the same as for the G/L function. Use the MAN function in the same manner as the G/L function, however, the BIN BIAS values cannot be adjusted.

17.2.8 System Shutdown. The HNVS is shut down by placing the DAY/NT/OFF switch on the PDU in the OFF position. Then place the PWR switch on the FLIR/RNS to OFF. The cryogenic cooler is turned off, the turret moves to the stow position, and all power is removed from the system.

If the HNVS will be used within a 10 minute period, it should not be shut down. Select STOW function from menu page 1. STOW positions turret in the stowed position, and turns the FLIR video off. The system remains cooled down and avionics remain visible.

17.3 AN/AVS-7 HEADS-UP DISPLAY SYSTEM

The AN/AVS-7 heads up display (HUD) provides flight data to the pilot and copilot without viewing the instrument panel, thus allowing the pilots to concentrate their scan outside the cockpit. The system serves as an aid to pilots during night flight operations by providing operational symbology information about the aircraft into an optical combiner that is attached to the AN/AVS-6 Aviator's Night Vision Imaging System (ANVIS). The HUD system consists of the signal data converter (SDC), converter control unit (CCU), display unit (DU) consisting of the optical unit (OU) and power supply calibration unit (PSCU), two HUD control switches located on the pilot's and copilot's collective controls, and air data transducer (ADT).

There are two programming modes and one operational mode which allow the pilot and copilot to independently select the symbology for their respective display modes from a master set of symbols in the signal data converter. Pilot and copilot can independently select from four normal symbology modes and four declutter modes that were pre-programmed. Declutter mode has seven vital symbols that will always be displayed: HOOK, CAUT (master caution), FIRE, HUD system fail warning, NAV system fail warning, and model declutter number. An adjust mode, during operation, is used to adjust barometric altitude, pitch, and roll. If the HUD system loses operating power after adjustments have been made, the brightness, mode, barometric altitude, pitch, and roll must be adjusted as necessary. The system self test is divided into power-up or operator initialized built-in-test (BIT) and in-flight BIT. The system BIT is initialized during power-up or selected by the operator. Part of the BIT is a periodic test that is performed automatically along with normal system operation. A failure of the SDC, NAV signals, pilot's DU, or copilot's DU will illuminate the CCU FAIL light and display a Fail message on the display unit. When a fail message is displayed on the DU, the operator should acknowledge the failure and rerun BIT to confirm the fault.

Power from the No. 3 primary ac bus is provided through a circuit breaker marked HUD REF. The No. 3 primary dc bus provides power through a circuit breaker marked HUD PWR. Both are located on the right cabin circuit breaker panel.

17.3.1 Heads Up Display Controls. The CCU (Figure 17-22) provides the interface between the operator and the SDC. It consists of all the controls necessary to independently select the displays prior to and during flight, to control the symbology position and intensity, to provide symbology selection by the operator and allow initiation of the built in test (BIT). The CCU is located on the center console.

Switches and indicators are:

CPLT

The BRT/DIM switch is the copilot's control for display brightness.

The DSPL POS D/U/L/R knobs are the copilot's controls for display position down/up (outer knob) and left/right (inner knob).

The MODE 1-4/DCLT switch is the copilot's mode select 1-4 and declutter switch.

PLT

The BRT/DIM switch is the pilot's control for display brightness.

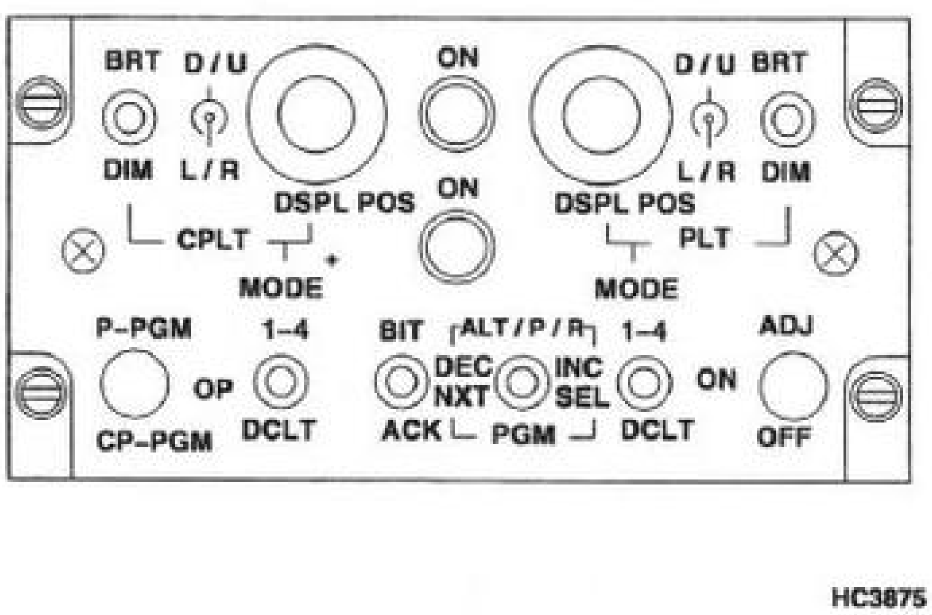


Figure 17-22. HUD Converter Control Unit

The DSPL POS D/U/L/R knobs are the pilot's controls for display position down/up (outer knob) and left/right (inner knob).

The MODE 1-4/DCLT switch is the pilot's mode select 1-4 and declutter switch.

The FAIL indicator indicates a system failure.

The ON indicator indicates system ON.

The ADJ/ON/OFF switch selects adjust mode, enabling the INC/DEC switch to adjust altitude, pitch, or roll. Turns power on or off to HUD system.

The P-PGM/OP/CP-PGM switch selects pilot program mode, operational mode, or copilot program mode. Used with the PGM NXT/SEL switch.

The BIT/ACK switch selects built-in-test or used to acknowledge a displayed fault, completion of an adjustment, or completion of a programming sequence.

The ALT/P/R DEC/INC switch is active when adjust mode is selected to decrease/increase altitude/pitch roll. When adjusting altitude (MSL) a momentary movement of the INC/DEC switch will change data in 5 ft increments. When the INC/DEC switch is held for one second data will change in 10 ft increments. Pitch and roll change in increments of 1 degree.

The PGM NXT/SEL switch is active when program mode is selected. Allows operator to preprogram the four normal modes and four declutter modes. Operator can select a flashing symbol for display and/or go to the next symbol. Once complete, operator toggles the ACK switch to save programmed display.

The pilot/copilot collective control switches (Figure 17-23) are described as follows:

The BRT/DIM positions allow pilot/copilot to control brightness of their respective displays.

The MODE/DCLT positions allow pilot/copilot to select respective display modes or declutter modes.

The OU (Figure 17-24) attaches to either ANVIS goggles monocular housing. Set EYE SELECT switch on PSCU to L or R. A focus ring on the OU provides control for focusing the display.

17.3.2 Modes of Operation. There are two programming modes and one operational mode for the HUD

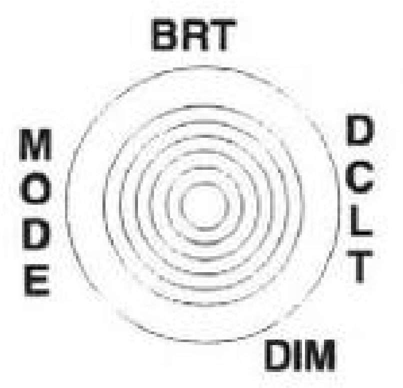


Figure 17-23. HUD Collective Control Switch

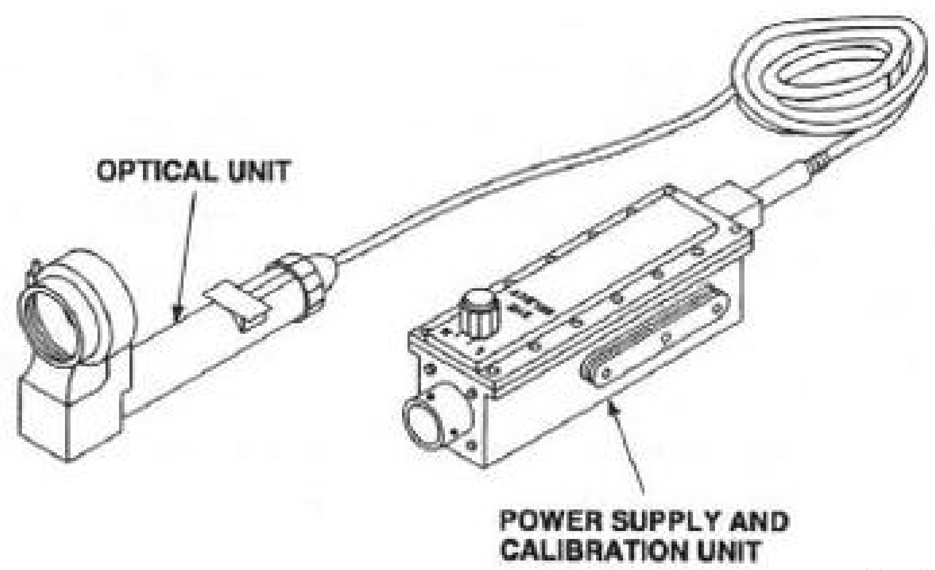


Figure 17-24. HUD Display Unit

system selected by the programming switch on the CCU. The adjust mode is a submode under the operational mode.

1. Pilot programming — switch set to P-PGM.

2. Copilot programming — switch set to CP-PGM.

3. Operation (flight mode) — switch set to OP.

(Adjust - ADJ/ON/OFF switch to ADJ).

17.3.3 Display Modes. Symbology display modes are programmable by the pilot and copilot via the CCU. Modes are defined by selecting from a master symbology set (Figure 17-25), and a navigation symbology set (Figure 17-27). Up to eight display modes, three normal (Figure 17-26), one navigation (Figure 17-28), and four associated declutter display modes can be programmed for each user and can be selected for display using the display mode selection switch on the pilot or copilot collective control or on the CCU. Each display is created by entering the programming mode and deselecting symbols from the master mode symbology. All displays are retained in system memory after power is removed. The default declutter mode has a non-deselectable symbology display of:

HUD System Fail Warning	Symbol 14
Fire Warning	Symbol 15
Master Caution	Symbol 17
Hook Message	Symbol 18
NAV System Fail Warning (Nonfunctional without AFC 471)	Symbol 19
Mode Number/Declutter Marker	Symbol 20
Program/Adjust/OK/Fail	Symbol 21

17.3.4 Starting Procedures

1. ADJ/ON/OFF switch — OFF.

2. Verify optical unit support clamps installed on ANVIS can be rotated.

3. Check DU lens.

Note

Check surface of lens for cleanliness. Clean in accordance with NAVAIR 16-35 HUD-2.

4. Remove ANVIS neck cord.

WARNING

Failure to remove the ANVIS neck cord prior to operation of the HUD may prevent egress from the aircraft in an emergency.

5. Install optical unit on ANVIS goggles. Attach optical unit to either monocular housing. Do not tighten OU clamp completely with thumbscrew at this time. The OU display may have to be rotated to horizon after the system is operating.

Note

The helmet may now have to be rebalanced.

No.	Symbol	Source	Range/Description
1	Aircraft Heading Fix Index	HUD System	Heading reference point.
2	Angle of Roll - Scale	HUD System	±30° (10° units)
3	Angle of Roll - Pointer	AHRS/GPS	±45° (pointer flashes when roll exceeds ±45°)
4	Magnetic Heading - Numeric	AHRS/GPS	000° to 359°
5	Digital Airspeed (KIAS)	Air Data Transducer	40 to 220 knots (no symbol ≤40 knots, reappears at 42 knots)
6	Digital Ground Speed Ind.	CDNU (ARINC 429)	0 to 999 knots
7	Barometric Altitude, Digital	Air Data Transducer	-1000 to +20,000 ft MSL (10 ft units)
8	Velocity Vector	APN-217	±15 knots fore/aft, ±15 knots left/right. (No symbol when ground speed is ≥40 knots, reappears at ≤35 knots.) Nonfunctional without AFC 471.
9	Aircraft Reference	HUD System	In normal modes, symbol is blanked during certain pitch and roll conditions. In declutter mode, symbol always appears.
10	RAD ALT Pointer	Pilot's Radar Altimeter	0 to 500 ft
11	Digital RAD ALT Reading (AGL)	Pilot's Radar Altimeter	0 to 990 ft (0 to 100 ft, 1 ft units; 100 to 990 ft, 10 ft units). The symbol will disappear above 990 ft and reappear at 950 ft. In normal modes, symbol position changes with airspeed. In declutter modes, symbol position will not change.
12	RAD ALT Low Altitude Warning	Pilot's Radar Altimeter	Blinking square around symbol-11, set on pilot's radar indicator. Box will flash five times and remain on as long as the warning is active.
13	RAD ALT Analog Scale	Pilot's Radar Altimeter	0 to 500 ft (0 to 100 ft, 10 ft tic marks; 101 to 500 ft, 300 ft and 500 ft tic marks; blanked at ≥510 ft)
14	ANVIS/HUD System Fail/ Programming Messages	HUD System	CPM, SDR, SDA, PS, PDU, CPDU, PGM, and NAV
15	FIRE	Fire Master Light	FIRE will appear when fire master light is on.
16	Inclinometer/Ball (Trim)	Lateral Accelerometer	2 balls (L/R)
17	Master Caution Messages	Master Caution Light	CAUT will appear when master caution light is on.
18	HOOK	Cargo Hook Control Panel	HOOK will appear when flight mode unsafe light is on.
19	Navigation System Warnings	CDNU (ARINC 429)	GPS or DOP symbols will flash five times and remain on. DOP is nonfunctional without AFC 471

Figure 17-25. HUD Master Mode Symbology Set (Sheet 1 of 2)

No.	Symbol	Source	Range/Description
20	Mode Number/Declutter Marker	HUD System	1 to 3 (normal modes 1 through 3) 4 (navigation mode) 1D to 4D (declutter mode) Appears for five seconds.
21	Program/Adjust/OK/Fail	HUD System	ADJ, PROG, OK, and FAIL
22	Vertical Speed Pointer	Vertical Velocity Ind.	±2000 fpm (pointer flashes when the vertical speed exceeds ±2000 fpm limit)
23	Vertical Speed Scale (VSI)	Vertical Velocity Ind.	±2000 ft/min (±1000 fpm, 500 fpm units)
24	Horizon Line	AHRS	Pitch: ±45° Roll: ±180°
25	Torque - Numeric	Pilot's torque IND.	0 to 160% (0 to 120%, 2% units; 121 to 160%, 1% units)
26	Angle of Pitch - Scale	HUD System	±30° (10° units) (Symbol movement limited to ±45° pitch.)
27	Commanded Ground Speed	CDNU (ARINC 429)	0 to 999 knots
28	Range to Waypoint, Digital	CDNU (ARINC 429)	0 to 4095 nautical miles
29	Bearing to Waypoint, Digital	CDNU (ARINC 429)	0° to 359°
30	Bearing to Waypoint, Pointer	CDNU (ARINC 429)	±65°
31	Compass Reference Scale	HUD System	0° to 359° (10° units)

Figure 17-25. HUD Master Mode Symbology Set (Sheet 2 of 2)

6. EYE SELECT switch on PSCU — L or R.

7. Connect PSCU to quick-release connector by rotating the connector engagement ring.

WARNING

CCU ADJ/ON/OFF switch must be OFF before connecting or disconnecting quick-release connector.

CAUTION

- The AN/AVS-7 system should not be used if the quick-release connector is not in working order.
- Keep the protective caps on the ANVIS goggles whenever it is not in use. Operate the ANVIS system only under darkened conditions.

Note

Ensure ANVIS operator procedures have been completed.

8. P-PGM/OP/CP-PGM switch — OP.

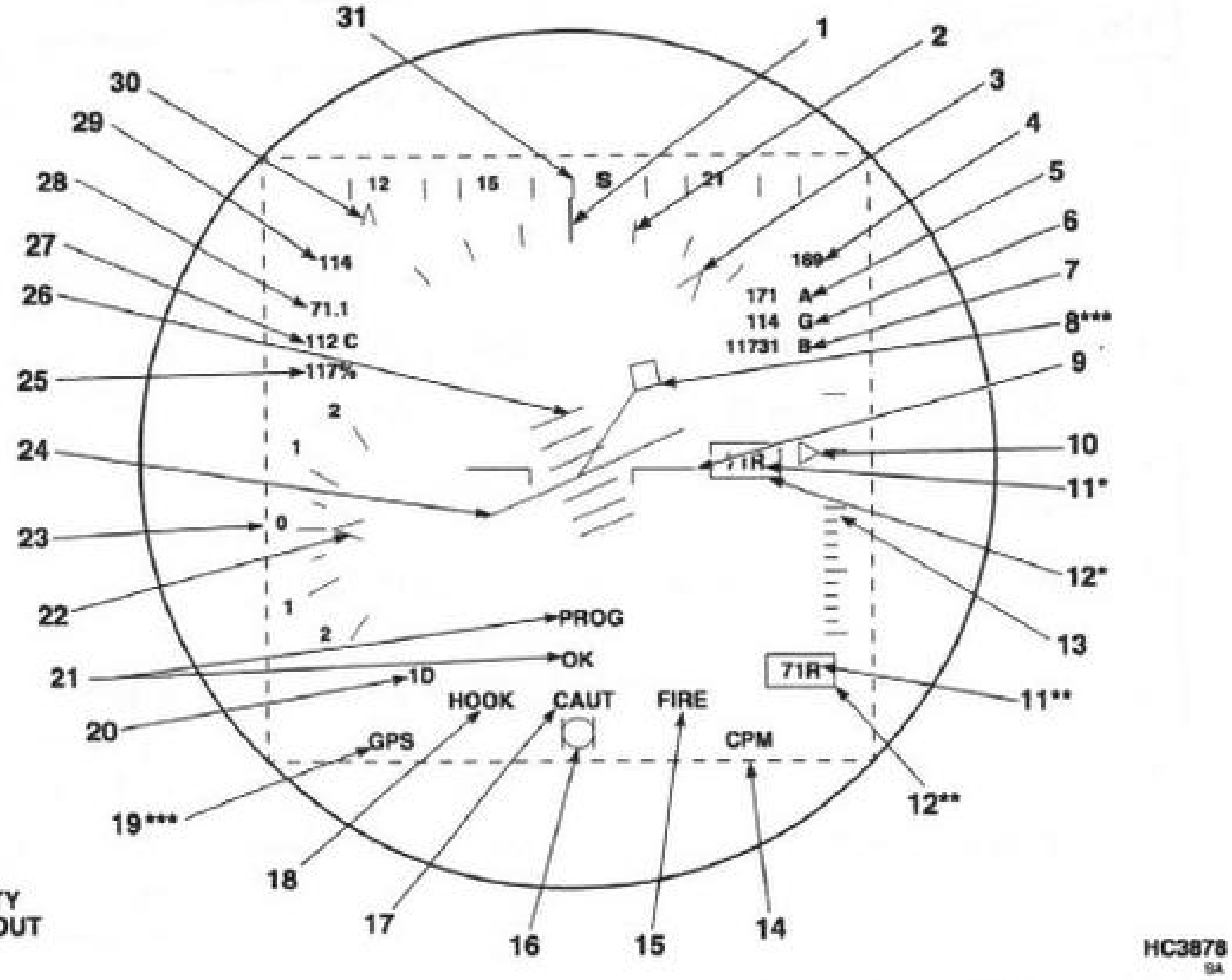
9. ADJ/ON/OFF switch — ON. SYS ON and FAIL lights illuminate and BIT will initiate automatically.

10. Check FAIL light. Light should extinguish after 10 seconds. BIT is complete.

Note

- Allow 1 minute for display warmup.
- Display intensity is preset to low each time ADJ/ON/OFF switch is set from OFF to ON.
- If a fault is displayed in the DU, acknowledge fault and rerun BIT to confirm fault.

11. Set BRT/DIM switch as desired.



NOTE

* AIRSPEED ≤ 60 KNOTS
** AIRSPEED ≥ 65 KNOTS
*** DOP MESSAGE AND DOPPLER VELOCITY VECTOR ARE NON–FUNCTIONAL WITHOUT AFC–471.

Figure 17-26. HUD Master Mode Symbology Display

12. Set DSPL POS control as required. Center display in field of view.

13. Check that the display is aligned to horizon. Tighten OU clamp.

17.3.5 Operator Self Test (BIT)

1. Press BIT/ACK switch to BIT and hold. The ON and FAIL light will illuminate. At end of BIT, FAIL indicator will extinguish.

2. Verify on display unit(s) the symbol generator test mode software for CH-53E (Figure 17-29). (Version number and date will change as software is updated).

3. Release BIT/ACK switch.

17.3.6 Displayed System Faults. The system self-test is divided into powerup or operator-initialized BIT and in-flight BIT. The faults result as warnings and messages that blink at a rate of 2 per second in the Display Units.

Part of the BIT is a periodic test that is performed automatically along with normal system operation. This BIT monitors and/or tests SDC functions and/or signals. A failure of the SDC, NAV signals, pilot's DU, or copilot's DU will illuminate the converter control FAIL light and display a FAIL message PGM, CPM, SDR, SDA, PS, PDU, CPDU, or NAV on the display unit. The PGM message indicates that the operator of the other display is programming his symbol set. The NAV message indicates that the ANVIS/HUD is not receiving data via the ARINC 429 data bus. All of the messages displayed shall flash five times, then remain on for the duration of its appearance. The ACK switch on the Converter Control will reset the symbol with the exception of PGM. The reset symbol(s) will not appear again until either system BIT is run or system power is cycled. This symbol does not appear in the programming mode.

The following helicopter status messages are also displayed:

1. The FIRE symbol will illuminate and blank simultaneously with the illumination and blanking of the aircraft Fire warning light.

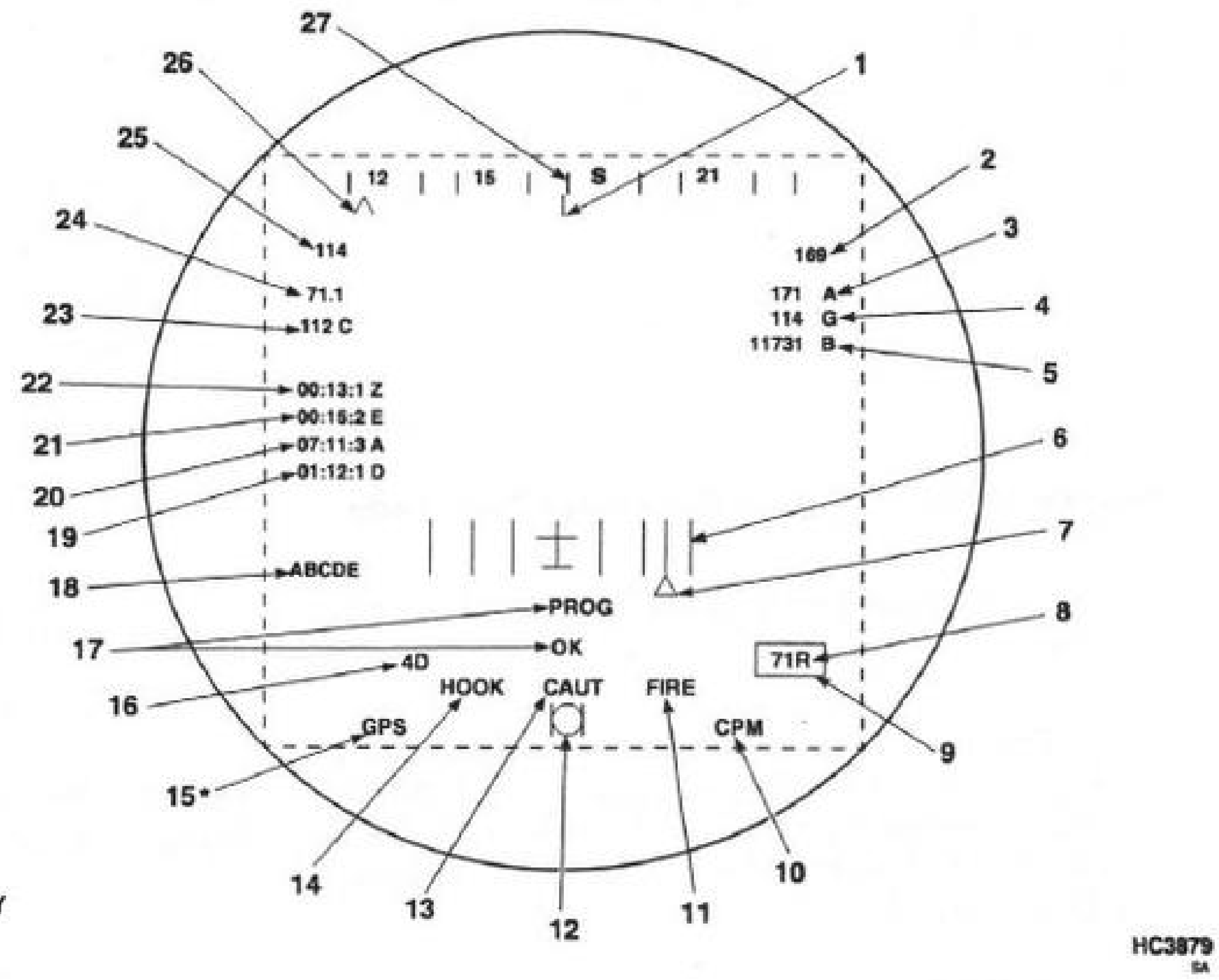
2. The CAUT symbol will appear simultaneously with the illumination of the aircraft's MASTER CAUTION light (when the Master Caution discrete is active). The message disappears once the aircraft's master caution light is reset.

No.	Symbol	Source	Range/Description
1	Aircraft Heading Fix Index	HUD System	Heading reference point.
2	Magnetic Heading - Numeric	AHRS/GPS	000° to 359°
3	Digital Airspeed (KIAS)	Air Data Transducer	40 to 220 knots (no symbol ≤40 knots, reappears at 42 knots)
4	Digital Ground Speed Ind.	CDNU (ARINC 429)	0 to 999 knots
5	Barometric Altitude, Digital	Air Data Transducer	-1000 to +20,000 ft MSL (10 ft units)
6	Horizontal Percent Deviation Scale	HUD System	±150% (±3 dots)
7	Horizontal Percent Deviation Scale Pointer	CDNU (ARINC 429)	-128% to +127%
8	Digital RAD ALT Reading (AGL)	Pilot's Radar Altimeter	0 to 990 ft (0 to 100 ft, 1 ft units; 100 to 990 ft, 10 ft units). The symbol will disappear above 990 ft and reappear at 950 ft.
9	RAD ALT Low Altitude Warning	Pilot's Radar Altimeter	Blinking square around symbol 11, set on pilot's radar indicator. Box will flash five times and remain on as long as the warning is active.
10	ANVIS/HUD System Fail/ Programming Messages	HUD System	CPM, SDR, SDA, PS, PDU, CPDU, PGM, and NAV
11	FIRE	Fire Master Light	FIRE will appear when fire master light is on.
12	Inclinometer/Ball (Trim)	Lateral Accelerometer	2 balls (L/R)
13	Master Caution Messages	Master Caution Light	CAUT appears when master caution light is on.
14	HOOK	Cargo Hook Control Panel	HOOK appears when flight mode unsafe light is on.
15	Navigation System Warnings	CDNU (ARINC 429)	GPS or DOP symbols will flash five times and remain on. DOP is nonfunctional without AFC 471
16	Mode Number/Declutter Marker	HUD System	1 to 3 (normal modes 1 through 3) 4 (navigation mode) 1D to 4D (declutter mode) Appears for five seconds.
17	Program/Adjust/OK/Fail	HUD System	ADJ, PROG, OK, and FAIL
18	Waypoint Identifier	CDNU (ARINC 429)	5 Characters (Waypoint ID #1 from CDNU)
19	Estimated Time of Arrival at Destination	CDNU (ARINC 429)	00:00:0 to 23:59:5 (D)
20	Estimated Time of Arrival (ETA)	CDNU (ARINC 429)	00:00:0 to 23:59:5 (A)
21	Estimated Time Enroute (ETE)	CDNU (ARINC 429)	00:00:0 to 06:39:5 (E)
22	Greenwich Mean Time (GMT)	CDNU (ARINC 429)	00:00:0 to 23:59:5 (Z)

Figure 17-27. HUD Navigation Mode Symbology Set (Sheet 1 of 2)

No.	Symbol	Source	Range/Description
23	Commanded Ground Speed	CDNU (ARINC 429)	0 to 999 knots
24	Range to Waypoint, Digital	CDNU (ARINC 429)	0 to 4095 nautical miles
25	Bearing to Waypoint, Digital	CDNU (ARINC 429)	0° to 359°
26	Bearing to Waypoint, Pointer	CDNU (ARINC 429)	±65°
27	Compass Reference Scale	HUD System	0° to 359° (10° units)

Figure 17-27. HUD Navigation Mode Symbology Set (Sheet 2 of 2)



NOTE

* DOP MESSAGE AND DOPPLER VELOCITY VECTOR ARE NON-FUNCTIONAL WITHOUT AFC–471.

Figure 17-28. HUD Navigation Mode Symbology Display

3. The HOOK symbol will appear simultaneously with the illumination of the Flight Mode Unsafe indication. The message disappears when the cargo hooks are retracted to their stowed position (Closed).

4. In the event that aircraft system navigation data is not valid, warning messages with the priorities listed shall appear (nonfunctional without AFC 471):

   a. GPS — GPS Nav Valid Discrete is not active (logic 0).

   b. DOP — Doppler Invalid Discrete is active. These symbols shall flash five times then remain on for the duration of their appearance. The ACK switch will clear the symbol; it will not appear again until either system reset or power down.

17.3.7 Programming Procedure

1. Select mode to be programmed (1N through 4N). The first mode that will appear is "1N" (Normal Mode 1).

Note

The programming procedure for the pilot and copilot is identical.

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SA

Figure 17-29. Symbol Generator Test Mode

2. P-PGM/OP/CP-PGM switch — P-PGM or CP-PGM.

3. Check for "PROG" blinking in display. Verify that a complete set of symbology is displayed and attitude reference symbol is blinking. Verify "PGM" is displayed in the HUD FAIL message location for the DU not being programmed.

4. BIT/ACK switch to ACK for programming the full display or go to step 5 and select desired symbols.

5. PGM SEL/NXT control to SEL for selecting symbol. Selected symbol stops blinking. If symbol is not desired, toggle switch to NXT and the symbol will disappear.

Note

All symbols have been programmed when "PROG" annunciator is the only symbol flashing.

6. BIT/ACK switch — ACK (Hold for 1 second).

7. Verify "OK" displayed (2 seconds).

Note

If programming is not accepted, "FAIL" will be displayed. At that time, attempt to re-program the same mode if fail reappears notify maintenance personnel.

8. MODE 1-4/DCLT switch — DCLT (1D through 4D). The first DCLT mode that will appear is "1D" (Declutter Mode 1).

Note

- Declutter mode is recognized by the appearance of aircraft reference and angle of pitch scale symbology.
- If MODE 1-4/DCLT switch is toggled to DCLT a second time, the display will cycle back to the DCLT's normal mode (1N-4N). The MODE 1-4/DCLT switch must be set to MODE 1-4 to advance to another mode.

9. Repeat steps 4. through 7. for declutter.

10. Set MODE 1-4/DCLT switch — AS REQUIRED.

11. Repeat steps 4. through 10. until all desired modes are programmed.

12. P-PGM/OP/CP-PGM switch — OP.

17.3.8 Adjustment of Barometric Altitude, Pitch, and Roll

WARNING

An improperly adjusted barometric altimeter will result in an improperly set HUD barometric altitude display.

Note

Barometric altimeter should be set to the most current altimeter settings, field elevation.

1. P-PGM/OP/CP-PGM switch — OP.

2. ADJ/ON/OFF switch — ADJ.

3. Check "ADJ" blinking in display.

4. Set INC/DEC switch — AS REQUIRED.

Note

Changes to barometric altimeter settings will require a corresponding change to the HUD barometric altitude. Each .01 inch change in pressure equals 10 feet.

5. BIT/ACK switch — ACK.

6. Repeat steps 3. through 5. for pitch and roll.

7. ADJ/ON/OFF switch — ON.

17.3.9 In-flight Operation

WARNING

Whenever the symbology displayed in the DU is suspected of being incorrect the pilot/copilot will compare the data with the aircraft instrument indicator and take the appropriate action.

1. Set BRT/DIM switch — AS DESIRED.

WARNING

- Excessive brightness of the symbology display may impair vision outside of the cockpit.
- Interruption of aircraft electrical power will cause DU to default to dim and MODE 1N. Any adjustments made to the barometric altitude, pitch and roll prior to flight will be lost, thereby decreasing the accuracy of the barometric altitude, pitch and roll.

2. Set MODE 1-4/DCLT switch — AS REQUIRED.

Note

Whenever the symbology is interfering with the outside visibility, decluttering may be selected to remove symbology.

17.3.10 System Shutdown Procedure

1. ADJ/ON/OFF switch — OFF.

2. Turn off ANVIS system.

3. Disconnect DU by grasping the PSCU and rotating the quick-release connector engagement ring and pull downward. Remove OU by loosening thumbscrew on OU, then remove from the ANVIS and place into storage case.

WARNING

- CCU ADJ/ON/OFF switch must be OFF before connecting or disconnecting quick-release connector.
- Do not disconnect DU by pulling on the cable connected to the PSCU. The DU could be damaged or the cable may separate from the PSCU creating an explosive atmosphere hazard.
- Do not attempt to egress the aircraft without performing disconnect as this may result in neck injury.

CAUTION

Do not disconnect DU by pulling on cable. To do so may damage the DU

4. Reattach neck cord to ANVIS goggles.

17.3.11 Emergency Egress. The quick-release feature allows you to exit quickly from the aircraft in an emergency without:

1. Damaging or turning the unit off.

2. Getting tangled in cords.

3. Being restrained in the cockpit by hardwired connections.

4. Removing ANVIS goggles.

It is up to the operator to determine the desired mode of disconnect based upon his evaluation of the emergency condition and whether or not the ANVIS goggles will be needed following egress. The available means of disconnect are as follows:

1. Release the ANVIS goggles from the helmet.

2. Disconnect the OU from the ANVIS goggles via the thumbscrew.

3. Grasp PSCU and pull down.

PART VIII

WEAPON SYSTEMS

CHAPTER 18
Armament

18.1 ARMAMENT

The helicopter is provisioned for the installation of gun mounts that will accommodate either an XM-218 (0.50 caliber) or M-60 (7.62 mm) weapon. The gun mount provisions are located so that one weapon may be fired through the escape hatch, on the left forward side of the cabin, and the other through the upper half of the personnel door, on the right forward side of the cabin. See Figure 18.1 for the fields of fire appropriate to each type of weapon. As each weapon has a different field of fire, it must be installed with an associated pintle. The armament equipment consists of gun mounts, machineguns, pintle assemblies, ammunition trays, and bag assemblies. Pip pins are provided to aid quick installation and removal of the gun mounts from mounting brackets. An ICS station is provided for the left gunner while the right gunner uses the ICS at the aircrewman's station. Refer to NAVAIR 01-230HM-75-17, Conventional Weapons Checklist CH-53 Crew Served Guns for preflight procedures; and CH-53 Tactical Manual (Volume I) for employment techniques.

WARNING

Although stops are provided, extreme care must be taken to prevent firing weapons into the tanks, rotor blades, or airframe.

CAUTION

To preclude inadvertent damage to the tail rotor or aircraft fuselage, brass shall not be dropped overboard.

18.1.1 XM-218 0.50-Caliber Aircraft Machinegun. The XM-218 0.50-caliber aircraft machinegun is an air-cooled, recoil-operated, alternate-feed weapon. It provides close-in suppressive fire.

18.1.2 M-60D, 7.62-MM Machinegun. The M-60D is a belt-fed, gas-operated, air-cooled automatic weapon. It may be fired from several different types of mounts or as a shoulder weapon. The Model D, which is flexible-mounted, is used on assault support helicopters.

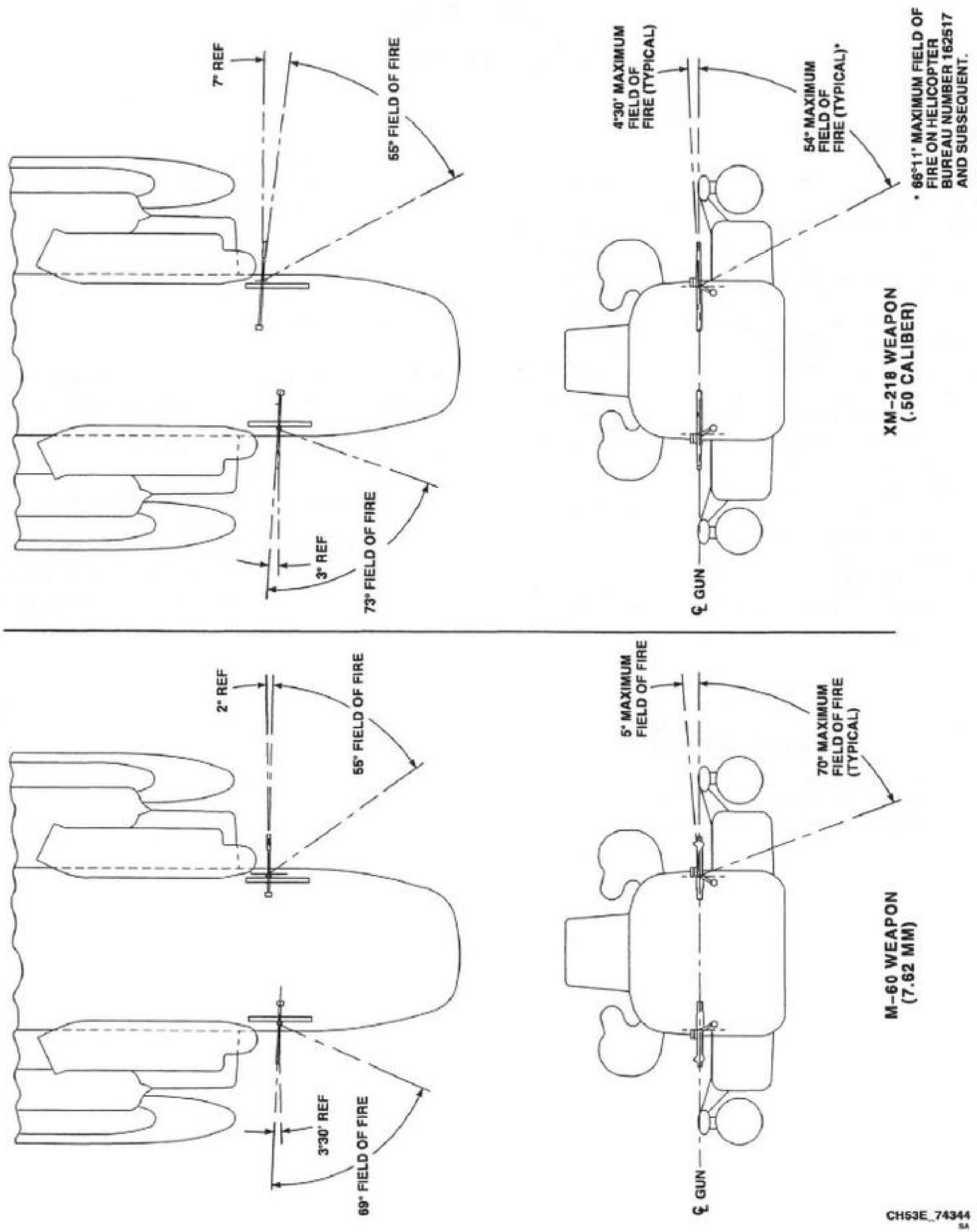


Figure 18-1. Armament Field of Fire

CHAPTER 19
Aircraft Survivability Equipment

19.1 INTRODUCTION

This chapter is an unclassified presentation of CH-53E aircraft survivability equipment systems. The systems include the AN/APR-39(V)1 radar signal detecting set, AN/AAR-47 missile warning system, and AN/ALE-39 countermeasures dispensing set. Refer to the CH53 TACMAN (Volumes I and II) for a complete component description and employment procedures.

19.2 AN/APR-39(V)1 RADAR SIGNAL DETECTING SET

The AN/APR-39(V)1 is a passive, omnidirectional radar warning system that receives and displays information concerning the radar environment about the aircraft. The equipment responds to those radars usually associated with hostile fire-control radars and also accepts missile guidance radar signals. The system provides visual and aural indications of the presence and direction of emitters. Non-threat radars are generally excluded. The equipment consists of the following:

1. Control unit
2. Radar signal indicator (CRT)
3. Comparator
4. Receivers (2)
5. Forward spiral antennas (2)
6. Aft spiral antennas (2)
7. Blade antenna

19.2.1 Controls and Functions. Figure 19-1 illustrates the controls and describes the control functions of the detecting set control unit. Figure 19-2 shows the controls and functions of the radar signal indicator.

19.2.2 Modes of Operation. The equipment may be operated in either the discriminator-off mode (DSCRM OFF) or the discriminator-on mode (DSCRM ON).

WARNING

Display strobe lengths indicate only received signal amplitude. Since many variables can affect the attenuation of the signals, strobe length should not be interpreted as being directly indicative of distance to the emitter.

When operated in the discriminator-off mode, all high-band received signals with an amplitude greater than the predetermined threshold level are displayed on the CRT and an audio signal, representative of the combined amplitudes and pulse repetition frequencies (PRFs), is present at the headset. The displays indicate the total radar environment in which the aircraft is operating. Each radial strobe on the CRT is a line of bearing to an active emitter. When a SAM radar complex becomes a threat to the aircraft (low-band signals correlated with high-band signals), the unique alarm audio is superimposed on the PRF audio signal and the MA lamp and associated strobe start flashing. Lengths of strobes and audio levels depend on the relative strength of the intercepted signals. A typical display when operating in the discriminating-off mode is shown in Figure 19-3.

Note

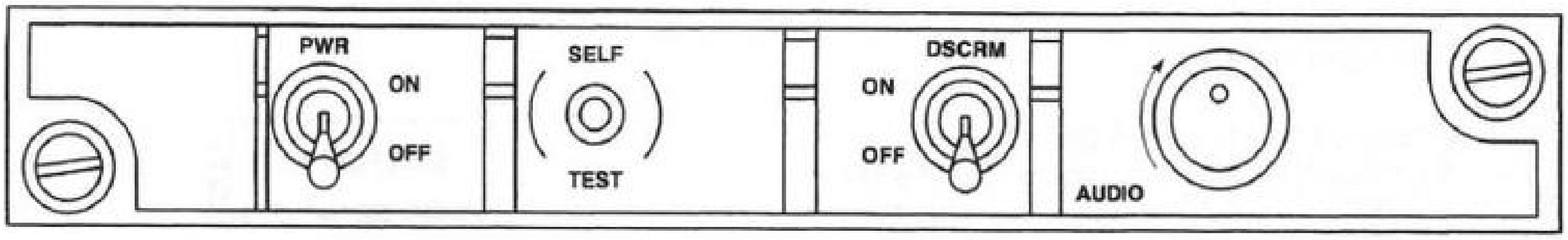
In this mode, received low-band signals which are not correlated with a wide-band intercept will cause the MA lamp to flash and an alarm audio will be present.

When operating in the discriminator-on mode, signals are processed to determine their conformance to certain threat-associated criteria:

1. The signal level must be greater than the minimum threshold level.

2. Pulse width must be less than the maximum pulse width.

3. PRF must be greater than the minimum pulses per second (PPS).



CONTROL NAME	DESCRIPTION	FUNCTION
PWR	TWO-POSITION TOGGLE SWITCH	CONTROLS APPLICATION OF AIRCRAFT +28 VDC TO THE AN / APR-39(V)1. A. ON POSITION APPLIES OPERATING POWER. THE AN / APR-39(V)1 IS FULLY OPERATIONAL 1 MINUTE AFTER SWITCH IS TURNED ON. B. OFF POSITION REMOVES OPERATIONAL POWER FROM AN / APR-39(V)1.
SELF-TEST	PUSHBUTTON SWITCH (SPRING LOADED)	WHEN DEPRESSED, ENERGIZES THE SELF-TEST FUNCTION.
DSCRM	TWO-POSITION TOGGLE SWITCH	SELECTS AN / APR-39(V)1 MODE OF OPERATION. A. ON (FORWARD POSITION) ACTIVATES THE DISCRIMINATOR CIRCUIT. B. OFF (AFT POSITION) DEACTIVATES THE DISCRIMINATOR CIRCUIT.
AUDIO	POTENTIOMETER	CONTROLS THE LEVEL OF THE AUDIO OUTPUT TO THE AIRCRAFT INTERPHONE CONTROL SYSTEM.

CH53E_153001 (R2)
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Figure 19-1. Detecting Set Control Unit

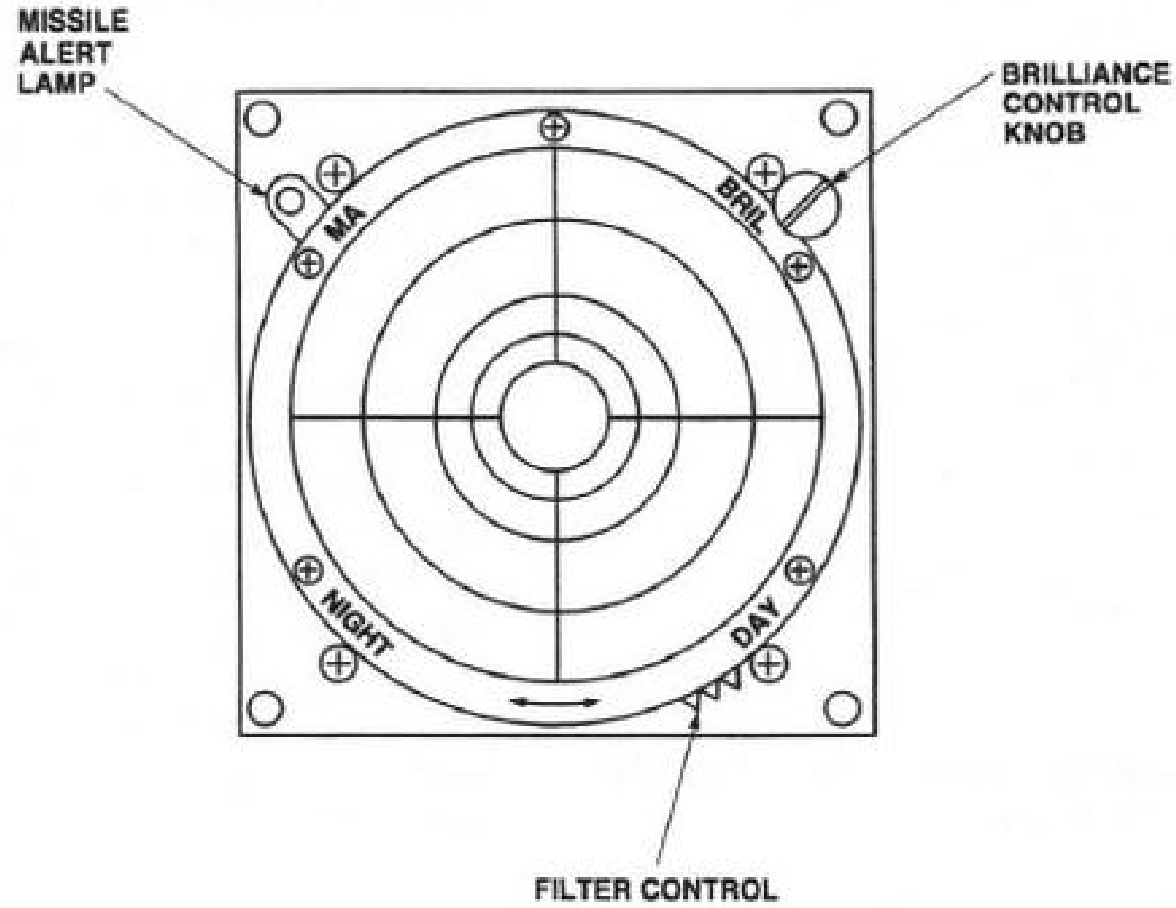
4. The pulse train must exist with not less than minimum pulse train persistence.

The CRT display is divided into eight sectors. Strobes are displayed only in the those sectors in which signals meeting all threat criteria are present. This reduces display clutter by eliminating low-level and wide-pulse-width signals and by selective sector display. Intercepts which meet these requirements are displayed as described in discriminator-off mode operation above.

Note

In this mode, uncorrelated low-band signals will not give any indication.

A typical display when operating in the discriminator-on mode is shown in Figure 19-4 with an assumed threat identified in the 360° to 045° sector only.



CONTROL NAME	DESCRIPTION	FUNCTION
DIRECTION DISPLAY	CRT DISPLAY	SHOWS A LINE-OF-BEARING RADIAL STROBE FOR EACH PROCESSED EMITTER SIGNAL.
MA INDICATOR	LAMP	FLASHES ON AND OFF TO INDICATE TIME CORRELATION BETWEEN THE MISSILE GUIDANCE AND ASSOCIATED TRACKING RADARS (SAM RADAR COMPLEX).
BRIL CONTROL	POTENTIOMETER	VARIES THE BRILLIANCE OF THE CRT DISPLAY. USED IN CONJUCTION WITH THE FILTER CONTROL TO PRODUCE A HIGHLY VISIBLE UNOBSTRUSIVE DISPLAY UNDER MOST LIGHTING CONDITIONS.
FILTER CONTROL		VARIES THE DENSITY OF THE RED POLARIZING FACEPLATE FILTER (PRIMARY FOR DAY OR NIGHT OPERATION).

CH53E_153002 (R2)
SA

Figure 19-2. Radar Signal Indicator

19.2.3 Operation. To operate the AN/APR-39, proceed as follows:

CAUTION

To prevent damage to the receiver detector crystals, ensure that the AN/APR-39 antennas are at least 100 yards from active ground-based or airborne radar antennas. Allow an extra margin for new, unusual, or high-powered emitters.

1. Check that the 28 vdc bus (No. 3 primary dc bus) for AN/APR-39 is energized.

2. Set PWR switch on control unit to ON. Allow a minimum of 30 seconds for warmup.

3. Depress and hold SELF-TEST switch, adjust BRIL and FILTER controls for desired CRT display brilliance and color (maximum red for night). Adjust AUDIO for desired output level, release SELF-TEST switch.

4. Position DSCRM switch in accordance with mission requirements.

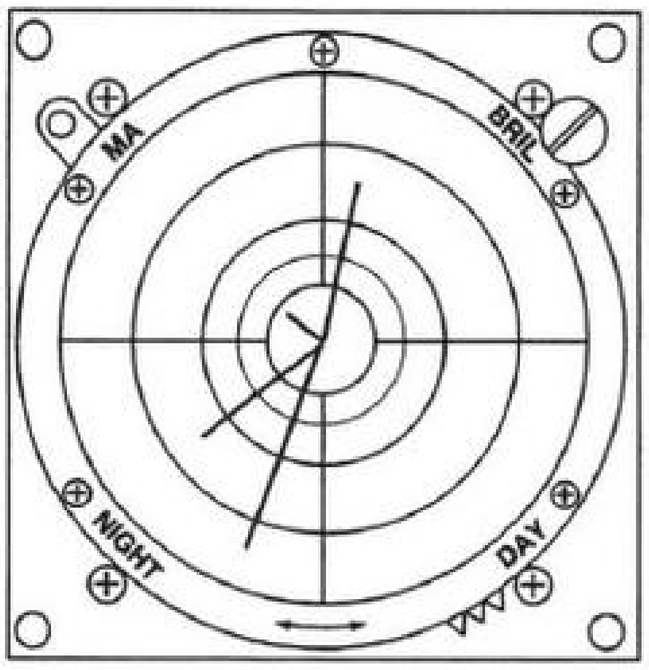


Figure 19-3. Typical Discriminator-off Mode Display

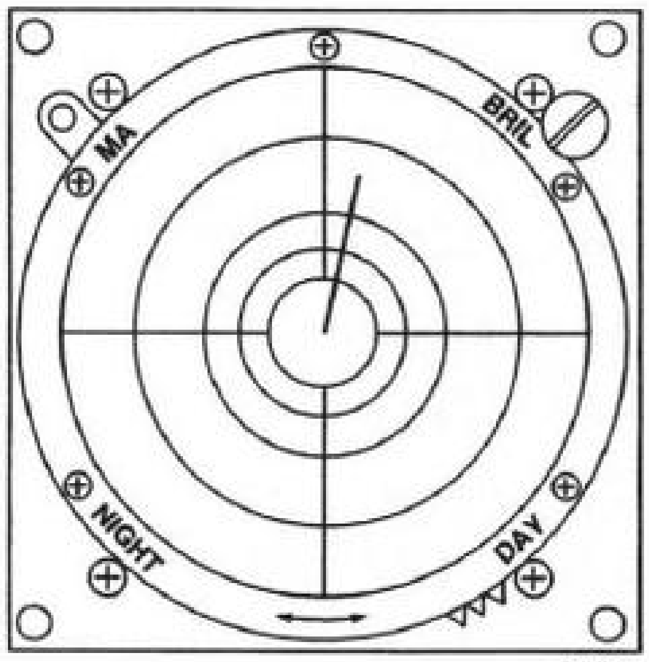


Figure 19-4. Typical Discriminator-on Mode Display

5. Perform self-test as shown in Figure 19-5 when any malfunction is detected.

Note

The self-test confidence procedure checks the AN/APR-39(V)1 circuits except: antennas (units 6 through 10); high-pass filters and detectors in the high-band receivers (units 4 and 5); band-pass filter and detector in the low-band receiver section (unit 3); analysis signal commutator (unit 3); and high- and low-band blanking circuits (unit 3).

19.2.4 Shutdown Procedures. The equipment is shut down by placing the PWR switch in the OFF position.

19.3 AN/AAR-47 MISSILE WARNING SET

19.3.1 Description. The AN/AAR-47 Missile Warning Set (MWS) is a passive electro-optical threat warning system designed to protect the helicopter against surface-to-air and air-to-air missiles. The MWS system detects the exhaust plume radiation emissions that emanate from a missile fired at the helicopter. It discriminates against false targets and those missiles not aimed at the aircraft. Threats will trigger the system to automatically provide an audio and visual sector warning message to the pilot via the control indicator. At the appropriate time, the MWS initiates countermeasures by sending a command signal to the AN/ALE-39 countermeasures dispensing set. Thus, the system operates automatically in an environment that is beyond the capabilities of pilot reaction time for countermeasures deployment. The equipment consists of the following:

1. Computer Processor — The computer processor contains the electronics that perform the data processing and input/output functions of the MWS. The computer processor receives and processes threat signals from the Optical Sensor Convertors (OSCs).

2. Control Indicator(CI) — The CI provides system on/off control, initiates built-in-test (BIT) displays BIT and threat warning indications, and provides audible warning signals to the helicopter crew. Indicator lights are NVG-compatible.

3. Optical Sensor Converters (OSC, 4) — The OSCs sense the exhaust plume radiation emissions of a missile's rocket engine and convert the sensed radiation to equivalent digital pulse signals. These signals are then sent to the computer processor for processing.

WARNING

The optical sensor converters contain a hazardous material (nitrous sulfate) in the inner blue filters. If a sensor is broken, do not pick up the remnants without gloves. The hazardous material will appear in a powdered form.

Note

- The sensors must be cleaned prior to flight to optimize their performance.

(1) Depress and hold SELF TEST.	a. FWD and aft strobes appear, extending to approximately the third circle on the indicator graticule (Figure 15-10), and 2.5 kHz (approximately) PFR audio is present immediately. b. Within approximately 6 seconds, alarm audio present and the MA lamp starts flashing.
(2) Rotate indicator BRIL control cw and ccw.	Indicator strobes brighten (cw) and dim (ccw) as control is rotated. (Set control for desired brightness level.)
(3) Rotate control unit AUDIO control between max ccw and max cw.	Audio not audible at max ccw and clearly audible at max cw.
(4) Release SELF TEST.	All indications cease.
(5) Set DSCRM to ON. Press and hold SELF TEST. **NOTE** Occasionally during the period between pressing SELF TEST and appearance of the first strobe, a distorted dot on the indicator and intermittent audio will be present. This is not a fault indication.	a. Within approximately 4 seconds a fwd or aft strobe (either may appear first) and 1.2 kHz (approximately) PRF audio present. b. Within about 6 seconds the other strobe will appear and PRF audio frequency will double. c. Several seconds later alarm audio present and MA lamp starts flashing.
(6) Release SELF TEST.	All indications cease.

Figure 19-5. AN/APR-39 Self-Test Procedure

- MWS audio tone is similar to the low-altitude warning system tone.

19.3.2 Controls and Functions. Figure 19-6 illustrates the controls and describes the control functions of the control indicator.

19.3.3 Mode of Operation. The AN/AAR-47 MWS operates automatically, requiring no pilot inputs during the mission. Refer to the CH-53 Tactical Manual (Volume II) for specific threat indications.

The MWS provides 360 coverage for the aircraft with coverage divided into four 90 zones. Threats are displayed as being in one of these four zones on the control indicator (CI). The computer processor evaluates the count streams, searching for temporal patterns that signify incoming missiles. If a missile pattern is detected, the computer processor sends a signal to the AN/ALE-39 to commence dispensing, signals the controller to identify the appropriate quadrant, and triggers an audio warning in the pilot's headset.

WARNING

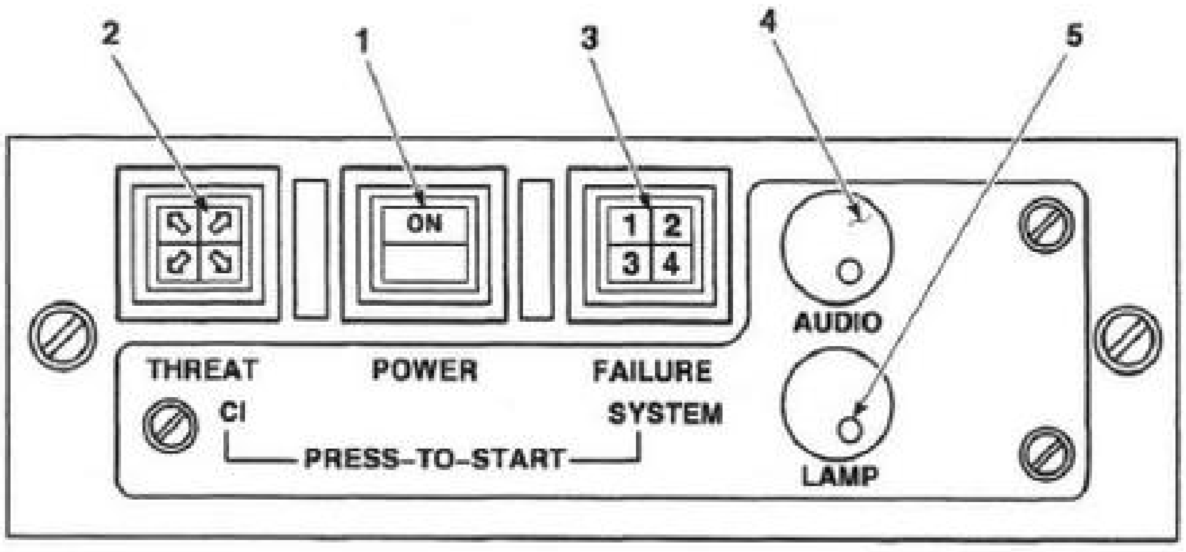
The AN/ALE-39 must have one of the chaff, flare, or jammer modes set to "R" or no flares can be dispensed by the MWS in response to a threat. Threats will still be declared, but manual flare dispensing will be required. The short time to impact will make effective responses extremely unlikely.

19.3.4 Operation

Note

The POWER switch is mechanically latched. It must be depressed completely to actuate.

Press and release the POWER switch (Figure 19-6). The switch remains in a slightly depressed position. The ON indicator illuminates.



NOTE

CONTROL-INDICATOR LIGHTING IS NVG COMPATIBLE.

HC3967

Index	Control/Indicator	Function
1	MWS POWER Control/Indicator (pushbutton)	Turns the MWS on and off.
2	THREAT Indicator/CI Test Switch (pushbutton/lamp)	Divided into four quadrants with arrows that light to display the direction of the threat. It also doubles as a push-to-test switch which activates the CI self-test.
3	BIT FAILURE Indicator/SYSTEM Test Switch (pushbutton/lamp)	Divided into four quadrants with the failure of an individual sensor indicated by the illumination of the corresponding quadrant. A failure of the CP is shown by the simultaneous lighting of all four quadrants. It also doubles as a push-to-test switch which activates system self-test.
4	AUDIO Control (potentiometer)	Sets the loudness of the audio warning.
5	LAMP Control (potentiometer)	Adjusts the illumination of the displays.

Figure 19-6. AN/AAR-47 Control Indicator

Note

The countermeasures dispenser must be loaded, turned on, and properly programmed in accordance with applicable instructions before countermeasures can be dispensed. See CH-53 Tactical Manual (Volumes I and II).

19.3.4.1 Self-Test Procedures. The AN/AAR-47 self-test is designed to check system integrity. With the exception of the sensor converters, all circuits and cables of the system are included in the self-test logic.

WARNING

System self-test should not be performed anytime a missile attack is likely. The test will prevent proper recognition of threat(s) while in progress (5 to 15 seconds).

Details of the self-test procedures are presented in Figure 19-7. If any abnormalities are encountered while conducting the self-test, refer to Figure 19-8 for trouble-shooting procedures.

TEST DESCRIPTION	PROCEDURE/NORMAL INDICATION	REMARKS
1. Continuous BIT	Apply electrical power. Continuous BIT is active whenever MWS is energized. The indicators will flash and aural tone will air.	This tests the Optical Sensor Convertor (OSC), Computer Processor (CP), and Low-Voltage Power Supply. It also checks cables.
2. Initiated BIT a. Control Indicator (CI) Test	Apply electrical power and press CI Press-To-Test (Threat Indicator) button. If all tested components pass, the CI FAILURE and THREAT indicators will illuminate and an aural tone will be aired while button is held and for 2 seconds afterward.	This test checks to see that indicators are working correctly on the CI. It also allows user to adjust the brightness of lights and volume of the aural tone. **NOTE** If there are any abnormal indications encountered during this test, refer to Figure 19-8 for troubleshooting techniques.
b. System Test	Momentarily press SYSTEM Press-to-Test (Failure Indicator) button. If all components pass BIT, the CI FAILURE indicators will illuminate for 5 to 10 seconds. Aural tone will be aired to alert operator that system is back on-line.	This test checks Microprocessor Assembly, Sensor, System Interface Assemblies, OSC, and Main Memory Assembly that make up the CP. It also checks Low-Voltage Power Supply. **NOTE** • If SYSTEM Press to Test is held for longer than 2 seconds, a system failure may occur. • If there are any abnormal indications encountered during this test, refer to Figure 19-8 for troubleshooting techniques.

Figure 19-7. AN/AAR-47 MWS Testing Procedures

19.3.4.2 BIT Operation. The BIT operation of the MWS provides three functions: continuous BIT, which is operative whenever the MWS is ON; control indicator test, which is operator activated; and initiated BIT, which is also operator activated.

19.3.4.2.1 Continuous BIT. The CBIT is active whenever the MWS is energized and constantly monitors system performance, reporting failures on the CI. There are three modes of CBIT: sensor performance monitoring, computer processor performance monitoring, and low-voltage power supply monitoring. The FAILURE/SYSTEM indicator displays the results of CBIT tests. If no failures are detected, there are no indications of CBIT operation. Failures are displayed by illumination of the appropriate lamp for the failed quadrant on the display (or illumination of all quadrant lamps for a computer processor failure).

Pressing the THREAT indicator/CI test switch checks for proper operation of the CI, tests the CI's indicator lamps, allows the operator to adjust audio/lamp levels, and verifies that the CI indicators are working before performing the initiated BIT.

When the switch is pressed and held, power is applied to all indicators on the CI, and an audio warning tone is generated, allowing for adjustment of lamp brightness and audio output volume. A successful test is indicated by all lamps illuminating and an audio tone through the ICS.

FAILURE INDICATION	ACTION
A single Failure Indicator flashing on CI at power up (Continuous BIT).	The sensor in flashing quadrant is suspect. Disconnect power from system and remove sensor. Replace suspect sensor with a known good sensor and reapply power to system. If problem repeats with new sensor installed, disconnect power and verify that wiring is correct using a multimeter.
All four Failure Indicators continue flashing on CI after power up (Continuous BIT).	This indicates a system failure; therefore, the CP is suspect. Reapply power to system to verify that no mistakes were made. If problem persists, check all wiring to verify that it is routed correctly using a multimeter. If the wiring is correct, replace the CP with a known good unit.
No aural tone present on Initiated BIT CI Test.	Increase volume on the CI and reinitiate the test. If problem continues, check wiring to the radio control panel using a multimeter.
No aural tone after completion of Initiated BIT System Test signaling that system is back on-line.	Reinitiate test and watch to see that indicators flash on the CI. If they flash, disconnect power to system and check wiring to radio control panel with a multimeter. If wiring is correct, replace the CP with a known good unit.
No launch indication on the AN/ALM-225 Test Set during Dispenser System Test.	Disconnect power from the AN/AAR-47 system and the AN/ALE-39 system and check wiring between the two systems using a multimeter. If wiring is correct, replace the CP with a known good unit. Reinitiate test. If problem persists, check out of the AN/ALE-39 system.
Failure Indicators fail to illuminate at power up or during test procedure.	Replace lamps in the CI and reinitiate test. If problem persists, replace the CI with a known good unit.

Figure 19-8. Troubleshooting for AN/AAR-47 MWS

The CI test should be performed as a part of preflight and postflight testing of the MWS. It may be performed at any time the MWS is operating. It is wise, but not necessary, to perform the CI test prior to starting the IBIT system self-test. This precaution will prevent a failed indicator segment from being mistaken for a faulty sensor or other misleading indication. Any deviation from the previously stated results indicates an MWS failure.

19.3.4.2.2 Initiated BIT. When IBIT is initiated by pressing the BIT FAILURE indicator/SYSTEM test switch, test signals are provided to illuminate all threat and BIT lamps as well as activate the audio and relay output signals. The signals are maintained 2 to 4 seconds after the switch is released. The face of the BIT FAILURE indicator/SYSTEM test switch (Figure 19-6) is divided into four quadrants, labeled 1 through 4. Each of the labeled quadrants represents one of the four OSCs. A failure of any one of the OSCs will cause the corresponding indicator quadrant to light and remain lit after the switch is released. When all four quadrants of the indicator are lit simultaneously, a failure of the computer processor unit (or an extremely unlikely circumstance of fours simultaneously failed OSCs is indicated. The system may be operated in a degraded coverage mode with one or more failed OSCs.

Note

If the BIT FAILURE indicator/SYSTEM test switch is held in for longer than two seconds, a system failure may occur.

19.3.5 Shutdown Procedure

Note

> The POWER switch is mechanically latched. It must be depressed completely before it will unlatch.

Press and release the POWER switch. The POWER indicator ON lamp extinguishes.

19.4 AN/ALE-39 COUNTERMEASURES DISPENSING

The AN/ALE-39 countermeasures dispensing (AFC 310) provides effective countermeasures against radar-guided weapons systems and/or infrared seeking missile threats. It is a manually initiated, electrically actuated, fully automatic system to dispense a selectable mix of jammers, flares, and chaff. The system consists of a countermeasures dispenser panel, an arming control panel, a dispenser programmer, pilots' and crew initiate switches, two firing sequencers, and two external dispenser pods. The left weight-on-wheels scissors switch disables the system on the ground. The No. 1 primary dc bus circuit breaker panel in the cabin furnishes power and control through two circuit breakers marked PWR-CONT under the general heading CM DISP.

Note

> Complete programming and operating information is found in the CH-53 Tactical Manual (Volumes I and II).

19.4.1 Controls and Functions

19.4.1.1 Countermeasures Dispenser Control Panel (CDCP). The control panel marked ALE-39 is on the cockpit console (Figure 19-9). The salvo/power switch marked SALVO FLARE-ON-OFF is one of two switches used to arm the system. OFF removes power from the cockpit control, the programmer, and disables the arming relay. ON activates cockpit control, the programmer, and the arming relay. SALVO FLARE energizes a circuit which rapidly dispenses all countermeasures in case of emergency. To place the switch in SALVO FLARE the lever lock of the switch is pulled out and lifted up. Above the heading LOAD REMAIN are three subtractive counters and rotary selector switches marked CHF, FLR, and JMR. The counters indicate the available payloads of chaff, flares, and jammers remaining in the dispenser pods. Below the heading MODE are three release option windows and rotary pushbuttons marked CHF, FLR, and JMR. The pushbuttons select release options for chaff, flares, and jammers shown in the mode windows, which will be released from the dispenser pods.

19.4.1.2 Arming Control Panel. The arming panel marked DISP is on the cockpit console (Figure 19-10, FO-8). The ARM-SAFE is a lever lock switch, normally in SAFE, which is pulled out and lifted up to ARM. It is the second of two switches used to arm the system. Two amber DIM-PUSH indicator lamps go on when the system is armed. The indicator lamps show ARM for the respective left and right dispenser pod. Pressing the light switch will alternately turn it dim and bright. The LAMP TEST switch, when pressed, will test the ARM lamps.

19.4.1.3 Initiate Switch (Pilots')

WARNING

> The initiate switches are momentary switches which must be released to enable the system to initiate a new operation.

A four-way toggle switch marked ECM for manual firing of the countermeasures is on each pilot's collective pitch grip (Figure 2-25 and FO-8). The switch, controlled with the pilot's thumb, has marked positions CHF-FLR-JMR-MIX for dispensing chaff, flares, jammers, or a mixture of cartridges depending on programmer setting.

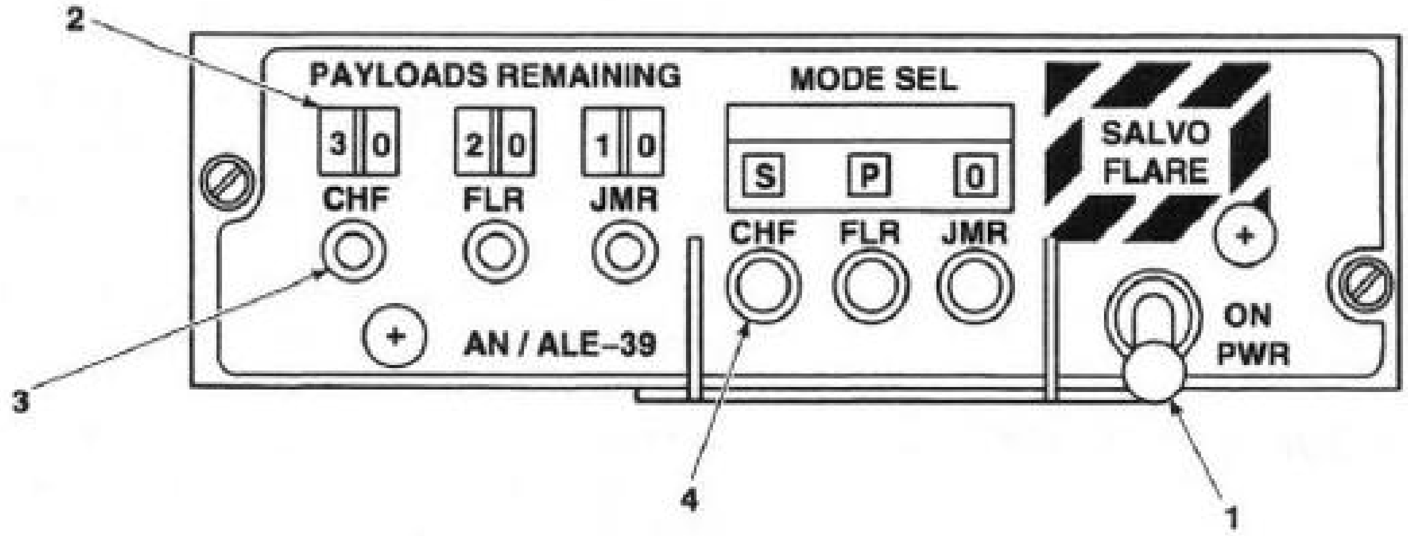
19.4.1.4 Initiate Switch (Crew)

WARNING

> The initiate switches are momentary switches which must be released to enable the system to initiate a new operation.

