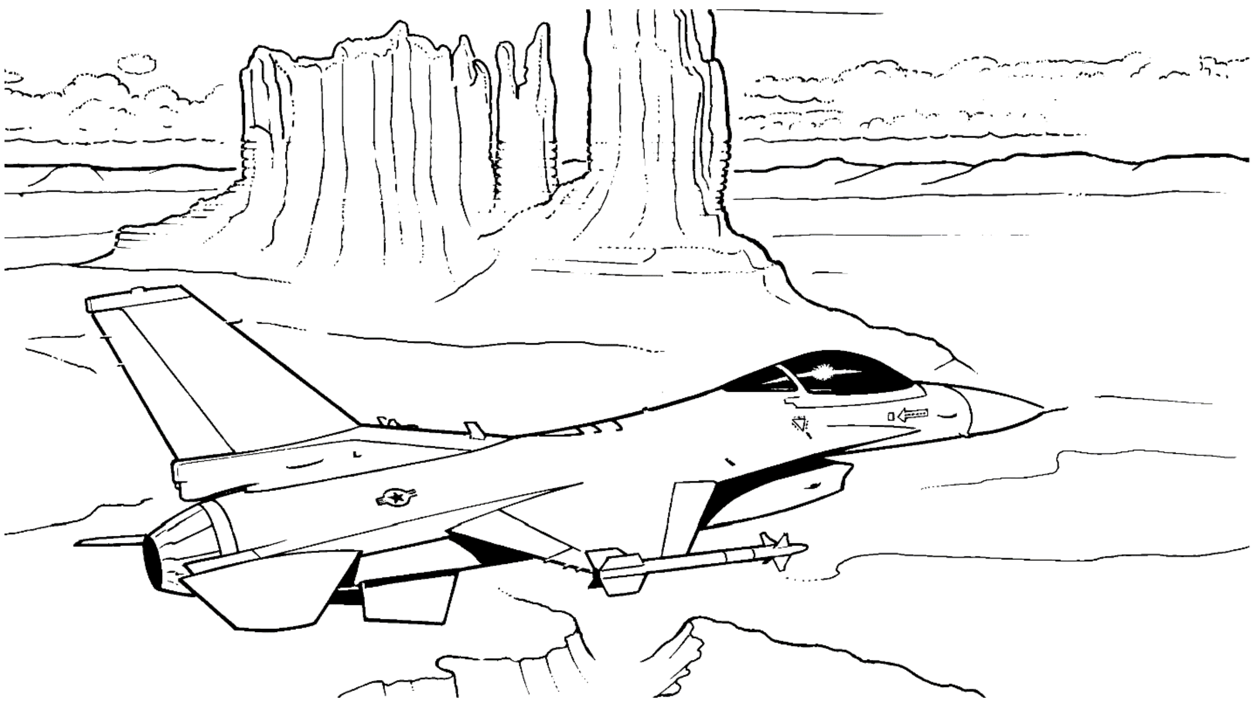
FLIGHT MANUAL

F-16C AND F-16D

BLOCKS 50, 52, 52+ and MLU



Ver.: BMS 4.37.4

Date: 18 April 2024

Foreword

This guide encompasses essential information for the secure and effective operation of the aircraft.
These instructions offer a comprehensive understanding of the aircraft, covering its characteristics, along with specific procedures for normal and emergency operations. Recognizing the diverse experience levels of pilots, the instructions are crafted to be accessible even for those with minimal experience in operating the aircraft. While avoiding overly technical flight principles, this manual aims to provide clear and concise guidance. It offers optimal operating instructions for a range of conditions, though adjustments may be needed in the face of multiple emergencies, adverse weather, challenging terrain, and other factors.

The Dash-1 covers Aircraft Systems, Normal Procedures, Emergency Procedures, Flight Characteristics, and Operating Limitations.

This document is to read in complement with the BMS Dash-34 and the BMS Training Manual as well as the BMS F-16 checklists.

In terms of performance data for the F-16, please refer to the PDF in the *\Docs\02 Aircraft Manuals & Checklists\01 F-16\F-16 Flight Model* folder.

The following manuals supplement this manual to establish the complete Falcon BMS series:

- TO 1F-16CM/AM-34-1-1 BMS (Avionics, Weapon systems, Support equipment and munitions).
- BMS-Training (Documentation to accompany Falcon BMS training missions).
- BMS-Comms & Navigation Manual (How to get the best out of ATC, Radio & Charts).
- BMS-Naval-Ops (Naval Operations from aircraft carrier in BMS).
- Checklists and Cockpit Diagrams (Normal and abnormal procedures).
- Airport Approach & Navigation Charts (including KTO AIP).

These documents are located in the *\Docs* folder of your Falcon BMS install, along with other supporting documents.

All changes in this document coming with 4.37.0 are marked with a **black** line.

All changes in this document coming with 4.37.1 are marked with a **blue** line.

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All changes in this document coming with 4.37.4 are marked with a **orange** line.

The BMS DEV team.

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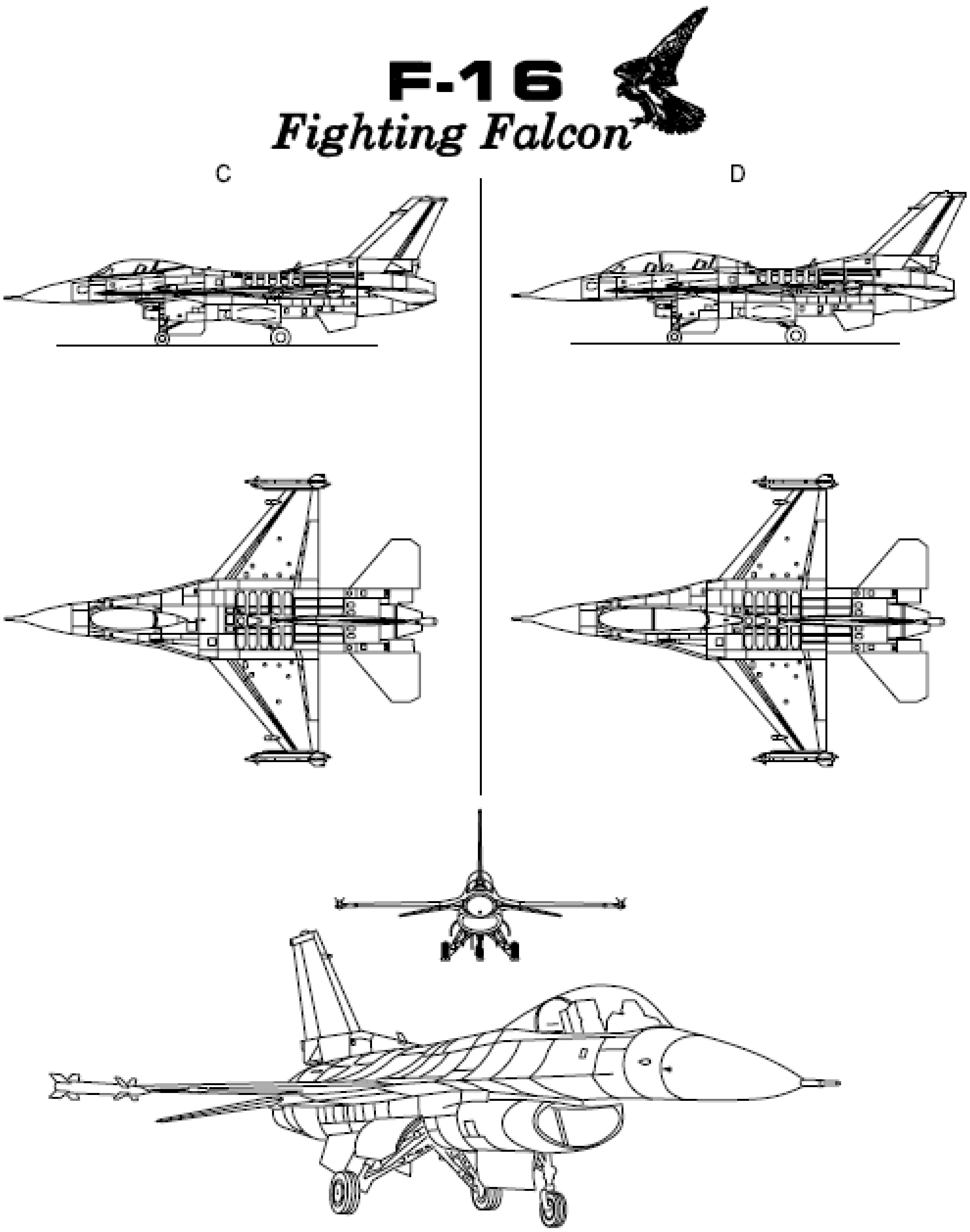

F-16
Fighting Falcon
C
D

1 The Aircraft

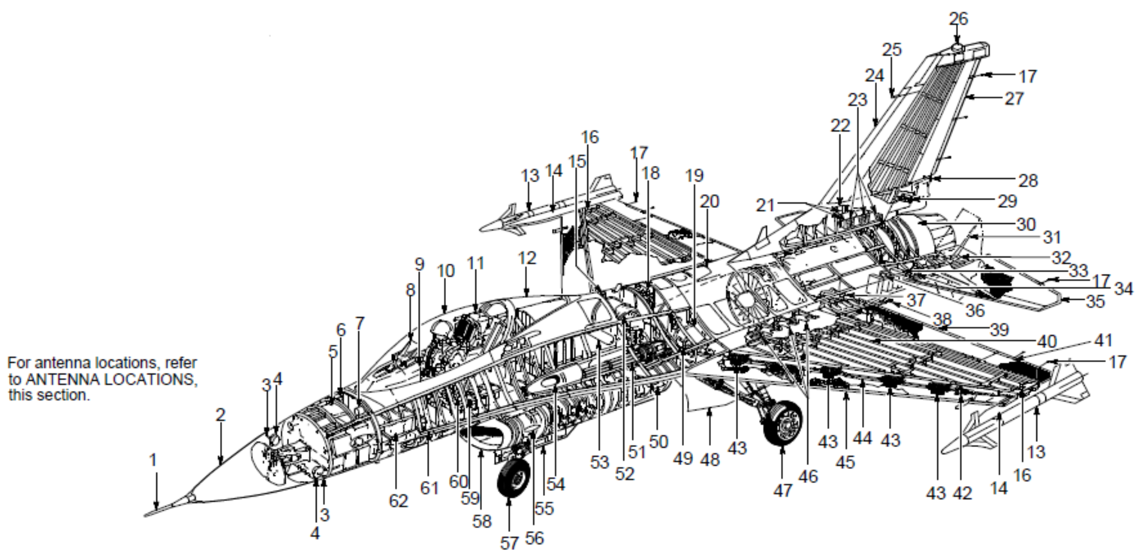
The F-16C is a single-engine, single-seat, multirole tactical fighter with full air-to-air and air-to-surface combat capabilities.

The wing and tail surfaces are thin and feature moderate aft sweep. The wing has automatic leading-edge flaps which enhance performance over a wide speed range.

Flaperons are mounted on the trailing edge of the wing and combine the functions of flaps and ailerons. The horizontal tails have a small negative dihedral and provide pitch and roll control through symmetrical/differential deflection.

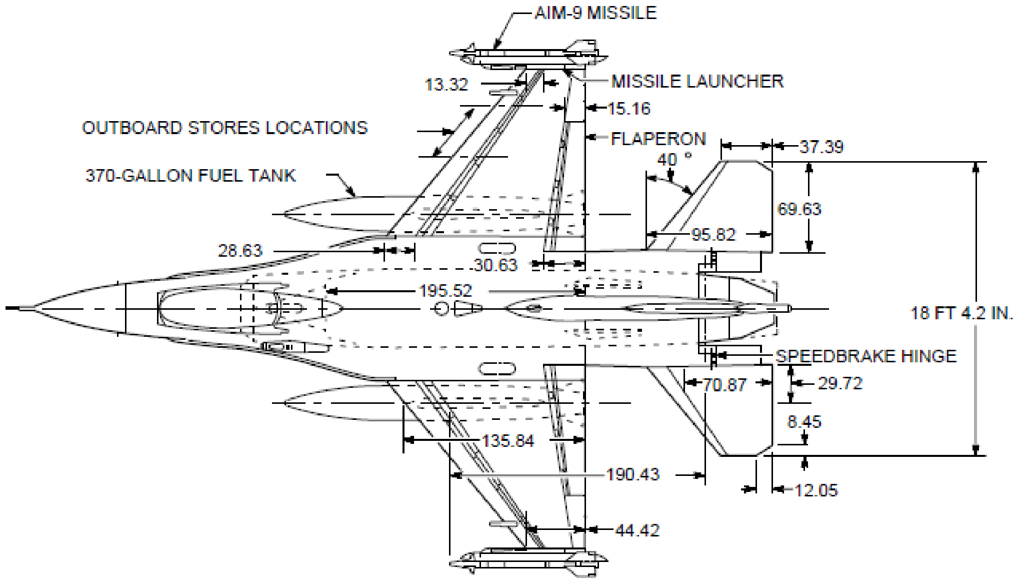
The vertical tail, augmented by twin ventral fins, provides directional stability. All flight control surfaces are actuated hydraulically by two independent hydraulic systems and are directed by signals through a fly-by-wire system.

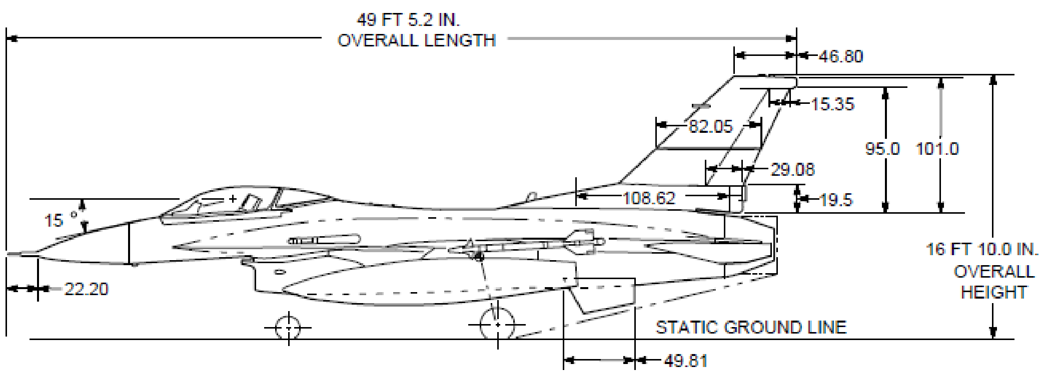
1.1 Aircraft General Arrangement



1. Air Data (Pitot) Probe
2. Nose Radome
3. AOA Probe
4. AOA Transmitter
5. Forward Electronic Equipment Bay
6. Cockpit Pressure Regulator
7. Cockpit Pressure Safety Valve
8. Head-Up Display (HUD)
9. Instrument Panel
10. Canopy (Movable)
11. Ejection Seat
12. Canopy (Fixed)
13. AIM-9 Missile
14. Missile Launcher
15. AR and Formation Light
16. Position/Formation Light
17. Static Discharger
18. LEF Drive Unit
19. Hydraulic Reservoir
20. AR Slipway
21. FLCS Accumulators
22. Anticollision Strobe Light Power Supply
23. Vertical Tail Attachment Fittings
24. Vertical Tail
25. Vertical Tail-Mounted Floodlight
26. Anticollision Strobe Light
27. Rudder
28. Position Light
29. Rudder ISA
30. Turbofan Engine
31. Speedbrake
32. Speedbrake Actuator
33. Chaff/Flare Dispenser
34. Horizontal Tail ISA
35. Horizontal Tail
36. Formation Light
37. Flaperon ISA
38. Hook
39. Flaperon
40. Wing Structural Box
41. Fixed Trailing Edge Panel
42. Asymmetry Brake
43. LEF Rotary Actuator
44. LEF Torque Shaft
45. LEF
46. Wing Attachment Fittings
47. MLG
48. MLG Door
49. LEF Angle Drive Gearbox
50. Air-Conditioning Package
51. M61A1 20MM Gun
52. Ammunition Drum
53. EPU Nitrogen Bottle
54. Gun Port
55. NLG Door
56. Position Light
57. NLG
58. Engine Air Inlet
59. Left Console
60. Throttle
61. Strake
62. Lower Equipment Compartment

1.2 Aircraft General Data





NOTE: Dimensions are in inches unless specified otherwise.

WINGS

Area	300 Sq Ft
Span	30 Ft
Aspect Ratio	3.0
Taper Ratio	0.2275
Sweep (LE)	40°
Dihedral	0°
Airfoil	NACA 64A204
Incidence	0°
Twist	
At BL 54.0	0°
At BL 180.0	3°
Flaperon Area	31.32 Sq Ft
LEF Area	36.71 Sq Ft

HORIZONTAL TAILS

Area	63.70 Sq Ft
Aspect Ratio	2.114
Taper Ratio	0.390 (Theo)
Sweep (LE)	40°
Dihedral	-10°
Airfoil	
At Root	6% Biconvex
At Tip	3.5% Biconvex

VERTICAL TAIL

Area	54.75 Sq Ft
Aspect Ratio	1.294
Taper Ratio	0.437
Sweep (LE)	47.5°
Airfoil	
At Root	5.3% Biconvex
At Tip	3.0% Biconvex
Rudder Area	11.65 Sq Ft

SPEEDBRAKES

Area (4 Element Clamshell)	14.26 Sq Ft (3.565 Sq Ft Ea)

VENTRAL FIN (EACH)

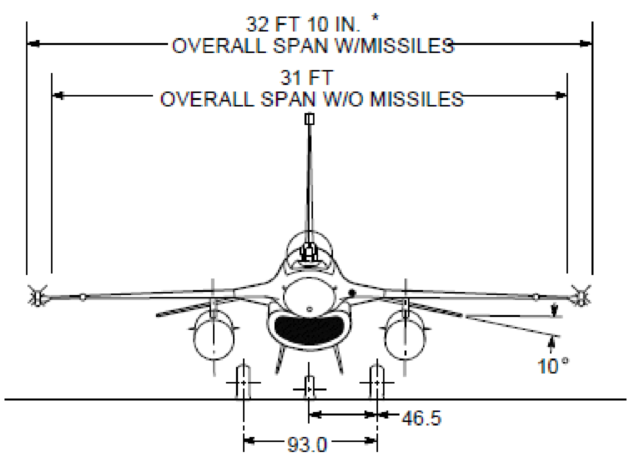
Area	8.03 Sq Ft
Span	23.356 In. Theo (27.5 In. Actual)
Aspect Ratio	0.472 (Theo)
Taper Ratio	0.760 (Theo)
Sweep (LE)	30°
Dihedral (Cant)	15° Outboard
Airfoil	
At Root	3.886% Modified Wedge
At Tip	Constant 0.03R

LANDING GEAR (LG)

Main Gear (MLG)	
Tire Size	27.75 x 8.75-14.5 24 Ply
Stroke	10.5 In.
Static Rolling Radius	11.0 In.
Nose Gear (NLG)	
Tire Size	18 x 5.7-8 18 Ply
Stroke	10.0 In.
Static Rolling Radius	7.5 In.

ENGINE

F100-PW-220/220E	
Thrust	25,000 Lb Class
Compressor Diameter	34.8 In.
Engine Length	191.1 In.
F100-PW-229	
Thrust	29,000 Lb Class
Compressor Diameter	34.8 In.
Engine Length	208 In.
F110-GE-100	
Thrust	28,000 Lb Class
Compressor Diameter	35.8 In.
Engine Length	183.76 In.
F110-GE-129	
Thrust	29,500 Lb Class
Compressor Diameter	35.8 In.
Engine Length	183.76 In.



* Add 3 inches for AIM-120 missiles

1.3 Cockpit Designation Code

System and/or component effectivity for a particular aircraft version/cockpit and engine version is denoted by a letter code enclosed in a box located in the text or on an illustration. The symbols and designations are as follows:

AIRCRAFT, COCKPIT

No code: F-16C and F-16D aircraft

C F-16C aircraft
D F-16D aircraft
DF F-16D aircraft, forward cockpit
DR F-16D aircraft, rear cockpit
TB Thunderbird Aircraft

An asterisk (*) preceding steps is used to highlight procedures for **D** aircraft which apply to both **DF** Front and **DR** Rear cockpits.

1.4 Aircraft gross Weight

C **PW220** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 19,700 pounds and with full internal JP-8 fuel 26,900 pounds.

D **PW220** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,400 pounds and with full internal JP-8 fuel 26,300 pounds.

C **PW229** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,300 pounds and with full internal JP-8 fuel 27,500 pounds.

D **PW229** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,000 pounds and with full internal JP-8 fuel 26,900 pounds.

C **GE100** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,500 pounds and with full internal JP-8 fuel 27,700 pounds.

D **GE100** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,200 pounds and with full internal JP-8 fuel 27,100 pounds.

C **GE129** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,600 pounds and with full internal JP-8 fuel 27,800 pounds.

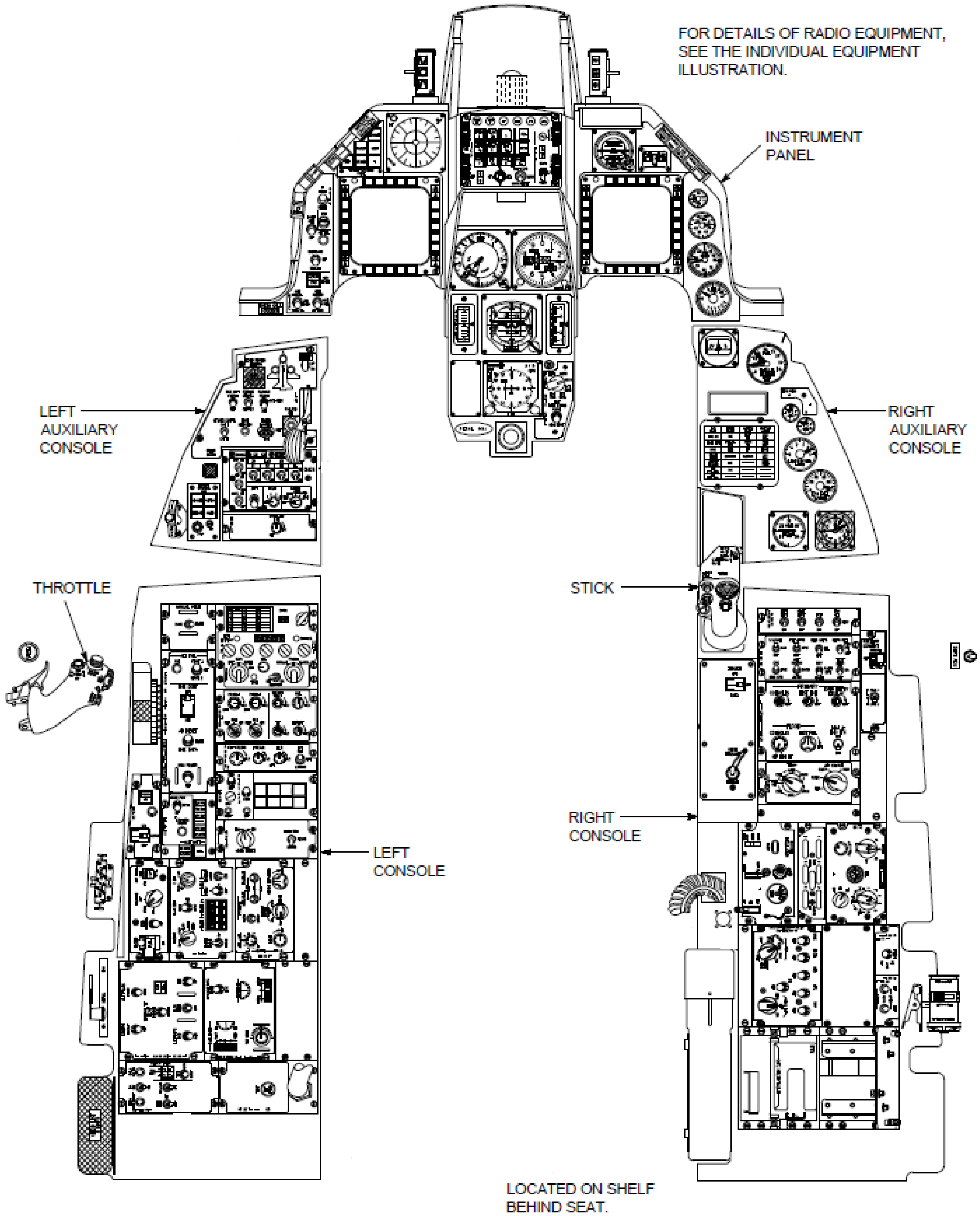
D **GE129** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,300 pounds and with full internal JP-8 fuel 27,200 pounds.

TB **C** The GW of the aircraft including pilot and engine oil is approximately 19,000 pounds and with full internal JP-8 fuel and smoke oil 26,600 pounds.

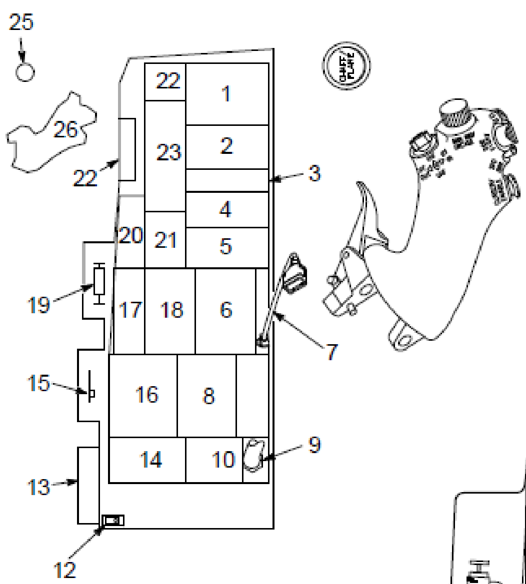
TB **D** The GW of the aircraft including pilot and engine oil is approximately 19,800 pounds and with full internal JP-8 fuel and smoke oil 26,100 pounds.

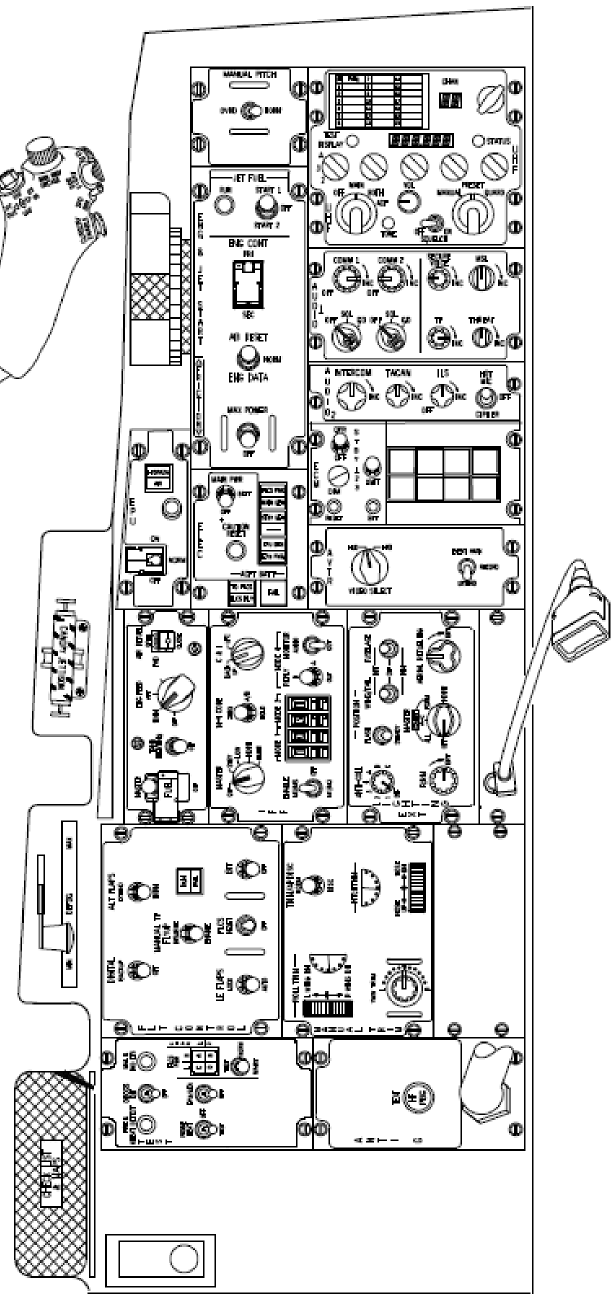
These GWs are approximate and shall not be used for computing aircraft performance.

1.5 Cockpit Arrangement



1.5.1 Left Console

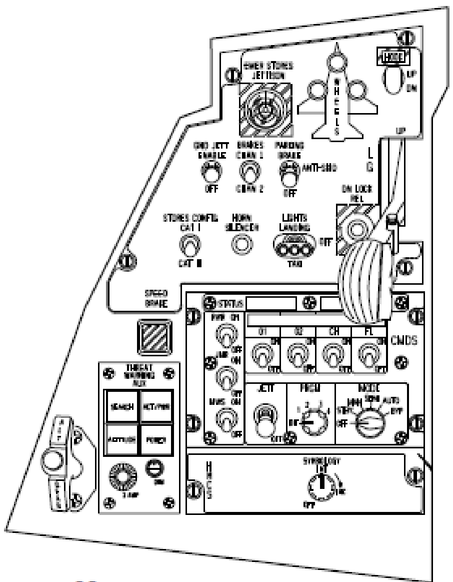


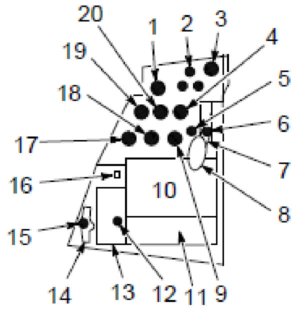


1. UHF Backup Control Panel
2. AUDIO 1 Control Panel
3. AUDIO 2 Control Panel
4. ECM Pod Control Panel
5. AVTR Control Panel
6. EXT LIGHTING Control Panel
7. HMCS QDC Lower Half
8. MANUAL TRIM Panel
9. G-Suit Hose Connection
10. ANTI G TEST Button
11. DF STICK CONTROL Switch
12. HMCS Stowing Bracket
13. Stowage
14. TEST Switch Panel
15. DEFOG Lever
16. FLT CONTROL Panel
17. Fuel Control Panel
18. IFF Control Panel
19. CANOPY JETTISON T-Handle
20. EPU Control Panel
21. ELEC Control Panel
22. Throttle FRICTION Control
23. ENG & JET START Control Panel
24. MANUAL PITCH Override Switch
25. CHAFF/FLARE Dispense Button
26. Throttle

1.5.2 LEFT AUXILIARY CONSOLE AND RIGHT AUXILIARY CONSOLE

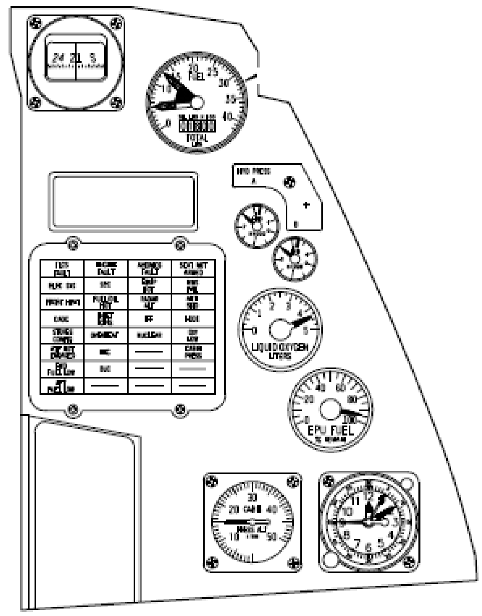
LEFT AUXILIARY CONSOLE

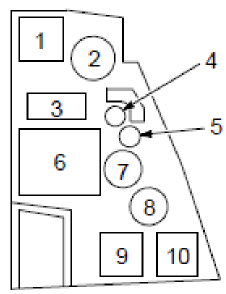




1. EMER STORES JETTISON Button (Covered)
2. WHEELS Down Lights (Green)
3. HOOK Switch (Lever Lock)
4. ANTI-SKID Switch
5. DN LOCK REL Button
6. LG Handle Down Permission Button
7. LG Handle
8. LG Handle Warning Light (Yellow)
9. LANDING TAXI LIGHTS Switch
10. CMDS Control Panel,
    LESS CHAFF/FLARE Control Panel
11. HMCS Control Panel
12. THREAT WARNING AUX (DIM) Knob
13. THREAT WARNING AUX Controls and Indicators
14. ALT GEAR Handle
15. ALT GEAR Reset Button
16. SPEED BRAKE Position Indicator
17. STORES CONFIG Switch
18. HORN SILENCER Button
19. GND JETT ENABLE Switch (Lever Lock)
20. BRAKES Channel Switch