Two momentary contact press type initiate switches marked CM DISP are in the cabin. One is at the hoist station and one is at the port ramp station. Each is lit when the system is armed, and has the same function as the pilot's initiate switch MIX position.

19.4.1.5 Programmer. The programmer (Figure 19-11) marked AN/ALE 39 is installed above the left cabin circuit breaker panel. Programmed dispensing routines can be set in the indicator windows with 2 rows of 7 thumbwheel switches. QTY (quantity) and INTV (interval) can be set for CHAFF, JAMMER, and FLARE dispensing.

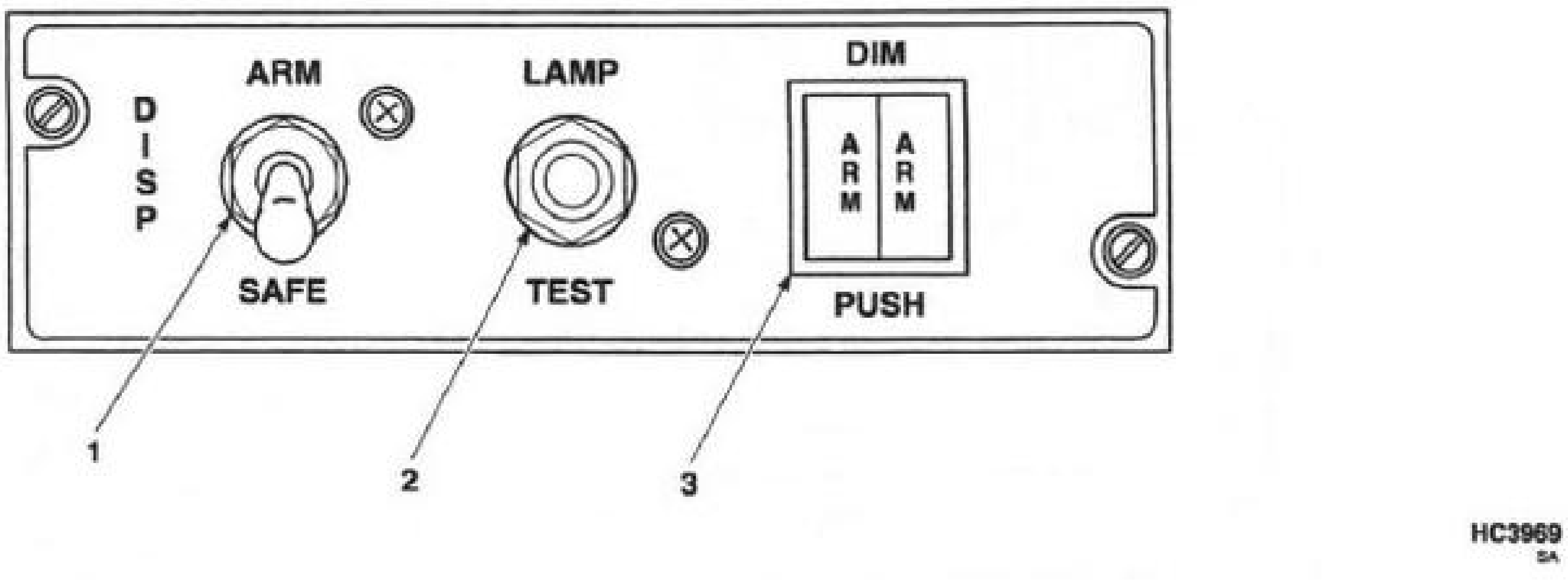


Index	Control Name	Function
1	Power Switch (3-position lever lock toggle switch)	OFF — Power off to ALE-39 ON — Activates ALE-39 SALVO FLARE — Fire all flares in dispensers
2	Counters	Indicates number of expendables, by type, remaining in dispensers. CHF — chaff FLR — flare JMR — jammer
3	Payload Reset	Sets quantity of each type of expendable loaded.
4	Mode Select switches (one for each countermeasure)	O — Disables specified countermeasure S — Single, one countermeasure per actuation of dispenser switch P — Program initiates program sequences as per programmer R — RWR, series of payloads will be dispensed under control of the radar warning receiver, if installed M — Multiple burst of 2, 3, or 4 flares in parallel, depending on the number of dispense sections containing flares G — Programmed sequence, in parallel for each F-designated subsection

Figure 19-9. AN/ALE-39 Countermeasures Dispenser Control Panel

The type LOAD can be set as C, F, or J for left and right pod payload sections (L10, L20, R10, R20). The programmer accepts encoded command signals from the CDCP, decodes the commands, and provides the two sequencer switches in the dispenser pods stepping pulses for dispensing countermeasure payloads. Lifting the reset switch and placing it in the direction of the arrow for at least 5 seconds will clear all settings in the programmer and cancel the program.

19.4.1.6 External Dispensers. A detachable pod is externally mounted on each side of the aft cabin ahead



Nomenclature		Function
1	ARM/SAFE switch (toggle switch)	Allows system to fire only when set to ARM. Prevents unintentional firing when set to SAFE.
2	LAMP TEST (pushbutton switch)	Push to test lights of ARM indicators.
3	ARM indicators	When lit, indicates system can be fired; push to change brightness level.

Figure 19-10. Arming Control Panel

of the cargo ramp hinge points. Each pod contains an ALE-29 dispenser module, ALE-29 dispenser housing, and ALE-39 sequencer switch. Each module has 30 discharge tubes electrically partitioned into payload sections of 10 and 20. The pods face 5° above the horizontal plane and 10° aft of the helicopter beam. The sequencer switches transfer the initiator signal from the programmer to the dispenser to cause the desired payload to be discharged. A lever-operated SAFE-ARM safety switch and a safing pin insert are contained on each pod. A protective cover is provided for installation when the pod is installed but not in use. The pod is bracket-mounted for quick installation and removal. The sequencer electrically disconnects at the aircraft skin and a dust cap is to be installed when the pod is removed.

19.4.1.7 Countermeasures Override Switch. The switch, above the programmer, marked OFF and O RIDE is normally OFF. Placed in O RIDE allows bypass of the weight-on-wheels switch to enable arming the system on the ground for maintenance.

19.4.2 Modes of Operation. The AN/ALE-39 system has the capability of dispensing up to 60 chaff, flare, or jammer expendables. Expendables may be all one type or a combination of types, but all expendables loaded in each dispenser subsection are designated as one type. All types of expendables can be dispensed in either manual or programmed mode, independently or concurrently. The dispensing function can be initiated by any INITIATE switch or by the missile warning system.

Dispensing programs for chaff, flare, and jammers are set in the programmer. In flight, the programmer generates control signals for programmed dispensing of expendables in preset sequences or single dispensing of expendables initiated manually. The flexibility of the programmer allows the chaff, flare, and jammer programs to proceed independently or concurrently and also allows the single dispensing mode to be selected.

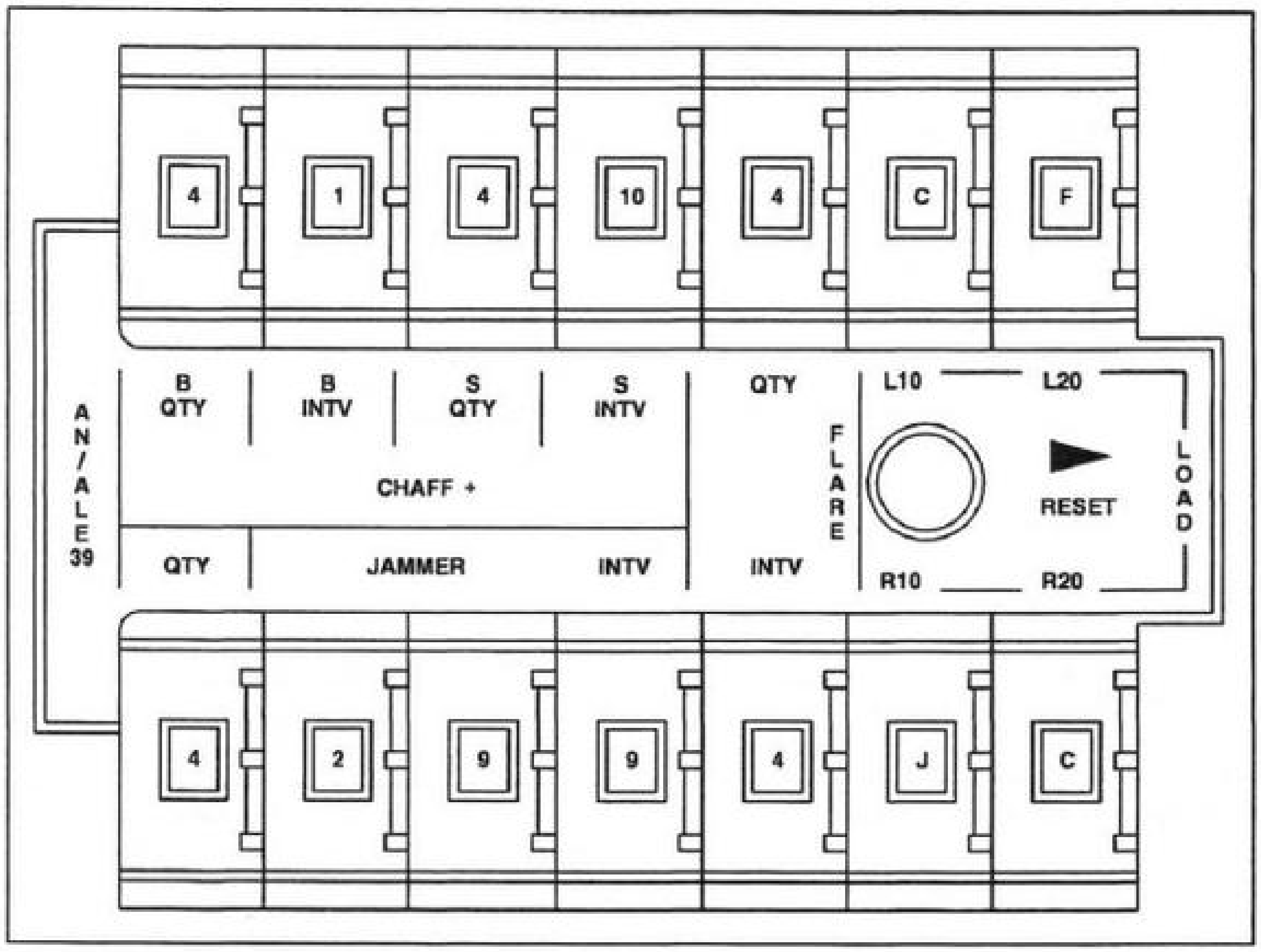


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Figure 19-11. AN/ALE-39 Programmer Control

Equipped with a suitable MWS, the CDCP offers automatic dispensing in which the MWS and AN/ALE-39 programmer are linked. Dispensing of the required expendables is determined by the program set in the CDCP and requires minimum pilot attention.

The CDCP is normally set for the desired mode of operation for each expendable type at the beginning of the mission. The desired mode of operation is set by individual CHF (chaff), FLR (flare), and JMR (jammer) MODE switches on the CDCP.

19.4.3 Operation

1. Ensure that the dispensers are loaded with the appropriate expendables in the correct sequence.

2. Ensure that the threat-appropriate program has been set in the programmer.

3. Ensure that the correct modes and payloads have been set in the CDCP.

4. Check that the CM DISP PWR-CONT circuit breaker on the No. 1 primary dc bus is in.

5. Place the PWR switch on the CDCP to ON.

6. Depress the lamp test pushbutton on the arming control panel. Ensure both arm indicators illuminate.

7. Have aircrewman arm the dispensers by placing the dispenser safety handles to ARM.

8. Launch aircraft.

9. Place the DISP switch on the arming control panel to ARM and ensure both ARM indicator lights illuminate.

Note

System arming will not occur if the helicopter is on the deck. The main landing gear weight-on-wheels switch disables the system.

10. Expendables using any of the initiate switches when equipped with a powered and operable MWS, the system will automatically dispense expendables.

WARNING

The AN/ALE-39 must have one of the chaff, flare, or jammer modes set to "2" or no expendables can be dispensed by the MWS in response to a threat.

11. Placing the CDCP PWR switch to SALVO will dispense all expendables designated as flares.

19.4.4 Shutdown Procedures

1. Place DISP switch on the arming control panel to SAFE. Ensure both arm indicator lights extinguish.

2. Place PWR switch on CDCP to OFF.

3. Once on deck, have aircrewman safe the dispensers by placing the dispenser safety handles to SAFE.

PART IX

FLIGHT CREW COORDINATION

CHAPTER 20
Flight Crew Coordination

20.1 INTRODUCTION

This chapter covers the responsibilities and duties of each crewmember. If a crewmember assumes another crewmember's duties, he will be responsible for accomplishing these duties. All crewmembers are responsible in aiding the helicopter aircraft commander (HAC) to ensure safe conduct of the flight.

The duties of the pilot/aircrew are necessarily integrated; however, the ultimate responsibility for safety of flight and mission accomplishment rests with the HAC. The HAC shall constantly monitor total aircrew performance to ensure that all flight operations are conducted in the most professional manner possible. To ensure the cooperation, initiative, and coordination during system malfunction, emergencies, and unfamiliar circumstances, strict adherence to regulations, aircrew briefs, and clear, concise, open communications between aircrew are imperative. There are a number of elements that affect every aircrewman's level of situational awareness. These include physical flying skills, experience and training, spatial orientation, health and attitude, and cockpit management skills. Situational awareness is the responsibility of the entire aircrew.

The contents of this chapter are not designed to be used as an in-flight checklist but should be used as a basis for squadron and unit ground training syllabuses. So used, this chapter will enhance the successful and safe completion of each unit's mission through intelligent and proper compliance with all NATOPS procedures and other applicable directives.

20.2 AIRCREW POSITION DESCRIPTIONS/ GENERAL RESPONSIBILITIES

20.2.1 Helicopter Aircraft Commander. The HAC is responsible for the safe and orderly conduct of the flight as delineated in OPNAVINST 3710.7. This responsibility exists from commencement of preflight planning until the flight is completed and/or when he is relieved from duty by proper authority.

The HAC is responsible for ensuring that the helicopter and equipment are thoroughly inspected in sufficient time prior to departure to permit the correction of any discrepancies without delaying the scheduled takeoff. However, the HAC has the authority to delay or discontinue a flight when, in the HAC's opinion, conditions are unsafe for starting or continuing the flight. The HAC is further responsible for determining that the gross weight and center of gravity are within prescribed limits. The HAC must know each crewmember's duties and related responsibilities. The HAC is responsible for thoroughly briefing the crew on all mission particulars, ensuring that passengers have been briefed on the operational use of emergency equipment, and are familiar with warning signals and emergency procedures. The HAC is also responsible for ensuring that required flight logs, records, and maintenance forms are properly documented. The HAC will be thoroughly familiar with this manual and all other pertinent directives. At the discretion of the HAC, the aircrew duties and responsibilities outlined in the following paragraphs may be reassigned as appropriate within the crew.

20.2.2 Copilot. The copilot is second in command and responsible for assisting the HAC's duty performance and should be prepared to assume those responsibilities that will ensure the safe accomplishment of the mission.

The copilot may control the aircraft as Pilot At Controls (PAC) in any phase/mode of flight, at the HAC's discretion, provided the individual is qualified for such flight in accordance with this manual and other directives.

In the event of disability of the HAC during flight, the copilot shall take command of the aircraft and assume the authority, duties, and responsibilities of the HAC to the next enroute station or to a closer alternate, as the situation warrants.

He shall perform such duties as briefed by the HAC and communicate any abnormalities.

20.2.3 Aircrewman. The aircrewman is the HAC's extension of authority in the cabin section. The aircrewman performs essential functions as an integral member of the helicopter crew. He shall perform such duties as briefed by the HAC and communicate any abnormalities. His presence in the cabin compartment is required on all flights regardless of the mission. The aircrewman shall carry out the HAC's instructions and is responsible for supervision of the safe, orderly embarkation/debarkation of all passengers, their conduct in flight, the loading/unloading of all internal cargo and baggage, and monitoring the hookup, lift, and delivery of all externally transported cargo.

The aircrewman shall maintain a constant communication link (ICS or visual) with the cockpit and cabin during flight operations. The aircrewman may detect system failures before the pilot does and must inform the HAC of potential malfunctions before the condition becomes serious. He may effect minor repairs while airborne. He supervises any additional crewmembers which the mission may require.

The aircrewman shall directly supervise the operation of any aircraft system activated from the cabin. The aircrewman should maintain constant situational awareness, monitor flight maneuvers as practical, and when, in the individual's opinion, the flight is bordering on unsafe conditions, advise the HAC and copilot.

20.2.4 Assistant Aircrewman. The assistant aircrewman shall perform cabin duties as directed by the HAC and aircrewman. He will assist in cabin activities that include systems activation, internal/external cargo loading/unloading, and passenger embarkation/ debarkation. The assistant aircrewman shall maintain ICS contact with the cockpit whenever the aircrewman is not connected to the ICS and advise the rest of the aircrew of any suspected discrepancy.

The assistant aircrewman should maintain situational awareness, monitor flight maneuvers as practical, and when, in the individual's opinion, the flight is bordering on unsafe conditions, advise the rest of the aircrew.

20.2.5 Aerial Gunner. The aerial gunner duties primarily consist of maintenance and operation of installed crew-served weapon systems. When directed, the aerial gunner may perform other cabin duties, under the direct supervision of the aircrewman, to facilitate mission accomplishment or ensure safety of flight.

20.3 SPECIFIC RESPONSIBILITIES

20.3.1 Flight/Mission Planning

20.3.1.1 HAC. Flight/mission planning is the ultimate responsibility of the HAC and shall cover all matters pertinent to the flight/mission to be flown. The planning should be conducted before the flight commences and should be in such details as to allow a complete understanding of the mission. The HAC should give specific instructions, where necessary, to cover any special situation that may occur. At a minimum this should include:

1. Threat analysis
2. Weather evaluation
3. Mission equipment requirements
4. Aircraft performance
5. Aircraft limitations
6. Weight and balance computations
7. Fuel planning
8. Flight crew composition and qualifications.

Pertinent publications, charts, and manuals should be reviewed as required.

20.3.1.2 Copilot. The copilot shall be actively involved in flight/mission planning. He shall prepare a power computation form for anticipated aircraft configurations and ambient conditions to be encountered during the flight. He prepares a detailed navigation plan based on the latest weather and intelligence information and ensuring equipment such as maps, charts, flight publications, and fuel packets needed for the missions are aboard the aircraft. The copilot shall also inform the HAC of any training or qualification deficiencies which could adversely affect mission accomplishment or planning.

20.3.1.3 Aircrewman. The aircrewman shall coordinate installation of mission equipment and verify aircraft fuel loading and cg requirements.

20.3.1.4 Aerial Gunner. The aerial gunner shall coordinate installation of required weapon systems and ammunition.

20.3.2 Flight Crew/Ground Crew Briefing

20.3.2.1 HAC. The HAC has the responsibility to brief all flight crewmembers on the flight/mission in accordance with Part III of this manual and applicable directives.

The briefing of the copilot and other flight crew may be separate; however, the HAC shall ensure that all crewmembers have a clear understanding of the mission, their duties, and integrated functioning. Aircraft communication/ signals must be clearly understood by the entire flight crew to ensure timely transfer and assimilation of accurate information.

The HAC shall ensure briefings with ground crew/support personnel and passengers are conducted as the mission requires. These briefings should emphasize communications, command and control, safety, and emergency procedures. If confusion is apparent, the mission/flight shall be delayed/aborted until an adequate briefing can be effected.

20.3.2.2 Copilot/Aircrewman/Aerial Gunner. Aircrewmembers are responsible to query the HAC on any matter or crew duty not clearly understood during the briefing. The following list includes the items to be discussed during the crew briefing:

1. Mission
2. Flight plan
3. Fuel load
4. Emergency/survival equipment (Part V)
5. Enroute weather
6. Special equipment
7. Personnel equipment (i.e., protective head gear and/or flotation devices)
8. Loading
9. Duties and responsibilities of crewmembers.

20.3.3 Preflight

20.3.3.1 HAC. The HAC shall ensure that a thorough preflight is conducted and will be present to supervise the preflight except as authorized to deviate from local directives.

20.3.3.2 Copilot/Aircrewmen. These crewmembers shall assist in performance of the preflight. Additionally, the aircrewman shall:

1. Perform a thorough preflight inspection of the helicopter and complete the necessary forms.
2. Correct any minor discrepancies found.
3. Ensure that the area around the helicopter is clear of FOD to the maximum extent practical.
4. Secure all needed items in the helicopter and remove all unnecessary loose gear.
5. Ensure that any special equipment required by the mission is aboard the helicopter.
6. Ensure that the portable fire extinguisher, life preservers, and first aid kits are inspected, serviced, and properly sealed.
7. Ensure that all helicopter lights are in operating condition prior to a night flight.
8. Accompany and assist the pilot in his preflight inspection. He will review with the pilot in command the limitations on the aircraft.
9. Ensure that all aircraft windows are clean.
10. Adjust all safety belts to maximum length.
11. Ensure that all drain plugs are in place before overwater flights.

20.3.3.3 Aerial Gunner. The aerial gunner shall ensure the proper stowage, installation, and functioning of assigned crew-served weapon systems.

20.3.4 Prestart/Start/Pretaxi

20.3.4.1 HAC. The HAC shall ensure prestart, start, pretaxi procedures contained in Part III of this manual are completed utilizing the NATOPS pocket checklist.

20.3.4.2 Pilot Not At Controls (PNAC). The PNAC shall assist the Pilot At Controls (PAC) in a challenge/response execution of all prestart, start, and pretaxi checklists.

20.3.4.3 Aircrewman. The aircrewman shall:

1. Remain connected to the ICS system and position himself so he can observe the aircraft, the rotor head, the tail pylon, and the HAC.
2. Ensure a fire guard is posted prior to and during APP starting.
3. Clear the area prior to blade/pylon movement, including control checks.
4. Observe the blade and pylon spread/fold sequence and notify the HAC of any irregularities or malfunctions as they occur.
5. Supervise internal cargo loading of the aircraft.

6. Ensure passengers are briefed IAW PASSENGER BRIEFING GUIDE in the AIRCREW POCKET CHECKLIST.

7. Ensure required safety/protective equipment is properly fitted and donned by embarked passengers and aircrew.

8. Ensure all gear is properly stowed/secured in the cabin and passenger seatbelts fastened prior to taxi.

9. During engine start/rotor engagement the aircrewman shall:

   a. Ensure that a qualified fire guard is posted during engine starts.

   b. Maintain a listening watch on the ICS and communicate as required.

WARNING

The fireguard shall remain clear of the plane of rotation of the compressor and turbine area at all times and shall wear proper safety equipment.

   c. Act as lookout to ensure that the area around the helicopter is clear and that no unauthorized personnel are under the rotor disc during engagement and runup.

   d. Notify the pilot in command of any irregularities during engine start and rotor engagement.

10. Advise the HAC of the number of passengers embarked and the amount of cargo aboard prior to taxi.

11. Ensure Pretaxi Checklist is completed.

20.3.4.4 Assistant Aircrewman. Assist as directed by the HAC and aircrewman.

20.3.5 Taxi

20.3.5.1 HAC. The HAC shall ensure completion of the Taxi Checklist in Part III of this manual. The HAC is responsible for the safe movement of the aircraft whether physically at the controls or not. During periods of impaired visibility or when adequate ground taxi markings are not available, ground taxi direction shall be utilized.

20.3.5.2 PNAC. The PNAC shall assist in aircraft clearance and advise the PAC of any obstacles noted. The PNAC shall monitor appropriate radio frequencies and advise the PAC of any taxi amendments/traffic not acknowledged.

20.3.5.3 Aircrewman. The aircrewman shall perform such duties as directed. Assist in aircraft clearance, and advise the HAC of any obstacles. The aircrewman shall check cabin integrity and make a positive statement to the HAC reporting the following:

1. All passenger safety belts are fastened.

2. Cabin occupants and/or embarked cargo are ready for taxi/takeoff.

20.3.5.4 Assistant Aircrewman/Aerial Gunner. The aircrew shall assist in aircraft clearance and advise the HAC of any obstacles noted. When required, they may assist in taxi directing.

WARNING

When the aircrewman is not in his seat with his seatbelt on, he shall be secured with an aircrewman safety harness until the completion of the flight. When necessary activities require movement in the cabin, the aircrewman may move from station to station using the aircrewman safety harness. When the single-point external hatch is open, all aircrew shall remain attached to the helicopter with the approved safety belt. If movement is required, it shall only be conducted while on the deck or in a low hover.

20.3.6 Pretakeoff/Takeoff/Climbout

20.3.6.1 HAC. The HAC shall ensure that the NATOPS pretakeoff checklists are completed prior to takeoff. The HAC shall assign responsibility to monitor and advise on rotor performance, engine performance, caution panel, climb rate, altitude, attitude, airspeed, and obstacle clearance as required. Additionally, he shall ensure that cockpit task priorities are established prior to becoming airborne.

20.3.6.2 PNAC. The PNAC shall assist the PAC with the takeoff/climbout.

20.3.6.3 Aircrewman. The aircrewman shall inform the pilot of any obstacles and/or other aircraft that are potential hazards and advise the HAC of any discrepancies.

20.3.6.4 Assistant Aircrewman/Aerial Gunner. The assistant aircrewman and aerial gunner shall assist in providing obstacle clearance information.

20.3.7 Instrument Takeoff/Instrument Climb/Departure

20.3.7.1 HAC. Prior to takeoff the HAC shall ensure:

WARNING

The HNVS system provides for increased situational awareness for the PAC. The FLIR image and symbology shall not be used exclusive of other flight instruments.

1. Spatial disorientation, attitude, airspeed, bank, and altitude limitations have been reviewed as required.

2. The Instrument Flight Checklist has been completed.

3. Appropriate publications are available.

4. Clearance/departure instructions reviewed by cockpit aircrew.

Specific cockpit crew responsibilities for the pilot at the controls and the pilot not at the controls regarding flight parameters, communication, navigation, and other cockpit duties not directly affecting physical control of the aircraft shall be performed as briefed. In addition, approach procedures for the primary instrument approach at the departure field shall be reviewed to facilitate a return in the event of an emergency during takeoff or departure. The pilot at the controls shall advise the copilot should symptoms of spatial disorientation be experienced.

20.3.7.2 PNAC. The PNAC shall monitor aircraft performance, advise the PAC of any discrepancies, and inform the PAC, when briefed, when attitude, airspeed, angle of bank, or altitude limitations are approached. He shall be prepared to take control of the aircraft if the PAC requests assistance because of spatial disorientation or if a loss of control appears imminent. The PNAC shall advise the PAC should symptoms of spatial disorientation be experienced. To avoid spatial disorientation, the PNAC shall advise the PAC when the FLIR system is initiated.

WARNING

The observer seat shall not be occupied during takeoff or landing.

20.3.8 En Route

20.3.8.1 HAC. The HAC assigns responsibility for and ensures periodic monitoring of performance instruments, caution and advisory panels, and fuel management panel. He ensures a lookout is maintained and periodically confers with the aircrewman to ascertain cabin conditions.

20.3.8.2 Aircrewman. The aircrewman shall:

1. Be responsible to the HAC for the condition and conduct of operations in the cabin compartment.

2. At all times, especially during night and simulated instrument flight, maintain a lookout for other aircraft.

3. Ensure that passengers remain in their seats with their safety belts fastened unless directed otherwise by the HAC.

4. Alert HAC to unusual conditions or potentially hazardous situations.

5. Enforce smoking regulations.

6. Ensure security of internal cargo.

7. Maintain ICS contact with cockpit. Notify the HAC if his duties require him to break ICS contact.

8. Transfer internal fuel as briefed by the HAC.

9. Assist in monitoring aircraft performance instruments.

20.3.9 Missions

20.3.9.1 HAC. The HAC ensures the assigned mission is executed as briefed and in accordance with the procedures established in Parts III and VI of this manual. If the mission requirements deviate from original planning so as to require excessive replanning and briefing or exceed the capabilities of the aircraft or aircrew, the HAC shall either abort the mission or perform only that portion of the mission briefed and within the capabilities of the aircraft and aircrew. The HAC shall evaluate "add on" missions as they are assigned.

20.3.9.2 PNAC. The PNAC updates aircraft performance data based upon the ambient conditions encountered and advises the PAC of any changes, hazards, or discrepancies.

20.3.9.3 Aircrewman. The aircrewman advises the HAC of any system degradation/malfunction, hazard, or other discrepancies which could adversely affect mission accomplishment.

20.3.9.4 Aerial Gunner. The aerial gunner complies with all weapon conditions and safety procedures.

20.3.10 Instrument Descent/Approach

20.3.10.1 HAC. The HAC shall:

WARNING

The HNVS system provides for increased situational awareness for the PAC. The FLIR image and symbology shall not be used exclusive of other flight instruments.

1. Review the instrument approach to be flown.

2. Assign lookout responsibility.

3. Coordinate voice procedures for transitioning from IMC to VMC conditions during the approach to landing.

4. Brief responsibilities for a planned missed approach.

20.3.10.2 PNAC. The PNAC monitors rate of descent, airspeed, angle of bank, attitude, clearance limits, and altitude restrictions. He alerts the PAC to any suspected spatial disorientation. The HNVS system aids the PNAC in performing navigational duties. The FLIR image and symbology shall not be used exclusive of other flight instruments.

20.3.10.3 Aircrewman. The aircrewman acts as lookout during the instrument approach. He checks cabin integrity, ensures all gear is secured/stowed, passengers seated, and seatbelts secured.

20.3.11 Prelanding/Landing

20.3.11.1 HAC The HAC ensures the NATOPS Prelanding Checklist is completed. He reevaluates aircraft performance as necessary. He monitors flight control displacement and descent and closure rates during all landings to ensure that aircraft limitations are not exceeded. The HAC is responsible for initiation of a wave-off whenever an unacceptable approach is recognized.

20.3.11.2 PNAC. The PNAC shall assist the PAC regarding the Prelanding Checklist, monitor assigned frequencies, advise the PAC of any clearance changes or traffic calls not acknowledged, and call for a wave-off whenever an unacceptable approach is recognized.

20.3.11.3 Aircrewman. The aircrewman shall:

1. Ensure that the cabin is ready for landing with all passenger safety belts fastened and all cargo secured.

2. Make a positive statement to the pilot in command reporting the following:

    a. All passenger safety belts fastened.

    b. Cabin occupants and/or embarked cargo ready for landing.

    c. Tailskid position on each approach.

    d. Crewmen set for landing.

3. Observe the landing zone for any potential hazards and inform the pilot when the tail rotor is clear of all obstacles.

4. Notify the cockpit of any unusual circumstances.

5. Call for a wave-off whenever an unacceptable approach is recognized.

20.3.12 Postlanding

20.3.12.1 HAC. If internal cargo or passengers are to be embarked or debarked prior to shutdown, ensure that the aircraft is stopped, wheel brakes as required, tip-path as required, aircrewmen alerted to mode and direction of entry/exit, and that the ramp is clear prior to activation.

20.3.12.2 PNAC. The PNAC monitors aircraft system parameters, maintains lookout.

20.3.12.3 Aircrewman. The aircrewman ensures embarked passengers remain seated with seatbelts secured until given clearance to debark. When cleared by the HAC, he supervises the offload/onload of internal cargo and the embarkation/debarkation of passengers with special emphasis on tip-path hazards. The aircrewman ensures that embarked passengers and cargo are secured prior to aircraft movement as outlined in prestart/start/pretaxi duties.

During refueling the aircrew shall:

1. Position the ramp as required.

2. Ensure that all passengers debark and remain well clear of the aircraft during refueling operations.

3. Insert auxiliary fuel tank safety pins and chocks.

4. Maintain ICS communication with the cockpit when hot refueling operations are being conducted.

5. Ensure crewmembers handling hot refueling are wearing proper flight gear with helmet visors down.

6. Monitor fuel cell pressure gauges for pressure increase during refueling.

7. Notify the HAC of any unusual circumstances and be prepared to discontinue refueling by disconnecting the hose immediately in the event any potentially dangerous situation is observed.

20.3.13 Shutdown

20.3.13.1 HAC. The HAC ensures shutdown is conducted in accordance with the NATOPS checklist. He is aware of flight control positioning to prevent damage/injury.

20.3.13.2 PNAC. The PNAC assists the PAC with the Shutdown Checklist.

20.3.13.3 Aircrewman. The aircrewman shall:

1. Insert auxiliary fuel tank safety pins, chocks, and landing gear pins.

2. Maintain ICS contact with the cockpit during engine shutdown.

3. Ensure that a qualified fireguard is posted during engine shutdown.

4. Ensure that the area around the helicopter is clear during engine shutdown and that no unauthorized personnel are under the rotor disc until the rotor head stops.

5. Visually check the droop stops as the rotor rpm decreases and advise the cockpit when all droop stops are in position.

20.3.14 Postflight

20.3.14.1 HAC. The HAC supervises a thorough postflight inspection. He notes any discrepancies and reports them to maintenance control.

20.3.14.2 Copilot. The copilot assists with postflight duties. He advises the HAC and records any discrepancies noted.

20.3.14.3 Aircrewman. The aircrewman shall:

1. Perform postflight inspection.

2. Debrief the HAC regarding any maintenance material discrepancies noted during the flight so that the aircrewman may include this information on the required reports.

3. Service, secure, and tie down the helicopter as required.

20.3.14.4 Aerial Gunner. The aerial gunner performs postflight on assigned crew-served weapon systems and assists the aircrewman in their postflight responsibilities.

20.3.15 Debrief

20.3.15.1 HAC. As soon as practical, the HAC debriefs all flight and ground crew personnel involved in the flights/mission concerning overall and individual coordination and performance. He discusses any improvements for the future conduct of similar flight/missions.

20.3.15.2 Copilot/Aircrewman. The copilot/aircrewman provides constructive input on crew performance and mission accomplishment to all flight and ground crew personnel involved.

20.3.16 Emergencies

20.3.16.1 HAC. Prior to flight, the HAC shall ensure that specific crew duties, in the event of an emergency, are thoroughly briefed and understood. Upon encountering an emergency, he shall ensure the timely and accurate application of corrective or precautionary procedures.

20.3.16.2 Copilot. The copilot shall be thoroughly familiar with all emergency procedures and assist the HAC in execution of those procedures.

20.3.16.3 Aircrewman. The aircrewman shall be thoroughly familiar with all emergency procedures and shall prepare the cabin, as required, for emergency landing and evacuation.

20.4 SELECTED MISSION PROCEDURES

20.4.1 External Cargo Operations

20.4.1.1 HAC/Copilot. Refer to Part III of this manual.

20.4.1.2 Aircrewman. The aircrewman shall:

1. Be prepared to direct the PAC as necessary. Use standard flight crewmember ICS communication and/or visual signals defined in Part III of this manual.

2. Observe the conditions of the pickup/drop zone and notify the cockpit of any potential hazards.

3. Ensure that the cargo hook(s)/pendant(s) are properly closed and that the load is correctly attached prior to informing the load is ready for liftoff.

4. Constantly observe the cargo in flight and keep the cockpit informed of its condition.

5. Be prepared to release the load if directed by the HAC.

6. The Crew Chief and Aerial Observer shall switch positions in the helicopter cabin to call external lift directions only while the helicopter is on the deck or in a low hover and after positive two-way communication with the pilots. During flight at night, cabin lighting should be turned on prior to conducting such a crew position change or when conducting any crew-intensive cabin actions around an open single-point external hatch.

7. During night operations, cockpit curtain may be closed to reduce cockpit glare.

WARNING

- Any time single-point external hatch is unsecured, troop seats adjacent to the hatch should be up and secured, and movement on the port side of the hatch is prohibited. If the single-point hatch is open and the troop seats are down, limited walking space exists between the starboard side of the single-point external hatch and the troop seats. Aircrewman must exercise caution when walking in this area to prevent falling from the helicopter.

- When the aircrewman is not in his seat with his seatbelt on, he shall be secured with an aircrewman safety harness until the completion of the flight. When necessary activities require movement about the cabin, the aircrewman may move from station to station using the aircrewman safety harness.

- When the single-point external hatch is open, all aircrew shall remain attached to the helicopter with the approved safety belt. If movement is required, it shall only be conducted while on the deck or in a low hover.

20.4.2 Confined and Mountain Area Landings. Refer to Part III of this manual.

20.4.3 Operational Troop/Passenger Lifts

20.4.3.1 HAC/Copilot. Refer to Part III of this manual.

20.4.3.2 Aircrewman. The aircrewman shall:

1. Prepare the cabin for the troop lift by erecting all seats.

2. Supervise in the orderly embarkation and debarkation of passengers.

3. Provide troop life preservers to passengers before overwater fights and ensure they are properly fitted and donned.

4. Visually check each passenger to ensure that he is seated and has his safety belt properly fastened.

5. Secure any loose baggage or equipment carried aboard by the passengers.

6. Make a positive statement to the HAC reporting the following:

    a. Number of passengers embarked.

    b. All passengers safety belts fastened

    c. Cabin occupants and/or internal cargo ready for taxi/takeoff.

7. Ensure that all troop life preservers are removed and returned when overwater flight is completed.

8. Signal passengers when clear to debark.

20.4.4 Formation Flights

20.4.4.1 HAC/Copilot. Refer to Part III of this manual.

20.4.4.2 Aircrewman. The aircrewman shall:

1. Advise the HAC of any change of the formation and periodically provide status on flight integrity.

2. Advise the HAC of any other aircraft in the vicinity of the formation.

3. Advise the HAC of any uncomfortable situation.

20.4.5 Shipboard-Based Procedures

20.4.5.1 HAC/Copilot. Refer to Part III of this manual.

20.4.5.2 Aircrewman. In addition to all normal responsibilities, the aircrewman shall:

1. Ensure that the aircraft tiedowns are slack prior to starting engines and engaging the main rotor.

2. Ensure that all aircraft tiedowns and chocks are removed prior to takeoff and verbally reported to the HAC.

3. Ensure ramp area is clear prior to operation.

20.4.6 Paratroop Delivery Operations

20.4.6.1 HAC/Copilot. Refer to Part III of this manual or other applicable directives.

20.4.6.2 Aircrewman. In addition to all normal responsibilities, the aircrewman shall:

1. Act as the communication link between the HAC and the jump master if the ICS communication between the HAC and the jump master is degraded.

2. Ensure that all personnel follow necessary safety precautions en route and during paratroop delivery operations.

3. Open cargo ramp door and position cargo ramp 10° to 15° below level.

4. Check tail skid is in the up position.

5. Ensure that the number of personnel in the vicinity of the ramp is never so great that the acceptable aft cg limit is exceeded. He will receive instructions concerning the cg from the HAC during the preflight brief and supervise the course of paratroop delivery operation.

6. Ensure that all paratroopers exit the helicopter from the right side (left side looking aft) of the cargo ramp.

7. Notify the HAC of any unusual circumstances of the paratroopers as they leave the helicopter.

20.4.7 Functional Checkflights. Refer to Part III of this manual.

20.4.8 Search Air Rescue. Refer to Part III of this manual.

PART X

NATOPS EVALUATION

CHAPTER 21
NATOPS Evaluation

21.1 CONCEPT

The standard operating procedures prescribed in this manual represent the optimum method of operating the helicopter. The NATOPS evaluation is intended to evaluate compliance with NATOPS procedures by observing and grading individuals and units. This evaluation is tailored for compatibility with various operational commitments and missions of both Navy and Marine Corps units. The prime objective of the NATOPS evaluation program is to assist the unit commanding officer in improving unit readiness and safety through constructive comment. Maximum benefit from the NATOPS evaluation program will be achieved only through the active vigorous support of all pilots and crewmembers.

21.2 IMPLEMENTATION

The NATOPS evaluation program shall be carried out in every unit operating Naval aircraft. The various categories of flight crewmembers desiring to attain/retain qualification in the helicopter shall be evaluated in accordance with OPNAVINST 3710.7. Individual and unit NATOPS evaluations will be conducted annually; however, instruction in and observation of adherence to NATOPS procedures must be on a daily basis within each unit to obtain maximum benefits from the program. The NATOPS coordinators, evaluators, and instructors shall administer the program as outlined in OPNAVINST 3710.7. Evaluees who receive a grade of unqualified on a ground or flight evaluation shall be allowed 30 days in which to complete a reevaluation. A maximum of 60 days may elapse between the date the initial ground evaluation was commenced and the date the flight evaluation is satisfactorily completed.

21.3 DEFINITIONS

The following terms, used throughout this section, are defined as to their specific meaning within the NATOPS program.

21.3.1 NATOPS Evaluation. A periodic evaluation of individual flight crewmember standardization consisting of an open book examination, a closed book examination, an oral examination, and a flight evaluation.

21.3.2 NATOPS Reevaluation. A partial NATOPS evaluation administered to a flight crewmember who has been placed in an unqualified status by receiving an unqualified grade for any of his ground examinations or the flight evaluation. Only those areas in which an unsatisfactory level was noted need be observed during a reevaluation.

21.3.3 Qualified. That degree of standardization demonstrated by a very reliable flight crewmember who has a good knowledge of standard operating procedures and a thorough understanding of aircraft capabilities and limitations.

21.3.4 Conditionally Qualified. That degree of standardization demonstrated by a flight crewmember who meets the minimum acceptable standards. He is considered safe enough to fly as pilot in command or to perform normal duties without supervision, but more practice is needed to become qualified.

21.3.5 Unqualified. That degree of standardization demonstrated by a flight crewmember who fails to meet minimum acceptable criteria. He should receive supervised instruction until he has achieved a grade of qualified or conditionally qualified.

21.3.6 Area. A routine of preflight, flight, or postflight.

21.3.7 Sub Area. A performance subdivision within an area, which is observed and evaluated during an evaluation flight.

21.3.8 Critical Area/Sub Area. Any area or sub area which covers items of significant importance to the overall mission requirements, the marginal performance of which would jeopardize safe conduct of the flight.

21.3.9 Emergency. An aircraft component, system failure, or condition that requires instantaneous recognition, analysis, and proper action.

21.3.10 Malfunction. A component or system failure or condition that requires recognition and analysis, but which permits more deliberate action than that required for an emergency.

21.4 GROUND EVALUATION

Before commencing the flight evaluation, an evaluee must achieve a minimum grade of qualified on the open book and closed book examinations. The oral examination is also part of the ground evaluation, but may be conducted as part of the flight evaluation. To assure a degree of standardization between units, the NATOPS instructors shall use the bank of questions contained in this section in preparing portions of the written examinations.

21.4.1 Open Book Examination. The number of questions on the examination will not exceed 100 or be less than 50. The purpose of the open book examination portion of the written examination is to evaluate the crewmember's knowledge of appropriate publications and the aircraft. The maximum time for this examination shall not exceed 60 days. The examination should be completed within 60 days of the flight evaluation. To obtain a grade of qualified, an evaluee must obtain a minimum score of 3.5.

21.4.2 Closed Book Examination. A portion of the questions for the closed book examination shall be taken from the question bank and shall include questions concerning normal procedures and aircraft limitations. The number of questions on the examination will not exceed 50 or be less than 25. The examination should be completed within 60 days of the flight evaluation. To obtain a grade of qualified, an evaluee must obtain a minimum score of 3.3.

21.4.3 Oral Examination. The questions may be taken from this manual and drawn from the experience of the instructor/evaluator. Such questions should be direct and positive and should in no way be opinionated.

21.4.4 Operational Flight Training (OFT) Procedures Evaluation. An OFT may be used to assist in measuring the crewmember's efficiency in the execution of normal operating procedures and his reaction to emergencies and malfunctions. In areas not served by these facilities, this may be done by placing the crewmember in an aircraft and administering the appropriate questions.

21.4.5 Grading Instructions. Examination grades shall be computed on a 4.0 scale and converted to an adjective grade of qualified or unqualified.

21.4.6 Oral Examination and OFT Procedure Check (if conducted). A grade of qualified or unqualified shall be assigned by the instructor/evaluator.

21.5 FLIGHT EVALUATION

The NATOPS evaluation flight is intended to evaluate unit/individual compliance with approved standardized operating procedures. The successful completion of all ground checks and examinations is required before commencement of the flight evaluation. Insofar as possible, evaluation flights will be scheduled so as not to interfere with squadron operations. The flight evaluation should conform to any syllabus flight. Only those areas observed or required by the mission assigned will be evaluated. Determination of the final flight evaluation grade will be made as outlined in FINAL GRADE DETERMINATION in this chapter.

21.5.1 Pilot. BRIEFING.

PREFLIGHT.

1. Records check.
2. Preflight check.
3. Crew briefing.
4. Proficiency in computer usage.

START/ENGAGE/POST ENGAGEMENT.

1. Start.
2. Engage.
3. Post engagement.

TAXI.

1. Procedures.
2. Taxi.

TAKEOFF/TRANSITION.

1. Procedures.
2. Type takeoff.
    a. Vertical.
    b. Running.
    c. Crosswind.
    d. Maximum gross.

3. Transition.

CLIMB/CRUISE.

1. Procedures.
2. Power control.
3. Helicopter control.

APPROACH AND LANDING.

1. Procedures.
2. Power control.
3. Helicopter control.
4. Type of landing.
   a. Vertical.
   b. Running.
   c. Crosswind.
   d. Maximum gross.

AUTOROTATION.

1. Procedures.
2. RPM control.
3. Airspeed control.
4. Recovery.

EMERGENCY PROCEDURES.

1. Procedures.
2. Helicopter control.

SHUTDOWN/POSTFLIGHT.

1. Shutdown.
2. Postflight inspection.

CREW COORDINATION.

DEBRIEFING.

MISSION EVALUATION AREAS.

CONFINED AREA LANDING.

1. Procedures.
2. Approach.
3. Power control.
4. Helicopter control.

INTERNAL CARGO.

1. CG within limits.

EXTERNAL CARGO.

1. Procedures (single- and two-point).
2. Signal response.
3. Helicopter control.
4. Use of CG load indicator.

NAVIGATION.

HIFR.

HELICOPTER AIR REFUELING.

21.5.2 Aircrew. PREFLIGHT AND POSTFLIGHT EVALUATION.

PREFLIGHT.

1. Aircraft inspection.
2. Yellow sheet.
3. Compliance with MRCs.

CONDITION OF AIRCRAFT.

1. Cleanliness.

CABIN GEAR.

1. Security.
2. Condition.

GROUND SAFETY PRECAUTIONS.

1. Observance.

LOADING INTERNAL CARGO.

1. Weight and balance.
2. Use of tiedowns.

AUXILIARY POWER PLANT.

1. Inspection.
2. Operation.

RANGE EXTENSION FUEL SYSTEM.

1. Installation.
2. Operation.

BRIEFING OF PASSENGERS.

HAND SIGNALS.

1. Day.
2. Night.

FUELING AND SERVICING.

1. Gravity.
2. Pressure.
3. HIFR.

POSTFLIGHT AND DAILY.

1. Inspection.
2. Compliance with MRCs.

SECURING OF AIRCRAFT.

1. Stowage of gear.
2. Tiedowns and covers.

FLIGHT EVALUATION.

PERSONAL FLIGHT EQUIPMENT.

1. Availability.
2. Condition.
3. Usage.

SAFETY REGULATIONS.

1. Compliance.

EMERGENCY PROCEDURES.

1. Proficiency.
2. Compliance.

FLIGHT PARAMETERS.

1. Knowledge.
2. Alertness.

VOICE PROCEDURES.

CONFINED AREA LANDINGS.

1. Observation.
2. Communication.

INSTRUMENT FLIGHT.

1. Alertness.
2. Communication.

EXTERNAL CARGO OPERATIONS.

1. Procedures (single- and two-point).
2. Voice procedures.

WINCH OPERATIONS.

1. Loading.
2. Unloading.

UTILITY HOIST OPERATIONS.

1. Procedures.
2. ICS communication.

PILOT-CREW COORDINATION

21.5.3 Flight Evaluation Grading Criteria. Only those sub areas provided or required will be graded. The grades assigned for a sub area shall be determined by comparing the degree of adherence to standard operating procedures with adjectival ratings listed below. Momentary deviations from standard operating procedures should not be considered as disqualifying provided such deviations do not jeopardize flight safety and the evaluee applies prompt corrective action.

21.5.3.1 Qualified. Well standardized; evaluee demonstrated highly professional knowledge of and compliance with NATOPS standards and procedures. Momentary deviations from minor missions in noncritical areas are permitted if prompt and timely remedial action is initiated by the evaluee.

21.5.3.2 Conditionally Qualified. Satisfactorily standardized; one or more significant deviations from NATOPS standards and procedures, but no errors in critical areas and no errors jeopardizing mission accomplishment or flight safety.

21.5.3.3 Unqualified. Not acceptably standardized; evaluee fails to meet minimum standards regarding knowledge of and/or ability to apply NATOPS procedures; one or more significant deviations from NATOPS standards and procedures which could jeopardize mission accomplishment or flight safety.

21.5.4 Records and Reports. The NATOPS Evaluation Report, OPNAV Forms 3510-8, shall be completed for each evaluation conducted and forwarded to the evaluee's commanding officer only. This report shall be filed in the Naval Aviator/Naval Flight Officer/Qualification Jacket.

21.5.5 Flight Evaluation Grade Determination. The following procedure shall be used in determining the flight evaluation grade. A grade of unqualified in any critical area/sub area will result in an overall grade of unqualified for the flight. Otherwise, flight evaluation (or area) grades shall be determined by assigning the following numerical equivalents to the adjective grade for each sub area. Only the numerals 0, 2, and 4 will be assigned in sub areas. No interpolation is allowed.

Unqualified	0.0
Conditionally qualified	2.0
Qualified	4.0

To determine the numerical grade for each area and the overall grade for the flight, add all the points assigned to the sub areas and divide this sum by the number of sub areas graded. The objective grade shall then be determined on the basis of the following scale:

0.0 to 2.19 — Unqualified
2.2 to 2.99 — Conditionally qualified
3.0 to 4.0 — Qualified

EXAMPLE:

$$\frac{(4+2+4+2+4)}{5} = \frac{16}{5} = 3.20$$ Qualified (add sub area numerical equivalents)

In the case of enlisted flight crewmembers, an entry shall be made in the administrative remarks section of his personnel record upon satisfactory completion of the NATOPS evaluation as follows:

(DATE) Completed a NATOPS evaluation in (aircraft designation) as (flight crew position) with an overall grade of (qualified or conditionally qualified).

21.6 FINAL GRADE DETERMINATION

The final NATOPS evaluation grade shall be the same as the grade assigned to the flight evaluation. An evaluee who receives an unqualified on any ground examination or the flight evaluation shall be placed in an unqualified status until he achieves a grade of conditionally qualified or qualified on a reevaluation.

An entry shall be made in the Pilot/NFO Log Book under "Qualifications and Achievements" as follows:

QUALIFICATION			DATE	SIGNATURE	
NATOPS eval.	(Aircraft model)	(Crew posit.)	(Date)	(Authenticating signature)	(Unit which administered eval.)

21.6.1 Example NATOPS Evaluation Form. Figure 21-1 may be used by the instructor/evaluator to grade items and make written comments during the NATOPS evaluation flight. Per OPNAVINST 3710.7, a NATOPS Evaluation Form shall be retained with each 3710/7 in Part D of the evaluee's NATOPS jacket.

CH–53E PILOT NATOPS EVALUATION FORM

Evaluee ____________________
Evaluee SSN ____________________
Instructor ____________________
Date of Flight ____________________
Total Hours ____________________
Model Hours _____/_____
Flight Duration _____._____
Helicopter Buno ____________________
Date of Last Eval ____________
Expires ____________

Open Book Date and Grade ____________ ___.___
Closed Book Date and Grade ____________ ___.___
Final Overall Grade ____________

☐ Turn–in completed ATF to S–3 Pilot Training (USMC)
☐ TMR code 2L4 entered in NALCOMIS

Phase I Ground Evaluation	Q	CQ	UQ	Comments
Open / Closed Book	☐	☐	☐	______
Oral Exam	☐	☐	☐	______

Phase II Flight Evaluation	Q	CQ	UQ	Comments
PREFLIGHT	☐	☐	☐	______
Records Check	☐	☐	☐	______
Preflight Check	☐	☐	☐	______
Crew Brief	☐	☐	☐	______
START/ENGINE/POST ENGAGEMENT	☐	☐	☐	______
Start	☐	☐	☐	______
Engage	☐	☐	☐	______
Post Engagement	☐	☐	☐	______
TAXI	☐	☐	☐	______
TAKEOFF/TRANSITION	☐	☐	☐	______
Procedures	☐	☐	☐	______
Takeoffs	☐	☐	☐	______
Vertical	☐	☐	☐	______
Running	☐	☐	☐	______
Crosswind	☐	☐	☐	______
Max Gross	☐	☐	☐	______
CLIMB/CRUISE	☐	☐	☐	______
Procedures	☐	☐	☐	______
Power Control	☐	☐	☐	______
Helicopter Control	☐	☐	☐	______
APPROACH AND LANDING	☐	☐	☐	______
Procedures	☐	☐	☐	______
Power Control	☐	☐	☐	______
Helicopter Control	☐	☐	☐	______
Landing	☐	☐	☐	______
Vertical	☐	☐	☐	______
Running	☐	☐	☐	______
Crosswind	☐	☐	☐	______
Max Gross	☐	☐	☐	______
AUTOROTATION	☐	☐	☐	______
INSTRUMENT PROCEDURES	☐	☐	☐	______

	Q	CQ	UQ	Comments
AFCS OFF	☐	☐	☐	______
EMERGENCY PROCEDURES	☐	☐	☐	______
SYSTEMS/LIMITATIONS KNOWLEDGE	☐	☐	☐	______
AIRCREW COORDINATION	☐	☐	☐	______
Decision Making	☐	☐	☐	______
Assertiveness	☐	☐	☐	______
Mission Analysis	☐	☐	☐	______
Communication	☐	☐	☐	______
Leadership	☐	☐	☐	______
Adaptability/Flexibility	☐	☐	☐	______
Situational Awareness	☐	☐	☐	______
SHUTDOWN/POSTFLIGHT	☐	☐	☐	______
DEBRIEF	☐	☐	☐	______

Phase III Mission Evaluation Areas	Q	CQ	UQ	Comments
CONFINED AREA LANDINGS	☐	☐	☐	______
EXTERNAL CARGO	☐	☐	☐	______
INTERNAL CARGO	☐	☐	☐	______
NAVIGATION	☐	☐	☐	______
OTHER ____________	☐	☐	☐	______

Narrative of Flight:

Strengths: ____________________

Weakness: ____________________

Narrative: ____________________

HC3707
SA

Figure 21-1. NATOPS Evaluation Forms (Sheet 1 of 2)

CH-53E AIRCREW NATOPS EVALUATION FORM

Evaluee ____________________
Evaluee SSN ____________________
Instructor ____________________
Date of Flight ____________________
Total Hours ____________________
Model Hours _____/_____
Flight Duration _____._____
Helicopter Buno ____________________
Date of Last Eval ____________
Expires ____________

Open Book Date and Grade ____________ ____.____
Closed Book Date and Grade ____________ ____.____
Final Overall Grade ____________

☐ Turn-in completed ATF to S-3 Pilot Training (USMC)
☐ TMR code 2L4 entered in NALCOMIS

Phase I Ground Evaluation	Q	CQ	UQ	Comments
Open / Closed Book	☐	☐	☐	______
Oral Exam	☐	☐	☐	______
Phase II Flight Evaluation				
PREFLIGHT	☐	☐	☐	______
Aircraft Inspection	☐	☐	☐	______
Yellow Sheet	☐	☐	☐	______
Compliance with MRCs	☐	☐	☐	______
CONDITION OF AIRCRAFT	☐	☐	☐	______
Cleanliness	☐	☐	☐	______
CABIN GEAR	☐	☐	☐	______
Security	☐	☐	☐	______
Condition	☐	☐	☐	______
GROUND SAFETY PRECAUTIONS	☐	☐	☐	______
Observance	☐	☐	☐	______
LOADING INTERNAL CARGO	☐	☐	☐	______
Weight and Balance	☐	☐	☐	______
Use of Tiedowns	☐	☐	☐	______
AUXILIARY POWER PLANT	☐	☐	☐	______
Inspection	☐	☐	☐	______
Operation	☐	☐	☐	______
RANGE EXTENSION FUEL SYSTEM	☐	☐	☐	______
Installation	☐	☐	☐	______
Operation	☐	☐	☐	______
BRIEFING OF PASSENGERS	☐	☐	☐	______
HAND SIGNALS	☐	☐	☐	______
Day	☐	☐	☐	______
Night	☐	☐	☐	______
FUELING AND SERVICING	☐	☐	☐	______
Gravity	☐	☐	☐	______
Pressure	☐	☐	☐	______
HIFR	☐	☐	☐	______
POSTFLIGHT AND DAILY	☐	☐	☐	______
Inspection	☐	☐	☐	______
Compliance with MRCs	☐	☐	☐	______

	Q	CQ	UQ	Comments
SECURING OF AIRCRAFT	☐	☐	☐	______
Stowage of Gear	☐	☐	☐	______
Tiedowns and Covers	☐	☐	☐	______
Phase III Mission Evaluation Areas				
PERSONAL FLIGHT EQUIPMENT	☐	☐	☐	______
Availability	☐	☐	☐	______
Condition	☐	☐	☐	______
Usage	☐	☐	☐	______
SAFETY REGULATIONS	☐	☐	☐	______
Compliance	☐	☐	☐	______
EMERGENCY PROCEDURES	☐	☐	☐	______
Proficiency	☐	☐	☐	______
Compliance	☐	☐	☐	______
FLIGHT PARAMETERS	☐	☐	☐	______
Knowledge	☐	☐	☐	______
Alertness	☐	☐	☐	______
VOICE PROCEDURES	☐	☐	☐	______
CONFINED AREA LANDINGS	☐	☐	☐	______
Observation	☐	☐	☐	______
Communication	☐	☐	☐	______
EXTERNAL CARGO OPERATIONS	☐	☐	☐	______
Procedures	☐	☐	☐	______
Voice Procedures	☐	☐	☐	______
WINCH OPERATIONS	☐	☐	☐	______
Loading	☐	☐	☐	______
Unloading	☐	☐	☐	______
UTILITY HOIST OPERATIONS	☐	☐	☐	______
Procedures	☐	☐	☐	______
ICS Communication	☐	☐	☐	______
AIRCREW COORDINATION	☐	☐	☐	______
Decision Making	☐	☐	☐	______
Assertiveness	☐	☐	☐	______
Mission Analysis	☐	☐	☐	______
Communication	☐	☐	☐	______
Leadership	☐	☐	☐	______
Adaptability / Flexibility	☐	☐	☐	______
Situational Awareness	☐	☐	☐	______

Narrative of Flight:

Strengths: ________________________________
____

Weakness: ________________________________
____

Narrative: ________________________________
____
____
____
____
____
____

HC3708
SA

Figure 21-1. NATOPS Evaluation Forms (Sheet 2 of 2)

21.7 NATOPS EVALUATION QUESTION BANK

The following bank of questions is intended to assist the unit NATOPS instructor/evaluator in the preparation of ground examinations and to provide an abbreviated study guide. The questions from the bank may be combined with locally originated questions in the preparation of ground examinations.

21.7.1 Pilot's NATOPS Question Bank

1. The automatic control circuit, in conjunction with two pressure switches, function to open the EAPS doors between ________ KIAS.

2. The engine overspeed system actuates at about _____ N_f to protect against actual overspeed.

3. The engine overspeed test circuit will function after the engine has attained ________.

4. The engine fuel control unit senses, ________, ________, ________, ________, ________, and ________

5. The engine fuel control functions to prevent ________, ________, ________, ________, ________, and ________

6. The engine oil pressure lights on the caution panel (will/will not) indicate whether the oil pressure is too high or too low.

7. Ground idle N_g is variable with ________ and its range is ________ to ________.

8. The tail rotor is canted _____° and its diameter is ________.

9. A rise in T_5 to _____ before the engine reaches ground idle is an indication of a hot start.

   a. 627°C

   b. 638°C

   c. 650°C

   d. 790°C

10. The start abort switches (do/do not) shut off fuel to the engines.

11. With only two engines operating, a total torque indication of 70% would mean that:

    a. The total (sum) of the torques of the two operating engines equals 70%.

    b. The average torque of the two operating engines is 70%.

    c. The average torque of all three engines is 70%.

    d. Each operating engine is producing 70% Q.

12. A green rotor brake light on the lower portion of the tachometer goes on whenever N_r is between _____ and _____.

13. Nose gear box oil temperature caution lights will activate when the oil temperature reaches _____.

14. The fuel dumping system permits dumping of fuel from each main tank and each auxiliary fuel tank to reduce the gross weight of the helicopter.

    a. True

    b. False

15. The fuel boost pump failure caution lights go on any time fuel boost pump pressure has decreased to _____ psi.

16. The fuel low caution light will go on when there is approximately _____ lbs. of fuel remaining in either the No. 1 or No. 3 tank or _____ lbs. of fuel in either the No. 2 left or right.

    a. 340 ±20, 170 ±10

    b. 390 ±60, 195 ±30

    c. 666 ±30, 333 ±15

    d. 610 ±30, 305 ±15

17. The ENG FLTR BY-PASS caution light will go on when the pressure drop across any one of the filters is over _____ psi.

18. Each fuel filter will bypass when the pressure drop across it is over _____ psi.

19. The helicopter's fuel system cannot be purged while pressure refueling or fuel transfer is taking place.

a. True

b. False

20. Pressing and lighting the PURGE push button causes the pressure refueling and fuel transfer system to start purging. The purge cycle lasts for _____ minutes and shuts down automatically.

21. Each sponson can dump fuel at a rate of _____ gallons per minute.

22. The fuel dump system is capable of dumping all fuel from the main fuel cells.

a. True

b. False

23. Underfrequency protection is provided when N_r drops below _____.

24. The circuit breaker controlling the copilot's vertical gyro is located on the _________.

25. The copilot's spotlight receives power from which bus?

a. #1 monitor dc bus.

b. #3 monitor dc bus.

c. #1 primary dc bus.

d. #2 primary dc bus.

26. Because two generators are driven by the APP, it is possible to operate the copilot's spotlight on the ground without the rotor head turning.

a. True

b. False

27. To smooth out pilot roll inputs, a _________ is incorporated in the roll linkage between the cyclic and the AFCS roll servo.

28. When the EAPS is partially clogged below _____ to _____ KIAS, the secondary pressure switch causes the _____ caution light to go on.

29. The _____ coupling provides increased tail rotor thrust for collective increases.

30. The _____ provides longitudinal cyclic inputs proportional to pedal inputs, to compensate for the pitching moment produced by the vertical thrust component of the canted tail rotor.

31. The _____ loop is primarily a stability augmentation system that employs rate damping to improve helicopter stability.

32. The _____ loop maintains the flight regime selected by the pilot when he trims his flight controls.

33. The AFCS servos provide three separate functions:

a. ______________________________
____
____

b. ______________________________
____
____

c. ______________________________
____
____

34. The longitudinal bias actuator provides the pilot with a positive longitudinal cyclic gradient.

a. True

b. False

35. The output of the AFCS roll servo is linked directly to the mixing unit, which furnishes a single input to the _________ primary servo.

36. Fuel is transferred from the auxiliary fuel tanks to the main fuel tanks at a rate of about _____ gallons-per-minute.

37. There are five couplings providing automatic proportional transfer between the axes when the appropriate flight control is moved. They are _________, _________, _________, _________, and _________.

38. The longitudinal bias actuator is fully retracted from _____ to _____ knots and is fully extended at _________.

39. With RAD ALT hold engaged, if a failure occurs, the RAD ALT will automatically switch to BAR ALT hold.

a. True

b. False

40. When the AFCS servos are not pressurized, their only function is to provide a mechanical link ________.

41. The ________ loop stability signals are applied to the servo output and do not move the cockpit flight controls.

42. The output of the AFCS ________ and ________ servos are linked directly to the mixing unit, which furnishes output to the tail rotor servo plus the forward, aft, and lateral primary servos.

43. Pitch attitude hold, airspeed hold, and pitch trim are done by the ________ actuator from computer inputs.

44. During normal operations, each AFCS computer furnishes ________ of the correction signal to the AFCS servos and the longitudinal bias actuator.

45. ____________ provides damping to improve short term dynamic stability in pitch, roll and yaw inner loop axes.

46. ____________ applies a force at the cyclic pitch position, providing feedback cuing that is directly proportional to gravity forces.

47. Turn coordination provides yaw channel inputs to coordinate turns above ____ knots.

48. Above 60 knots, beeping the CYCLIC STICK TRIM BEEP BUTTON FWD and AFT re-references pitch trim at a rate of ____ knots-per-second to hold selected airspeed.

49. The attitude warning system will function if the helicopter has experienced a single computer failure.

a. True

b. False

50. During forward flight, with an airload on the nose gear door, emergency extension may take from ____ to ____ minutes.

51. The airspeed indicators in the cockpit are unreliable below ____ KIAS.

52. The copilot's vertical gyro indicator normally receives inputs from the ________ vertical gyro, and the pilot's vertical gyro indicator receives inputs from the ____________.

53. When the PUSH-TO-TEST control knob on the radar altimeter indicator is pressed, a visual indication of ________ on the indicator indicates satisfactory system operation.

54. The RDR ALT switch on the pilot's miscellaneous switch panel allows selection of the radar tracking rate. The LAND mode tracks at ____ per second, while the SEA mode tracks at ____ per second.

55. If the respective ENG ANTI-ICE caution light goes on after the engine anti-ice switches are turned on, they will remain on until the temperature increases above the low temperature sensor setting of ________.

56. The shoulder harness inertia reel will automatically lock if an impact force over ____ Gs is encountered in any direction.

57. When the HOIST CONTROL panel is placed to PILOT, placing the control switch to either UP or DOWN will cause the hoist cable to travel in the mode selected at a maximum cable speed of ____ feet-per-minute.

58. Maximum continuous power turbine inlet temperature is ____. Military temperature is ____. This temperature is allowable for ____ minutes.

59. On autorotative descent speed of ________ will produce a minimum sink rate, and ________ will provide the greatest distance.

60. At gross weights below ________ pounds, average torque is limited to ________ in a climb.

61. At gross weights above ________ pounds, 121% average torque may be used.

62. Density altitude varies with ____________, ____________, and ____________.

63. An increase in OAT, at a constant pressure altitude, causes ________ engine performance.

64. Before engine start, the pilot in the right seat shall check that the head has positioned correctly by observing that there is a rotor blade at the ________ position.

65. Engine oil high-pressure light may stay on for as long as ____ minutes, until oil has warmed.

66. During transition to forward flight, as airspeed increases above approximately ____ knots, translational lift will become effective and tend to cause the helicopter to climb.

67. A single-point performance check is done to determine if the engine is producing ________ acceptable torque, at a specific T_5, OAT, and pressure altitude.

68. Fuel shall not be dumped below ____ KIAS or above 130 KIAS.

69. Landing on slopes up to approximately ____ differ very little from normal, level landing, and any direction of landing may be accomplished.

70. When approaching power and telephone lines, it is advisable to fly over the poles or tower rather than over the wire.

a. True

b. False

71. To provide engine cooling before engine shutdown, one of the following conditions must occur before moving the speed control levers to SHUT-OFF.

a. ________________________________

b. ________________________________

c. ________________________________

72. An emergency brake application can be made at any N_r with all engines shut off and high-pressure rotor brake switch at EMER.

a. True

b. False

73. With all engines shut down, the rotor brake will stop the rotor within ____ seconds after high pressure brake application.

74. Land as soon as possible means:

a. Landing site and duration of flight is at the discretion of the pilot in command.

b. Land at the first site at which a safe landing can be made.

c. Land immediately.

75. A precautionary landing is described as a landing when further flight is possible but inadvisable.

a. True

b. False

76. A T_5 increase of 40°C at a constant torque is equal to a power loss of about ____%.

77. The maximum gross weight at which hover or level flight can be maintained ________ as density altitude increases.

78. Tail rotor drive system failure is always accompanied by loss of directional control and a sharp ________ yaw.

79. When the 1 STG M/R SERVO BYPAS caution light is observed after a utility hydraulic system failure, securing first stage flight control system will result in ________.

80. A/An ________ in torque for a given flight condition is an indication of main gear box impending failure.

81. Main rotor-to-drogue/probe clearance can be as little as ____ feet during ____-inch longitudinal cyclic inputs.

82. Receiver crews ________ attempt probe-to-drogue contact while in a turn at night.

83. Total time to extend the air refueling probe should not be over ________.

84. Refueling directly behind the refueling pod ________ recommended.

85. In the pitch linkage between the AFCS pitch servo and the mixing unit, there is a ________ that functions as a mechanical connection with AFCS off.

86. Auto bank automatically disengages and engages with attitude retention during a maneuver above ____ knots.

87. With AFCS off, pressing and lighting the TRIM pushbutton to read TRIM turns on ________, ________, and ________ ________.

88. Coordinated turn is disengaged and heading hold reengaged when roll attitude is within ____ of wing level, yaw rate is less than 0.66° per second, and roll rate is less than 0.33° per second.

89. A ________ will be indicated by a failure of the gas generator to accelerate to proper idle speed, accompanied by a low T_5 indication.

90. The maximum operating range of the TACAN set is ____ NM when the selected TACAN station is a surface station, and ____ NM when the selected station is an airborne station.

91. Use of the ________ channels in the TACAN A/A mode is encouraged to eliminate possible interference with ground status.

92. Airspeed hold is not available below ____ knots.

93. With the radar altimeter off, the landing gear up warning system will be activated any time the gear is up and airspeed is less than ____ knots.

94. When pressure refueling, fuel tank quantities should be monitored closely as the ________ may not secure refueling.

95. The ALE-39 dispenser module has 30 discharge tubes electrically partitioned into payload sections of ________ and ________.

96. The ALE-39 countermeasure dispensing set provides effective counter measures against ________ ________ weapons systems and/or ________ missile threats.

97. CG/HOOK LOAD indicator panel ________ keys are disabled in flight to prevent inadvertent data changes.

98. If the combined value of both dual point hooks is over 36,000 pounds, all ________ __ ________ segments in both hook displays light.

99. Practice autorotations should not be attempted in conditions of high gross weight and critical ________ loadings.

100. For heavy lift operations and landings, set rotor speed to ____% N_r.

101. When icing conditions are anticipated, engine ice ingestion can be prevented by manually closing the ________ and keeping them closed until after engine shutdown.

102. The scavenge blowers operate whenever the EAPS door is closed and the main transmission oil pressure is above ____ psi.

103. Placing a respective engine overspeed switch to TEST will energize the fuel control solenoid at any N_f. TRUE or FALSE

104. The ________ provides anticipation of load changes for reduction of transient droop by resetting the fuel control governor proportional to the power required.

105. The T_5 gauges are powered by thermocouples and do not require any additional power source. TRUE or FALSE

106. Servo 1 or Servo 2, CMPTR POWER and AFCS have to be turned on before the TRIM pushbutton provides ________ functions.

21.7.2 General NATOPS Question Bank

1. The helicopter is powered by three ________ or ________ engines producing individually ____ at a power turbine output speed of ____.

2. The design gross weight is ________ and the maximum weight-on-wheels is ________.

3. Maximum allowable gross weight is ________.

4. The helicopter normally has seats for ____ passengers, but has provisions for the installation of centerline seating giving it a seating capacity of ____.

5. The overall length of the helicopter with blades and pylon spread is ________.

6. The main rotor diameter is ________.

7. The length of the refueling probe is ________ when extended and ________ when retracted.

8. The ignition system consists of an ignition unit, a control circuit and _____ igniter plugs per engine.

a. 1

b. 2

c. 6

d. 12

9. The starter circuit to the start valve is routed through the ________, ________, ________, ________, ________, and ________.

10. In order to select continuous ignition, the ________ must be turned on.

11. The ________ switch positions the head for engine start so that hot engine exhaust gases do not damage the main rotor blades.