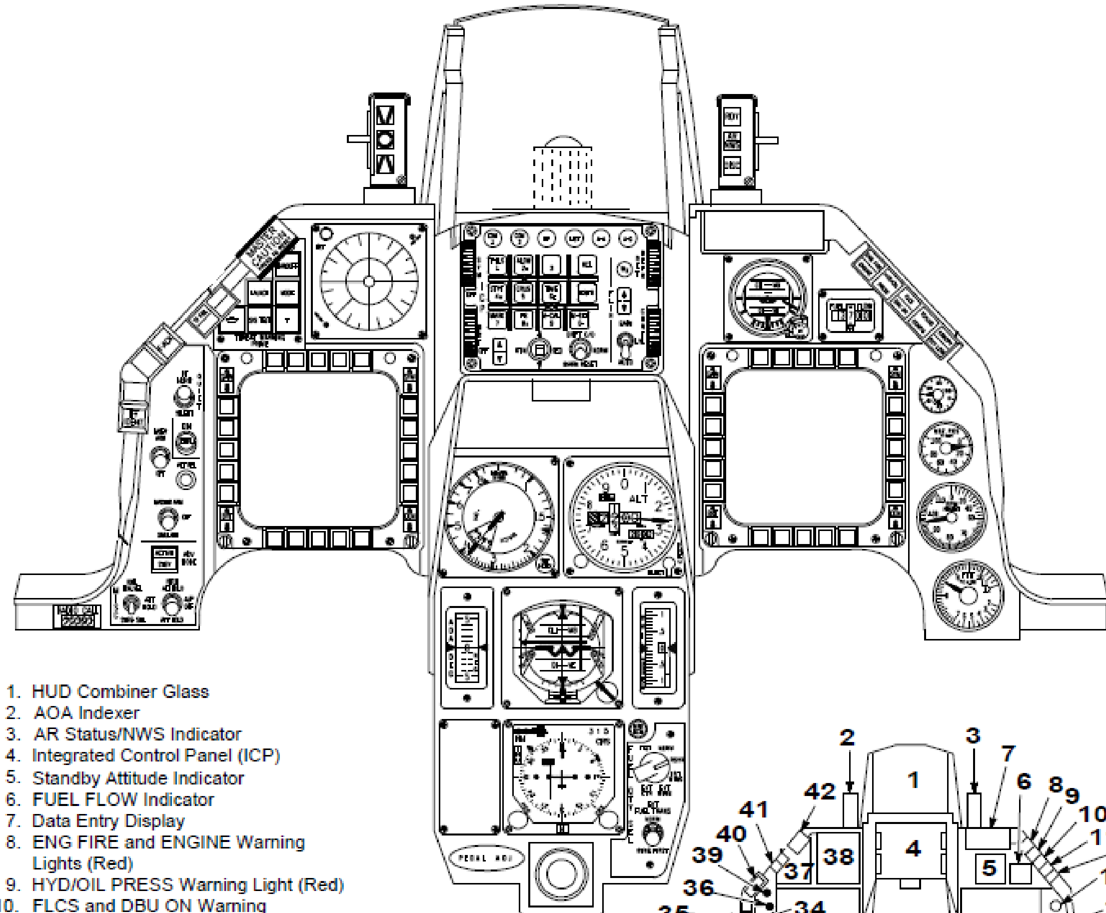
RIGHT AUXILIARY CONSOLE

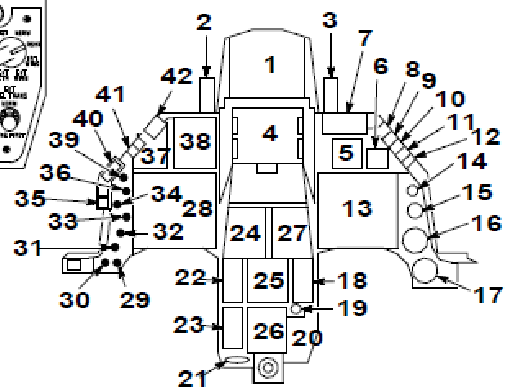




1. Magnetic Compass
2. FUEL Quantity Indicator
3. Pilot Fault List Display
4. System A HYD PRESS Indicator
5. System B HYD PRESS Indicator
6. Caution Light Panel
7. LIQUID OXYGEN Quantity Indicator
8. EPU FUEL Quantity Indicator
9. Cockpit Pressure Altimeter
10. Clock

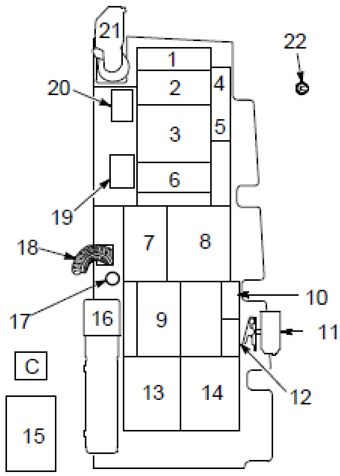
1.5.3 Instrument Panel

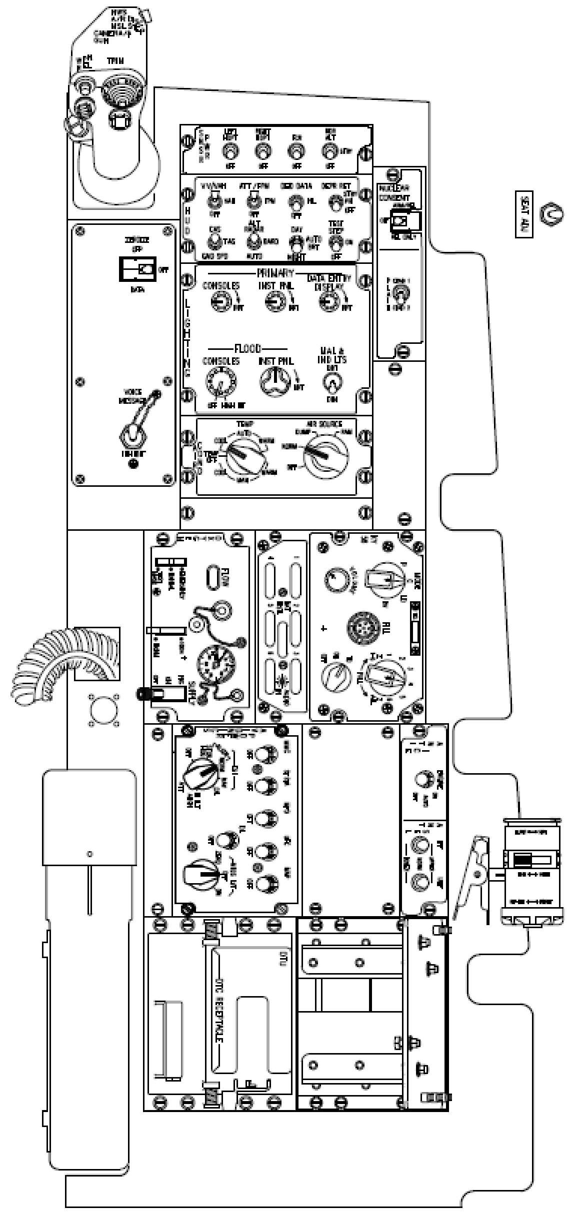




1. HUD Combiner Glass
2. AOA Indexer
3. AR Status/NWS Indicator
4. Integrated Control Panel (ICP)
5. Standby Attitude Indicator
6. FUEL FLOW Indicator
7. Data Entry Display
8. ENG FIRE and ENGINE Warning Lights (Red)
9. HYD/OIL PRESS Warning Light (Red)
10. FLCS and DBU ON Warning Lights (Red)
11. TO/LDG CONFIG Warning Light (Red)
12. CANOPY and OXY LOW Warning Lights (Red)
13. Right MFD
14. OIL Pressure Indicator
15. NOZ POS Indicator
16. RPM Indicator
17. FTIT Indicator
18. Vertical Velocity Indicator
19. MRK BCN Light
20. FUEL QTY SEL Panel
21. Rudder PEDAL ADJ Knob
22. AOA Indicator
23. INSTR MODE Select Panel
24. Airspeed/Mach Indicator
25. Attitude Director Indicator
26. Horizontal Situation Indicator
27. Altimeter
28. Left MFD
29. Autopilot PITCH Switch
30. Autopilot ROLL Switch
31. ADV MODE Switch
32. MASTER ARM Switch
33. [C] ALT REL Button
34. LASER ARM Switch
35. IFF IDENT Button
36. ECM Enable Light
37. THREAT WARNING Controls and Indicators
38. Advanced Threat Display, LESS Threat Warning Azimuth Indicator
39. RF Switch
40. F-ACK Button
41. TF FAIL Warning Light (Red)
42. MASTER CAUTION Light (Amber)
43. [DF] OVRD Light (Amber)

1.5.4 Right Console



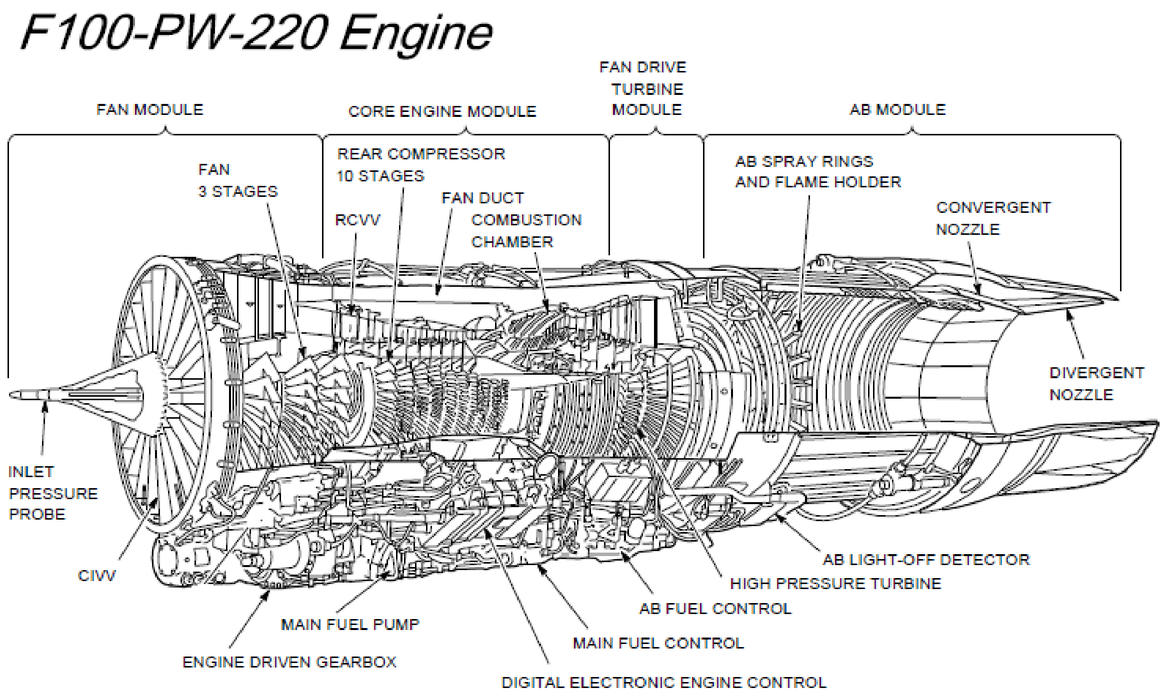


1. SNSR PWR Control Panel
2. HUD Control Panel
3. Interior LIGHTING Control Panel
4. NUCLEAR CONSENT Switch (Guarded)
5. PLAIN Cipher Switch
6. AIR COND Control Panel
7. OXYGEN REGULATOR Panel
8. Secure Voice Control Panel
9. AVIONICS POWER Panel
10. ENGINE ANTI-ICE Switch
11. Utility Light
12. ANT SEL Panel
13. DTU
14. AERP Mount
15. Chaff/Flare Programmer
16. Stowage
17. AERP Receptacle
18. Oxygen/Communication Hookup
19. VOICE MESSAGE Switch
20. ZEROIZE Switch
21. Stick
22. SEAT ADJ Switch

LOCATED ON SHELF
BEHIND SEAT.

2 Engine

The F100-PW-220 and F100-PW-220E engines have the same operating limitations, normal operating procedures, and emergency procedures. Both engines are referred to as PW220.

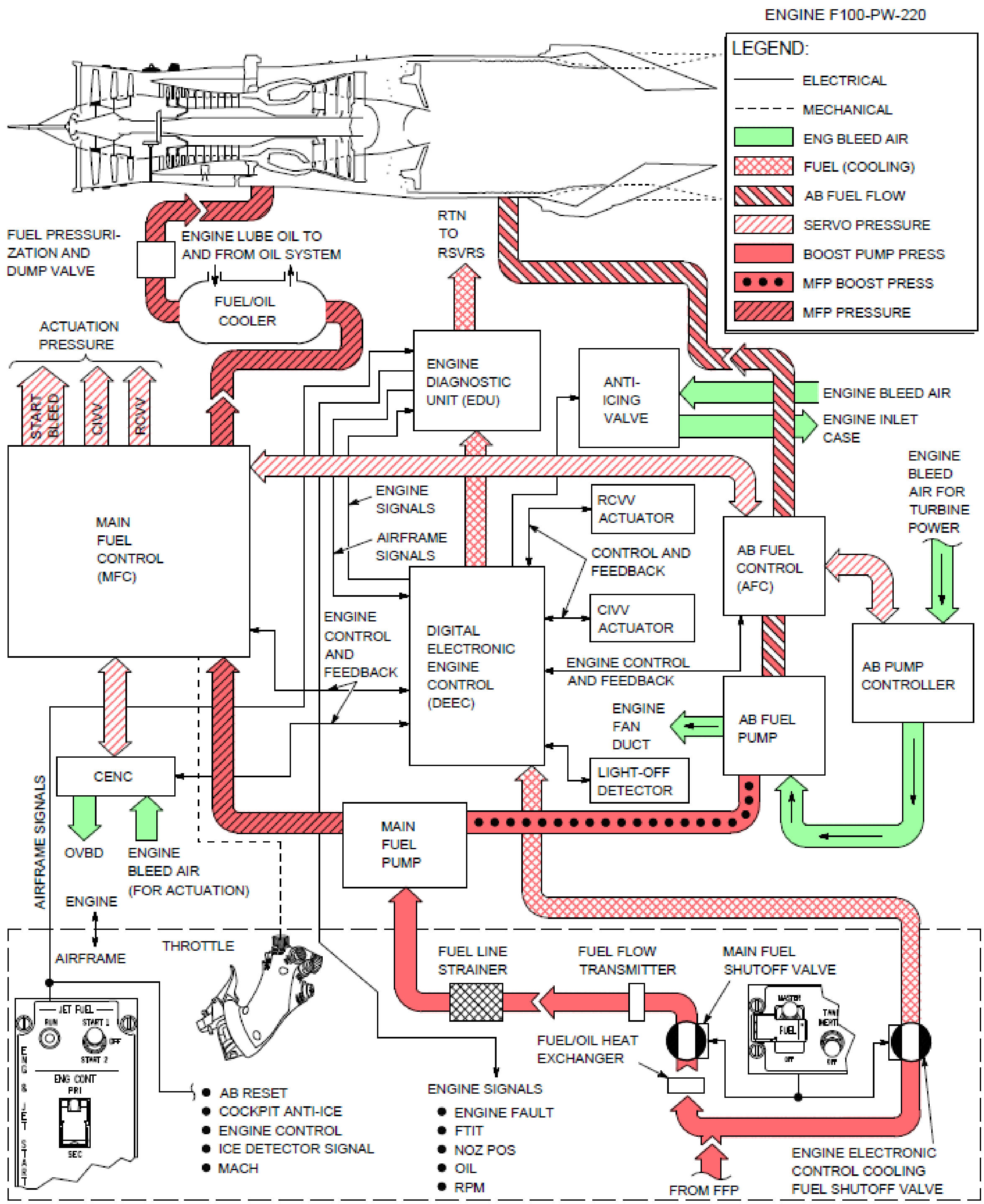


2.1 Engine General Description

The aircraft is powered by a single F100-PW-220 or F100-PW-220E afterburning turbofan engine. Maximum thrust is approximately 25,000 pounds.

2.2 Engine Fuel System

The engine fuel system delivers the required fuel to the engine for combustion and for use by the control system for scheduling the engine variable geometry.



2.3 Engine Control System

The engine control system is composed of three major components: the main fuel control (MFC), the afterburner (AB) fuel control, and the digital electronic engine control (DEEC). The engine has two modes of operation: primary (PRI) and secondary (SEC).

2.4 Main Fuel Control

The MFC operates in both the PRI and SEC modes. During PRI control, the MFC receives throttle inputs, fuel from the main fuel pump, and electrical commands from the DEEC. It controls main ignition, start bleed strap position, main engine fuel flow, and rear compressor variable vane (RCVV) position. The MFC also provides actuation pressure to the compressor inlet variable vane (CIVV) control, the convergent exhaust nozzle control (CENC), and both the AB fuel control and AB pump controller.

In SEC, the MFC receives throttle inputs, fuel from the main fuel pump, and static pressure and total temperature signals from the fan inlet case. The MFC controls main engine fuel flow, start bleed strap position, RCVV's, and engine ignition.

2.5 Afterburner Fuel Control

During primary operation, the AB fuel control receives fuel from the AB fuel pump and electrical commands from the DEEC. It provides AB ignition, AB segment sequencing, and fuel flow to the AB segments. During SEC control, AB fuel flow is inhibited.

2.6 Digital Electronic Engine Control

The DEEC is an engine-mounted, fuel-cooled, solid-state digital computer.

It controls the scheduling of engine fuel flow in PRI, nozzle position, CIVV's, RCVV's, start bleed strap position, and AB fuel flow sequencing.

The DEEC provides electrical signals to the MFC, CENC, and AB fuel control for engine stall recovery, segment 5 AB fuel flow redistribution, segment 1 AB limiting, and AB ignition.

The DEEC closed-loop idle control schedules MFC idle fuel flow to maintain a constant temperature-corrected fan speed which results in constant idle thrust in flight and on the ground. To reduce the idle thrust level, the nozzle is commanded open when the throttle is at or near IDLE and the LG handle is DN.

The DEEC limits minimum engine rpm throughout the flight envelope to maintain stable operation. At high altitude, low airspeed conditions, the DEEC protects against engine stalls. During transonic and supersonic conditions, the DEEC limits minimum idle rpm as a function of mach number (from CADC) to provide sufficient engine airflow. To minimize the possibility of stalls during AB operation at high altitude and low airspeed, the DEEC commands termination of segment 5 AB. At extremely high altitude and low airspeed, the DEEC limits AB operation to segment 1 AB.

When a stall is sensed, the DEEC cancels the AB (if throttle is in AB range) and opens the nozzle until the stall clears. For subsequent AB operation, the throttle must be retarded below AB before AB can be reinitiated.

An engine overspeed or overtemperature condition causes the DEEC to automatically transfer to SEC and illuminate the SEC caution light.

2.7 Secondary Engine Control

The SEC is a hydromechanical system which provides engine control in the event of a DEEC system malfunction. In SEC, the CIVV's move to a fixed (cambered) position, nozzle position is closed, the RCVV's are positioned by a hydromechanical control in the MFC, and AB operation is inhibited. SEC is selected manually with the ENG CONT switch or automatically by the DEEC. During SEC operation, the SEC caution light illuminates.

2.8 Main Fuel Pump

The gearbox-mounted main fuel pump provides pressurized fuel to the MFC and boosts pressure to the AB fuel pump.

2.9 Afterburner Fuel Pump

The AB fuel pump is driven by engine bleed air and provides pressurized fuel to the AB. The pump operates only during AB operation.

2.10 Compressor Inlet Variable Vane (CIVV) Control

The CIVV control positions the CIVV's using MFC fuel pressure in response to an electrical signal from the DEEC. In SEC, the CIVV's are in a fixed (cambered) position.

2.11 Rear Compressor Variable Vanes (RCVV's)

The first three stages of the rear compressor are equipped with variable geometry vanes. RCVV's are controlled by the DEEC and are positioned using pressurized fuel from the main fuel pump. In SEC, the RCVV's are positioned by a hydromechanical control in the MFC.

2.12 Compressor Bleed Air

Low-pressure bleed air is directed from the bleed strap into the fan duct to increase the compressor stall margin during starting. Pressurized fuel from the main fuel pump is used to drive the start bleed actuator. The bleed valve is scheduled as a function of engine rpm by the DEEC when starting in PRI and as a function of time and engine inlet pressure in SEC.

High-pressure bleed air is supplied to the EPU and engine nacelle ejectors. It is also used for engine inlet anti-icing, to drive the AB fuel pump, and to drive the CENC motor. Either low-pressure or high-pressure air is provided to the ECS depending on engine bleed pressure levels.

2.13 Pressurization Dump Vane

A pressurization and dump valve is located in the engine fuel manifold line between the fuel/oil cooler and fuel nozzles. It provides a minimum fuel pressure for MFC operation at low rpm and dumps the engine fuel manifold when the throttle is retarded to OFF.

2.14 Exhaust Nozzle

The exhaust nozzle is variable and consists of two sections. The divergent nozzle floats freely and moves in conjunction with the convergent nozzle. The convergent nozzle is controlled by the convergent exhaust nozzle control.

2.15 Convergent Exhaust Nozzle Control (CENC)

The CENC is actuated by a high-pressure bleed air motor. The nozzle schedule is controlled by the DEEC as a function of throttle input to the MFC.

In PRI with the LG handle down, the nozzle is approximately 70-95 percent open at IDLE (idle area reset). As the throttle is advanced, the nozzle closes. With the LG handle up, the nozzle is near minimum area except when approaching MIL or above.

At MIL and above, the DEEC schedules the nozzle to control engine pressure ratio as a function of fan speed.

When the throttle is advanced in the AB range, the DEEC commands the nozzle open to compensate for increasing AB fuel flow.

In SEC, the nozzle is positioned to the closed position and AB operation is inhibited.

2.16 Light-Off Detector

The engine incorporates an AB LOD, which, when combined with the DEEC logic, provides AB no-light and blowout detection. When the LOD senses an AB no-light or blowout, the DEEC automatically terminates AB fuel flow.

If the throttle is left in AB, the DEEC attempts AB light-off up to three times. If these attempts are unsuccessful, the throttle must be retarded to MIL or below and then advanced into AB for further AB attempts.

2.17 Engine Oil System

The engine is equipped with a self-contained oil system to lubricate the engine and gearbox. System pressure is nonregulated and varies with rpm, oil temperature, and altitude.

Below approximately 35,000 feet MSL, oil pressure should increase approximately 15 psi from IDLE to MIL. At very high altitudes (50,000 feet), the oil pressure increase is approximately 5 psi from IDLE to MIL. At all altitudes, however, a definite oil pressure increase should be evident when the rpm is increased.

2.18 Fuel Oil Hot Caution Light

The FUEL/OIL HOT caution light is located on the caution light panel. The oil hot function of the light is inoperative.

2.19 Engine Anti-Ice System

The anti-ice system routes high-pressure bleed air to and through the fixed fan inlet guide vanes, the CIVV's, and the inlet pressure probe support cone to prevent ice formation.

Additionally, the inlet probe is continuously heated electrically to prevent ice formation.

The system is controlled by the DEEC and a three-position ANTI ICE switch. The anti-ice system can be activated manually by placing the ANTI ICE switch to ON or automatically, if the ANTI ICE switch is in AUTO and a sensor located in the inlet senses the accumulation of ice.

Activation also occurs if emergency dc bus No. 2 power is lost (unless inhibited by the DEEC).

The inlet strut is electrically heated to prevent ice buildup. This heater is also controlled by the ANTI ICE switch for manual or automatic operation.

The DEEC prevents anti-ice operation above 30,000 feet MSL and when engine inlet or bleed air temperatures are high. In addition, a DEEC malfunction may result in loss of bleed air for engine anti-icing.

2.20 Engine Anti-Ice Switch

The engine ANTI ICE switch is located on the right console.
Functions are:

• ON – The inlet strut electrical heater turns on and the engine anti-ice system is activated (if not inhibited by the DEEC). If ice accumulation is detected, the INLET ICING caution light illuminates. The caution light remains on for approximately 70 seconds (Assuming that no additional ice accumulation occurs). If ice reaccumulates before the 70-second cycle expires, the caution light remains on and the cycle repeats until icing conditions no longer exist.

• AUTO – When an ice accumulation is detected, the INLET ICING caution light illuminates, the inlet strut electrical heater turns on, and the engine anti-ice system activates (unless inhibited by the DEEC). The caution light, inlet strut electrical heater, and engine anti-icing system remain on for approximately 70 seconds (Assuming that no additional ice accumulation occurs). If ice reaccumulates before the 70-second cycle expires, the cycle repeats until icing conditions no longer exist.

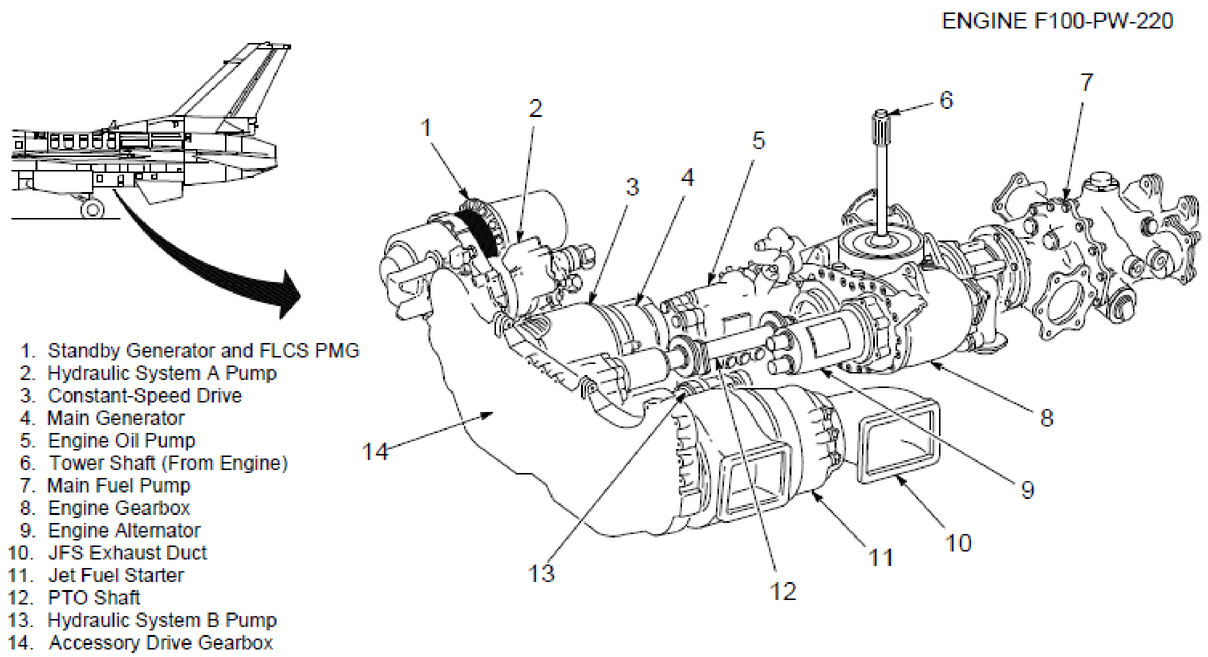
• OFF – Ice detector, engine anti-ice system, and inlet strut heater are off.

2.21 Inlet Icing Caution Light

The INLET ICING caution light, located on the caution light panel, illuminates when an ice accumulation is detected by the inlet ice detector or if a detection system failure occurs. The caution light remains on for approximately 70 seconds (assuming no additional ice accumulation). If more ice accumulates, the caution light may remain on for a longer period of time or may cycle off and then on again.

2.22 Engine and Accessory Drive Gearbox

The engine gearbox drives the main fuel pump, the oil pump assembly, the engine alternator, and the power takeoff (PTO) shaft, which powers the accessory drive gearbox (ADG). The ADG powers the main generator through the constant speed drive (CSD), system A and B hydraulic pumps, standby generator, and FLCS PMG. The jet fuel starter (JFS) is also mounted on the ADG.



2.23 Engine Alternator

The engine alternator is driven by the engine gearbox and provides sole power for the DEEC, engine and AB ignition, inlet pressure probe heater, and the rpm signal to the RPM indicator.

2.24 Engine ignition System

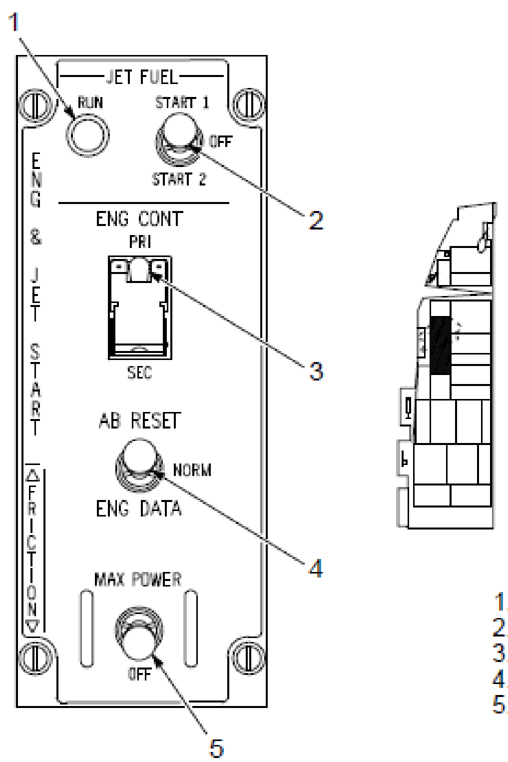
The ignition system is powered by the engine alternator and contains four igniter plugs (two for the engine and two for the AB). With the throttle at or above IDLE and engine rpm at 12 percent or above, engine ignition is continuous. When the throttle is moved into AB, AB ignition is activated by the DEEC for up to 3 seconds or until the LOD detects an AB light. In the event of an AB blowout or no-light condition with the throttle left in AB, AB ignition is automatically resequenced by the DEEC up to three additional times. For subsequent AB ignition, the throttle must be retarded to MIL or below and then returned to AB.

2.25 Jet Fuel Starter (JFS)

The JFS is a gas turbine which operates on aircraft fuel and drives the engine through the ADG. The JFS is connected by a clutch to the ADG and only provides torque when required to maintain engine rpm. If the ADG is not able to rotate (i.e., seized engine), the JFS runs, but the clutch prevents it from rotating the ADG. The JFS always receives fuel regardless of the FUEL MASTER switch position. The JFS is started by power from two brake/JFS accumulators used either singly or together. The brake/JFS accumulators are charged automatically by hydraulic system B or manually by a hydraulic hand pump located in the left wheel well. Automatic recharging takes between 40 seconds (hot ambient conditions) and 60 seconds (cold ambient conditions). The JFS is used to start the engine on the ground and to assist in engine airstart.

2.26 ENG & JET Start Control Panel

The ENG & JET START control panel is located on the left console.



1. RUN Light (Green)
2. JFS Switch
3. ENG CONT Switch
4. AB RESET Switch
5. MAX POWER Switch

2.27 JFS Switch

Functions are:

• OFF – Normal switch position. The JFS can be shut down at any time by selecting OFF. The switch returns to OFF automatically during a normal ground start at 50 percent rpm.

• START 1 – Vents one of the brake/JFS accumulators to the hydraulic start motor.

• START 2 – Vents both brake/JFS accumulators to the hydraulic start motor.

2.28 JFS Run Light

The green JFS RUN light illuminates within 30 seconds after initiating JFS start to indicate that the JFS has attained governed speed.

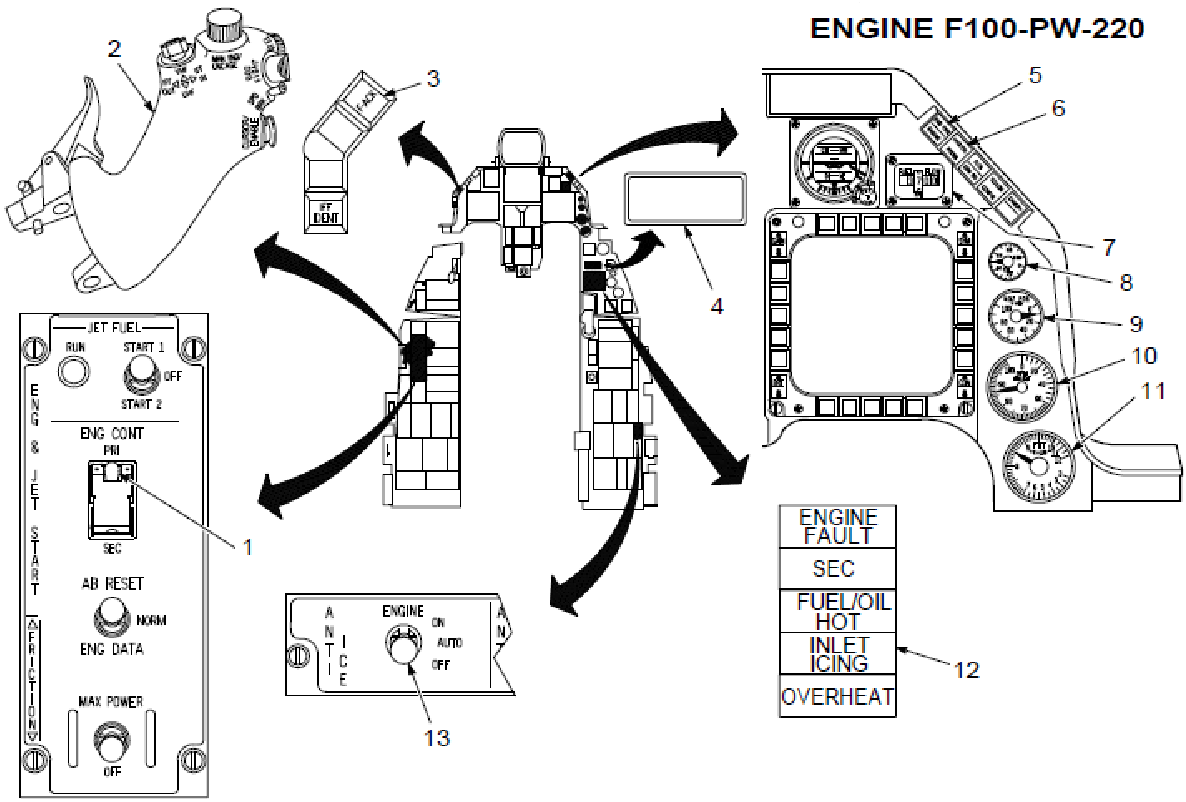
2.29 JFS Operation

During a ground engine start, the brake/JFS accumulators begin to recharge after the engine accelerates through 12 percent rpm. As the engine accelerates through 50 percent rpm, a sensor causes the JFS to shut down automatically and the JFS RUN light goes off.

During in-flight operation, the brake/JFS accumulators begin to recharge (provided system B hydraulic pressure is available) when the JFS reaches 70 percent of governed speed (3-4 seconds before the JFS RUN light illuminates). If the JFS RUN light does not illuminate within 30 seconds or the JFS RUN light goes off once illuminated, the JFS START switch will not reengage and the JFS cannot be restarted until the JFS has spooled down. JFS spooldown takes approximately 17 seconds from full governed speed. Once running, the JFS does not shut down until the JFS switch is manually positioned to OFF.

2.30 Engine Controls and Indicators

The engine instruments are located on the right side of the instrument panel.



1. ENG CONT Switch
2. Throttle
3. C DF F-ACK Button, DR FAULT ACK Button
4. Pilot Fault List Display
5. ENG FIRE and ENGINE Warning Lights (Red)
6. HYD/OIL PRESS Warning Light (Red)
7. FUEL FLOW Indicator
8. OIL Pressure Indicator
9. NOZ POS Indicator
10. RPM Indicator
11. FTIT Indicator
12. Caution Lights (Amber)
13. ANTI ICE Switch

2.31 ENG CONT Switch

The ENG CONT switch (guarded out of SEC) is located on the left console.
Functions are:

- **C** **DF** PRI – DEEC in operation (normal position).

- SEC – SEC operation. Transfer occurs when the switch is moved to the SEC position.

2.32 Engine Fault Caution Light

The ENGINE FAULT caution light, located on the caution light panel, indicates that an engine PFL item was detected. The ENGINE FAULT caution light goes off when the fault is acknowledged.

2.33 Pilot Fault List Display (PFLD)

Located on the right auxiliary console instrument panel, displays engine PFL's. Refer to FLCS WARNING, CAUTION, AND INDICATOR LIGHTS, this section, for a description of the **D**. Refer to PILOT FAULT LIST-ENGINE, PW220/229 Section, for a description of engine PFL's.

2.34 SEC Caution Light

The SEC caution light, located on the caution light panel, indicates that the engine is operating in SEC or that main fuel pump pressure is low.

2.35 EEC Caution Light

The EEC caution light, located on the caution light panel, is deactivated.

2.36 BUC Caution Light

The BUC caution light, located on the caution light panel, is deactivated.

2.37 RPM Indicator

The RPM indicator has a pointer display and the rpm signal is supplied by the engine alternator. RPM is expressed in percent from 0-100. The indicator is powered by battery bus No.1.

2.38 NOZ POS Indicator

The NOZ POS indicator displays the position of the CENC exhaust nozzle drive shafts which are calibrated from 0 percent (closed) to 100 percent (fully open). The indicator accurately reflects exhaust nozzle position in PRI and SEC unless both drive shafts are failed. The indicator is powered by emergency ac bus No. 2.

2.39 FTIT Indicator

The FTIT indicator displays an average FTIT in degrees C. The indicator has a range of 200°-1200°C in major increments of 100°C and is powered by battery bus No. 1.

2.40 Fuel Flow Indicator

The FUEL FLOW indicator is a digital indicator which displays the total fuel flow to the engine, including AB, in pph. The indicator has a range of 0-80,000 pph and is powered by emergency ac bus No. 1.

2.41 Oil Pressure Indicator

The OIL pressure indicator displays engine oil pressure from 0-100 psi and is powered by emergency ac bus No. 2.

2.42 HYD/OIL Press Warning Light

The HYD/OIL PRESS warning light, located on the edge of the right glareshield, serves as a monitor of engine oil pressure and hydraulic system pressure. For engine oil pressure, the warning light illuminates when oil pressure has been below approximately 10 psi for 30 seconds (time delay minimizes warning light illuminating during maneuvering). The light goes out when oil pressure exceeds approximately 20 psi. For hydraulic pressure, the warning light illuminates when either A or B system pressure decreases below 1000 psi. The light goes out when both system A and B pressures are above 1000 psi. During engine start, the warning light usually goes off before reaching idle rpm; however, acceptable operation is indicated if the light goes off after a 2-3% rpm increase above idle and remains off when the throttle is retarded to IDLE. The warning light is powered by battery bus No. 1.

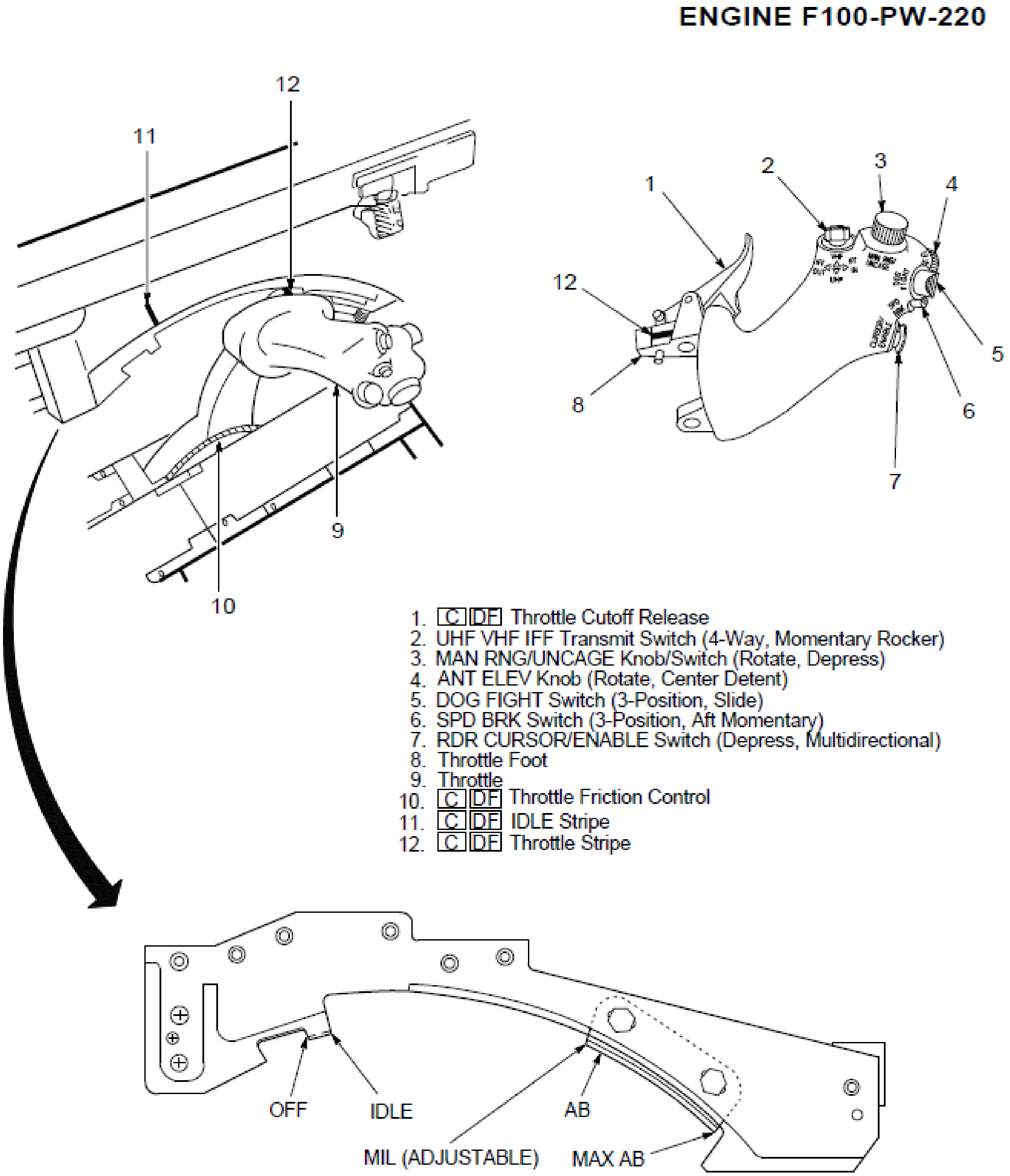
2.43 Engine Warning Light

The ENGINE warning light, located on the edge of the right glareshield, illuminates when RPM and/or FTIT indicator signals indicate that an engine overtemperature, flameout, or stagnation has occurred. Illumination also occurs for an engine alternator failure and may occur as a result of an RPM or FTIT indicator failure or an engine warning system failure. The warning light illuminates when the rpm decreases to sub idle (below 55 percent), when engine stagnates (determined from rpm/FTIT rates), or approximately 2 seconds after FTIT indication exceeds 1000°C. The warning light goes off when the condition that turned it on is eliminated. The warning light is powered by battery bus No. 1.

2.44 Reduced IDLE Thrust

The RIT switch, located on the left sidewall just aft of the throttle, is inoperative.

2.45 Throttle



The engine is controlled by a throttle mounted above the left console with detents at OFF, IDLE, MIL, and MAX AB.

The throttle is mechanically connected to the MFC. The OFF position terminates engine ignition and fuel flow. The IDLE position commands minimum thrust and is used for all ground starts and airstarts.

From IDLE to MIL, the throttle controls the output of the engine. Forward of the MIL position, the throttle modulates the operation of the AB (through five segments) while maintaining constant basic engine operation.

The throttle must be rotated outboard to allow advancement from OFF to IDLE and from MIL to AB.

Retarding the throttle from AB to MIL automatically rotates the throttle. At IDLE, a cutoff release at the base of the throttle must be actuated to allow the throttle to be rotated outboard and retarded to OFF. A single white reflective stripe is located on both the upper surface of the throttle foot and on the sidewall fairing, **DR** on both the lower throttle radius next to the console and on the panel outboard of the throttle radius.

Alignment of the two stripes aids in identifying the IDLE position. Six switches are located on the throttle. A throttle friction control is located inboard at the base of the throttle.

2.46 Engine Operating Characteristics

2.46.1 Ground Operations

Since the DEEC maintains constant idle thrust, rpm varies with temperature and pressure altitude (higher temperature or pressure altitude results in higher rpm). At MIL, the DEEC controls fan speed and engine pressure ratio to maintain consistent thrust. RPM and FTIT vary as a function of flight conditions.

2.46.2 Non-AB Operations in Flight

After a MIL takeoff, FTIT is usually 890°-960°C with rpm of 89-94 percent for any outside air temperature above 2°C. FTIT and engine rpm are lower for temperatures below 2°C.

Regardless of temperature, nozzle position should not exceed 30 percent at MIL.

Engine operation is continually optimized as flight conditions change. This is evident by slight changes in the NOZ POS, RPM, and FTIT indicator indications. At low altitudes (below approximately 10,000 feet), idle rpm should always be equal to or slightly higher than the ground idle rpm. As altitude increases, idle rpm increases to provide the engine sufficient stall margin during throttle transients.

At 1.4 mach and above, the minimum thrust level is MIL even though the throttle may be retarded below MIL. Typically, the minimum thrust level increases from idle to MIL between

0.84-1.4 mach. All of the minimum operating level features are deactivated during SEC operation.

A low frequency engine vibration may be sensed in flight or on the ground primarily at or near idle but may also occur at higher thrust settings. The vibration has no adverse effect on engine or aircraft structure and should disappear if engine rpm is either increased or decreased. Vibrations that change in intensity with throttle movement and are present across the throttle/rpm range may indicate a potential engine malfunction.

2.46.3 AB Operation in Flight

The DEEC monitors AB operation and takes appropriate action to prevent engine stalls. In AB, the DEEC provides the following:

• Fast acceleration capability: The AB has no limitations during throttle transients from IDLE to MAX AB. Near sea level, AB operation occurs immediately after AB is selected. At high altitude, a higher fan speed must be attained prior to AB operation. For example, during an IDLE-to-MAX AB throttle transient at low altitude, the AB lights just above idle thrust and the total time from idle thrust to MAX AB thrust is approximately 4 seconds. In contrast, at high altitude, the time from idle thrust to MAX AB thrust is approximately 11 seconds.

• AB fuel flow redistribution: Flight at high altitude and low airspeed results in the redistribution of segment 5 fuel flow to segment 3 to maintain AB stability.

• AB segment sequencing limiting: When AB is selected at extremely high altitudes and low airspeeds, only segment 1 AB is scheduled. However, if this area is entered with AB above segment 1, there will be no change. If AB segment 2 or greater is selected while in this area, the engine automatically sequences up to the requested throttle position as the aircraft exits the area. A self-recoverable AB stall may occur during this automatic sequencing if the engine is operating on approved fuels other than JP-4, NATO F-40, or JET B.

• AB recycle capability: The DEEC, in conjunction with the LOD, provides automatic AB recycle capability in the event of an AB blowout or no-light condition (if the throttle is left in AB). In that event, the DEEC automatically resets the control system to MIL, performs a control system check, and reattempts to light the AB up to three additional times before returning the engine to MIL. If the LOD is failed, the DEEC attempts one AB relight using a duct pressure signal to verify AB light off. No caution lights result from unsuccessful AB recycles. Additional AB attempts can be made by moving the throttle to MIL or below and then back into AB.

2.46.4 SEC Operation

The engine transfers to SEC when the ENG CONT switch is manually switched to the SEC position.

Transfer to SEC also occurs automatically if the DEEC senses a major engine control system malfunction or if loss of electrical power to the DEEC occurs.

When the engine transfers to SEC, the SEC caution light illuminates, and AB is inhibited.

RPM may increase or decrease slightly except at high altitude where rpm and FTIT decrease significantly if the transfer occurs with the throttle at or near IDLE. While subsonic in SEC, throttle movement is unrestricted between 15,000 and 40,000 feet MSL. The throttle may be moved in the AB range; however, the AB is inhibited.

Refer to ENGINE OPERATIONAL ENVELOPE chapter for transfer and throttle movement restrictions.

The SEC provides 80-100 percent of normal MIL thrust. This level provides a measure of protection against exceeding engine operating limits and provides sufficient thrust for safe flight operations.

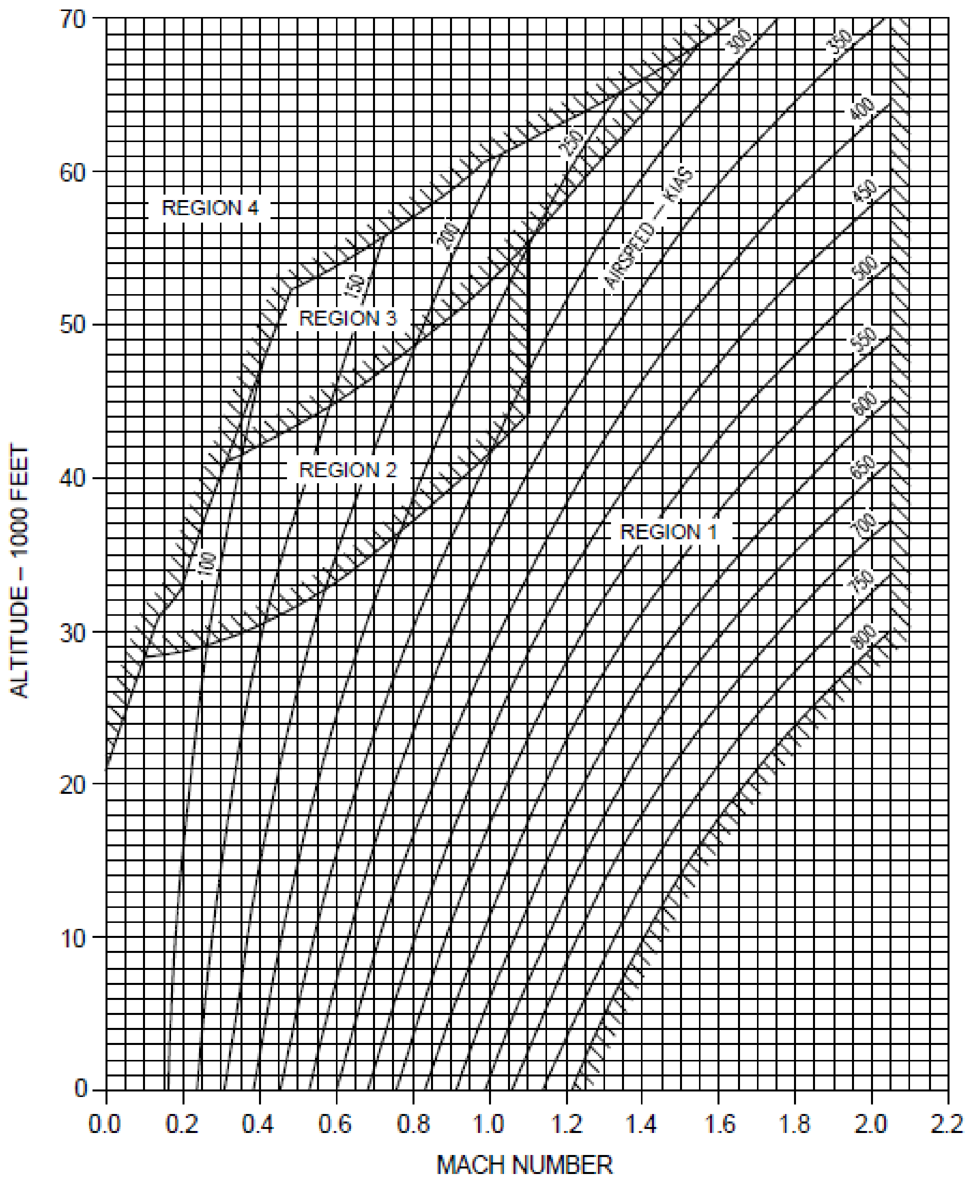
SEC idle thrust is approximately twice that in PRI with a normal nozzle during landing approach and ground operations because the nozzle is closed.

AB Envelope – Light-Off

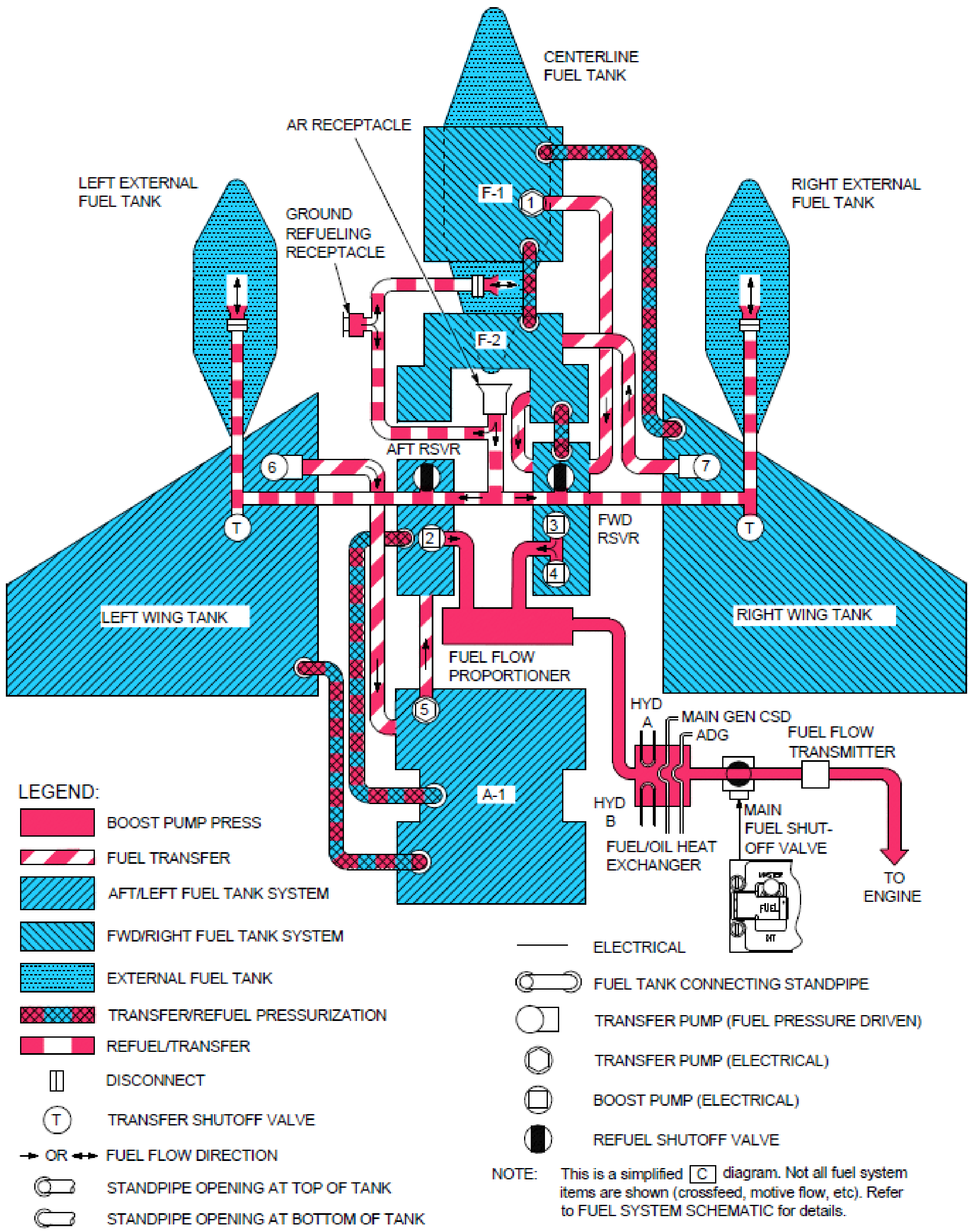
ENGINE F100-PW-220

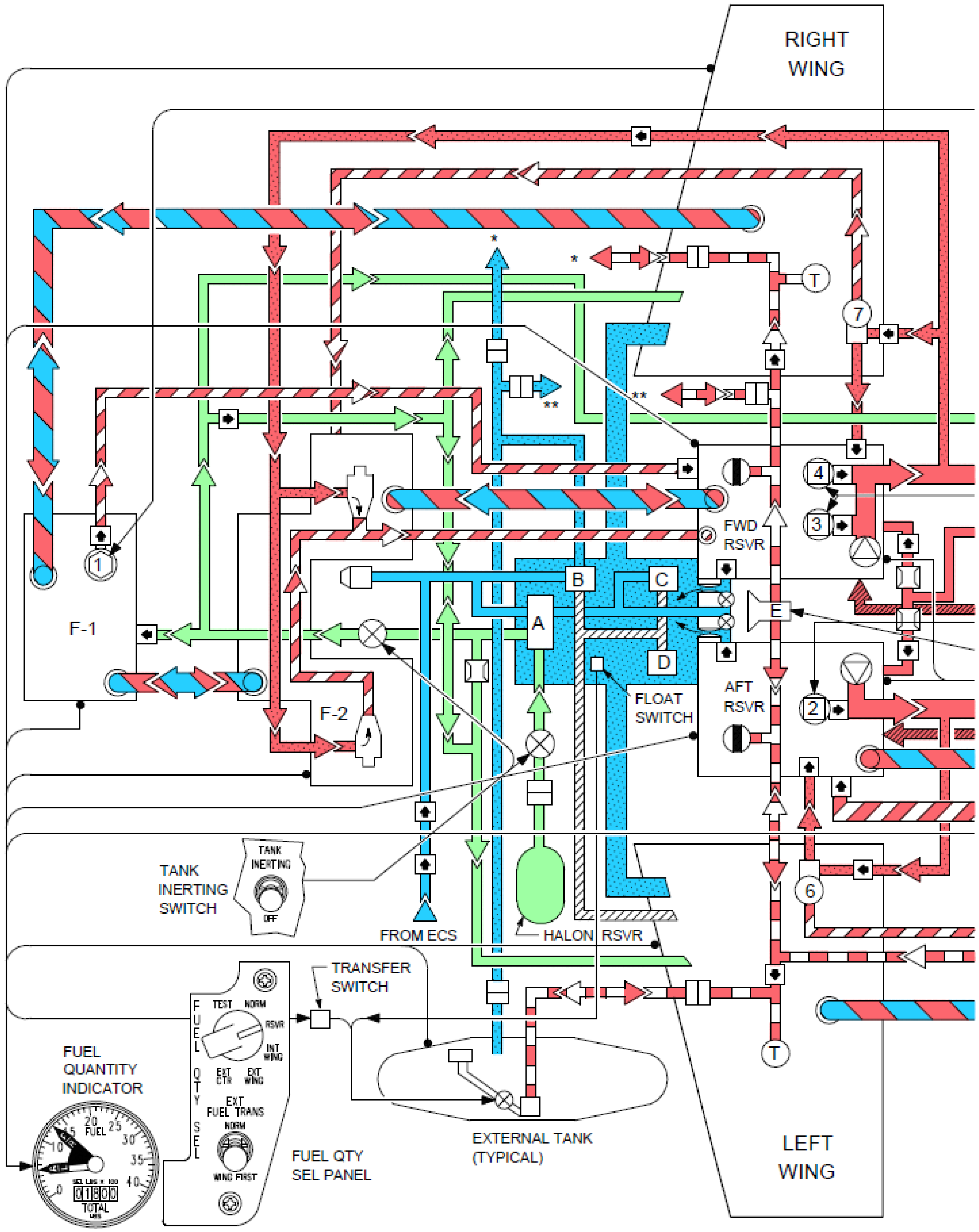
NOTES:

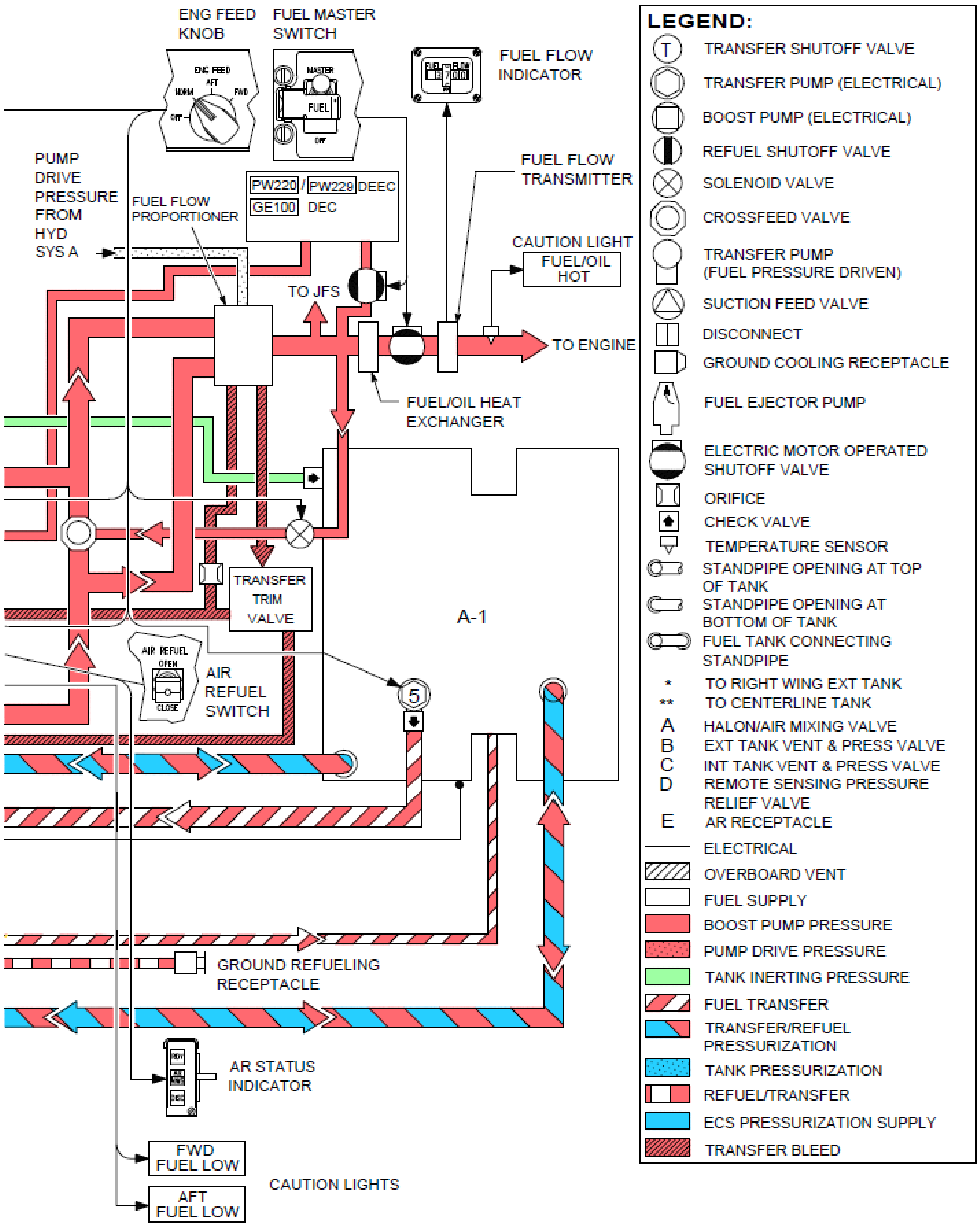
- Throttle movement is unrestricted throughout the aircraft flight envelope.
- Region 1 – Unlimited 5 segment AB operation.
- Region 2 – AB segments 1 through 4 available.
- Region 3 – AB segment 1 available.
- Region 4 – AB inhibited.



3 FUEL SYSTEM




RIGHT WING
LEFT WING
F-1
F-2
FWD RSVR
AFT RSVR
FLOAT SWITCH
FROM ECS
HALON RSVR
TANK INERTING SWITCH
TRANSFER SWITCH
FUEL QUANTITY INDICATOR
FUEL QTY SEL PANEL
EXTERNAL TANK (TYPICAL)



The fuel system is divided into seven functional categories. These are the fuel tank system, fuel transfer system, fuel tank vent and pressurization system, engine fuel supply system, fuel quantity/ fuel level sensing system, fuel tank explosion suppression system, and refueling/defueling system.

In BMS, the fuel system is a bit more simplified than in the real F-16, but everything that is modelled in BMS is in accordance with the real jet, therefore in order to be complete and thorough we decided to include the full functioning of the Fuel System.

3.1 Fuel Tank System

The aircraft has seven internal fuel tanks located in the fuselage and wings that are integral to the
structure. There are provisions for carrying three external tanks on the wings and the centerline station.

Five of the internal tanks are storage tanks: the left- and right-wing tanks, two forward fuselage tanks (F-1 and F-2), and the aft fuselage tank (A-1).

The two internal reservoir tanks forward and aft) supply fuel directly to the engine. The F-1 fuel tank is reduced in size to allow room for the rear cockpit.

3.2 Fuel Transfer System

Fuel is transferred by two independent methods. The primary method provides a siphoning action through standpipes connecting the fuel tanks. Siphoning action depends on the absence of air in the bays receiving fuel. Air ejectors in each reservoir tank automatically expel air. In case of failure of the siphoning system, powered fuel pumps work continually to pump fuel from the internal tanks to the reservoirs. The powered transfer system also scavenges tanks to minimize unusable fuel by using electrically driven pumps and pumps powered by bleed fuel pressure from the engine manifold. Both methods operate simultaneously and independently to transfer fuel through the system.

The transfer system is divided into two separate tank systems, the forward and the aft.

The forward system consists of the right external tank (if installed), right internal wing tank, F-1, F-2, and the forward reservoir. The aft system consists of the left external tank (if installed), left internal wing tank, A-1, and the aft reservoir. If a centerline tank is installed, it is considered to be part of both forward and aft systems. The wing external tanks empty into the respective internal wing tanks. Fuel flows from the internal wing tanks to the fuselage tanks and then to the forward and aft reservoirs. Fuel is pumped to the engine from the reservoirs.

To automatically maintain the CG, fuel is transferred through the forward and aft systems simultaneously. If external tanks are installed, air pressure transfers fuel to the internal wing tanks. If the EXT FUEL TRANS switch is in NORM, the sequence of fuel flow is from the centerline tank to the internal wing tanks. After the centerline tank empties, each external wing tank flows to its respective internal wing tank.

The external tank fuel transfer valve in each internal wing tank shuts off fuel to prevent overfilling the internal tanks. If one of these valves fails, a float switch senses fuel and shuts off all external tank fuel transfer before fuel flows overboard. By placing the EXT FUEL TRANS switch to WING FIRST, the external wing tanks empty before the centerline tank, and the float switch does not prevent fuel from spilling overboard if a transfer valve fails. The automatic forward fuel transfer system supplements the function of the FFP by preventing undesirable aft CG.
The automatic forward fuel transfer system operates only when the FUEL QTY SEL knob is in NORM and the total forward fuselage fuel quantity indication is less than 2800 pounds. In the C, forward fuel transfer starts when the forward heavy fuel differential drops below 300 pounds and stops when the forward heavy fuel differential reaches 450 pounds. This system does not correct a forward fuel imbalance since it only transfers fuel from aft to forward. For proper operation, the automatic forward fuel transfer system depends on a properly functioning fuel quantity indicating system. Fuel is transferred through a solenoid operated trim valve powered from emergency dc bus No. 2. The automatic system is deactivated if electrical power is lost through failure, by moving the FUEL QTY SEL knob out of NORM, or during gravity feed conditions.