12. The helicopter has a single, articulated main rotor and an antitorque tail rotor.

a. True

b. False

13. The main rotor blades have a (an) _____ spar.

a. Aluminum

b. Fiberglass

c. Titanium

d. Stainless Steel

14. The hollow main rotor blade spar is pressurized with ________ to about ________ at an ambient temperature of _____ to _____.

15. The IBIS spar pressure indicator test button is always pressed with a ____________ to prevent radiation escape.

16. If main rotor blade spar pressure drops to ________ or less, the pressure indicator will show two black stripes indicating pressure is escaping through a crack in the spar or through a malfunctioning seal.

17. The main transmission gear box has _____ chip detectors, the accessory gear box has _____, and the intermediate, tail rotor, and both engine nose gear boxes each have _____.

18. The input drive to the main gear box from the No. 2 engine is through a ____________.

19. The main gear box has a built-in forward tilt of _____.

20. The rotor brake caution light will go on whenever the manifold pressure is above ________.

21. The ROTOR BRAKE ON advisory light visually indicates that the rotor brake switch is at ________ and that system pressure is about ________.

22. There must be electrical power on the helicopter in order to release the rotor brake.

a. True

b. False

23. The accessory gear box drives ________, ________, ________, ________, ________, and ________.

24. The accessory gear box has two oil filters, one for ____________ and the other for ____________.

25. The main gear box auxiliary oil system has no associated warning system.

a. True

b. False

26. The intermediate and tail rotor pressure caution lights receive their power through an emergency dc bus circuit breaker labeled:

a. AIT

b. MAIN/TR INT GB

c. INT-TAIL GB

d. ACCESS INT/TAIL

27. The tail rotor gear box and the intermediate gear box have combination chip and temperature detectors.

a. True

b. False

28. Under what two conditions will the automatic fuzz-burn feature be disabled in the main gear box?

a. ______________________________
____
____

b. ______________________________
____
____

29. The pilot can, from the cockpit, identify which chip detector in the main gear box has picked up chips.

a. True

b. False

30. The helicopter is equipped with _________ type fuel systems.

31. Fuel for the APP is supplied from the _________ fuel tank.

32. The capacity of the main fuel tank is as follows:

#1 tank _____ gals

#2 tank _____ gals

#3 tank _____ gals

33. The helicopter is equipped with ____ gallon auxiliary fuel tanks.

34. The fuel dump system has two dump pumps in each sponson.

a. True

b. False

35. The APP is set for operation up to ____ feet pressure altitude.

36. The APP control lever should be held at _________ until clutch engagement, and then allowed to return to _________.

37. Fuel consumption for the APP is approximately ____ pph, depending on OAT and the accessory loads being used.

38. Which of the following APP protective circuits is not bypassed during the engine start cycle:

a. Low oil pressure.

b. High exhaust gas temperature.

c. Overspeed.

d. Fire detection.

39. The helicopter has ____ brushless generators, each rated at _________ for operation up to ____ feet.

40. The _________ and _________ generators are driven by the accessory gear box.

41. Underfrequency protection (is/is not) available when the weight of the helicopter is removed from the landing gear.

42. The three generators in the helicopter provide ____ volts, ____ Hz, ____ phase power.

43. Each generator is routed through its supervisory panel that provides control and protection of the electrical system from _________, _________, _________, and _________.

44. _____________ during starting may occur if the generator has not been turned off before shutting down the APP and/or main rotor head after the preceding flight.

45. Relay chatter can be eliminated by _____________.

46. The loss of any single generator will result in the loss of which bus(es)?

a. No. 1 primary dc bus.

b. No. 2B primary ac bus.

c. No. 1 monitor ac bus.

d. No. 2 monitor ac bus.

47. The purpose of the three autotransformers is to reduce 115 vac down to 26 vac.

a. True

b. False

48. The emergency ac and dc circuit breakers are located in the ____________.

49. Current limiters function to limit the flow of current regardless of the voltage applied to the system.

a. True

b. False

50. The engine start hydraulic system draws its fluid from which hydraulic reservoir?

a. 1st stage reservoir.

b. 2nd stage reservoir.

c. Utility reservoir.

d. Engine start reservoir.

51. The second stage and utility hydraulic systems are equipped with a heat exchanger.

a. True

b. False

52. The hydraulic fluid from the second stage and utility hydraulic systems is cooled as it returns to its respective hydraulic systems reservoir.

a. True

b. False

53. The first stage hydraulic system is cooled by a ________ located at the inlet of the main transmission oil cooler, and along the edge of the tail rotor pylon.

54. The utility hydraulic system provides subsystem pressure for the following:

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

55. The UTILITY OIL HOT caution light will go on when utility hydraulic fluid temperature is over ____°C.

56. The top cylinder of the primary tandem servos is powered by the ____________ and the bottom cylinder is powered by the ____________.

57. The interlock that prevents either side of the tandem servos from being turned off if there is not at least 2000 psi to the other side also prevents securing first stage if utility pressure is less than 2000 psi.

a. True

b. False

58. The first stage, second stage and utility caution lights go on when system pressure drops below ____ psi.

59. The 1 STG M/R SERVO BYPASS or 2 STG M/R SERVO BYPASS caution light will go on to indicate

a. ____________________________________
____
____

b. ____________________________________
____
____

60. The _____________ provides pitch force feel to the cyclic.

61. The first stage of the AFCS servo, when selected, is pressurized by the _________ flight control hydraulic system.

62. The second stage of the AFCS servo, when selected, is pressurized by the _________ hydraulic system.

63. Illumination of the #1, #2, or #3 ENG OIL QTY LOW caution light indicates the associated tank has been depleted by _________ of its usable capacity and shall be replenished by _________.

64. Holding the low-pressure rotor brake switch at _________ for about _____ seconds engages the rotor brake with _____ psi hydraulic pressure.

65. There are _____ fuel flow sensors that will sense a fuel flow above _____ gpm and cause the appropriate fuel flow indicator light to go on.

66. A longer APP start interval may be obtained by using both accumulators _________. The No. 2 accumulator is brought into the system by _________, that is overhead on the right side of the cabin of the personnel door.

67. The _____________ is used to remove hydraulic pressure from the FAS actuator in case of a hydraulic leak in the FAS actuator.

68. The nose landing gear _____________ prevents nose gear vibration during forward motion on the ground.

69. If the pin is extended on the top of the landing gear strut, this is an indication that (hydraulic/nitrogen) servicing is necessary?

70. With the utility hydraulic system not pressurized, the wheel brakes are capable of holding the helicopter, loaded to 46,500 lbs. on a _________ slope.

71. The heater is rated at _________ BTUs and receives its fuel from the _________.

72. The heater uses about _____ pounds of fuel per hour.

73. An overheat switch in the heater will shut off if for any reason the heat in the plenum chamber rises to _____.

74. The heater should be cut off _____ minutes before removing electrical power from the system.

75. The vent fan and combustion air fan will continue to operate after the heater is shut off, until the temperature in the plenum chamber drops to _____.

76. Continuous ignition is automatically turned on whenever the engine's anti-ice system is turned on.

a. True

b. False

77. A loss of about _________ of each engine's horsepower will result at maximum power, when the engine air anti-icing system is on.

78. With EAPS installed, engine anti-icing capabilities are available with the exception of the _________ and _________ nose gear box fairing anti-ice.

79. The single-point hook opens automatically when the weight on the hook is reduced to _____ pounds when in the automatic mode.

80. Jettisoning of airborne cargo of over _________ pounds with the pilot's cargo release buttons or aircrewman's pendant may cause the cargo hook to recoil and strike the fuselage.

81. Two _________ pound limit cargo hooks, limited to a combined capacity of _________ pounds, are mounted on attachments under the cabin deck.

82. The two-point cargo hooks are on the longitudinal axis of the helicopter and are _____ feet apart.

83. With TWO PT MODE switch at _________, the loss of the load from one hook, for any reason, automatically opens both hooks electrically for load release.

84. The utility hoist has a capacity for _____ pounds with about _____ feet of usable cable length.

85. The hoist winch motor receives hydraulic power from the _________ hydraulic system and is controlled by an electrohydraulic hoist control valve.

86. The cabin section has provision for the installation of _________ pole type litters.

87. Each engine has _____ photocell flame detectors mounted through the fuselage fairing into the engine section and each detector provides a _________ scan.

88. A crash-generated force of _____ Gs automatically discharges the fire extinguishers into the engine compartments.

89. If more than one emergency T-handle is moved full aft, the fire extinguishing agent will be directed to the engine compartment of the _________ emergency T-handle actuated.

90. When pressure refueling, make sure that pressure from the fueling source is not over _____ psi before beginning fueling.

91. When tied down properly, the helicopter can withstand winds of up to _____ knots.

92. The NATO CODE for JP-4 is _________.

93. Rotors should not be engaged or disengaged in winds from any direction over _____ knots.

94. The tail skid/oil shock strut will withstand inadvertent ground contact to a sink rate of _____ feet-per-minute.

95. The two-point suspension system shall never be used independently or in conjunction with the single-point system.

a. True

b. False

96. The lateral CG limits of this helicopter are _____ inches right and _____ inches left regardless of the helicopter's configuration.

97. The _________ weight of a transport helicopter is the weight of the helicopter including the crew and all equipment required for the mission, but not including fuel or payload.

98. Restarting of APP before a _____-minute wait may cause a hot start.

99. The mechanical gust lock engaged interlock is automatically bypassed, when airborne, by a microswitch on the main landing gear scissors switch.

a. True

b. False

100. The helicopter is designed to permit emergency water landings with the ability to stay afloat for about _____ hours in 1- to 3-foot waves with a wind of 7 to 16 knots.

101. The failure of either rectifier will cause the ______________ to be dropped from the system.

102. The primary visual indications of loss of utility hydraulic fluid to the utility system are:

a. ______________________________

b. ______________________________

103. The master switch on the hoist control panel has to be at _________ or _________ before the hoist shear switch, on the cockpit console, can shear the cable.

104. Accessory gear box failure will result in the loss of _____ and _____ hydraulic pumps, and the _____ and _____ generators.

105. Each AFCS computer will store, indefinitely up to _____ in flight failure codes until cleared by maintenance personnel.

106. When the start valve is energized by depressing the engine starter button, the engine start pump provides _____ psi hydraulic pressure for engine starting.

107. Towing speeds shall not exceed _____ MPH, and sudden stops or sudden starts will be avoided.

108. The tail rotor blade BIM press to test is required every ____ flight hours.

109. The normal setting of the fuel control density selector is ____ for JP-4, 5, and 8.

110. Each photocell flame detector provides a ____° scan.

111. External power for the CH-53E should be ____ volts, ____ phase, ____ Hz AC.

112. Compressor stall is normally accompanied by unusual engine ________.

113. The IBIS detector continually senses its own radiation and sends a signal to the signal processor which energizes a relay that ________ the BIM caution light.

114. The main tanks or the range extension tanks may be refueled through the ground pressure refueling system without electrical power. TRUE or FALSE

115. The tail skid circuit is routed through the down side of the ramp control switch so that the tail skid will automatically ________ when the cargo ramp is lowered and the helicopter is ________.

21.7.3 Questions of Particular Interest to Crewmen.

1. The NATOPS Aircrew Pocket Checklist is a required item of equipment on all flights by aircrewmen.

   a. True

   b. False

2. There are currently ____ changes to the aircrewman's pocket checklist.

3. What are the aircrewman's actions if the helicopter develops an APP fire during ground operation?

   a. ________________________________

   b. ________________________________

4. What actions should the aircrewman take after notification by the pilot of an impending emergency landing (on land)? ________________________________

____

5. The two steps to follow in the elimination of smoke and fumes from the aircraft cabin are:

   a. ________________________________

   b. ________________________________

6. During pressure refueling, pumping pressure should be ____ to ____ psi.

7. The fuel nozzle grounding cable should always be attached after the fuel nozzle is attached to the fuel panel adapter.

   a. True

   b. False

8. What are the aircrewman's actions if the helicopter develops a fuselage fire in flight? ____________

____

9. When carrying internal cargo, and/or range extension fuel tanks, each piece of cargo is required to be secured in five different directions; forward, aft, side (both left and right) and vertical (up).

   a. True

   b. False

10. Why will high engine oil temperatures occur when the helicopter engines are operating and the rotor is not engaged? ____________________

____

11. At the completion of pressure refueling, the precheck valves must be left in the ________ position to allow fuel transfer from the internal auxiliary fuel tanks to the sponson fuel tanks.

12. During the cargo hook system functional check, the emergency cargo hook release handle is not tested.

   a. True

   b. False

13. The APP high exhaust temperature circuit breaker is set to function at ____°C.

14. MIL-L-23699 oil is used throughout the helicopter (engines, gear boxes, rotors, etc.).

a. True

b. False

15. The blades and pylon may be folded separately; however, the blades cannot be folded if the pylon has already been folded.

a. True

b. False

16. A passenger briefing guide is included in the Air Crew Pocket Checklist.

a. True

b. False

17. While in flight or away from home base maintenance facilities, malfunction information and troubleshooting and adjustment procedures can be found in the A1-H53BE-NFM-900, which is also known as the

________________________.

18. The main fuel tank sump drain valve is provided to ________________________ or to ________________________.

19. If, after closing a precheck valve on the pressure refueling panel, fuel continues to flow into that fuel tank, a malfunction exists in the respective __________.

20. Precheck valves on the pressure refueling panel can be left in either the open or closed position when the range extension tanks are to be used in flight.

a. True

b. False

21. When starting the APP with no external power applied to the helicopter, fire detection is available at _____%

22. Only one range extension fuel tank per range extension tank control panel circuit breaker can be operational at one time due to the electrical load involved.

a. True

b. False

23. In case of an in-flight fire in either of the electronics compartments, there is an emergency access panel between the cabin and the electronics compartments through which the fire extinguisher can be discharged.

a. True

b. False

24. What would happen if the fuel boost pump would fail? ____

____

25. The engine fire warning system will activate when subjected to light equivalent to that found in fires.

a. True

b. False

26. Fuel may be transferred from one range extension tank to other range extension tanks by turning on the desired transfer pump and placing the fuel selector valve in the AUX TANKS position.

a. True

b. False

27. When the external power monitor panel rejects an external power input, the __________ switch must be placed to the reset position.

28. The cabin compartment floor is capable of sustaining loads of 300 pounds per square foot.

a. True

b. False

29. The cargo tiedown rings installed in the cargo cabin floor are rated at _____ pounds.

30. List four items to be checked before lowering the ramp at an unfamiliar location:

a. ______________________

b. ______________________

c. ______________________

d. ______________________

31. The pilot's master ramp control switch must be in the __________ position before the crew ramp control panel will function.

32. A fire in the APP compartment will be indicated by __________________ and can be extinguished by __________________.

33. The fuel control unit uses the same density setting for both JP-4 and JP-5.

a. True

b. False

34. When checking engine oil level after engine has been at idle for some time, or the engine is cold, the engine should be __________ for __________ before checking the oil level.

35. When adding oil to the oil tanks, add oil to indicate _____.

36. When towing, the helicopter speed shall not exceed _____ mph, and sudden stops and starts shall be avoided.

37. The 28 vdc external power receptacle is collocated with the 115/200 vac external power receptacle.

a. True

b. False

38. When using other than chain tiedowns to secure the helicopter or the rotor blades, enough slack should be provided in all ropes to prevent overtightening due to moisture absorption.

a. True

b. False

39. The parking brakes are not to be set during freezing weather due to ______________.

40. The cargo conveyor system is limited to _____ lbs. for _____ ft.

41. When adjusting auto turns, each full turn of the pitch control rod equals _____% N.

42. What is the acceptable substitute for MIL-H-83282 in the main rotor head dampers? __________

43. The M32A-10 power cart is accepted for use on the CH-53E. TRUE or FALSE

44. When pressure refueling an aircraft equipped with internal tanks, the internal tanks must be refueled first. TRUE or FALSE

PART XI

PERFORMANCE DATA

CHAPTER 22
Standard Data

22.1 GENERAL

Note

A specially-programmed Hewlett-Packard (HP-41C) calculator is available for helicopter performance computations.

A loss of about 3% of each engine's horsepower will result at maximum horsepower with engine anti-icing turned on.

Indicated torque readout can vary ±3% from actual torque, due to instrument error. This applies to all charts where torque appears.

22.2 AIRSPEED CALIBRATION CHART

This chart (Figure 22-1) converts KIAS to KCAS in a climb or level flight.

For example, enter the bottom of the chart at 100 KIAS, trace up to the climb and level flight curves, then trace left and read 90 KCAS for climb and 106 KCAS for level flight.

22.3 TEMPERATURE CONVERSION CHART

The chart (Figure 22-2) permits conversion between Fahrenheit and Celsius temperatures.

22.4 DENSITY ALTITUDE CHART

This chart (Figure 22-3) furnishes density altitude by applying temperature to pressure altitude. In addition, the chart furnishes an airspeed conversion factor that, when multiplied by KCAS, furnishes KTAS.

For example, enter the bottom of the chart at 32°C, trace up to 0 feet pressure altitude, and then trace left and right. Density altitude read on the left is 1900 feet, and the airspeed conversion factor read on the right is 1.032.

22.5 TORQUE VS. SHAFT HORSEPOWER CHART

This chart (Figure 22-4) converts indicated torque to shaft horsepower at 95%, 100%, and 105% N_r.

For example, to find the shaft horsepower at 96% torque and 100% N_r, enter the bottom of the chart at 96% torque, trace up to the 100% N_r curve and then trace left and read 3080 horsepower.

22.6 ENGINE PERFORMANCE CHARTS

The engine performance charts provide torque, at specific T_5 temperatures, when ambient temperature is applied to pressure altitude. Engine limitations that should not be exceeded are appropriately identified on the charts.

22.6.1 Maximum Power Available Charts. These charts (figures 22-5 and 22-7) provide torque at 773°C (T64-416) or 792°C (T64-416A) T_5 for 100% and 103% N_r, when wheel height and ambient temperature factors are applied to pressure altitude.

For example, at 100% N_r, if the helicopter is hovering at 18 feet wheel height at sea level with an ambient temperature of 32°C, enter the wheel height chart from the left. Trace across to intersect the curve, and down to read a 9.5° rise above ambient. Add 9.5 to the ambient temperature, enter at 41.5°C from the bottom. Trace up to sea level (note, power limited by temperature). Trace left to read 107% torque.

22.6.2 Military Power Available Charts. These charts (figures 22-6 and 22-8) are used in the same way as Figure 22-5 to provide torque available at 753°C T_5, for 100% and 103% N_r.

AIRSPEED CALIBRATION
PILOT AND COPILOT SYSTEM

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS ON

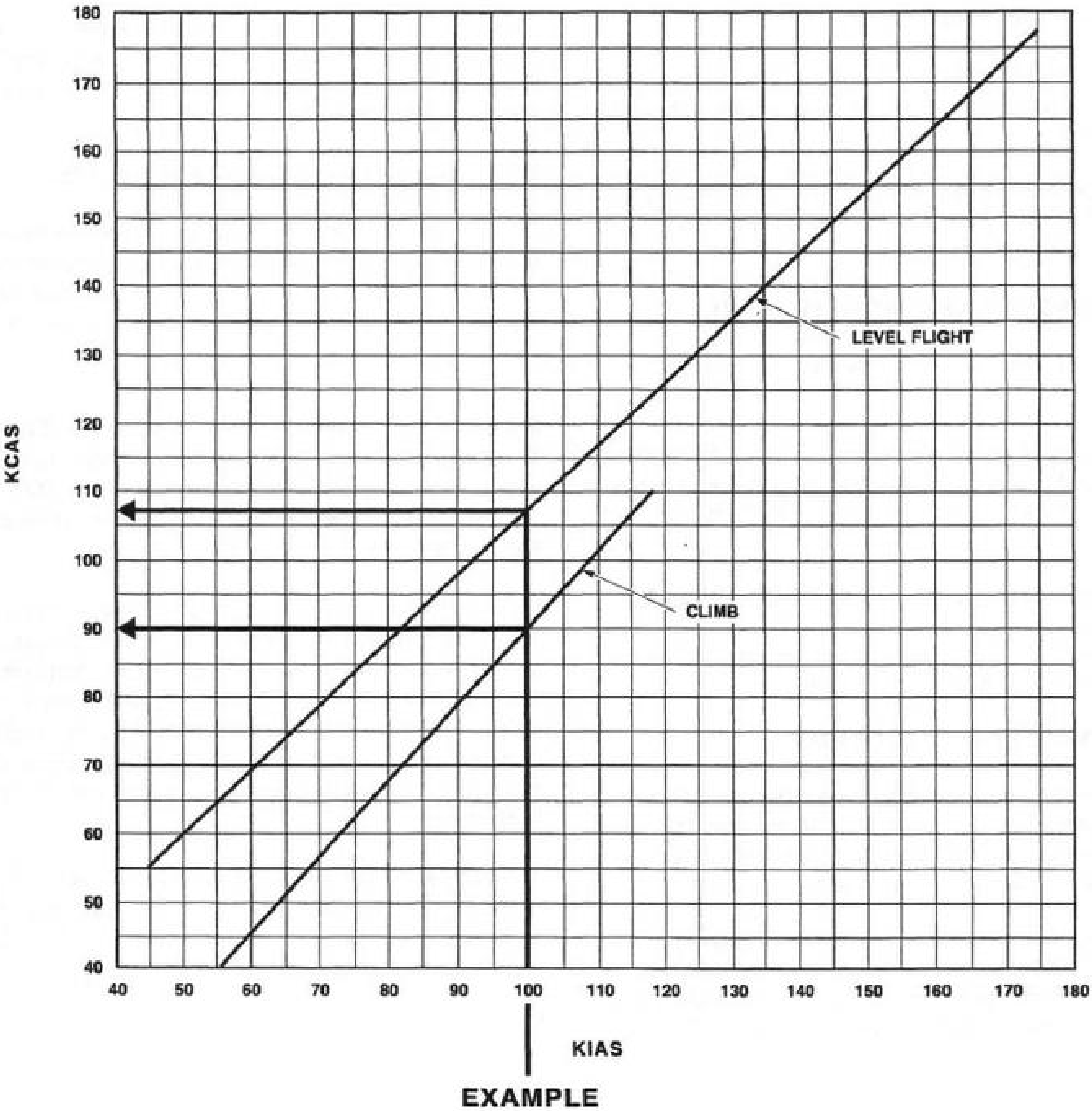
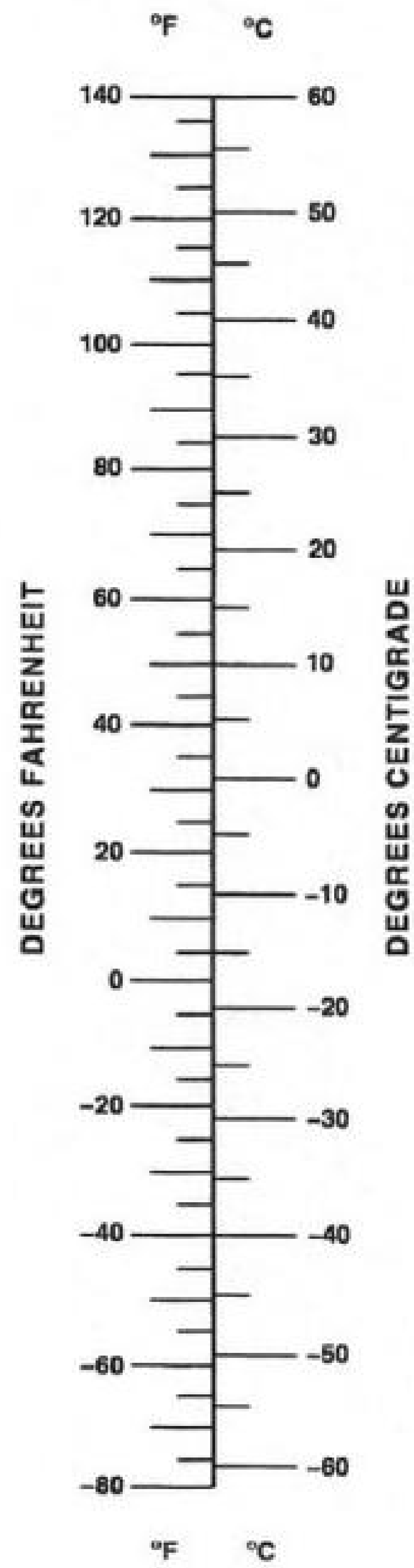


Figure 22-1. Airspeed Calibration

TEMPERATURE CONVERSION



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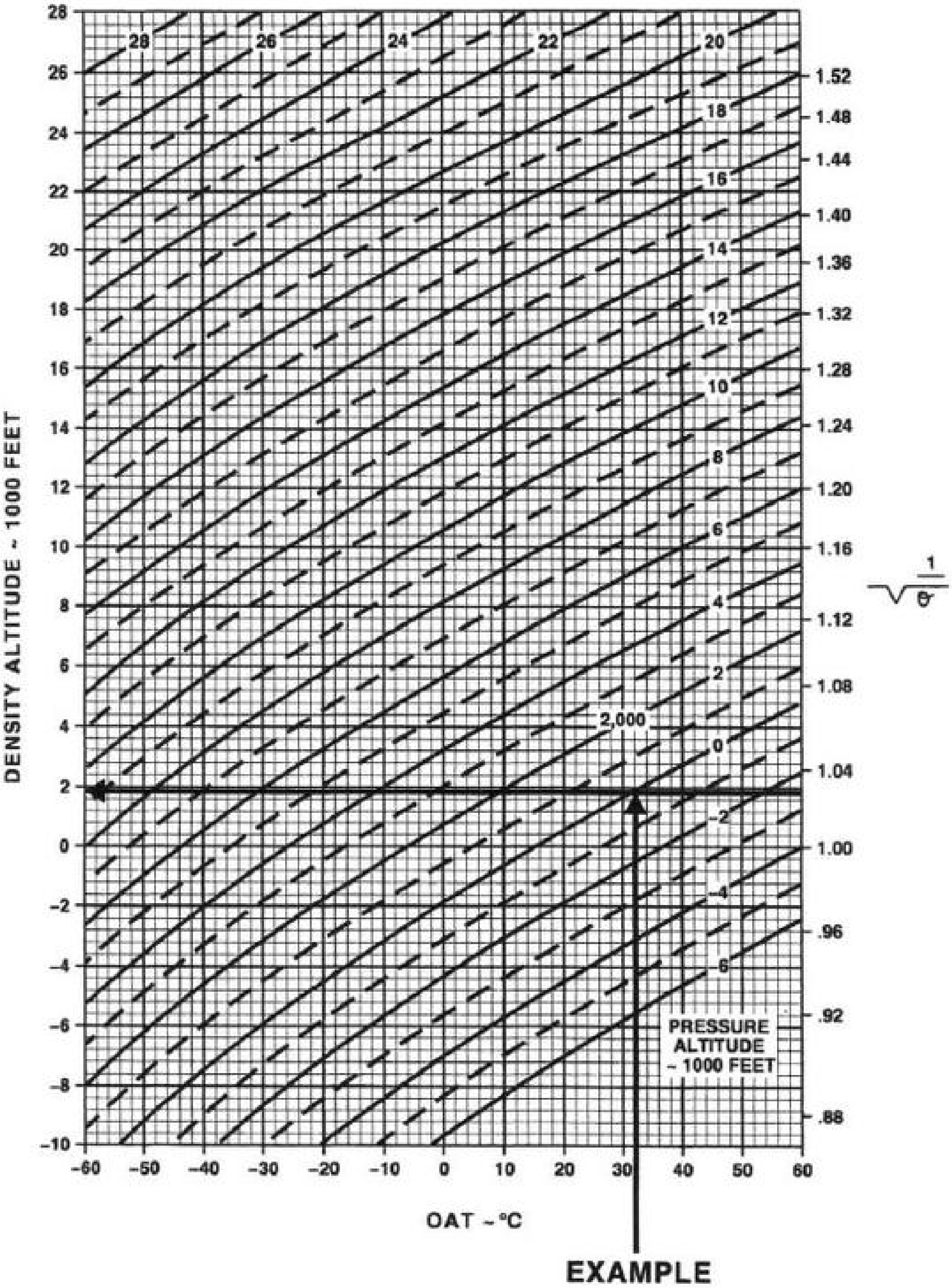
SA

Figure 22-2. Temperature Conversion

DENSITY ALTITUDE



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9A

Figure 22-3. Density Altitude

INDICATED TORQUE VS ENGINE SHAFT HORSEPOWER

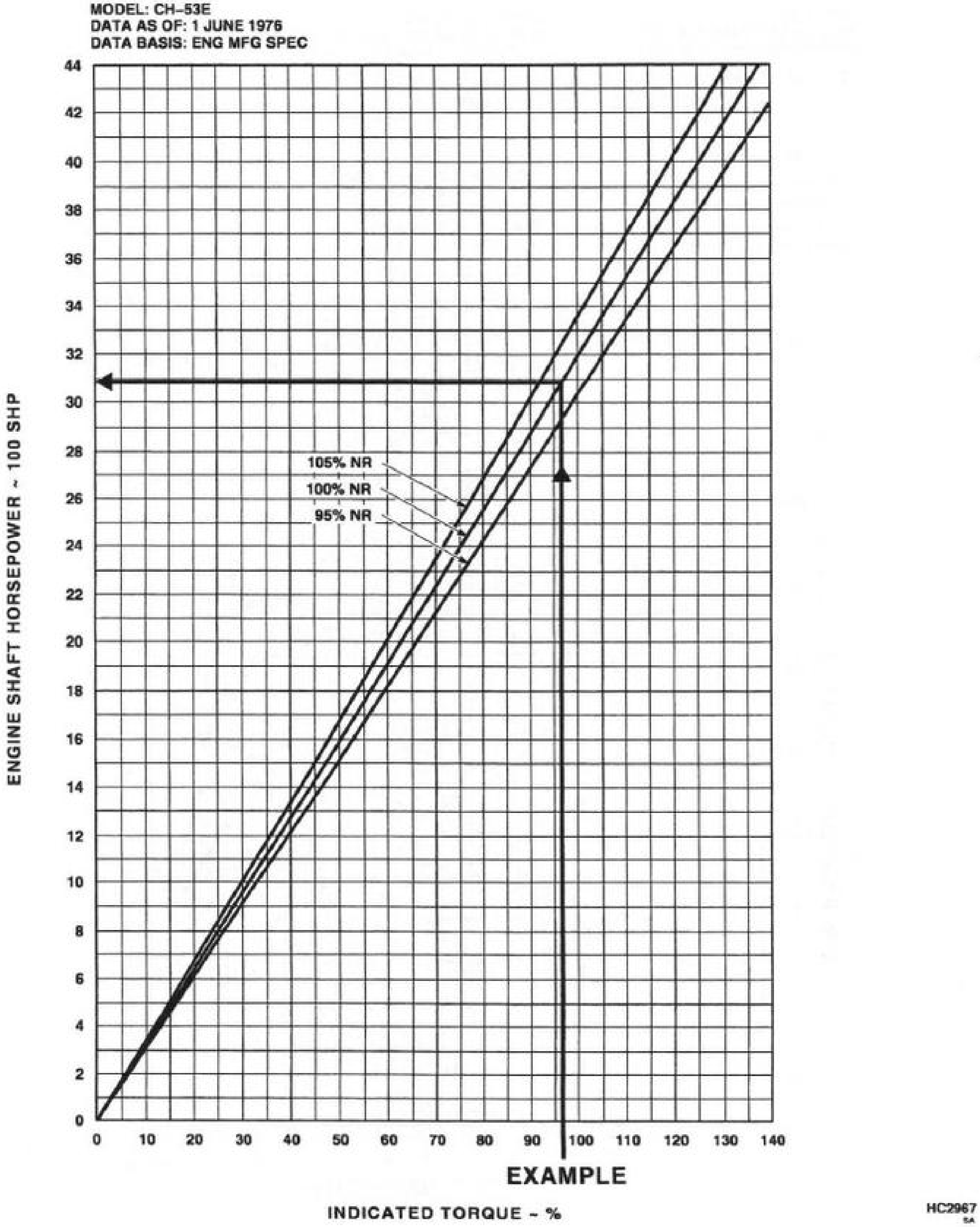


Figure 22-4. Torque vs. Shaft Horsepower

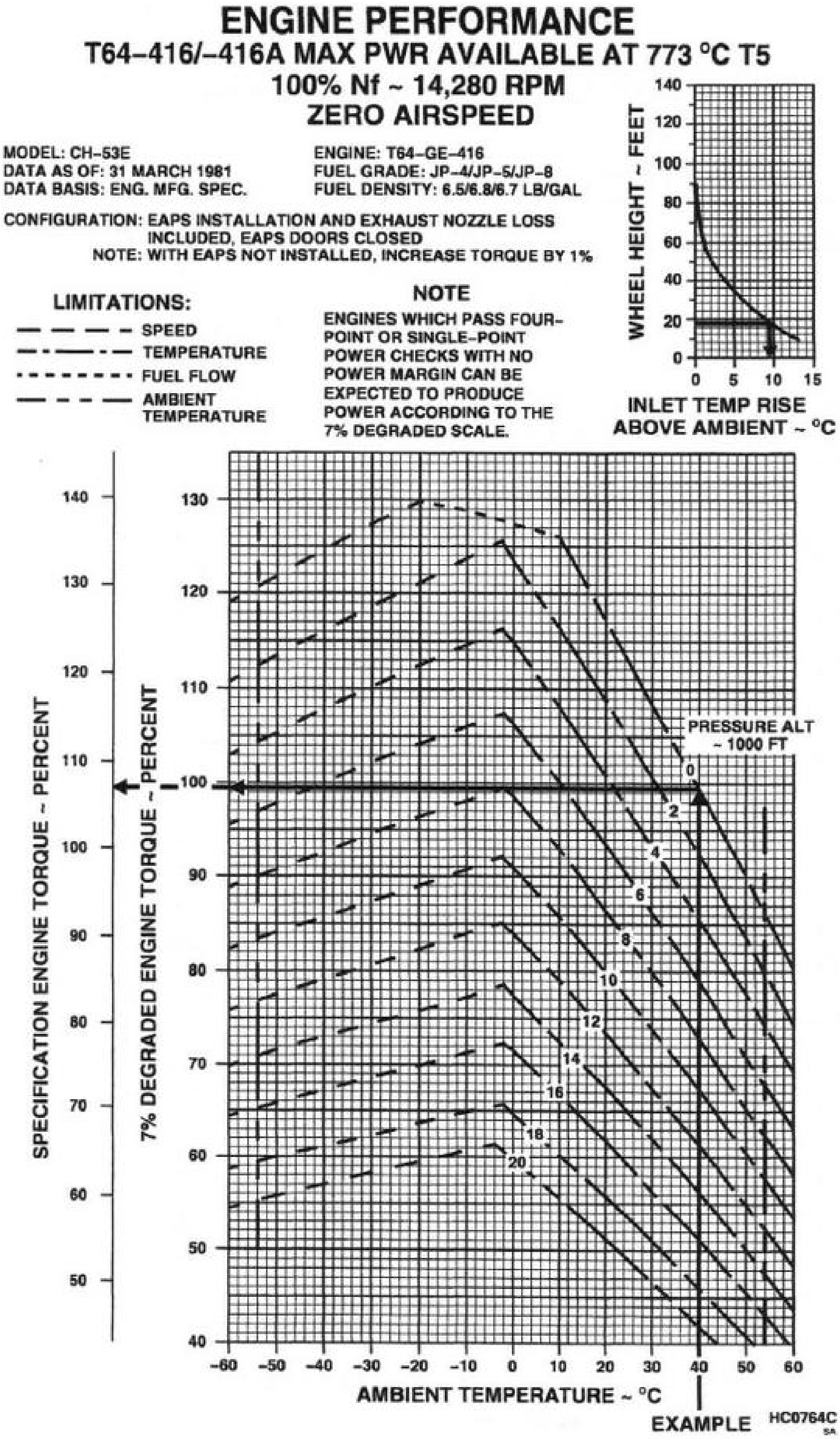


Figure 22-5. Maximum Power Available

ENGINE PERFORMANCE
753 °C T5 MILITARY POWER
100% Nf ~ 14,280 RPM
ZERO AIRSPEED

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: ENG. MFG. SPEC.

ENGINE: T64-GE-416
FUEL GRADE: JP-4/JP-5/JP-8
FUEL DENSITY: 6.5/6.8/6.7 LB/GAL

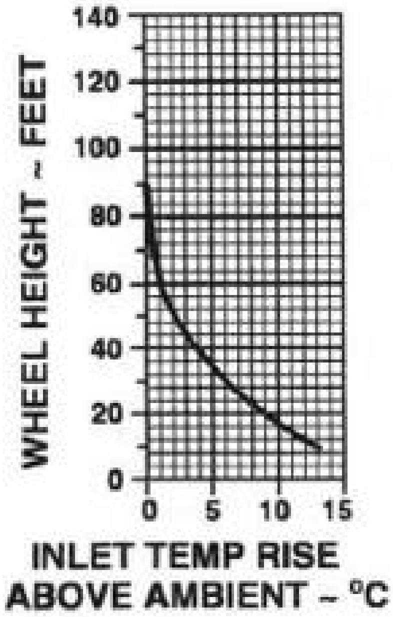
CONFIGURATION: EAPS INSTALLATION AND EXHAUST NOZZLE LOSS INCLUDED, EAPS DOORS CLOSED
NOTE: WITH EAPS NOT INSTALLED, INCREASE TORQUE BY 1%

LIMITATIONS:

- — — — — SPEED
- —·—·— TEMPERATURE
- · · · · · · · FUEL FLOW
- — - - — AMBIENT TEMPERATURE

NOTE

ENGINES WHICH PASS FOUR-POINT OR SINGLE-POINT POWER CHECKS WITH NO POWER MARGIN CAN BE EXPECTED TO PRODUCE POWER ACCORDING TO THE 7% DEGRADED SCALE.



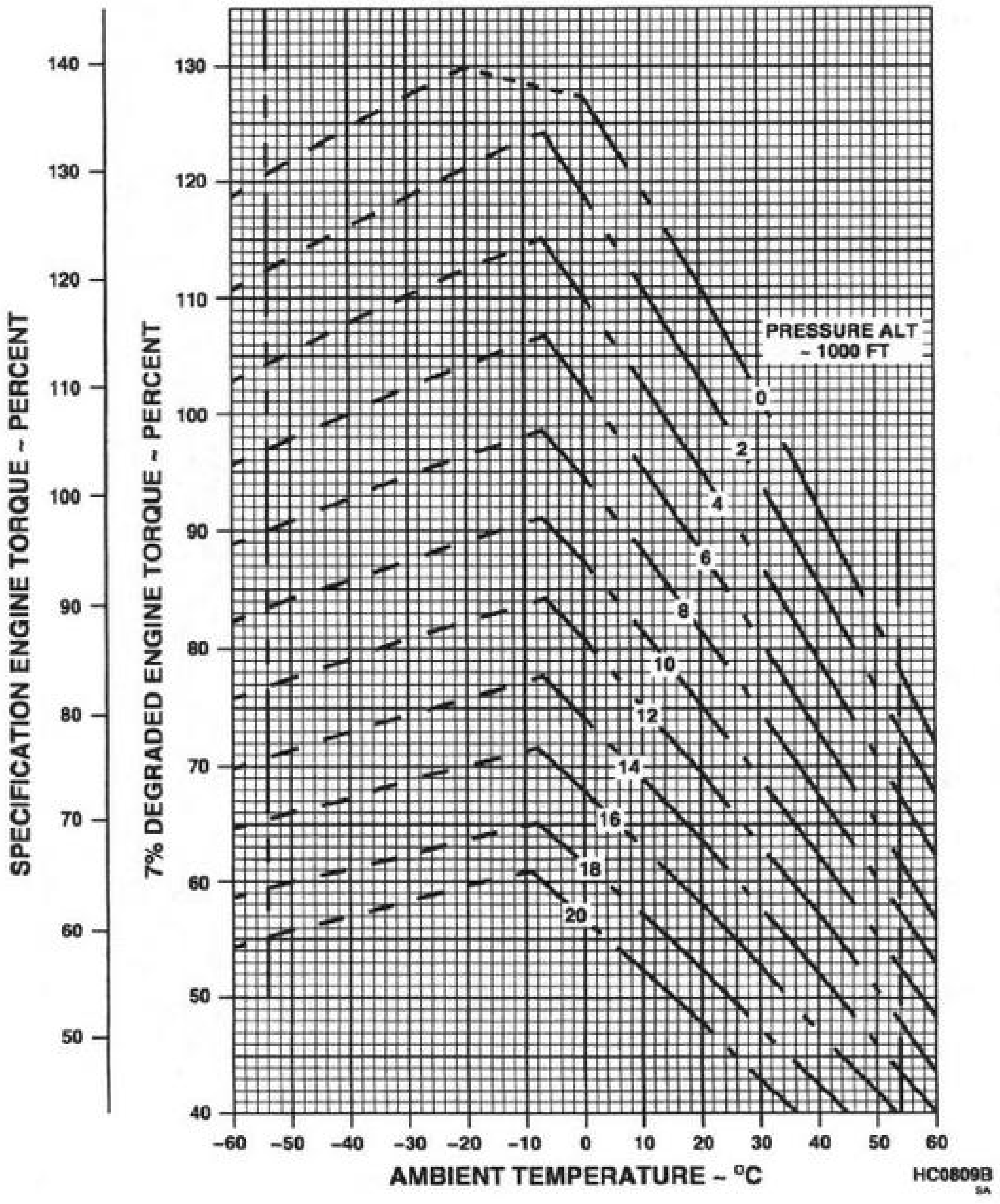


Figure 22-6. Military Power Available

ENGINE PERFORMANCE

T64–416 / –416A MAX PWR AVAILABLE AT 773 °C T_5
103% Nf ~ 14,708 RPM
ZERO AIRSPEED

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: ENG MFG SPEC

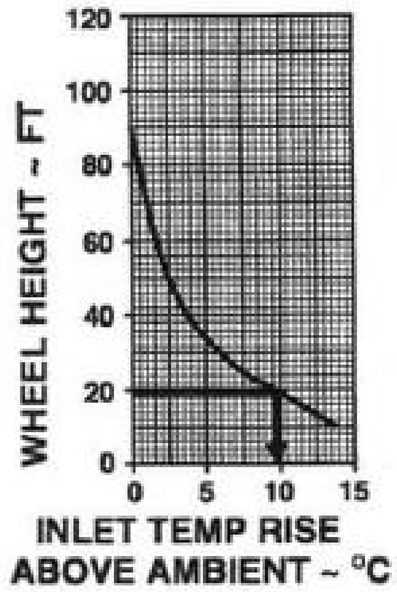
ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EAPS INSTALLATION AND EXHAUST NOZZLE LOSS INCLUDED, EAPS DOORS CLOSED
NOTE: WITH EAPS NOT INSTALLED, INCREASE TORQUE BY 1%

LIMITATIONS:
- — — — — SPEED
- —·—·— TEMPERATURE
- - - - - - - - FUEL FLOW
- —— — — —— AMBIENT TEMPERATURE

NOTE

ENGINES WHICH PASS FOUR-POINT OR SINGLE-POINT POWER CHECKS WITH NO POWER MARGIN CAN BE EXPECTED TO PRODUCE POWER ACCORDING TO THE 7% DEGRADED SCALE.



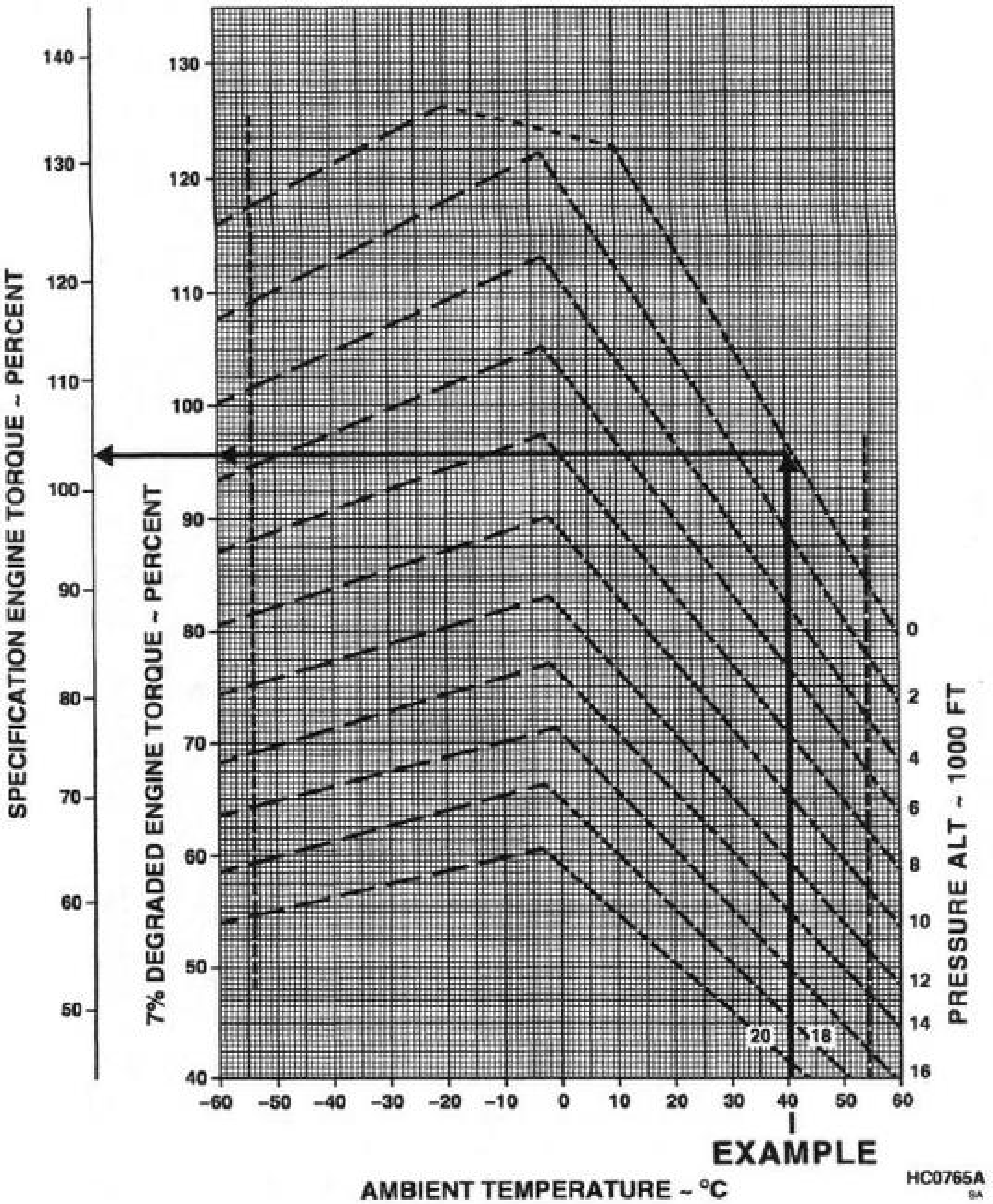
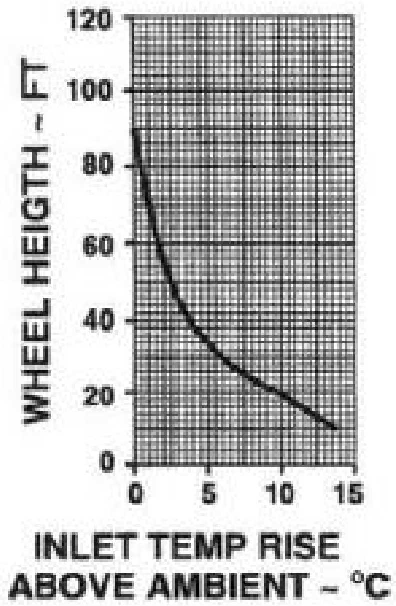


Figure 22-7. Maximum Power Available

ENGINE PERFORMANCE
753°C T5 MILITARY POWER
103% Nf ~ 14,708 RPM

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: ENG MFG SPEC

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL



CONFIGURATION: EAPS INSTALLATION AND EXHAUST NOZZLE LOSS INCLUDED. EAPS DOORS CLOSED
NOTE: WITH EAPS NOT INSTALLED, INCREASE TORQUE BY 1%

LIMITATIONS:

- — — — — SPEED
- —·—·— TEMPERATURE
- · · · · · · · FUEL FLOW
- — - - — AMBIENT TEMPERATURE

NOTE

ENGINES WHICH PASS FOUR-POINT OR SINGLE-POINT POWER CHECKS WITH NO POWER MARGIN CAN BE EXPECTED TO PRODUCE POWER ACCORDING TO THE 7% DEGRADED SCALE.

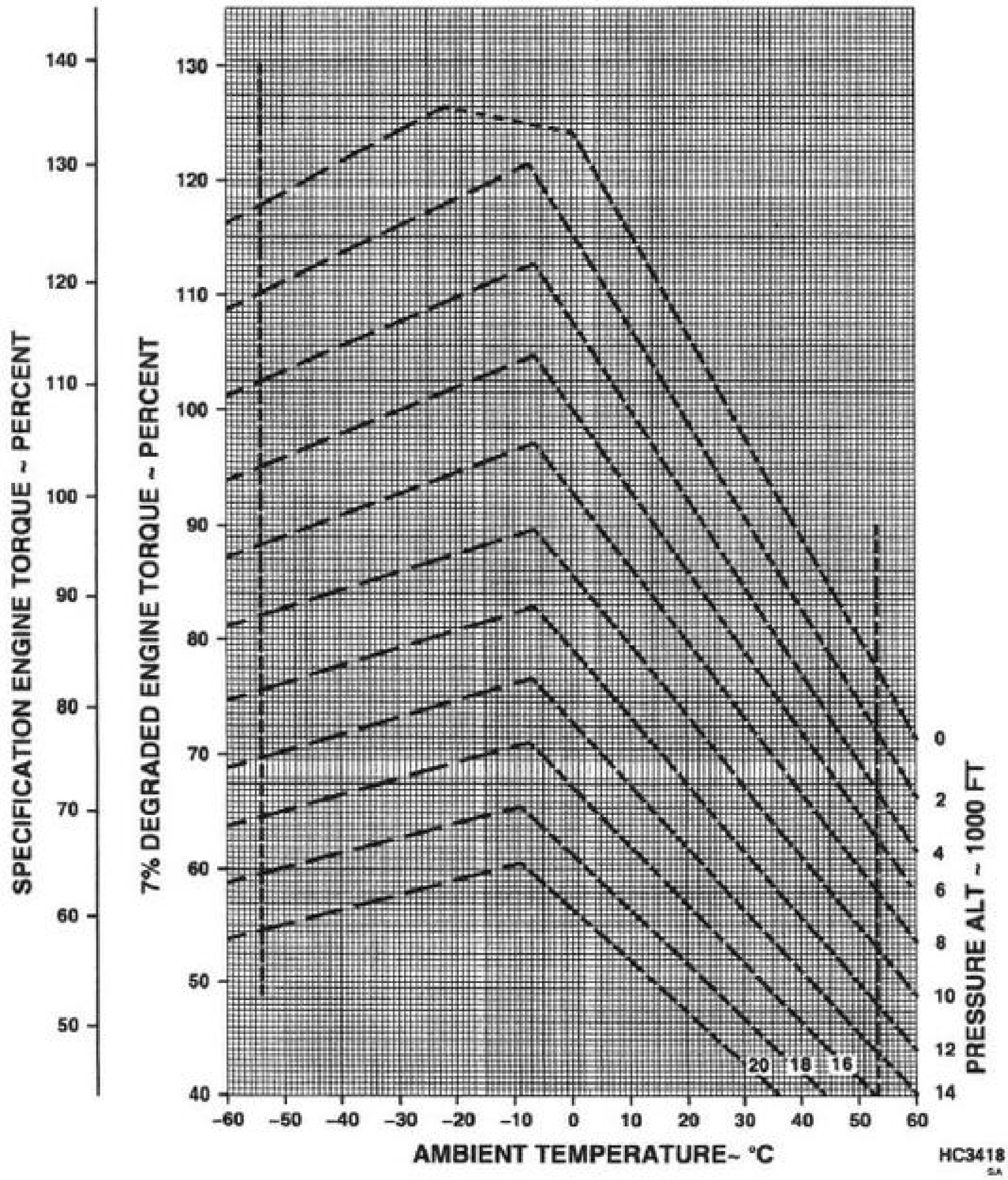


Figure 22-8. Military Power Available

CHAPTER 23
Takeoff

23.1 HOVER CHARTS

The indicated torque required to hover charts provide data for various wheel heights in and out of ground effect, when density altitude is applied to gross weight and headwind factors. The ability to hover out of ground effect at various rotor speeds (N_r) chart provides the gross weight that can be hovered out of ground effect when pressure altitude is applied to outside air temperature and rotor speed factors.

23.1.1 Factors. The charts provide data with external tanks and supports installed. For torque required charts (Figures 23-2 through 23-5) reduce torque required by .6% if tanks and supports off. For ability to hover chart (Figure 23-6) increase gross weight by 300 lb. if tanks and supports off. If EAPS off, increase gross weight by 500 lbs.

23.1.2 Takeoff Distance to Clear 50-Feet Chart. The takeoff chart (Figure 23-1) reads takeoff distance using pressure altitude, ambient temperature and headwind as variables.

For example, if the helicopter was at a gross weight of 50,000 pounds, pressure altitude of 6000 feet, ambient temperature of 0°C, and had a 6-knot headwind, enter the chart at 50,000 pounds gross weight, trace up to 6000 feet pressure altitude. Trace right to the 0°C ambient temperature line. Then trace down to the baseline and follow the influence line from there to 6 knots. Trace straight down to read 500-foot takeoff distance.

23.1.3 Torque Required to Hover at 10-Feet Charts. These charts provide data for when density altitude is applied to gross weight and headwind factors. Figure 23-2 refers to 100% N_r and Figure 23-6 refers to 103% N_r.

For example (using Figure 23-2), to find the torque required for a 10-foot hover at 65,000 pounds gross weight at a density altitude of 8000 feet and with a 20-knot headwind while at 100% N_r, enter the left side of the chart at 8000 feet and trace right to the 65,000-pound gross weight curve. Then trace down to the headwind baseline and follow the influence line to the 20-knot headwind intersection. Trace down and note that 93% torque is required to hover under these conditions.

23.1.4 Torque Required to Hover at 40-Feet Charts. These charts (figures 23-3 for 100% N_r and 23-7 for 103% N_r) are used in the same way as Figure 23-2.

23.1.5 Torque Required to Hover at 70-Feet Charts. These charts (figures 23-4 for 100% N_r and 23-8 for 103% N_r) are used in the same way as Figure 23-2.

23.1.6 Torque Required to Hover OGE Charts. These charts (figures 23-5 for 100% N_r and 23-9 for 103% N_r) are used in the same way as Figure 23-2.

The height established for out of ground effect is 140 feet between the wheels and the takeoff surfaces.

23.1.7 Ability to Hover OGE at Various N_r's Chart. The chart (Figure 23-10) provides the gross weight that the helicopter can hover out of ground effect when pressure altitude is applied to outside air temperature and rotor speed factors.

For example, to find the gross weight a helicopter can hover out-of ground effect at, with a pressure altitude of 4000 feet, 35°C with 105% N_r, enter the left side of the chart at 4000 feet, trace right to 35°C, and then trace down to the rotor speed baseline. Then follow the influence line up to 105% N_r. Now trace down and read 57,500 pounds gross weight.

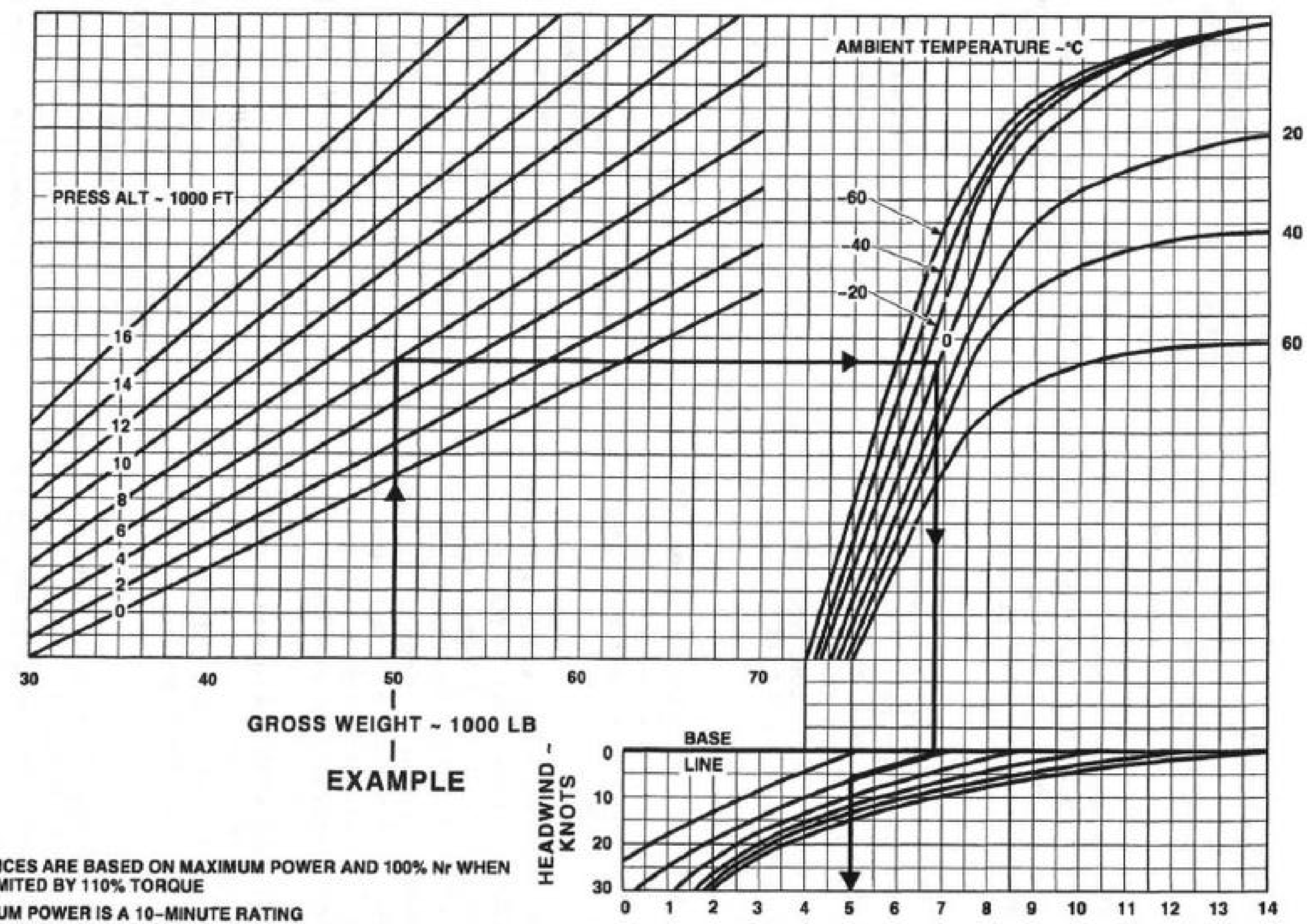
23.1.8 Blade Stall Chart. The blade stall chart (Figure 23-11) gives structural blade stall limits in level flight and level turn as indicated airspeed. This is done using the variables of pressure altitude, temperature, N_r %, gross weight, and angle of bank. For example, enter the chart from the top left at 8000-feet pressure altitude, go right, across to 60°C. Trace down to the first baseline and up the influence line to 105% N_r. Trace down to the second baseline and follow the influence line up to 50,000 pounds gross weight. Now trace down to the last baseline, and follow influence lines to angle of bank of 20°. Trace down to 147 knots CAS and 143 knots IAS.

THREE–ENGINE ROLLING TAKEOFF
TOTAL DISTANCE TO CLEAR 50 FEET

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: ESTIMATED

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON



NOTES

- DISTANCES ARE BASED ON MAXIMUM POWER AND 100% Nr WHEN NOT LIMITED BY 110% TORQUE
- MAXIMUM POWER IS A 10–MINUTE RATING
- TAKEOFFS MADE BY GROUND (ROLLING) ACCELERATION
- FLIGHT PATH – ACCELERATE ON THE GROUND TO 43 KIAS (25 KCAS) THEN ACCELERATE AND CLIMB TO CLEAR 50 FOOT BARRIER AT 55 KIAS (40 KCAS)

HC2968
SA

Figure 23-1. Takeoff Distance to Clear 50 Feet

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

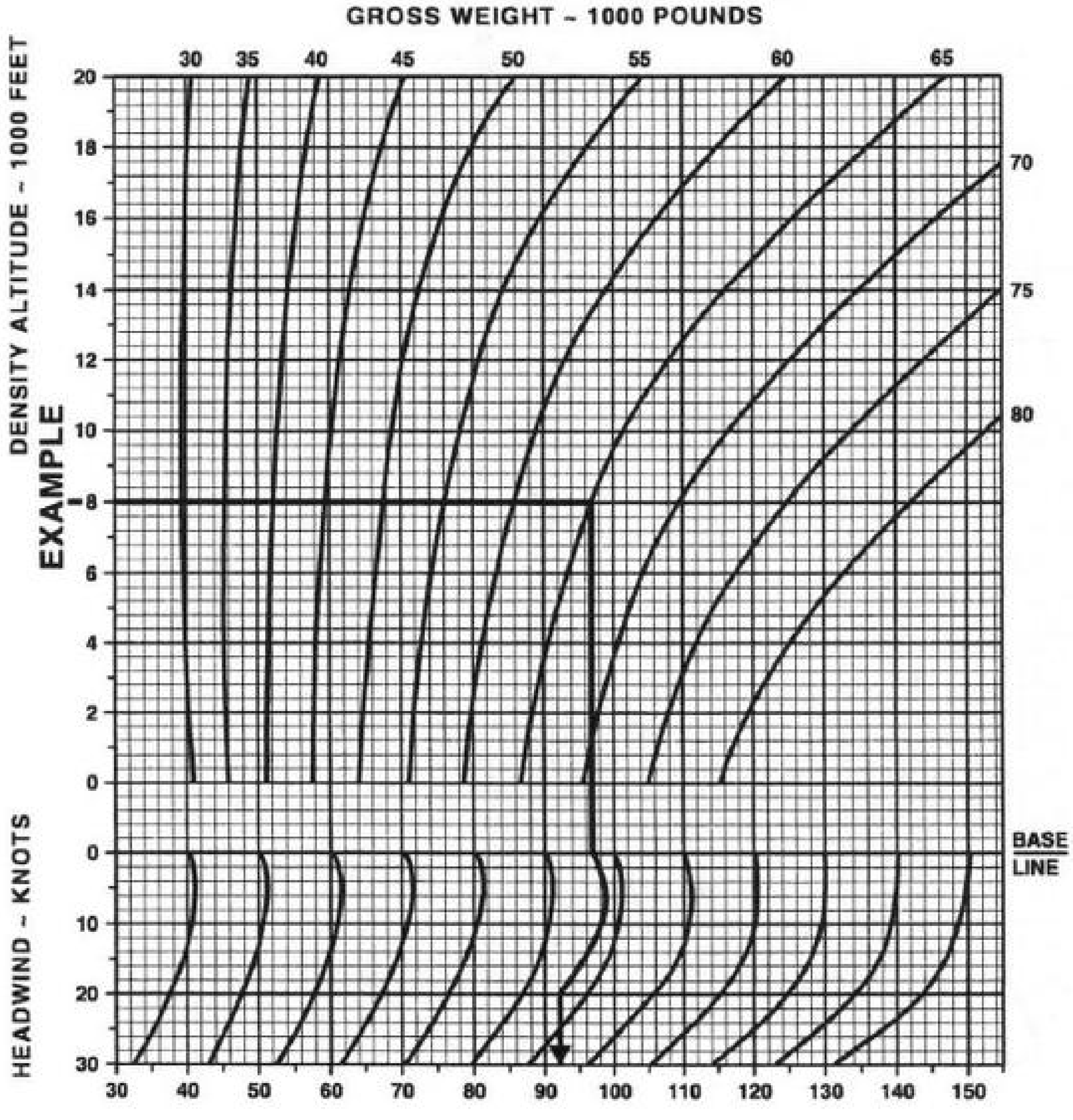
10-FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE

REDUCE TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS OFF.



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SA

Figure 23-2. Torque Required to Hover at 10 Feet (100% N_r)

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

40-FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE

REDUCE TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS OFF.

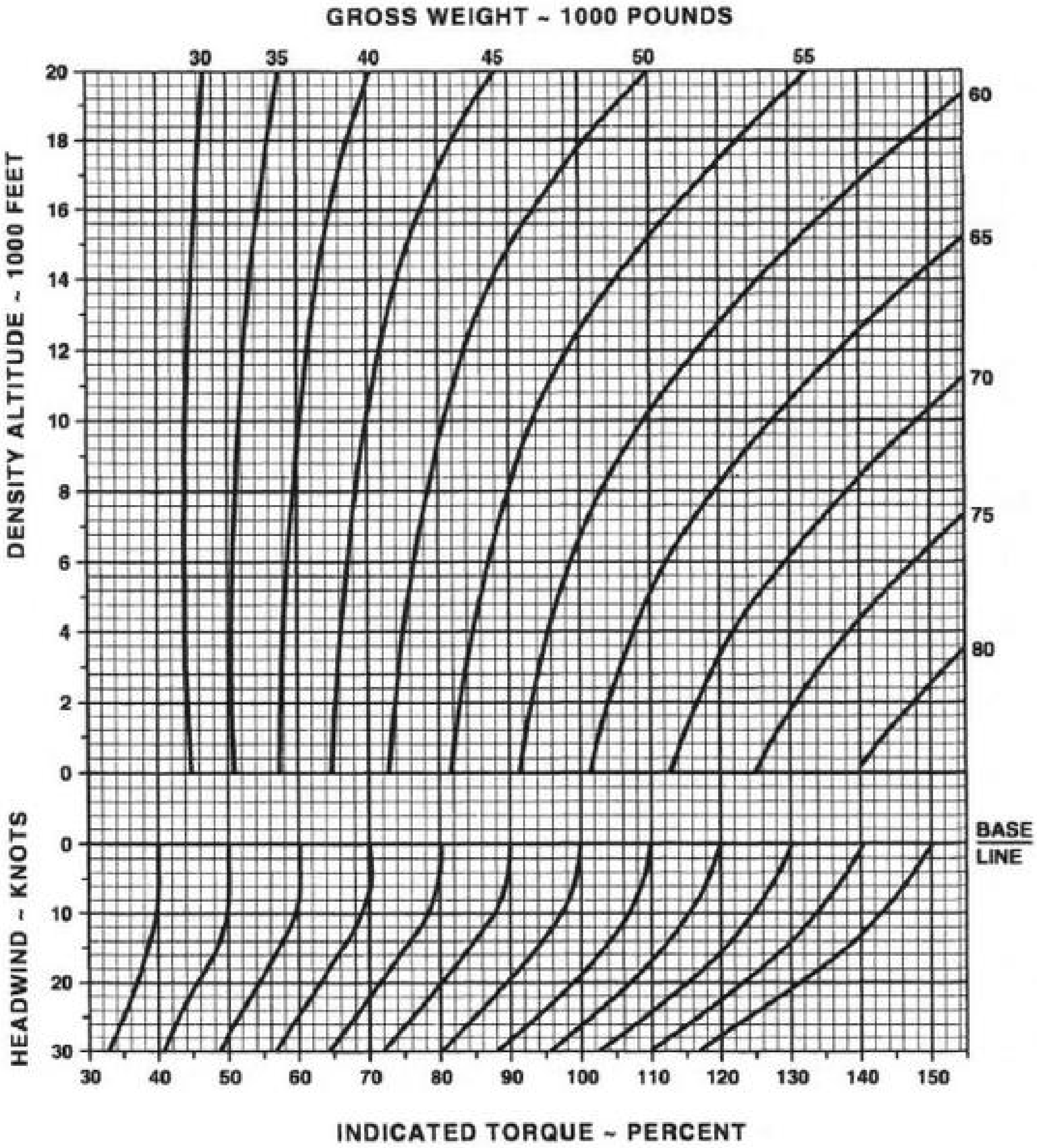

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Figure 23-3. Torque Required to Hover at 40 Feet (100% N_r)

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

70–FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
100% Nr

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE

REDUCE TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS OFF.

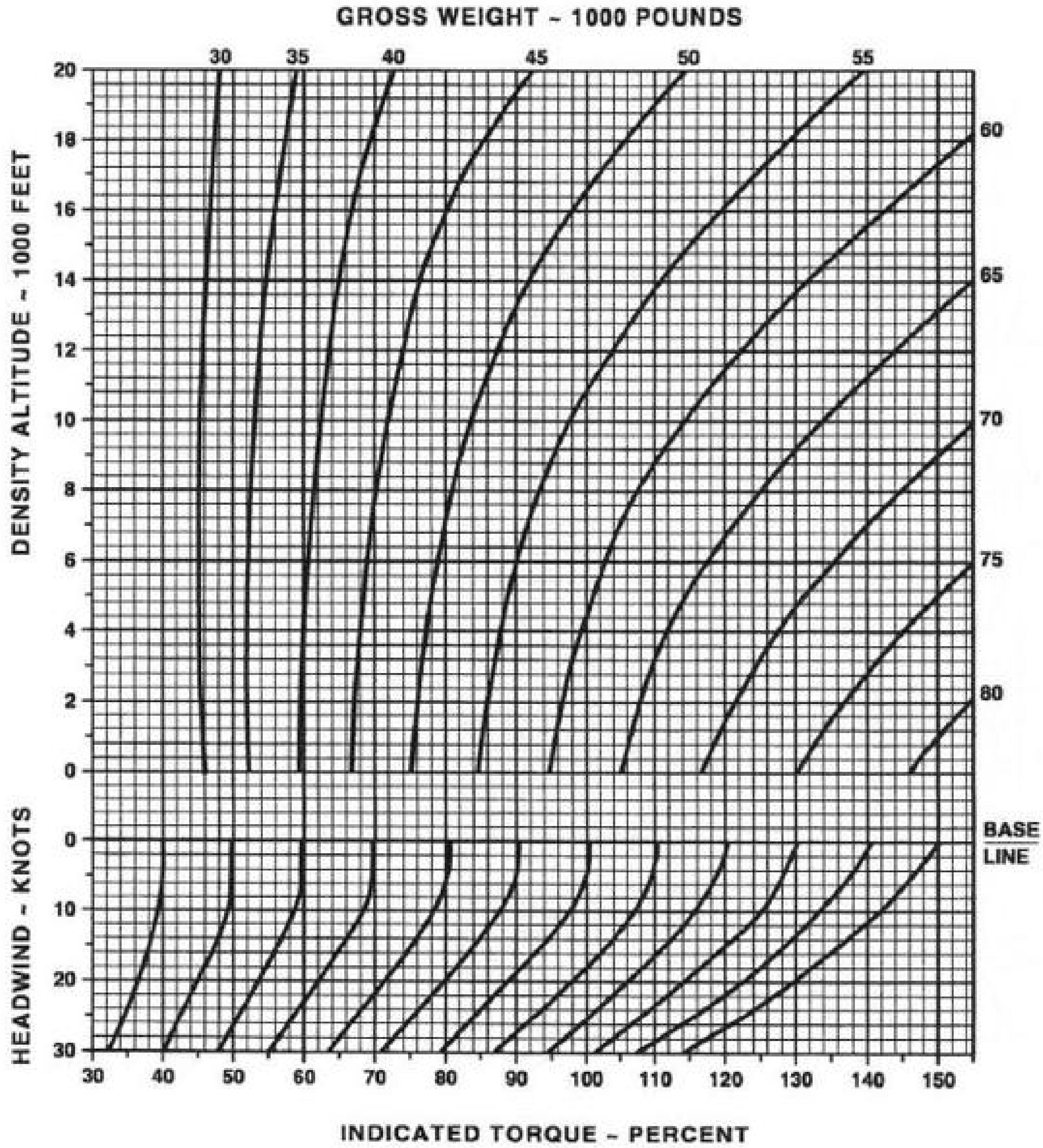

Figure 23-4. Torque Required to Hover at 70 Feet (100% N_r)

INDICATED TORQUE REQUIRED TO HOVER OUT OF GROUND EFFECT

STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE

REDUCE TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS OFF.