3.3 Fuel Tank Vent and Pressurization System

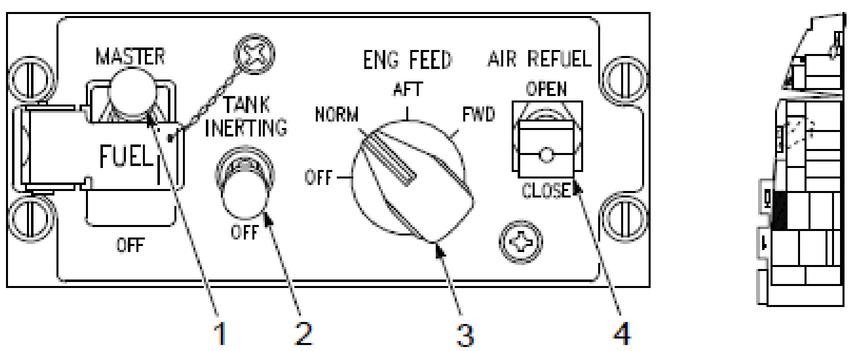
The fuel tank vent and pressurization system supplies cooled pressurized air from the ECS to force fuel from the external tanks to the internal wing tanks and to power the air ejector pumps whenever the AIR SOURCE knob is in NORM or DUMP. It also prevents fuel in internal tanks from vaporizing at high altitude. An external tank vent and pressurization valve regulates pressure supplied to the external tanks. If the combat schedule (reduced pressure) is activated by the TANK INERTING switch, Halon, if available, is mixed with air and the internal tank vent and pressurization valve controls the pressure. If the AIR SOURCE knob is placed in OFF or RAM or if the ECS is inoperative, tank pressurization is not available and external fuel cannot be transferred. With multiple generator failures, fuel tank pressurization continues, and external fuel still transfers.

3.4 Engine Fuel Supply System

When the ENG FEED knob is in NORM, boost pumps in the forward and aft reservoirs pump the fuel through the engine feedline to the fuel flow proportioner (FFP). In the FFP, twin constant displacement pumps, powered by hydraulic system A, supply equal amounts of fuel from each reservoir to maintain CG. Two fuel lines with check valves can bypass the FFP in case it fails so that fuel flow will not be interrupted. After fuel flows through the FFP, a small amount of cooling fuel is routed to the **PW220** **/** **PW229** DEEC, **GE100** **/** **GE129** DEC and then returned to the reservoirs. The remainder of the fuel passes through a fuel/oil heat exchanger to cool hydraulic systems A and B, the main generator CSD, and the ADG. Then fuel flows through an electric main fuel shutoff valve which has a full travel time of 2-4 seconds and is controlled by the FUEL MASTER switch. (The JFS always receives fuel regardless of the FUEL MASTER switch position.) After passing through the main fuel shutoff valve, fuel passes through the fuel flow transmitter (which operates the FUEL FLOW indicator) to the engine.

3.5 Fuel Quantity Indicating System

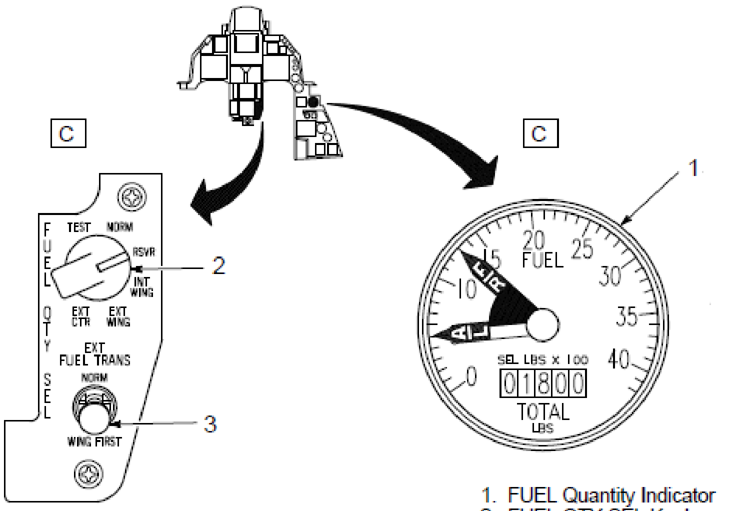
The fuel quantity indicating system displays the amount and location of fuel remaining. The totalizer shows all fuel in the internal and external tanks in pounds. The AL and FR pointers show the fuel quantity in the tanks as selected by the FUEL QTY SEL knob. Erroneous fuel indications may occur during or immediately after maneuvering flight. The selected tanks should normally be the fuselage tanks (FUEL QTY SEL knob in NORM). The difference between the forward and aft tanks should remain essentially constant since the FFP maintains an equal flow of fuel. C Normally, the forward tank fuel quantity is 0-600 pounds greater than the aft tank quantity. D Normally, the aft tank fuel quantity is 700-1350 pounds greater than the forward fuel quantity. If these values are exceeded in either direction, a red portion of the AL pointer becomes visible. Fuel distribution can be changed by rotating the ENG FEED knob to the FWD or AFT position until the imbalance is corrected.



1. FUEL MASTER Switch
2. TANK INERTING Switch
3. ENG FEED Knob
4. AIR REFUEL Switch

CONTROL	POSITION	FUNCTION
1. FUEL MASTER Switch (lever lock)	MASTER (guarded)	Opens main fuel shutoff valve which then opens the engine electronic control cooling fuel shutoff valve
	OFF	Closes main fuel shutoff valve which then closes the engine electronic control cooling fuel shutoff valve
2. TANK INERTING Switch (lever lock to OFF)	TANK INERTING	Reduces internal tank pressurization. If Halon is available, allows 20 seconds of initial Halon flow to F-1, A-1, and internal wing tanks; thereafter, allows a small metered flow of Halon to internal wing tanks and to be mixed with pressurization air
	OFF	Stops Halon flow. Returns internal tank pressurization to normal schedule

CONTROL	POSITION	FUNCTION
3. ENG FEED Knob	OFF	Deenergizes all electric-driven pumps. Engine supplied by FFP
	NORM	Energizes all pumps. CG maintained automatically
	AFT	Energizes pumps in aft tanks and opens crossfeed valve. Fuel is transferred from aft tanks to the engine and forward tanks. CG moves forward
	FWD	Energizes pumps in forward tanks and opens crossfeed valve. Fuel is transferred from forward tanks to the engine and aft tanks. CG moves aft
4. AIR REFUEL Switch	OPEN	Opens slipway door. Places FLCS in takeoff and landing gains when airspeed is below 400 knots
		Enables AR lights
		Reduces internal tank pressurization, depressurizes external tanks, and allows the refuel valve in each reservoir to open when a centerline tank is installed and refuel pressure is applied
	CLOSE	Reverses the OPEN actions



1. FUEL Quantity Indicator
2. FUEL QTY SEL Knob
3. EXT FUEL TRANS Switch

CONTROL/INDICATOR	POSITION	FUNCTION
1. FUEL Quantity Indicator	AL and FR pointers	Display fuel quantities as determined by the FUEL QTY SEL knob
	Totalizer	Displays total fuel in all fuel tanks (fuselage + wing + external). The totalizer and the fuel value displayed on the DED BINGO page should agree within 100 pounds of each other
	Red portion of AL pointer showing	Indicates fuel imbalance between forward and aft fuselage tanks
2. FUEL QTY SEL Knob	TEST	AL/FR pointers drive to 2000 (±100) pounds
		Totalizer drives to 6000 (±100) pounds
		Both fuel low caution lights illuminate
	NORM	AL pointer displays sum of fuel in the aft (left) reservoir and A-1 fuselage tanks
		FR pointer displays sum of fuel in the forward (right) reservoir and F-1, F-2 fuselage tanks

CONTROL/INDICATOR	POSITION	FUNCTION
2. FUEL QTY SEL Knob - continued	RSVR	AL/FR pointers display fuel in aft/forward reservoir tanks
	INT WING	AL/FR pointers display fuel in left/right internal wing tanks
	EXT WING	AL/FR pointers display fuel in left/right external wing tanks
	EXT CTR	AL pointer drops to zero
		FR pointer displays fuel in centerline tank
3. EXT FUEL TRANS Switch	NORM	Centerline tank transfers first and then external wing tanks
	WING FIRST	External wing tanks transfer first and then centerline tank

3.6 Reservoir Fuel Level Sensing System

Fuel level sensors in the reservoir tanks are used to turn on/off the air ejectors and the fuel low caution lights. When a reservoir tank is not full, the air ejector in that tank is operating. The reservoir tank sensors, associated sensor circuity, and fuel level sensing unit operate independently of the fuel quantity indicating system.

3.7 Fuel Low Caution Light

The fuel low caution lights, located on the caution light panel, indicate either a low fuel quantity in the reservoir tanks or a reservoir fuel level sensing system malfunction. The lights function independently of the fuel quantity indicating system. The FWD FUEL LOW caution light illuminates when fuel quantity in the forward reservoir drops below 400 pounds. The AFT FUEL LOW caution light illuminates when aft reservoir fuel quantity drops below 250 pounds. The caution lights are powered by emergency dc bus No. 1.

3.8 HUD Fuel Low/Bingo Indication

In addition to the fuel low caution lights, a fuel low condition may be indicated by the word FUEL in the HUD in conjunction with the home mode of the MMC or the previously entered bingo fuel value. With the FUEL QTY SEL knob in NORM, the bingo computation is based on the lesser of fuselage fuel weight or total fuel weight. That is, with the FUEL QTY SEL knob in NORM, bingo fuel warning will be triggered when either fuselage fuel or total fuel decreases below the bingo fuel value. With the FUEL QTY SEL knob out of NORM, the warning will only be triggered when total fuel decreases below the bingo value. With trapped external fuel, this could lead to fuel starvation before the bingo warning is triggered.

The VMS provides a BINGO-BINGO message in the headset when the bingo fuel warning is activated with weight-off wheels. For a more detailed description of the home mode and the bingo fuel option, refer to TO 1F-16CM/AM-34-1-1 BMS, chapters 2.2.1.2.6.1.10.4 and 2.2.1.2.6.1.5.3.

3.9 HUD TRP Fuel Warning

A trapped external fuel condition is indicated by flashing TRP FUEL and FUEL in the HUD. Five conditions must be met for a TRP FUEL warning to occur.

Conditions are:

• FUEL QTY SEL knob is in NORM.

• Aerial refueling has not occurred within previous 60 seconds.

• Fuselage fuel has been at least 500 pounds less than fuselage capacity for 30 seconds.

• Total fuel has been at least 500 pounds greater than Fuselage fuel for 30 seconds.

• Fuel flow has been less than 18,000 pph for 30 seconds.

A false TRP FUEL warning may occur after the following:

• A fuel leak which exceeds the transfer rate of the external tank(s).

• Prolonged AB use if fuel flow to the engine exceeds the transfer rate from the external tank(s).

• Receiving a partial fuel load during air refueling with an external tank(s).

The TRP FUEL warning clears automatically after the condition is corrected; the FUEL mnemonic may be manually reset by placing the WARN RESET switch to WARN RESET.

3.10 Fuel/Oil Hot Caution Light

The FUEL/OIL HOT caution light, located on the caution light panel, illuminates when the temperature of fuel to the engine becomes excessive. GE100 GE129 The caution light also comes on as a function of hot oil. Refer to ENGINE GE100/129, this section.

3.11 Fuel QTY Sel Knob out of Norm

When the FUEL QTY SEL knob is out of NORM, caution indications appear on the HUD and HMCS if weight is off wheels and the fuel knob is out of NORM for five minutes or 500 pounds of fuel burn, whichever comes first.

FUEL SW appears in HMCS window 13 and HUD window 15 located in the lower left corner of the displays. In addition, FUEL flashes in HUD window 12. When WARN RESET is accomplished, the flashing FUEL indication on the HUD is removed but FUEL SW on the HUD and HMCS is not cleared. To remove all fuel indications on the HUD and HMCS, position the fuel switch back to NORM.

3.12 Fuel Tank Explosion Suppression System

The fuel tank explosion suppression system places the fuel tank vent and pressurization system on a reduced pressure schedule and inserts the fuel vapors inside the tanks (if serviced with Halon). The system, intended for use only in combat or during emergencies, is controlled by the TANK INERTING switch on the fuel control panel. The system uses Halon as an inserting agent which prevents combustion when mixed with air. For the agent specification and reservoir location, SERVICING DIAGRAM, this section. The Halon reservoir has a heater, controlled by a thermostatic switch, which assures sufficient operating pressure. The RMLG WOW switch prevents operation of the heater while the aircraft is on the ground.

When the TANK INERTING switch is placed to TANK INERTING, the fuselage and internal wing tanks are placed on a reduced pressure schedule and a valve at the Halon reservoir is opened. At each activation of the TANK INTOERTING switch, Halon (if available) is released into the F-1, A-1, and internal wing tanks for 20 seconds for initial inerting. Thereafter, a continuous metered flow of Halon is provided to the internal wing tanks and is mixed with the pressurization air to maintain the inert condition. The metered flow continues until the system is turned off or until the MAIN PWR switch is positioned to OFF. Because of limited Halon supply, the system should be activated after the external tanks have emptied, but before half of the internal fuel is depleted. Since the 20 seconds of initial inerting occurs each time the TANK INERTING switch is placed to TANK INERTING, do not cycle the switch. The fuel tank explosion suppression system does not protect the external fuel tanks.

4 Refueling System

4.1 Ground Refueling

In BMS you have the option for "Hotpit Refueling" when standing at any EOR, taxiway or parking position. Further technical aspects are not implemented at this point.

4.2 Air Refueling

4.2.1 Air Refueling (AR) System

The AR system consists of a hydraulically actuated receptacle and slipway door, a signal amplifier, and the associated controls and indicators. Hydraulic system B provides pressure for operation of the door and latch mechanism. The receptacle is located on the top fuselage centerline aft of the canopy. When the slipway door is opened, a mechanical linkage retracts the aft end of the slipway door into the fuselage, forming a slipway into the receptacle.

When the AIR REFUEL, switch is placed to OPEN, the external tanks are depressurized, external fuel does not transfer, and the FLCS is placed in takeoff and landing gains if airspeed is below 400 knots. When closed, the slipway door is flush with the fuselage skin. The AR receptacle is equipped with four lights, two located on each side. An AR floodlight is located on the top fuselage centerline immediately aft of the canopy. A light on the upper leading edge of the vertical tail floods the AR receptacle area and the upper fuselage. During AR operations, the AR boom enters the receptacle and is automatically latched in place by a hydraulic actuating mechanism. The HOT MIC switch allows intercom communications with compatible tankers through the AR boom.

When the last refuel shutoff valve closes, a pressure switch automatically provides a signal to unlatch the boom from the receptacle. A disconnect signal can be manually initiated at anytime during AR by the receiver or by the tanker boom operator.

Disconnect from the boom may occur before all tanks are full if the external fuel tank configuration consists of only a centerline fuel tank. Such a disconnect typically occurs when refueling with an initial internal fuel load of 4000 pounds or more and the centerline tank empty. At disconnect, the aircraft total fuel may be up to 1600 pounds less than full, with many occurrences resulting in approximately 1000 pounds less than full.

Fuel venting from under the left wing can occur during AR, particularly when the aircraft is configured with external fuel tank(s). Terminating the AR operation in a partially filled condition could result in fuel imbalance. When a partial fuel load is required, fuel distribution should be monitored and corrected as required by use of the ENG FEED knob.

4.2.2 NWS A/R Disc MSL Step Button

The NWS A/R DISC MSL STEP button is located on the outboard side of the stick. The A/R DISC function of the switch is activated when the aircraft is airborne, and the AIR REFUEL switch is positioned to OPEN. The button provides a means of manually disconnecting the AR boom. Depressing the switch causes the boom latching mechanism to unlatch and release the boom.

4.2.3 Air Refueling (AR) Status Indicator

The AR status indicator, located to the right of the HUD, contains three lights.
Functions are:

• RDY – Illuminates blue when the AR slipway door is open, and the system is ready.

• AR/NWS – Illuminates green when the boom is latched in place.

• DISC – Illuminates amber when a disconnect occurs. After the disconnect, the system automatically recycles to ready, and the RDY light illuminates after a 3-second delay. A lever for dimming the three lights is located on the right side of the unit.

5 Environmental Control System (ECS)

The ECS combines air-conditioning and pressurization functions to provide temperature-controlled, pressure-regulated air for heating, cooling, ventilating, canopy defogging, cockpit pressurization, canopy sealing, G-suit pressurization, fuel tank pressurization, electronic equipment cooling, pressure breathing for g (PBG) and OBOGS. Most of these functions are lost when the AIR SOURCE knob is placed to OFF or RAM. Refer to AIR SOURCE KNOB **C** **DF**, this section. Above 35,000 feet MSL, automatic changes in operation of the ECS may appear as short duration (approximately 15 seconds) losses of cockpit airflow alternating with normal cockpit airflow levels. These airflow changes are normal and are designed to prevent total ECS shutdowns.

5.1 Electrical Failures

Content will be added in future versions.

5.2 Air-Conditioning

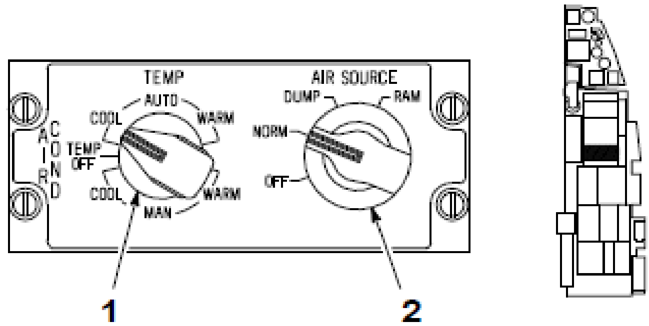
Content will be added in future versions.

5.3 Pressurization

Content will be added in future versions.

5.4 Air Source Knob

The AIR SOURCE knob is located on the ECS panel.



1. TEMP Knob
2. AIR SOURCE Knob

Functions are:

• **OFF** – Engine bleed air valves close. All air conditioning, cooling, and pressurizing functions shut off, including G-suit, PBG, canopy seal, fuel tank pressurization, and **143** OBOGS. The EQUIP HOT caution light will illuminate shortly after OFF is selected. Refer to EQUIP HOT CAUTION LIGHT, this section.

• **NORM** – Air-conditioning system set for automatic temperature and pressure regulation.

• **DUMP** N/I

• **RAM** N/I

5.5 Equip Hot Caution Light

The EQUIP HOT caution light, located on the caution light panel, illuminates when the avionic equipment cooling air temperature/pressure is insufficient. Degraded equipment performance and/or damage can result from overheating. Therefore, when the EQUIP HOT caution light illuminates, the electronic equipment should be turned off unless it is essential for flight. Illumination of the EQUIP HOT caution light automatically interrupts electrical power to the radar. Turning the radar to OFF in flight does not close the radar cooling air shutoff valve. A short duration or intermittent EQUIP HOT caution light may occur when ground cooling air is disconnected.

5.6 Cockpit Pressure Altimeter

The cockpit pressure altimeter, located on the right auxiliary console outboard of the stick, is labeled CABIN PRESS ALT.

5.7 Cabin Press Caution Light

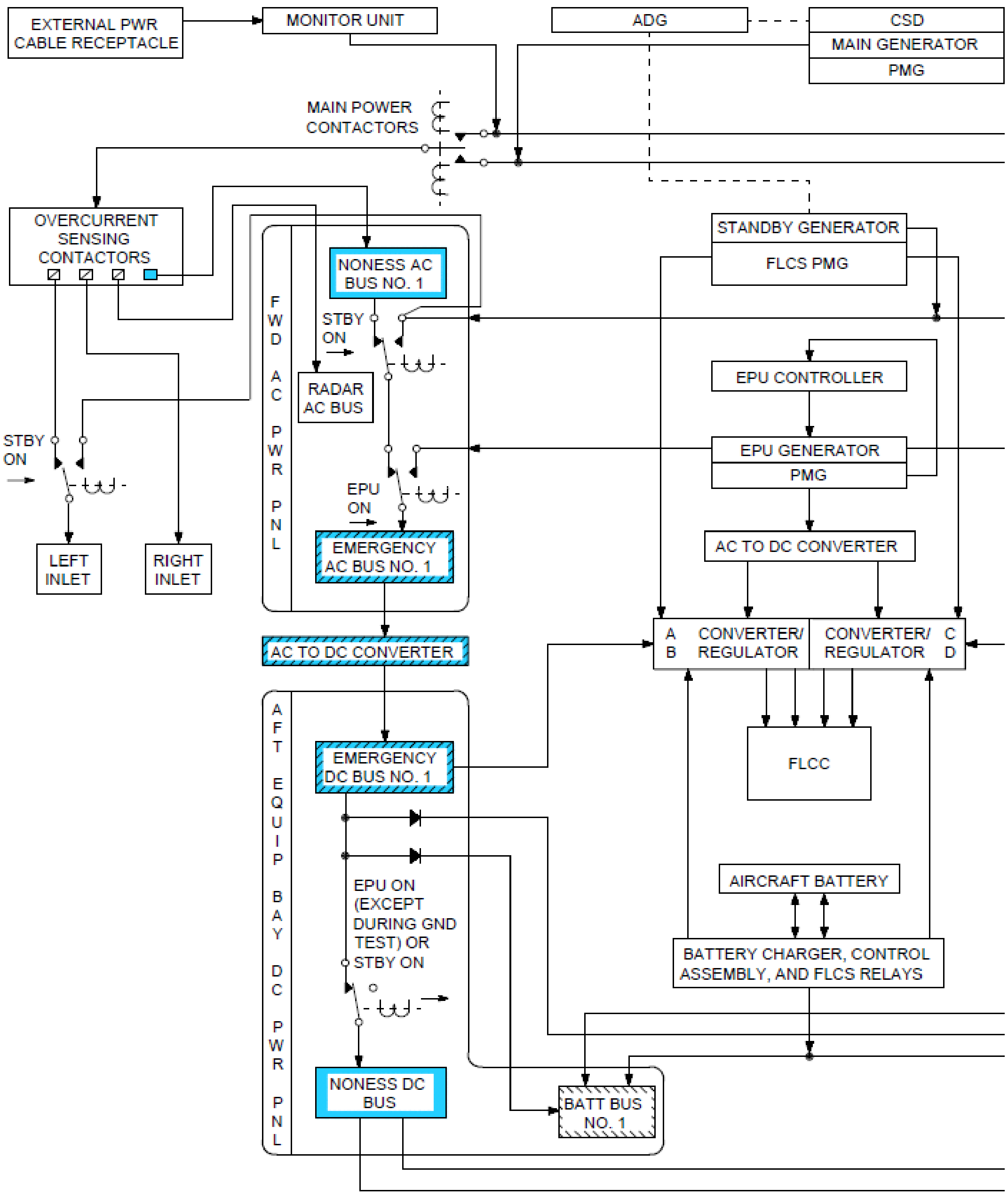
The CABIN PRESS caution light, located on the caution light panel, illuminates when the cockpit pressure altitude is above 27,000 feet.

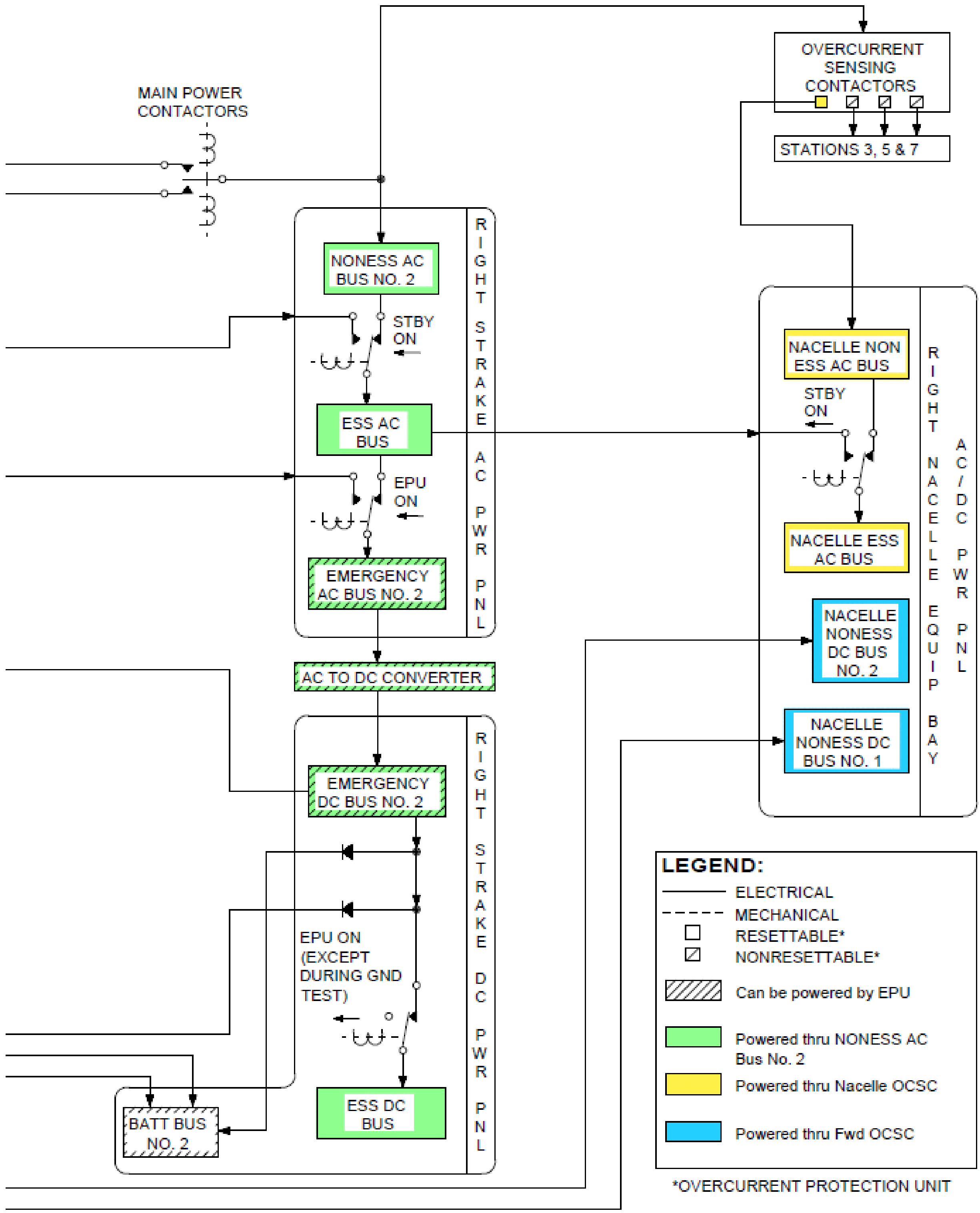
5.8 Anti-G System

The panel is there but the interaction with the system is not implemented.

6 Electrical system

6.1 Electrical System Diagram





The electrical system consists of a main ac power system, a standby ac power system, an emergency ac power system, a dc power system, a FLCS power supply, and provisions for external ac power.

6.2 Main Power AC system

AC power is normally supplied by a 60 kva main generator located on and driven by the ADG. The main generator supplies power to the overcurrent protection panels and nonessential, essential, and emergency ac buses.

6.3 Overcurrent Sensing Contactors

The eight overcurrent sensing contactors protect certain acv buses; stations 3, 5, and 7; and inlet stations from overcurrent. The ELEC CAUTION RESET button on the ELEC control panel is used to reset a tripped overcurrent sensing contactor on nonessential ac bus No. 1 and the nacelle nonessential ac bus. The overcurrent sensing contactor may not remain reset if the fault persists. The items with non-resettable overcurrent protection units are the radar ac bus; stations 3, 5, and 7; and left and right inlet stations.

6.4 STBY AC Power System

The standby ac power system consists of the essential and emergency ac buses and is powered (if the main generator is inoperative) by a 10 kva standby generator which is located on and driven by the ADG. The standby generator has power available whenever the ADG is rotating and comes online when the main generator is not supplying power, as long as the MAIN PWR switch is in MAIN PWR. The standby generator has an integral FLCS PMG which supplies power to the four FLCS branches. Refer to FLCS POWER SUPPLY, this section, for further discussion of the FLCS PMG.

6.5 Emergency AC Power System

If the main and standby generators fail, emergency ac power is supplied automatically by a 5 kva EPU generator driven by the EPU. The system supplies power to the emergency ac buses. The EPU generator has a PMG which supplies dc power through an ac to dc converter to the four FLCS branches. Refer to EMERGENCY POWER UNIT (EPU), this section, for further discussion of the EPU.

6.6 DC Power System

DC power is supplied by ac to dc converters or by the aircraft battery. With the main generator operating, the AC to DC converters power emergency dc bus No. 1, battery bus No. 1, nonessential DC bus, nacelle DC bus, emergency DC bus No. 2, essential DC bus, and battery bus No. 2. With the standby generator operating, the AC to DC converters power emergency DC bus No. 1, battery bus No. 1, emergency DC bus No. 2, essential DC bus, and battery bus No. 2.

With the EPU generator operating, the AC to DC converters power emergency DC bus No. 1, battery bus No. 1, emergency DC bus No. 2, and battery bus No. 2.

With the main, standby, or EPU generator operating, the aircraft battery is disconnected. The battery is charged by the battery charger/control assembly if the main or standby generator is operating. If all generators fail, the air-craft battery is connected and powers battery bus No. 1 and battery bus No. 2. The battery buses are powered in all cases to provide start power to the EPU. Also, the battery provides a source of power to the FLCS.

6.7 FLCS Power Supply

The primary FLCS power supply includes a dedicated FLCS PMG and two dual-channel converter regulators and four branch power supplies within the FLCC.

The FLCS PMG is the primary power source for the FLCS during normal operations.

The FLCS PMG is integral with the standby generator and generates power whenever the ADG is rotating.

The PMG has four outputs, one for each branch of the FLCS, and generates sufficient power to operate the FLCS at 40 percent rpm or greater. Other FLCS power sources are the main generator, the standby generator, the EPU generator, the EPU PMG, and the aircraft battery.

Two converter/regulators, having two channels each, provide a separate channel for each branch of the FLCS. Both converter/ regulators receive power from the FLCS PMG, the aircraft battery, and if the EPU is running, the EPU PMG.

The branch A and B converter/regulator also receives power from emergency dc bus No. 1, and the branch C and D converter/ regulator also receives power from emergency dc bus No. 2. Each converter/regulator channel converts ac power from the FLCS PMG to dc, selects the power source with the highest voltage (within limits), and provides dc power to the respective FLCC branch. Converter/regulator output voltages are regulated to prevent overvoltage to the FLCS. The converter/ regulators also provides fault indications for display on the ELEC control panel and provide test indications to the TEST switch panel.

The aircraft battery can provide temporary emergency power to the FLCS. The length of time that the aircraft battery is able to power the FLCS is a function of the state of charge. The FLCS incorporates four latching relays which function to prevent depletion of the aircraft battery during ground maintenance. The relays prevent the FLCC from being connected to the aircraft battery until a JFS start is initiated.

6.8 External Power Provisions

Not applicable for now in BMS, for now the electrical system mimics the behavior but the whole electrical circuit is not implemented yet.

6.9 Electrical System Normal Operation

Prior to engine start, the MAIN PWR switch is placed to BATT to permit a check of the aircraft battery.

The ELEC SYS, MAIN GEN, STBY GEN, and FLCS RLY lights come on. The FLCS RLY light illuminates because the four FLCS relays are open and the FLCC is not connected to the aircraft battery.

The FLCS PMG light is not illuminated since it requires FLCS power. The ACFT BATT TO FLCS light does not illuminate since the FLCS relays are open.

With the FLCS PWR TEST switch held in TEST, the FLCS relays close but do not latch.

The FLCS PMG and the ACFT BATT TO FLCS lights illuminate and the FLCS RLY light goes off.

The FLCS PWR lights on the TEST switch panel illuminate, indicating that the power output of the FLCC is good. With the FLCS PWR TEST switch in NORM and the MAIN PWR switch positioned from BATT to MAIN PWR, the lights do not change.

If external power is connected, the MAIN GEN light goes off. If the FLCS PWR TEST switch is placed to TEST with the MAIN PWR switch in MAIN PWR, the FLCS relays are latched closed.

The FLCS RLY light remains off when the FLCS PWR TEST switch is returned to NORM. The aircraft battery is now powering the FLCC and depletes more rapidly. To eliminate the increased battery load, cycle the MAIN PWR switch to BATT and back to MAIN PWR to open the FLCS relays (FLCS RLY light illuminates).

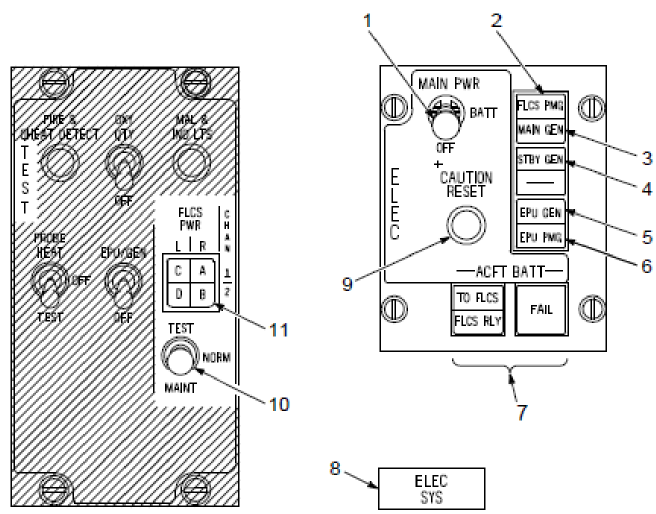
When the JFS switch is moved to either start position, the FLCS PMG light (and ACFT BATT TO FLCS light if engine is started on battery power) illuminates and the FLCS RLY light goes off, indicating that the FLCS relays have closed.
During engine start, the FLCS PMG light (and ACFT BATT TO FLCS light if engine is started on battery power) goes off at 40% RPM approximately for **PW220** / **PW229** or 44 % RPM for **GE100** / **GE129** 44 engine.

The STBY GEN light goes off at approximately 55% for PW220 / PW229 or 60% for GE100 / GE129 the MAIN GEN light goes off approximately 10 seconds later if both generators are operating normally.

External power, if used, is disconnected from the aircraft buses when the main generator comes online. Any time after selecting MAIN PWR, including in flight, the FLCS PWR TEST switch may be held momentarily in TEST to check FLCC power output. During the EPU test, the FLCS PWR lights come on to indicate that EPU PMG power is available to the FLCS. During engine shutdown, the ELEC SYS caution light and FLCS PMG, MAIN GEN, and STBY GEN lights come on as the engine spools down. The ACFT BATT TO FLCS light also illuminates.

6.10 Electrical system Controls and Indicators

1. MAIN PWR Switch
2. FLCS PMG Indicator Light
3. MAIN GEN Indicator Light
4. STBY GEN Indicator Light
5. EPU GEN Indicator Light
6. EPU PMG Indicator Light
7. ACFT BATT Indicator Lights
8. ELEC SYS Caution Light
9. ELEC CAUTION RESET Button
10. FLCS PWR TEST Switch
11. FLCS PWR Indicator Lights

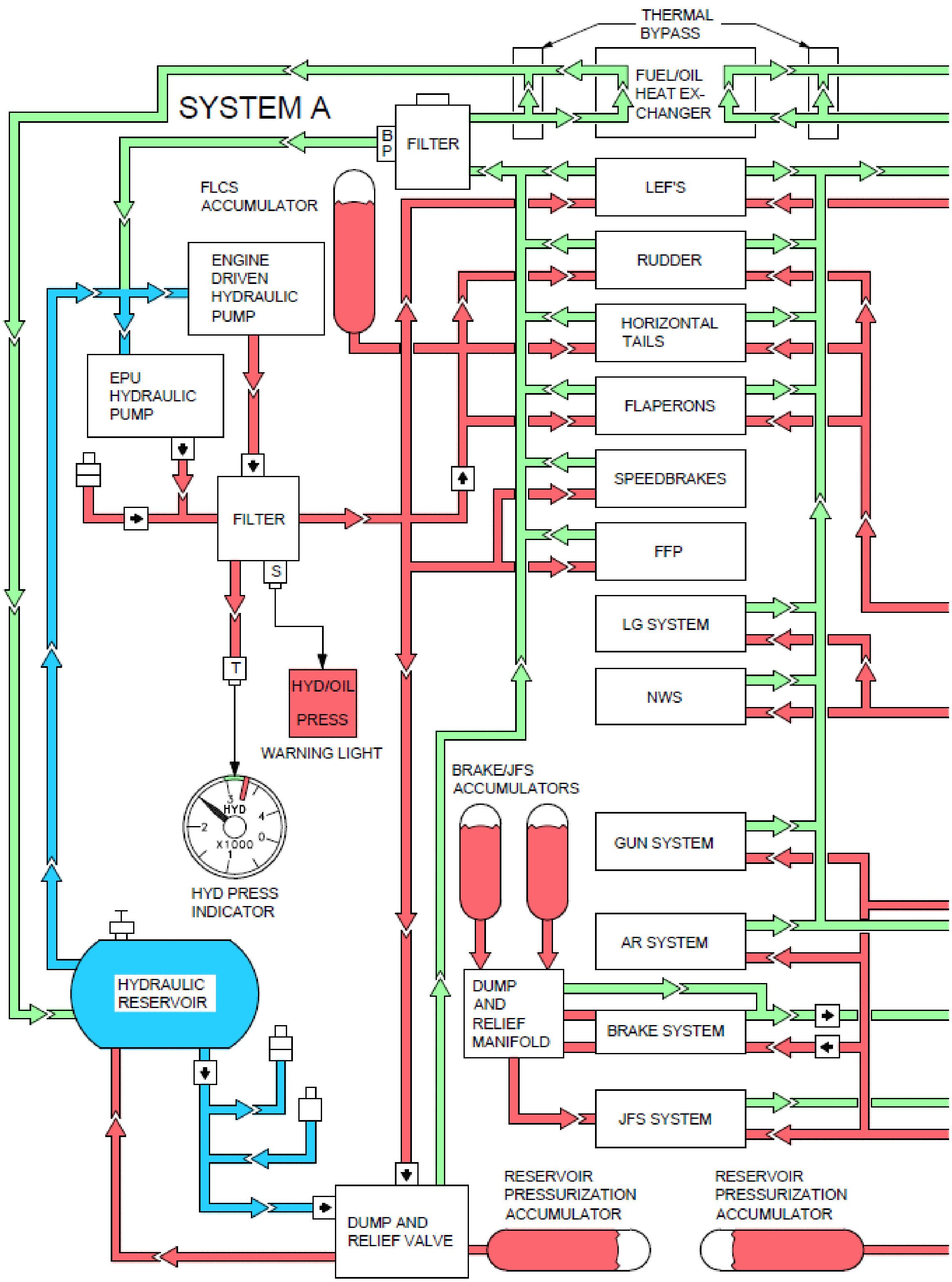


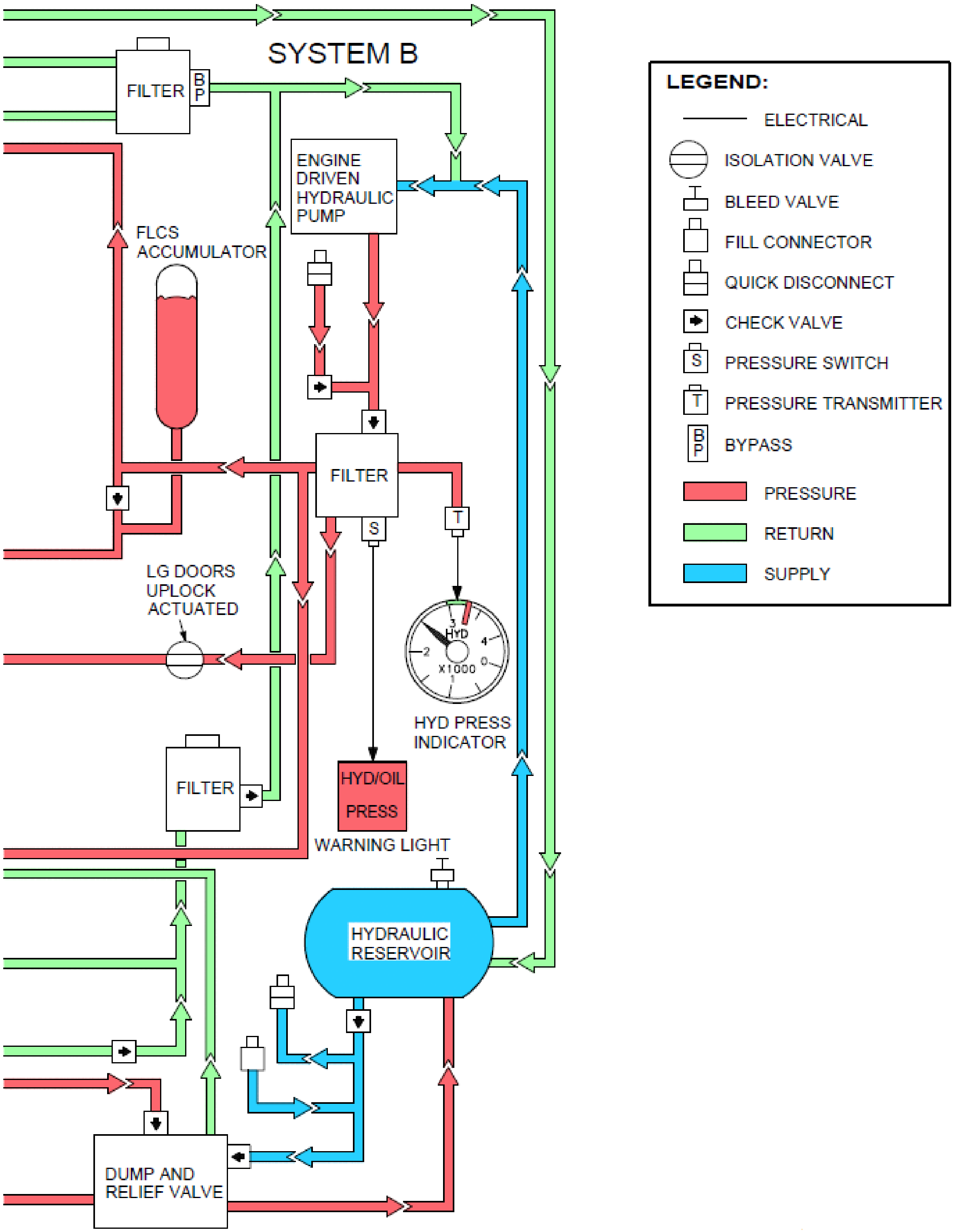
CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
1. MAIN PWR Switch	MAIN PWR	Connects external power or the main generator to the electrical system and enables standby generator. Determines function of FLCS PWR TEST switch. If ac power is not available, connects aircraft battery to the battery buses
NOTE During ground operation, if the MAIN PWR switch is moved from MAIN PWR to OFF without a delay of 1 second in BATT, the EPU does not activate and electrical power for braking, NWS, hook, and radios is lost.	BATT	Connects aircraft battery to the battery buses, disconnects main generator or external power, resets main generator, disables standby generator, and determines function of FLCS PWR TEST switch
	OFF	In flight - disconnects main generator from electrical system and disables standby generator
		On ground - disconnects main generator or external power from aircraft electrical system and disables standby generator. Disconnects the aircraft battery from the battery buses. Canopy operation is available after engine shutdown
2. FLCS PMG Indicator Light	FLCS PMG (amber)	In flight - None of the FLCS branches are receiving power from the FLCS PMG
		On ground - FLCS PMG power is not available at one or more FLCS branches. Light is delayed 60 seconds after initial NLG WOW

<table>
<tr><th>CONTROL/INDICATOR</th><th>POSITION/INDICATION</th><th colspan="2">FUNCTION</th></tr>
<tr><td>3. MAIN GEN Indicator Light</td><td>MAIN GEN (amber)</td><td colspan="2">Indicates external power or main generator not connected to one or both nonessential ac buses</td></tr>
<tr><td>4. STBY GEN Indicator Light</td><td>STBY GEN (amber)</td><td colspan="2">Indicates standby generator power is not available</td></tr>
<tr><td>5. EPU GEN Indicator Light</td><td>EPU GEN (amber)</td><td colspan="2">Indicates the EPU has been commanded on but the EPU generator is not providing power to both emergency ac buses. The light does not function with the EPU switch in OFF (WOW) and the engine running</td></tr>
<tr><td>6. EPU PMG Indicator Light</td><td>EPU PMG (amber)</td><td colspan="2">Indicates the EPU has been commanded on but EPU PMG power is not available to all branches of the FLCS</td></tr>
<tr><td rowspan="5">7. ACFT BATT Indicator Lights</td><td rowspan="2">FAIL (amber)</td><td colspan="2">In flight - indicates aircraft battery failure (20V or less)</td></tr>
<tr><td colspan="2">On ground - indicates aircraft battery or battery charger failure. Light is delayed 60 seconds after MLG WOW</td></tr>
<tr><td rowspan="2">TO FLCS (amber)</td><td colspan="2">In flight - indicates battery power is going to one or more FLCS branches and voltage is 25V or less</td></tr>
<tr><td colspan="2">On ground - indicates battery power is going to one or more FLCS branches</td></tr>
<tr><td>FLCS RLY (amber)</td><td colspan="2">Indicates that voltage on one or more of the four FLCS branches connected to the aircraft battery is inadequate (below 20V) or that one or more FLCS branches are not connected to the battery</td></tr>
<tr><td>8. ELEC SYS Caution Light</td><td>ELEC SYS (amber)</td><td colspan="2">Illuminates in conjunction with any of the above lights</td></tr>
<tr><td>9. ELEC CAUTION RESET Button</td><td>Push</td><td colspan="2">Resets resettable overcurrent protection units and ELEC SYS caution light and clears MASTER CAUTION light for future indications. Resets main and standby generators</td></tr>
<tr><td rowspan="5">10. FLCS PWR TEST Switch</td><td rowspan="3">TEST</td><td colspan="2">When MAIN PWR switch is in:</td></tr>
<tr><td>MAIN PWR</td><td>BATT</td></tr>
<tr><td>Tests FLCC power output</td><td>Tests FLCC power output on aircraft battery</td></tr>
<tr><td>NORM</td><td>Normal position. Tests EPU PMG power availability during EPU/GEN test on ground</td><td>NA</td></tr>
<tr><td>MAINT</td><td colspan="2">For maintenance use on the ground. Inoperative in flight</td></tr>
</table>

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
11. FLCS PWR Indicator Lights	A, B, C, and D (green)	Illuminate to indicate proper power output of FLCC during FLCS power tests

7 Hydraulic System




SYSTEM B
FILTER
B P
ENGINE DRIVEN HYDRAULIC PUMP
FLCS ACCUMULATOR
FILTER
S
T
LG DOORS UPLOCK ACTUATED
HYD
X1000
HYD PRESS INDICATOR
FILTER
HYD/OIL PRESS
WARNING LIGHT
HYDRAULIC RESERVOIR
DUMP AND RELIEF VALVE
LEGEND:
ELECTRICAL
ISOLATION VALVE
BLEED VALVE
FILL CONNECTOR
QUICK DISCONNECT
CHECK VALVE
PRESSURE SWITCH
PRESSURE TRANSMITTER
BYPASS
PRESSURE
RETURN
SUPPLY

Hydraulic pressure is supplied by 3000 psi hydraulic systems designated as systems A and B.

The systems are powered by two independent engine-driven pumps located on the ADG. Each system has a reservoir to store hydraulic fluid.

The reservoirs are pressurized by their respective hydraulic system to insure positive pressure at the pump. For hydraulic system cooling, refer to ENGINE FUEL SUPPLY SYSTEM, this section.

Both systems operate simultaneously to supply hydraulic power for the primary flight controls and LEF's. If one of the systems should fail, the remaining system provides sufficient hydraulic pressure; however, the maximum actuation rate of the FLCS is reduced.

System A also supplies power to the FFP and the speed brakes.

All remaining utility functions, consisting of the gun and gun purge door, AR system, LG, brakes, and NWS are supplied by system B. System B also charges the brake/JFS accumulators (which provide start power for the JFS and backup pressure for the brakes), provided the engine is rotating at a minimum of 12 percent rpm.

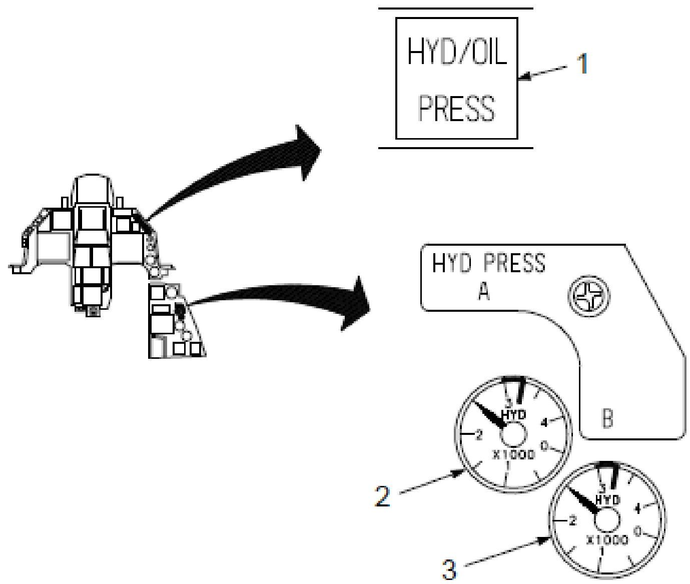
System B takes between 40 seconds (hot ambient conditions) and 60 seconds (cold ambient conditions) to recharge the brake/JFS accumulators.

The LG can be extended pneumatically in the event of hydraulic system B failure. Should both hydraulic systems fail, a third hydraulic pump located on the EPU automatically provides hydraulic pressure to system A.

Refer to EMERGENCY POWER UNIT (EPU), this section, for a further discussion of the EPU.

Each hydraulic system has a FLCS accumulator which is isolated from the main system by check valves. These FLCS accumulators serve a dual function. If demand exceeds the pump maximum flow rate during rapid control surface movement, the FLCS accumulators provide additional hydraulic flow. Also, if both hydraulic systems fail, the FLCS accumulators provide adequate hydraulic pressure to the flight controls while the EPU comes up to speed.

7.1 Hyd Press indicator and Warning Light



1. HYD/OIL PRESS Warning Light
2. System A HYD PRESS Indicator
3. System B HYD PRESS Indicator

7.2 HYD Press indicators

The HYD PRESS indicators, one for system A and one for system B, are located on the right auxiliary console. The indicators are powered by emergency ac bus No. 2.

7.3 HYD OIL/Press warning Light

A HYD/OIL PRESS warning light, located on the right glareshield, comes on when hydraulic system A or B pressure drops below 1000 psi or when engine oil pressure drops below 10 (±2) psi. For the oil pressure function only, there is a 30-second time delay in the light circuit to minimize transient lights during negative g maneuvers. The light is powered by the battery bus No. 1.

8 Emergency Power Unit (EPU)

The EPU is a self-contained system which simultaneously provides emergency hydraulic pressure to system A and emergency electrical power.

The EPU automatically activates when both main and standby generators fail or when both hydraulic system pressures fall below 1000 psi.

The EPU may be operated manually regardless of failure conditions. The EPU requires dc power from either battery bus No. 1 or No. 2 for automatic or manual activation. When the EPU is operating, the emergency ac and dc buses are powered by the EPU generator. To reduce electrical loads, the nonessential and essential dc buses are unpowered whenever the EPU is operating (except when activated for ground test using the EPU/GEN test switch). When operating, the EPU augments hydraulic system A as required. If the normal system A hydraulic pump fails, the EPU is the only source of system A pressure.

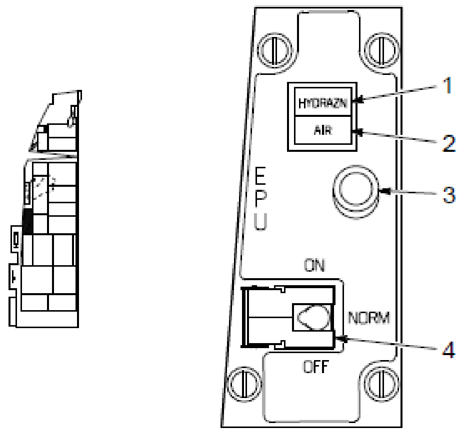
The EPU uses engine bleed air and/or hydrazine to operate. Normally, engine bleed air is used to maintain operating speed. When bleed air is insufficient, hydrazine augmentation automatically occurs. Hydrazine is always used when the EPU is commanded to start except when activated during ground test using the EPU/GEN test switch. On system command, hydrazine is forced by nitrogen pressure into a decomposition chamber.

The gaseous products of the reaction spin the turbine/gearbox which then powers the EPU generator and hydraulic pump. Hydrazine exhaust is vented overboard on the lower inboard side of the right strake and consists primarily of nitrogen, hydrogen, ammonia, and water.

The temperature of exhaust gases can reach 1600°F (871°C) and will ignite in the presence of a flame. The exhaust gases have an ammonia odor, are irritating to the nose and eyes, and should be avoided to the maximum extent possible.

8.1 EPU Controls and Indicators

EPU Control Panel
C DF (Typical)



1. HYDRAZN Light (Amber)
2. AIR Light (Amber)
3. EPU Run Light (Green)
4. EPU Switch

8.1.1 EPU Ground Safety Switch

The ground safety switch, located on the right side of the engine inlet, is used to disable the EPU on the ground. With the EPU safety pin installed, the EPU does not operate.

8.1.2 EPU Switch

The EPU switch, located on the EPU control panel, is a three-position toggle switch.

Functions are:

- **OFF:**
    1. Prevents or terminates EPU operation on the ground (WOW).
    2. Does not prevent or terminate EPU operation in flight for main and standby generator failures if switch was cycled or placed to NORM at any time since takeoff (since WOW).
    3. Prevents EPU operation in flight if switch has remained in the OFF position since takeoff (since WOW).
    4. Terminates EPU operation in flight except during main and standby generator failures.

5. NORM – The system is armed for automatic operation except during engine shutdown on the ground. With WOW and throttle in OFF, the EPU does not activate when the main and standby generators drop offline.

- **NORM:**

    1. The system is armed for automatic operation except during engine shutdown on the ground. With WOW and throttle in OFF, the EPU does not activate when the main and standby generators drop off line.

- **ON:**

    1. Commands EPU to run regardless of failure conditions. Operation will cease when switch is positioned to OFF except for main and standby generator failures in flight.

The switch has a split guard; the top half can be raised to move the switch to ON, and the bottom half can be raised to move the switch to OFF. When both sections of the guard are down, the switch is retained in the NORM position.

8.1.3 EPU Run Light

The EPU run light, located on the EPU control panel, illuminates when the EPU turbine speed is within the proper range and the EPU-driven hydraulic pump discharge pressure is above 2000 psi.

8.1.4 HYDRAZN Light

The HYDRAZN light, located on the EPU control panel, illuminates when the EPU is commanding hydrazine for operation (whether hydrazine is available or not) or if a primary speed control failure has occurred.

8.1.5 Air Light

The AIR light, located on the EPU control panel, illuminates whenever the EPU has been commanded to run with the EPU safety pin removed. It remains on even when the EPU is augmented by hydrazine.

8.1.6 EPU/GEN Test switch

The EPU/GEN test switch, located on the TEST switch panel, has positions of OFF and EPU/GEN. The switch is spring loaded to the OFF position. It provides a means to test the EPU generator and EPU PMG output to FLCS on the ground without using hydrazine.

8.1.7 EPU Fuel Quantity Indicator

The EPU FUEL quantity indicator, located on the right auxiliary console, is graduated 0-100 and indicates the percent of hydrazine remaining. The indicator is powered by battery bus No. 2.

8.1.8 Hydrazine Leak Detector

The hydrazine leak detector is a silicone base, mustard yellow disc visible through access door 3208. The viewing area is black on one half to provide contrast with the mustard yellow disc. The mustard yellow turns purple/black in the presence of hydrazine and/or its vapors, indicating a leak in the EPU and or fuel tank system.

8.2 EPU Fired Indicator

The EPU fired indicator is located next to the EPU ground safety switch on the right side of the engine inlet. Normally, the indicator displays a gray and black disc. If the EPU has been activated, the indicator displays six equally spaced black and white triangles.

8.3 EPU Operation

The EPU is designed to operate automatically for main and standby generator failure, dual hydraulic system failure, PTO shaft or ADG failure, and engine flameout or if the engine is shut down in flight.

The EPU can also be activated manually.

After receiving any start command, the EPU requires approximately 2 seconds to come up to speed. EPU startup may not be audible. Once operating, however, the EPU may be heard but does not sound the same as during the EPU ground check.

A lack of sound during EPU startup does not indicate lack of EPU operation which must be confirmed by monitoring the EPU run light.

EPU rpm is controlled by three speed controls. The primary and secondary speed controls are based on EPU rpm. The tertiary speed control is based on EPU PMG frequency.

When the EPU is operating, engine thrust settings should be maintained to prevent using hydrazine. This normally requires a minimum of 75-85 % RPM for **PW220** / **PW229** and 82-90% RPM for **GE100** / **GE129** depending on pressure altitude. If the engine fails, hydrazine alone is used to power the EPU. With hydrazine only, operating time of the system is approximately 10 minutes under normal load requirements. Increased flight control movement reduces this operating time. When the EPU is the sole source of hydraulic power, EPU loss results in loss of aircraft control.

9 Landing Gear (LG) System

The LG system is normally operated by hydraulic system B. The NLG is extended and retracted by hydraulic pressure. The MLG's are retracted hydraulically but are extended by freefall assisted by airloads. All the LG doors are hydraulically activated with electrical sequencing during retraction and mechanical sequencing during extension. If hydraulic system B fails, the LG may be extended pneumatically.

9.1 Main Landing Gear (MLG)

The two MLG are independent of each other and retract forward with a mechanical wheel twist into two separate wheel wells. Each MLG wheel is equipped with three fusible (thermal pressure relief) plugs.

9.2 Nose Landing Gear (NLG)

The NLG retracts aft with a 90-degree mechanical wheel twist into the wheel well. A torque arm quick-disconnect is provided so that the nosewheel can be turned beyond the steerable range for towing.

9.3 Landing Gear Handle (LG)

The LG handle, located on the LG control panel has a wheel shaped grip. Movement of the handle operates electrical switches (powered by emergency dc bus No. 2) to command LG retraction or extension. A warning light in the LG handle, powered by battery bus No. 2 illuminates when the LG and doors are in transit or have failed to lock in the commanded position. The warning light also illuminates when all LG are not down and locked, airspeed is less than 190 knots, altitude is less than 10,000 feet, and rate of descent is greater than 250 feet per minute.

The handle is locked in the DN position when the aircraft is on the ground (weight on wheels). In flight, a signal from the left MLG WOW switch automatically activates a solenoid which unlocks the handle, allowing movement to the UP position. The handle is locked in the UP position to prevent LG extension during high g maneuvers.

9.4 LG Handle Down Permission Button

The LG handle down permission button, located on the LG handle, unlocks the handle electrically to permit movement to the DN position. The button energizes an electrical solenoid which releases the spring-actuated handle lock. The button must be depressed before downward force is applied to the LG handle. The electrical solenoid may not unlock the handle while any appreciable downward force is applied.

9.5 DN Lock Release Button

C **DF** The DN LOCK REL button, located on the LG control panel, when depressed, mechanically unlocks the spring-actuated handle lock if the electrical solenoid should fail or not be powered. It overrides all electrical LG control signals. Depressing this button and raising the LG handle on the ground retracts the LG. The DN LOCK REL button may not unlock the LG handle while any appreciable downward force is applied. **DR** For DN LOCK REL button differences, refer to F-16D AIRCRAFT, this section.

9.6 ALT GEAR Handle

The ALT GEAR handle, located just outboard of and below the LG control panel, is used to extend the LG if normal extension is not possible. Pulling the ALT GEAR handle supplies pneumatic pressure to open all LG doors, extend the NLG, and shut off the LG selector hydraulic valve. The LG/hook emergency pneumatic bottle is also used to lower the hook and contains sufficient pneumatic pressure for one LG extension and to hold the hook down. The bottle cannot be recharged in flight. Since pneumatic pressure is reduced by expansion as the actuators extend, less than the normal extending force is available. An LG reset button, located on the ALT GEAR handle, provides a means of retracting the LG after an alternate extension if system B hydraulic pressure is available.

9.7 L/G Warning Horn

The LG warning horn is an intermittent fixed volume signal which sounds in the headset when the NLG or MLG is not down and locked and all the following conditions exist:

- Airspeed is below 190 knots.
- Pressure altitude is less than 10,000 feet.
- Rate of descent is greater than 250 fpm.

9.8 Horn Silencer Button

The HORN SILENCER button is located on the LG control panel. Depressing the button silences the LG warning horn. If the warning condition is eliminated, the horn resets. If it is not eliminated, subsequent LG audio warnings do not occur.

9.9 TO/LDG CONFIG Warning Light

The TO/LDG CONFIG warning light, located on the right glareshield, illuminates in flight whenever pressure altitude is less than 10,000 feet, airspeed is less than 190 knots, rate of descent is greater than 250 fpm, and either of the following conditions exists:

• TEF's not full down.

• NLG or either MLG not down and locked (accompanied by LG warning horn).
The TO/LDG CONFIG warning light illuminates on the ground if TEF's are not full down.

With TEF's full down, rapid reversals of roll command inputs may cause the TO/LDG CONFIG warning light to momentarily illuminate if the altitude, airspeed, and rate of descent conditions outlined above are met or WOW.

9.10 WHEELS Down Lights

The three green WHEELS down lights, located on the LG control panel, are arranged on the silhouette of the aircraft. When any LG is down, its respective light is on. A safe up and locked LG condition is indicated when all three of the lights and the LG handle warning light are off.

The lights are powered by battery bus No. 1 (to energize downlock relays) and emergency dc bus No. 1 (to illuminate lights).

9.11 LG Weight-on-Wheels (WOW) Switches

The LG WOW switches, located on both MLG's and on the NLG, operate as a function of LG strut extension to allow or terminate various system functions.

9.12 LANDING GEAR OPERATION

Movement of the LG handle to the UP position causes the following events:

• LG handle warning light illuminates.

• LG unlocks and retracts.

• Three WHEELS down lights go off.

• MLG wheel spin is stopped.

• LG doors close and lock.

• LG handle warning light goes off.

• Hydraulic pressure is removed from LG.

• FLCS switches to cruise gains.

• TEF's retract to streamlined position.

• Electrical power is removed from brake channel 1.

Movement of the LG handle to the DN position causes the following events:

• LG handle warning light illuminates.

• LG doors and LG unlock, extend, and lock into place.

• Three WHEELS down lights illuminate.

• LG handle warning light goes off.

• TEF's extend.

• FLCS switches to takeoff and landing gains.

• **PW220** / **PW229** LG DN nozzle scheduling is activated.

• Speedbrakes close to 43 degrees if not overridden.

• Electrical power is supplied to brake channel 1.

LG WOW Switch

RIGHT MLG – SYSTEMS

Aircraft Battery	FCR
Air Data Probe	FLCC
Altimeter (ELECT)	LG Warning
AOA Probes	Pitot Probe
Brakes/Antiskid	Probe Heat Monitor
ECS	SMS
Engine Controls	[C] VMS
EPU	

Fails to Ground Position in Flight	**Fails to In-Flight Position on Ground**
FCR can not transmit	FCR can transmit
Stores cannot be emergency jettisoned unless GND JETT ENABLE switch is in ENABLE	Stores can be emergency jettisoned with GND JETT ENABLE switch in OFF
[C] VMS is inoperative	[C] VMS is operative unless INHIBIT is selected
Brakes can be applied before touchdown if toe brakes are depressed	With simultaneous failure of left and right MLG WOW switches and ANTI-SKID switch in ANTI-SKID, toe brakes are inoperative when groundspeed is less than 20 knots
ANTI-SKID switch holds in PARKING BRAKE with throttle in OFF to IDLE range	With simultaneous failure of left and right MLG WOW switches, ANTI-SKID switch must be held in PARKING BRAKE to operate parking brake
With simultaneous failure of left and right MLG WOW switches, ACFT BATT FAIL light indicates aircraft battery failure (voltage 20V or less) or battery charger failure	ACFT BATT FAIL light indicates aircraft battery failure only
	EPU is commanded on during engine shutdown; operation cannot be terminated with the EPU switch
[C] LG and low speed warning tones are inoperative	
Probe heat monitor is inoperative unless TEST or PROBE HEAT is selected	Probe heat monitor is operative
	All probe heaters except total temperature are on
	FLCS BIT cannot be initiated

LG WOW Switch

LEFT MLG – SYSTEMS

Aircraft Battery	Ground Test Panel (fuel pump lights)
AOA Probe (right)	JFS Ground Cutout
Brakes/Antiskid	LG Handle
Chaff/Flare Dispenser	LG Warning
EPU	Total Temperature Probe
FLCC	D VMS
Fails to Ground Position in Flight	**Fails to In-Flight Position on Ground**
Chaff/Flare Dispenser is inoperative	Chaff/Flare Dispenser is operative
	AOA probe heater (right) is on
JFS shuts down automatically during engine start	JFS does not shut down automatically during engine start
LG UP position cannot be selected unless DN LOCK REL button is depressed	LG UP position can be selected without DN LOCK REL button depressed
TO/LDG CONFIG warning light is on with TEF's not down	TO/LDG CONFIG warning light is off with TEF's up
Total temperature probe heater is inoperative	Total temperature probe heater is on
D VMS is inoperative	D VMS is operative unless INHIBIT is selected
Brakes can be applied before touchdown if toe brakes are depressed	With simultaneous failure of right and left MLG WOW switches and ANTI-SKID switch in ANTI-SKID, toe brakes are inoperative when groundspeed is less than 20 knots
ANTI-SKID switch holds in PARKING BRAKE with throttle in OFF to IDLE range	With simultaneous failure of right and left MLG WOW switches, ANTI-SKID switch must be held in PARKING BRAKE to operate parking brake
	Fuel pump lights on external ground test panel are inoperative
With simultaneous failure of right and left MLG WOW switches, ACFT BATT FAIL light indicates aircraft battery failure (voltage 20V or less) or battery charger failure	ACFT BATT FAIL light indicates aircraft battery failure only
D LG and low speed warning tones are inoperative	EPU is commanded on during engine shutdown; operation cannot be terminated with the EPU switch
	FLCS BIT cannot be initiated

LG WOW Switch

NLG – SYSTEMS

Air Data Probe	FLCS Power
AOA Probe (left)	C NWS
C AR	Pitot Probe
FLCP	Speedbrakes
Fails to Ground Position in Flight	**Fails to In-Flight Position on Ground**
	Air data, pitot, and left AOA probe heaters are on
AOA indicator displays zero degrees	
C A/R DISC button is inoperative	C A/R DISC button is operative
	FLCS fails BIT
NWS can be engaged and follows rudder inputs with NLG down	NWS is inoperative
Speedbrakes are not limited to 43 degrees with right MLG down and locked	Speedbrakes do not remain open more than 43 degrees
ACFT BATT TO FLCS light indicates aircraft battery bus is supplying power to one or more FLCS branches	ACFT BATT TO FLCS light indicates battery bus is supplying power to one or more FLCS branches (bus voltage 25 vdc or less)
FLCS PMG light indicates FLCS PMG power is not available at one or more FLCS branches	FLCS PMG light indicates the FLCS PMG is not supplying power to any FLCS branches

10 Nosewheel Steering (NWS) System

The NWS is electrically controlled using dc bus No. 1 power and is hydraulically operated using system B pressure. Steering signals are provided through the rudder pedals. Should NWS be engaged with the rudder pedals displaced, the nosewheel drives to the rudder pedal commanded position. NWS is limited to 32 degrees in each direction; however, turn radius can be reduced by using inside brake. NWS is automatically disengaged when the NLG strut is fully extended.
NWS is not available following an alternate LG extension and may not be available anytime the NLG WHEELS down light is not illuminated. Refer to TURNING RADIUS AND GROUND CLEARANCE.