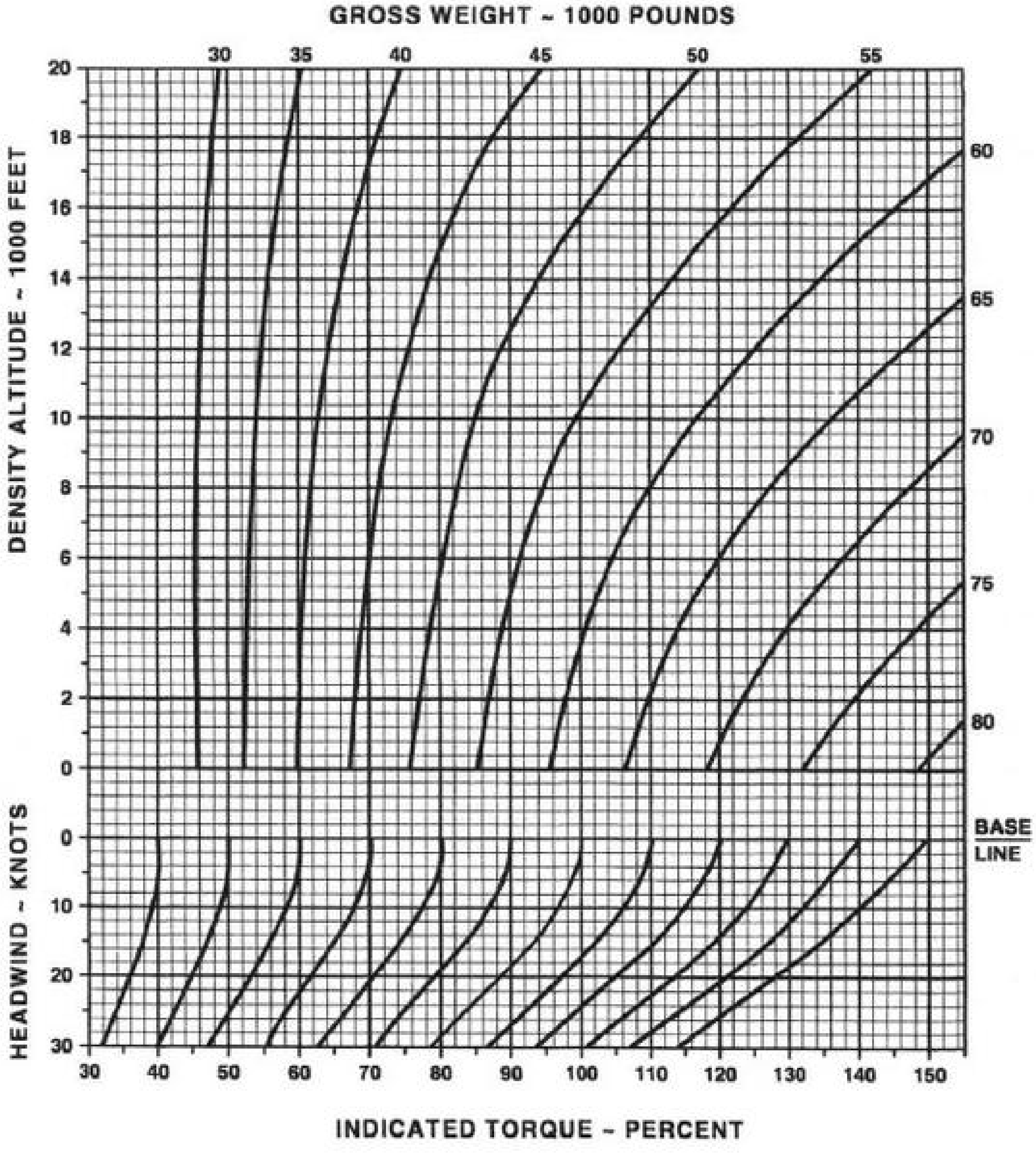

Figure 23-5. Torque Required to Hover OGE (100% N_r)

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

10-FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
103% Nr

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS INSTALLED

NOTE

ADD TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS ARE INSTALLED.

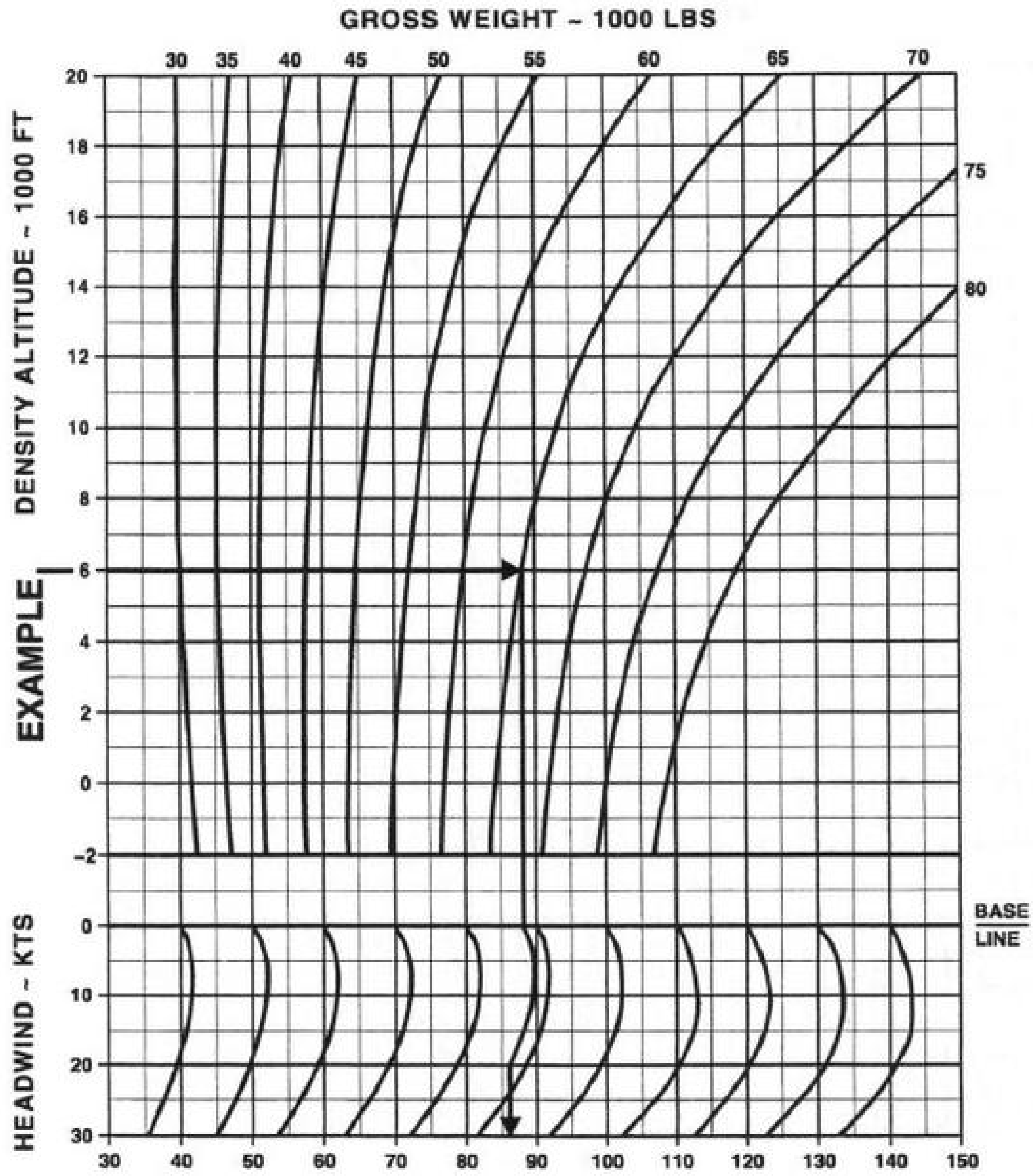

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Figure 23-6. Torque Required to Hover at 10 Feet (103% N_r)

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

40–FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
103% Nr

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS INSTALLED

NOTE

ADD TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS ARE INSTALLED.

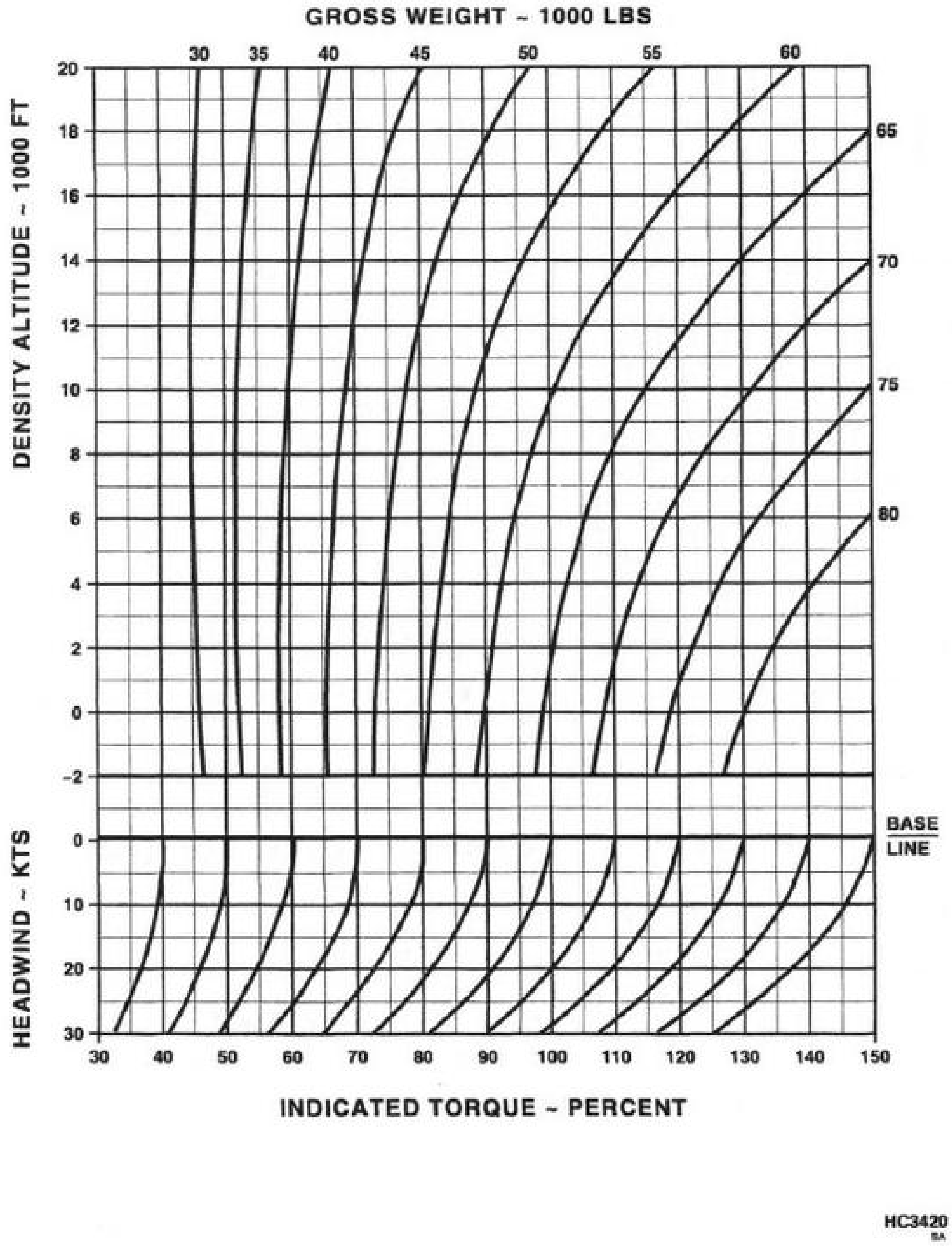


Figure 23-7. Torque Required to Hover at 40 Feet (103% N_r)

INDICATED TORQUE REQUIRED TO HOVER IN GROUND EFFECT

70-FOOT WHEEL HEIGHT
STANDARD TEMPERATURE
103% Nr

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS INSTALLED

NOTE

ADD TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS ARE INSTALLED.

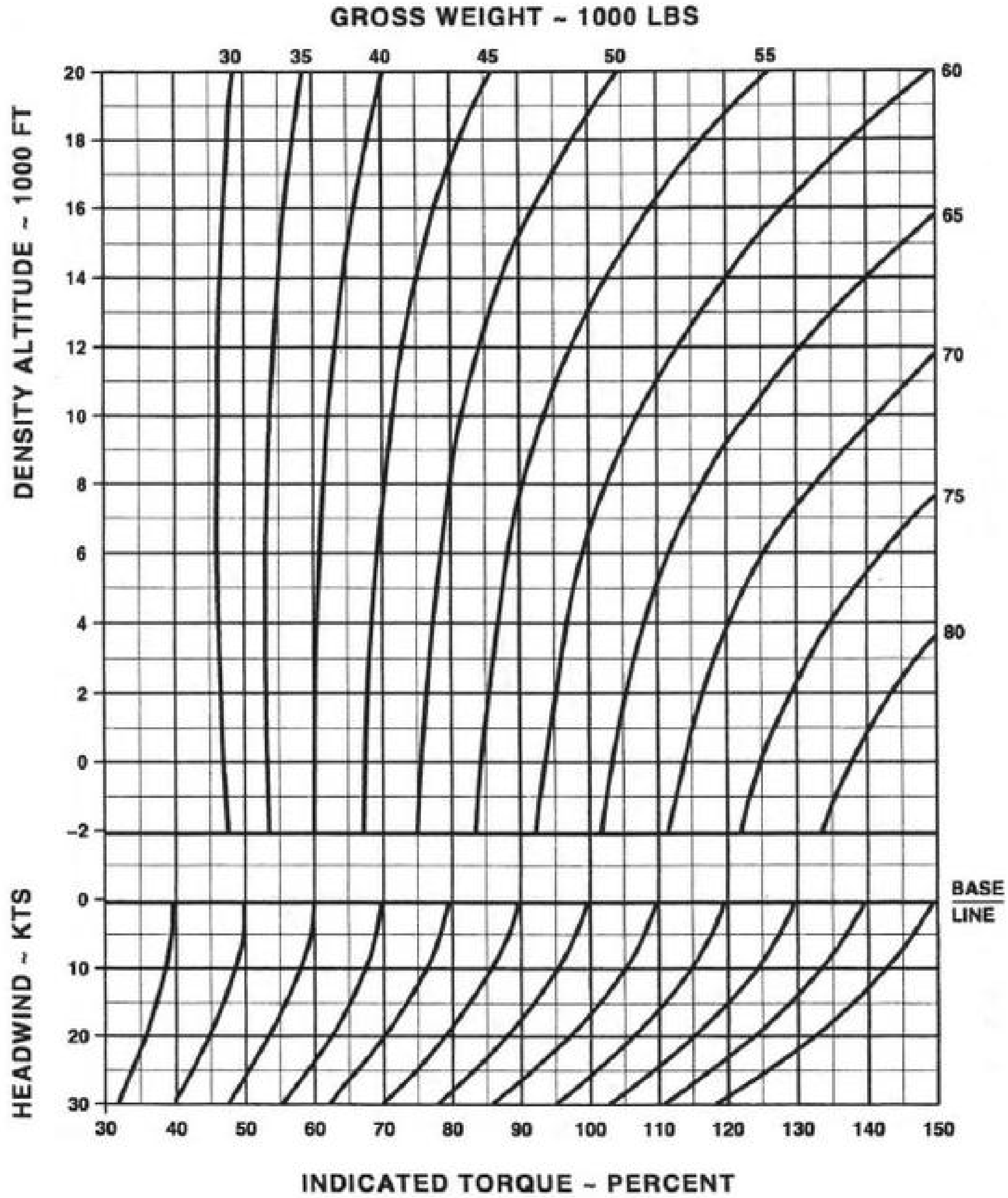


Figure 23-8. Torque Required to Hover at 70 Feet (103% N_r)

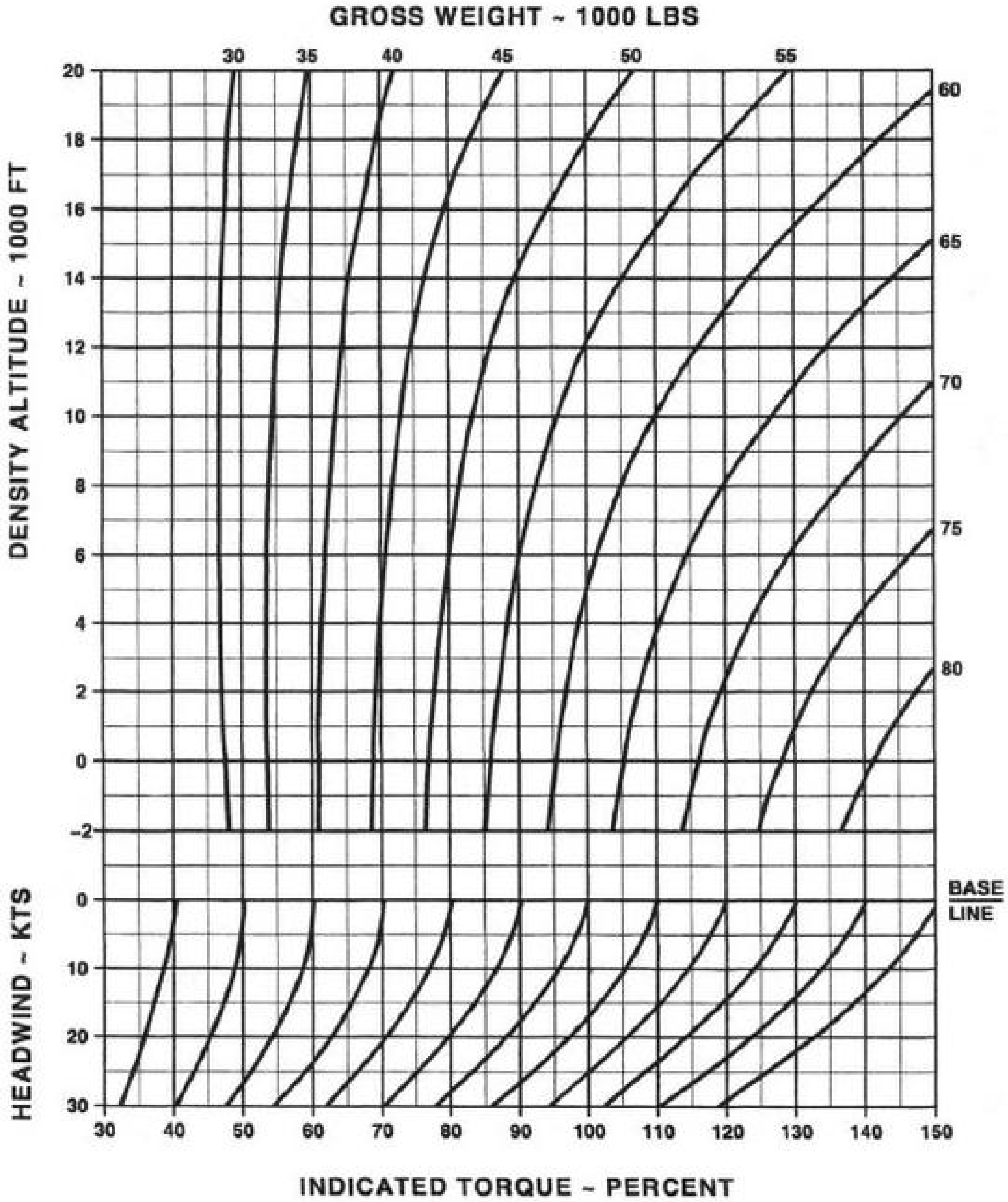
INDICATED TORQUE REQUIRED TO HOVER OUT OF GROUND EFFECT
STANDARD TEMPERATURE
103% Nr

MODEL: CH-53E
DATA AS OF: 1 OCTOBER 1986
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS INSTALLED

NOTE

ADD TORQUE REQUIRED BY 0.6% IF TANKS AND SUPPORTS ARE INSTALLED.



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SA

Figure 23-9. Torque Required to Hover OGE (103% N_r)

THREE–ENGINE ABILITY TO HOVER OUT OF GROUND EFFECT AT VARIOUS ROTOR SPEEDS MAXIMUM POWER

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTES:

- WITH EXTERNAL TANKS OFF, INCREASE WEIGHT BY 300 POUNDS DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.
- – — – 30 MINUTE TRANSMISSION TORQUE RATING IN UPPER CHART
- WHEN LIMITED BY TRANSMISSION RATING USE DASHED INFLUENCE LINES ON ROTOR RPM SCALE
- INCREASE GROSS WEIGHT BY 300 LBS IF TANK AND SUPPORTS OFF. INCREASE WEIGHT BY 500 LBS WITH EAPS NOT INSTALLED.

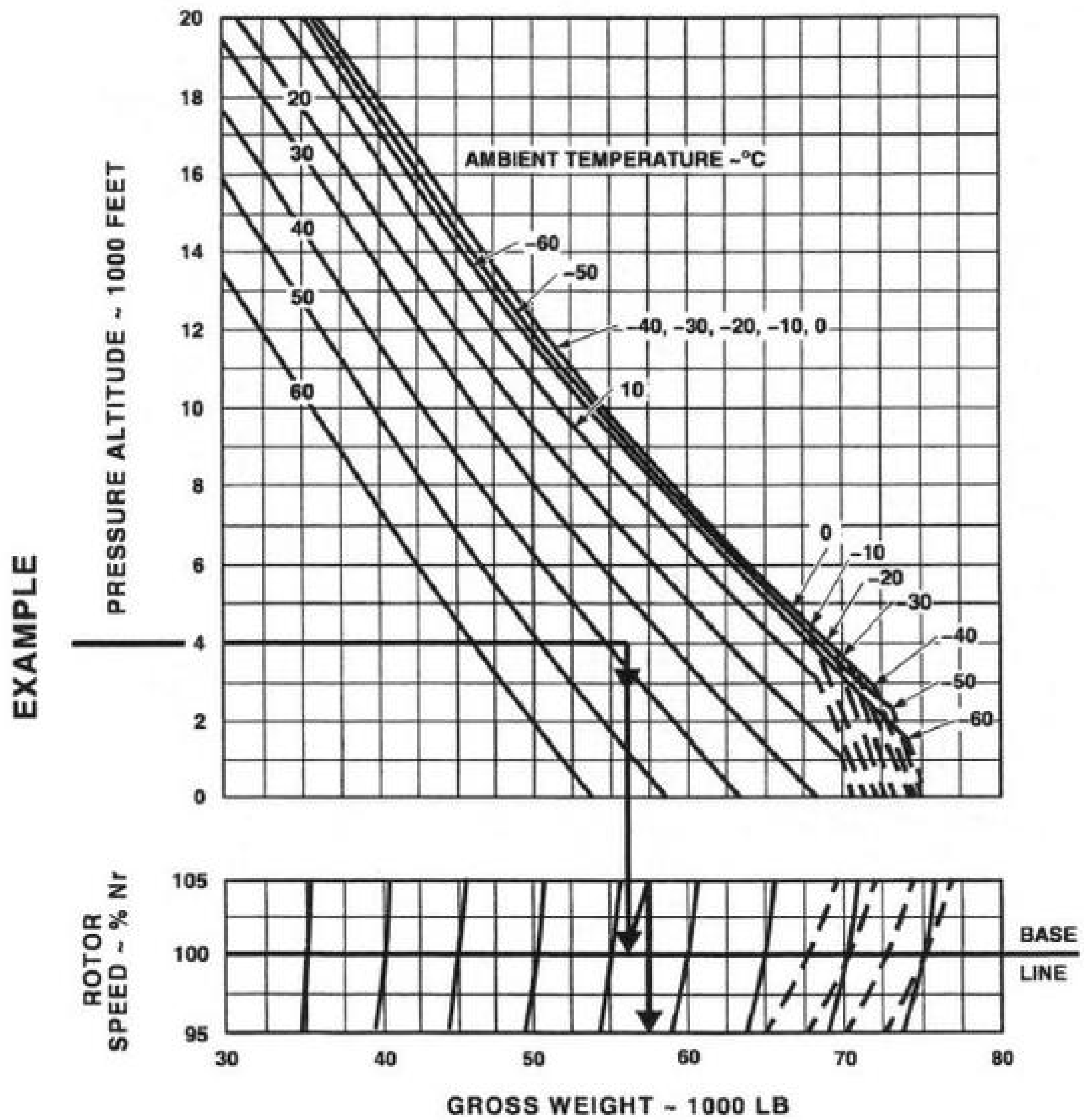

Figure 23-10. Ability to Hover OGE at Various N_r's

INCIPIENT BLADE STALL

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

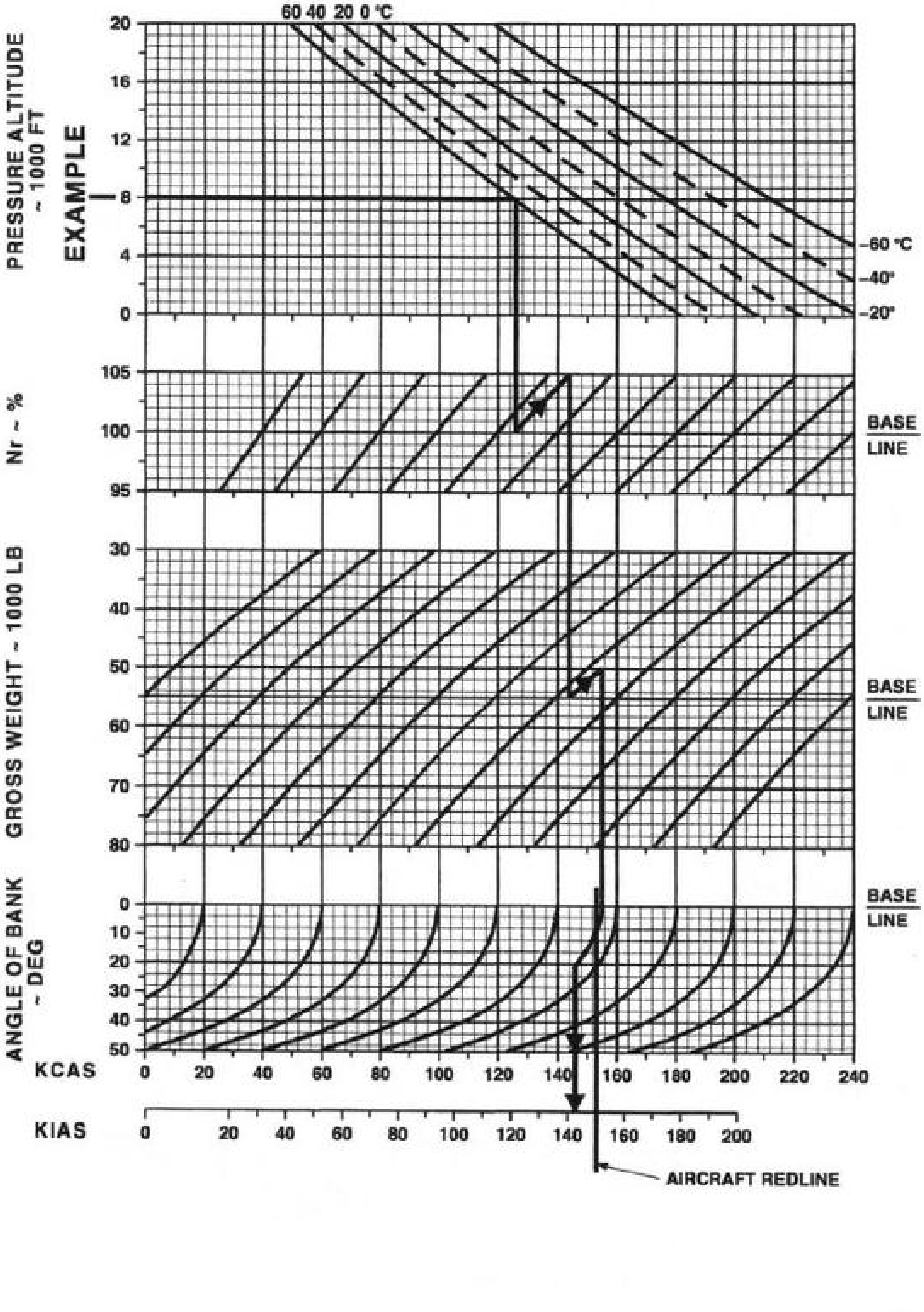

Figure 23-11. Blade Stall Chart

CHAPTER 24
Climb

24.1 THREE-ENGINE CLIMB AT MILITARY POWER — COLD DAY

The chart (Figure 24-1) provides the time to climb, horizontal distance covered, fuel consumed, rate of climb, at various gross weights, for a cold day.

Note

> Since the takeoff is from above a sea level pressure altitude, it will be necessary to determine climb data from sea level pressure altitude to 2000 feet pressure altitude and from sea level pressure altitude to 4000 feet pressure altitude. The difference between the data necessary to climb to both altitudes will then be the data necessary to climb from 2000 feet pressure altitude to 4000 feet pressure altitude.

1. Enter bottom of chart at 40,000 pounds gross weight, trace up to 2000 feet pressure altitude in the time parameter block, then trace left to the temperature baseline. Follow the influence line to the 420°C line, then trace left and note that time to climb to 2000 feet pressure altitude is 1 minute. Follow the same procedure to determine that the time to climb to 4000 feet pressure altitude and 415°C OAT is 1.25 minutes. The difference between the time to climb to 2000 feet pressure altitude and the time to climb to 4000 feet pressure altitude is 0.25 minutes, which is the computed time to climb from 2000 to 4000 feet pressure altitude.

2. Enter bottom of chart at 40,000 pounds gross weight, trace up to 2000 feet pressure altitude in the distance parameter block, then trace left to the parameter baseline. Follow the influence line to the 420°C line, then trace left and note that the distance covered in a climb to 2000 feet pressure altitude is 1 nautical mile. Follow the same procedure to determine that the distance covered in a climb to 4000 feet pressure altitude and 415°C OAT is 1 nautical mile. The difference between the distance covered to climb to 2000 feet pressure altitude and the distance covered to climb to 4000 pressure altitude is zero, which is the computed distance covered to climb from 2000 to 4000 feet pressure altitude.

3. Enter bottom of chart at 40,000 pounds gross weight, trace up to the 2000 feet pressure altitude in the fuel parameter block, then trace left to the temperature baseline. Follow the influence line to the 420°C line, then trace left and note the fuel consumed in a climb to 2000 feet pressure altitude is 525 pounds. Follow the same procedure to determine that the amount of fuel consumed in a climb to a pressure altitude of 4000 feet and 415°C OAT is 500 pounds. The difference between the fuel used to climb to 2000 feet pressure altitude and the fuel used to climb to 4000 feet pressure altitude is 25 pounds, which is less the computed fuel used to climb from 2000 to 4000 feet pressure altitude. Take 250 pounds of fuel for warmup and taxi. Subtract the 25 pounds to show a total fuel consumption of 200 pounds to takeoff from a 2000 feet pressure altitude site and climb to a 4000-foot pressure altitude level.

4. Enter bottom of chart at 40,000 pounds gross weight, trace up to 4000 feet pressure altitude in the rate of climb parameter block, then trace left to the temperature baseline. Follow the influence line to the 420°C line, then trace left and note 4300 feet-per-minute initial rate of climb. Follow the same procedure to determine that the final rate of climb at 4000 feet pressure altitude and 415°C OAT is 4400 feet-per-minute. The average rate of climb is 4350 feet-per-minute.

5. Enter left side of climb speed schedule at 2000 feet pressure altitude, trace right to the best climb speed curve, then trace down and read best climb speed of 96 KIAS. Follow the same procedures to determine that the best climb speed for 4000 pressure altitude is 94 KIAS. Note that the initial rate of climb of 4300 feet per minute at 96 KIAS changes to 4400 feet per minute at 94 KIAS.

24.2 THREE-ENGINE CLIMB AT MILITARY POWER — WARM DAY CHART

The chart (Figure 24-2) uses like factors in the same way as Figure 24-1.

THREE-ENGINE CLIMB
753 °C MILITARY POWER
30 MINUTE LIMITATION
COLD DAY

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: CLIMB POWER LIMITED TO 110% TORQUE FOR GROSS WEIGHTS BELOW 60,000 LBS
NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT

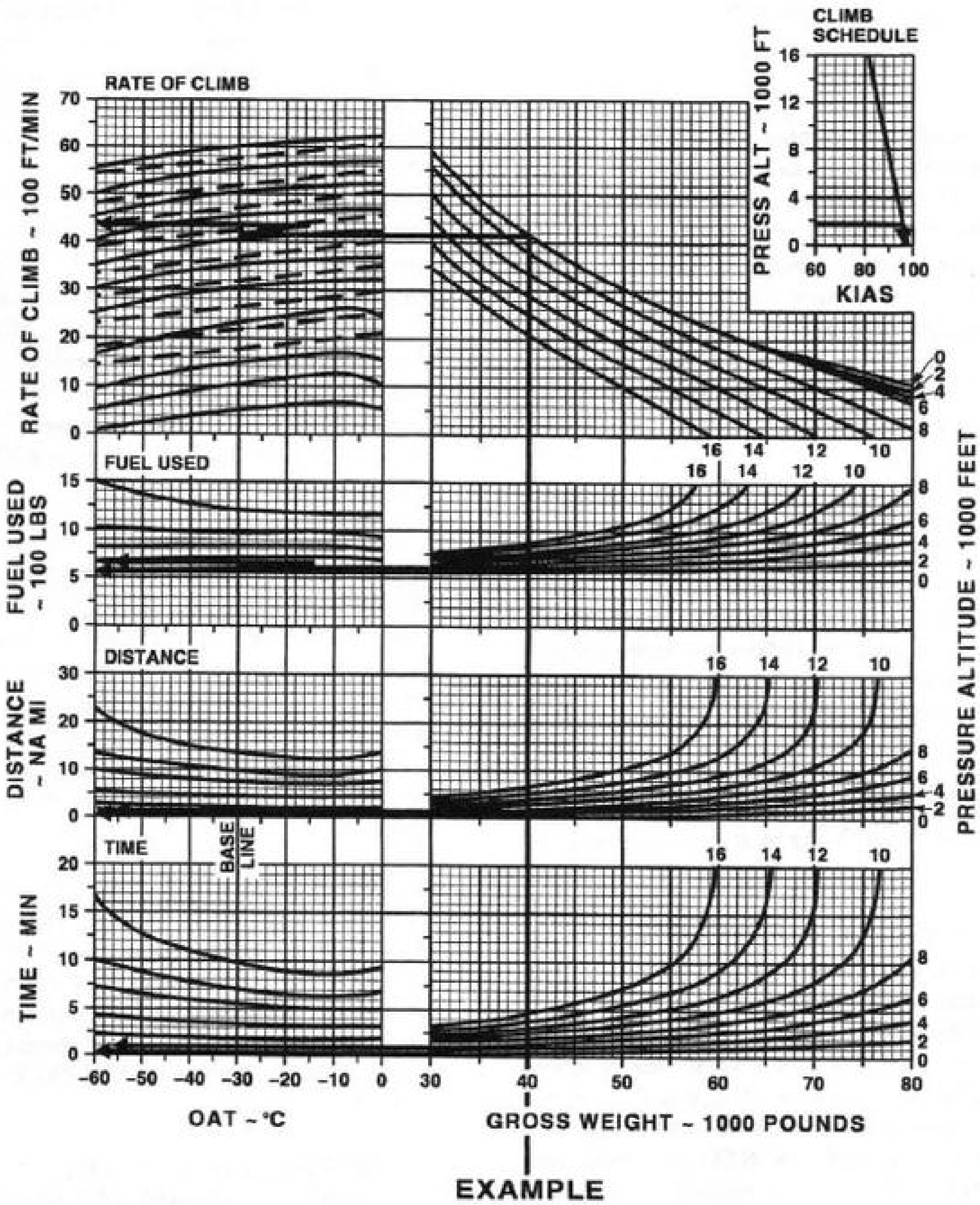

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Figure 24-1. Three-Engine Climb at Military Power — Cold Day

THREE-ENGINE CLIMB

753 °C T5 MILITARY POWER
30 MINUTE LIMITATION
WARM DAY

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: CLIMB POWER LIMITED TO 110% TORQUE FOR GROSS WEIGHTS BELOW 60,000 LBS
NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT

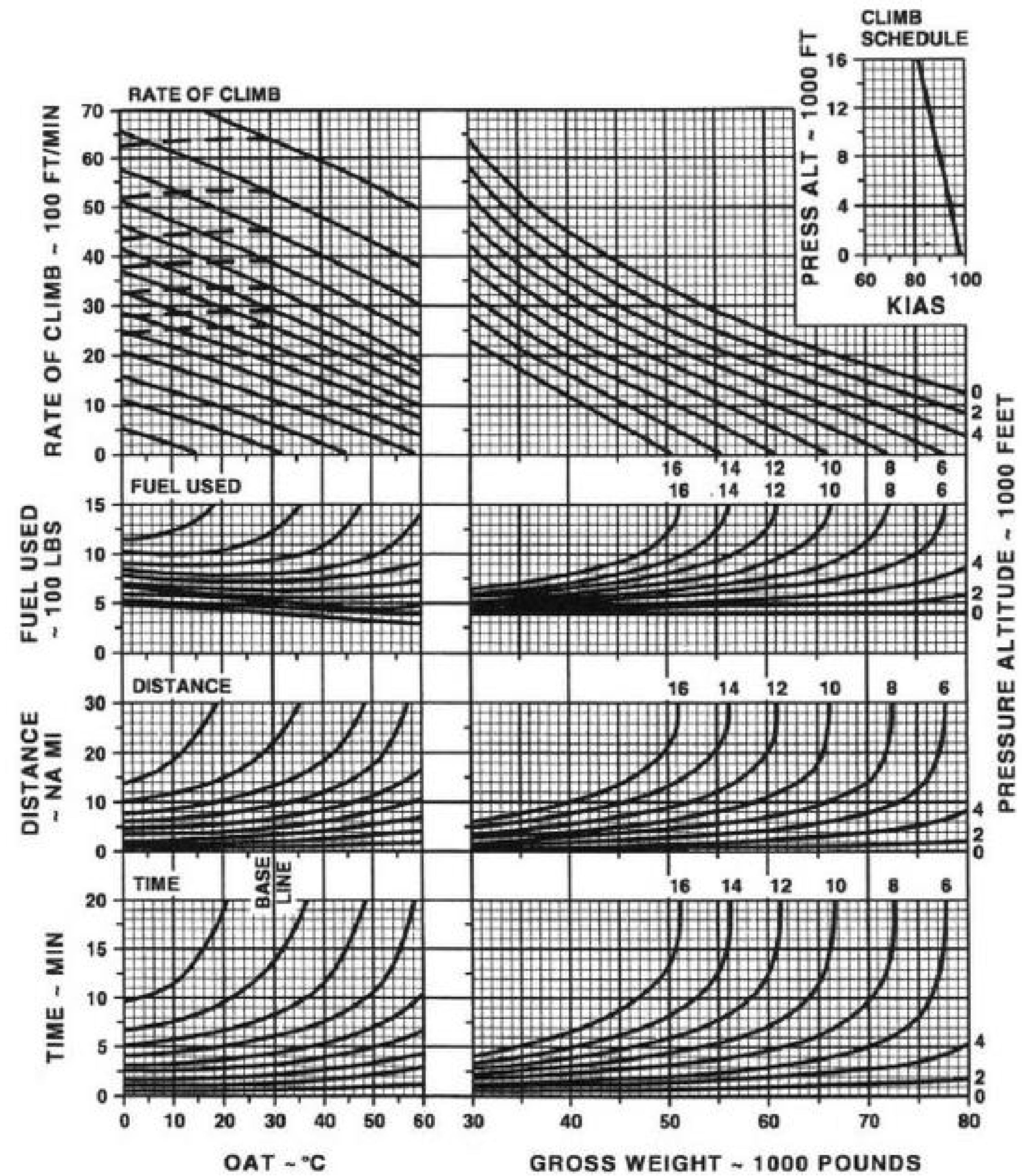


Figure 24-2. Three-Engine Climb at Military Power — Warm Day

CHAPTER 25
Range/Cruise

25.1 RANGE/CRUISE CHARTS

The range charts provide unit range, indicated and calibrated airspeed, and approximate torque when gross weight is applied to pressure altitude. The optimum cruise altitude chart provides data for determining the pressure altitude and airspeed that will produce optimum cruising range based on gross weight and ambient temperature.

25.1.1 Factors. The charts provide data with external tanks, supports, and EAPS installed. For maximum range charts (Figure 25-1 through 25-3) increase the specific range at a given weight by .001, and the speed by two knots if tanks and supports off; and increase specific range by .001, and speed by two knots if EAPS off. For maximum continuous power range charts (Figure 25-4) increase the specific range by .0004, and the speed by two knots if tanks and supports off; and increase specific range by .0004, and speed by two knots if EAPS off. For dual engine maximum range or maximum continuous power charts (Figures 25-5 through 25-8) increase specific range by .001, and speed by two knots if tanks and supports off; and increase specific range by .001, and speed by two knots if EAPS off.

25.1.2 Three-Engine Maximum Range, Standard Temperature +40°C Chart. The chart (Figure 25-1) provides the unit range, indicated and calibrated airspeed, and approximate torque when gross weight is applied to pressure altitude to produce maximum range for the helicopter.

For example, to find the unit range, cruise speed, and torque required for maximum range at 50,000 pounds gross weight at a pressure altitude of 6000 feet, enter the bottom of the chart at 50,000 pounds gross weight. Trace up to the 6000-foot curve, then trace left and read the unit range in nautical miles per pound of fuel 0.0435. Enter the next grid at 50,000 pounds, trace up to the 6000-foot curve, and then trace left and read 118 KIAS, the cruise speed required for maximum range. The approximate torque required to maintain this speed is found by entering the next grid at 50,000 pounds, tracing up to the 6000-foot curve, and then tracing left to read 61.0% torque.

25.1.3 Three-Engine Maximum Range, Standard Temperature Chart. The chart (Figure 25-2) is used the same way as Figure 25-1).

25.1.4 Three-Engine Maximum Range, Standard Temperature -40°C Chart. The chart (Figure 25-3) is used the same way as Figure 25-1.

25.1.5 Three-Engine Range at Maximum Continuous Power Chart. The chart (Figure 25-4) is used the same way as Figure 25-1.

25.1.6 Dual-Engine Maximum Range, Standard Temperature +40°C Chart. The chart (Figure 25-5) is used the same way as Figure 25-1.

25.1.7 Dual-Engine Maximum Range, Standard Temperature Chart. The chart (Figure 25-6) is used the same way as Figure 25-1.

25.1.8 Dual-Engine Maximum Range, Standard Temperature -40°C Chart. The chart (Figure 25-7) is used the same way as Figure 25-1.

25.1.9 Dual-Engine Range at Maximum Continuous Power Chart. The chart (Figure 25-8) is used the same way as Figure 25-1.

25.1.10 Optimum Cruise Altitude, Standard Temperature +40°C Chart. The chart (Figure 25-9) provides data for determining the pressure altitude and airspeed that will produce optimum cruising range based on gross weight and ambient temperature. Unit range and approximate torque required for optimum range may also be determined from this chart. Conditions at which two-engine operation will result in extending cruise range beyond that provided by three-engine operation may also be determined from this chart.

For example, using 50,000 pounds, trace from the bottom of the chart up to the range, calibrated airspeed, pressure altitude and torque graphs, respectively. Then trace left on each one to read 0.0435 nautical miles-per-pound, 110 knots CAS, 105 knots IAS, 10,000 feet pressure altitude and 60% torque, respectively.

25.1.11 Optimum Cruise Altitude, Standard Temperature Chart. The chart (Figure 25-10) is used the same way as Figure 25-9.

25.1.12 Optimum Cruise Altitude, Standard Temperature -40°C Chart. The chart (Figure 25-11) is used the same way as Figure 25-9.

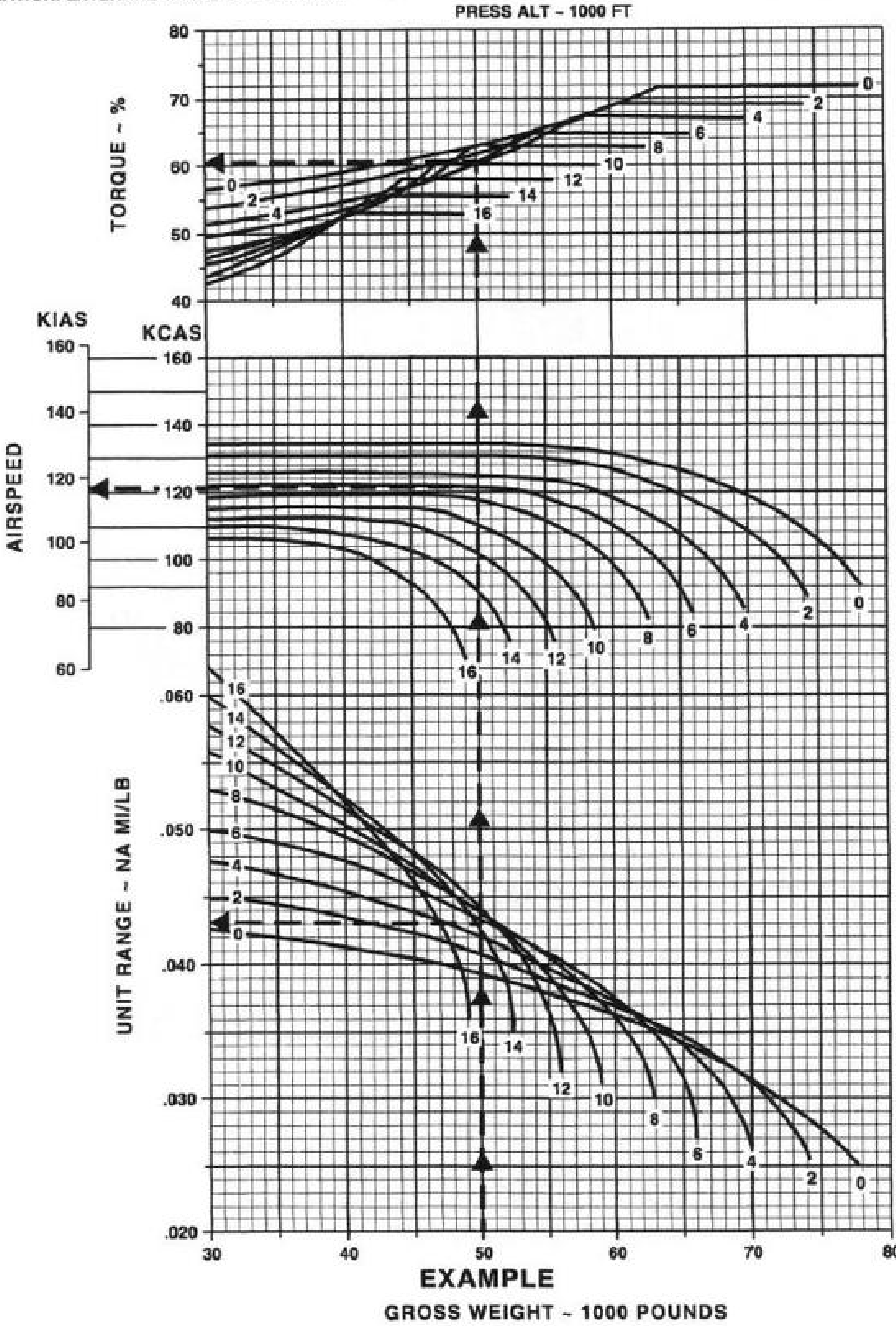
THREE-ENGINE MAXIMUM RANGE

STANDARD TEMPERATURE
+40°C
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL



NOTE
INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE
INCREASE UNIT RANGE BY 0.001 IF TANKS AND SUPPORTS OFF, AND 0.001 IF EAPS OFF.

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Figure 25-1. Three-Engine Maximum Range, Standard Temperature +40°C

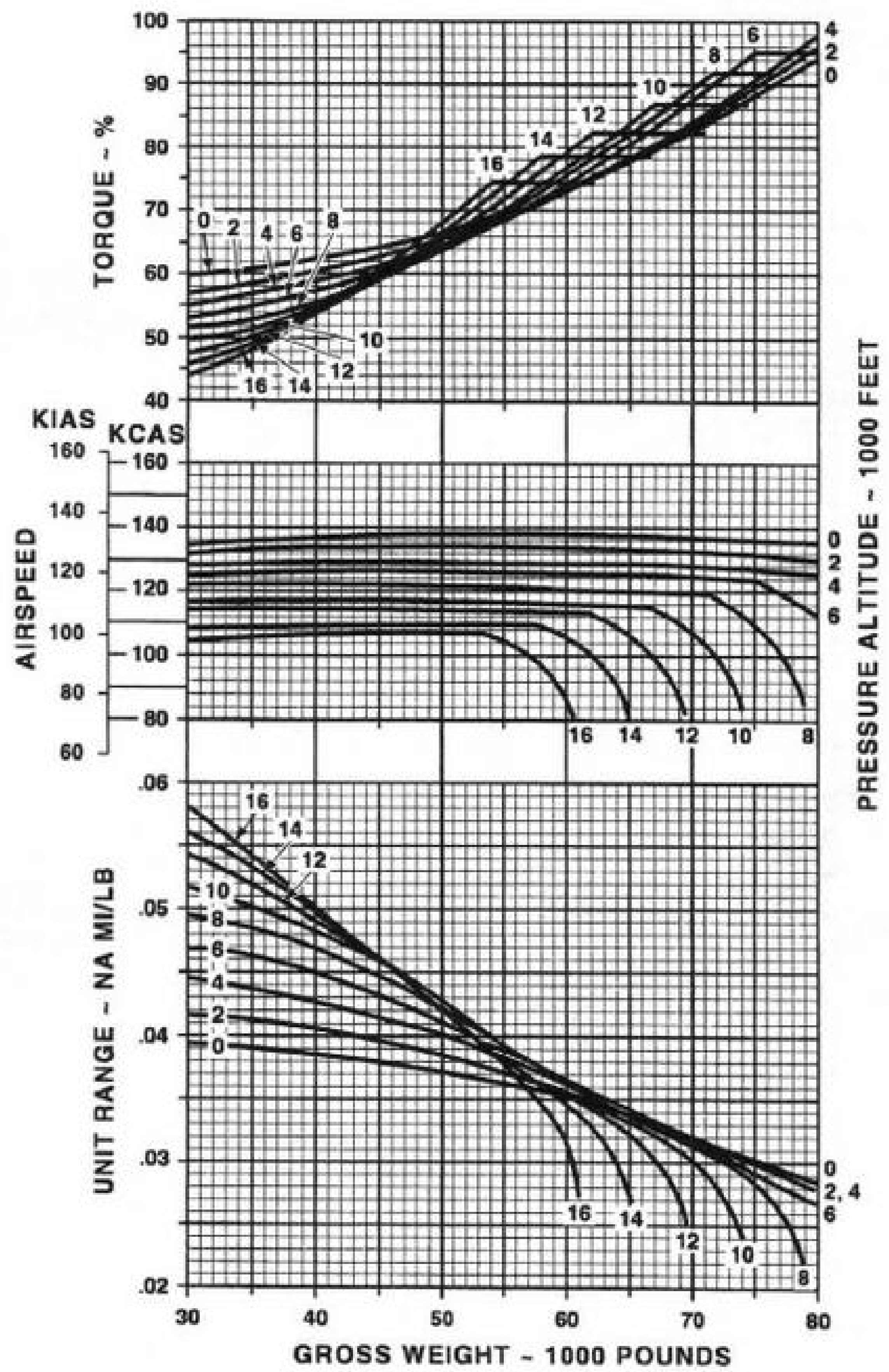
THREE-ENGINE MAXIMUM RANGE

STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON



NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY .001 IF TANKS AND SUPPORTS OFF AND .001 IF EAPS OFF.

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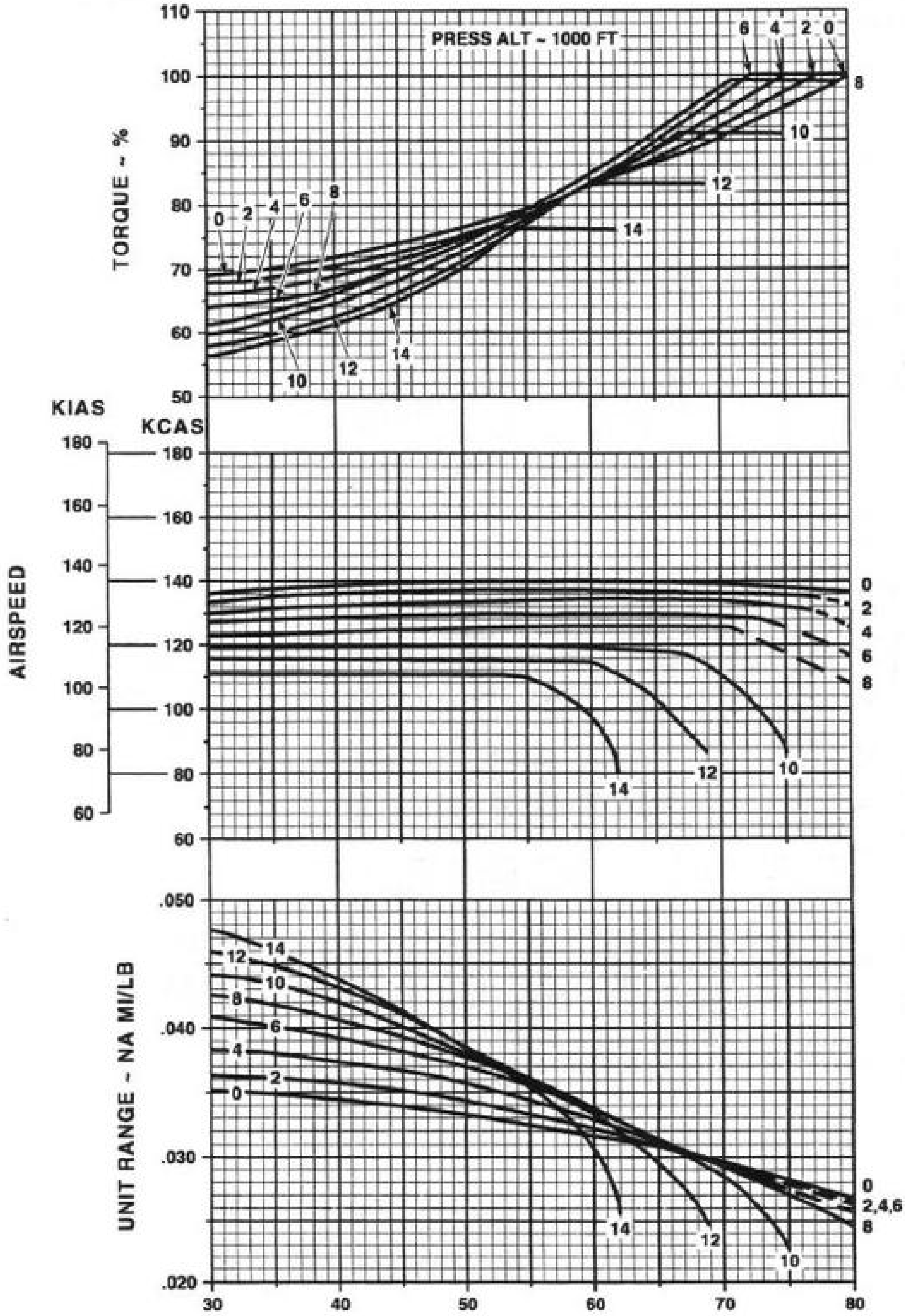
Figure 25-2. Three-Engine Maximum Range, Standard Temperature

THREE-ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
-40°C
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: — — — MAXIMUM CONTINUOUS TRANSMISSION TORQUE RATING



NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY 0.001 IF TANKS AND SUPPORTS OFF, AND 0.001 IF EAPS OFF.

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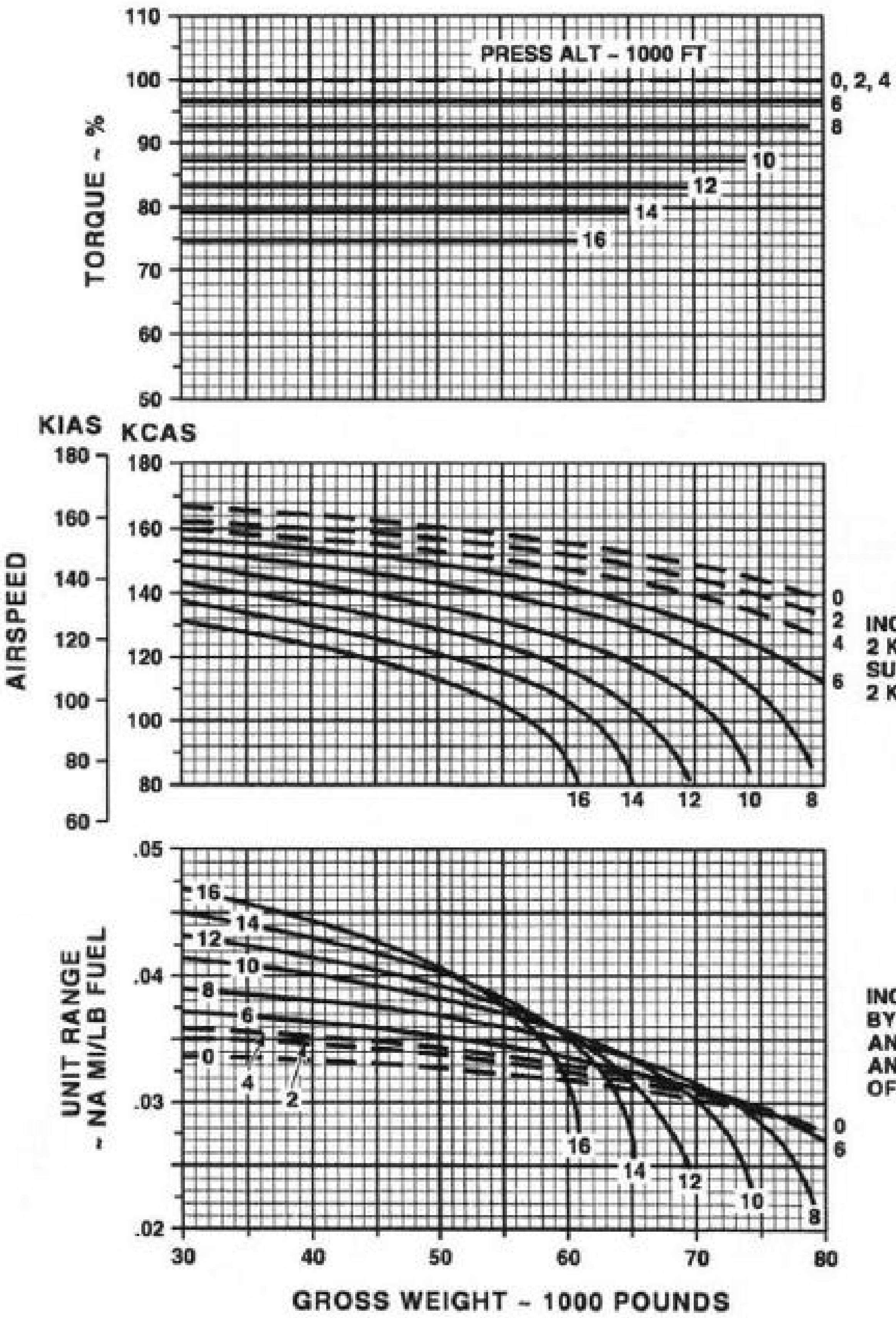
Figure 25-3. Three-Engine Maximum Range, Standard Temperature -40°C

THREE-ENGINE RANGE AT MAXIMUM CONTINUOUS POWER
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: — — - MAXIMUM CONTINUOUS TRANSMISSION RATING



NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY .0004 IF TANKS AND SUPPORTS OFF, AND .0004 IF EAPS OFF.

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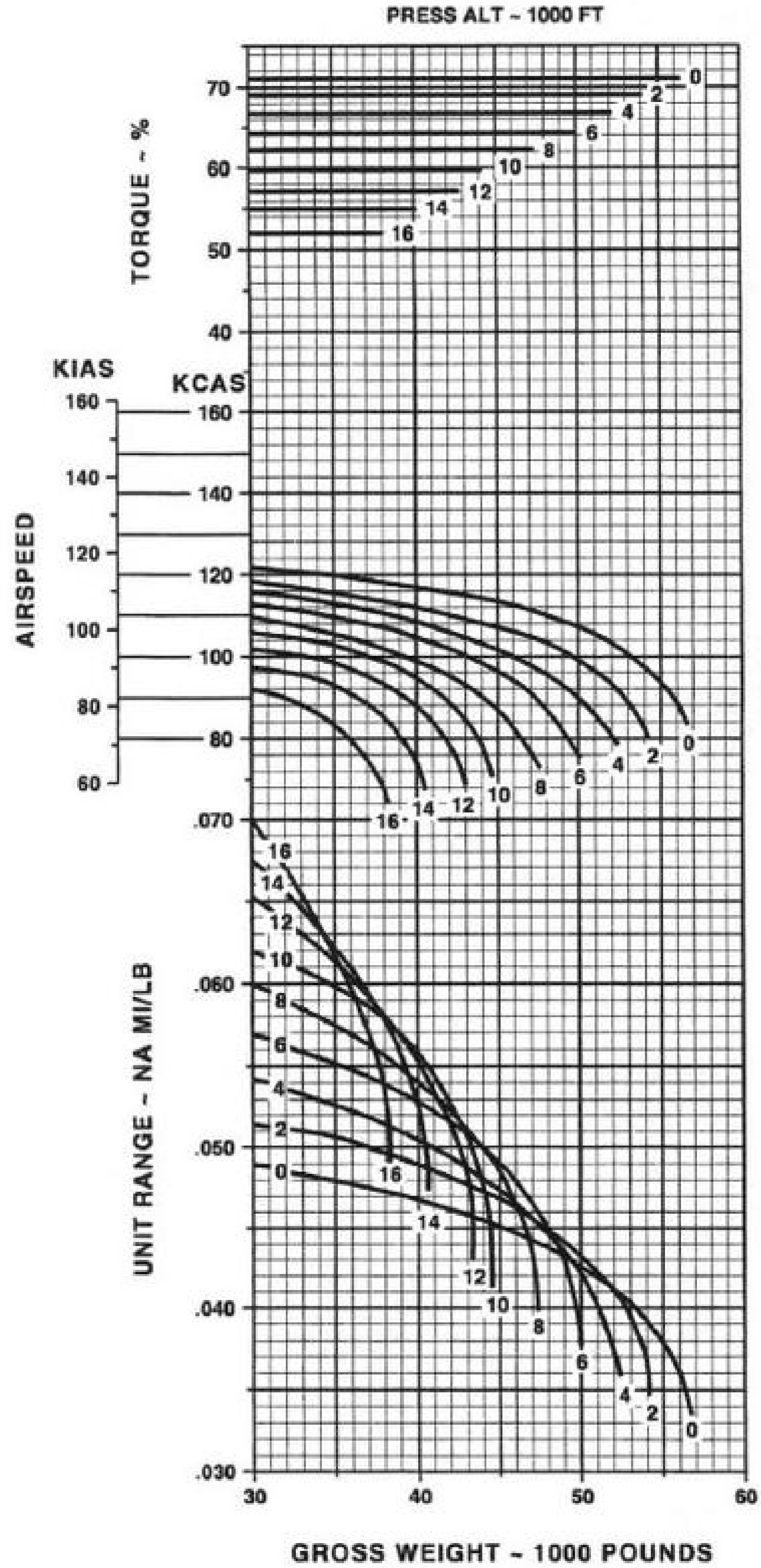
Figure 25-4. Three-Engine Range at Maximum Continuous Power

DUAL-ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
+40°C
MAXIMUM CONTINUOUS POWER
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL



NOTE
INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE
INCREASE UNIT RANGE BY 0.001 IF TANKS AND SUPPORTS OFF, AND 0.001 IF EAPS OFF.

FOR BEST RANGE AT INDICATED ALTITUDES TRANSITION FROM DUAL TO 3-ENGINE OPERATION AT OR ABOVE SPECIFIED GROSS WEIGHT

ALTITUDE	GROSS WEIGHT
000	55000
2000	53000
4000	50000
6000	48000
8000	46500
10000	43750
12000	42250
14000	40000
16000	37500

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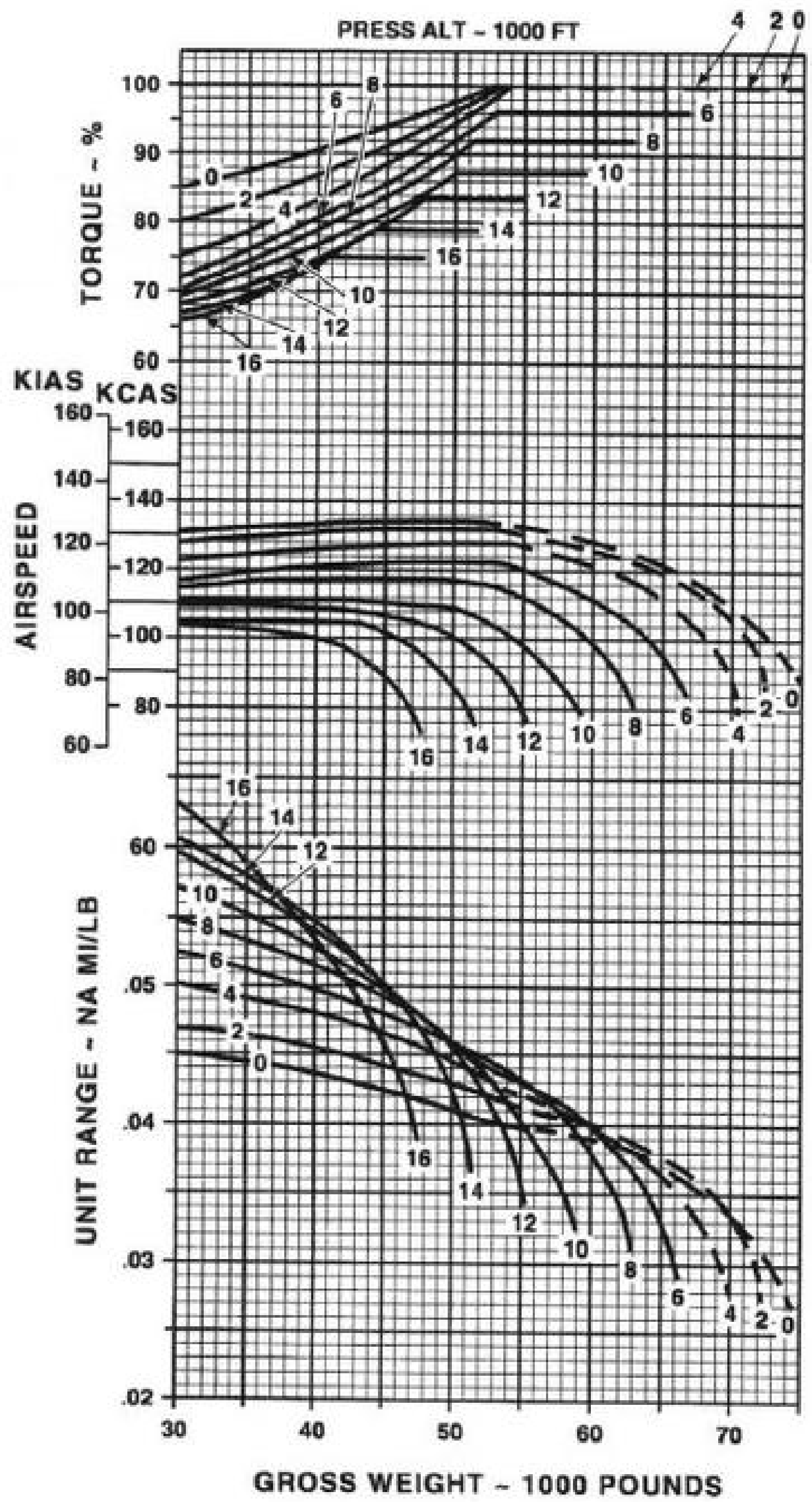
Figure 25-5. Dual-Engine Maximum Range, Standard Temperature +40°C

DUAL-ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: — — — MAXIMUM CONTINUOUS TRANSMISSION TORQUE RATING



FOR BEST RANGE AT INDICATED ALTITUDES, TRANSITION FROM DUAL TO THREE-ENGINE OPERATION AT OR ABOVE SPECIFIED GROSS WEIGHT.

ALTITUDE	GROSS WEIGHT
000	72000
2000	71000
4000	68000
6000	65000
8000	61150
10000	56250
12000	53500
14000	50000
16000	45000

NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY .001 IF TANKS AND SUPPORTS OFF, AND .001 IF EAPS OFF.

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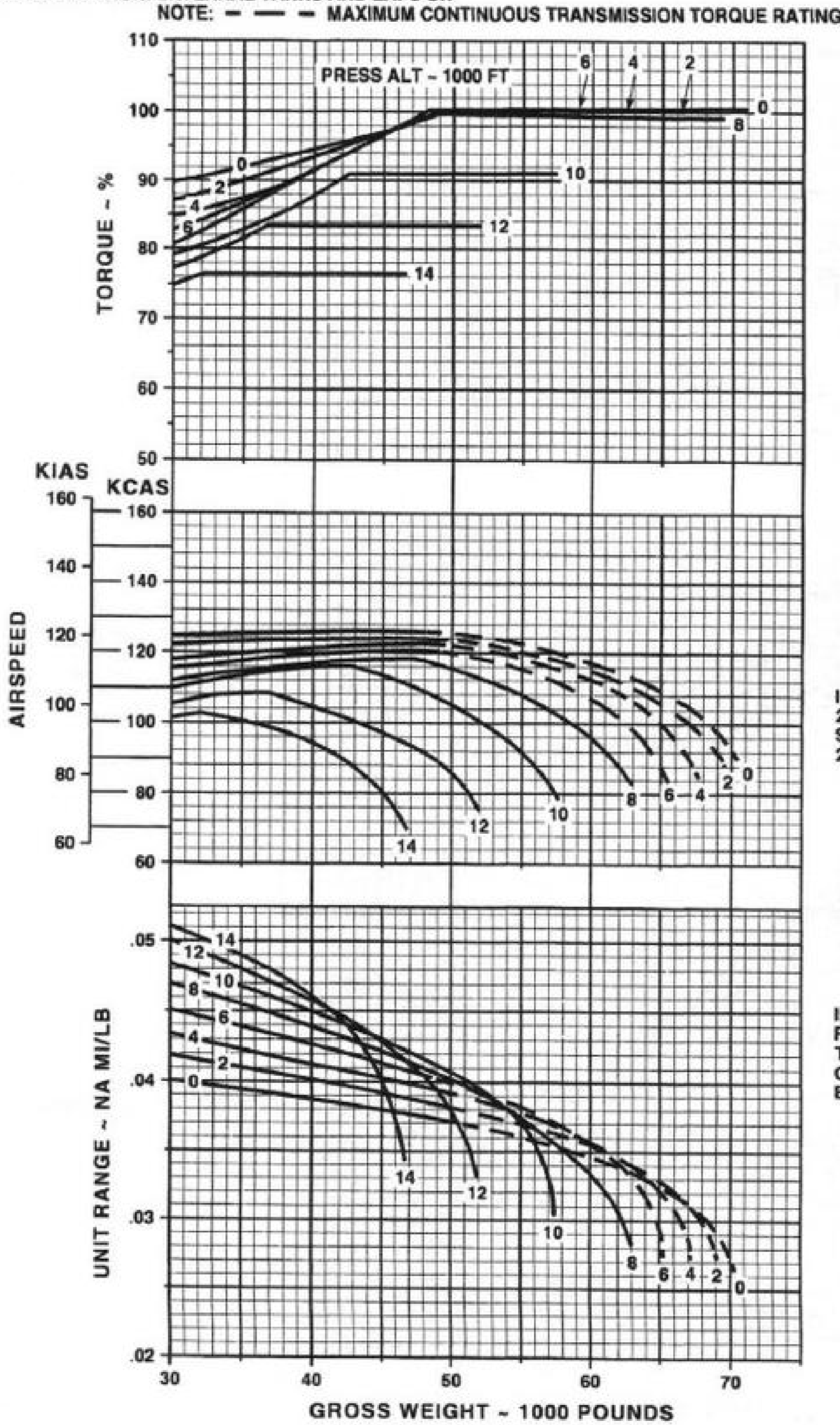
Figure 25-6. Dual-Engine Maximum Range, Standard Temperature

DUAL-ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
-40°C
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONGIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL



FOR BEST RANGE AT INDICATED ALTITUDES, TRANSITION FROM DUAL TO 3-ENGINE OPERATION AT OR ABOVE SPECIFIED GROSS WEIGHT.