10.1 NWS CONTROLS AND INDICATORS

10.1.1 NWS A/R DISC MSL STEP Button

The NWS A/R DISC MSL STEP button, located on the outboard side of the stick, is used to engage, or disengage NWS when the aircraft is on the ground. Once depressed, NWS is engaged, and the button may be released. If the button is held depressed, continuous NWS is provided.

10.1.2 NWS Light

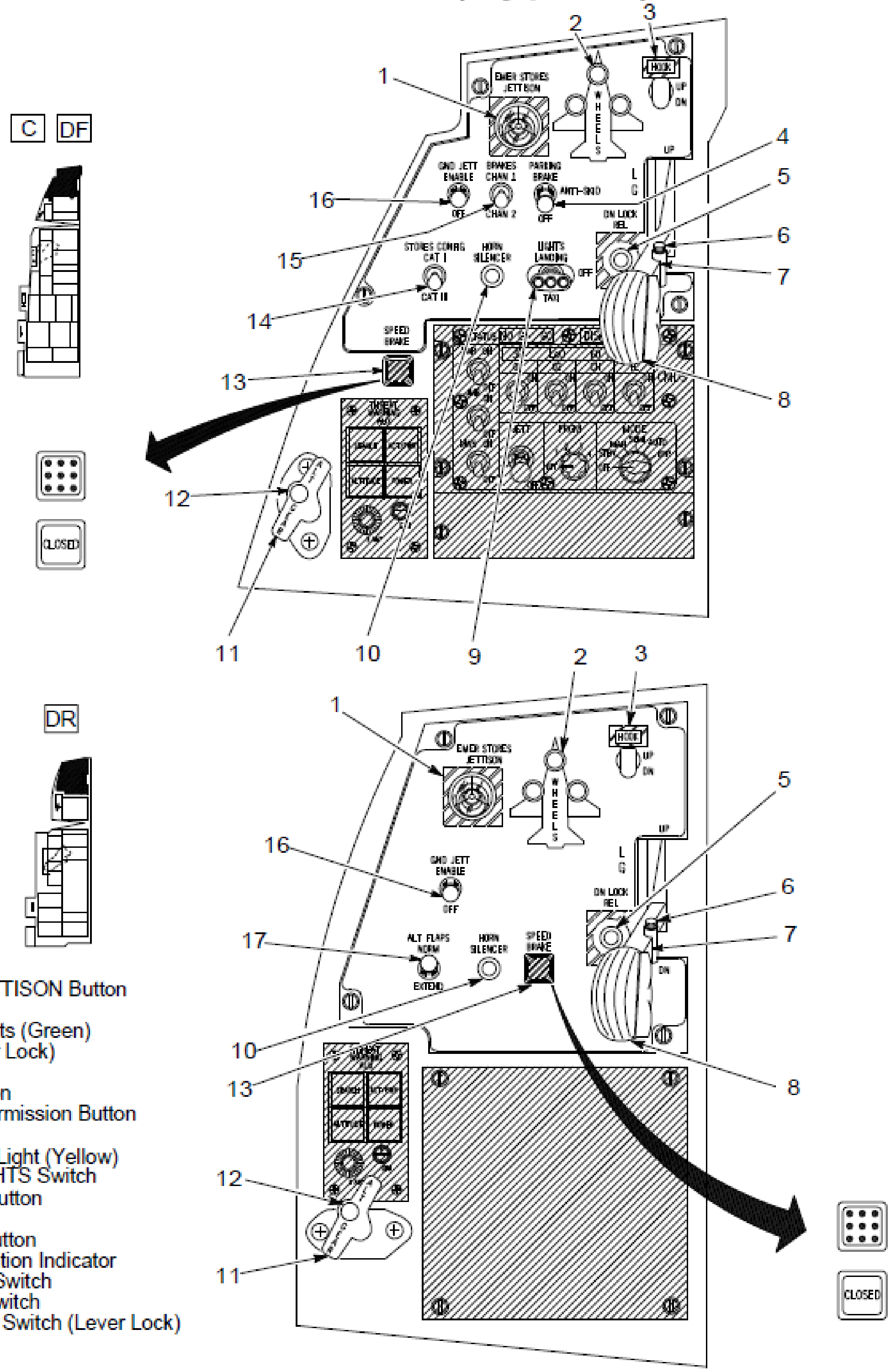
The NWS light, the center element of the AR/NWS status indicator located on the top of the glareshield, illuminates green when NWS is engaged. NWS does not operate even though the NWS light is illuminated when the NWS FAIL caution light is on or when system B hydraulic pressure is unavailable. On the ground, NWS continues to operate with the AIR REFUEL switch in OPEN even though the NWS light is off.

10.1.3 NWS Fail Caution Light

The NWS FAIL caution light, located on the caution light panel, illuminates when a failure in the NWS system has caused electrical power to be switched off.

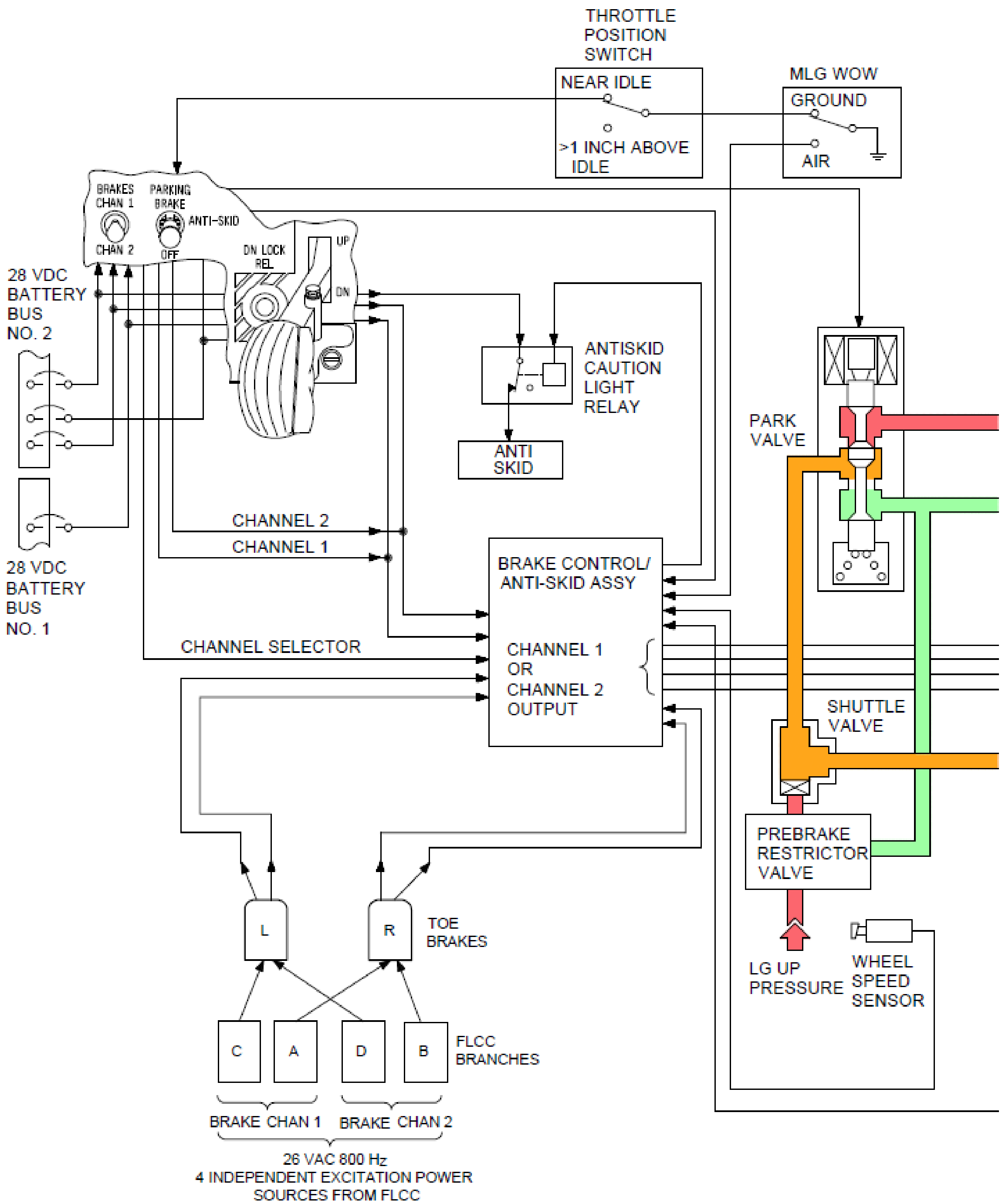
10.2 Landing Gear Controls and Indicator

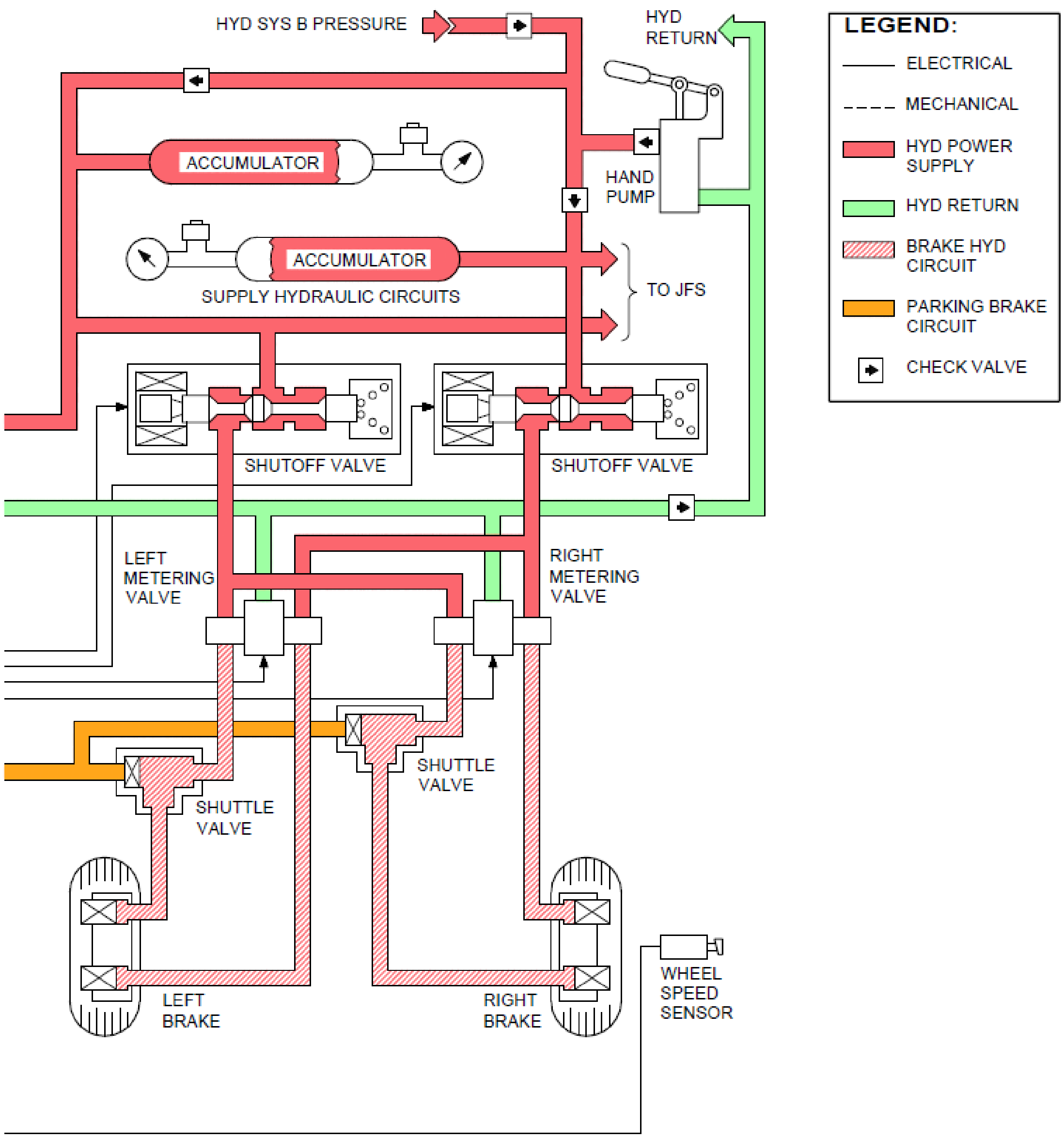
Landing Gear Control Panel (Typical)



1. EMER STORES JETTISON Button (Covered)
2. WHEELS Down Lights (Green)
3. HOOK Switch (Lever Lock)
4. ANTI-SKID Switch
5. DN LOCK REL Button
6. LG Handle Down Permission Button
7. LG Handle
8. LG Handle Warning Light (Yellow)
9. LANDING TAXI LIGHTS Switch
10. HORN SILENCER Button
11. ALT GEAR Handle
12. ALT GEAR Reset Button
13. SPEED BRAKE Position Indicator
14. STORES CONFIG Switch
15. BRAKES Channel Switch
16. GND JETT ENABLE Switch (Lever Lock)
17. ALT FLAPS Switch

11 Wheel Brake System





Each MLG wheel is equipped with a hydraulically powered multiple disc brake. The brakes are electrically controlled by conventional toe brake pedals. The amount of braking gradually increases as pedal pressure is applied. A parking brake is also provided. An antiskid system protects against blown tires and is only available when using toe brakes. Brake hydraulic power is supplied by system B. If system B fails or the engine is operating at less than 12 percent rpm, the toe brakes and parking brake are available until the brake/JFS accumulators deplete. Continuous use of the toe brakes, even with the parking brake set, depletes brake/JFS accumulator fluid and causes loss of all braking capability after approximately 75 seconds (brake/JFS accumulators initially fully charged). When holding the aircraft stationary, use of the parking brake is preferred since brake/JFS accumulator fluid is not depleted.

12 Toe Brake System

The toe brakes use electrical power from the FLCC and CHAN 1 and CHAN 2 dc power sources. The brake pedals require FLCC power to operate. The pedal signals are supplied to the brake control/anti-skid assembly which, in turn, uses both CHAN 1 and CHAN 2 dc power sources to operate valves for controlling hydraulic pressure to the brakes. CHAN 1 and CHAN 2 are powered by battery buses No. 1 and No. 2, respectively. The electrical power sources are grouped to provide two redundant channels. Channel 1 uses FLCC branches A and C and CHAN 1 dc power. Channel 2 uses FLCC branches B and D and CHAN 2 dc power. If one FLCC branch fails, one toe brake in either CHAN 1 or CHAN 2 is inoperative. An inoperable FLCC branch may illuminate the FLCS FAULT caution light and generate a BRK PWR DEGR PFL. FLCS PWR lights on the TEST switch panel should be used to determine the proper BRAKES channel switch position.

After engine shutdown (main and standby generators and FLCS PMG not operating), the brakes remain powered as long as the MAIN PWR switch is not moved out of MAIN PWR. If the MAIN PWR switch is moved to BATT, the FLCS relays open and the FLCC is no longer powered by the aircraft battery. Therefore, the toe brakes are inoperative. Regardless of which channel is selected, hydraulic pressure to three of the six pistons in each brake is controlled by electrical power from one dc power source and pressure to the other three pistons of each brake is controlled by electrical power from another dc power source. A loss of one dc power source when CHAN 1 is selected results in degraded brake operation (only one-half of the pistons are powered and significantly more brake pedal force than normal is required to stop).

Due to redundancy features, selecting CHAN 2 may restore full braking. If all dc power sources fail or if all FLCC branches are off, the toe brakes are totally inoperative.

Channels 1 and 2 use separate redundant circuit elements for controlling the brakes and operate the same except that when CHAN 1 is selected, both dc power sources are switched off when the LG handle is up. With CHAN 1 selected, the brakes only operate with the LG handle down; with CHAN 2 selected, the brakes are operable with the LG handle either up or down. If the LG handle is stuck in the UP position, CHAN 2 must be selected to achieve braking.

12.1 SPIN DOWN BRAKING SYSTEM

The spin down braking system provides hydraulic brake pressure to stop MLG wheel spin during LG retraction. The hydraulic pressure is relieved when the LG is up and locked.

12.2 BRAKES CHANNEL SWITCH

The BRAKES channel switch, located on the LG control panel, has positions of CHAN 1 and CHAN 2 and allows wheel brake system switching. CHAN 1 is the normal position.

12.3 PARKING BRAKE

The parking brake is activated by the ANTI-SKID switch located on the LG control panel, and supplies full, unmetered pressure to three of the six pistons in each brake. The parking brake holds the aircraft stationary without the use of toe brakes. It can also be used for emergency braking if the toe brakes are inoperative. The parking brake is powered by battery bus No. 2 and system B hydraulics or one brake/JFS accumulator (the brake/ JFS accumulator which is not used for START 1).

12.4 ANTISKID SYSTEM

The antiskid system is available in either brake channel anytime the toe brakes are powered.
The antiskid system will deliver a corresponding deceleration rate to a given pedal deflection. The deceleration skid control will dampen brake pedal inputs to the brakes resulting in a smoother, more efficient stop than with previous antiskid systems. To optimize braking performance and reduce wear on aircraft brakes and tires, smoothly apply brakes in a single application.

Functions are:

- Touchdown skid control – Prevents brake application prior to wheel spin up even if brake pedals are fully depressed.
- Deceleration skid control – Active when either brake pedal deflection is less than 85 percent of maximum and runway surface can provide the requested deceleration.
- Maximum performance skid control – Active when both brake pedal deflections are equal to or greater than 85 percent or runway surface cannot provide requested deceleration.
- Antiskid failure detection – Detects a failure affecting braking or in a system component.

If a failure affecting braking performance is detected while the aircraft is moving above 5 knots groundspeed, the ANTISKID caution light illuminates. In most cases this represents the loss of a wheel speed sensor signal, and the system switches to an alternate braking mode. In this mode, if differential braking is applied (15 percent or greater difference between pedals), both brakes alternate between pedal pressure as metered and no pressure. Braking effectiveness is reduced by 50 percent or greater. If brake pedals are within 15 percent, the system uses the information from the remaining good wheel speed sensor and stopping distance is increased by approximately 25 percent on both wet and dry runways.
The alternate mode continues until the BRAKES channel switch is switched to CHAN 2 and the ANTI-SKID switch is placed to OFF. The ANTI SKID caution light remains on and braking is manual. The brakes then can be locked by applying too much pedal pressure, which may result in blown tires. The antiskid system incorporates a hydroplaning protection function which prevents brake application until the wheels have spun up, even if WOW has occurred before spinup. Full antiskid function becomes active at 12 knots groundspeed when accelerating and is available to below 5 knots when decelerating. Maximum braking below 12 knots groundspeed may result in tire flat spotting.

12.5 ANTI-SKID Switch

The ANTI-SKID switch, located on the LG control panel, is not lever-locked in the ANTI-SKID position and can be bumped to OFF.

Functions are:

• PARKING BRAKE:

Full unmetered brake pressure is applied with the throttle in the OFF to IDLE range and WOW. Advancing the throttle more than 1 inch beyond IDLE automatically returns the switch to ANTI-SKID which releases the parking brake.

• ANTI-SKID: Antiskid protection is available.

• OFF: Parking brake feature is deactivated, and antiskid functions are as follows:

- With BRAKES channel switch in CHAN 1 – Touchdown skid control is not available, but deceleration and maximum performance skid control remain active.
- With BRAKES channel switch in CHAN 2 – All antiskid functions are deactivated.

12.6 ANTI SKID Caution Light

The ANTI SKID caution light, located on the caution light panel, illuminates at groundspeeds above 5 knots when a malfunction affecting braking performance is detected. If a system malfunction not affecting braking performance (e.g., loss of redundancy) is detected, the light illuminates when groundspeed is below 5 knots. The caution light is not latched and will extinguish above 5 knots if a failure that does not affect braking performance is present. The ANTI SKID caution light illuminates when power is applied to the brake control/antiskid assembly and goes off when power-up BIT has been successfully completed (approximately 1/2 second later). This brief illumination of the ANTI SKID caution light may be observed when power is first applied or after the LG handle is placed down with the BRAKES channel switch in CHAN 1. The ANTI SKID caution light illuminates when the LG handle is down, and the switch is in OFF.

13 Speedbrake System

The speedbrake system consists of two pairs of clamshell surfaces located on each side of the engine nozzle and inboard of the horizontal tail and is powered by hydraulic system A. The speedbrakes open to 60 degrees with the right MLG not down and locked. With the right MLG down and locked, speedbrake opening is limited to 43 degrees to prevent the lower surfaces from striking the runway during landing. This limit can be overridden by holding the SPD BRK switch in the open (aft) position. When the NLG strut compresses on landing, the speedbrakes can be fully opened and remain fully open without holding the SPD BRK switch.

13.1 SPEEDBRAKE CONTROLS AND INDICATORS

13.1.1 SPD BRK Switch

The SPD BRK switch, located on the throttle, is a thumb-activated, three-position slide switch. The open (aft) position is spring-loaded to off (center) and allows the speedbrakes to be incrementally opened. The closed (forward) position has a detent, allowing a single motion to close the speedbrakes. To prevent possible creeping, the switch should be left in the closed position. **DR** For SPD BRK switch differences, refer to F-16D AIRCRAFT, this section.

The speedbrake switches are connected in parallel and function so that either can override the other by holding in the open position. If one switch is in the closed position, the speedbrakes close when the other is released from the open position.

13.1.2 SPEED BRAKE Position Indicator

A three-position SPEED BRAKE indicator is located on the
LG control panel.

Positions are:

• CLOSED – Both speedbrakes closed.

• Speedbrake symbol – Speedbrakes not closed.

• Diagonals – Electrical power removed from the indicator. Diagonals also appear momentarily during switching.

14 Arrestment System

The hook is electrically controlled and pneumatically operated. Pneumatic pressure is supplied by the LG/hook emergency pneumatic bottle which contains sufficient pressure to lower the LG and hook. When extended, pneumatic pressure holds the hook on the runway. When subsequently retracted, the hook rises enough to allow the cable to drop off the hook or to be disengaged.
The hook is spring-loaded partially up to allow taxiing over a cable. The hook must be raised manually to reset it to the stowed position.

14.1 ARRESTMENT SYSTEM CONTROLS AND INDICATORS

14.1.1 HOOK Switch

The HOOK switch, located on the LG control panel, is lever locked in the UP or DN position. Positioning the switch to DN causes the hook to extend. Returning the switch to UP partially retracts the hook, allowing for cable disengagement and for taxi over the cable. D Either HOOK switch may be used to extend the hook. Both switches must be positioned to UP to raise the hook.

14.1.2 HOOK Caution Light

The HOOK caution light, located on the caution light panel, illuminates anytime the hook is not up and locked.

15 Wing Flap System

15.1 LEADING EDGE FLAPS (LEF'S)

The LEF's consist of a spanwise flap on each wing leading edge controlled as a function of mach number, AOA, and altitude by command signals from the FLCC. An asymmetry sensing and braking mechanism prevents LEF asymmetry. If an asymmetry is sensed, the LEF's lock, FLCS LEF LOCK PFL is displayed, and the FLCS warning light illuminates. The LEF's may drift up after being locked manually. The LEF's are automatically programmed when the LE FLAPS switch is in AUTO.

Exceptions are:

- When weight is on both MLG (the LEF's are 2 degrees up).
- When the throttle is at IDLE and MLG wheel speed is greater than 60 knots groundspeed (the LEF's are 2 degrees up).
- LEF asymmetry brakes are locked.
- When the FLCS is operating on standby gains. Refer to STANDBY GAINS, section 16.3.3.

15.2 LE FLAPS Switch

The LE FLAPS switch is covered as a part of the FLT CONTROL panel.

15.3 FLCS LEF LOCK PFL

The FLCS LEF LOCK PFL is activated by malfunctions in the flap drive unit or flap commands. The FLCS LEF LOCK PFL is also activated if the LEF's are manually locked, or the asymmetry brakes are activated. The FLCS warning light illuminates when the FLCS LEF LOCK PFL occurs.

15.4 TRAILING EDGE FLAPS (TEF'S) (FLAPERONS)

The flaperons are located on the wing trailing edge and function as ailerons and TEF's. The flaperons have a maximum command deflection of 20 degrees down and 23 degrees up. When acting as flaps, the deflection is downward; when acting as ailerons, the deflection is up or down, as commanded. Both functions are operable whenever the FLCS is powered. The TEF's are controlled as a function of the LG handle position, the ALT FLAPS switch, airspeed, and mach number. Positioning the LG handle to DN or the ALT FLAPS switch to EXTEND causes the TEF's to deflect downward. At all airspeeds below 240 knots, the TEF position is 20 degrees down. Above

240 knots, the TEF's reduce deflection as a function of airspeed until nearly/fully retracted at 370 knots.

15.5 ALT FLAPS Switch

The ALT FLAPS switch is located **C** **DF** on the FLCP and **DR** on the LG control panel. With the switch in NORM, the TEF's are controlled by the LG handle and airspeed. Placing the switch to EXTEND lowers the TEF's only, depending on airspeed. The ALT FLAPS switch does not affect the operation of the LEF's unless the FLCS is operating on standby gains. Refer to STANDBY GAINS, this section.

16 Flight Control System (FLCS)

The FLCS is a digital four-channel, fly-by-wire system which hydraulically positions control surfaces. Electrical signals are generated through a stick, rudder pedals, and a MANUAL TRIM panel. A main component of the FLCS is the flight control computer (FLCC). Redundancy is provided in electronic branches, hydraulic systems, power supplies, and sensor systems. A FLT CONTROL panel (FLCP) provides a BIT RUN FAIL light and controls.

Command signals to the FLCC are initiated by applying force to the stick and rudder pedals. These signals are processed by the FLCC along with signals from the air data system, flight control rate gyros, accelerometers, and INS. The processed signals are transmitted to the ISA's of the horizontal tails, flaperons, and rudder which are positioned to give the commanded response. Pitch motion is controlled by symmetrical movement of the horizontal tails. Roll motion is controlled by differential movement of the flaperons and horizontal tails. Yaw motion is controlled by the rudder. Roll coordination is provided by an ARI. The ARI function is not available whenever MLG wheel speed exceeds 60 knots or if AOA exceeds 35 degrees. After takeoff, ARI is activated within 2 seconds after the LG handle is raised (spin down braking system). If the LG handle remains down, 10-20 seconds are required for the MLG wheels to spin down and activate ARI.

16.1 DIGITAL BACKUP (DBU)

DBU provides a software backup in the event of software problems in the primary program. The DBU is a reduced set of control laws which automatically engages when software problems in the FLCC force a majority of the branches into a failed state. DBU can only be disengaged by use of the DIGITAL BACKUP switch. DBU operation does not significantly impact aircraft handling qualities during normal cruise operation or landing.

During DBU operation:

• The AOS feedback function is inoperative.

• Autopilot and stick steering are inoperative.

• Gun compensation is not provided.

• With the LG handle in DN, the TEF's are positioned to 20 degrees down. With the LG handle in UP and the ALT FLAPS in EXTEND, the TEF's are positioned to 20 degrees down if airspeed is less than 290 knots.

• There is no roll rate input to the AOA limiter. Maximum roll rate command is a constant 167 degrees per second.

• STORES CONFIG switch is inoperative.

• Stick commands are essentially CAT III limited. Rudder pedal commands are essentially CAT I limited.

• Dual air data failures are not recognized in DBU. Standby gains are not engaged. If the LG handle is in UP, midvalue air data is always selected. If the LG handle is in DN, gains are fixed at normal landing values.

• Pitch trim centering at wheel spin-up is inoperative.

• AOA indications do not set to zero and random AOA indications are possible in gusty wind conditions with NLG WOW.

• LEF scheduling is simplified and optimized for a cruise condition at approximately 20,000 feet MSL.

• LEF's are not commanded to 2 degrees up when MLG wheel speed is greater than 60 knots and the throttle is IDLE or if MLG WOW.

• DBU does not support communication on the MUX bus, so failures while in DBU are not reported.

16.2 FLCS LIMITERS

FLCS limiters are provided in all three axes to help prevent departures/spins.

16.2.1 AOA/G LIMITER

In cruise gains, the AOA/g limiter reduces the maximum positive g command as a function of AOA.

The maximum negative g command is a function of airspeed.

Below 15.8 degrees AOA, the maximum positive g command is +9.3g.

As AOA increases, the maximum allowable positive g command decreases.

The maximum AOA depends on the position of the STORES CONFIG switch.

In CAT I, the maximum AOA is 25.8 degrees.

In CAT III, the maximum AOA varies from approximately 16-18 degrees as a function of GW and g.

The negative g available above approximately 250 knots is -3g. Below 250 knots, the available negative g varies between -3g and zero g as a function of airspeed, altitude, and AOA. In takeoff and landing gains, the STORES CONFIG switch has no effect on limiting or gains. Maximum positive g is a function of airspeed and AOA.

The negative g command limit is not a function of airspeed. It is a fixed limit. The maximum AOA for 1g is approximately 21 degrees.

In inverted or upright departures, the AOA/g limiter will override stick pitch commands if the MPO is not engaged.

The MPO can always override the negative g function of the limiter. It can also override the AOA function of the limiter when the AOA exceeds 35 degrees.

Refer to MANUAL PITCH OVERRIDE (MPO) SWITCH, this section.

16.2.2 Roll Rate Limiter

In cruise gains, the roll rate limiter reduces available roll rate authority to help prevent roll coupled departures. This authority is reduced as airspeed decreases, AOA increases, or trailing edge down horizontal tail deflection increases. Roll authority is further reduced for large total rudder commands. In takeoff and landing gains, roll rate limiting is available but is a fixed value independent of AOA, airspeed, or horizontal tail position.

16.2.3 Rudder Authority Limiter

In cruise gains, the rudder authority limiter reduces the pedal commanded rudder deflection as a function of AOA, roll rate, and STORES CONFIG switch position for departure protection. However, ARI authority, stability augmentation, and trim authority are not reduced. In takeoff and landing gains, category I rudder authority limiting is provided.

16.2.4 Yaw Rate Limiter

When AOA exceeds 35 degrees, the yaw rate limiter overrides pilot roll and rudder commands and provides flaperon with and rudder against the yaw rate until AOA is below 32 degrees to enhance spin resistance. The yaw rate limiter provides no protection against yaw departures in the normal flying range (-5 to 25 degrees AOA).

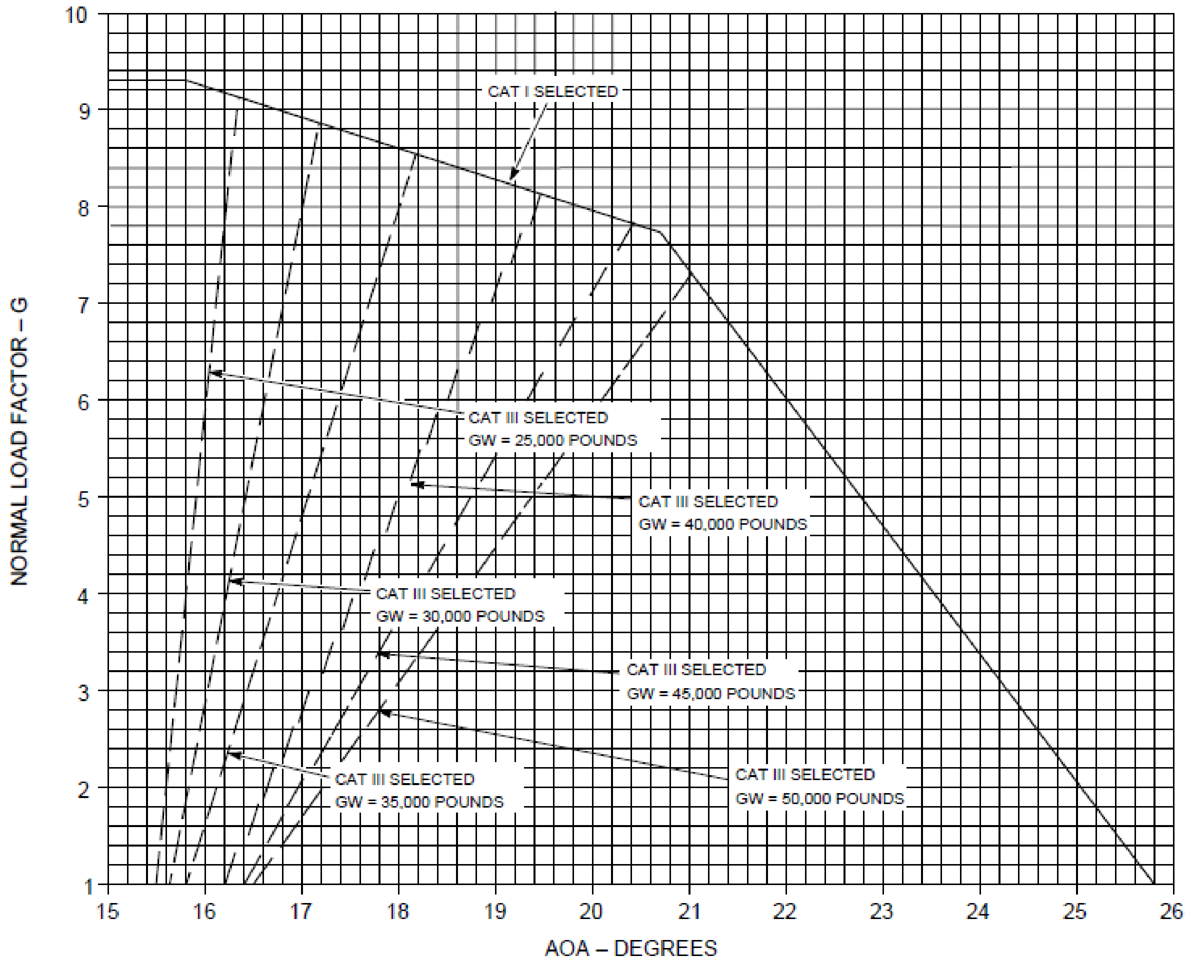
When AOA decreases below -5 degrees and airspeed is less than 170 knots, the yaw rate limiter engages but does not affect pilot roll and rudder commands. Pilot roll and rudder commands are inhibited during inverted departures only when the MPO is engaged. The yaw rate limiter provides rudder against the yaw rate until AOA is above -5 degrees to enhance spin resistance.

Automatic yaw rate limiting to enhance spin resistance is independent of the angle-of-sideslip feedback function; thus, limiting is available even if the FLCS AOS FAIL PFL is present.

FLCS Limiter Functions

	PITCH AXIS	ROLL AXIS	YAW AXIS
CAT I	Maximum AOA= approximately 26° g command system until approximately 16° AOA g/AOA command system above approximately 16° AOA	Maximum roll rate command decreases with: - AOA above 15° - Airspeed less than 250 knots - Horizontal tail deflection more than 5° trailing edge down	Maximum deflection (pedal command) reduced for: - AOA >14° (zero roll rate) - Roll rate >20°/sec NOTE: Zero rudder authority available at 26° AOA.
CAT III	Maximum AOA = 16° - 18° (depending on GW) g command system until 7° AOA at 100 knots to 15° AOA at 420 knots and above g/AOA command system above these values	Maximum roll rate command reduced by approximately 40 percent of CAT I authority. Additional decreases as function of AOA, airspeed, and horizontal tail position	Maximum deflection (pedal command) reduced for: - AOA>3° (zero roll rate) - Roll rate>20°/sec NOTE: Zero rudder authority available at 15° AOA.
NOTES	1. In takeoff/landing gains, the FLCS operates as a pitch rate command system until 10° AOA and a pitch rate/AOA command system above 10° AOA 2. +9.3 g is maximum command until approximately 16° AOA. Maximum g command decreases as a function of AOA and airspeed. 3. Tolerance of maximum g command is +/-1.5%.	1. In takeoff/landing gains, maximum roll rate is fixed at approximately one-half the maximum roll rate available in cruise gains, regardless of AOA, airspeed, or horizontal tail deflection 2. Above 35° AOA, the yaw rate limiter cuts out stick roll commands and provides roll axis antispin control inputs.	1. Above 35° AOA, the yaw rate limiter provides yaw axis antispin control inputs. 2. Below -5 ° AOA and less than 170 knots, the yaw rate limiter provides antispin rudder inputs; pilot roll and rudder commands are cut out only when MPO is engaged. 3. Maximum deflection (30°) always available thru ARI and stability augmentaion.

AOA/G Limiter Function (Cruise Gains)



16.3 FLCS GAINS

During normal operation, the FLCS receives inputs (gains) from the Air Data Converter (ADC) and provides relatively constant aircraft response for a given stick input, regardless of altitude or airspeed. This response varies slightly depending on configuration. In the event of a dual air data failure, the FLCS switches to standby (fixed) gains.

16.3.1 Cruise Gains

The FLCS is in cruise gains with the LG handle in UP, the ALT FLAPS switch either in NORM or in EXTEND above 400 knots, and the AIR REFUEL switch either in CLOSE or in OPEN above 400 knots. At low AOA, the pitch axis of the FLCS is a g command system. As AOA increases, the FLCS switches to a blended g and AOA system to provide a warning of high AOA/low airspeed. Roll rate limiting is available and maximum roll rate decreases as a function of low airspeed, high AOA, and horizontal tail position.

16.3.2 Takeoff and Landing Gains

The FLCS is in takeoff and landing gains with the LG handle in DN, the ALT FLAPS switch in EXTEND (below 400 knots), or the AIR REFUEL switch in OPEN (below 400 knots). In takeoff and landing gains, the FLCS pitch axis operates as a pitch rate command system until 10 degrees AOA and a blended pitch rate and AOA command system above 10 degrees AOA. Roll rate limiting is available but is a fixed value independent of AOA, airspeed, or horizontal tail position.

16.3.3 Standby Gains

In standby gains, control response is tailored for a fixed altitude (sea level, standard day) and airspeed (LG handle in UP, approximately 600 knots: LG handle in DN, approximately 230 knots). The FLCS warning light and FLCS FAULT caution light illuminate. When operating on standby gains, the LEF's are at zero degrees with the LG handle in UP and the ALT FLAPS switch in NORM. The LEF's deflect 15 degrees down with the LG handle in DN or the ALT FLAPS switch in EXTEND. The operation of the TEF's is not affected in standby gains. A standby gains condition can be reset in flight, back to the first failure condition, by using the FLCS RESET switch. The original air data system failure is latched upon occurrence of the second failure and does not reset. If reset is successful, the FLCS warning light goes off.

16.4 FLCS DATA RECORDER

The FLCS data recorder is attached to the ejection seat and departs the aircraft on ejection. It retains the same information as the FLCC including FLCS failure data, airspeed, altitude, true heading and elapsed time from takeoff.

16.5 ANGLE-OF-SIDESLIP (AOS) FEEDBACK FUNCTION

The angle-of-sideslip feedback function provides improved departure prevention by using AOS and AOS rate feedback. AOS and AOS rate are calculated in the FLCC using INS data. The calculated AOS is also monitored in the FLCC by comparing it to an AOS derived from differential pressure
sensor signals. This monitoring detects one of two possible failures:

- AOS derived from INS failed
- AOS derived from differential pressure sensor is erroneous.

Either failure deactivates the AOS feedback function and activates the FLCS FAULT caution light and the FLCS AOS FAIL PFL. The AOS feedback function positions the control surfaces (Primarily the rudder) to reduce sideslip when all of the following conditions are met:

• Airspeed is less than 350 knots.

• AOA is greater than 10 degrees.

• AOS exceeds 2 degrees.

• AOS monitor has not detected a failure.

• DBU is not engaged.

• MPO switch is in NORM.

• FLCS is in cruise gains.

• FLCS is not in standby gains.

• Terrain following and autopilot are not engaged.

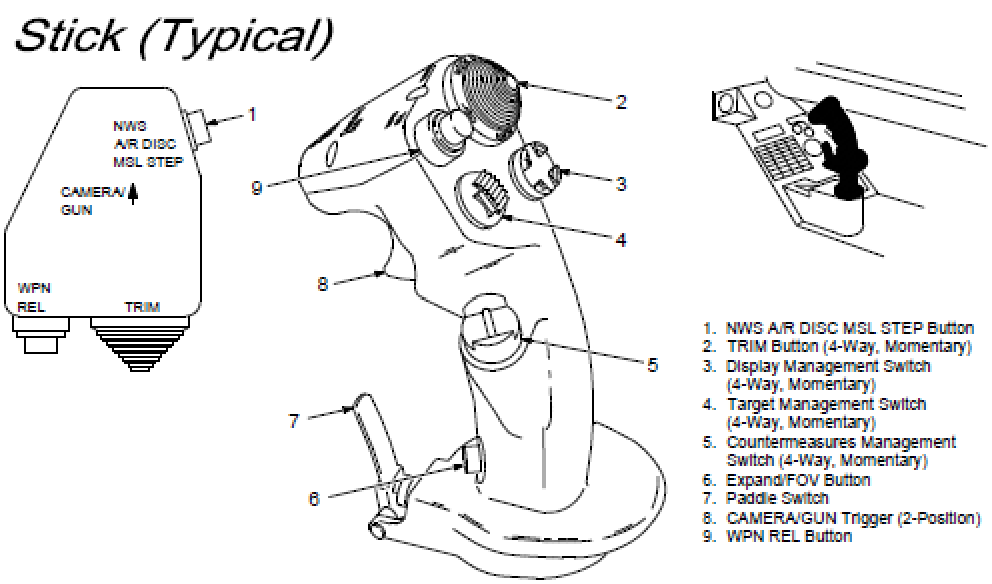
16.6 GUN COMPENSATION

The FLCS automatically compensates for the off-center gun and the aerodynamic effects of gun gas emissions during firing by moving the flaperons and rudder. Gun compensation is optimized for 0.7-0.9 mach range; therefore, all excursions may not be eliminated. For example, gun firing at low mach may result in nose left excursions while nose right excursions are likely at higher mach. Failure monitoring of gun compensation circuits is not provided and there are no caution light indications for incorrect compensation.

17 FLIGHT CONTROL SYSTEM (FLCS) CONTROLS

17.1 Stick

The stick is a force-sensing unit which contains transducers in both pitch and roll axes, moves approximately 1/4 inch in both axes, and is rotated slightly cw. Maximum nose up and nosed own pitch commands are generated by 25 and 16 pounds of input, respectively. Roll commands are generated by a maximum of 17 pounds in cruise gains and by 12 pounds in takeoff and landing gains. When using the switches/buttons on the stick, inadvertent inputs to the FLCS are possible. The wrist rest and armrest assemblies which may be used in conjunction with the stick are located on the right-side wall aft of the stick.



CONTROL		POSITION	FUNCTION
1. NWS A/R DISC MSL	(NWS)	Depress (on ground)	Activates NWS
STEP Button		Depress (2nd time)	Deactivates NWS
	(A/R DISC)	Depress (in flight)	Disconnects boom latching. AIR REFUEL switch must be in OPEN position
	(MSL STEP)	Depress (in flight)	Activates missile step function. Refer to TO 1F-16CM/AM-34-1-1 BMS detailed description of switch functions
2. TRIM Button	(NOSE DOWN)	Fwd	Trims nosedown
(4-way,	(NOSE UP)	Aft	Trims noseup
momentary)	(LWD)	Left	Trims left wing down
	(RWD)	Right	Trims right wing down

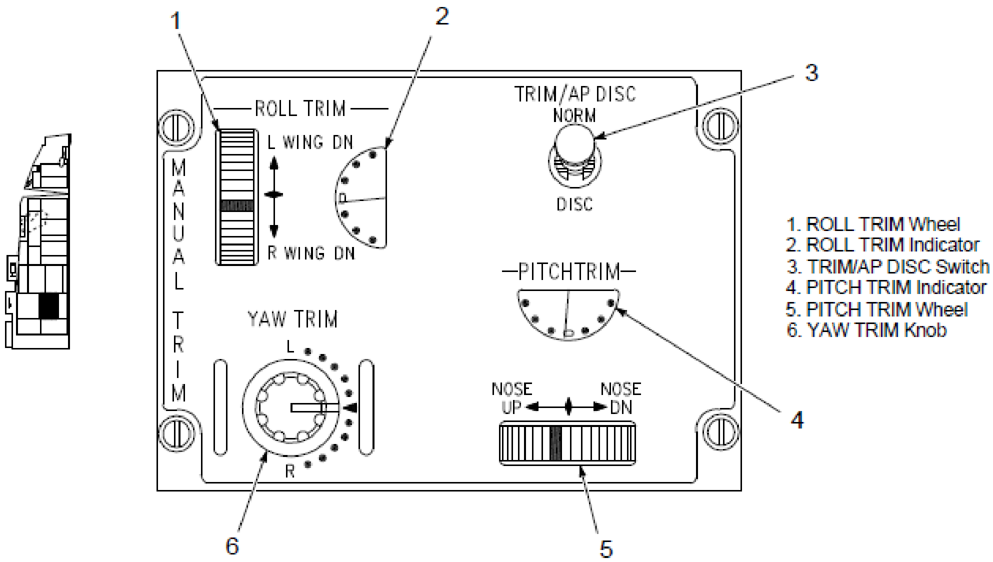
CONTROL	POSITION	FUNCTION
3. Display Management Switch (4 way, momentary)	Up	Refer to TO 1F16CM/AM-34-1-1 BMS
	Down	
	Left	
	Right	
4. Target Management Switch (4-way, momentary)	Up	
	Down	
	Left	
	Right	
5. Countermeasures Management Switch (4 way, momentary)	Fwd	
	Aft	
	Left	
	Right	
6. Expand/FOV Button	Depress	Successive depressions sequence through the available field-of-view (FOV) selections for the sensor/system mode being displayed on the DOI
7. Paddle Switch	Depress	Interrupts the autopilot while switch is depressed
		D For stick override function, refer to F-16D AIRCRAFT, this section
8. CAMERA/GUN Trigger (2-position)	Squeeze trigger to detent	Provides consent for laser fire (if selected and armed)
	Squeeze trigger past detent	Fires gun (if selected and armed), and consent for laser fire continues
9. WPN REL Button	Depress	Signals consent to MMC to initiate weapon release

17.2 Rudder Pedals

The rudder pedals are force-sensing units containing transducers. Force on the applicable rudder pedal produces electrical yaw command signals. The rudder pedals are also used to generate brake and NWS signals. Rudder pedal feel is provided by mechanical springs.

17.3 MANUAL TRIM Panel

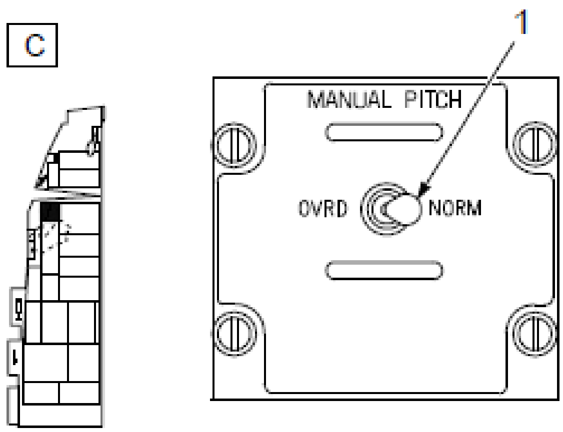
The MANUAL TRIM panel, located on the left console, contains trim controls and indicators.



CONTROL	POSITION	FUNCTION
1. ROLL TRIM Wheel	L WING DN rotation	Trims left wing down
	R WING DN rotation	Trims right wing down
2. ROLL TRIM Indicator	Visual	Indicates roll trim
3. TRIM/AP DISC Switch	NORM	Energizes stick TRIM button. Permits autopilot engagement
	DISC	Deenergizes stick TRIM button, prevents autopilot engagement, and deactivates trim motors (manual trim wheels still operative)
4. PITCH TRIM Indicator	Visual	Indicates pitch trim
5. PITCH TRIM Wheel	NOSE UP rotation	Trims noseup
	NOSE DN rotation	Trims nosedown
6. YAW TRIM Knob	CCW rotation	Trims nose left
	CW rotation	Trims nose right

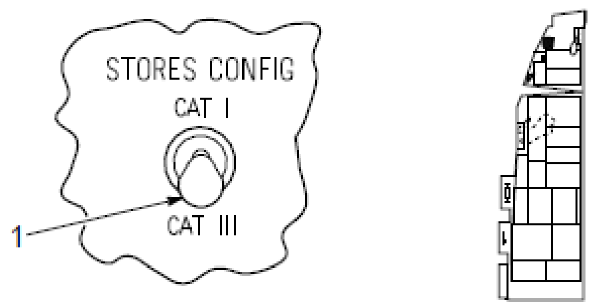
17.4 MANUAL PITCH Override (MPO) Switch

The MPO switch, located on the left console, has two positions, NORM and OVRD, and is spring-loaded to the NORM position. This switch is used during a deep stall condition to enable manual control of the horizontal tails. Positioning and holding the switch to OVRD overrides the negative g limiter. If AOA exceeds the limiter, the FLCS commands the horizontal tails to the full nose down position to effect a recovery. For AOA below 35 degrees, MPO switch activation to OVRD overrides the negative g limiter. For AOA of 35 degrees and above, MPO switch activation to OVRD overrides the AOA/g limiter, commands the horizontal tails proportional to stick force in pitch, and allows rudder inputs.



17.5 STORES CONFIG Switch

The STORES CONFIG switch, located on the LG control panel, has two positions, CAT I and CAT III. The CAT III position shall be selected when the aircraft is configured with a category III loading. AOA limiting is provided. Refer to FLCS LIMITERS, this section, for a description of categories I and III AOA limiter.



1. STORES CONFIG Switch

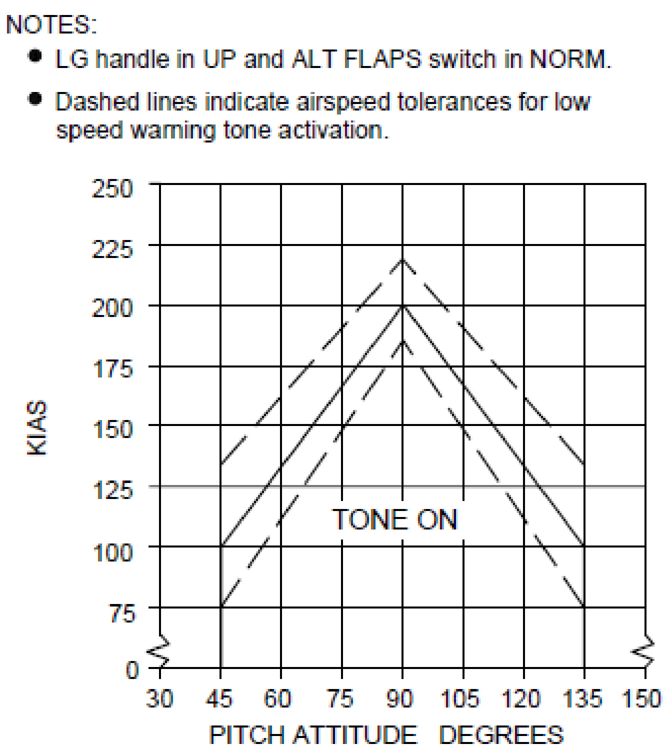
17.6 Low Speed Warning Tone

A low-speed warning tone (steady) sounds in the headset when one of the following conditions exist:

• AOA is 15 degrees or greater with LG handle down or ALT FLAPS switch in EXTEND.

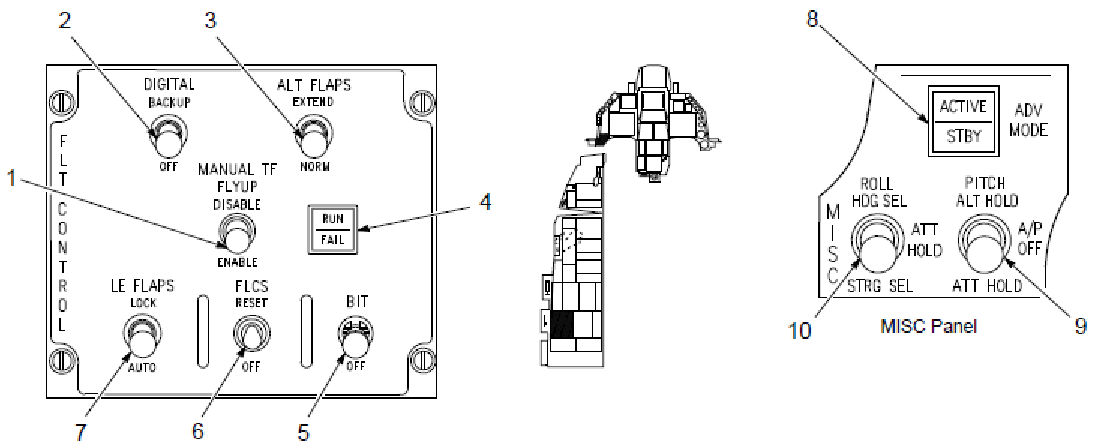
• Combined airspeed and pitch angle fall on a point within the tone on area with LG handle up and ALT FLAPS switch in NORM.

The low-speed warning tone has priority over the LG warning horn. Depressing the HORN SILENCER button silences the low-speed warning tone. The low-speed warning tone is reactivated only after the original warning condition is eliminated. The MAL & IND LTS test button does not test the low-speed warning tone.



17.7 FLIGHT CONTROL Panel (FLCP)

The FLCP, located on the left console, contains indicator lights and controls related to flight control functions.



1. MANUAL TF FLYUP Switch
2. DIGITAL BACKUP Switch
3. ALT FLAPS Switch
4. RUN FAIL Light
5. BIT Switch
6. FLCS RESET Switch
7. LE FLAPS Switch
8. ADV MODE Switch
9. Autopilot PITCH Switch
10. Autopilot ROLL Switch

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
1. MANUAL TF FLYUP Switch (lever lock)	DISABLE	Switch position is inoperative
	ENABLE	Switch position is inoperative
2. DIGITAL BACKUP Switch (lever lock)	BACKUP	Selects backup software program within the FLCC
	OFF	Normal position
3. ALT FLAPS Switch (lever lock)	NORM	TEF operation controlled by LG handle
	EXTEND	TEF's extend regardless of LG handle positions.
4. RUN/FAIL Lights	RUN (green)	Indicates FLCS BIT is running
	FAIL (red)	Indicates a failure during the FLCS BIT
5. BIT Switch	OFF	Normal position
(solenoid held in BIT and lever-locked to OFF)	BIT	Commands BIT if weight is on main LG and wheel speed is less than 28 knots groundspeed

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
6. FLCS RESET Switch	OFF	Normal position
(spring loaded to OFF)	RESET	Momentary position which performs servo or electronic reset of FLCS system failures. Resets FLCS warning light, CADC, FLCS FAULT, and MASTER CAUTION lights and clears PFL's if fault is cleared
7. LE FLAPS Switch (lever lock)	AUTO	LEF's are automatically controlled as a function of mach, altitude, and AOA
	LOCK	Manually locks the LEF's in position and illuminates the FLCS warning light and FLCS LEF LOCK PFL
8. ADV MODE Switch	—	Depressing switch illuminates ATF NOT ENGAGED caution light. (Switch position is inoperative)
9. Autopilot PITCH Switch	ALT HOLD	Engages pitch and roll axes of autopilot. Autopilot maintains constant altitude as determined by CADC; roll mode is determined by ROLL switch
	A/P OFF	Disengages pitch and roll axes of autopilot
	ATT HOLD	Engages pitch and roll axes of autopilot. Autopilot maintains constant pitch attitude as determined by INS; roll mode is determined by ROLL switch
10. Autopilot ROLL Switch	HDG SEL	Autopilot turns the aircraft to capture and maintain the heading selected by the heading reference marker on the HSI
NOTE:	ATT HOLD	Autopilot maintains roll attitude as determined by the INS
Autopilot roll modes are functional when the PITCH switch is out of A/P OFF.	STRG SEL	Autopilot steers aircraft to the selected steerpoint

17.8 FLCS WARNING, CAUTION, AND INDICATOR LIGHTS

The instrument panel, caution panel, PFLD, FLCP, ELEC control panel, TEST switch panel, and avionic system contain warning, caution, and indicator lights related to the FLCS. The FLCS is interfaced to the avionic system via the multiplex (MUX) bus to provide PFL (Pilot Fault List) and MFL (Maintenance Fault List) reporting.

17.9 FLCS Warning Light

The FLCS warning light, located on the right glareshield, illuminates to indicate a dual malfunction in the FLCC electronics, including the processors, power supplies, input commands or sensors, AOA, or air data inputs. The FLCS warning light also illuminates if the LEF's are locked or Built-in.Test (BIT) fails. The FLCS warning light remains illuminated until FLCS reset action is successful in clearing the failure. If an active warning fault exists and a subsequent warning level malfunction occurs, the FLCS warning light goes off momentarily to retrigger HUD WARN and voice warning. More specific system failure information can be obtained from the PFLD.

17.10 DBU ON Warning Light

The DBU ON warning light, located on the right glareshield, illuminates to indicate the FLCC has automatically switched failure is identified, the failed input is set to 11 degrees AOA. If a second AOA failure subsequently occurs, the 11-degree signal existing in the first failed branch prevents hard over AOA inputs and may provide AOA information for landing. During DBU operation, AOA failures are not reported, and a first AOA failure is not set to 11 degrees.

17.11 FLCS FAULT Caution Light

The FLCS FAULT caution light, located on the caution light panel, illuminates when the FLCC reports a caution level PFL item which requires pilot action. The caution light goes off either when the fault is acknowledged or when FLCS reset action is successful in clearing the failure. If the FLCS FAULT caution light is illuminated and a subsequent malfunction occurs, the caution light goes off momentarily to activate the MASTER CAUTION light and retrigger voice caution. More specific system failure information can be obtained from the PFLD or the MFD FLCS page.

17.12 Built-In Test (BIT)

The BIT switch, located on the FLCP, is a two-position switch which is lever-locked in OFF and solenoid held in BIT. When engaged (green RUN light illuminates), the BIT runs for approximately 45 seconds . A failure during the BIT sequence or a BIT interlock failure terminates BIT, returns the switch to OFF, illuminates the red FAIL light and the FLCS warning light, and sends a FLCS BIT FAIL PFL message. BIT failures are non-resettable and the red FAIL light does not go off until a subsequent BIT is successfully completed. A BIT detected bus communication failure results in illumination of the FLCS FAULT caution light and a FLCS MUX DEGR PFL. A FLCS reset extinguishes the caution light but the PFL remains.

Successful completion of BIT is indicated by the BIT switch automatically returning to OFF, the green RUN light going off, no FLCS BIT FAIL PFL, and a BIT PASS message onthe FLCS page of the MFD.

17.13 Autopilot

The autopilot provides attitude hold, heading select, and steering select in the roll axis and attitude hold and altitude hold in the pitch axis. These modes are controlled by PITCH and ROLL switches on the MISC panel. The TRIM/AP DISC switch on the MANUAL TRIM panel disengages the autopilot. The paddle switch on the stick interrupts autopilot operation while the switch is held depressed.

The PITCH switch is a three-position switch which is solenoid held in an engaged position and returns to A/P OFF if any of the following conditions occur:

- AIR REFUEL switch - OPEN.
- ALT FLAPS switch - EXTEND (below 400 knots).
- A/P FAIL PFL occurs.
- AOA greater than 15 degrees.
- DBU - Engaged.
- LG handle - DN.
- Low speed warning tone sounds.
- MPO switch – OVRD.
- STBY GAIN PFL occurs.
- TRIM/AP DISC switch - DISC.

Movement of the PITCH switch out of A/P OFF engages both the pitch and roll autopilot modes selected.
The ROLL switch is a three-position switch which enables one of the three roll autopilot modes whenever a pitch autopilot mode is selected.

17.13.1AUTOPILOT OPERATION

The autopilot is fully engaged when the PITCH switch is not in A/P OFF and the aircraft attitude is within autopilot pitch and bank limits. Autopilot options are selected by positioning the PITCH switch (ALT HOLD, A/P OFF, or ATT HOLD) and the ROLL switch (HDG SEL, ATT HOLD, or STRG SEL). Stick trim is inoperative with the autopilot engaged. The manual trim is operable and may be used while the autopilot is engaged. However, due to the limited authority of the autopilot, engagement of any mode in other than a trimmed flight condition degrades autopilot performance.
The autopilot loop in the FLCC receives inputs from the INS and CADC by means of the AMUX bus. A lack of data, inaccurate data, or degradation/failure of the AMUX disconnects the autopilot and activates the FLCS FAULT caution light and the FLCS A/P FAIL PFL message. The sensor information used by the autopilot does not include the redundancy of the FLCS so its use must be closely monitored at low altitude or in close formation. If AOA is greater than 15 degrees, the autopilot disconnects and the FLCS FAULT caution light and the FLCS A/P FAIL PFL message activates.
Additionally, the FLCC monitors autopilot operation for a failure to maintain the selected mode and for prolonged engagement outside of autopilot attitude limits with no stick inputs. Detection

of a failure results in activation of the FLCS FAULT caution light and the FLCS A/P DEGR PFL message.

Positioning the PITCH switch to ALT HOLD enables the FLCS to use CADC information to generate commands to the horizontal tails which result in the aircraft maintaining a constant altitude. The FLCS limits the pitch command to +0.5g-+2g. Engagement of altitude hold at rates of climb or dive less than 2000 fpm selects an altitude within the pitch command g limits. Engagement above rates of 2000 fpm causes no unsafe maneuvers; however, the engaged altitude may not be captured. Control accuracy of ±100 feet is provided to 40,000 feet pressure altitude for normal cruise conditions.

The altitude reference may be changed by depressing the paddle switch, changing altitude, and releasing the paddle switch. ALT HOLD in the transonic region may be erratic.

Positioning the PITCH switch to ATT HOLD allows an attitude signal from the INU to be used to maintain the selected pitch attitude. This mode does not function if pitch angle exceeds ±60 degrees; however, the PITCH switch remains engaged. In addition, the PITCH switch can be engaged in excess of ±60 degrees of pitch, but ATT HOLD will not function until the aircraft pitch is returned within system limits.

Positioning the ROLL switch to HDG SEL allows the FLCS to use a signal from the HSI to maintain the heading set on the HSI. Adjusting the HSI heading reference marker to the aircraft heading prior to engagement maintains the existing aircraft heading; otherwise when the autopilot is engaged with the ROLL switch in HDG SEL, the aircraft turns to capture the heading indicated by the heading reference marker on the HSI. The roll command does not exceed a 30-degree bank angle or a 20-degree/second roll rate. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

Positioning the ROLL switch to ATT HOLD routes an attitude signal from the INU to the FLCS which results in the aircraft maintaining the selected roll attitude. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

Positioning the ROLL switch to STRG SEL allows the autopilot to steer the aircraft to the selected steerpoint using roll commands. The roll command does not exceed a 30- degree bank angle or a 20-degree/second roll rate. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

17.13.2STICK STEERING

Stick steering is operable only with the pitch and roll attitude hold modes. Stick steering operation is accomplished by applying force to the stick. With ATT HOLD selected, a force applied in the appropriate axis large enough to activate stick steering causes the autopilot to drop the selected reference and the system accepts manual inputs from the stick.

17.14 AOA DISPLAYS AND INDICATORS

17.14.1 AOA INDICATOR

The AOA indicator, located on the instrument panel, displays actual AOA in degrees. The indicator has a vertically moving tape display indicating an operating range of -5 to approximately +32 degrees. The tape is color coded from 9-17 degrees to coincide with the color-coded symbols on the AOA indexer.

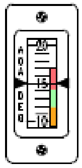
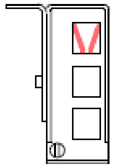
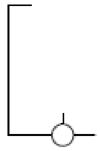
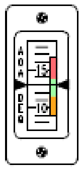
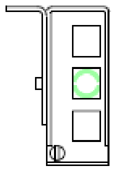
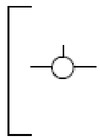
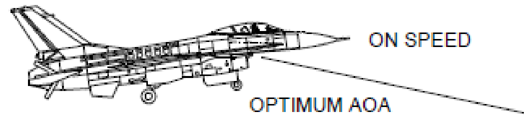
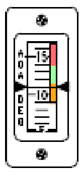
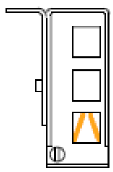
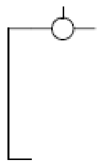
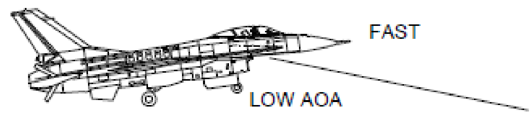
17.14.2 AOA INDEXER

The AOA indexer, located on the top left side of the glareshield, consists of three color-coded symbols arranged vertically. The indexer provides a visual head-up indication of aircraft AOA by illuminating the symbols individually or in combinations as shown. The indexer lights display AOA correction (based on approximately 13 degrees AOA). This correction may be used during landing approaches as visual direction toward optimum landing AOA. The AOA indexer operates continuously with the LG handle up or down. A dimming lever, located on the left side of the indexer, controls the intensity of the lighted symbols. The indexer lights are tested by activation of the MAL & IND LTS switch on the TEST switch panel. The test should be performed with the dimming lever in the bright position.

17.14.3HUD AOA DISPLAY

The HUD AOA bracket and flightpath marker provide a visual head-up indication of aircraft AOA.The flightpath marker aligned with the top of the bracket indicates 11 degrees AOA. The flightpath marker centered on the bracket indicates 13 degrees AOA. The flightpath marker aligned with the bottom of bracket indicates 15 degrees AOA. The HUD AOA display is only available with the NLG lowered.

AOA Displays

INDICATOR	INDEXER	HUD DISPLAY	ATTITUDE
 15			
 13			
 11			

18 AIR DATA SYSTEM

The air data system uses probes and sensors to obtain static and total air pressures, AOA, sideslip, and air temperature inputs. These air data parameters are processed and supplied to various systems. Proper AOA transmitter and fuselage air data probe operation is essential for safe flight operation. Interference from foreign objects (especially ice, internal or external) or improperly installed AOA transmitters can result in erroneous AOA data at weight off wheels. Reporting of false high AOA concurrently from two sources can cause the FLCC to command full nose down pitch which is impossible for the pilot to stop. Ground use of probe covers protects the system from foreign objects and moisture intrusion. Ice on/in the probes is eliminated by using probe heat prior to takeoff.

18.1 AIR DATA SYSTEM PROBES AND SENSORS

18.1.1 Air Data Probes

Two air data probes provide data inputs to the air data system. One air data probe (pitot probe) is mounted on the nose and provides a dual source of static and total pressure. The other air data probe is mounted on the forward right side of the fuselage and provides a source of AOA, sideslip, static pressure, and total pressure.