ALTITUDE	GROSS WEIGHT
000	69000
2000	67750
4000	65750
6000	63250
8000	60000
10000	55750
12000	49500
14000	44500

NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY 0.001 IF TANKS AND SUPPORTS OFF, AND 0.001 IF EAPS OFF.

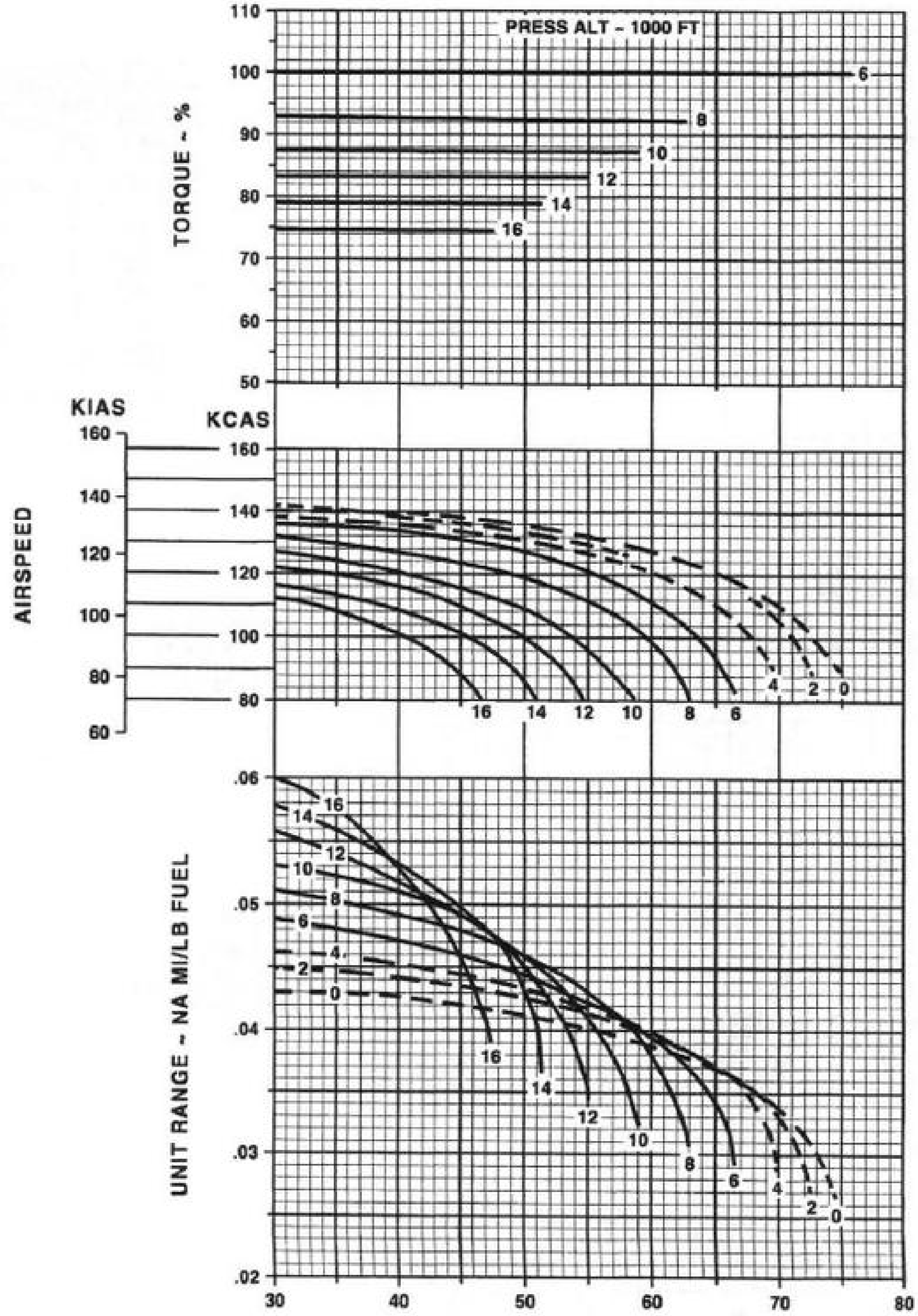
Figure 25-7. Dual-Engine Maximum Range, Standard Temperature -40°C

DUAL–ENGINE RANGE
AT MAXIMUM CONTINUOUS POWER
STANDARD TEMPERATURE
100% Nr

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: – — — – MAXIMUM CONTINUOUS TRANSMISSION RATING



NOTE

INCREASE SPEED BY 2 KTS IF TANKS AND SUPPORTS OFF, AND 2 KTS IF EAPS OFF.

NOTE

INCREASE UNIT RANGE BY 0.001 IF TANKS AND SUPPORTS OFF, AND 0.001 IF EAPS OFF.

Figure 25-8. Dual-Engine Range at Maximum Continuous Power

DUAL–OR THREE–ENGINE OPTIMUM CRUISE ALTITUDE

STANDARD TEMPERATURE +40 °C

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE JP–4 / JP–5 / JP–8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: — — DUAL-ENGINE CRUISE RECOMMENDED
—— THREE-ENGINE CRUISE RECOMMENDED
THREE-ENGINE OPERATION ONLY BELOW 3000 FEET

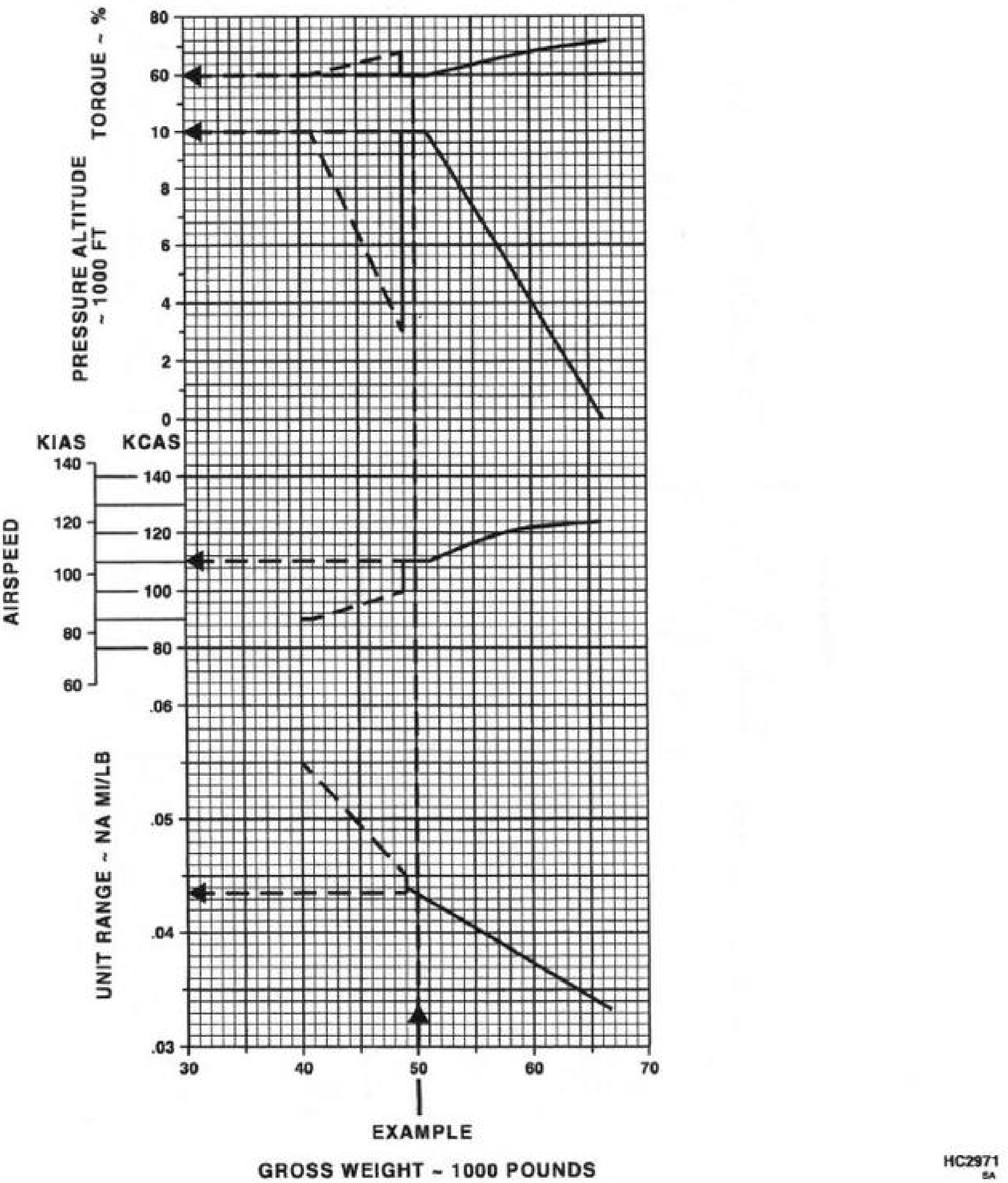


Figure 25-9. Optimum Cruise Altitude, Standard Temperature +40°C

DUAL–OR THREE–ENGINE OPTIMUM CRUISE ALTITUDE

STANDARD TEMPERATURE

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE JP–4 / JP–5 / JP–8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: — — DUAL–ENGINE CRUISE RECOMMENDED
NOTE: ——— THREE–ENGINE CRUISE RECOMMENDED
NOTE: THREE–ENGINE OPERATION ONLY BELOW 3000 FEET

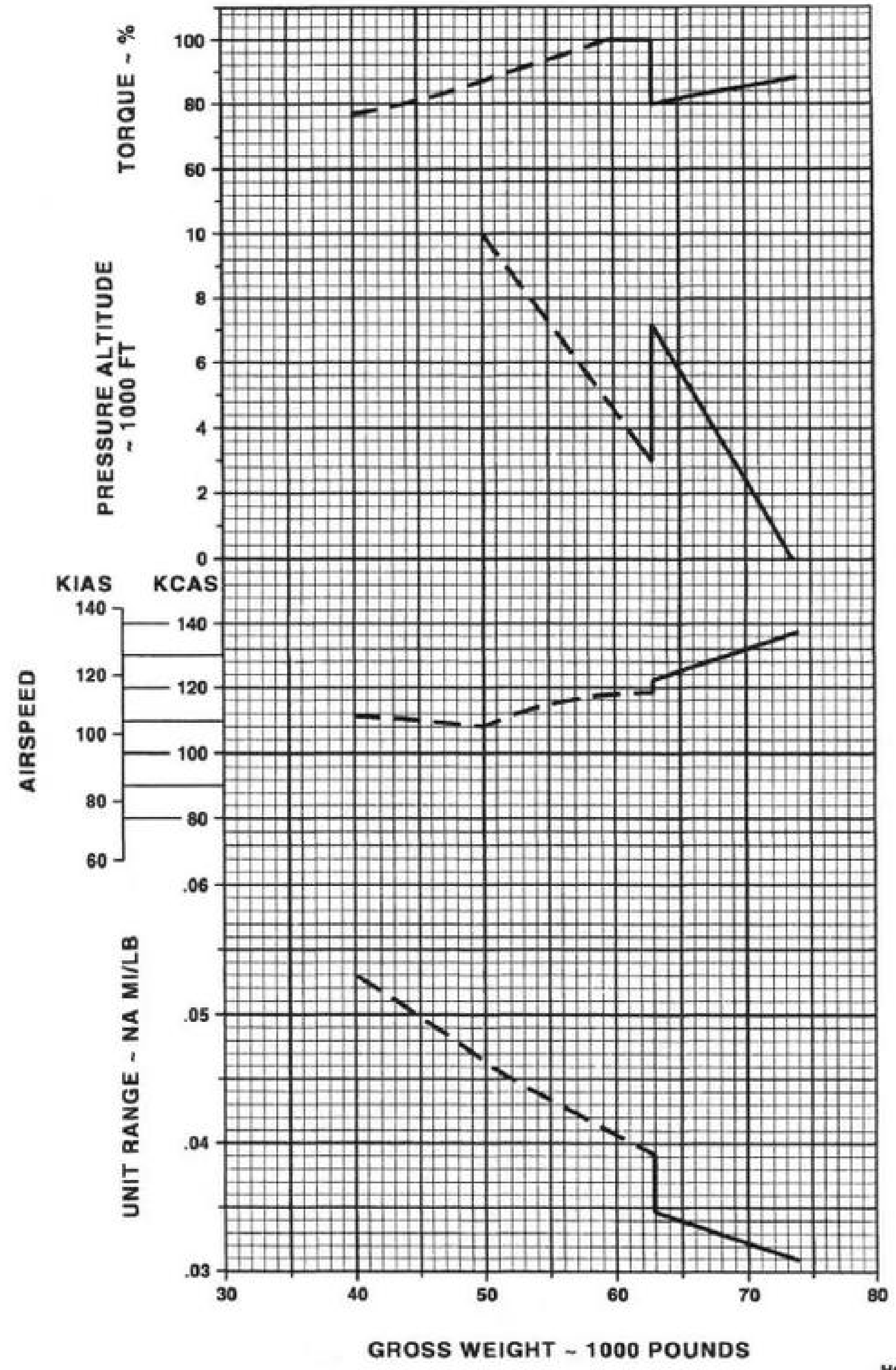


Figure 25-10. Optimum Cruise Altitude, Standard Temperature

DUAL–OR THREE–ENGINE OPTIMUM CRUISE ALTITUDE

STANDARD TEMPERATURE

−40 °C

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE JP–4 / JP–5 / JP–8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: — — DUAL–ENGINE CRUISE RECOMMENDED
——— THREE–ENGINE CRUISE RECOMMENDED
THREE–ENGINE OPERATION ONLY BELOW 3000 FEET

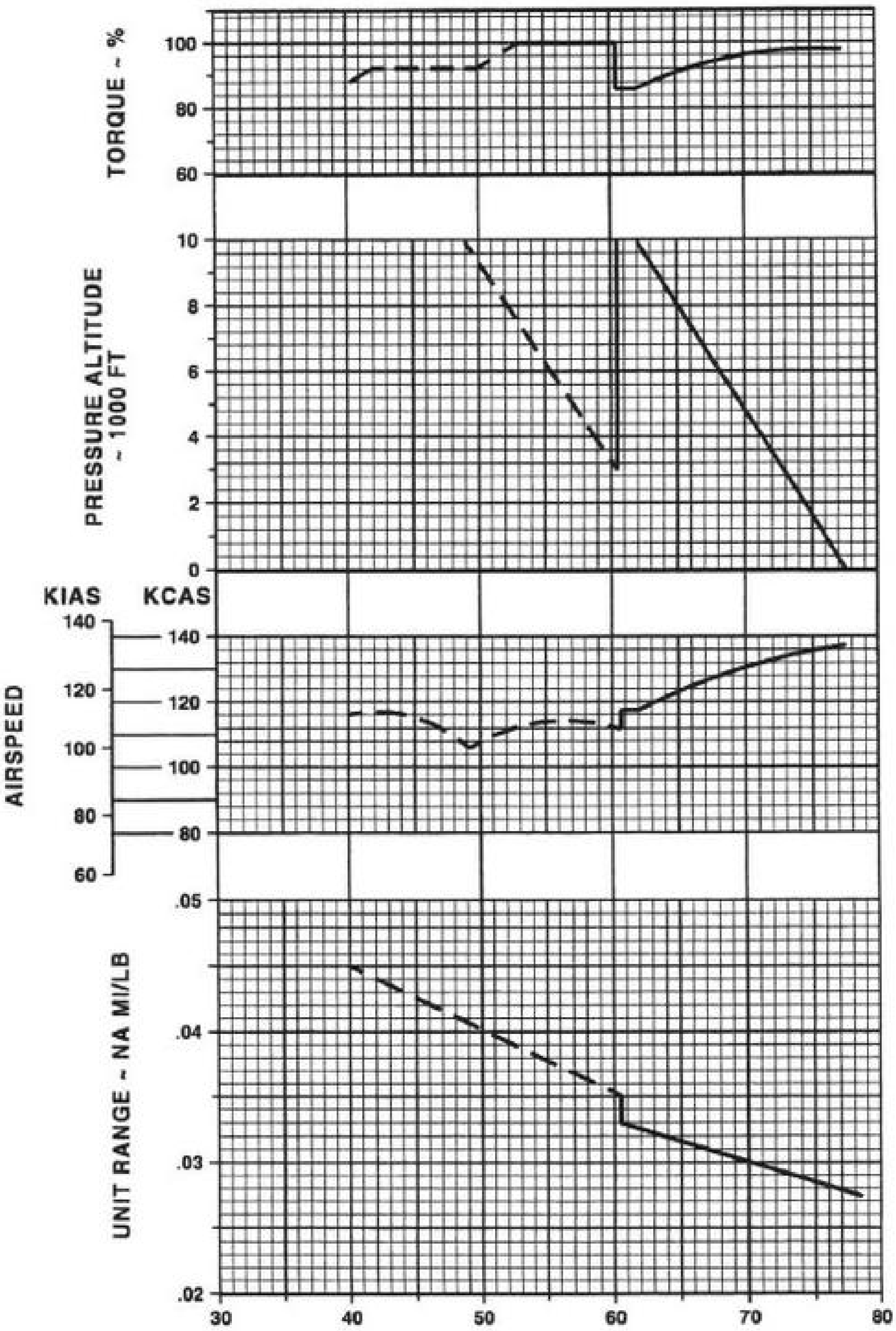


Figure 25-11. Optimum Cruise Altitude, Standard Temperature -40°C

CHAPTER 26
Endurance

26.1 ENDURANCE CHARTS

The charts provide fuel flow, indicated and calibrated airspeed, and approximate torque when gross weight is applied to pressure altitude to produce maximum endurance.

26.1.1 Three-Engine Maximum Endurance Chart. The chart (Figure 26-1) provides the fuel flow, indicated and calibrated airspeed, and torque required when gross weight is applied to pressure altitude to produce maximum endurance for the helicopter.

For example, to find the fuel consumption, cruise speed and approximate torque required for maximum endurance at 65,000 pounds gross weight at a pressure altitude of 14,000 feet, enter the bottom of the chart at 65,000 pounds. Trace up to the 14,000 foot curve, then trace left and read the fuel consumption: 3775 pounds per hour. Enter the next grid at 65,000 pounds, trace up to the 14,000 foot curve, and then trace left and read 73 KIAS, the cruise speed for maximum endurance. The approximate torque required to maintain this speed is found by entering the next grid at 65,000 pounds, tracing up to the 14,000 foot curve, and then tracing left to read 79% torque.

26.1.2 Dual-Engine Maximum Endurance Chart. The chart (Figure 26-2) is used the same way as Figure 26-1.

26.1.3 25-Knot Endurance Chart. The chart (Figure 26-3) provides fuel flow at 25 knots when gross weight is applied to pressure altitude and ambient temperature.

For example, if fuel flow was desired when the ambient temperature was +10°C, pressure altitude was 4000 feet, and gross weight was 65,000 pounds. Enter the chart from the left at 65,000 pounds and trace right to 4000 feet pressure altitude. Trace down from this point to the baseline and follow the influence lines up to +10°C. Trace down to read 49.2 pounds/hour of fuel flow.

26.1.4 Hover Endurance Chart. The chart (Figure 26-4) provides the fuel flow when gross weight is applied to pressure altitude and outside air temperature to provide hovering endurance.

For example, to find the fuel consumption when hovering out of ground effect at sea level, at 62,500 pounds gross weight, with an OAT of 32°C, enter the left side of the chart at 62,500 pounds. Trace right to the pressure altitude and then trace down to the temperature baseline. Follow the influence line up to 32°C, and then trace down to read fuel consumption, 5125 pounds-per-hour.

THREE-ENGINE MAXIMUM ENDURANCE
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

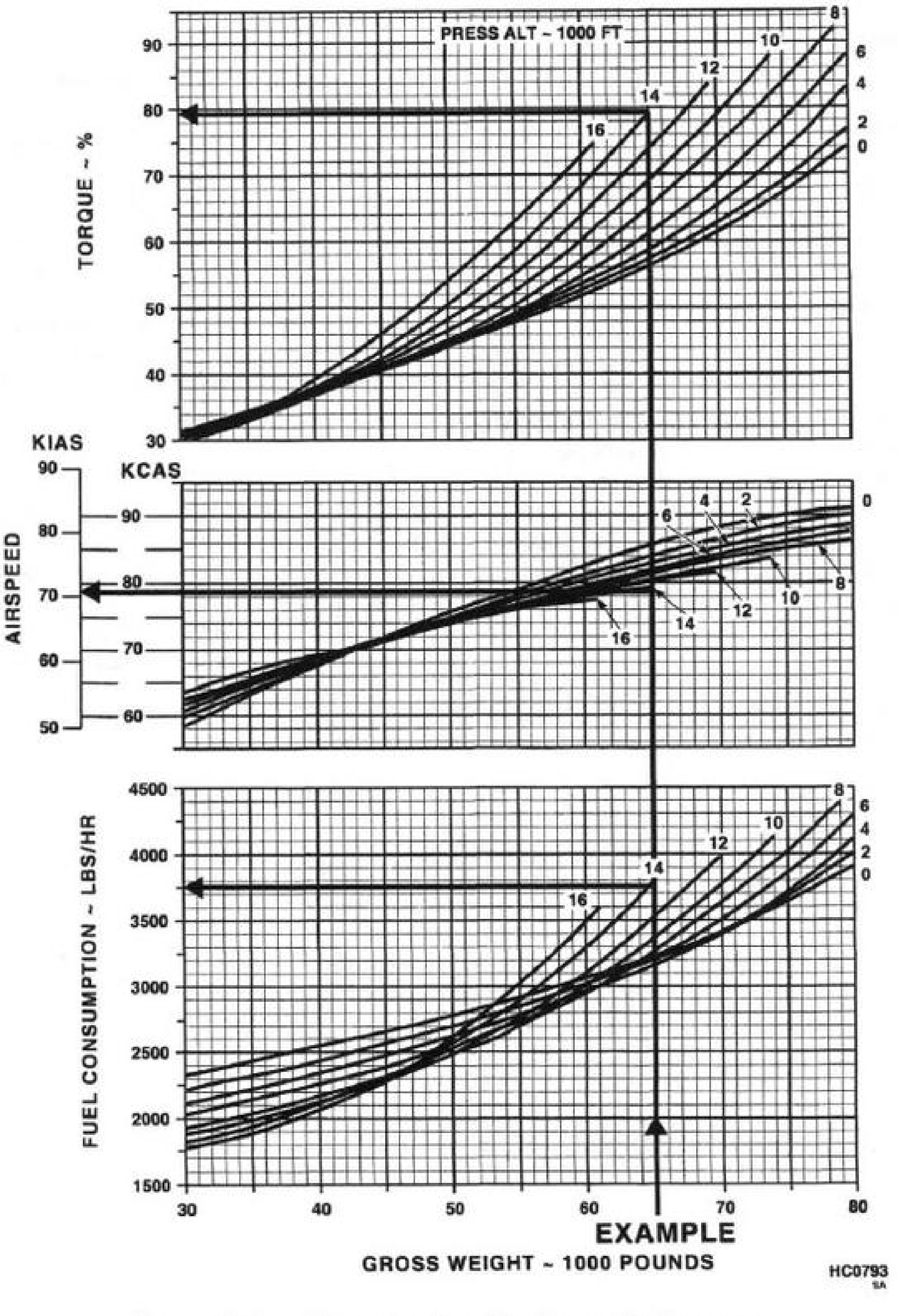


Figure 26-1. Three-Engine Maximum Endurance

DUAL-ENGINE MAXIMUM ENDURANCE
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: FOR TRANSITION TO THREE-ENGINE OPERATION, MAXIMUM ENDURANCE IS REDUCED BY 10 TO 20% AT ANY SPECIFIED GROSS WEIGHT AND ALTITUDE.

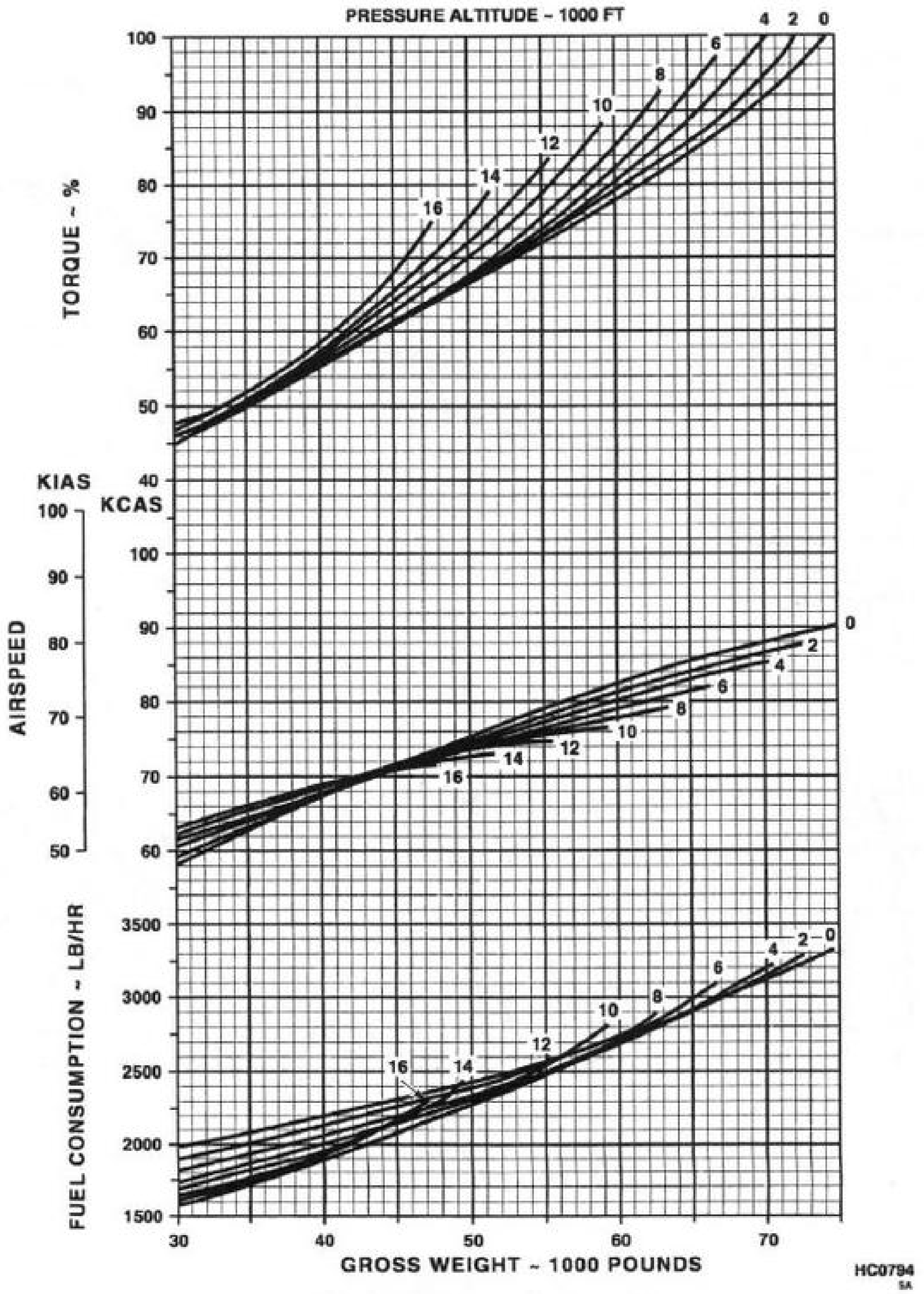


Figure 26-2. Dual-Engine Maximum Endurance

THREE-ENGINE ENDURANCE
AT 25 KNOTS
OUT OF GROUND EFFECT
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: WHEN LIMITED BY TRANSMISSION RATING USE DASHED INFLUENCE LINES ON TEMPERATURE SCALE

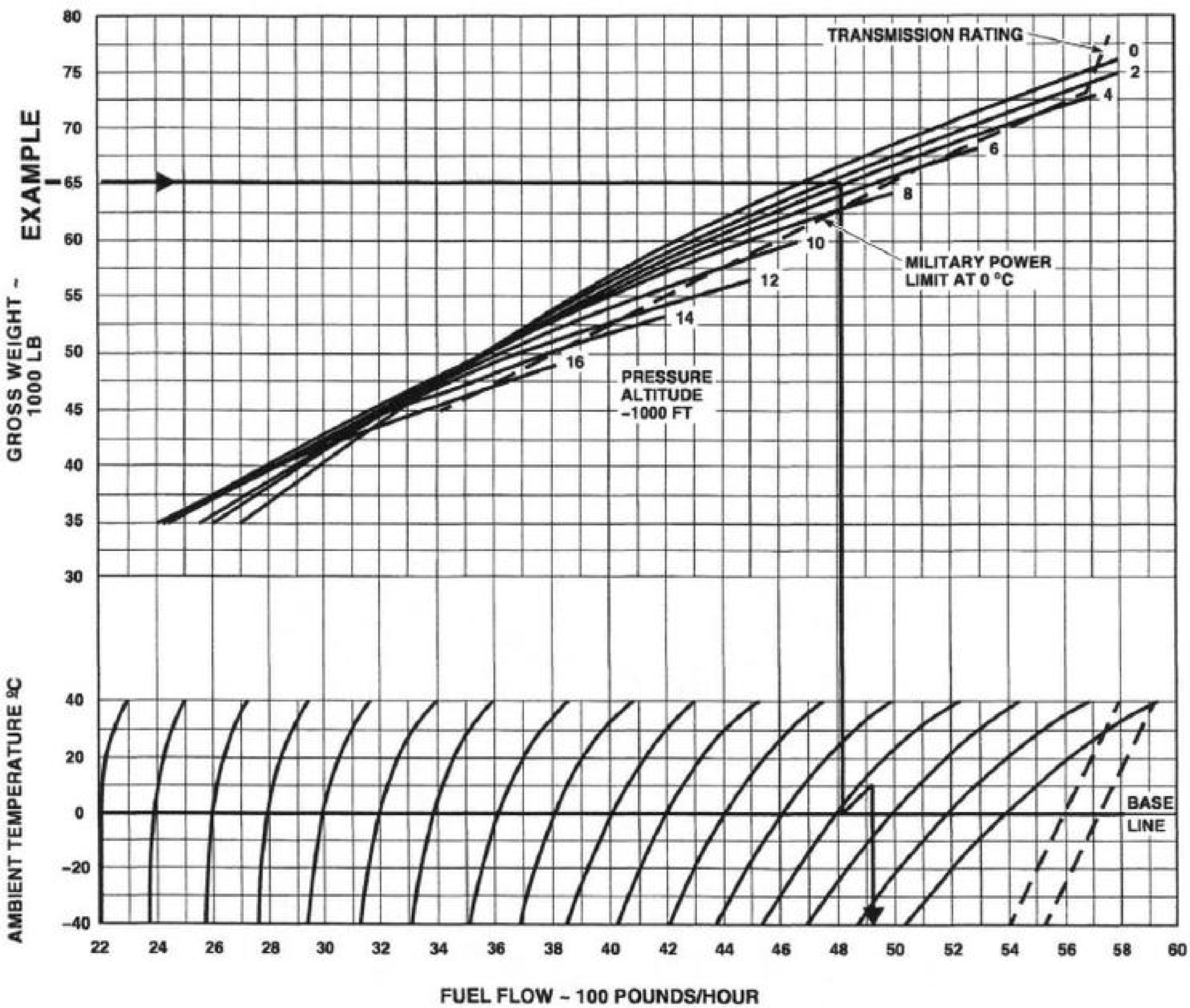


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Figure 26-3. 25-Knot Endurance

THREE-ENGINE HOVER ENDURANCE
OUT OF GROUND EFFECT
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTES: REFER TO ABILITY TO HOVER CHART FOR DETERMINING MAXIMUM GROSS WEIGHTS

WHEN LIMITED BY TRANSMISSION RATING USE DASHED INFLUENCE LINES ON TEMPERATURE SCALE

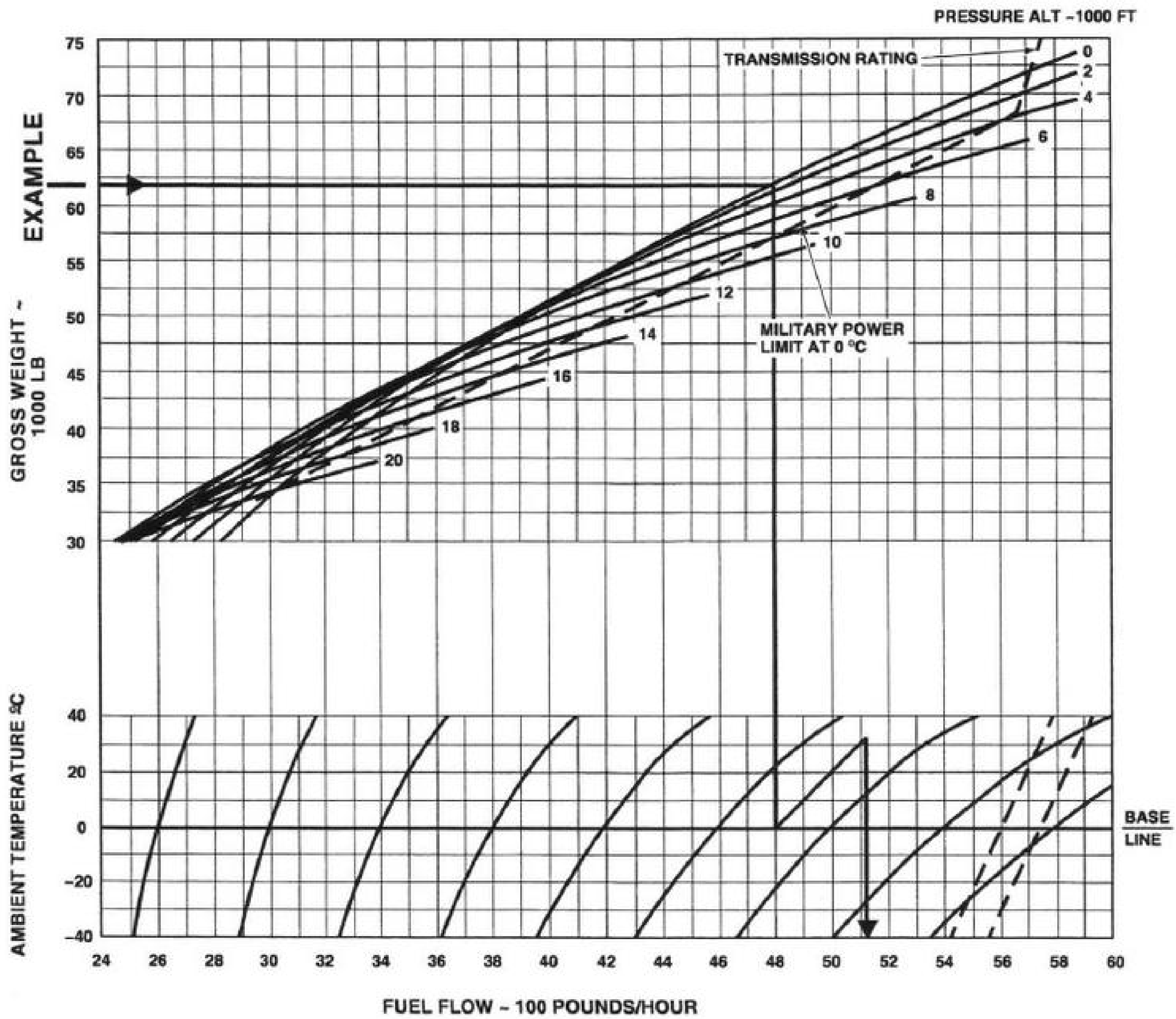

Figure 26-4. Hover Endurance

SINGLE OR DUAL ENGINE
LANDING DISTANCE GROUND ROLL
NO GRADIENT

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: ESTIMATED

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: GROUND ROLL DISTANCES WERE DETERMINED BY CONSIDERING A SINGLE- OR DUAL-ENGINE APPROACH ENTRY (POWER ON) AT APPROXIMATE 200 FOOT HEIGHT, 90 KIAS, 105% Nr, AT A RATE OF DESCENT OF 1000 FEET / MINUTE, AND A TOUCHDOWN SPEED OF 30 KCAS. TOTAL LANDING DISTANCE (GROUND ROLL AND AIR DISTANCE) MAY BE DETERMINED BY ADDING 700 FEET OF AIR DISTANCE FOR EACH 50 FEET OF OBSTACLE HEIGHT, TO GROUND ROLL DISTANCE DETERMINED FROM THIS CHART.

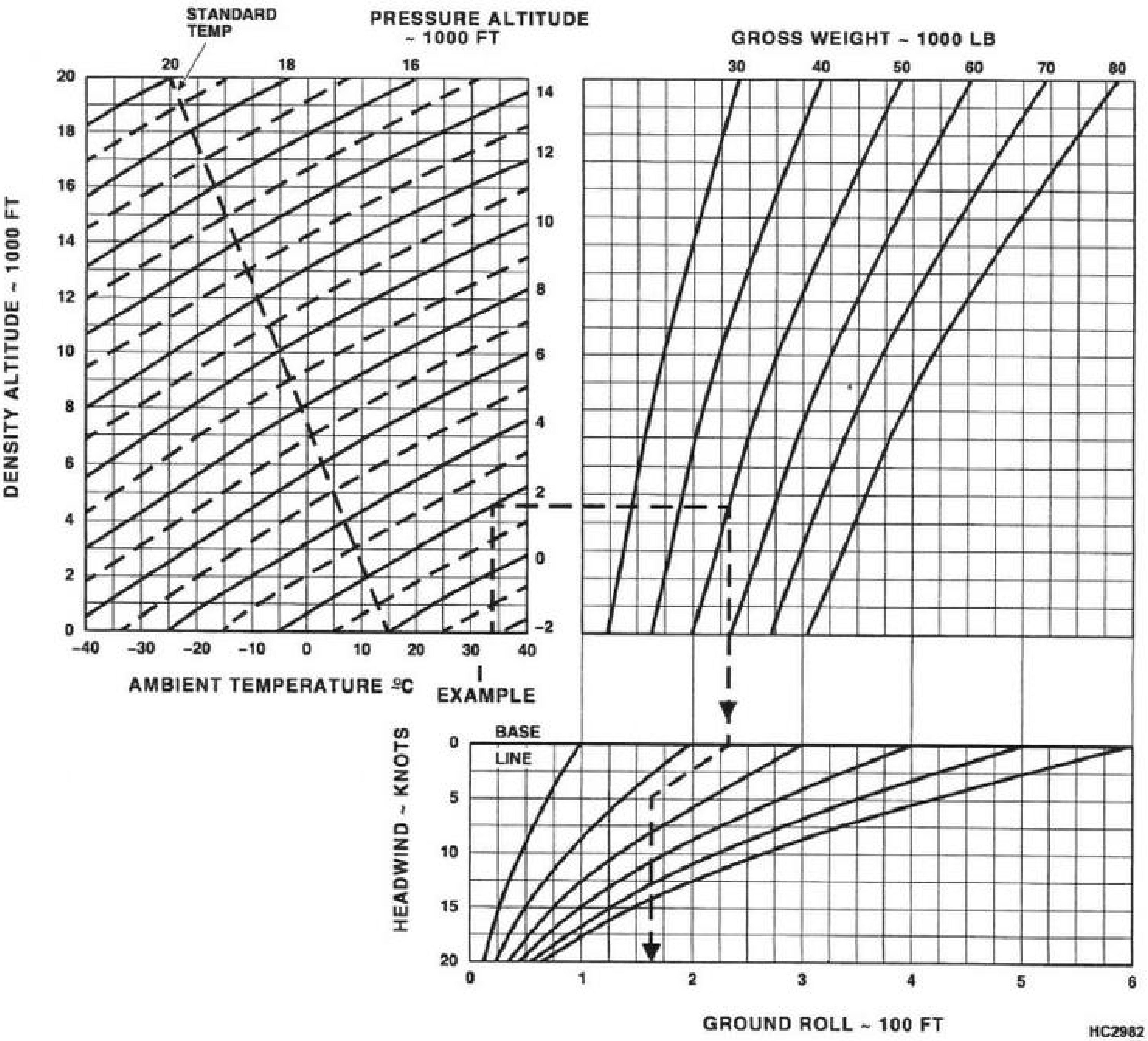

Figure 27-16. Single- or Dual-Engine Landing Distance

SINGLE-ENGINE ENGINE MAXIMUM ENDURANCE
STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

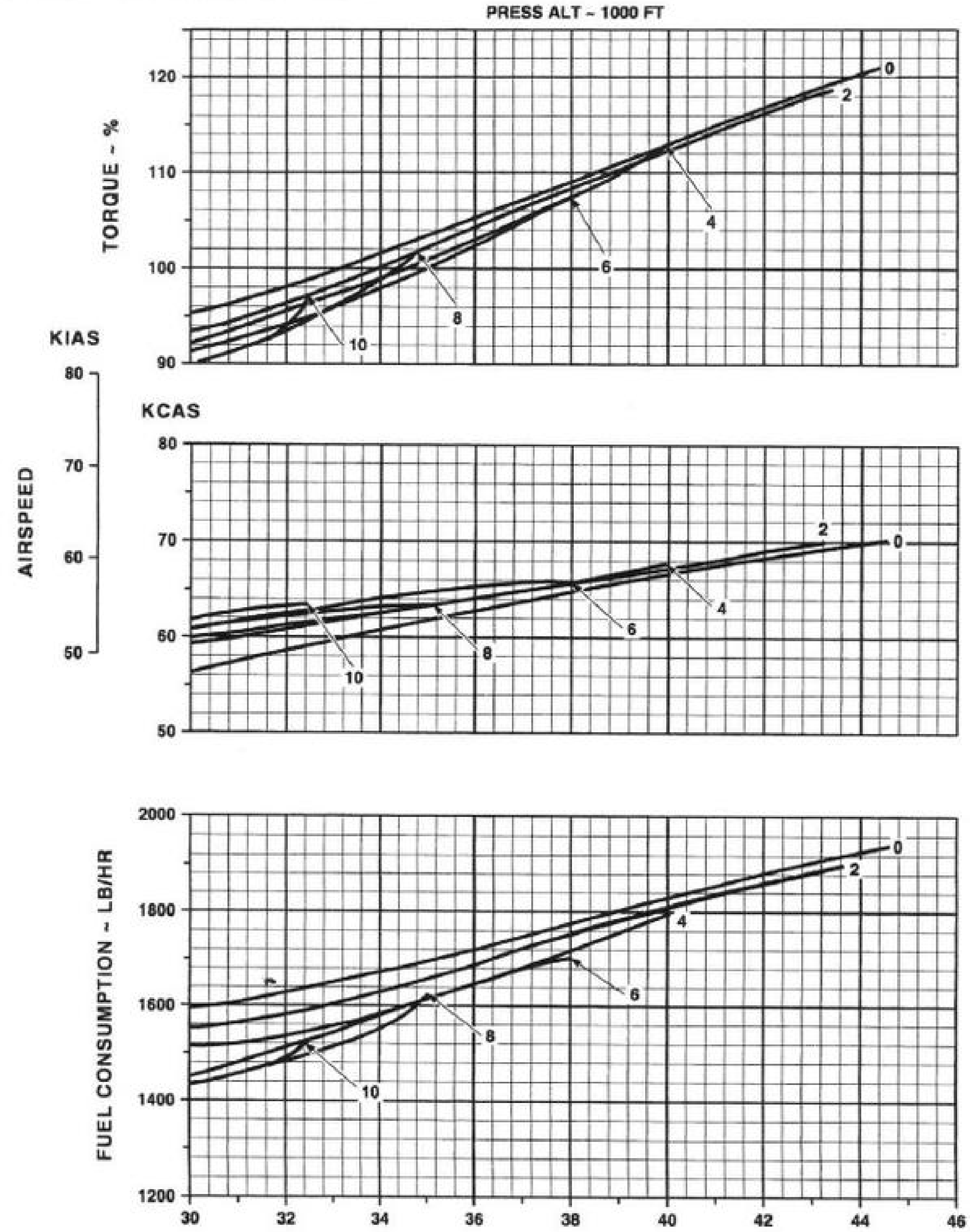

Figure 27-15. Single-Engine Maximum Endurance

SINGLE–ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
–40 °C
MILITARY POWER
100% Nr

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE:– — – 30 MINUTE TRANSMISSION TORQUE RATING

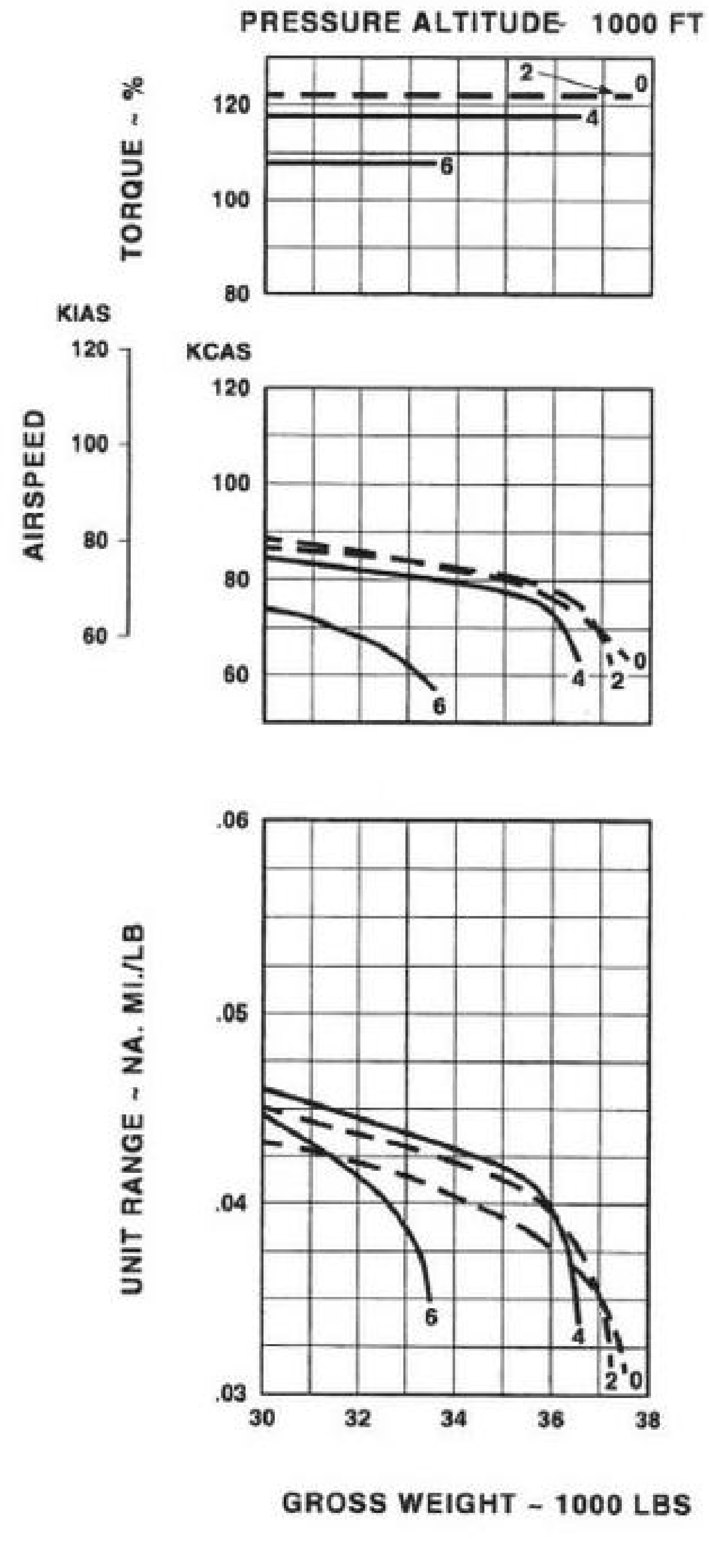

Figure 27-14. Single-Engine Maximum Range, Standard Temperature -40°C

SINGLE–ENGINE MAXIMUM RANGE
STANDARD TEMPERATURE
MILITARY POWER
100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE:– — – 30 MINUTE TRANSMISSION TORQUE RATING

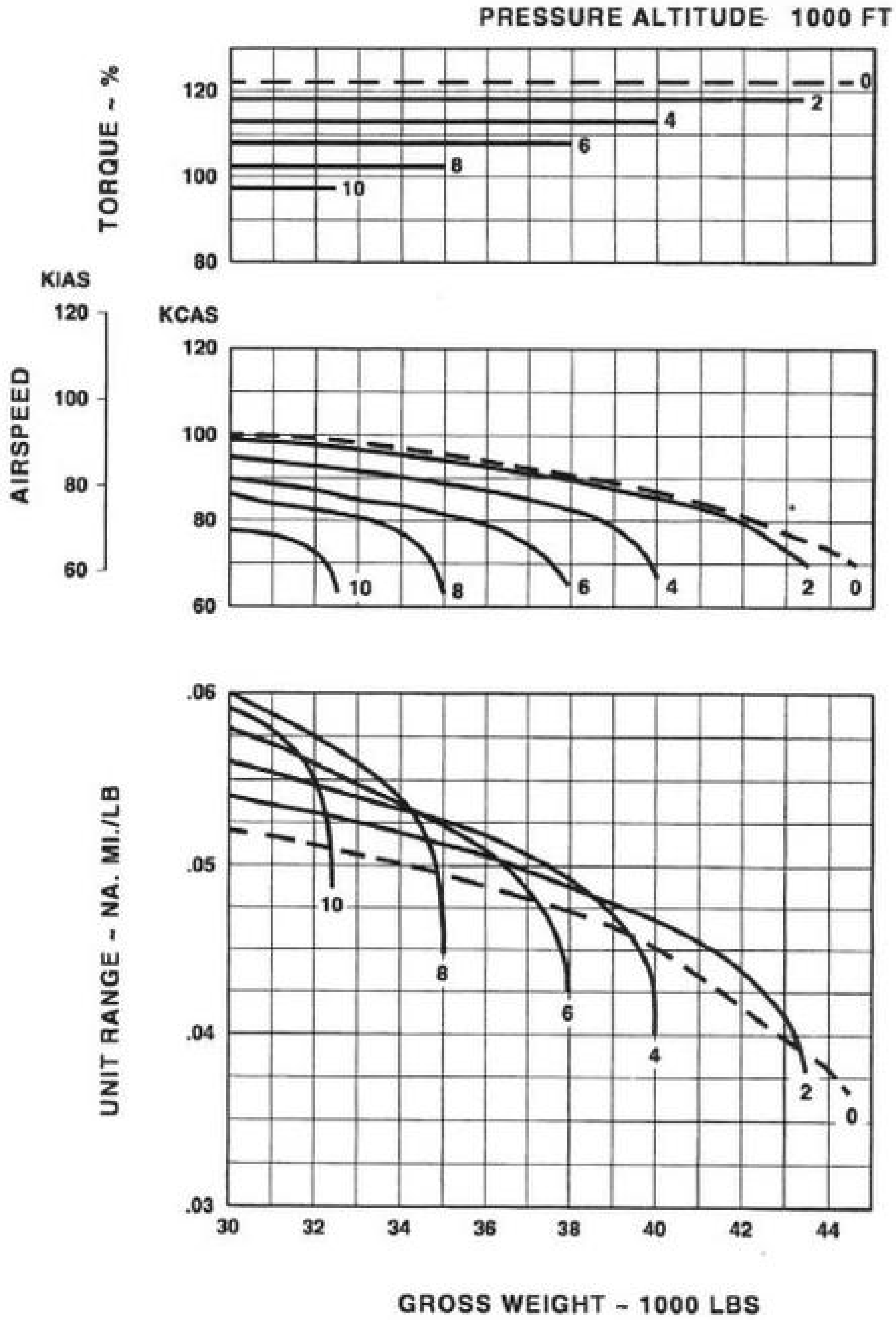

Figure 27-13. Single-Engine Maximum Range, Standard Temperature

DUAL-ENGINE ABILITY TO MAINTAIN 80 KNOT LEVEL FLIGHT AT VARIOUS ROTOR SPEEDS
MILITARY POWER LESS 7% DEGRADATION

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTES: WITHOUT EAPS INCREASE WEIGHT BY 1000 LBS, DUE TO INCREASE IN TORQUE.
- - - 30 MINUTE TRANSMISSION TORQUE RATING IN UPPER CHART.
WHEN LIMITED BY TRANSMISSION RATING USE DASHED INFLUENCE LINES ON ROTOR RPM SCALE.

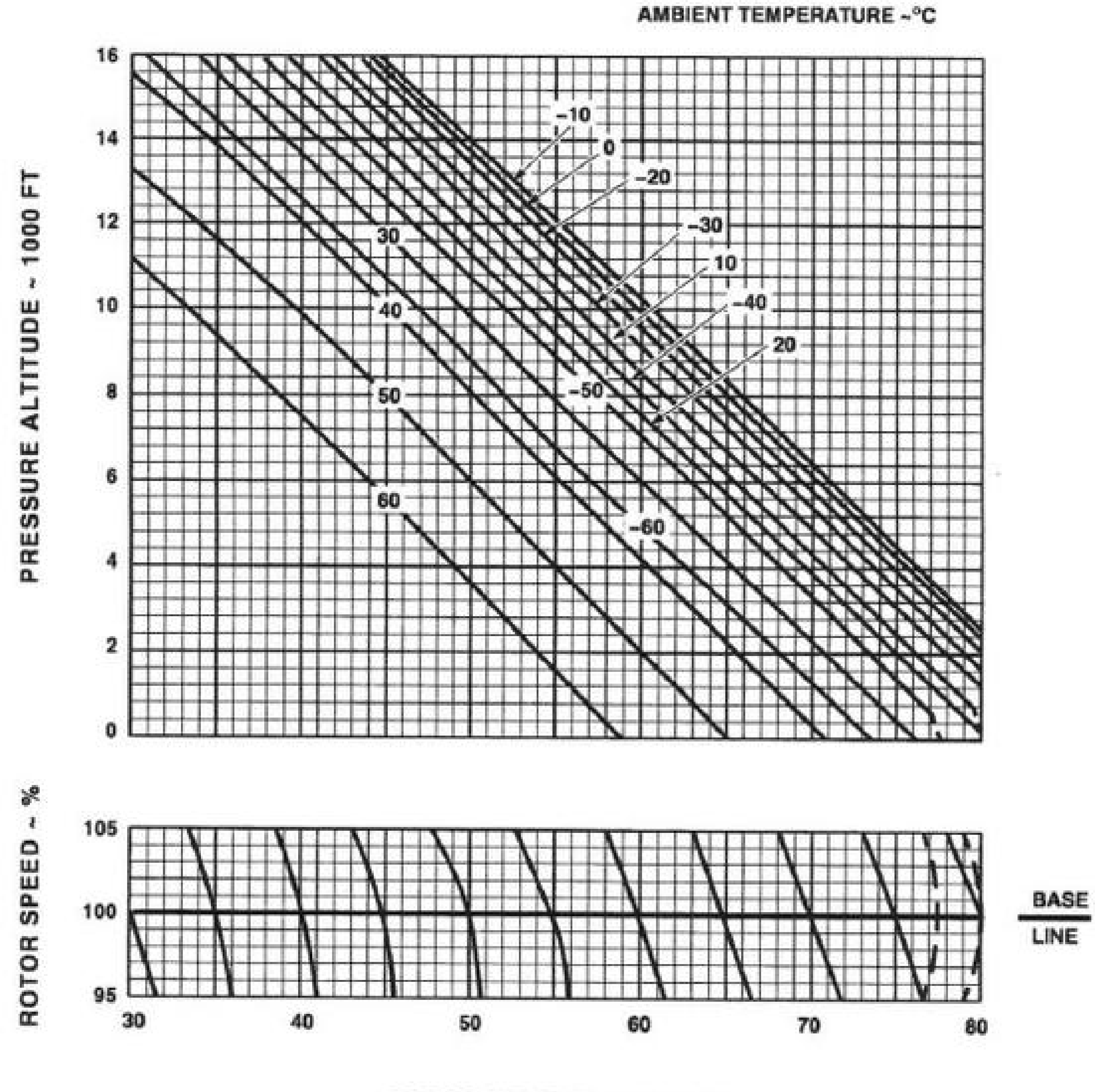

Figure 27-12. Dual-Engine Ability to Maintain 80 Knot Level Flight at Various N_r's

SINGLE-ENGINE ABILITY TO MAINTAIN 70 KNOT LEVEL FLIGHT AT VARIOUS ROTOR SPEEDS
MILITARY POWER LESS 7% DEGRADATION

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

CONFIGURATION: EAPS ON EXTERNAL TANKS JETTISONED

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTES: WITHOUT EAPS INCREASE WEIGHT BY 2000 LBS, DUE TO INCREASE IN TORQUE.
- - - 30 MINUTE TRANSMISSION TORQUE RATING IN UPPER CHART.
WHEN LIMITED BY TRANSMISSION RATING USE DASHED INFLUENCE LINES ON ROTOR RPM SCALE.

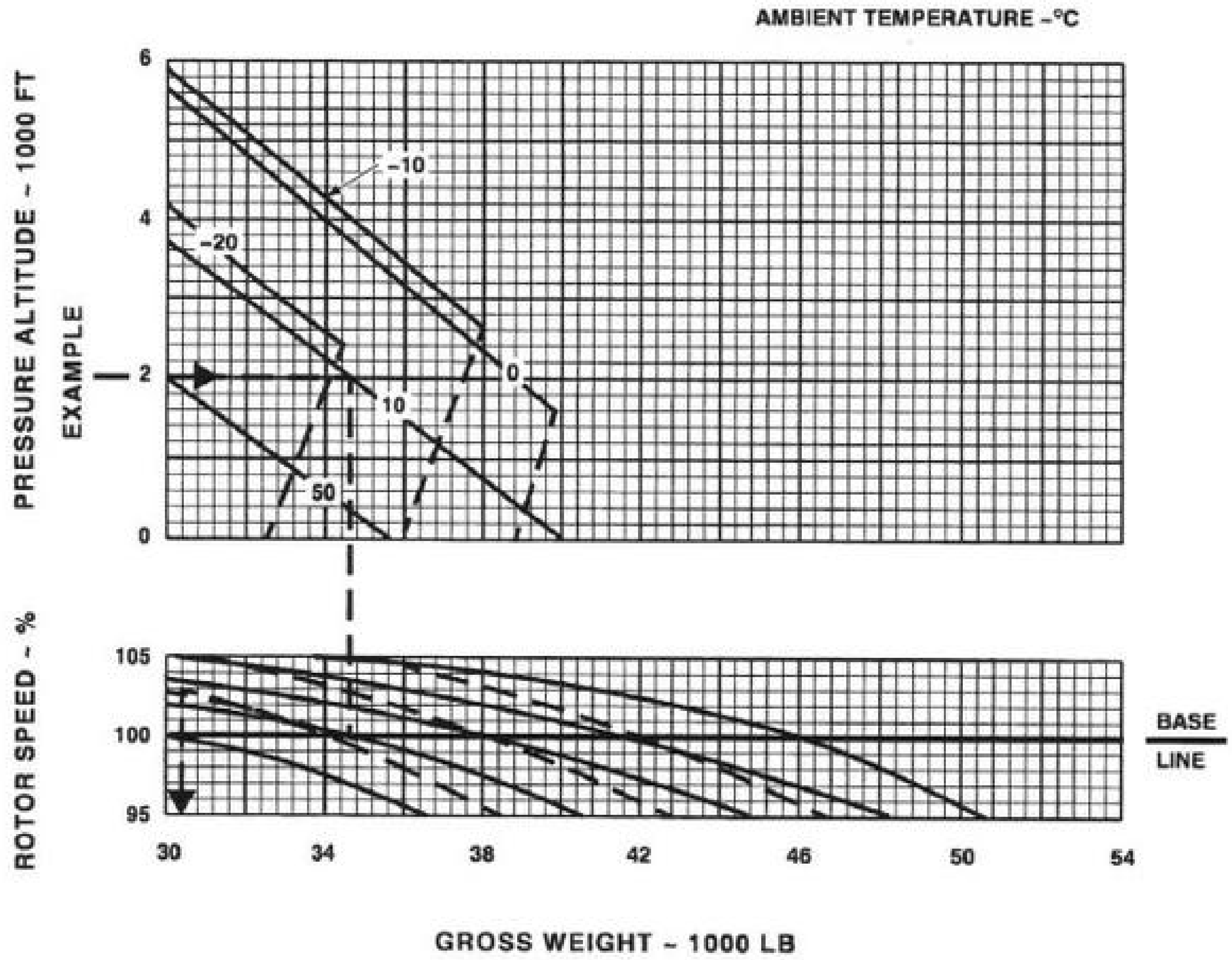

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Figure 27-11. Single-Engine Ability to Maintain 70 Knot Level Flight at Various N_r's

SINGLE- OR DUAL-ENGINE
ABILITY TO MAINTAIN LEVEL FLIGHT 100% Nr

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

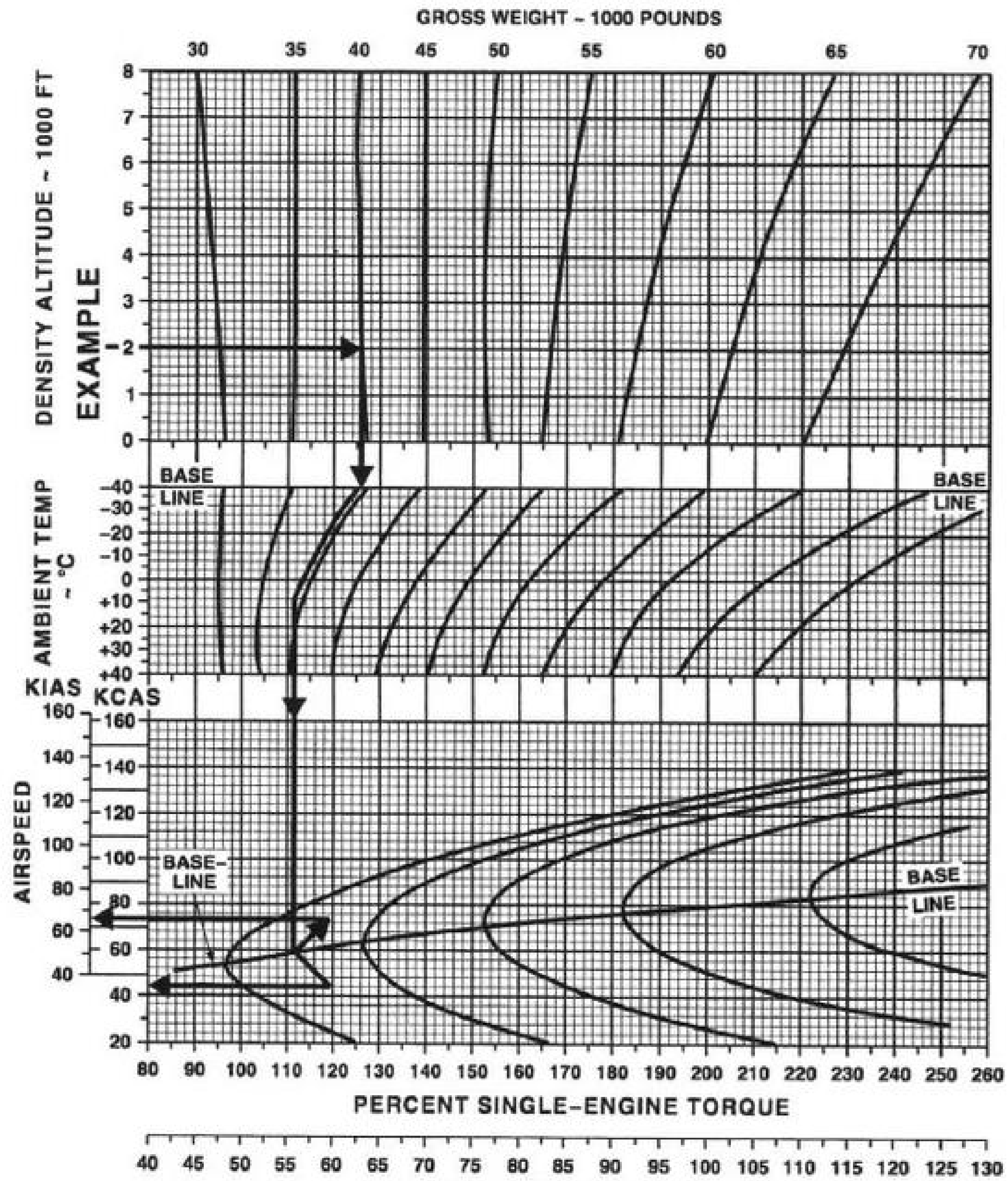

Figure 27-10. Single- or Dual-Engine Ability to Maintain Level Flight

27.3.1 Single- or Dual-Engine Ability to Maintain Level Flight Chart. The chart (Figure 27-10) provides the speed range wherein one- or two-engine level flight may be maintained at various density altitudes and gross weights at a torque value the engine(s) is (are) actually producing.

For example, to find the speed range for single- or dual-engine level flight at gross weight 40,000 pounds, 2000 feet density altitude, 10°C OAT and a single-engine torque of 120% or a dual-engine torque of 60%. The torque available is provided from the Military Power Available (753°C T_5) figure in Chapter 22. Enter the left side of the chart at 2000 feet, trace right to the 40,000-pound curve and then trace down to the temperature baseline where blade tip Mach is compensated for. Follow the influence line to 10°C OAT and then trace down to the airspeed baseline. Follow the influence line up to 120% torque and then trace left and read 66 KIAS. Trace down from the baseline to 120 trace left and read 40 KCAS. This is the speed range for single-engine 120% torque or dual-engine 60% torque. Totalizer will continue to indicate 40%.

27.3.2 Single-Engine Ability to Maintain 80 Knot Level Flight at Various N_r's Chart. The chart (Figure 27-11) provides the gross weight at which one-engine level flight at 80 KIAS can be maintained at various pressure altitudes, temperatures, and rotor speeds.

For example, to find the gross weight at which level flight at 80 KIAS can be maintained, at 2000-feet pressure altitude, 10°C OAT, and 103% N_r, enter the left side of the chart at 2000 feet. Trace right to the 10°C curve, and then trace down to the rotor speed baseline. Follow the influence line to 103% N_r and then trace down and read 30,400 pounds.

27.3.3 Dual-Engine Ability to Maintain 80 Knot Level Flight at Various N_r's Chart. The chart (Figure 27-12) is used the same way as Figure 27-11.

27.3.4 Single-Engine Maximum Range, Standard Temperature Chart. The chart (Figure 27-13) is based on military power to provide maximum range during one-engine operation. The chart is used in the same way as the range charts in Chapter 25.

27.3.5 Single-Engine Maximum Range, Standard Temperature -40°C Chart. The chart (Figure 27-14) is based on military power to provide maximum range during on-engine operation. The chart is used in the same way as the range charts in Chapter 25.

27.3.6 Single-Engine Maximum Endurance Chart. The chart (Figure 27-15) provides maximum endurance for the helicopter during one-engine operation. The chart uses like factors in the same manner as the endurance charts in Chapter 26.

27.3.7 Single- or Dual-Engine Landing Distance Chart. The chart (Figure 27-16) provides the landing distance ground roll when pressure altitude, temperature, gross weight, and headwind component are introduced into the chart.

For example, to determine landing distance at 2000 feet pressure altitude, 32°C OAT, 50,000 pounds gross weight, with a 5-knot headwind, enter the bottom of the upper left grid at 32°C. Trace up to the 2000-foot pressure altitude curve, trace across to the 50,000-pound curve in the next grid, and then trace down to the headwind grid's baseline. Follow the influence line to 5 knots and trace down to read 170-feet ground roll.

DUAL–ENGINE CLIMB
753 °C T5 MILITARY POWER
30 MINUTE LIMITATION
WARM DAY

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT.

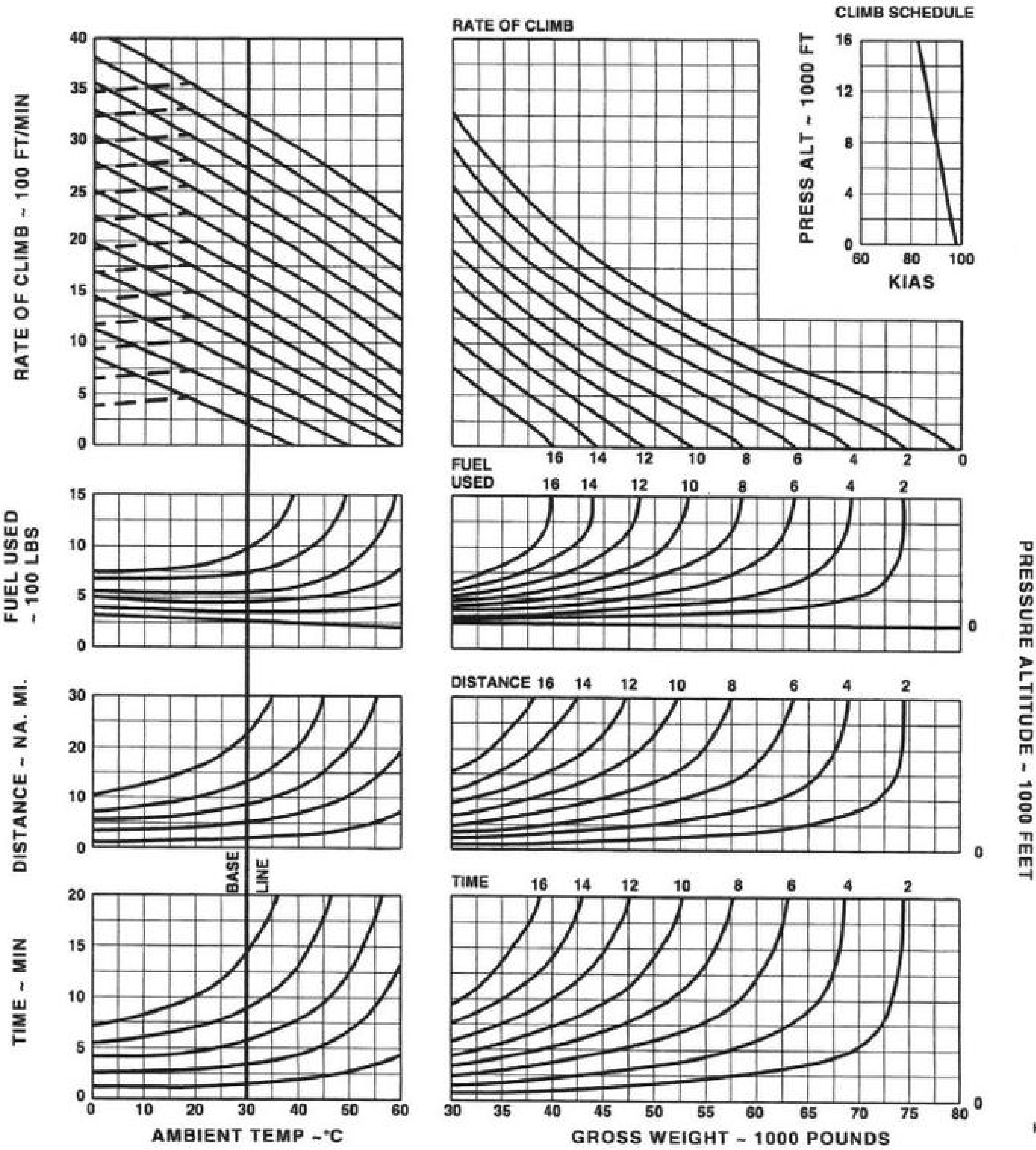

Figure 27-9. Dual-Engine Climb at Military Power — Warm Day

DUAL-ENGINE CLIMB
753 °C T5 MILITARY POWER
30-MINUTE LIMITATION
COLD DAY

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT.

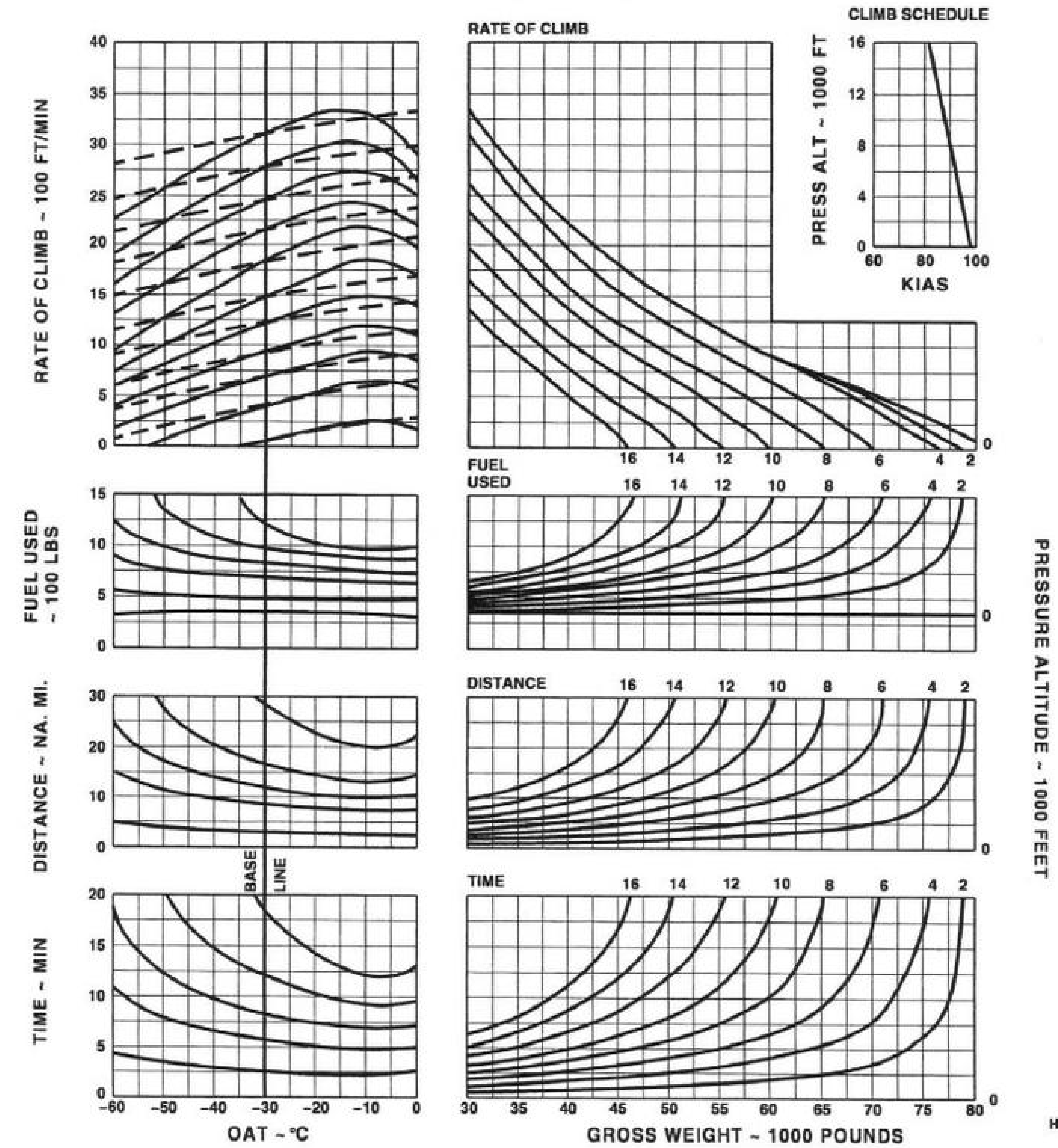

Figure 27-8. Dual-Engine Climb at Military Power — Cold Day

DUAL-ENGINE CLIMB

773 °C (T64–416) OR 792 °C (T64–416A) T_5 MAX PWR
10–MINUTE LIMITATION
WARM DAY

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT.

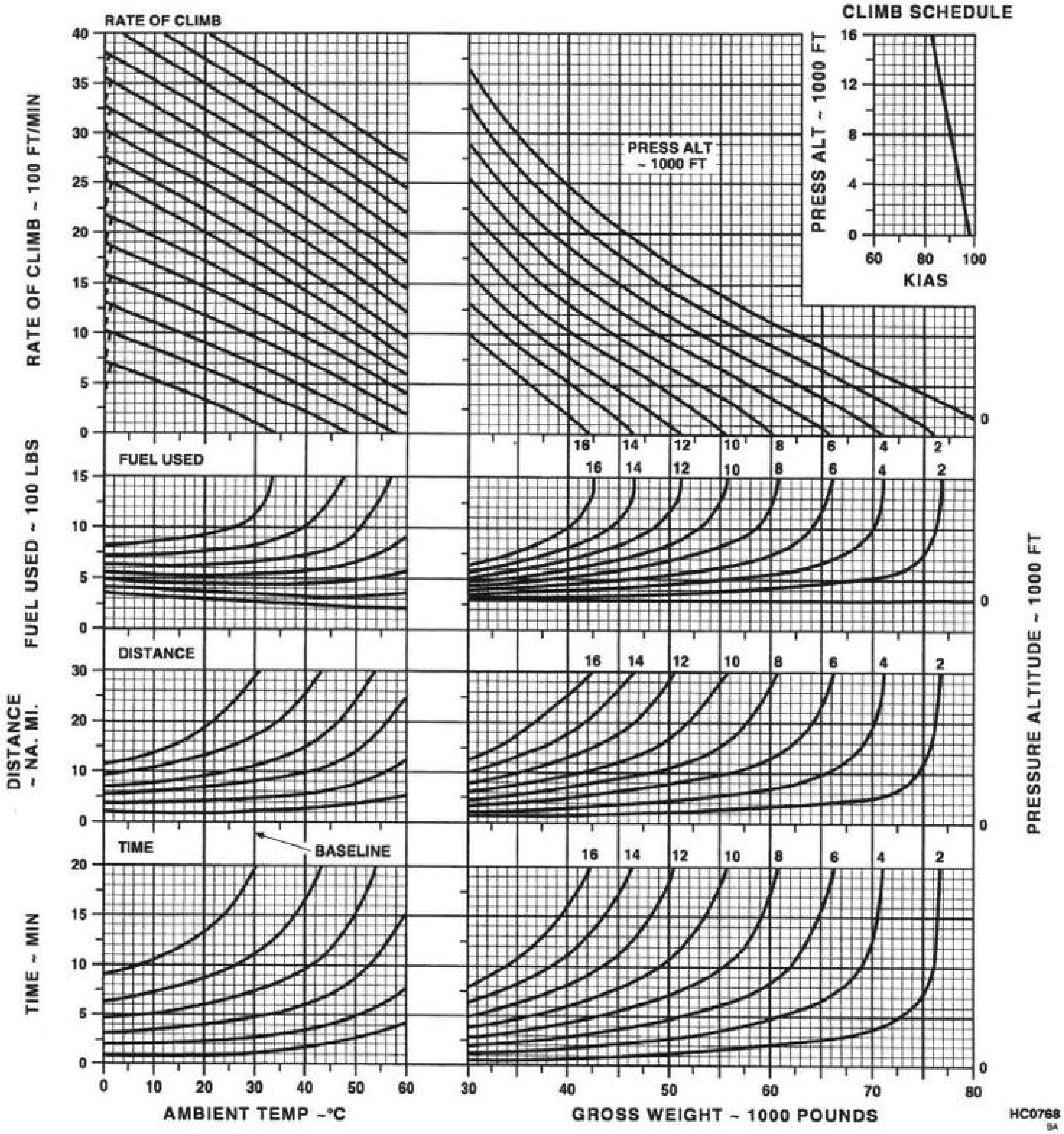

Figure 27-7. Dual-Engine Climb at Maximum Power — Warm Day

DUAL–ENGINE CLIMB
773 °C (T64–416) OR 792 °C (T64–416A) T_5 MAX PWR
10–MINUTE LIMITATION
COLD DAY

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64–GE–416
FUEL GRADE JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON
NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT.

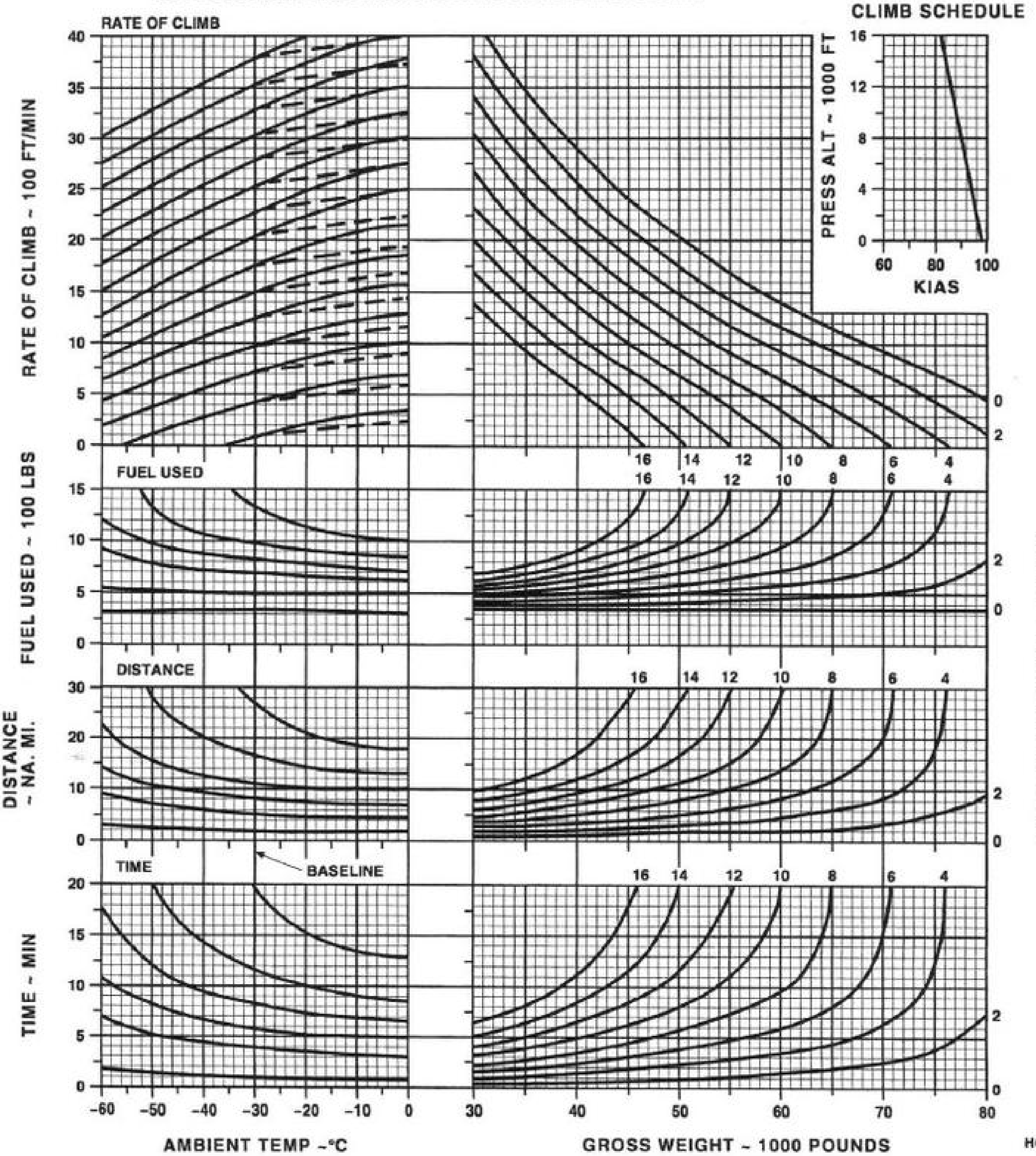

Figure 27-6. Dual-Engine Climb at Maximum Power — Cold Day

SINGLE–ENGINE CLIMB
773 °C (T64–416) OR 792 °C (T64–416A) T5 MAX PWR
10–MINUTE LIMITATION
WARM DAY

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT

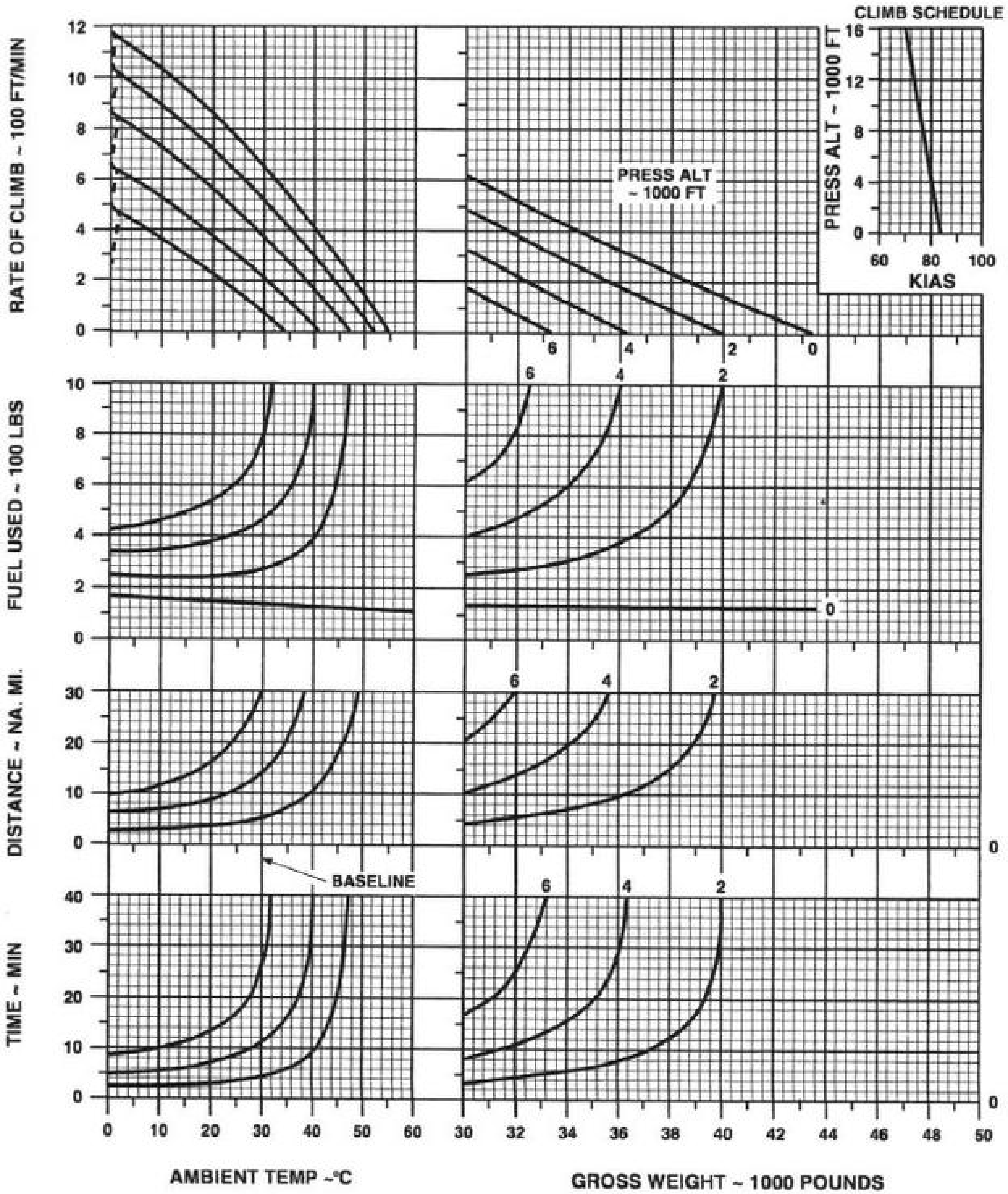

Figure 27-5. Single-Engine Climb at Maximum Power — Warm Day

SINGLE–ENGINE CLIMB
773 °C (T64–416) OR 792 °C (T64–416A) T_5 MAX PWR
10–MINUTE LIMITATION
COLD DAY

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST

ENGINE: T64-GE-416
FUEL GRADE JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: USE DASHED LINES WHEN OPERATING ON TRANSMISSION LIMIT

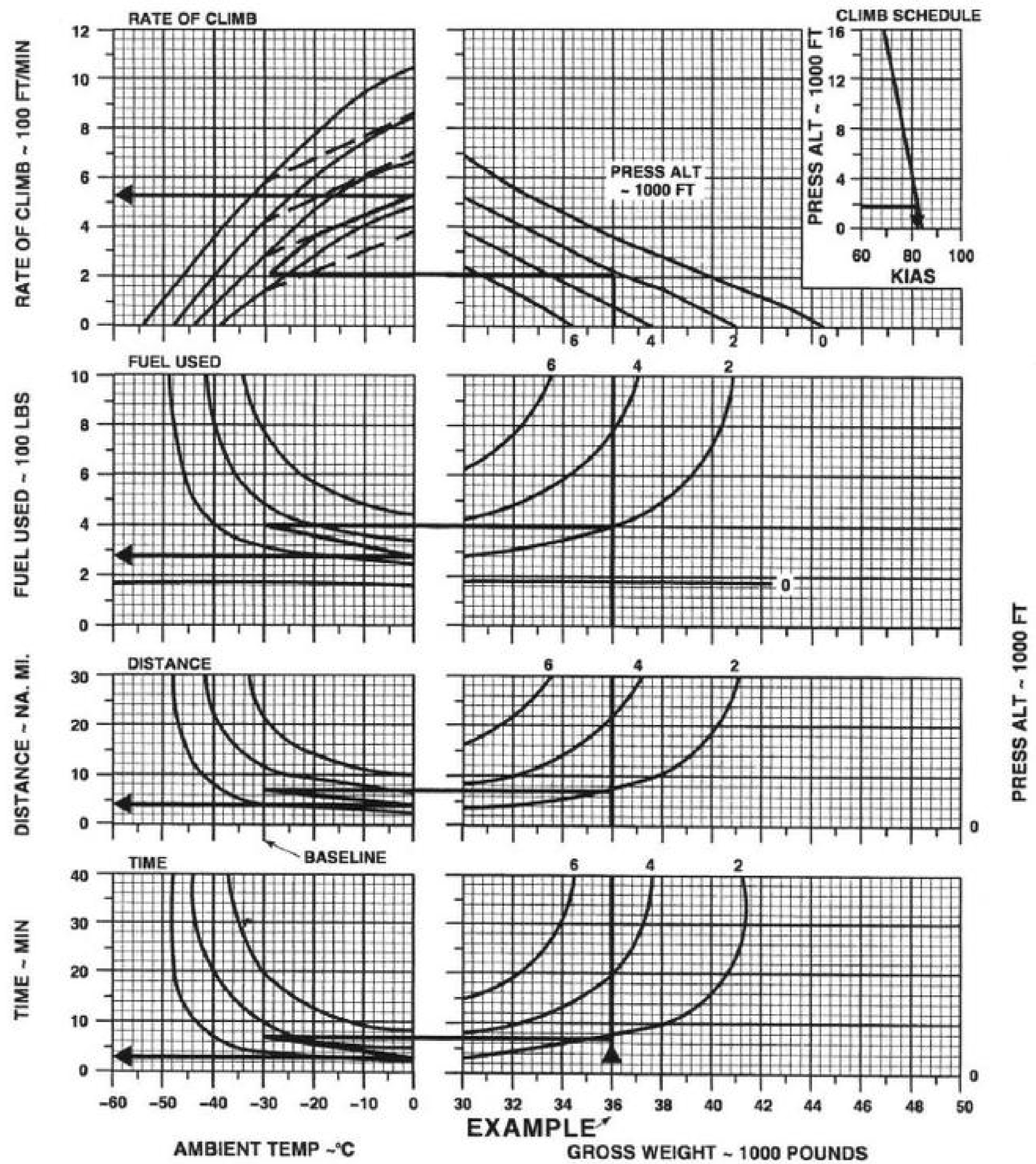

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Figure 27-4. Single-Engine Climb at Maximum Power — Cold Day

HEIGHT VELOCITY DIAGRAM
SINGLE-ENGINE FAILURE
SEA LEVEL STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF:
DATA BASIS: ESTIMATED
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE

AVOID CONTINUOUS FLIGHT IN THE REGIONS WITH DIAGONAL LINES AT SPEEDS, ALTITUDES, AND GROSS WEIGHTS INDICATED. SINGLE-ENGINE FAILURE IN THESE REGIONS MAY CAUSE THE RATE-OF-DESCENT LIMITATION OF THE LANDING GEAR TO BE EXCEEDED.

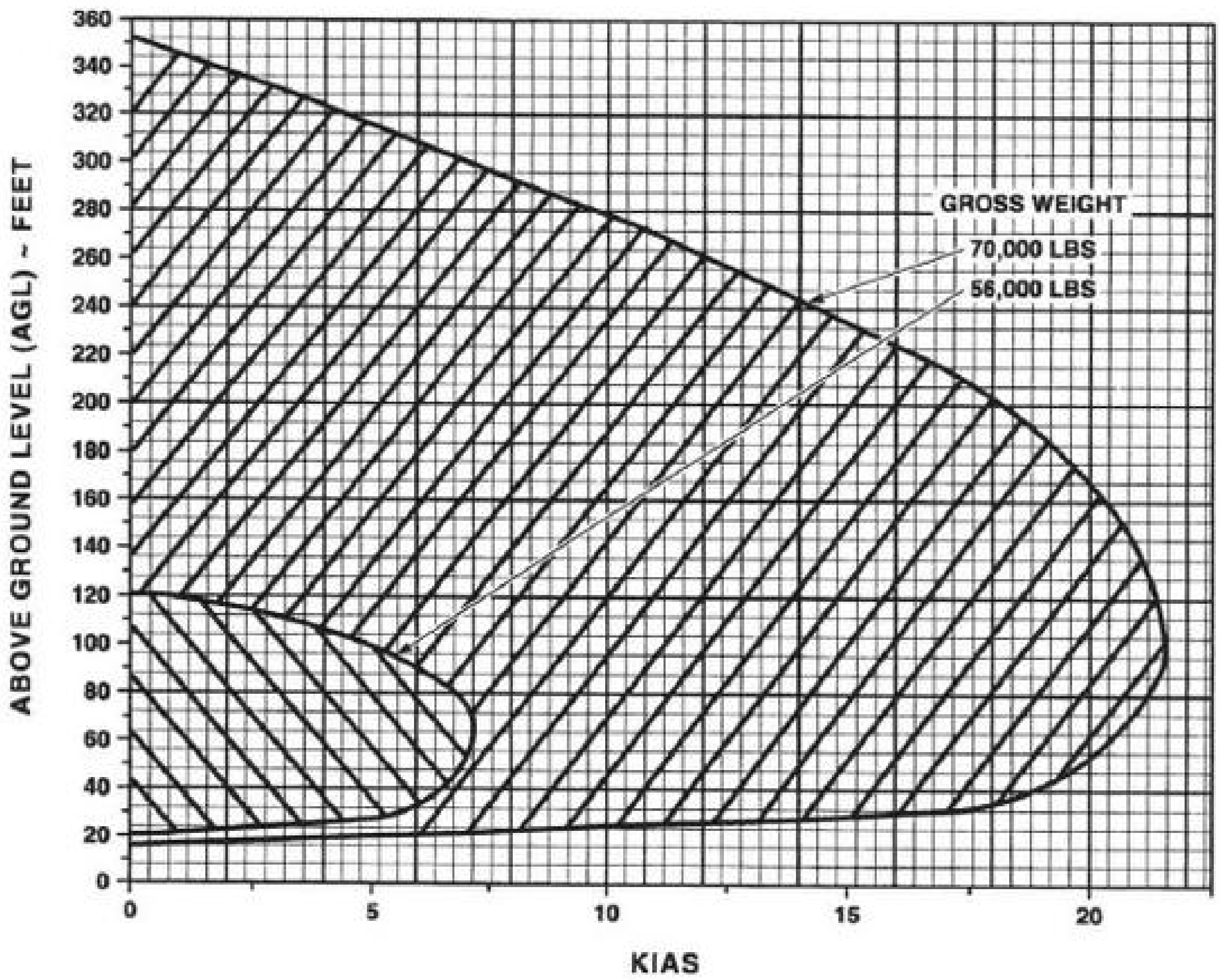

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Figure 27-3. Height-Velocity Diagram, Single-Engine Failure

HEIGHT VELOCITY DIAGRAM
DUAL-ENGINE FAILURE
SEA LEVEL STANDARD TEMPERATURE
100% N_r

MODEL: CH-53E
DATA AS OF:
DATA BASIS: ESTIMATED
CONFIGURATION: EAPS ON, NO EXTERNAL TANKS

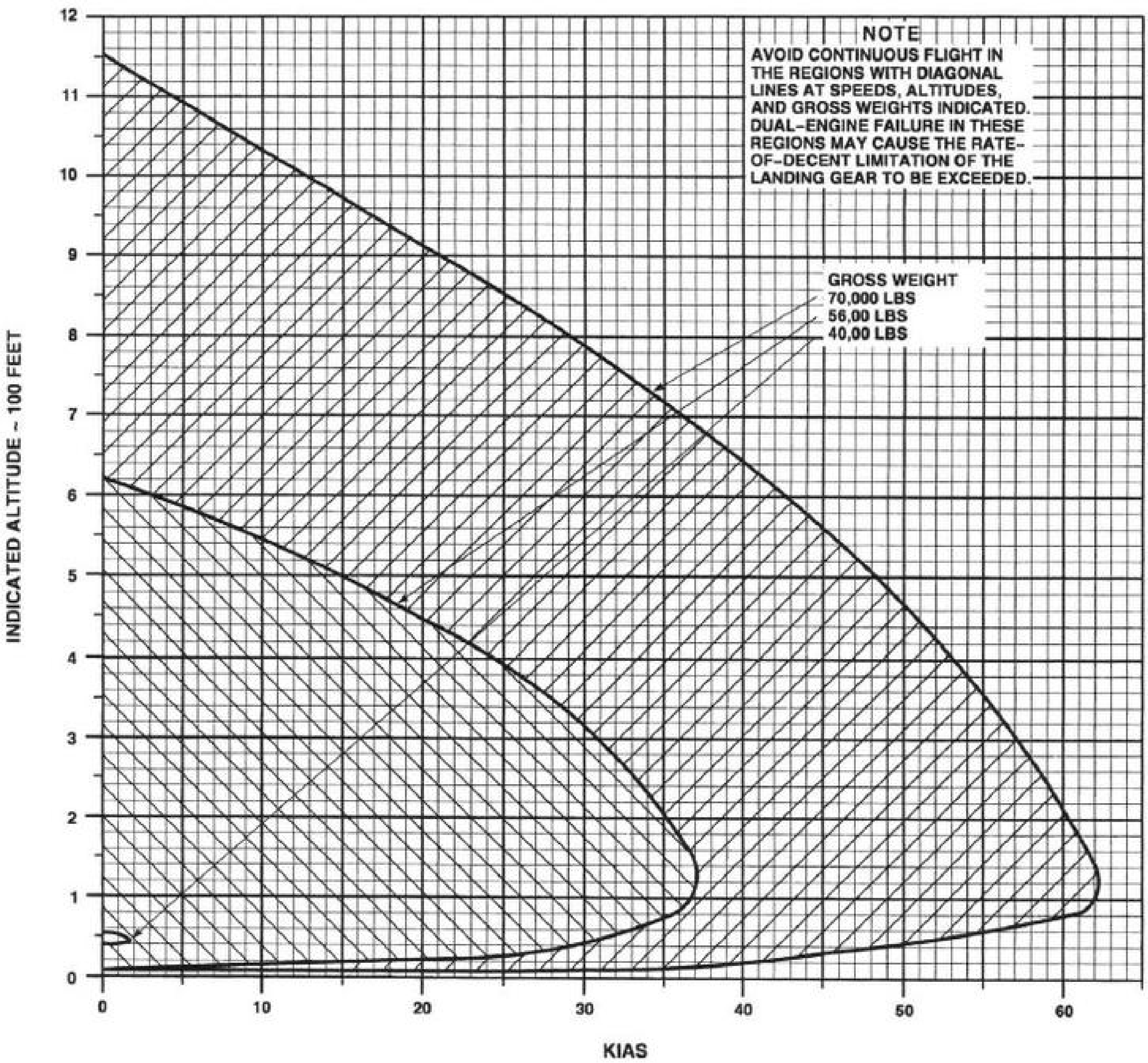

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Figure 27-2. Height-Velocity Diagram, Dual-Engine Failure

HEIGHT VELOCITY DIAGRAM
THREE ENGINE FAILURE
SEA LEVEL STANDARD TEMPERATURE
100% Nr

MODEL: CH-53E
DATA AS OF: MARCH 1996
DATA BASIS: ESTIMATED

NOTE:

IT IS ESTIMATED THAT A THREE-ENGINE FAILURE IN THE SHADED AREA LEAVES INSUFFICIENT ALTITUDE FOR THE CORRECT AUTOROTATIVE APPROACH TO AN EMERGENCY LANDING AND THAT THE SUBSEQUENT LAND BACK WILL EXCEED THE DESIGN LIMITATIONS OF THE AIRCRAFT

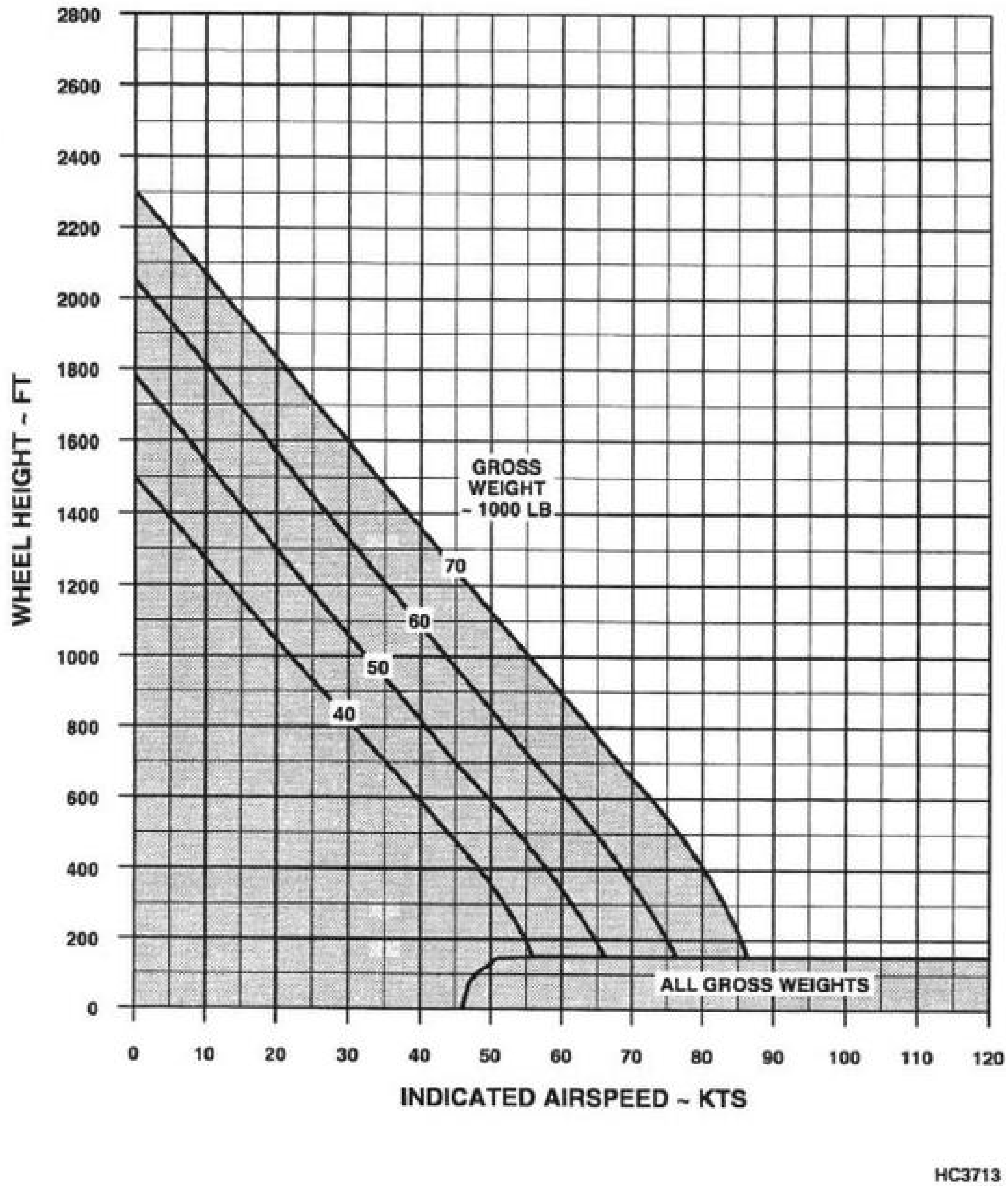

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Figure 27-1. Height-Velocity Diagram, Three-Engine Failure

CHAPTER 27
Emergency

27.1 HEIGHT-VELOCITY DIAGRAMS

The height-velocity diagrams provide the limiting altitude and corresponding airspeed combinations for a safe landing after one or more engines have failed. Each diagram has several shaded areas for different gross weights showing combinations of altitude and airspeed which should be avoided.

27.1.1 Height-Velocity Diagram, Three-Engine Failure. The height-velocity diagram for a three-engine failure (Figure 27-1) is based on 100% N_r for standard day conditions at sea level.

For example, at 65,000 pounds gross weight, 400 feet AGL at 70 KIAS, enter the left side of the chart at the 400-foot line and trace right to where it is crossed by the 70 KIAS line. Note that this point is to the left of a line which would define a helicopter at 65,000 pounds. This combination of altitude and airspeed does not allow the pilot enough response time to accelerate the helicopter out of the shaded area in order to make a safe landing with a three-engine failure. (Refer to the autorotation charts in Chapter 12 for the best autorotation airspeeds.) Altitude and/or airspeed should be increased. At this gross weight, if the airspeed is to remain at 70 KIAS, the helicopter will have to fly at least 525 feet above the surface. If the altitude must remain at 400 feet AGL, airspeed will have to be increased to at least 75 KIAS.

27.1.2 Height-Velocity Diagram, Dual-Engine Failure. The height-velocity diagram for a dual-engine failure (Figure 27-2) is used the same way as Figure 27-1.

27.1.3 Height-Velocity Diagram, Single-Engine Failure. The height-velocity diagram for a single-engine failure (Figure 27-3) is used the same way as Figure 27-1.

27.2 CLIMB CHARTS

The climb charts provide a means of computing the time to climb, the horizontal distance covered, the fuel consumed, and the rate-of-climb for various gross weights. These values are computed by applying the gross weights to various conditions of pressure altitude and temperature. The fuel used includes warmup and takeoff from sea level. Also included is a climb speed schedule for various pressure altitudes. A temperature scale relates the OAT at various pressure altitudes. The temperature scale is either based on a warm day (0 to 60°C) or a cold day (-60 to 0°C), for each series of charts.

27.2.1 Single-Engine Climb at Maximum Power — Cold Day Chart. The chart (Figure 27-4) provides the time to climb, horizontal distance covered, fuel consumed, and rate of climb, at various gross weights, for a cold day.

For example, to find the single-engine time to climb to 2000 feet pressure altitude, distance traveled, fuel consumed, rate-of-climb, and best airspeeds at 36,000 pounds gross weight and 0°C OAT, enter the bottom of the chart at 36,000 pounds. Trace up to the 2000-foot curve in the time grid, trace left to the temperature baseline, follow the influence line to 0°C, and then trace left to read time to climb: 3 minutes. Enter the distance grid at 36,000 pounds, trace up to the 2000-foot curve, trace left to the temperature baseline, follow the influence line to 0°C, and then trace left to read distance traveled: 4 miles. Enter the fuel grid at 36,000 pounds, trace up to the 2000-foot curve, trace left to the temperature baseline, follow the influence line to 0°C, and then trace left to read fuel consumed: 280 pounds. Enter the rate-of-climb grid at 36,000 pounds, trace up to the 2000-foot curve and trace left to the temperature baseline. Consult the maximum power available chart and note power will be transmission limited for most of the climb. Follow the dashed influence lines to 0°C, then trace left to read the final rate-of-climb: 540 feet-per-minute. Enter the left side of the climb schedule grid and note best climb speed at sea level is 84 KIAS and 82 KIAS at 2000 feet.

27.2.2 Single-Engine Climb at Maximum Power — Warm Day Chart. The chart (Figure 27-5) is used the same way as Figure 27-4.

27.3 DUAL-ENGINE CLIMB CHARTS

The climb charts-dual engines (Figures 27-6 through 27-9) are based on maximum and military power and provide dual-engine climb data for the helicopter on cold and warm days. The charts use like factors in the same manner as the climb charts in Chapter 24; therefore, explanatory text and sample problem data are not included.

CHAPTER 28
Special

28.1 EXTERNAL LOAD DRAG CHARTS

These charts are used to determine the effect various external load shapes have on aircraft performance.

28.1.1 Increase in Drag Area Due to External Load Chart. The chart (Figure 28-1) is used to convert the frontal area of various shapes into drag area to be used in conjunction with the sea level standard temperature external capabilities charts.

For example, a cube with a frontal area of 50 square feet has a drag area of 40 square feet.

28.1.2 External Lift Capability 0- and 40 Square-Foot Drag Area, Sea Level, and 15°C Chart. The chart (Figure 28-2) provides the external capabilities for zero- and 40-square-foot drag areas.

For example, at 60,000-pounds gross weight with an external load drag area of 40 square feet, enter the bottom of the chart at the desired KTAS, take 110 KTAS for instance and trace up to the 60,000-pound curve, then trace left and read fuel consumption 0.0305 nautical miles per pound of fuel.

The charts that follow (Figures 28-3 to 28-10), use the same way to determine performance as Figure 28-2 above.

INCREASE IN DRAG AREA DUE TO EXTERNAL LOAD

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: ESTIMATED

CONFIGURATION: EXTERNAL TANKS AND EAPS ON

NOTE: DRAG AREA INCREASE DETERMINED FROM CHART MAY BE INCREASED SIGNIFICANTLY DUE TO LOAD HANDLING CHARACTERISTICS AND SUSPENSION SLING ARRANGEMENT.

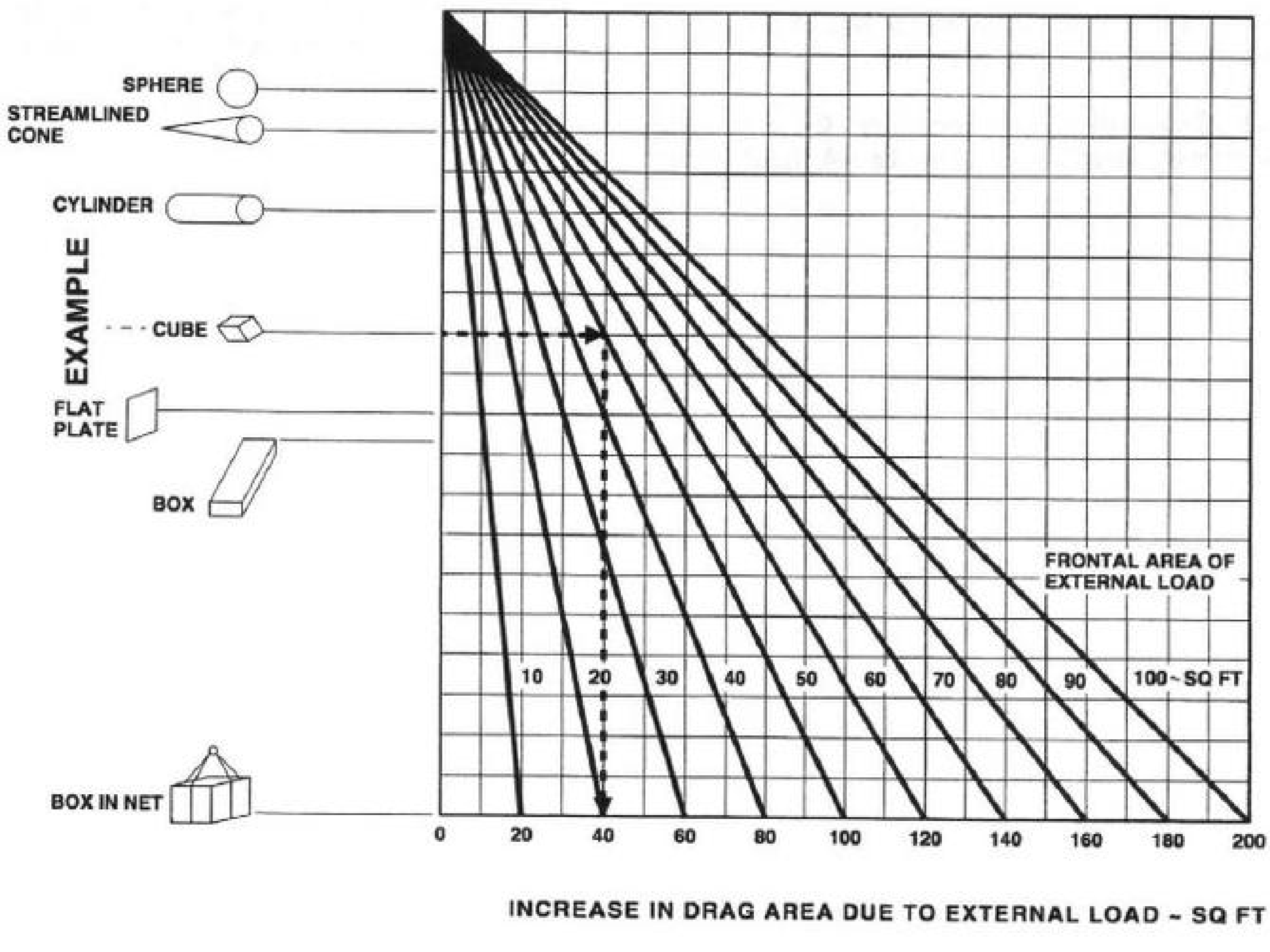


Figure 28-1. Increase in Drag Area Due to External Load

THREE-ENGINE FORWARD FLIGHT PERFORMANCE EXTERNAL CAPABILITIES
SEA LEVEL STANDARD TEMPERATURE (15C)

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

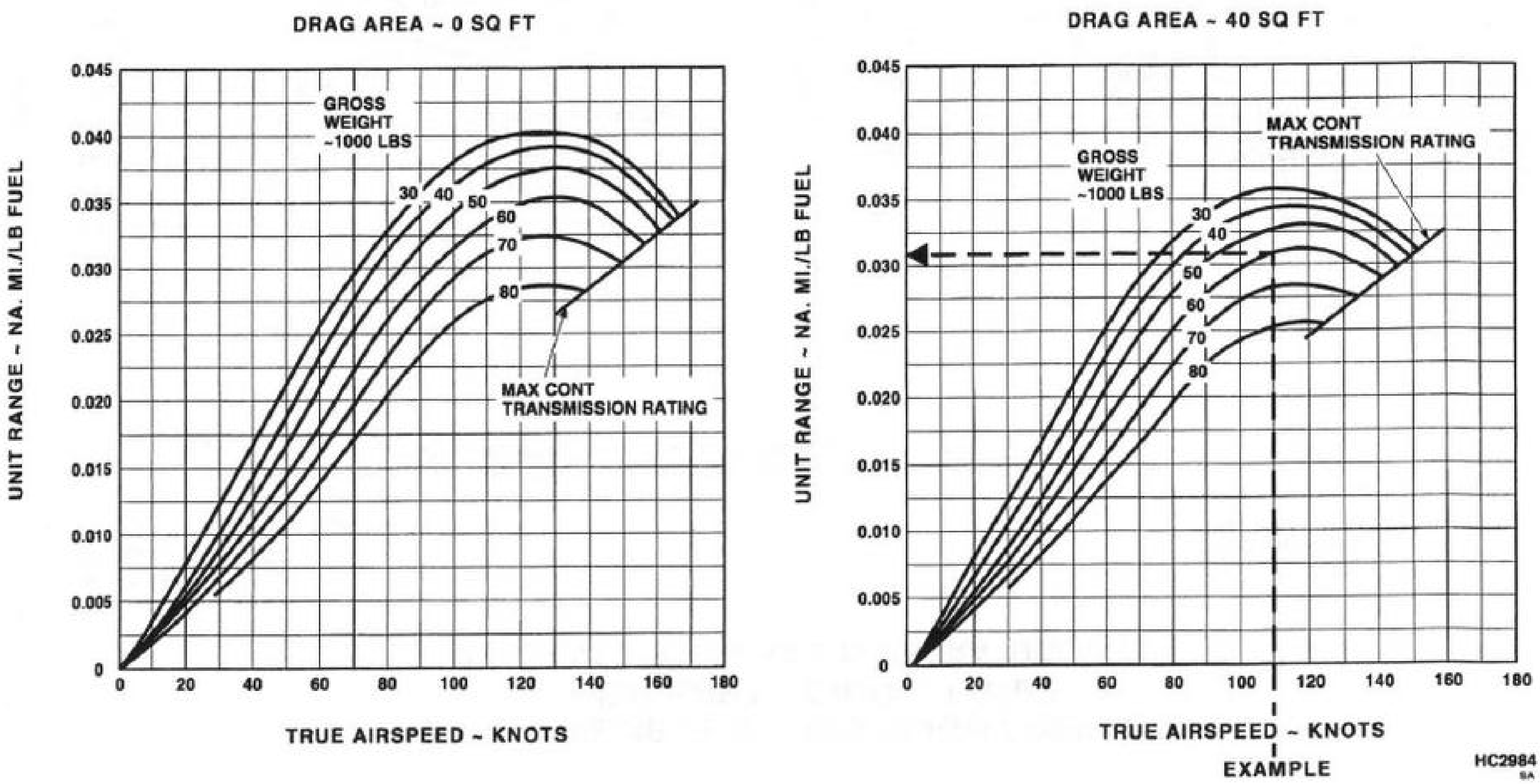


Figure 28-2. External Lift Capability 0- and 40-square-foot Drag Area, Sea Level, and 15°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
SEA LEVEL STANDARD TEMPERATURE (15C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

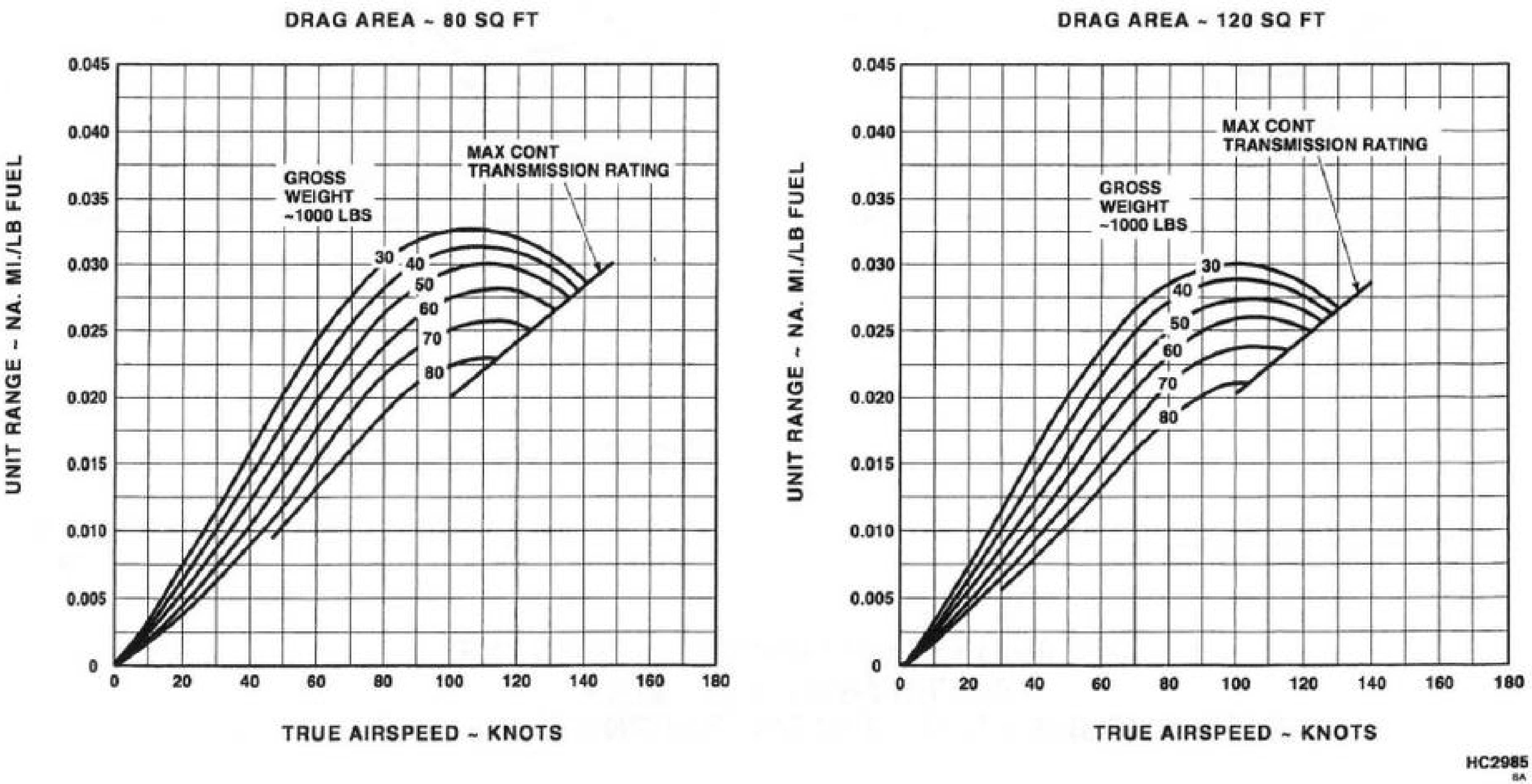


Figure 28-3. External Lift Capability 80- and 120-square-foot Drag Area, Sea Level, and 15°C

THREE-ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
SEA LEVEL STANDARD TEMPERATURE (15C)

MODEL: CH-53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64-GE-416
FUEL GRADE: JP-4 / JP-5 / JP-8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

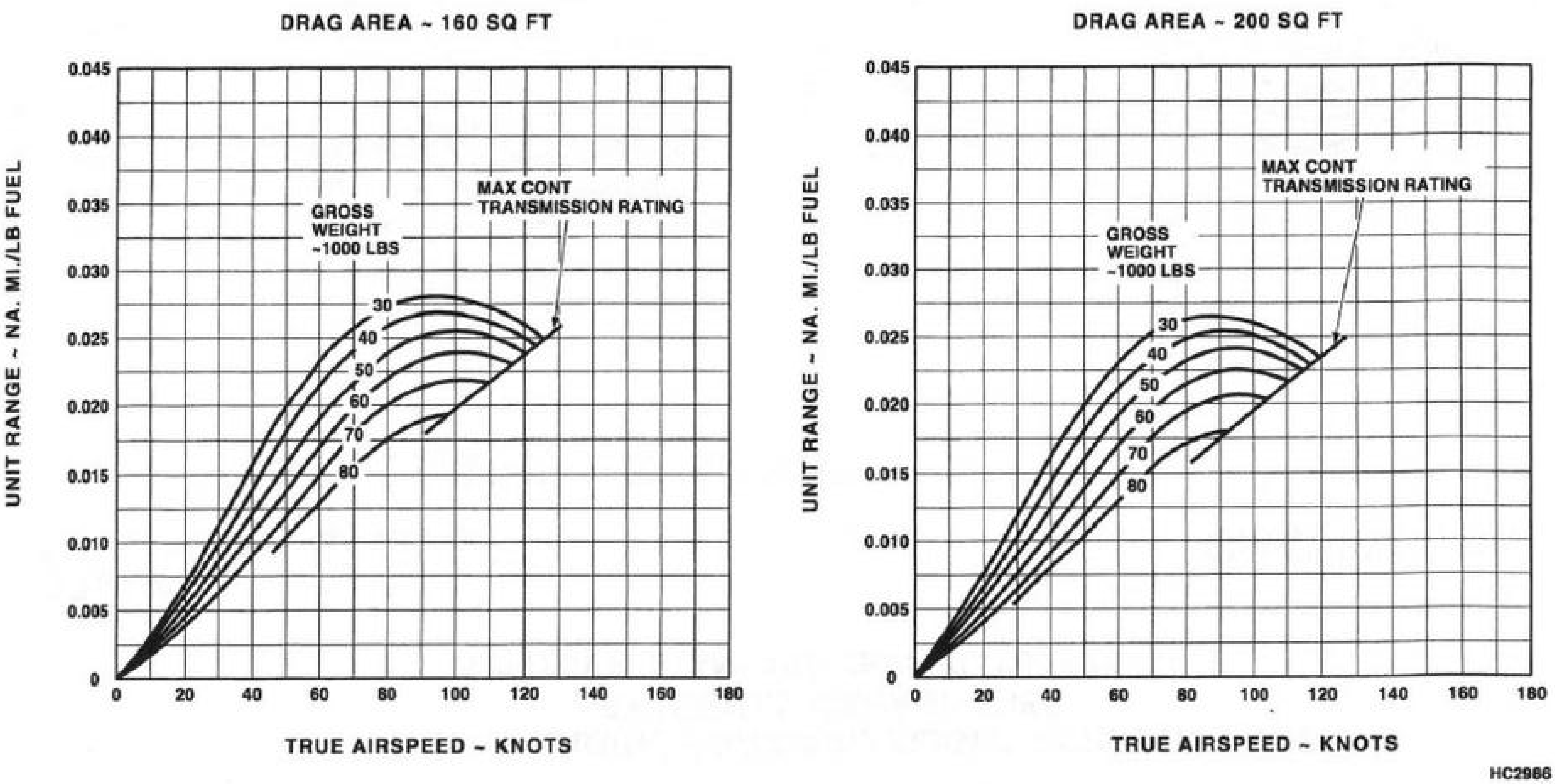


Figure 28-4. External Lift Capability 160- and 200-square-foot Drag Area, Sea Level, and 15°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
4000 FEET   STANDARD TEMPERATURE (7.1°C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

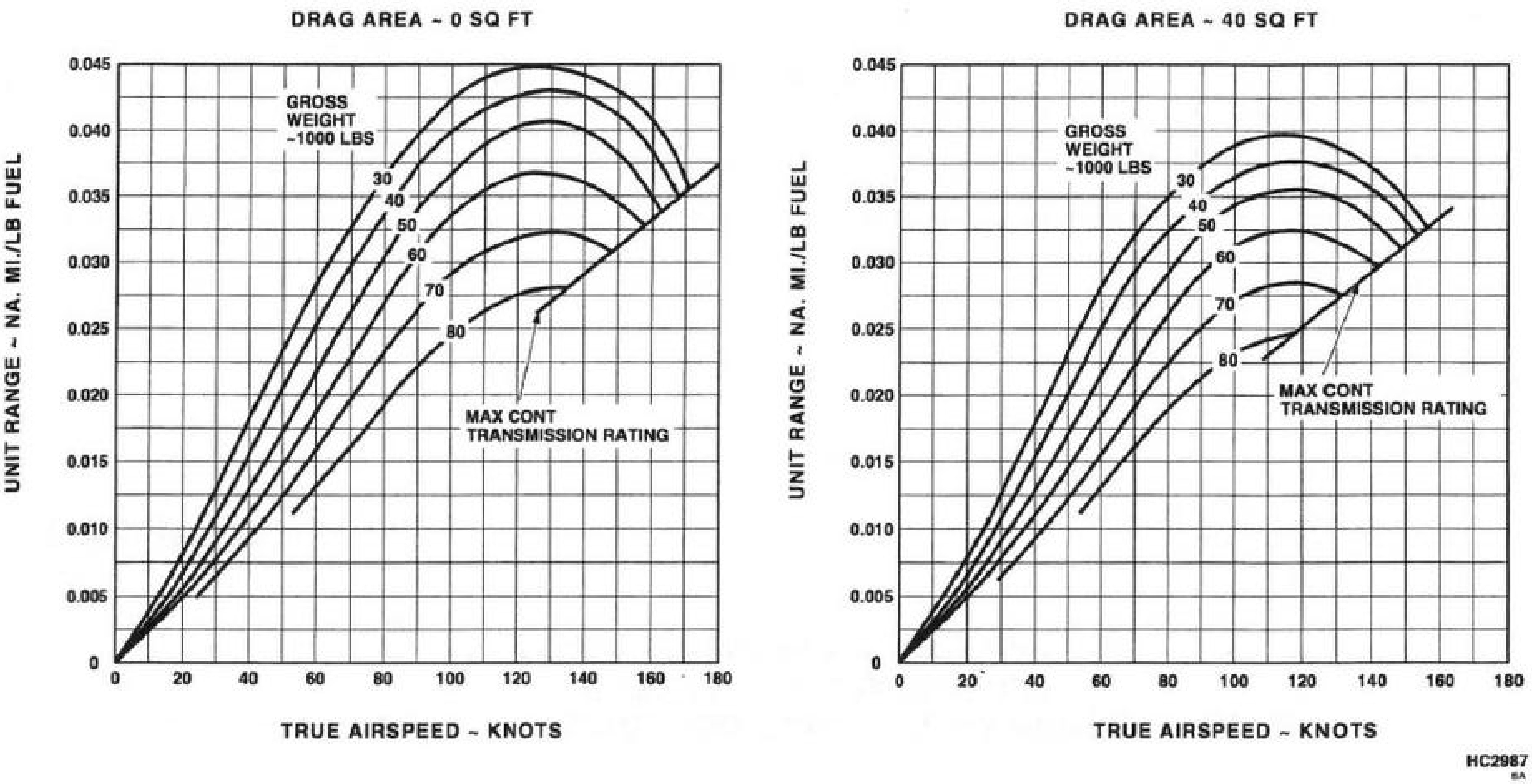


Figure 28-5. External Lift Capability 0- and 40-square-foot Drag Area, 4000 Feet, and 7°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
4000 FEET STANDARD TEMPERATURE (7.1C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

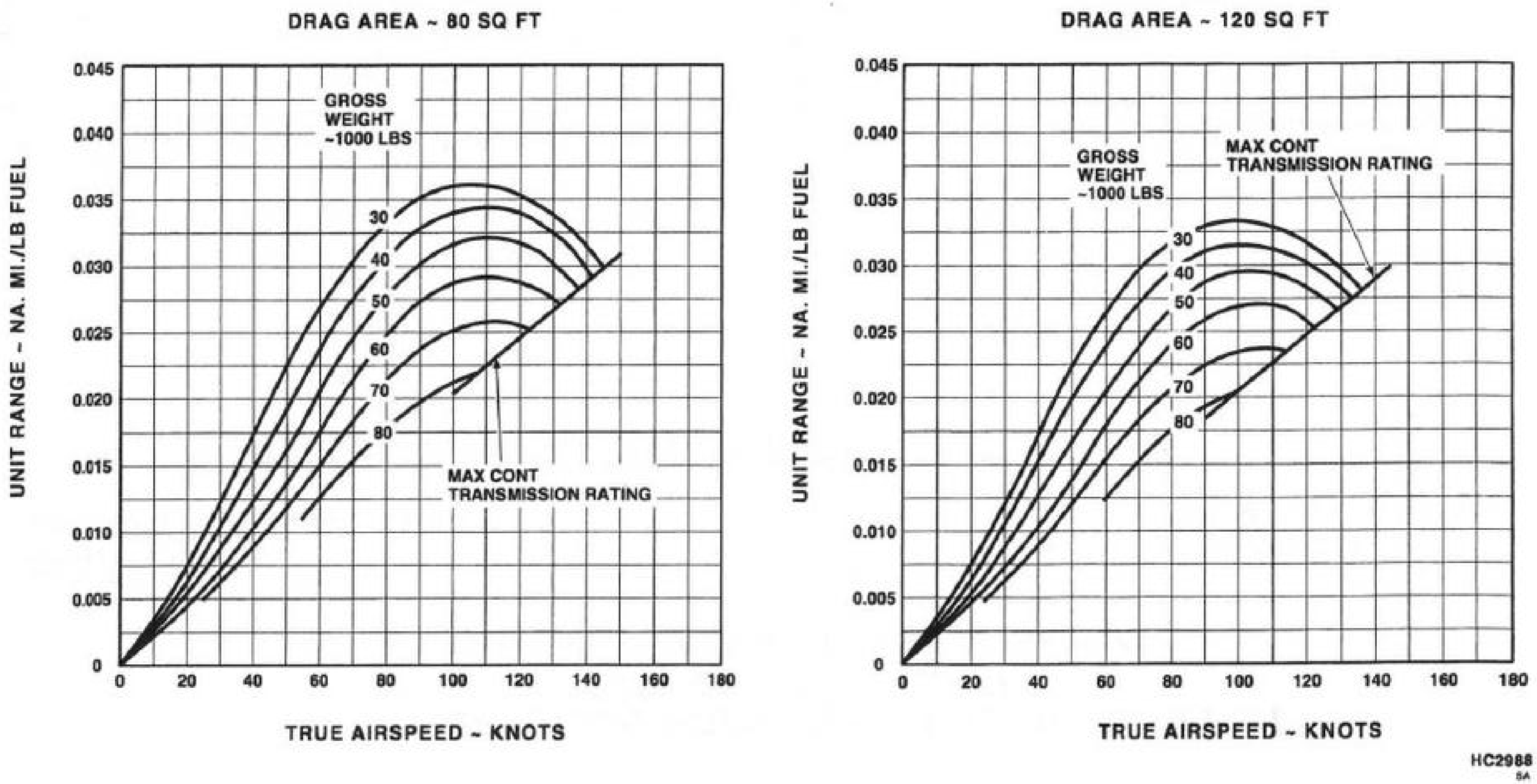


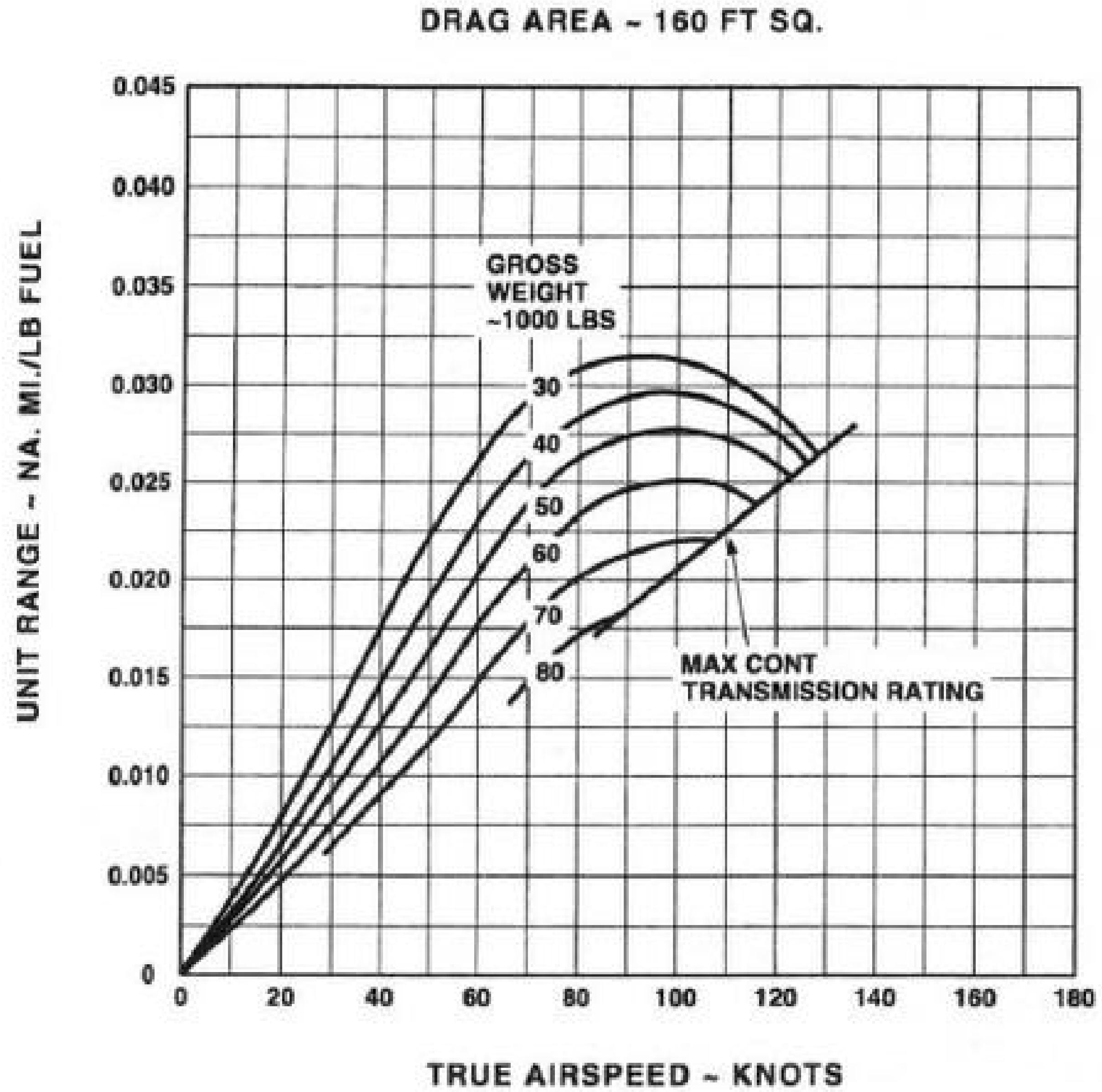
Figure 28-6. External Lift Capability 80- and 120-square-foot Drag Area, 4000 Feet, and 7°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
4000 FEET STANDARD TEMPERATURE (7.1°C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.



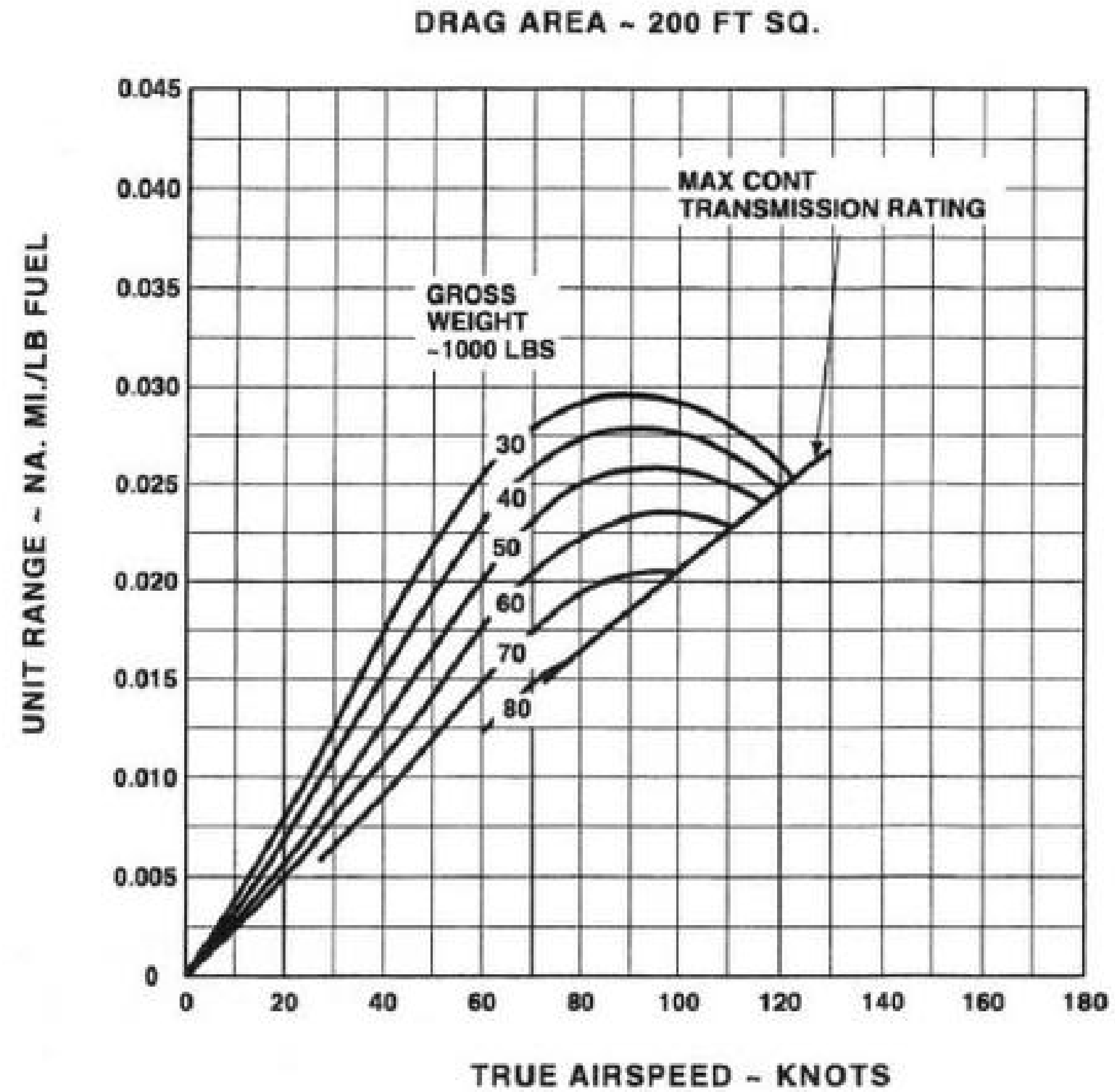


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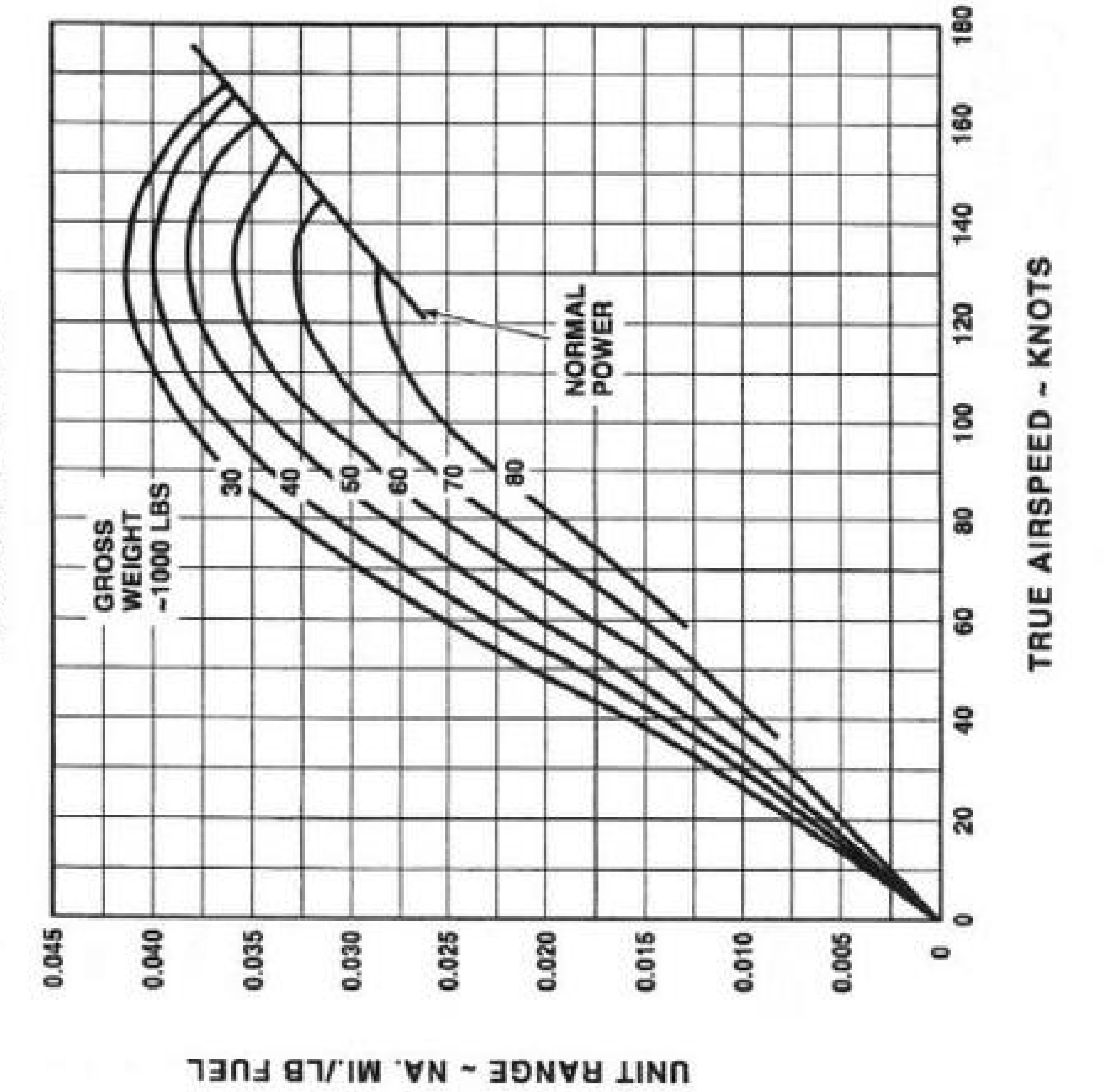
Figure 28-7. External Lift Capability 160- and 200-square-foot Drag Area, 4000 Feet, and 7°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
SEA LEVEL STANDARD TEMPERATURE (35C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.



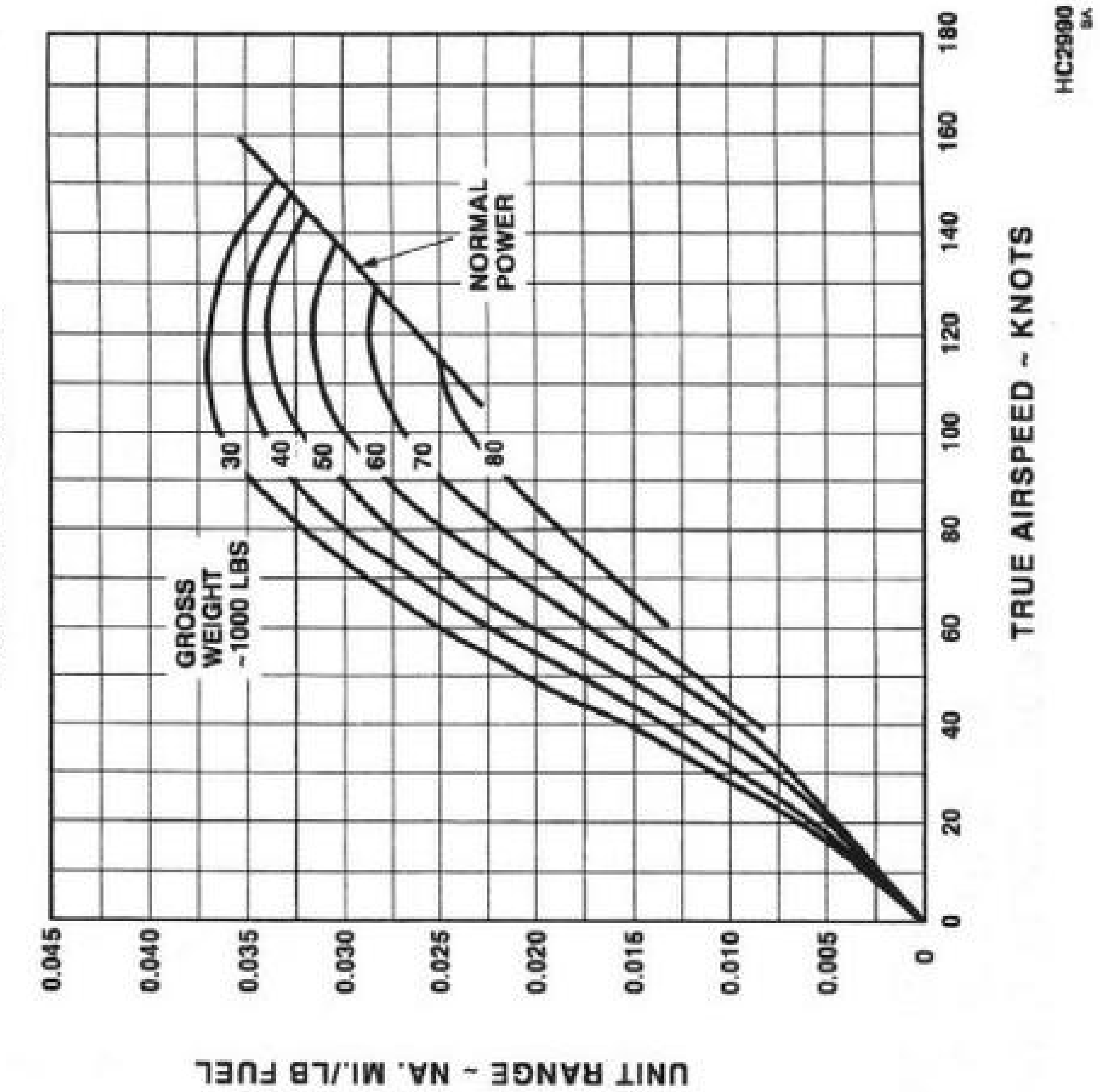


Figure 28-8. External Lift Capability 0- and 40-square-foot Drag Area, Sea Level, and 35°C

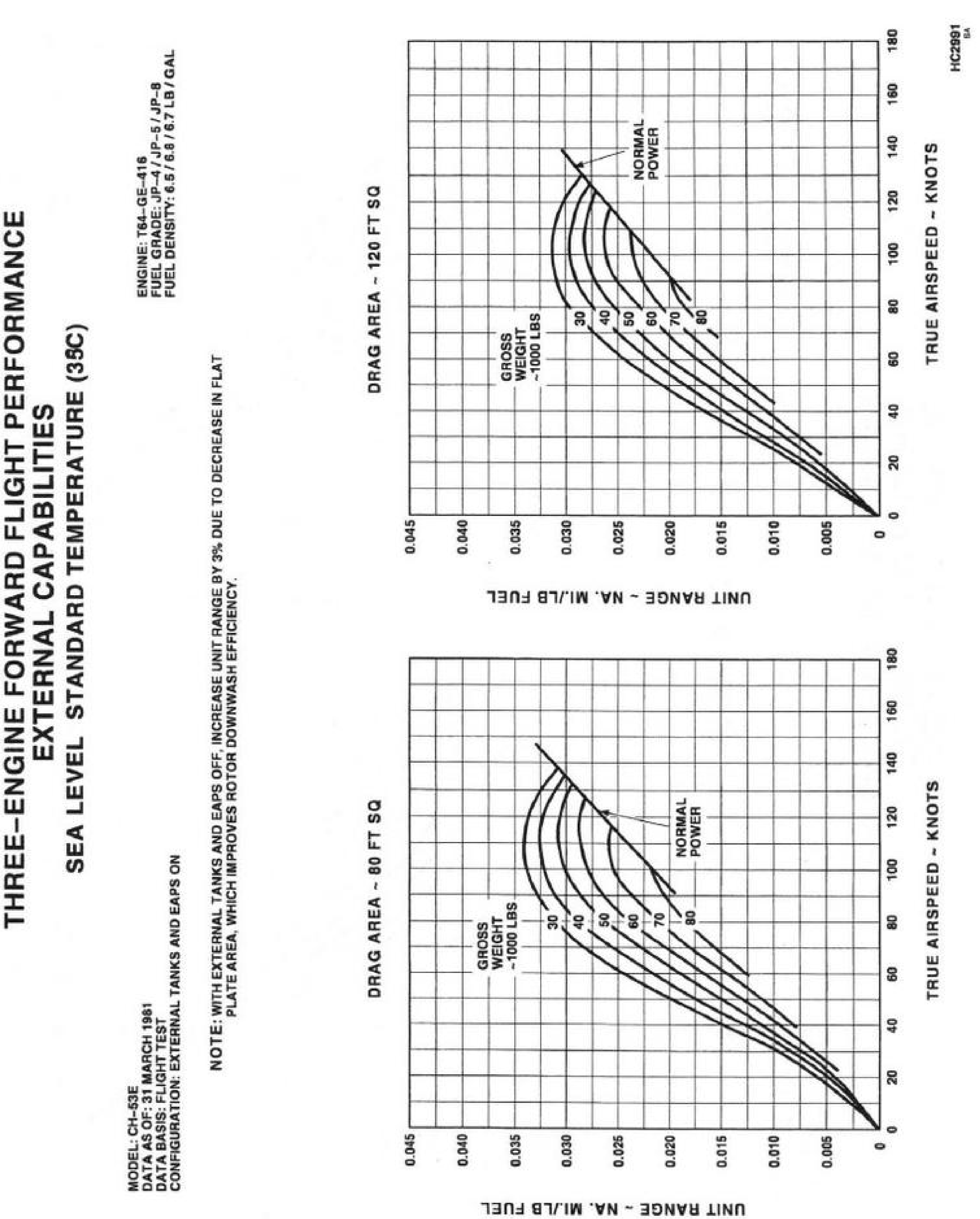


Figure 28-9. External Lift Capability 80- and 120-square-foot Drag Area, Sea Level, and 35°C

THREE–ENGINE FORWARD FLIGHT PERFORMANCE
EXTERNAL CAPABILITIES
SEA LEVEL STANDARD TEMPERATURE (35C)

MODEL: CH–53E
DATA AS OF: 31 MARCH 1981
DATA BASIS: FLIGHT TEST
CONFIGURATION: EXTERNAL TANKS AND EAPS ON

ENGINE: T64–GE–416
FUEL GRADE: JP–4 / JP–5 / JP–8
FUEL DENSITY: 6.5 / 6.8 / 6.7 LB / GAL

NOTE: WITH EXTERNAL TANKS AND EAPS OFF, INCREASE UNIT RANGE BY 3% DUE TO DECREASE IN FLAT PLATE AREA, WHICH IMPROVES ROTOR DOWNWASH EFFICIENCY.

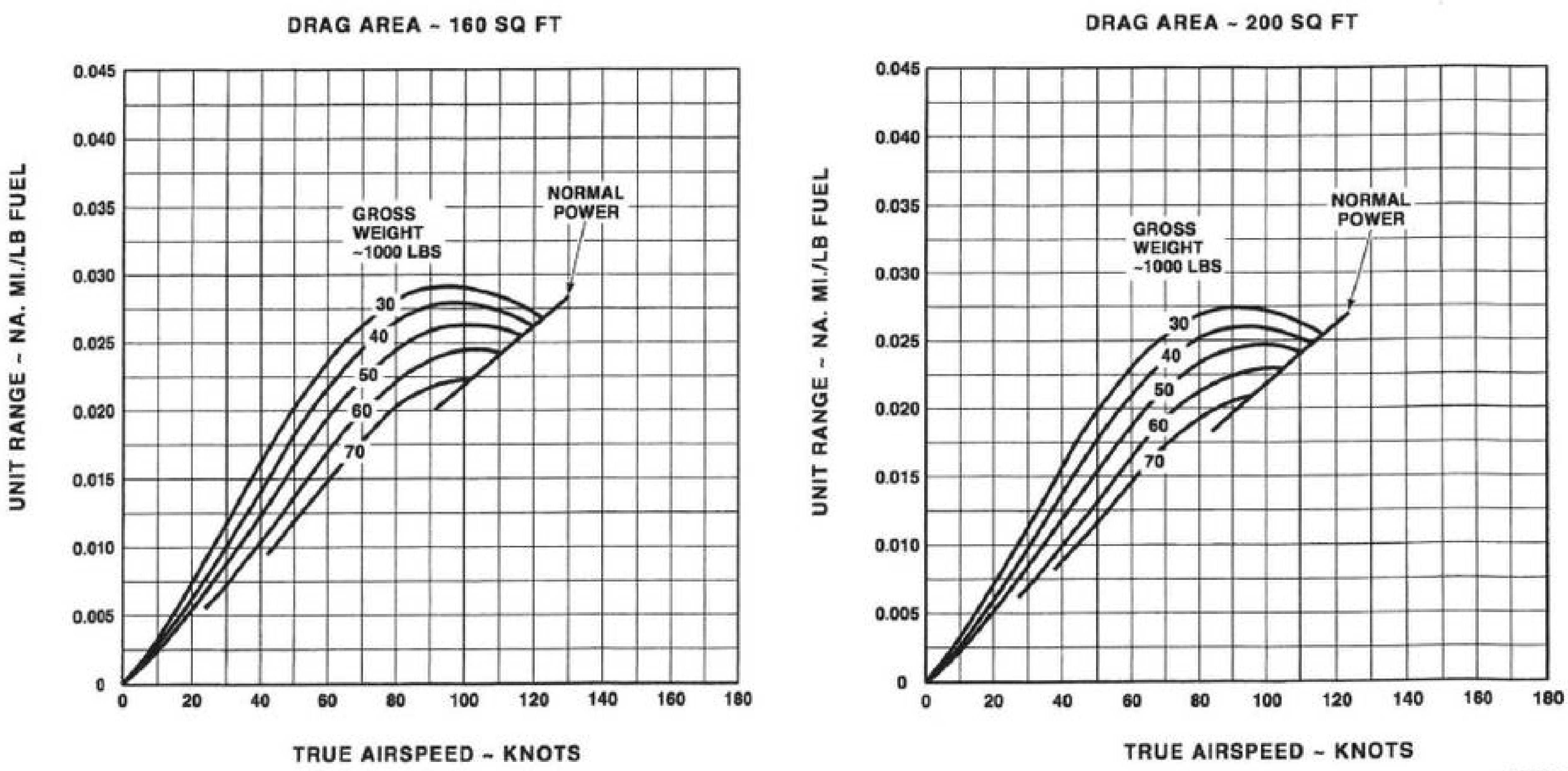


Figure 28-10. External Lift Capability 160- and 200-square-foot Drag Area, Sea Level, and 35°C

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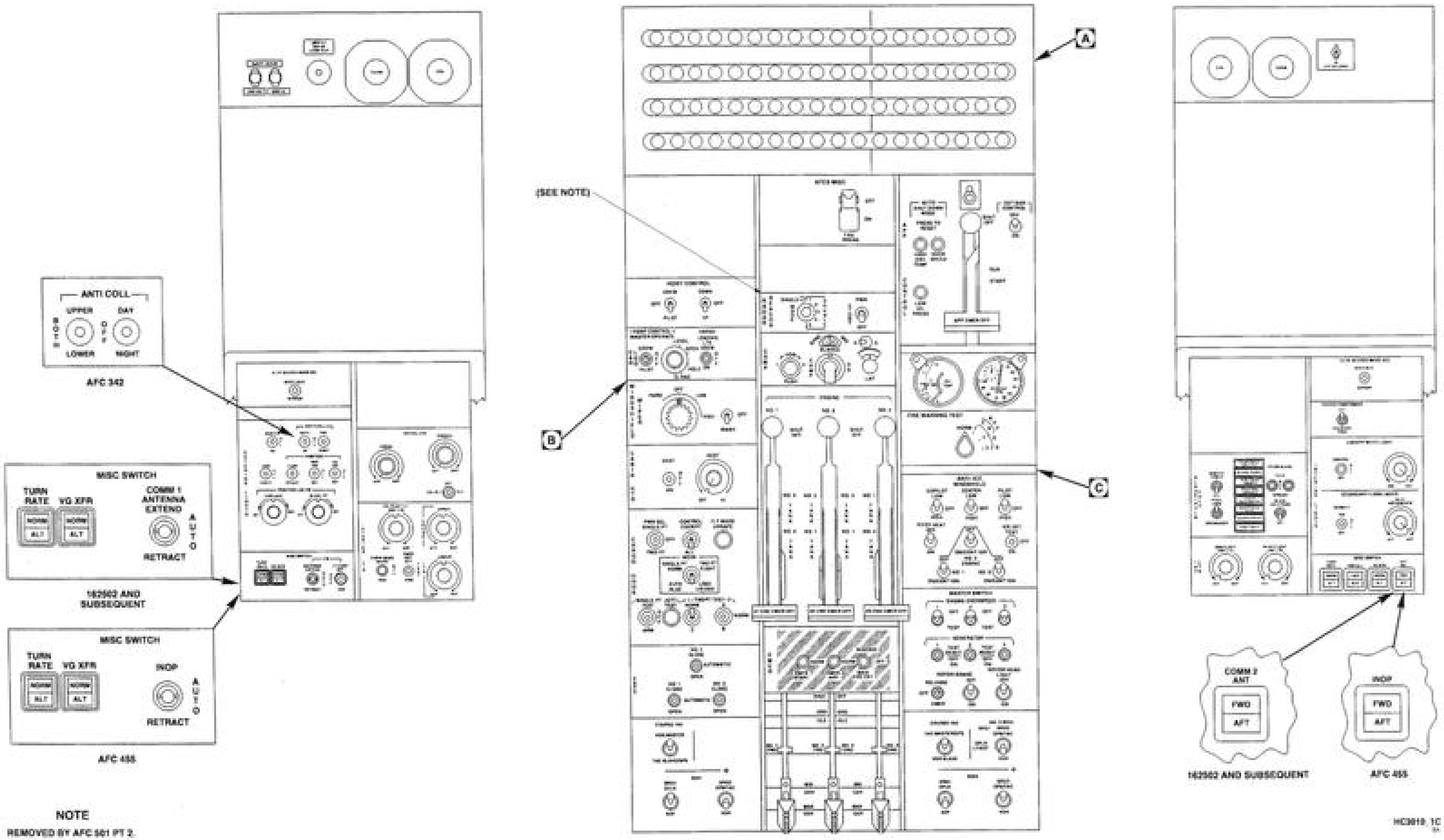
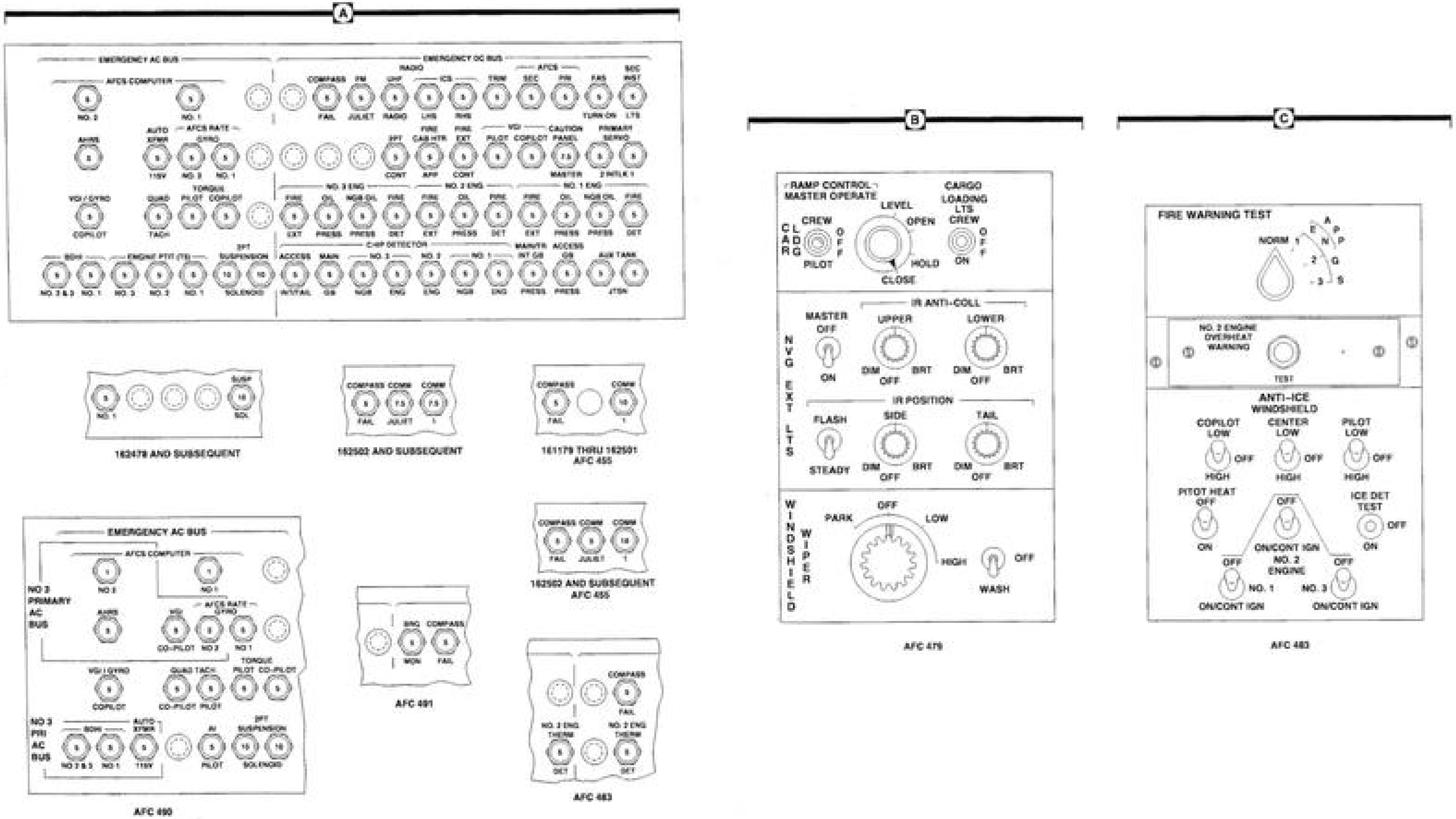
FOLDOUT ILLUSTRATIONS

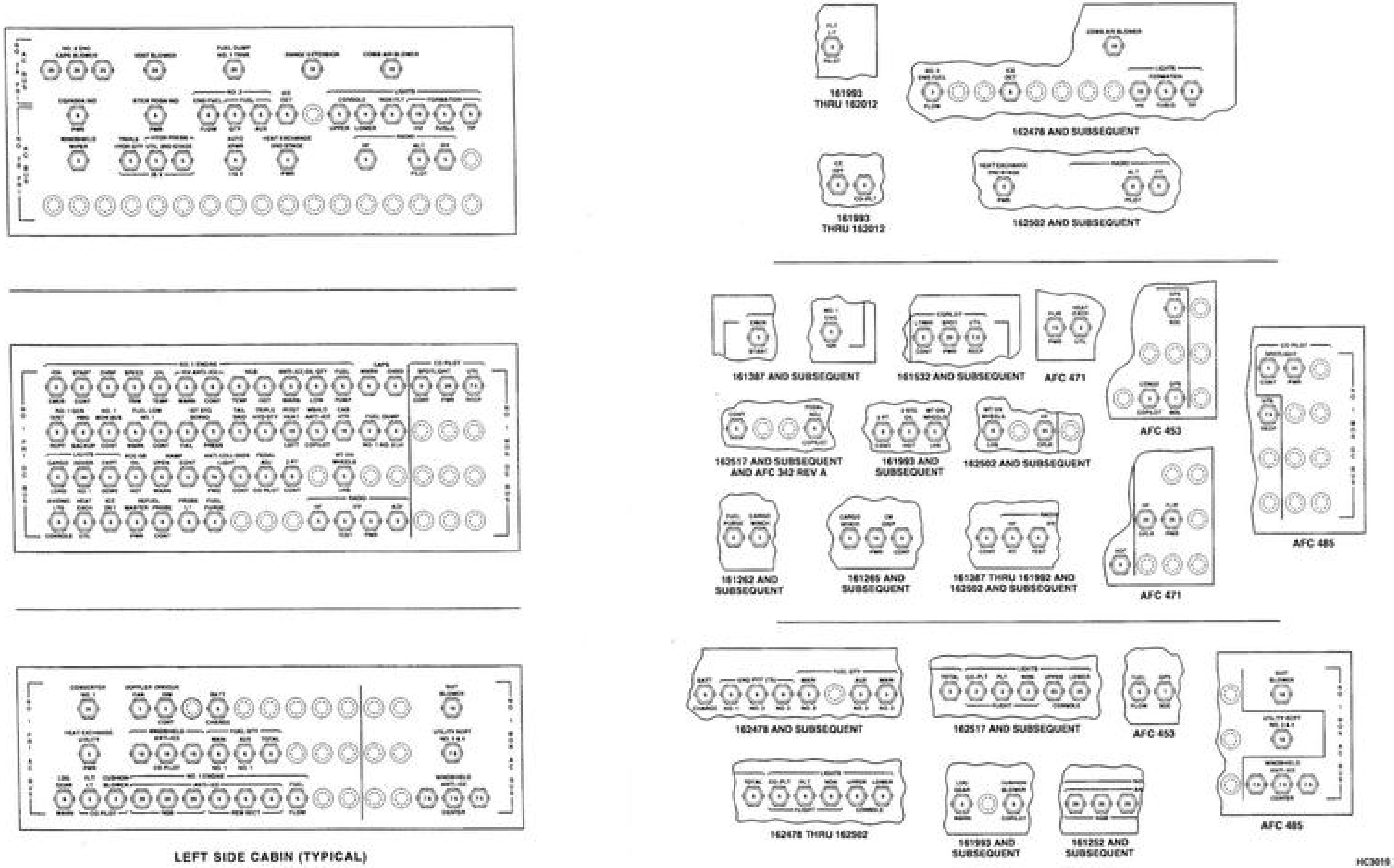


Overhead Control Panel/Circuit Breaker Panels (Sheet 1 of 2)

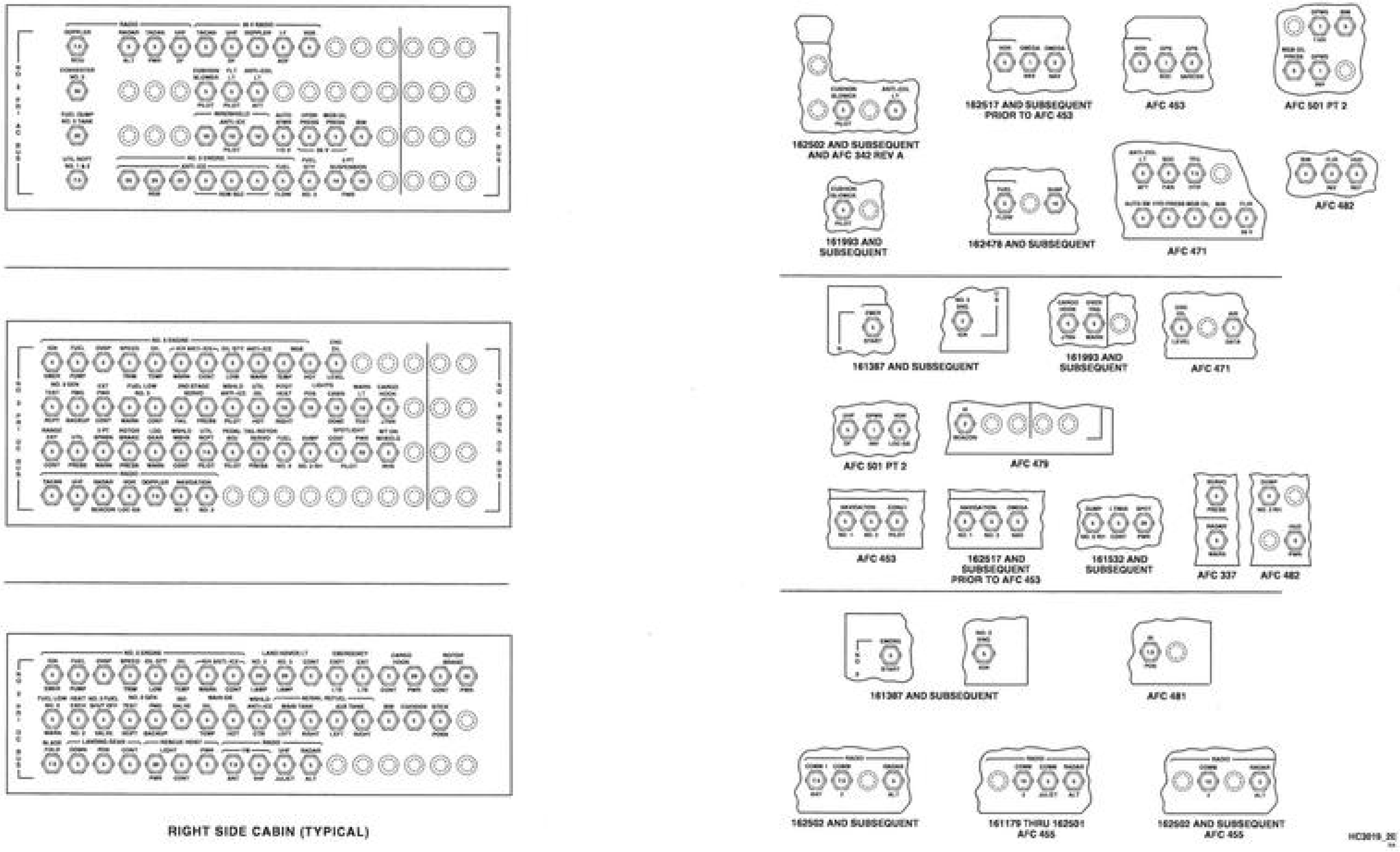


HC3010 2C

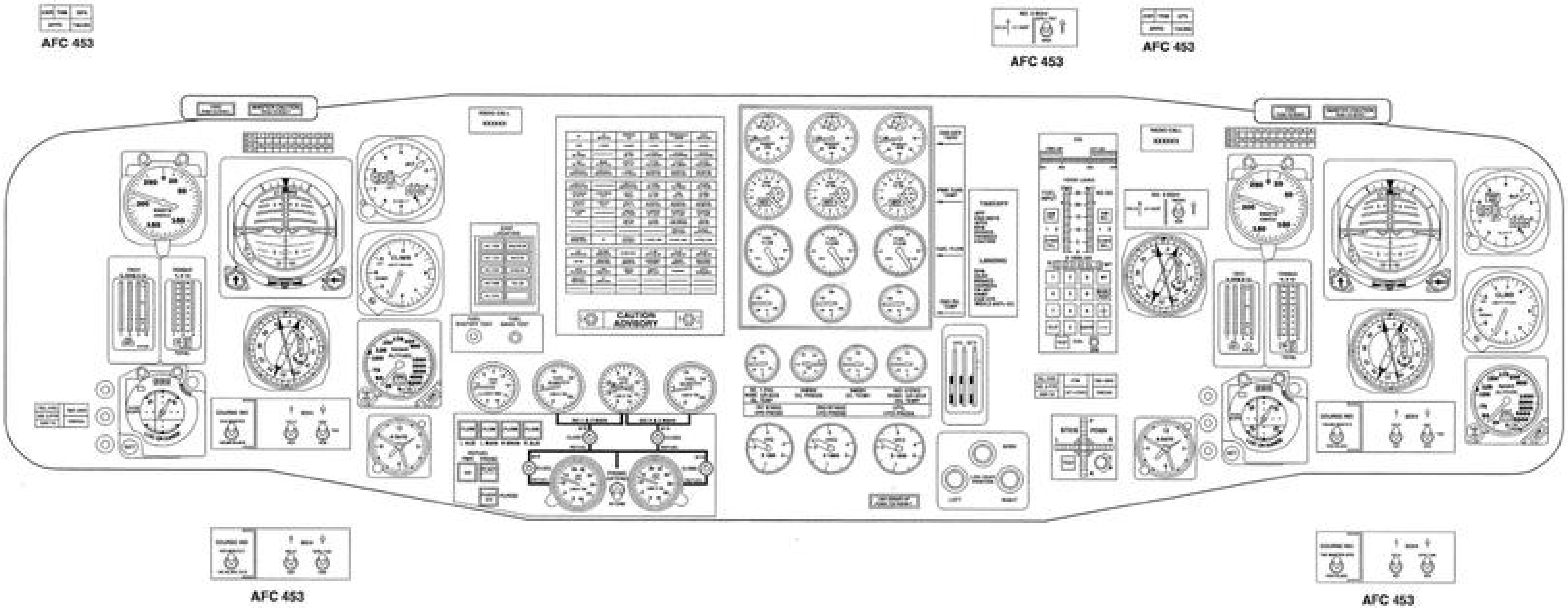
Overhead Control Panel/Circuit Breaker Panels (Sheet 2 of 2)



Cabin Circuit Breakers, Left Side/Right Side (Sheet 1 of 2)



Cabin Circuit Breakers, Left Side/Right Side (Sheet 2 of 2)



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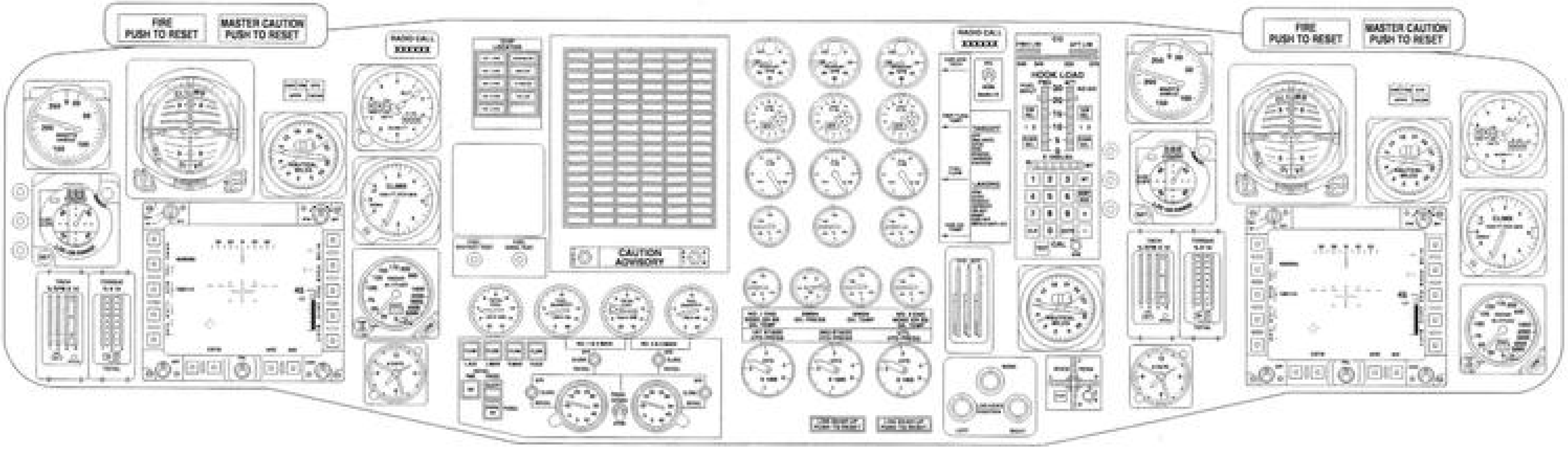
Instrument Panel (Sheet 1 of 2)



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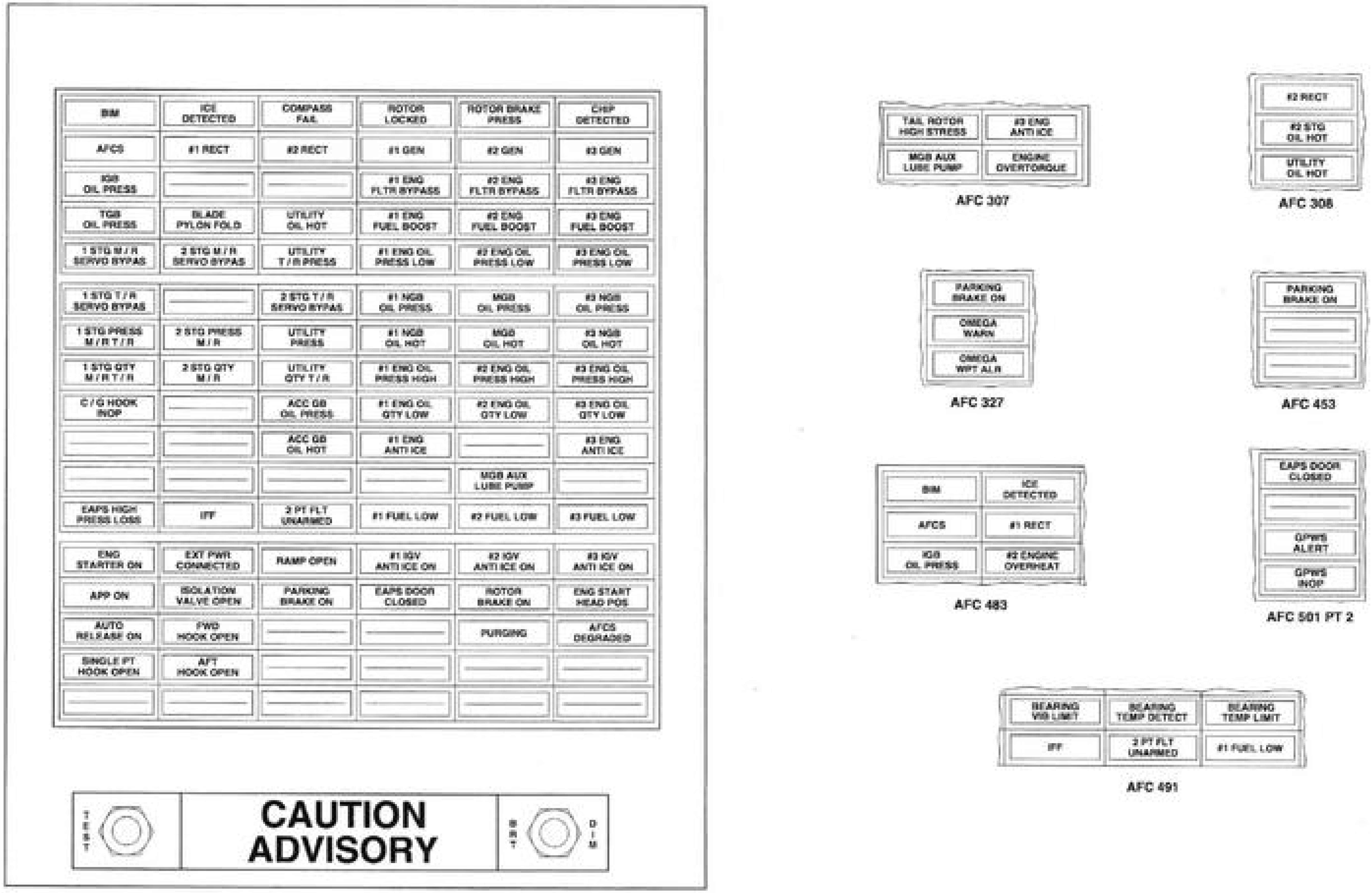
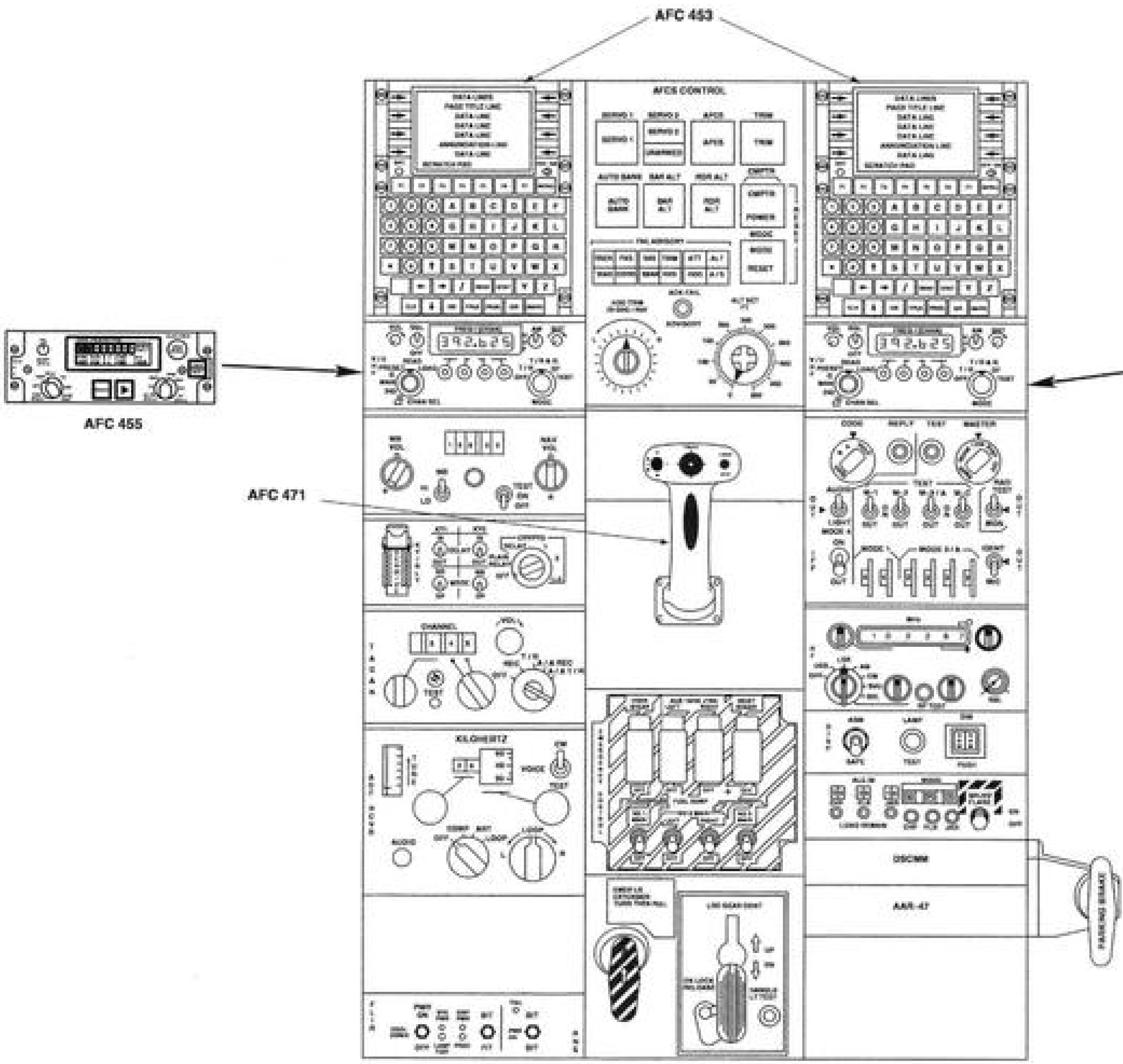
Instrument Panel (Sheet 2 of 2)



Caution Advisory Panel

Console (Sheet 1 of 2)



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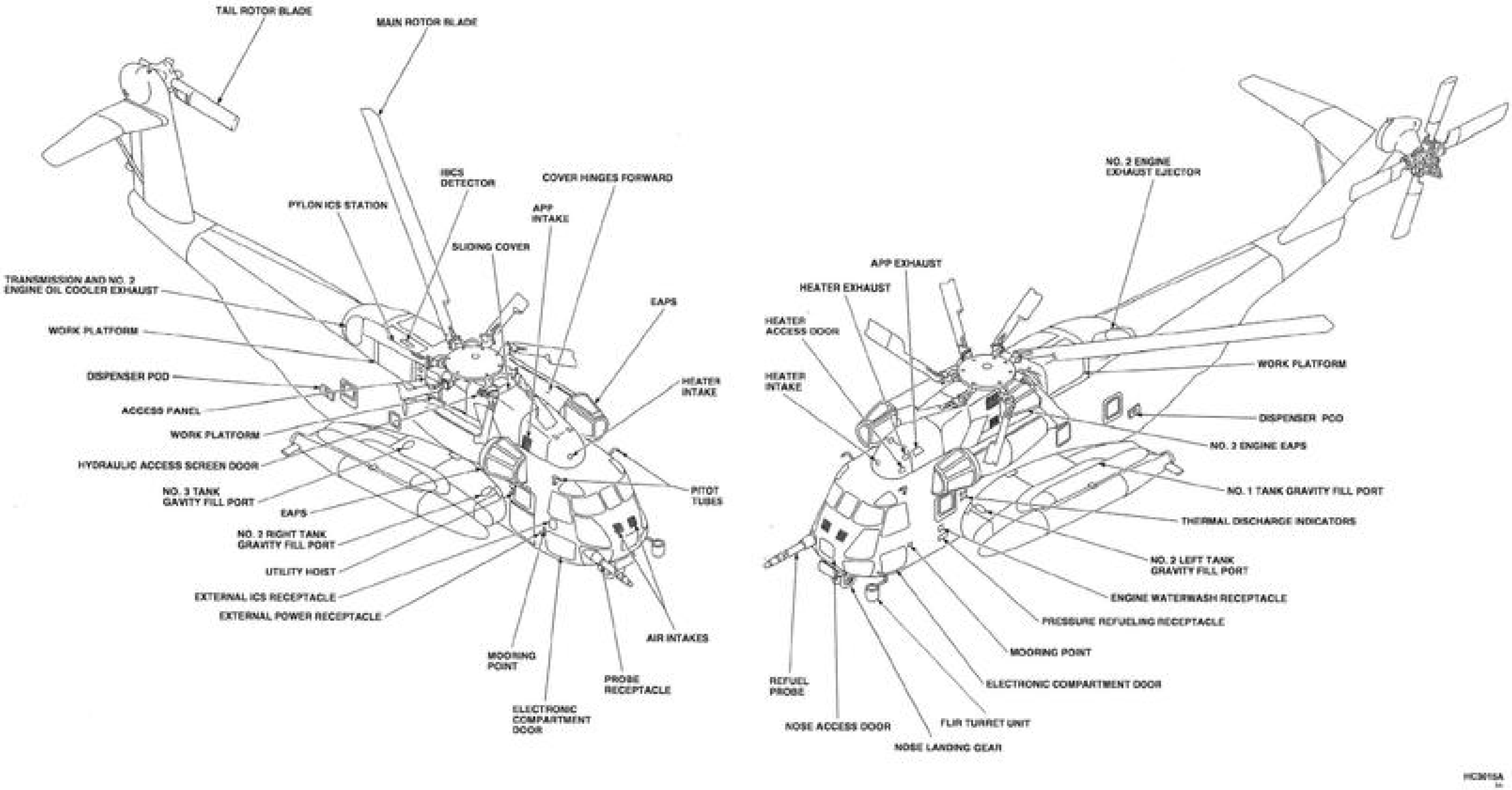
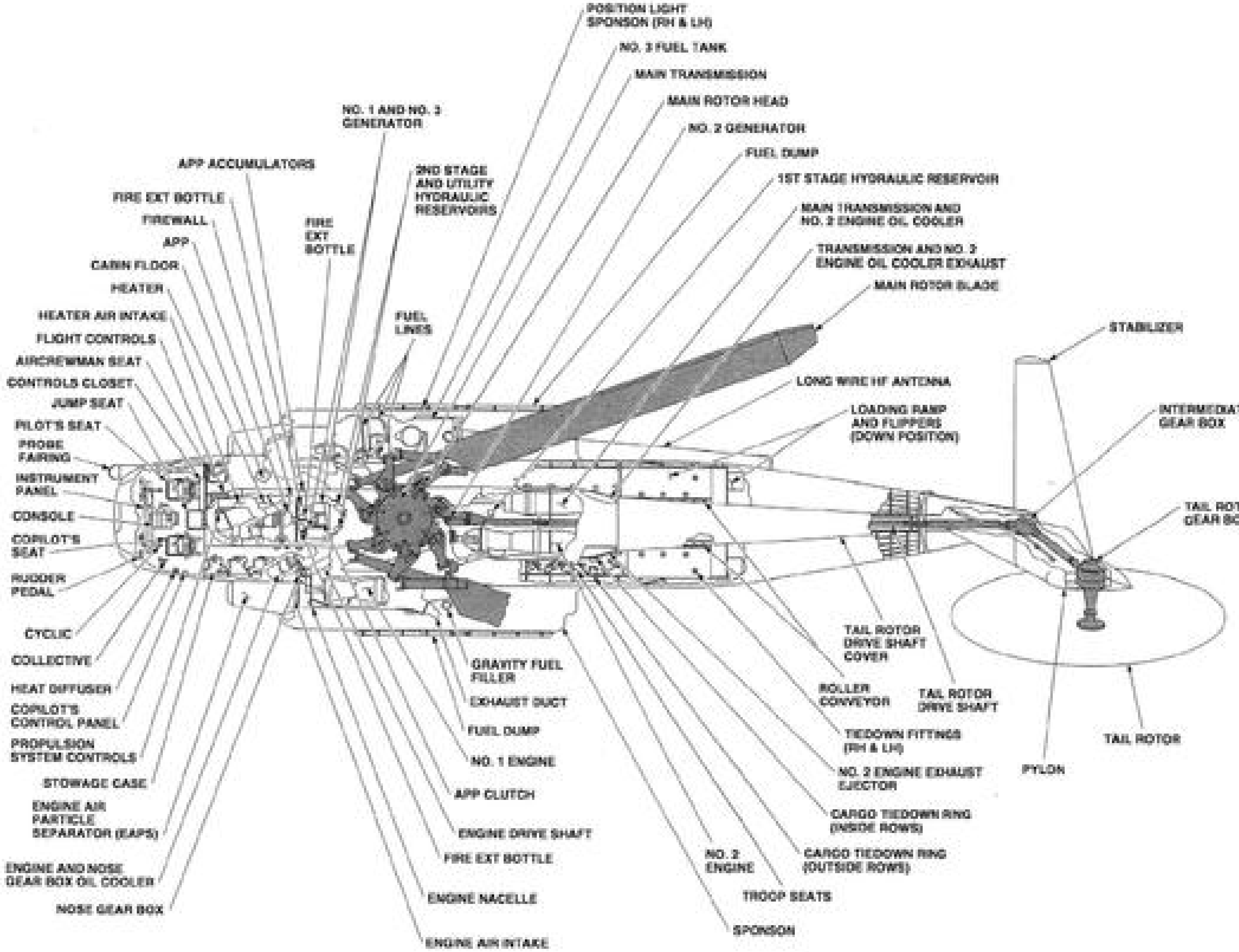
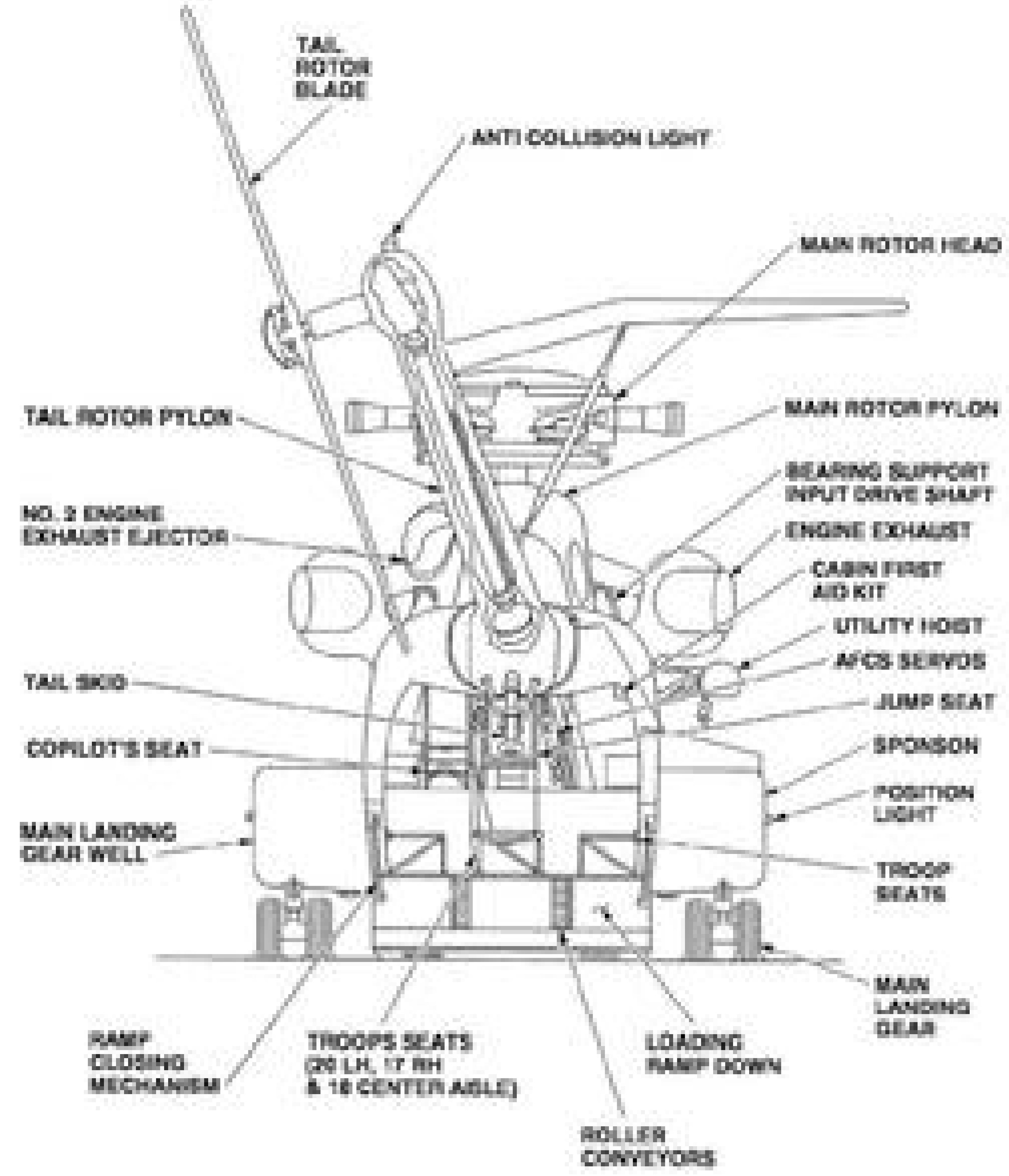
Console (Sheet 2 of 2)

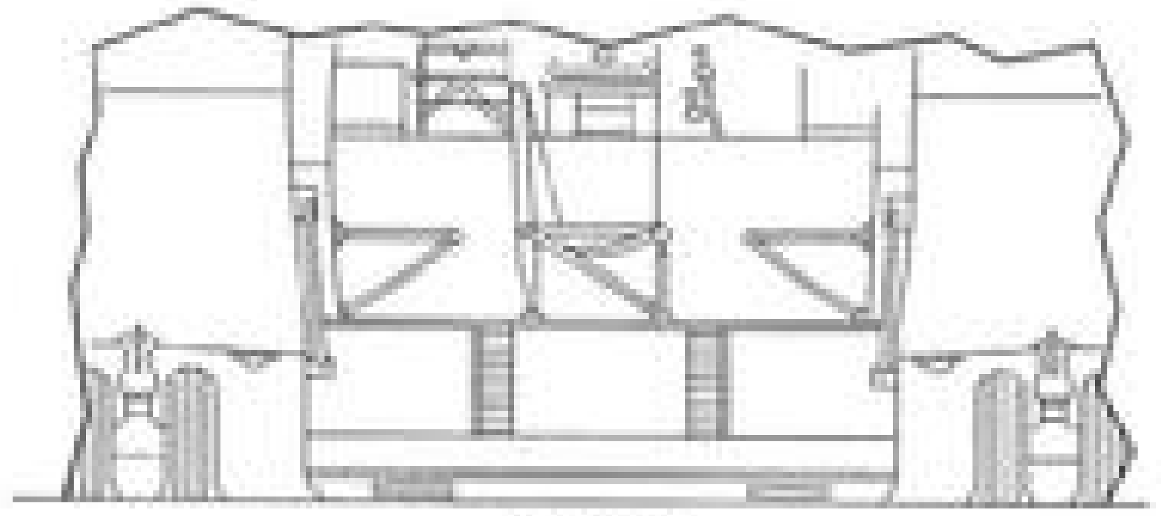
ICS Control Stations



General Arrangement Diagram







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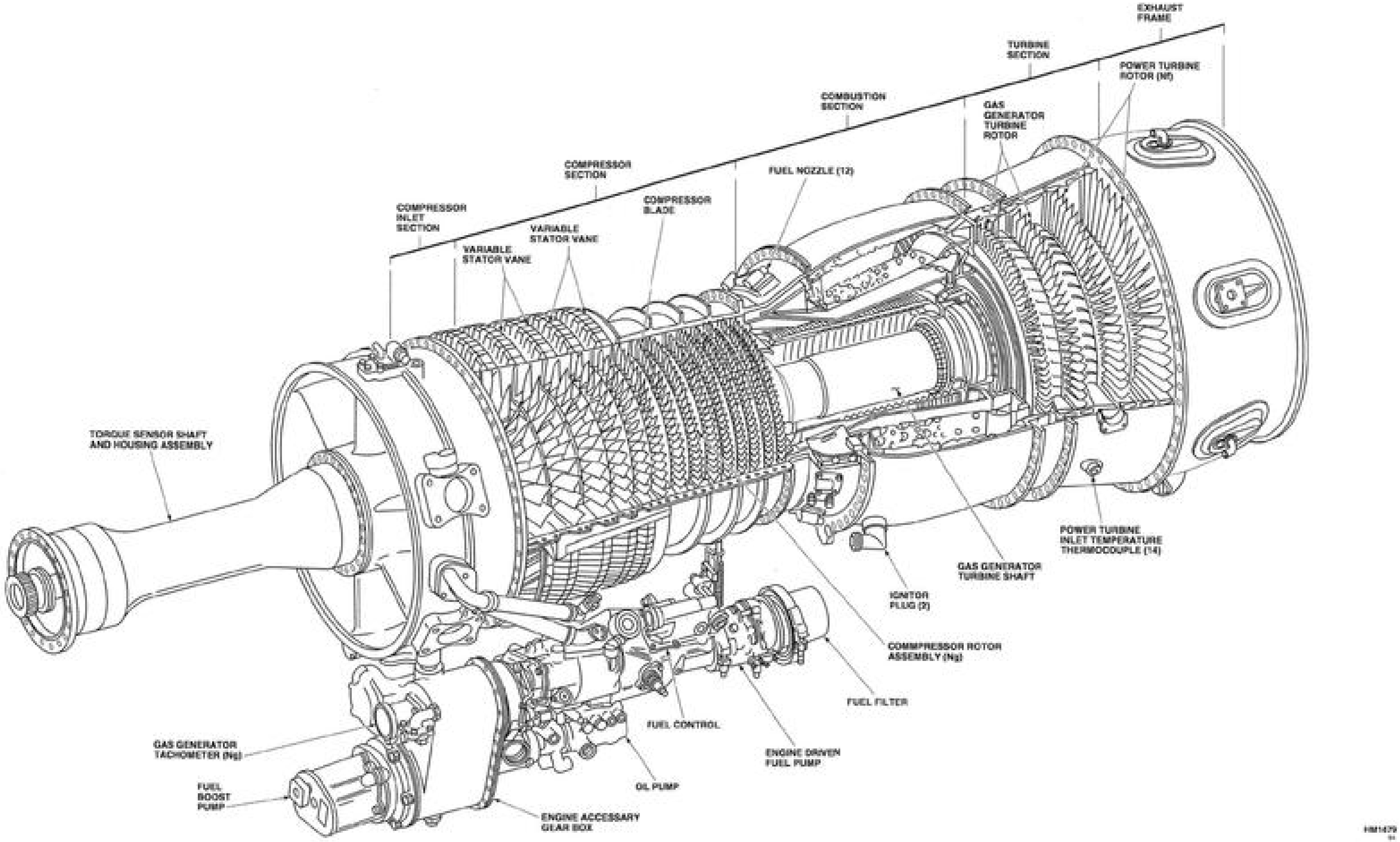
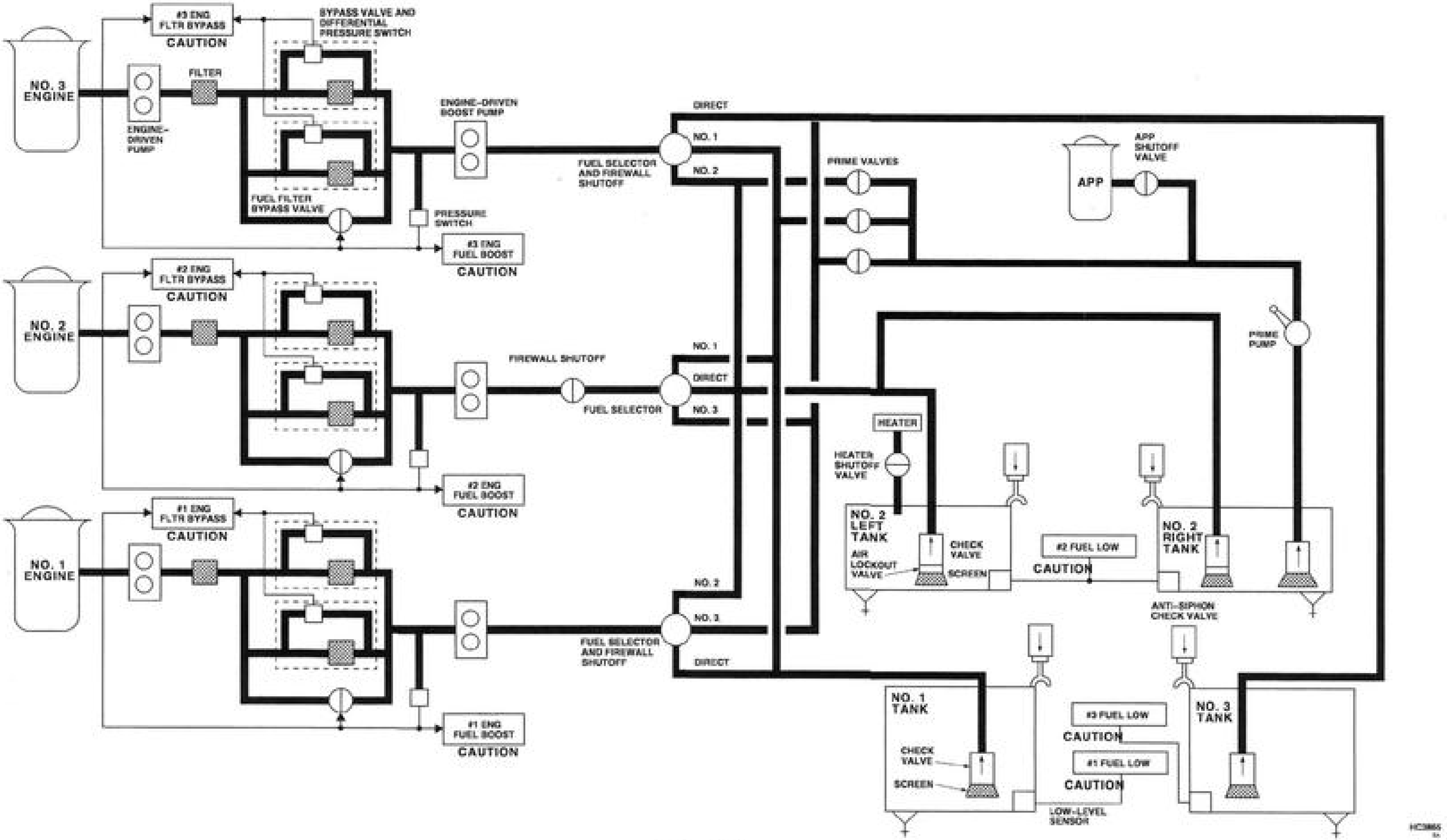
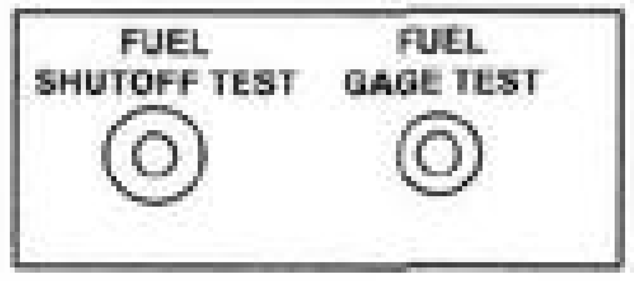
Interior Arrangement

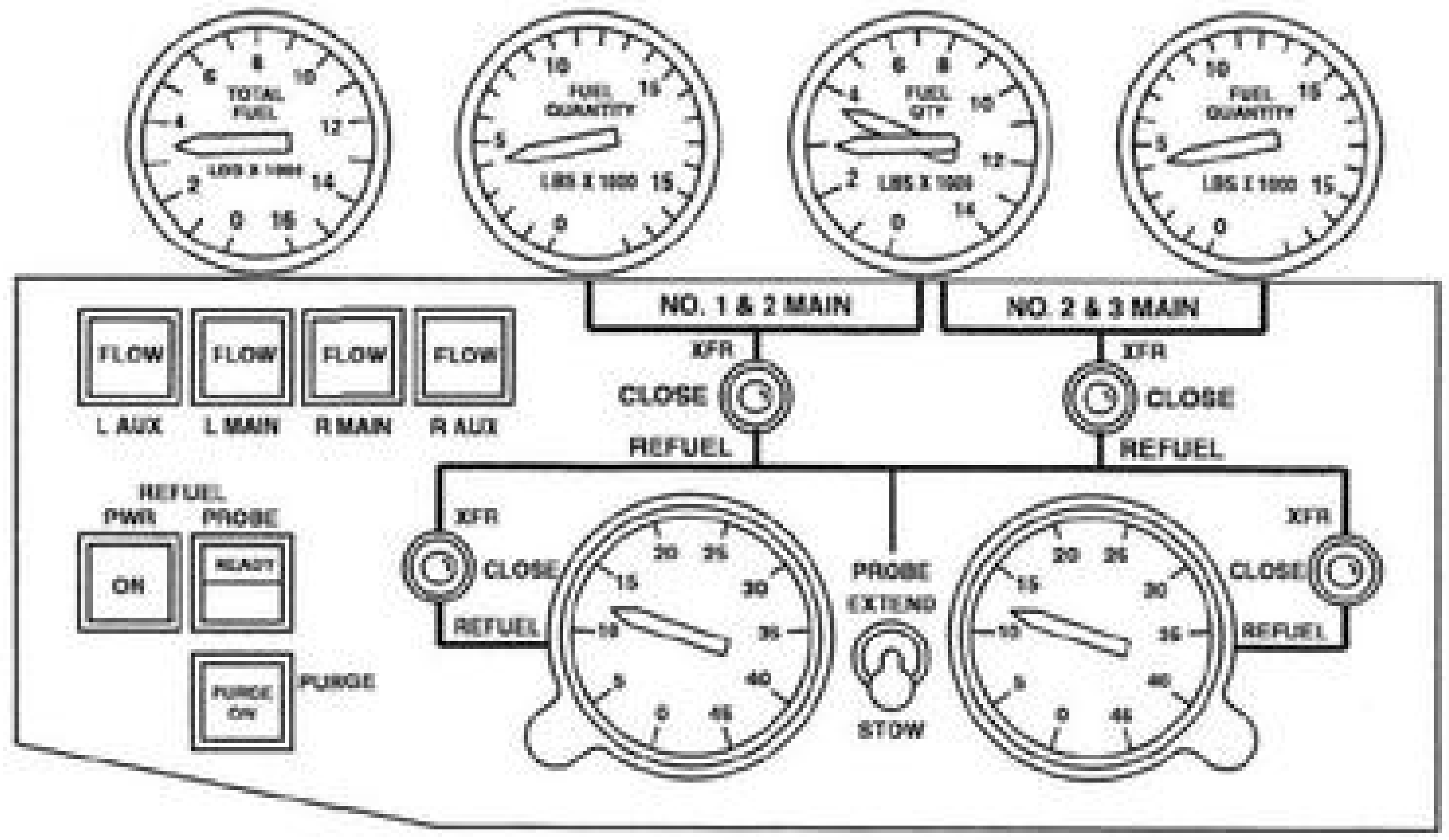

EXHAUST FRAME
TURBINE SECTION
POWER TURBINE ROTOR (Nf)
COMBUSTION SECTION
GAS GENERATOR TURBINE ROTOR
COMPRESSOR SECTION
FUEL NOZZLE (12)
COMPRESSOR INLET SECTION
COMPRESSOR BLADE
VARIABLE STATOR VANE
VARIABLE STATOR VANE
TORQUE SENSOR SHAFT AND HOUSING ASSEMBLY
POWER TURBINE INLET TEMPERATURE THERMOCOUPLE (14)
GAS GENERATOR TURBINE SHAFT
IGNITOR PLUG (2)
COMMPRESSOR ROTOR ASSEMBLY (Ng)
FUEL FILTER
FUEL CONTROL
ENGINE DRIVEN FUEL PUMP
GAS GENERATOR TACHOMETER (Ng)
FUEL BOOST PUMP
OIL PUMP
ENGINE ACCESSARY GEAR BOX
HM1479

The Engine



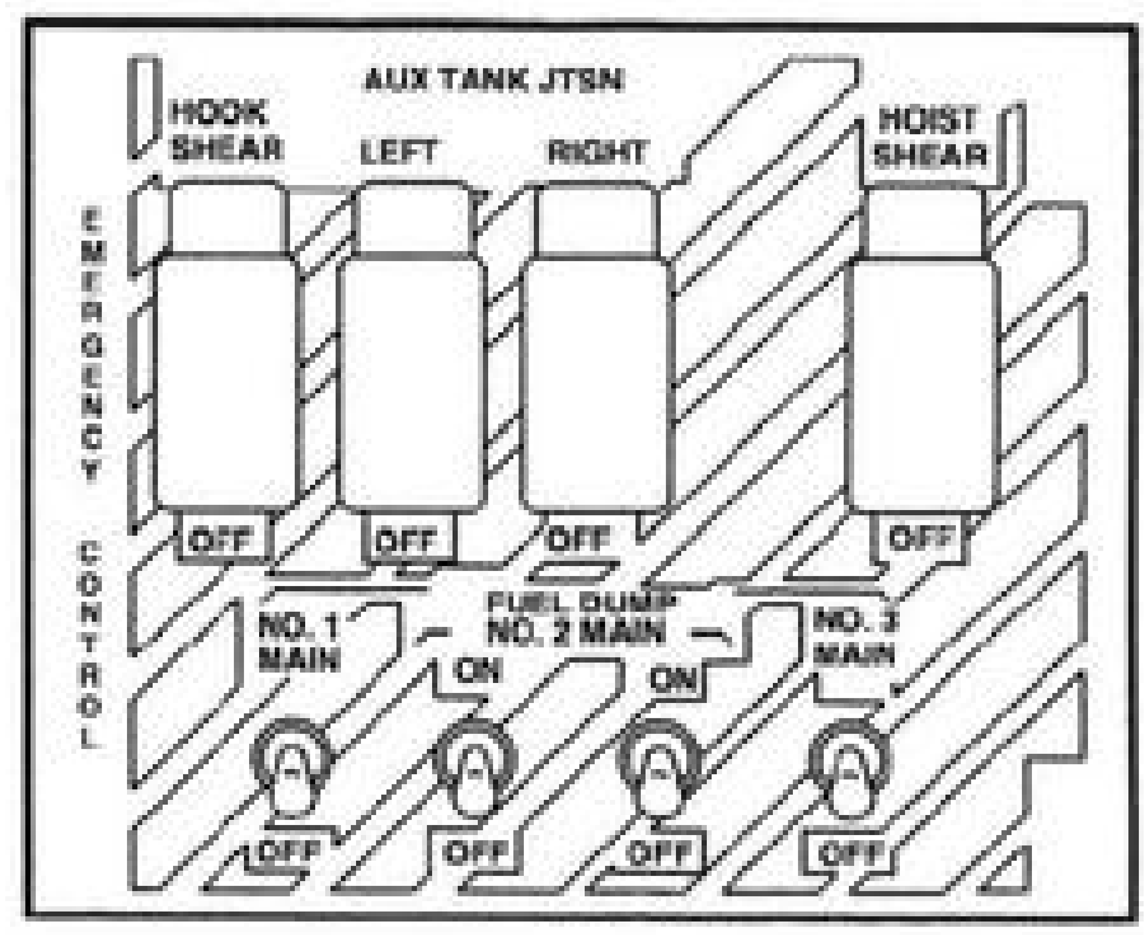
Fuel Feed System

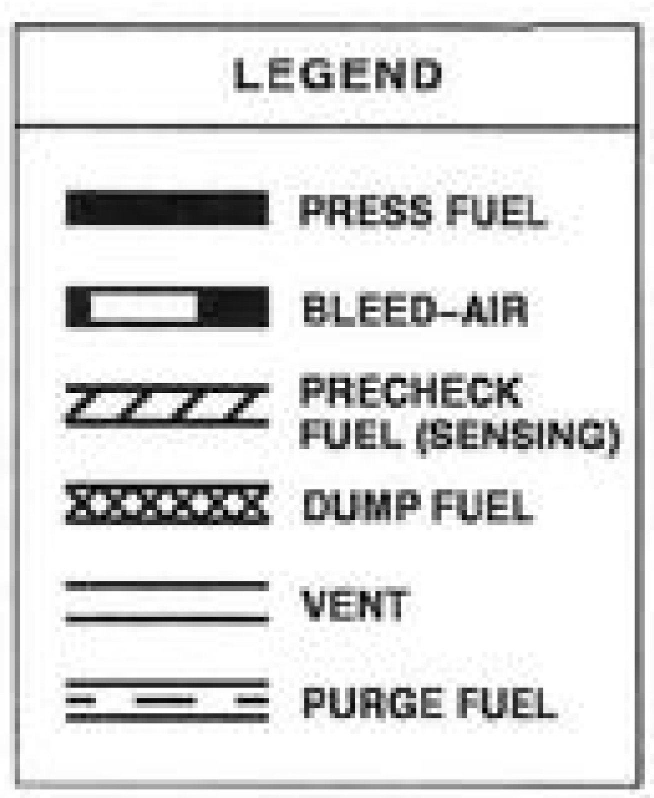




* LEFT AUX TANK FUEL VALVE AND LEFT AUX PURGE VALVE OPEN AND CLOSE SIMULTANEOUSLY DURING PURGE

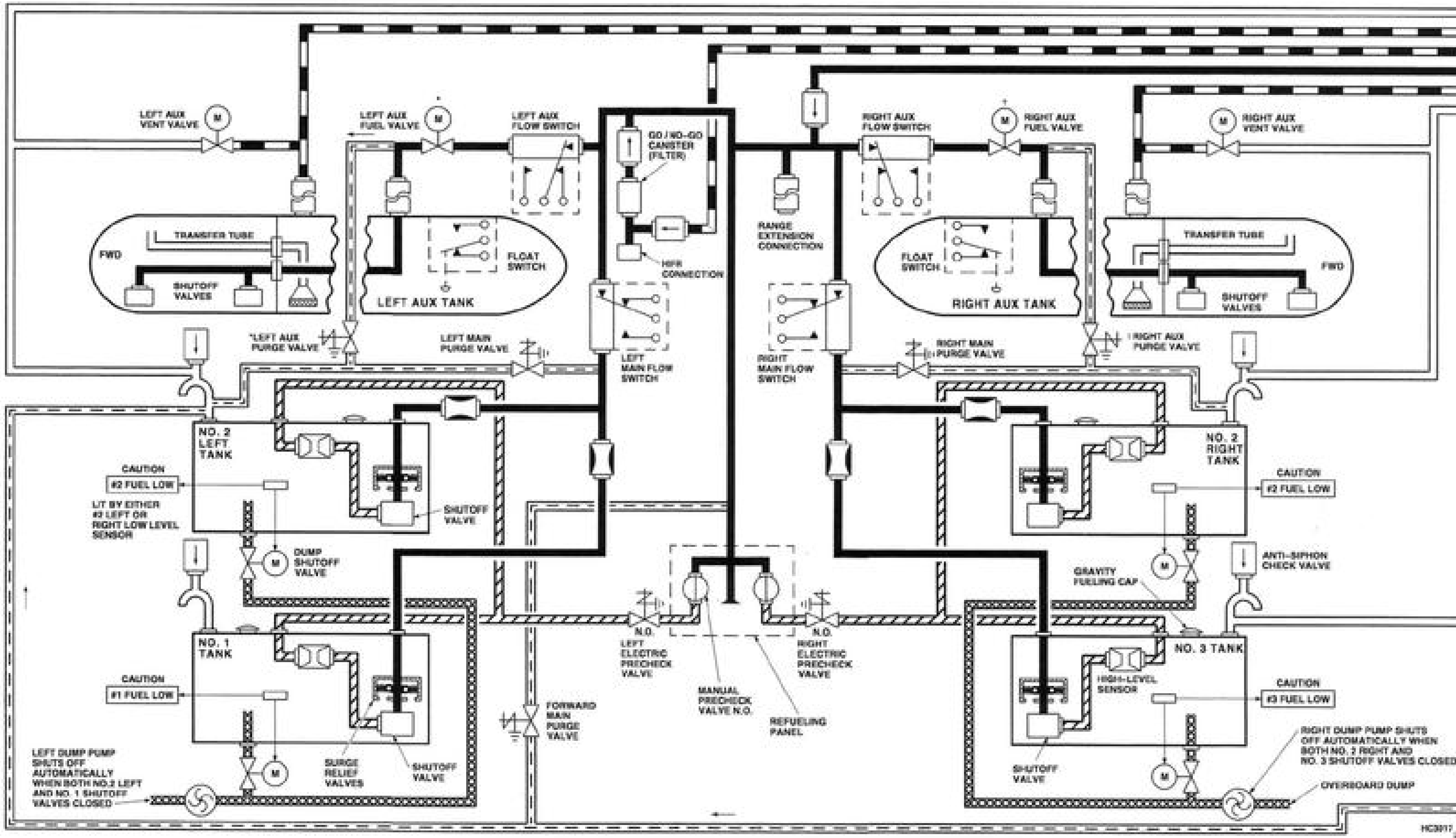
† RIGHT AUX TANK FUEL VALVE AND RIGHT AUX PURGE VALVE OPEN AND CLOSE SIMULTANEOUSLY DURING PURGE



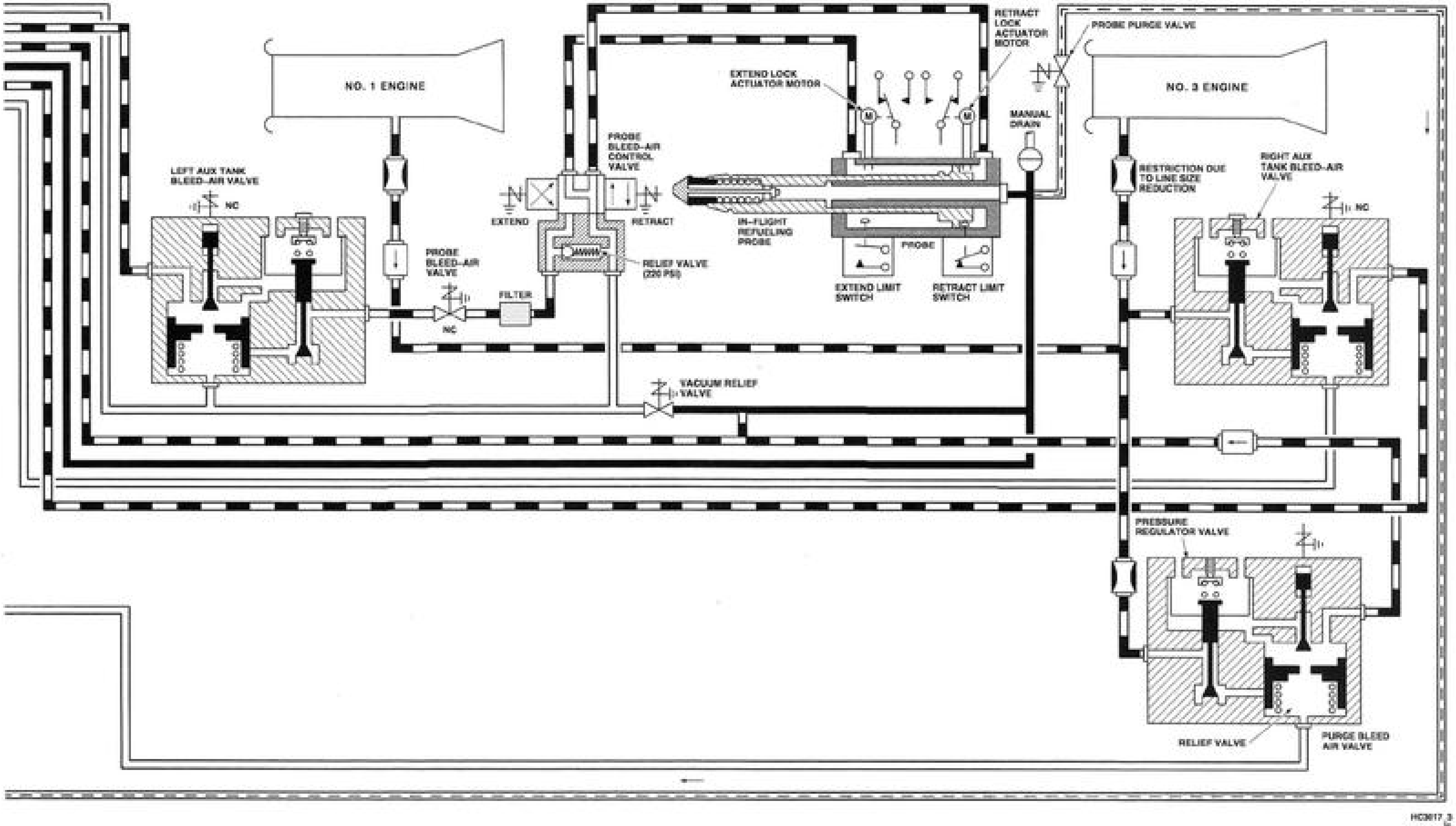


HC3017_1

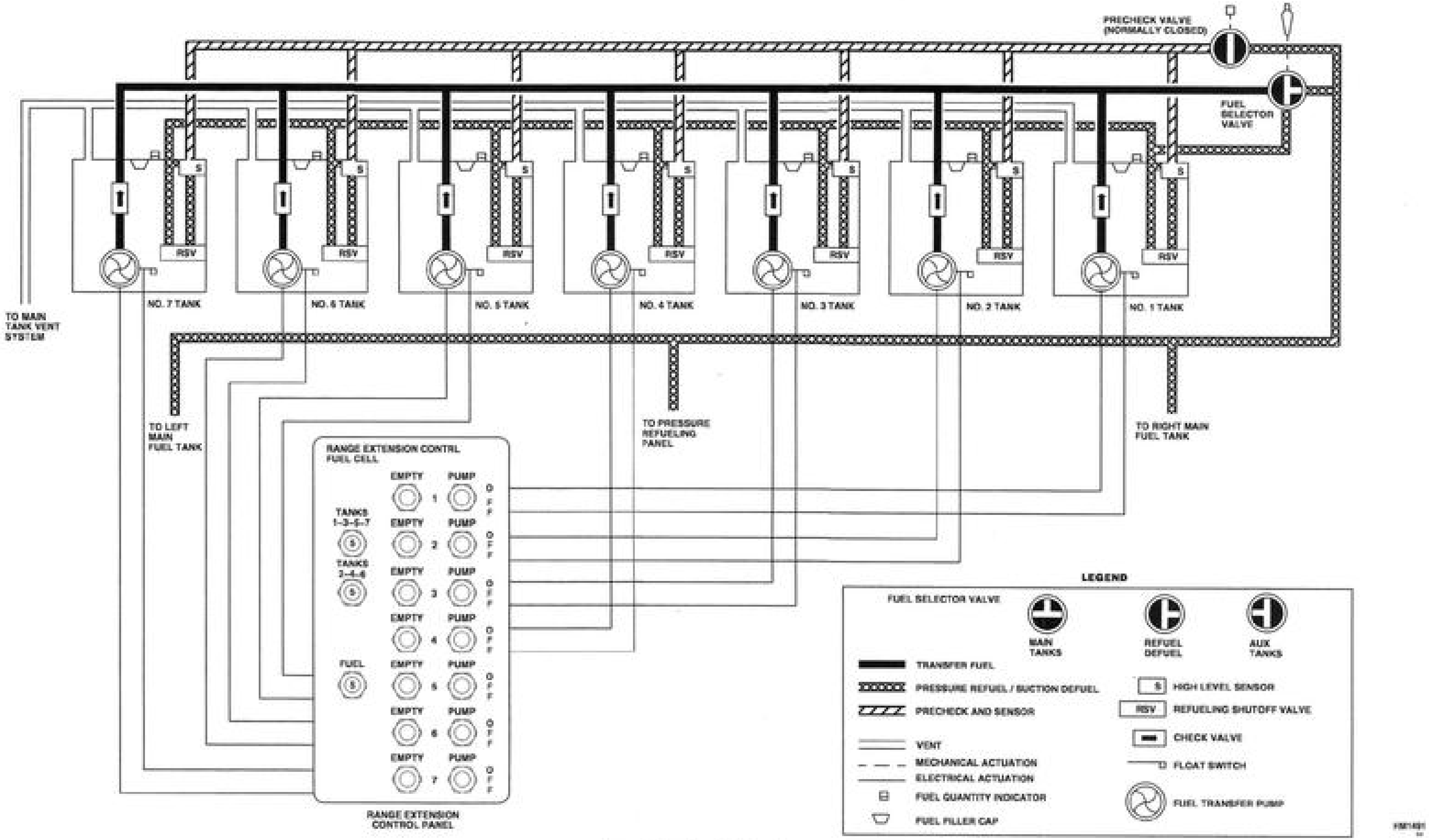
Pressure Fueling/Defueling, Transfer, Dump, and Purge Systems (Sheet 1 of 3)



Pressure Fueling/Defueling, Transfer, Dump, and Purge Systems (Sheet 2 of 3)

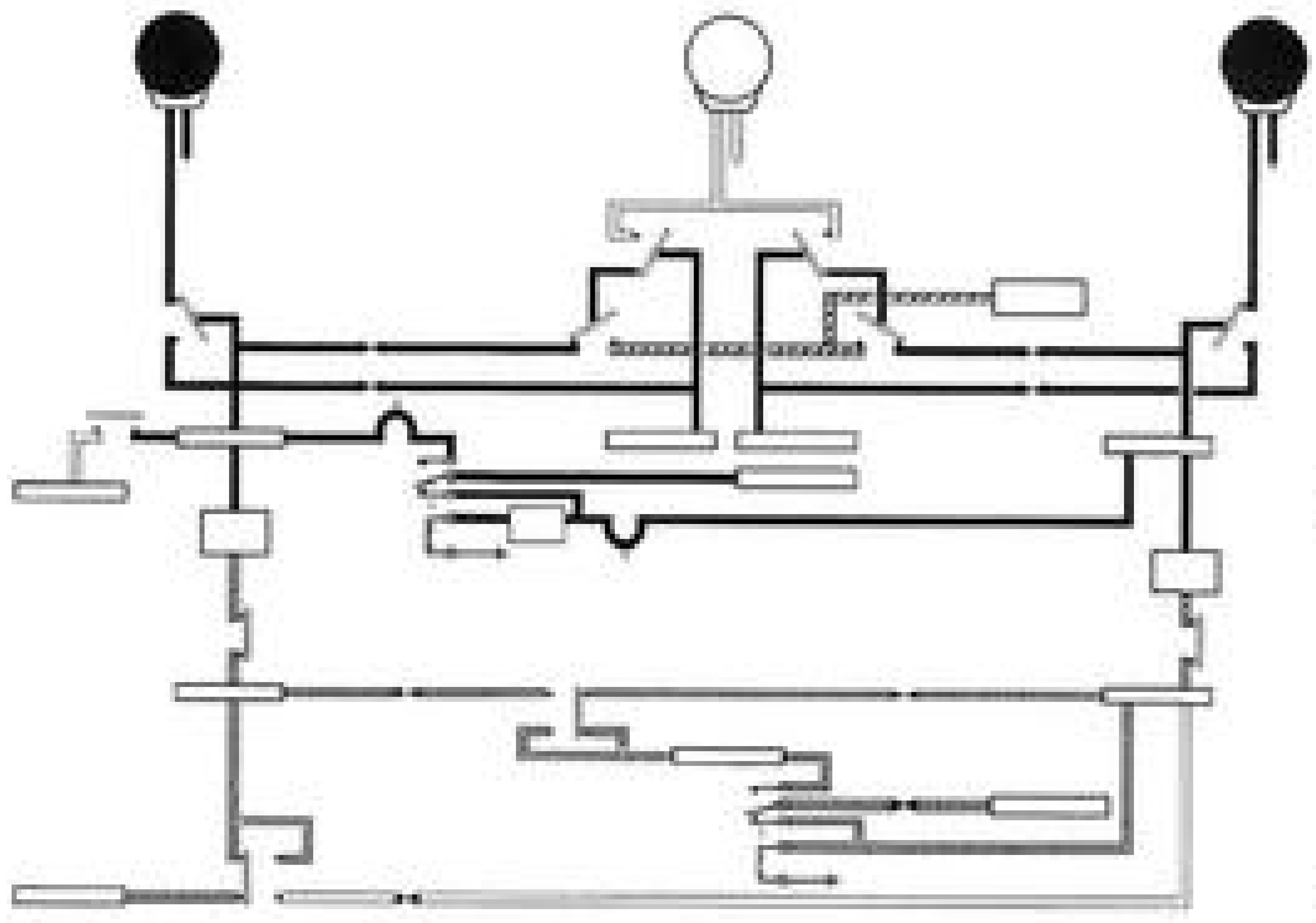


Pressure Fueling/Defueling, Transfer, Dump, and Purge Systems (Sheet 3 of 3)

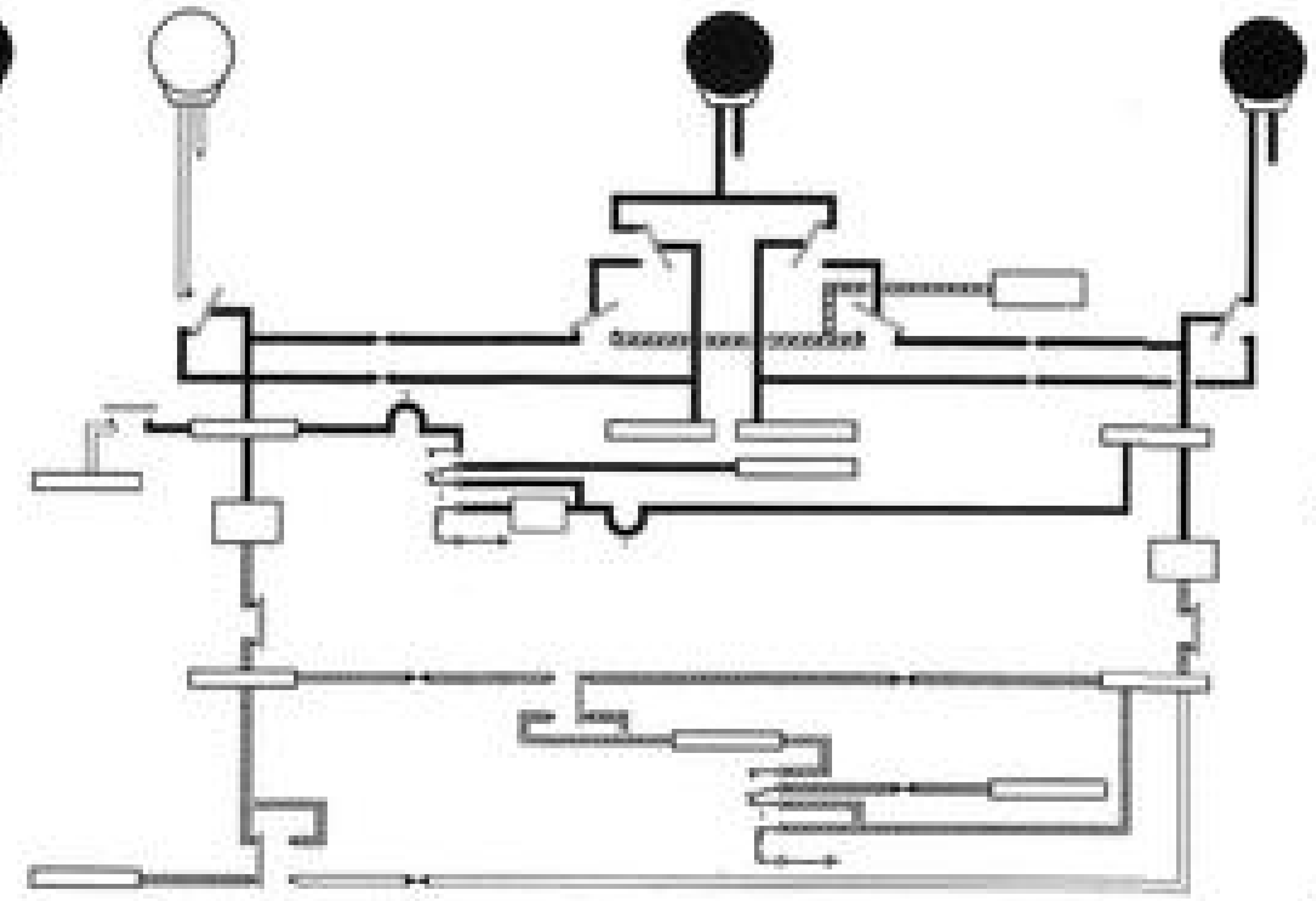


Range Extension Fuel System

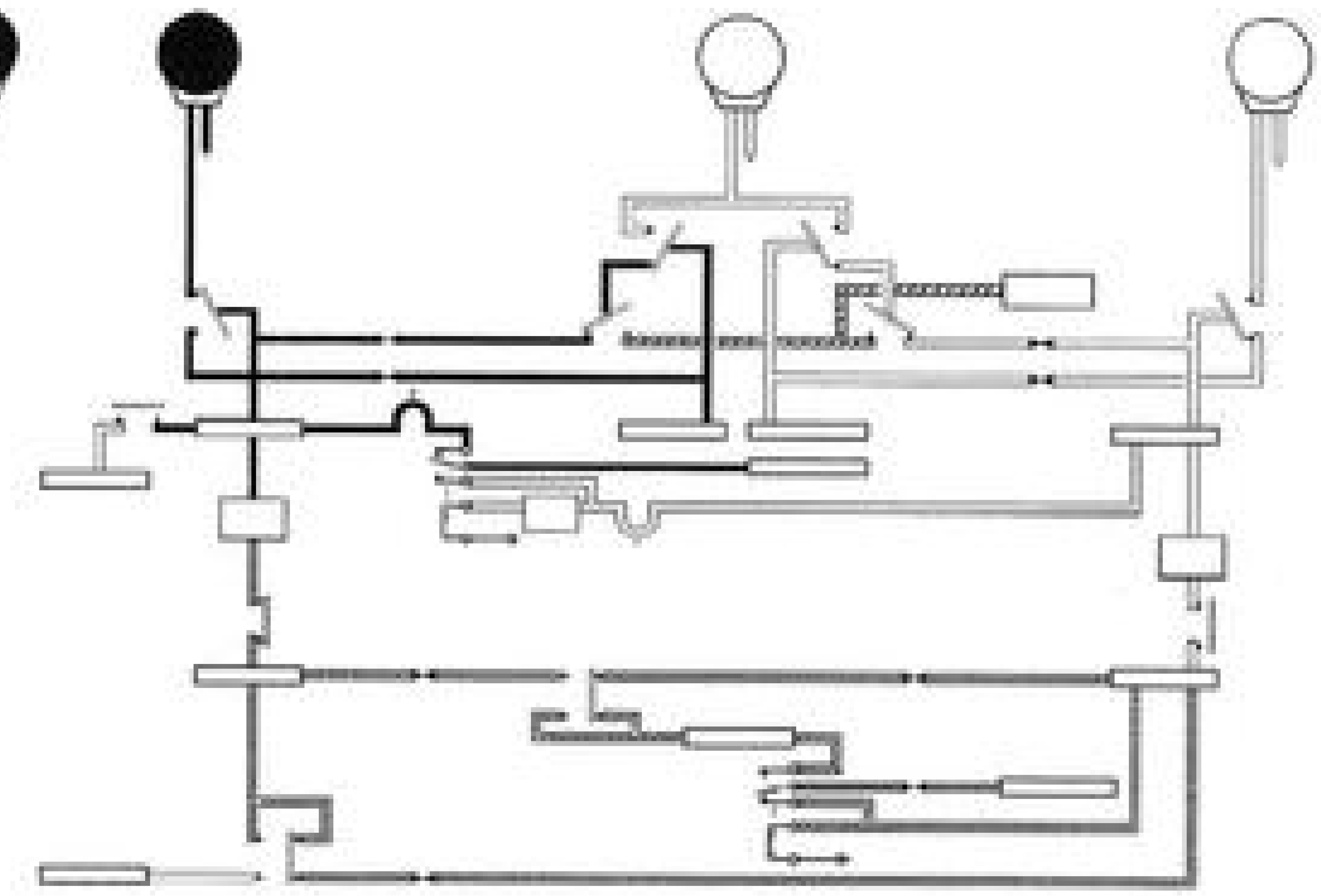
Electrical System Schematic (Sheet 1 of 2)



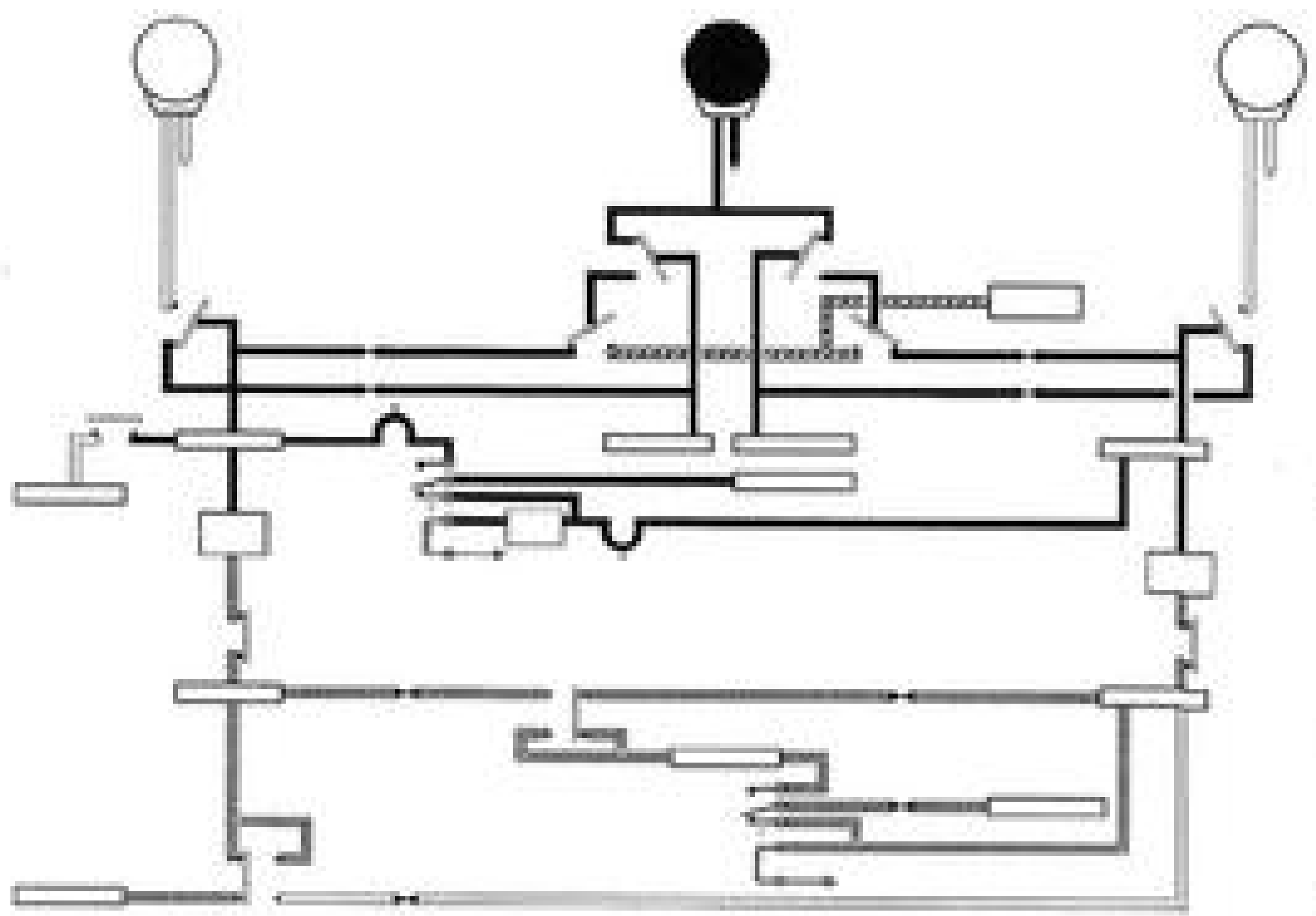
NO. 1 AND 3 GENERATORS OPERATING
ALSO APP GROUND OPERATION



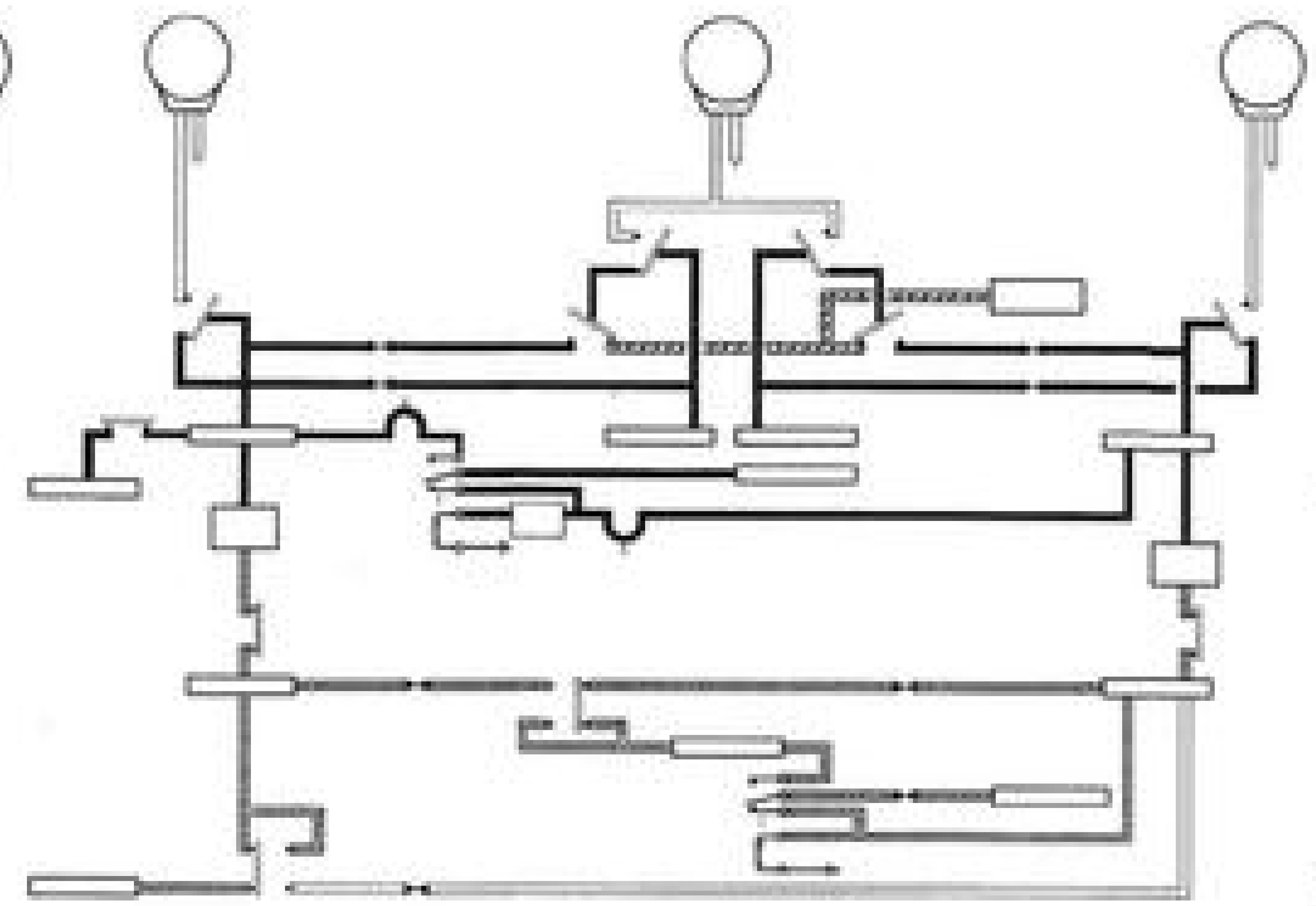
NO. 2 AND 3 GENERATORS OPERATING



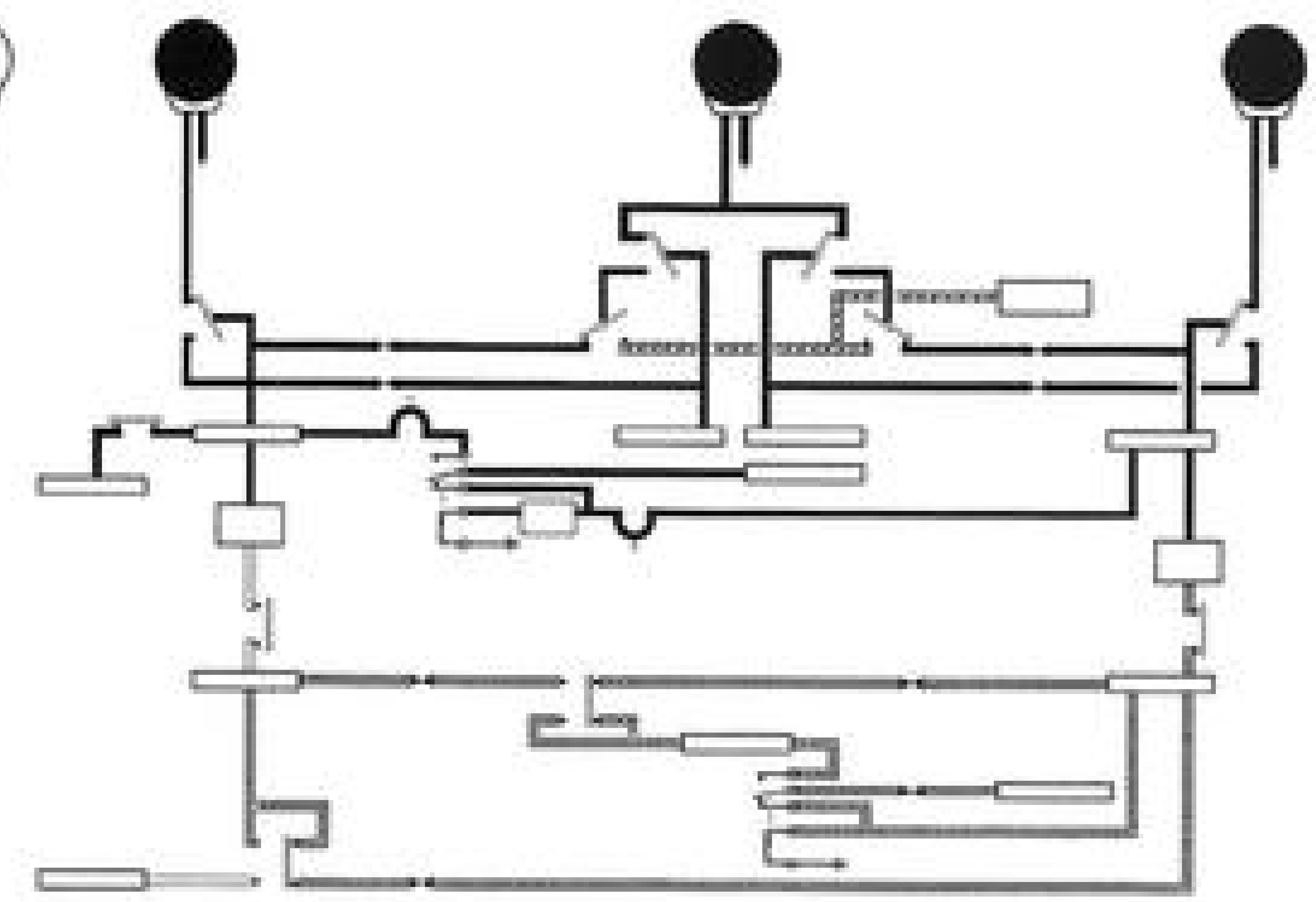
NO. 1 GENERATOR OPERATING



NO. 2 GENERATOR OPERATING



EXTERNAL POWER CONNECTED



NO. 2 RECTIFIER OPERATING

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Electrical System Schematic (Sheet 2 of 2)

Utility Hydraulic System (Sheet 1 of 6)

Utility Hydraulic System (Sheet 2 of 6)

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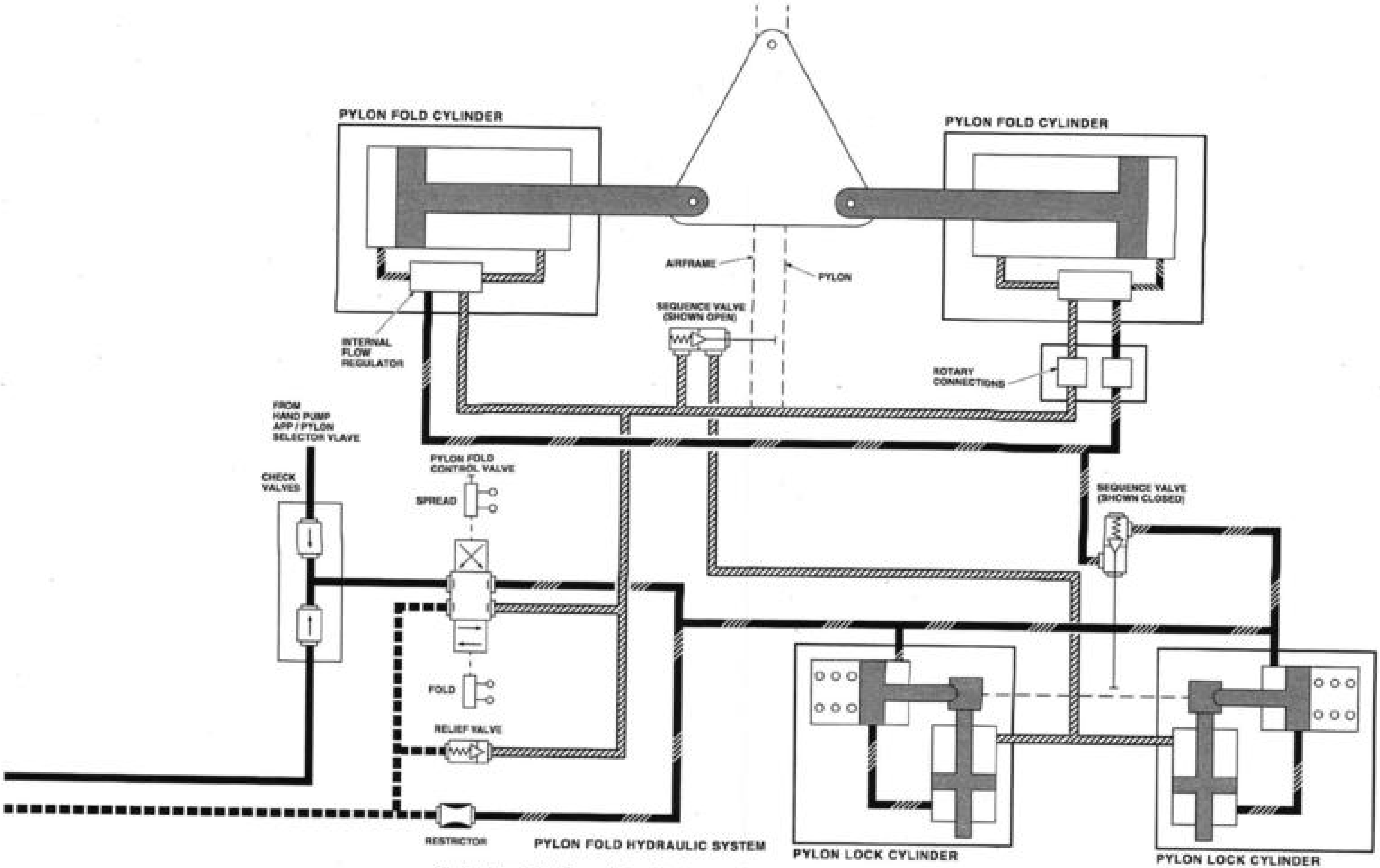
Utility Hydraulic System (Sheet 3 of 6)

Utility Hydraulic System (Sheet 4 of 6)

Utility Hydraulic System (Sheet 5 of 6)

Utility Hydraulic System (Sheet 6 of 6)

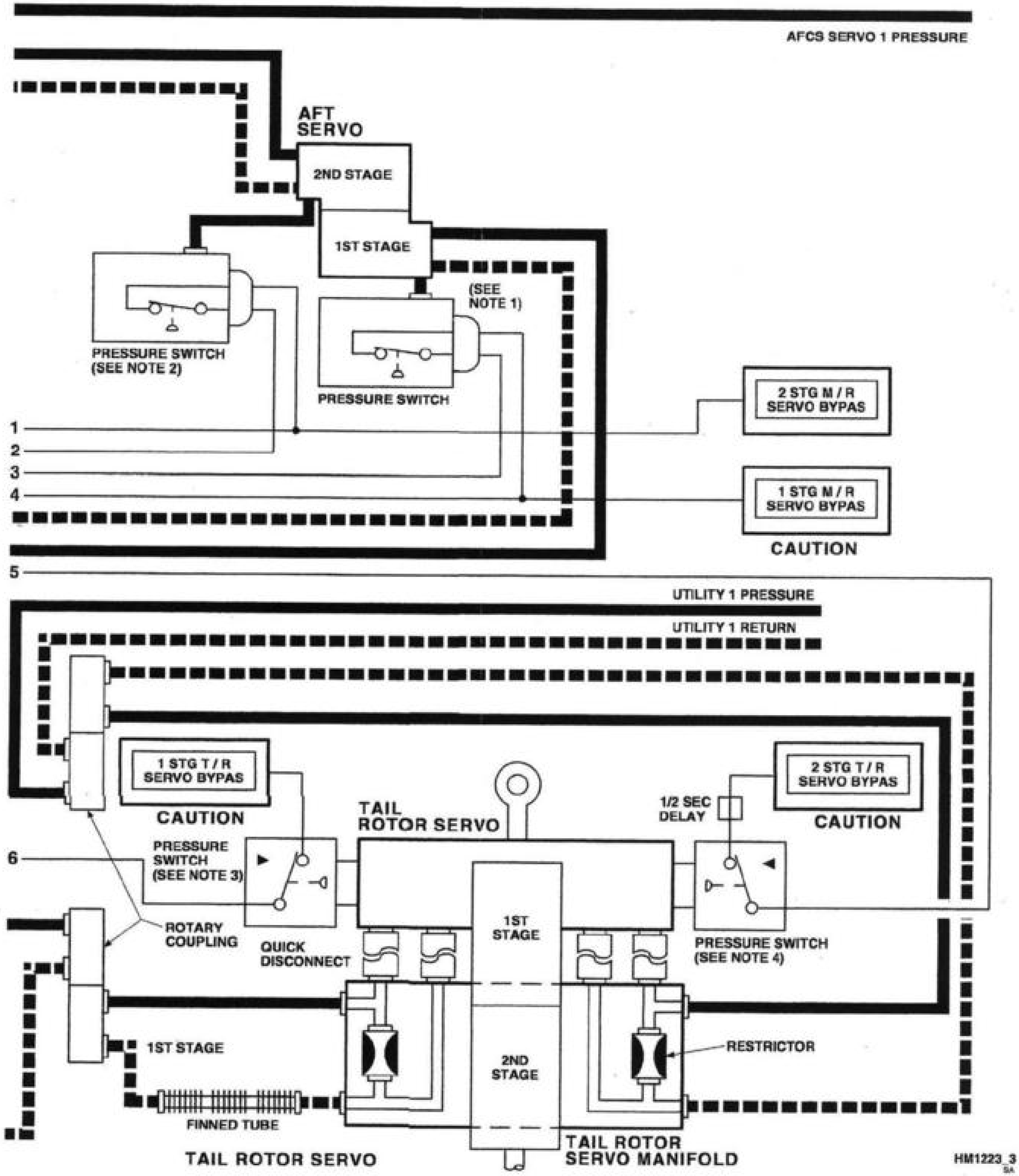
Blade Pylon Fold/Spread, Positioning, and Rotor Brake Hydraulic System (Sheet 1 of 2)



Blade Pylon Fold/Spread, Positioning, and Rotor Brake Hydraulic System (Sheet 2 of 2)

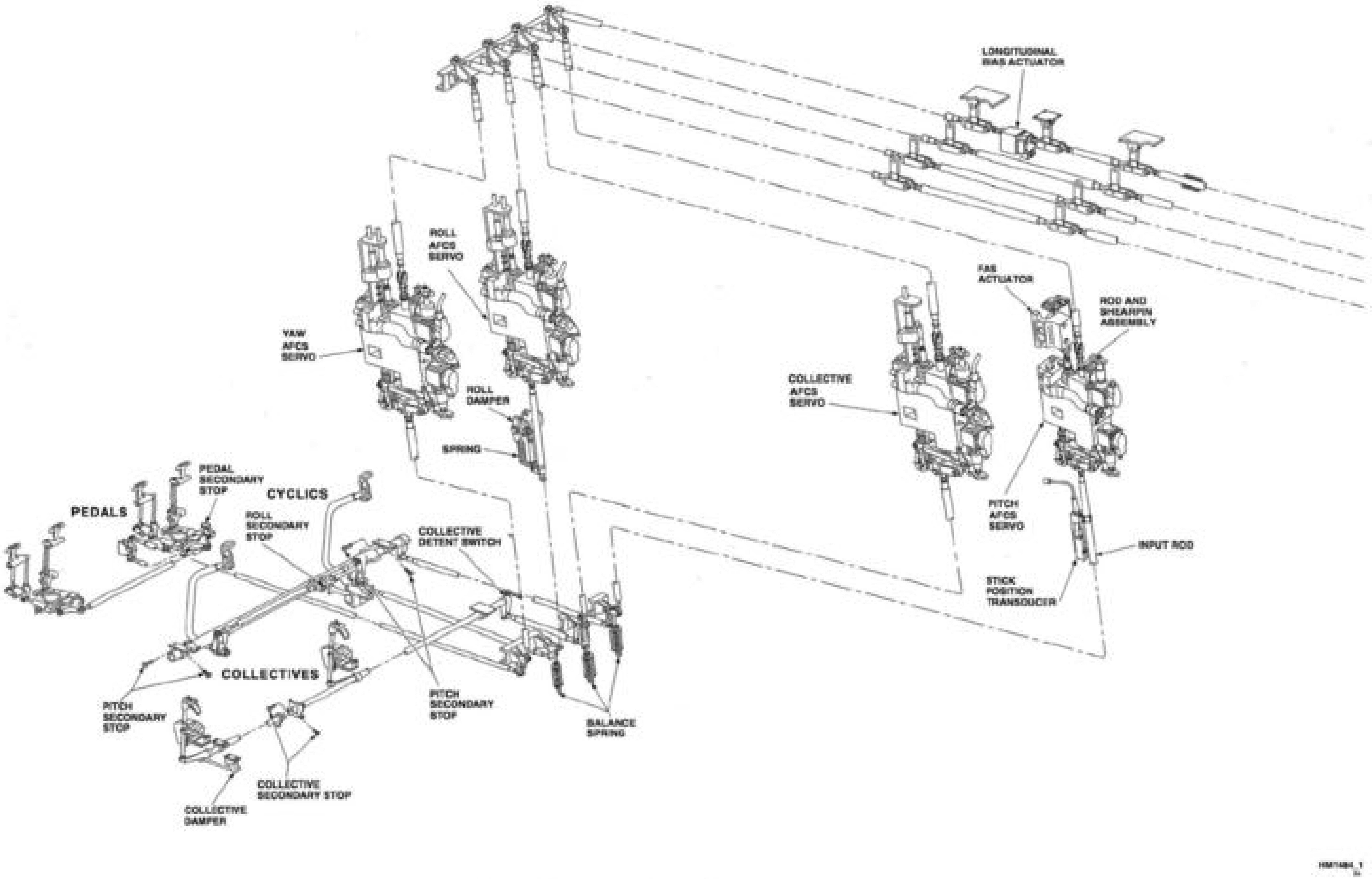
Flight Control Hydraulic System (Sheet 1 of 3)

Flight Control Hydraulic System (Sheet 2 of 3)



Flight Control Hydraulic System (Sheet 3 of 3)

AFCS Hydraulic System



Flight Control Schematic (Sheet 1 of 2)

Flight Control Schematic (Sheet 2 of 2)

COND.	PILOT ACTION	RESULTS	FOLD PANEL SWITCHES	FOLD PANEL LIGHTS	CHANGE TO CAUTION PANEL	CHANGE TO ADVISORY PANEL
			BLADE FOLD			
1.	None Aircraft Status 1. APP ON 2. No. 2 generator ON 3. Gust lock UNLOCKED 4. Rotor brake switch EMER 5. Speed levers SHUTOFF 6. Blades spread 7. Pylon spread 8. Second stage and utility pressure (2800 – 3300 psi) 9. Check flap restrainers in	None	None Initial Status 1. Master power switch OFF 2. Pitch lock switch at DISENGAGED 3. Blade fold position switch OFF 4. Blade fold/spread switch OFF 5. Pylon fold spread switch OFF (Switches remain the same except as noted below)	1. FLIGHT READY 2. BLADES SPREAD	None Initial Status 1. MGB OIL PRESS 2. ROTOR BRAKE PRESS	None Initial Status 1. APP ON 2. ISOLATION VALVE OPEN 3. ROTOR BRAKE ON
2.	Place master power switch to POWER	Safety valve opens; hydraulic pressure is available to blade fold system	Master power switch at POWER	1. FLIGHT READY goes off 2. SAFETY VALVE OPEN goes on	BLADE PYLON FOLD goes on	No change
3.	Place blade fold position switch to BLADE FOLD POSN	1. Rotor brake pressure dumps and repumps to 40 psi 2. Rotor head drives to proper position for blade fold (No. 1 blade over aft, left side of fuselage – one position only) 3. Rotor brake repumps to 975 psi after blades are in position	1. Master power switch at POWER 2. Blade fold position switch at BLADE FOLD POSN	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSITION (After positioning sequence)	No change	ROTOR BRAKE ON light goes out during positioning and goes on after positioning sequence is complete
4.	Position cyclic and collective to light stick position indicator	Rotor head is in position for pitch locks to engage	Same as condition 3	Same as condition 3	No change	No change
5.	Place pitch lock switch to PITCH LOCK	1. Pitch locks advance 2. Second stage hydraulic gage goes to zero; hydraulic pressure is removed from flight controls (with AFC 309, second stage hydraulic gage remains normal)	1. Master power switch at POWER 2. Blade fold position switch at BLADE FOLD POSN 3. Pitch lock switch at PITCH LOCK	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSITION 4. PITCH LOCK ADVANCED goes on as soon as any one of six pitch locks advances 5. PITCH LOCKS ENGAGED goes on after all six pitch locks are fully advanced	2 STG PRESS MR, 2 STG MR SERVO BYPASS, 2 STG T/R SERVO BYPASS, and UTILITY T/R press go on (with AFC 309, only 2 STG MR SERVO BYPASS goes on)	No change
6.	Place blade fold/spread switch to FOLD	Blades fold	1. Master power switch at POWER 2. Blade fold position switch at BLADE FOLD POSN 3. Pitch lock switch at PITCH LOCK 4. Blade fold/spread switch at FOLD	1. BLADES SPREAD light goes off 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSN 4. PITCH LOCK ADVANCED 5. PITCH LOCKS ENGAGED 6. BLADES FOLDED goes on when fully folded	No change	No change
7.	Place blade fold switch OFF	None	1. Master power switch at POWER 2. Blade fold position switch at BLADE FOLD POSN 3. Pitch lock switch at PITCH LOCK	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSN 3. PITCH LOCK ADVANCED 4. PITCH LOCK ENGAGED 5. BLADES FOLDED	No change	No change
			BLADE FOLD (Cont)			
8.	Place master power switch OFF (if pylon is to be folded immediately, leave fold master switch at ON POSN)	Safety valve remains open; pressure stays on	1. Blade fold posn switch at BLADE FOLD POSN 2. Pitch lock switch at PITCH LOCK	1. SAFETY VALVE OPEN remains on 2. HEAD IN FOLD POSN goes off 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED	No change	ROTOR BRAKE ON goes off (brake pressure remains at 975)
9.	Have crewchief lock mechanical gust lock (optional item)	Rotor head is mechanically locked in position	Same as condition 8	Same as condition 8	ROTOR LOCKED goes on	No change
			PYLON FOLD SUBSEQUENT TO BLADE FOLD			
1.	None Aircraft Status 1. APP ON 2. No. 2 generator ON 3. Rotor brake switch EMER 4. Speed levers SHUTOFF 5. Blades folded 6. Pylon spread 7. Utility press (2800-3300 psi) 8. Crewmember positioned under tail pylon with tail rotor restrainer	None	None Initial Status 1. Master power switch OFF 2. Blade fold position switch at BLADE FOLD POSN 3. Pitch lock switch at PITCH LOCK 4. Pylon and blade fold/spread switches OFF (Switches remain the same except as noted below)	1. PITCH LOCK ADVANCED 2. PITCH LOCKS ENGAGED 3. BLADES FOLDED 4. SAFETY VALVE OPEN	None	None
2.	Place master power switch to POWER	None	Master power at POWER	1. HEAD IN FOLD POSITION goes on 2. PITCH LOCKS ADVANCED 3. PITCH LOCKS ENGAGED 4. BLADES FOLDED	No change	ROTOR BRAKE ON goes on
3.	Place pylon fold/spread switch to FOLD	1. Tail rotor positioner actuator extends 2. Pylon lock pins retract, red flags extend 3. Drive shaft coupling disconnects, third red flags extends 4. Tail rotor positioner extends all the way (Tail rotor positions for minimum height)	1. Master power at POWER 2. Pylon fold/spread at FOLD	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED 6. PYLON UNSAFE FOR FLIGHT goes on	No change	No change
4.	Place pylon fold switch OFF	None	Master power at POWER	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED 6. PYLON UNSAFE FOR FLIGHT	No change	No change
5.	Place fold master switch OFF	None	Same as condition 1, initial status	1. HEAD IN FOLD POSITION goes off 2. PITCH LOCK ADVANCED 3. PITCH LOCKS ENGAGED 4. BLADES FOLDED 5. PYLON UNSAFE FOR FLIGHT	No change	ROTOR BRAKE ON goes off

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Blade/Pylon Fold/Spread Sequencing (Sheet 1 of 3)

COND.	PILOT ACTION	RESULTS	FOLD PANEL SWITCHES	FOLD PANEL LIGHTS	CHANGE TO CAUTION PANEL	CHANGE TO ADVISORY PANEL
			PYLON FOLD WITHOUT FOLDING BLADES			
1.	None Aircraft Status 1. APP ON 2. No. 3 generator ON 3. Gust lock UNLOCKED 4. Rotor brake EMER 5. Speed levers SHUTOFF 6. Blades spread 7. Pylon spread 8. Second stage and utility pressure (2600 – 3000 psi) 9. Crewmember positioned under tail pylon with tail rotor restrainer	None	None Initial Status 1. Master power switch OFF 2. Blade fold position switch OFF 3. Pitch lock switch at DISENGAGED 4. Pylon and blade fold/spread switches OFF 5. Switches remain the same except as noted below	1. BLADES SPREAD 2. FLIGHT READY	None Initial Status 1. MGB OIL PRESS 2. ROTOR BRAKE PRESS	None Initial Status 1. APP ON 2. ISOLATION VALVE OPEN 3. ROTOR BRAKE ON
2.	Place master power switch to POWER	Safety valve opens; hydraulic pressure is available to blade fold system	Master power switch at POWER	1. FLIGHT READY goes off 2. BLADE SPREAD 3. SAFETY VALVE OPEN goes on	BLADE PYLON FOLD goes on	No change
3.	Place pylon fold/spread switch to FOLD. As soon as blades are in position for pylon fold, pilot must stop pylon fold sequence by returning switch temporarily OFF until crewmember can restrain blades from windmilling. Return switch at fold and continue sequence	1. Rotor brake press dumps and repumps to 40 psi 2. Rotor head drives to proper position for pylon fold (Any one of seven blades over right side of aft fuselage) 3. Rotor brake repumps to 575 psi 4. Tail rotor positioner actuator extends 5. Pylon lockpins retract, red flags extend 6. Drive shaft coupling disconnects, third red flag extends 7. Tail rotor positioner fully extends; tail rotor positions for minimum height 8. Second stage hydraulic pressure goes to zero	1. Master power switch at POWER 2. Pylon fold/spread switch at FOLD	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSITION goes on 4. PYLON UNSAFE FOR FLIGHT goes on	2 STG M/R PRESS M/R, 2 STG M/R SERVO BYPASS, 2 STG T/R SERVO BYPAS, and UTILITY T/R PRESS go on	ROTOR BRAKE ON light goes off during positioning and goes on after positioning sequence is complete
4.	Place pylon fold/spread switch OFF	None	Master power switch at POWER	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSITION goes off 4. PYLON UNSAFE FOR FLIGHT	No change	No change
5.	Place fold master power switch OFF	Safety valve closes; hydraulic pressure is removed from blade fold system	Same as condition 1, initial status	1. BLADES SPREAD 2. SAFETY VALVE OPEN goes off 3. PYLON UNSAFE FOR FLIGHT	No change	No change

COND.	PILOT ACTION	RESULTS	FOLD PANEL SWITCHES	FOLD PANEL LIGHTS	CHANGE TO CAUTION PANEL	CHANGE TO ADVISORY PANEL
			PYLON SPREAD (BLADES CANNOT BE SPREAD UNTIL PYLON IS IN FLIGHT POSITION)			
1.	None Aircraft Status 1. Blades and pylon folded 2. APP ON 3. No. 3 generator ON 4. Gust lock, LOCKED (Optional) 5. Rotor brake switch EMER 6. Speed levers SHUTOFF 7. Utility press (2600 – 3000 psi)	None	Initial Status 1. Master power switch OFF 2. Pitch lock switch at PITCH LOCK 3. Blade fold switch at BLADE FOLD 4. Blade fold/spread switch OFF 5. Pylon fold spread switch OFF 6. Switches remain the same except as noted below	1. PITCH LOCK ADVANCED 2. PITCH LOCKS ENGAGED 3. BLADES FOLDED 4. PYLON UNSAFE FOR FLIGHT 5. SAFETY VALVE OPEN	None Initial Status 1. MGB OIL PRESS 2. ROTOR BRAKE PRESS 3. 2 STG PRESS M/R 4. 2 STG M/R SERVO BYPASS 5. 2 STG T/R SERVO BYPASS 6. UTILITY T/R PRESS	None Initial Status 1. APP ON 2. ISOLATION VALVE OPEN
2.	Place master power switch to POWER	None	Master power switch at POWER	1. HEAD IN FOLD POSITION goes on 2. PITCH LOCK ADVANCED 3. PITCH LOCKS ENGAGED 4. BLADES FOLDED 5. PYLON UNSAFE FOR FLIGHT	No change	ROTOR BRAKE ON goes on
3.	Place pylon fold/spread switch to SPREAD	Pylon spreads (Drive shaft coupling reconnects, lockpins extend and flags and tail rotor positioner retracts)	1. Master power switch at POWER 2. Pylon fold/spread switch at spread	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED 6. PYLON UNSAFE FOR FLIGHT goes out when the pylon is spread	No change	No change
4.	Place pylon fold/spread switch OFF	None	Master power switch at POWER	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED	No change	No change
			BLADE SPREAD			
1.	None Aircraft Status 1. Blades folded 2. APP ON 3. No. 3 generator ON 4. Gust lock LOCKED (Optional) 5. Rotor brake switch EMER 6. Speed levers SHUTOFF 7. Utility press (2600 – 3000 psi) 8. With AFC 300 second stage pressure (2600 – 3000 psi)	None	None Initial Status 1. Master power switch ON 2. Pitch lock switch at ENGAGED 3. Blade fold position switch at BLADE FOLD POSN 4. Blade fold/spread switch OFF 5. Pylon fold/spread switch OFF (Switches remain the same except as noted below)	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED	1. MGB OIL PRESSURE 2. ROTOR BRAKE PRESSURE 3. ROTOR LOCKED 4. 2 STG M/R SERVO BYPASS 5. 2 STG PRESS M/R 6. 2 STG T/R SERVO BYPASS (With AFC 300, 2 STG PRESS M/R AND 2 STG T/R SERVO BYPASS remain off)	1. APP ON 2. ISOLATION VALVE OPEN 3. ROTOR BRAKE ON

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Blade/Pylon Fold/Spread Sequencing (Sheet 2 of 3)

PILOT ACTION	RESULTS	FOLD PANEL SWITCHES	FOLD PANEL LIGHTS	CHANGE TO CAUTION PANEL	CHANGE TO ADVISORY PANEL
2. Have crewchief unlock gust lock (if applied)	Rotor head is mechanically unlocked	No change	Same as condition 1	ROTOR LOCKED goes off	No change
3. Place blade fold/spread switch at SPREAD	Blades spread and lock-pins go home	Blade fold/spread at SPREAD	1. SAFETY VALVE OPEN 2. HEAD IN FOLD POSITION goes off and then goes on after turning off blade/fold switch 3. PITCH LOCK ADVANCED 4. PITCH LOCKS ENGAGED 5. BLADES FOLDED goes off 6. BLADES SPREAD goes on when fully spread	No change	No change
4. Place blade fold/spread switch at OFF	None	Blade fold/spread switch at OFF	No change	No change	No change
5. Place pitch lock switch at DISENGAGED	Pitch locks retract	1. Blade fold/spread switch at SPREAD 2. Pitch lock switch at DISENGAGED	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD POSITION 4. PITCH LOCK ADVANCE goes off when all six pitch locks are retracted 5. PITCH LOCKS ENGAGED goes off as soon as one of six pitch locks retracts 6. Second stage pressure returns to normal (2600 – 3300 psi) (with AFC 309, second-stage pressure remains at normal)	2 STG M/R SERVO BYPASS 2 STG T/R SERVO BYPASS and UTILITY T/R PRESSURE go out (with AFC 309, only 2 STG M/R SERVO BYPASS goes off)	No change
6. Place blade fold position switch OFF	None	1. Blade fold/spread switch at SPREAD 2. Pitch lock switch at DISENGAGED 3. Blade fold position switch OFF	1. BLADES SPREAD 2. SAFETY VALVE OPEN 3. HEAD IN FOLD goes off	No change	No change
7. Place master switch OFF	Safety valve deenergized (Closes)	1. Blade fold/spread switch at SPREAD 2. Pitch lock switch at DISENGAGED 3. Blade fold position switch OFF 4. Master power switch OFF	1. BLADES SPREAD 2. FLIGHT READY goes on	BLADE PYLON FOLD goes off	No change

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Blade/Pylon Fold/Spread Sequencing (Sheet 3 of 3)

INNER LOOP FUNCTIONS

FUNCTION	SENSORS	AUTHORITY	EFFECTIVE AIRSPEED	COMMENTS
SAS 1. Provides damping in pitch, roll and yaw 2. Provides short term dynamic stability	Pitch, roll and yaw rate gyros	Approximately 10% in pitch, roll and yaw	All airspeeds	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor, servo, or actuator will not affect operational capability of the function. Fail operational
HOVER AUGMENTATION 1. Opposes aircraft acceleration along lateral and longitudinal axis 2. Improves hover stability	1. Lateral and longitudinal acceleration	85% within the authority of SAS function	Below 60 KIAS	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor, servo, or actuator will result in the loss of the AFCS function. Fail Safe 3. Aircraft attitude must be between +13.3° nose up and −4.4° nose down
GUST ALLEVIATION 1. Improves aircraft stability at all airspeeds 2. Provides limited attitude signals in pitch and roll	1. Pitch and roll vertical gyros	85% within the authority of SAS function	All airspeeds	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor, servo, or actuator will result in the loss of the AFCS function. Fail Safe
TURN COORDINATION 1. Improves aircraft turn coordination 2. Holds ball within 1/2 ball width of center 3. Inner loop	1. Roll rate gyro 2. Lateral accelerometer	±14% yaw	Greater than 60 KIAS	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor, servo, or actuator will result in the loss of the AFCS function. Fail Safe 3. If airspeed fails, turn coordination will continue to function
CYCLIC/PEDAL/COLLECTIVE DESENSITIZATION 1. Reduces the effect of pilot induced oscillations in pitch, roll and collective 2. Reduces the effect of yaw AFCS interaction with the aircraft bending modes	1. Collective, cyclic and pedal transducers	Same as SAS	All airspeeds	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor, servo, or actuator will not affect operational capability of the function. Fail operational
LONGITUDINAL BIAS ACTUATOR 1. Provides a positive cyclic gradient in pitch	1. Pitch rate gyros 2. Airspeed transducer	30% authority at a rate of 5.5% per second	Effective between 60 and 180 KIAS	1. Will not move cockpit flight controls 2. Malfunctioning of a sensor or actuator may or may not result in the loss of the AFCS function 3. Airspeed transducer failure programs airspeed at 120 KIAS and moves longitudinal BIAS actuator to mid-range 4. Pitch rate gyro input interacts to dampen the fluctuating airspeed signals and improve aircraft maneuvering
CYCLIC/PEDAL/COLLECTIVE DAMPING 1. Provides pitch and roll cyclic damping 2. Provides pedal rate damping 3. Provides collective damping				1. The FAS actuator provides cyclic pitch damping 2. The roll viscous damper provides cyclic roll rate damping 3. The yaw AFCS servo provides pedal damping 4. The collective viscous damper provides collective position damping 5. All dampers have shear pins or override devices

OUTER LOOP FUNCTIONS

FUNCTION	SENSORS	AUTHORITY	EFFECTIVE AIRSPEED	COMMENTS
COLLECTIVE TRIM 1. Holds collective at the pilots desired position	Collective trim position transducer	100% authority, 10% per second	All airspeeds	1. Malfunctioning of a sensor will result in the loss of AFCS function. Fail Safe 2. Pilot can override function by overpowering force gradient spring 3. Trim switch must be on 4. Trim release switch allows for referencing of trim 5. Will continue to operate with the loss of one computer
CYCLIC TRIM 1. Holds cyclic at the pilots desired position	Cyclic trim position transducers	100% authority, 10% per second	All airspeeds	1. Malfunctioning of a sensor or actuator will result in loss of AFCS function. Fail Safe 2. Loss of a computer will result in loss of pitch trim; roll trim will continue to operate 3. Pilot can override function 4. Trim switch must be on 5. Trim release switch allows for referencing of trim
PEDAL TRIM 1. Holds pedal at the pilots desired position	Pedal trim position transducer	100% authority, 10% per second	All airspeeds	1. Malfunctioning of a sensor will result in the loss of AFCS function. Fail Safe 2. Pilot can override function by overpowering force gradient spring. Pedal force will build to about 25 pounds 3. Trim switch must be on 4. Trim release switch (pedal microswitch, collective pedal trim release button) allows for referencing of trim 5. Pedal microswitches affect pedal trim below 60 KIAS 6. Collective trim switches affect pedal trim at all airspeeds 7. Will continue to operate with the loss of one computer
AUTOPILOT 1. Heading hold-yaw	1. AHRS gyro 2. Heading trim control	100% authority, 10% per second	All airspeeds	1. Moves cockpit flight controls 2. Malfunctioning of a sensor or actuator will result in loss of AFCS function. Fail Safe 3. Holds heading ±2° 4. Heading trim control knob on AFCS control panel allows for fine trimming of heading 5. Autoturn is available with airspeed greater than 60 KIAS 6. Heading hold disengages when: a. Airspeed is less than 60 KIAS and feet on pedals or pedal trim on collective pressed b. Airspeed is greater than 60 KIAS and pedal trim release on collective pressed c. Cyclic trim release depressed, or cyclic roll beep is engaged, or cyclic displaced laterally greater than 3.4% 7. Heading hold reengages when: a. Aircraft bank angle is less than 3° b. Yaw rate is less than 0.88° per second c. Roll rate is less than 0.33° per second d. Autoturn turn logic is not met
AUTOPILOT 1. Pedal force limiting	1. Pedal position transducer 2. Pedal trim position transducer			1. Malfunctioning of a sensor or actuator will result in loss of AFCS function. Fail Safe 2. Allows pilot to sideslip aircraft at speeds above 60 KIAS without excessive force 3. Pedal force is limited to 25 pounds 4. Disengages heading hold
AUTO TURN	Lateral acceleration	100% authority, 10% per second	Greater than 60 KIAS	1. Auto turn engage logic: a. Cyclic trim release depressed b. Roll beep engaged c. Cyclic displaced from trim greater than 3.4% 2. Lateral acceleration into yaw outer loop 3. Fail Safe

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AFCS Modes (Sheet 1 of 2)

OUTER LOOP FUNCTIONS

FUNCTION	SENSORS	AUTHORITY	EFFECTIVE AIRSPEED	COMMENTS
AUTOPILOT 1. Attitude hold–roll	Roll vertical gyros	100% authority, 10% per second	All airspeeds	1. Moves cockpit flight controls 2. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 3. Beeping rate 4° per second 4. Holds aircraft ± 1° up to 45° and ± 2° between 45° and 60° 5. Cyclic trim release button references attitude hold
AUTOPILOT 1. Attitude hold–pitch	Pitch vertical gyros	100% authority, 10% per second	Below 60 KIAS, or if airspeed transducer fails	1. Moves cockpit flight controls 2. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 3. Beeping rate 3° per second 4. Holds aircraft ± 1° 5. Cyclic trim release button references attitude hold
AUTOPILOT 1. Airspeed hold–pitch	1. Airspeed transducer	100% authority, 10% per second	Airspeed greater than 60 KIAS	1. Moves cockpit flight controls 2. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 3. Beeping rate 6 KIAS per second 4. Holds airspeed ± 5 KIAS up to 30° angle of bank. After 30° angle of bank airspeed hold is lost 5. Cyclic trim release button references airspeed hold 6. Beeped speed changes may be stopped by briefly depressing the beeper 7. For airspeed hold failure system degrades to attitude hold
AUTOBANK 1. Automatic reference of roll attitude hold	1. Roll trim position transducer 2. Roll rate gyro 3. Cyclic roll position transducer		Greater than 60 KIAS	1. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 2. If air data transducer fails, autobank will continue to function 3. If heading hold has reengaged, computers will level aircraft 4. Allows for automatic referencing of roll attitude hold at airspeeds greater than 60 KIAS
FAS–FORCE AUGMENTATION SYSTEM 1. Maneuvering force feel cue proportional to load factor	1. Pitch rate gyro 2. Airspeed transducer	100% authority, 100% per second.	All airspeeds	1. Moves cockpit flight controls 2. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 3. If air data transducer fails, FAS computations use 120 KIAS

OUTER LOOP FUNCTIONS

FUNCTION	SENSORS	AUTHORITY	EFFECTIVE AIRSPEED	COMMENTS
BAR ALT–BAROMETRIC ALTITUDE HOLD	1. Air data transducer 2. Vertical accelerometer			1. Malfunctioning of a sensor will result in loss of AFCS function. Fail Safe 2. Holds engaged barometric altitude ± 20 feet or 1% of altitude, whichever is greater 3. Collective trim switch will allow for temporary release and re-reference of altitude and flashes switch legend 4. BAR ALT switch on AFCS control panel will initiate permanent release
RAD ALT–RADAR ALTIMETER HOLD 1. Provide radar altimeter hold at altitude selected with the ALT SET knob up to 500 feet	1. Radar altimeter 2. Altitude set potentiometer		Limits rate of climb to 960 FPM Limits rate of descent to 200 FPM	1. Malfunctioning sensor will result in loss of functions. Fail Safe 2. Holds pilot's desired altitude above ground ± 7 feet or 5%, whichever is greater 3. Altitude select limited 0–500 feet 4. Collective trim release causes permanent release 5. RAD ALT will automatically transfer to BAR ALT if RAD ALT fails

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AFCS Modes (Sheet 2 of 2)

LIST OF EFFECTIVE PAGES

LIST OF EFFECTIVE PAGES (Cont)