18.1.2 AOA Transmitters

The AOA transmitters are mounted on each side of the radome and each provides sensor data to the FLCS proportional to local AOA. The probe of the transmitter protrudes through the radome to align with the airstream.

18.1.3 Total Temperature Probe

The total temperature probe provides the CADC with an analog signal which is required for true airspeed and air density computation. The probe is located on the underside of the right forebody strake.

18.1.4 Static Pressure Ports

Two flush-mounted static pressure ports used for measuring sideslip are located on the fuselage left and right sides aft of the forward equipment bay doors. These two ports provide inputs to a differential pressure sensor for angle-of-sideslip measurement. The measurement is also used to compensate the third AOA source error and to verify the AOS derived from the INS.

18.1.5 PROBE HEAT MONITOR

The probe heat monitor monitors current flow to the pitot, fuselage air data, and AOA probes (total temperature probe current is not monitored). If the current flow decreases below a certain value, the monitor illuminates the PROBE HEAT caution light. The monitor operates anytime the aircraft is airborne, regardless of the PROBE HEAT switch position.

18.1.6 PROBE HEAT SWITCH

The PROBE HEAT switch is located on the TEST switch panel. The pitot, fuselage air data, AOA, and the total temperature probe heaters are on anytime the aircraft is airborne, regardless of the PROBE HEAT switch position.

Functions are:

- PROBE HEAT - On the ground, this position energizes the pitot, fuselage air data, AOA, and the total temperature probe heaters and the probe heat monitor.
- OFF - On the ground, circuits deenergized.
- TEST - On the ground and in flight, this position performs a functional test of the probe heat monitoring system. The PROBE HEAT caution light flashes 3-5 times per second. If the caution light does not illuminate or if it illuminates but does not flash, the probe heat monitoring system is inoperative. The test feature does not verify proper operation of the probe heaters.

18.1.7 PNEUMATIC SENSOR ASSEMBLY (PSA)

The PSA converts pneumatic inputs from the nose air data probe and the fuselage air data probe into electrical signals. The PSA supplies static and impact pressure signals and single AOA signals to the input selector/monitor of each branch of the FLCC. A ratio of impact to static pressure is generated within the FLCC and used with AOA and static pressure to schedule the LEF’s and for gain scheduling. The input selector/monitors also are capable of detecting single and dual malfunctions of the air data sensor signals. Single static or impact pressure failures illuminate the FLCS FAULT caution light and the FLCS ADC FAIL PFL on the PFLD and MFD.

A dual malfunction of static or impact pressure signals results in the following:

- Illumination of the FLCS warning light, continued illumination of the FLCS FAULT caution light, and the FLCS ADC FAIL (for first failure) and STBY GAINS PFL messages.
- Activation of FLCS standby gains. Refer to STANDBY GAINS, this section.
- Loss of autopilot.

Pitot probe tip icing results in erroneously low airspeed indications, illumination of the FLCS FAULT caution light with a FLCS ADC FAIL PFL message, and flight control gains scheduled for low airspeed conditions.

18.1.8 CENTRAL AIR DATA COMPUTER (CADC)

The CADC receives total and static pressures, AOA, and total temperature inputs, converts the inputs into digital data, and then transmits the data to the using systems. The CADC has continuous BIT and initiated BIT features; initiated BIT is run during the FLCS BIT.

18.1.9 CADC CAUTION LIGHT

The CADC caution light, located on the caution light panel, illuminates whenever a malfunction in the CADC is detected. If there is a Mach signal failure from the CADC, the ENGINE FAULT caution light also illuminates and the PFL ENG MACH FAIL is displayed on the PFLD. A CADC malfunction may result in a FLCS AOS FAIL PFL and deactivation of the AOS feedback function.

19 WARNING, CAUTION, AND INDICATOR LIGHTS

Warning, caution, and indicator lights are used throughout the cockpit to call attention to a condition or to allow an item to be easily read. Red warning lights and the amber MASTER CAUTION light are all located on the edge of the glareshield. All of the lights, except the MASTER CAUTION light, are described under their respective systems. The warning and caution lights (except MASTER CAUTION) are not press-to-test or press-to-reset lights. Pressing these lights releases them from their modules and deactivates them. To reengage a released light, pull it out slightly and then press to reengage the module.

19.1 VOICE MESSAGE SYSTEM (VMS)

The VOICE MESSAGE SYSTEM (VMS) provides a warning message, a caution message, or discrete messages. The fixed volume voice message does not blank other audio and, therefore, may not be heard.

The warning message (WARNING-WARNING pause WARNING-WARNING) is automatically activated 1.5 seconds after illumination of any warning light on the glareshield.

The caution message (CAUTION-CAUTION) is automatically activated 7 seconds after the illumination of any light on the caution light panel. If the MASTER CAUTION light is reset immediately after its illumination, the voice caution message does not occur.

The warning/caution messages are reset for subsequent activation by:

• Resetting the WARN RESET on the ICP for voice warning.

• Resetting the MASTER CAUTION for voice caution.

• Eliminating the condition that originally activated the lights and messages.

Discrete voice messages are provided when certain conditions occur.

Messages are:

- ALTITUDE-ALTITUDE - Advises that:

  i) Descent is occurring after takeoff.
  ii) Radar altitude is below the entered radar ALOW value.
  iii) Barometric altitude is below the entered MSL ALOW value.

• BINGO-BINGO - Advises that the bingo fuel warning has been activated.

• IFF - Not operable in flight (message is heard during ground test).

• JAMMER - Not operable in flight (message is heard during ground test).

• LOCK - Advises that radar has locked on to target.

• PULLUP-PULLUP-PULLUP-PULLUP – Advises that ground avoidance advisory function (GAAF) warning was activated or that DTS ground proximity warning was activated.

• COUNTER - Active in semiautomatic mode only if REQCTR option is turned on via the DED CMDS BINGO page. Advises that a dispense command should be initiated.

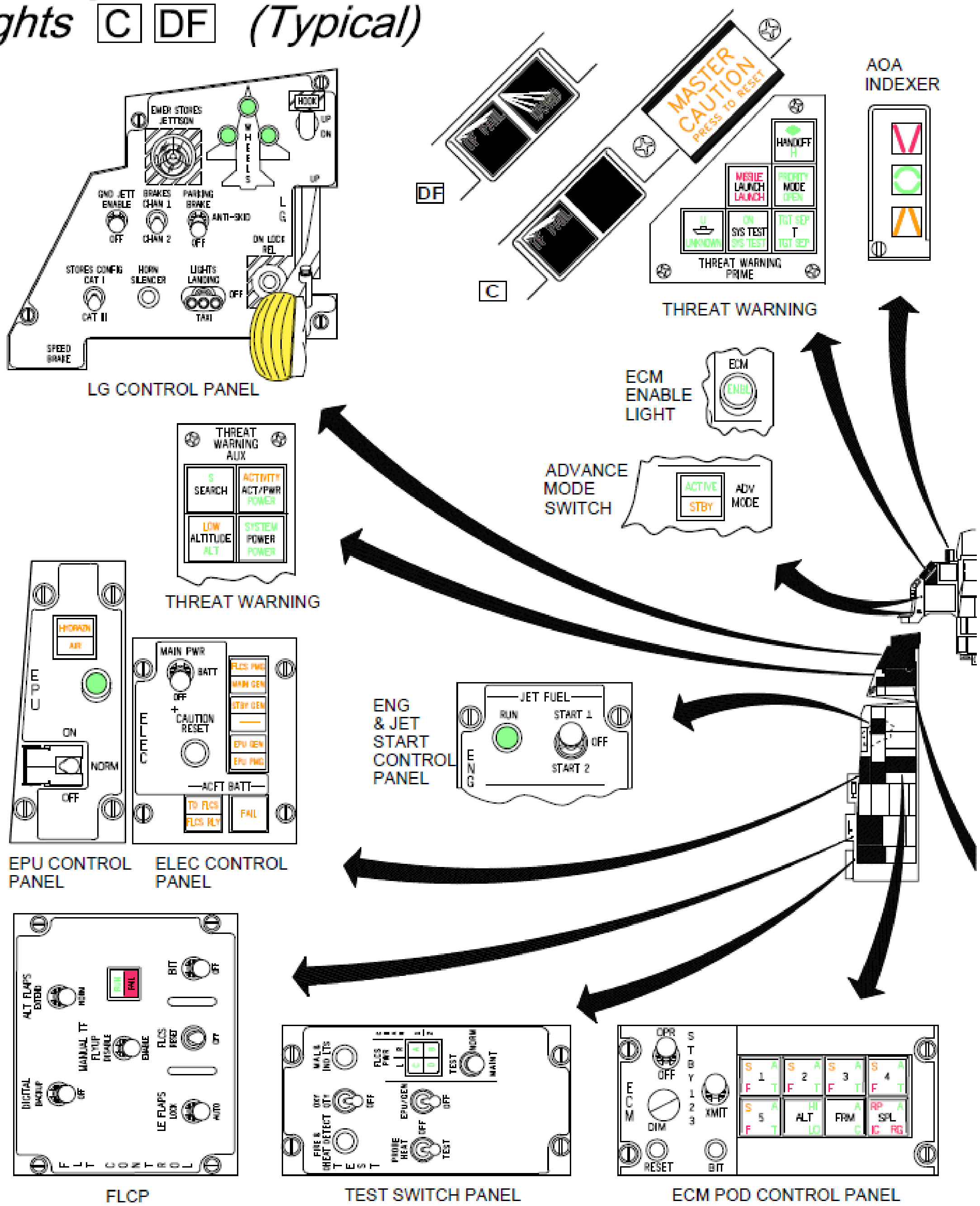
• CHAFF-FLARE - Active if FDBK option is turned on via the DED CMDS BINGO page. Advises that CMDS has initiated a dispense program.

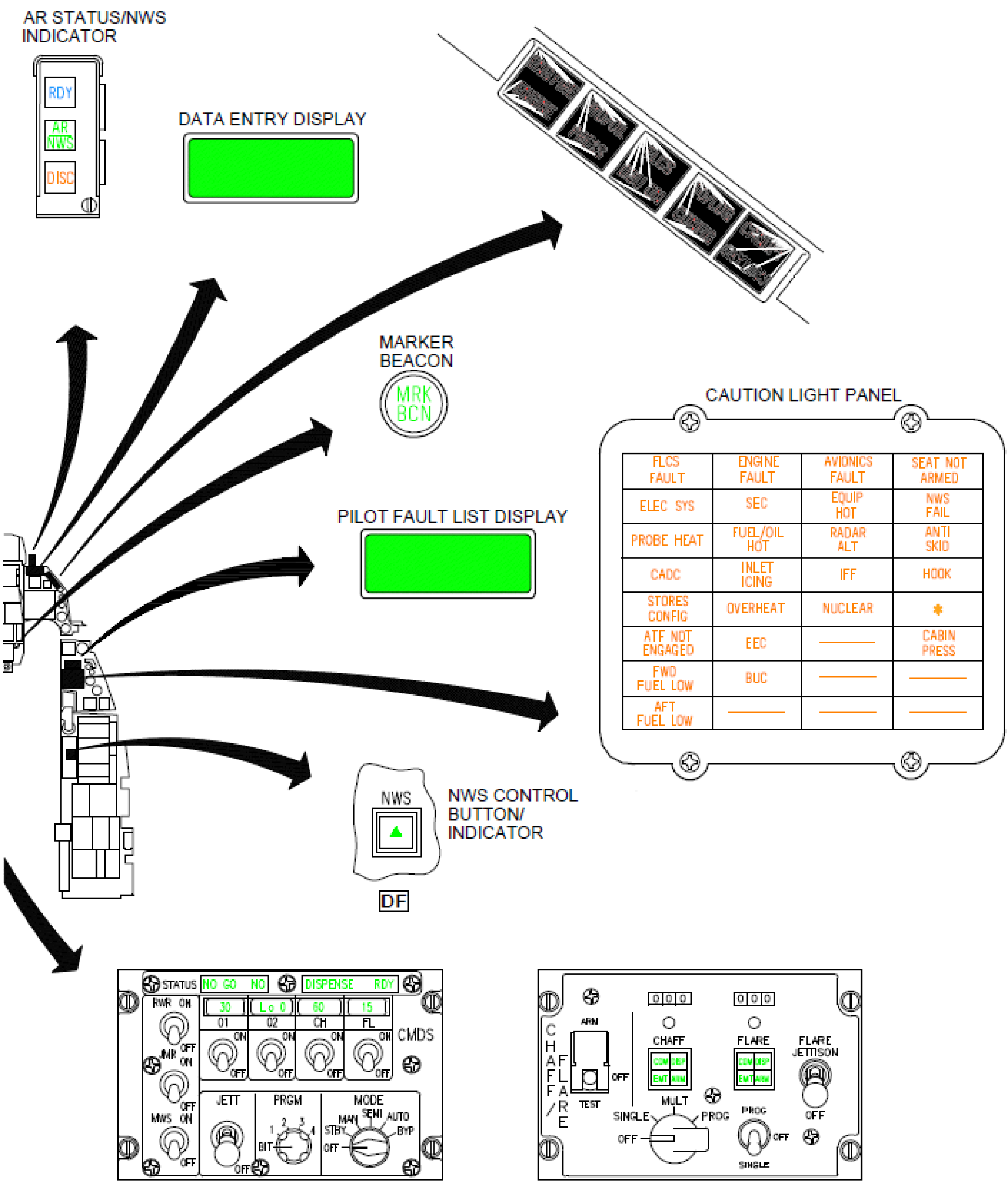
• LOW - Active if BINGO option is turned on via the DED CMDS BINGO page. Advises that expendable low quantity exists.

• OUT - Active if BINGO option is turned on via the DED CMDS BINGO page. Advises that expendable type is completely spent.

• DATA - Advises that IDM received data link target information.

Warning, Caution, and Indicator Lights C DF (Typical)

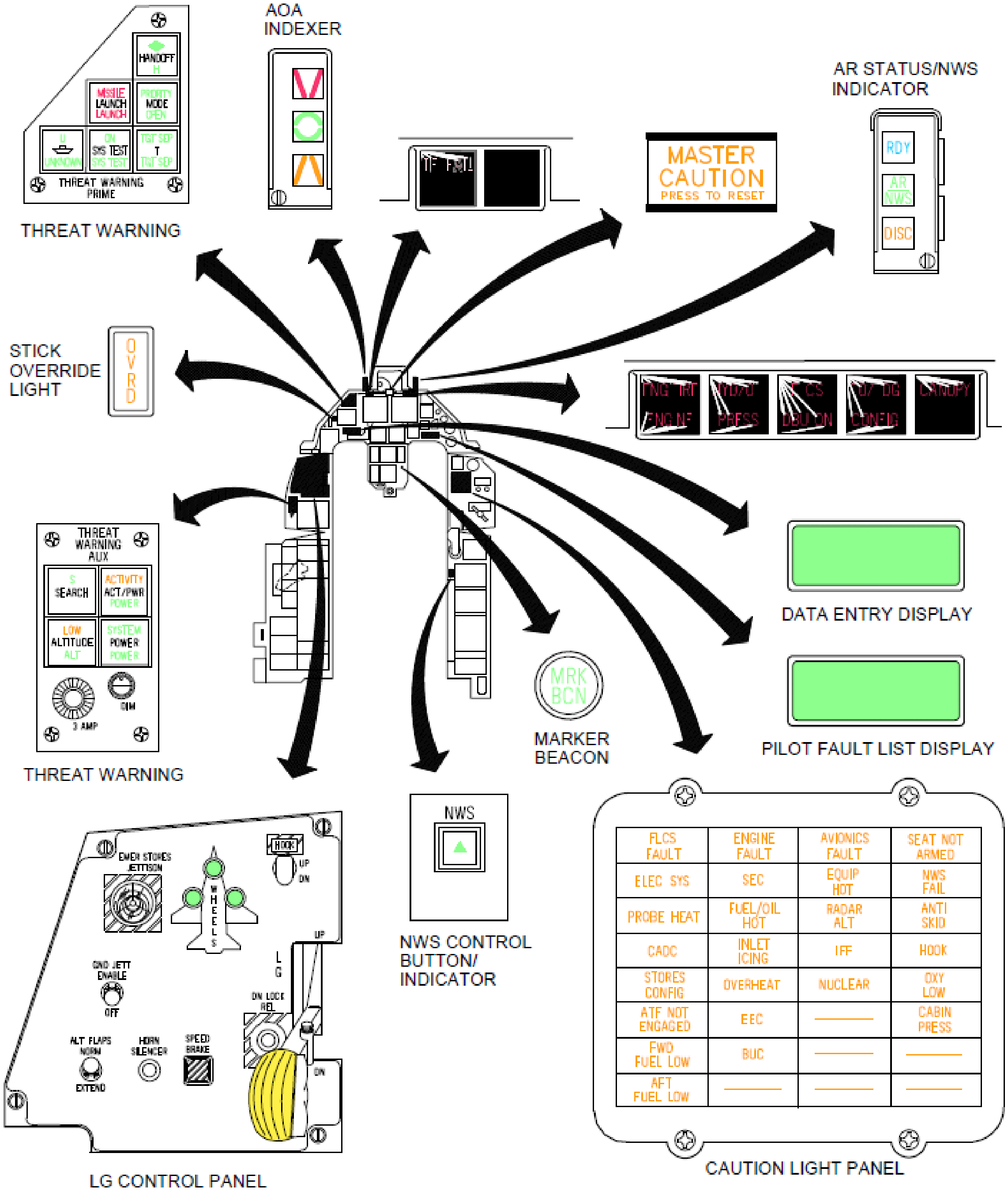




CMDS

CHAFF/FLARE CONTROL PANEL

Warning, Caution, and Indicator Lights DR (Typical)



All voice messages have priority over the low-speed warning tone and LG warning horn. Voice messages are also prioritized.

Priority sequence is:

- PULLUP.
- ALTITUDE.
- WARNING.
- JAMMER.
- COUNTER.
- CHAFF-FLARE.
- LOW.
- OUT.
- LOCK.
- CAUTION.
- BINGO.
- DATA.
- IFF.

The VMS does not function with WOW. However, it can be tested by pressing the MAL & IND LTS test button on the TEST switch panel. During test, each word is heard one time. The VMS is powered by battery bus No. 1.

19.2 VOICE MESSAGE Switch

The VOICE MESSAGE switch, located aft of the stick, is a two-position switch. Positions are marked VOICE MESSAGE and INHIBIT. During normal operation, the switch is safety-wired in VOICE MESSAGE. Placing the switch to INHIBIT disables all voice messages. INHIBIT should only be used to clear a voice message which repeats abnormally. Placing the switch back to VOICE MESSAGE enables normal operation.

19.3 MASTER CAUTION LIGHT

The MASTER CAUTION light, located on the **C** **DF** left upper edge, **DR** center of the glareshield, illuminates shortly after an individual light on the caution light panel illuminates (Except the IFF caution light) to indicate a malfunction or specific condition exists. The MASTER CAUTION light does not illuminate in conjunction with the warning lights. The MASTER CAUTION light may be reset by depressing the face of the light unless itis illuminated by the ELEC SYS caution light. For FLCS FAULT, ENGINE FAULT, and AVIONICS FAULT caution lights, the MASTER CAUTION light may also be reset by depressing the **C** **DF** F-ACK, DR FAULT ACK button. The light should be reset as soon as feasible so that other caution lights can be monitored should additional malfunctions or specific conditions occur. Unless it is reset, the MASTER CAUTION light remains illuminated as long as the individual caution light is illuminated. **DR** The MASTER CAUTION light is a repeater and cannot be reset individually.

19.4 CAUTION LIGHT PANEL

The caution light panel is located on the right auxiliary console. The ELEC SYS caution light must be reset at the ELEC control panel with the ELEC CAUTION RESET button. The caution light may appear non resettable in situations where the caution light is rapidly flashing or cycling on and off. The following caution lights may be reset with the **C** **DF** FACK, DR FAULT ACK button:

- FLCS FAULT.
- ENGINE FAULT.
- AVIONICS FAULT.

A dedicated explanation of each caution light is part of the corresponding chapters of this manual.
A compressed Caution Light Panel overview can be found in the BMS training manual, chapter 1.4.2

19.5 MAL & IND LTS Test Button

The MAL & IND LTS test button, located on the TEST switch panel, operates relays which test the illumination of all warning, caution, and indicator lights, the LG warning horn, and voice messages.

19.6 PILOT FAULT LIST DISPLAY (PFLD)

The PFLD, located on the **C** **DF** right auxiliary console, **DR** instrument panel, displays engine, avionics, and FLCS PFL's. In addition, a status line displays a system code to identify the system associated with an active fault(s). Two types of PFL's are displayed: warning level and caution level. Warning level PFL's are associated with the FLCS and are distinguished from caution level PFL's by a warning indicator which brackets the PFL message. When a FLCS warning level PFL occurs, the PFL message and FLCS code are displayed on the PFLD, the FLCS warning light illuminates, a flashing WARN is displayed in the HUD, and the voice warning message is activated. Caution level PFL's are associated with the FLCS, engine, and avionics system. When a caution level PFL occurs, the PFL message and system code are displayed on the PFLD, the appropriate system fault caution panel light illuminates, the MASTER CAUTION light illuminates, and the voice caution message is activated.

If multiple PFL's occur, they are displayed in the following priority order:

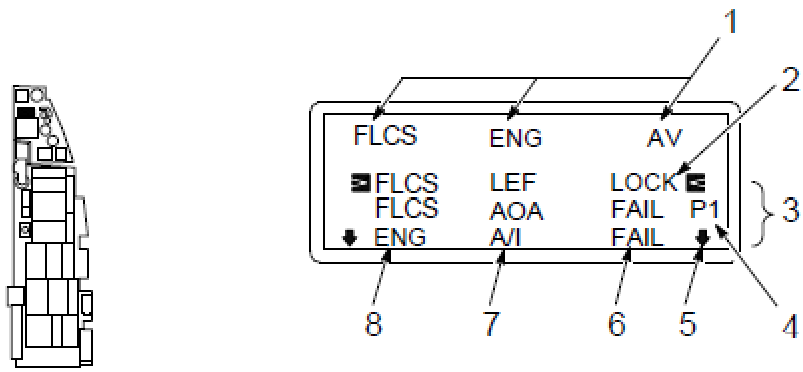
- FLCS warning level PFL's.
- FLCS caution level PFL's.
- Engine PFL's.
- Avionic PFL's.

Each page of the PFLD displays up to three PFL's. Additional pages are indicated by an arrow at each end of the bottom PFL and are accessed by depressing the **C** **DF** F-ACK, **DR** FAULT ACK button. Page numbers are also displayed when more than three PFL's are listed. PFL's are acknowledged and recalled by depressing the **C** **DF** F-ACK, **DR** FAULT ACK button. Acknowledging a caution level PFL clears it from the PFLD and extinguishes the associated caution panel light and MASTER CAUTION light (if not previously reset). Acknowledging a FLCS warning level PFL clears it from the PFLD; however, the FLCS warning light remains on. Subsequent depressions of the **C** **DF** F-ACK,**DR** FAULT ACK button perform fault recalls. At the time of a fault recall, PFL's that are no longer being reported as a failure within the originating system are not displayed and are cleared from memory.

The system code (FLCS, ENG, and/or AV) provides a real time indication of the presence of an active fault(s). If a code is displayed, there is at least one active PFL within the reported category. If no system codes are displayed, there are no active PFL's. Eliminating a FLCS failure condition by corrective action (e.g., FLCS reset) prior to fault acknowledgment removes all FLCS failure indications. For engine and avionic failure conditions and for FLCS failure conditions after fault acknowledgment, elimination of the failure condition will automatically remove/clear the system codes but not the PFL messages. Fault acknowledgment (if not previously accomplished) and fault recall are required to remove the PFL message(s). The PFLD blanks if the upfront controls fail.
The PFLD is powered by the nacelle essential ac bus.

All PFLD codes implemented in BMS are listed in the Dash-34 chapter 7.1.4.

Pilot Fault List Display

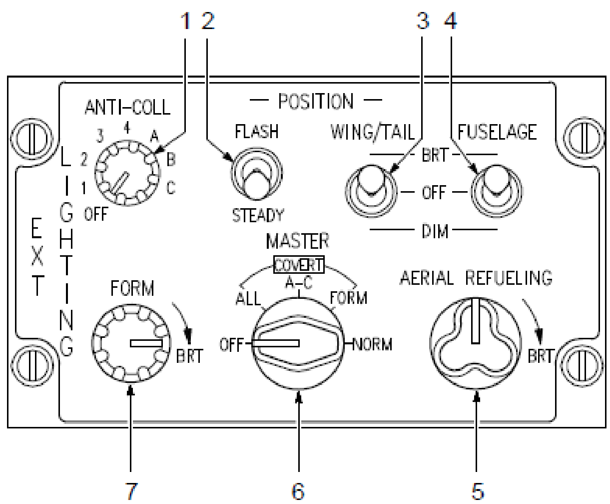


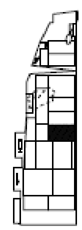
1. System Codes
2. Warning Indicator
3. PFL Message(s)
4. Page Number
5. Additional Page Indicator
6. Severity Indication
7. LRU or Function
8. Subsystem

20 LIGHTING SYSTEM

20.1 Exterior Lighting

All of the exterior lights except the landing and taxi lights are controlled from the EXT LIGHTING control panel.





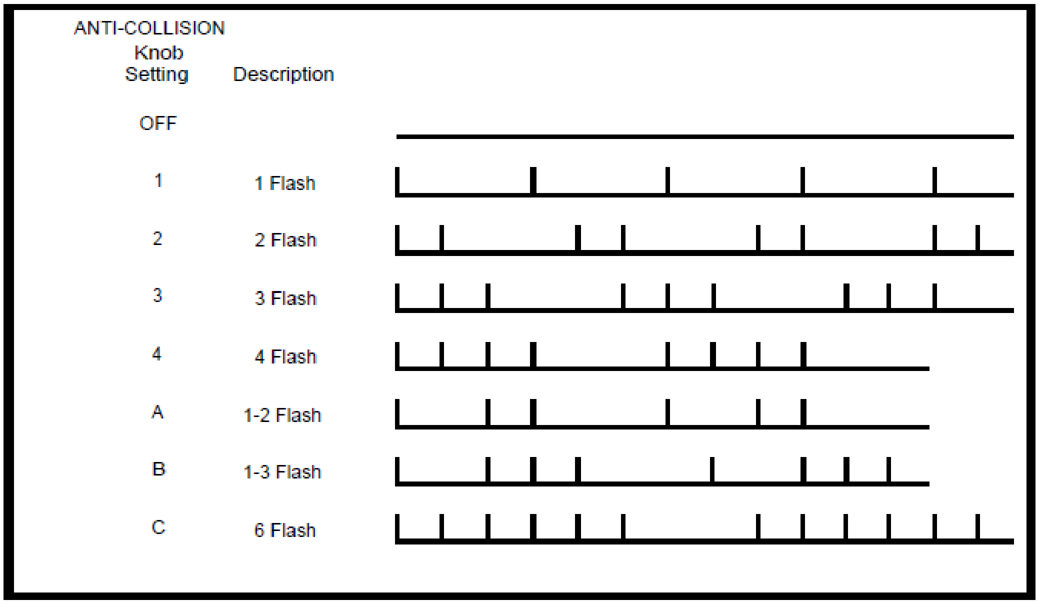
1. ANTI-COLL Pattern Knob
2. FLASH STEADY Switch
3. WING/TAIL Switch
4. FUSELAGE Switch
5. AERIAL REFUELING Knob
6. MASTER Knob
7. FORM Knob

		6. MASTER Knob			
CONTROL	POSITION	COVERT ALL	COVERT A/C	COVERT FORM	NORM
1. ANTI-COLL Knob	1, 2, 3, 4 A, B & C	Flashes set pattern (covert strobe)	Flashes set pattern (covert strobe)	Flashes set pattern (visible strobe)	Flashes set pattern (visible strobe)
	OFF	Off	Off	Off	Off
2. FLASH STEADY Switch	FLASH	All lights flash covert	All lights except the fuselage lights flash	All lights flash covert	All lights except the fuselage lights flash
	STEADY	All lights are covert steady	All lights steady	All lights are covert steady	All lights steady
3. WING/TAIL Switch	BRT	Upper wingtip, intake, upper formation, and tail lights on covert (lower wingtip and lower formation lights off)	Wing tip, intake, and tail lights on visible bright	Upper wingtip, intake, upper formation, and tail lights on covert (lower wingtip and lower formation lights off)	Wing tip, intake, and tail lights on visible bright

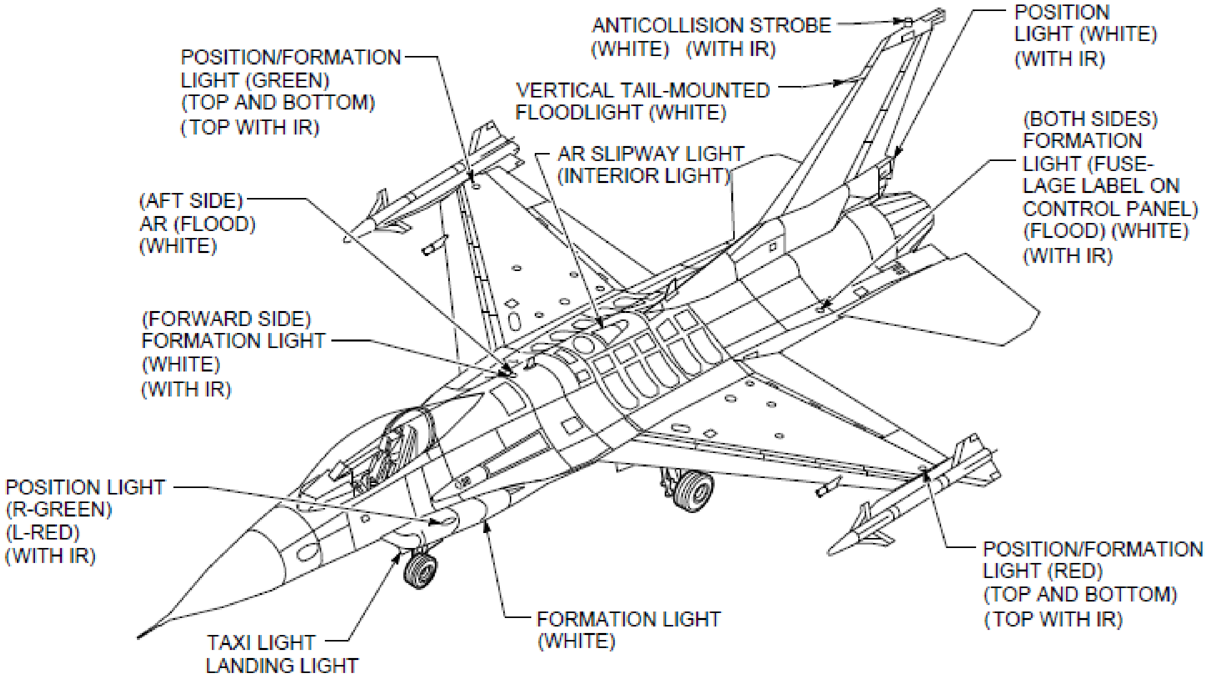
CONTROL	POSITION	6. MASTER Knob			
		COVERT ALL	COVERT A/C	COVERT FORM	NORM
3. WING/ TAIL Switch (Cont)	OFF	Wing tip, intake and tail lights off. Upper formation light covert bright	Intake and tail lights off. Wingtip lights controlled by FORM knob	Wing tip, intake and tail lights off. Upper formation light covert bright	Intake and tail lights off. Wingtip lights controlled by FORM knob
	DIM	Upper wingtip, intake, tail lights on covert dim. Upper formation light covert bright. (lower wingtip and formation lights off)	Wingtip, intake, and tail lights on visible dim	Upper wingtip, intake, tail lights on covert dim. Upper formation light covert bright. (lower wingtip and formation lights off)	Wingtip, intake, and tail lights on visible dim
4. FUSE- LAGE Switch	BRT	Fuselage lights covert bright	Fuselage lights visible bright	Fuselage lights covert bright	Fuselage lights visible bright
	OFF	Fuselage lights off	Fuselage lights off	Fuselage lights off	Fuselage lights off
	DIM	Fuselage lights covert dim	Fuselage lights visible dim	Fuselage lights covert dim	Fuselage lights visible dim
5. AERIAL REFUEL- ING Knob		Variable from off to bright	Variable from off to bright	Variable from off to bright	Variable from off to bright
7. FORM Knob		No effect	Controls formation lights (and wingtip lights when WING/ TAIL switch is in OFF) Variable from off to bright	No effect	Controls formation lights (and wingtip lights when WING/ TAIL switch is in OFF) Variable from off to bright

20.2 Anticollision Strobe Light

The anticollision strobe light is masked to minimize projections in the cockpit. The anticollision light has a strobe (visible to the unaided eye) as well as an infrared emitter (covert, visible to night vision devices but invisible to the unaided eye). The strobe is disabled, and the IR emitter enabled with the MASTER knob in COVERT ALL or COVERT A-C. The anticollision light can flash seven selectable patterns in each of four power supply switch settings.



20.3 30.3 Position/Formation Lights



20.4 Air Refueling Lights

The AR floodlight shares the housing of the top fuselage formation light. The light is directed aft to flood the receptacle, fuselage, wing, and empennage. The AR floodlight is not NVIS friendly. The AR slipway contains embedded lights on each side of the slipway. These lights are enabled when the AIR REFUEL switch is in OPEN. The intensity of these lights is controlled by the AERIAL REFUELING knob. These lights are not NVIS friendly.

20.5 Vertical Tail-Mounted Floodlight

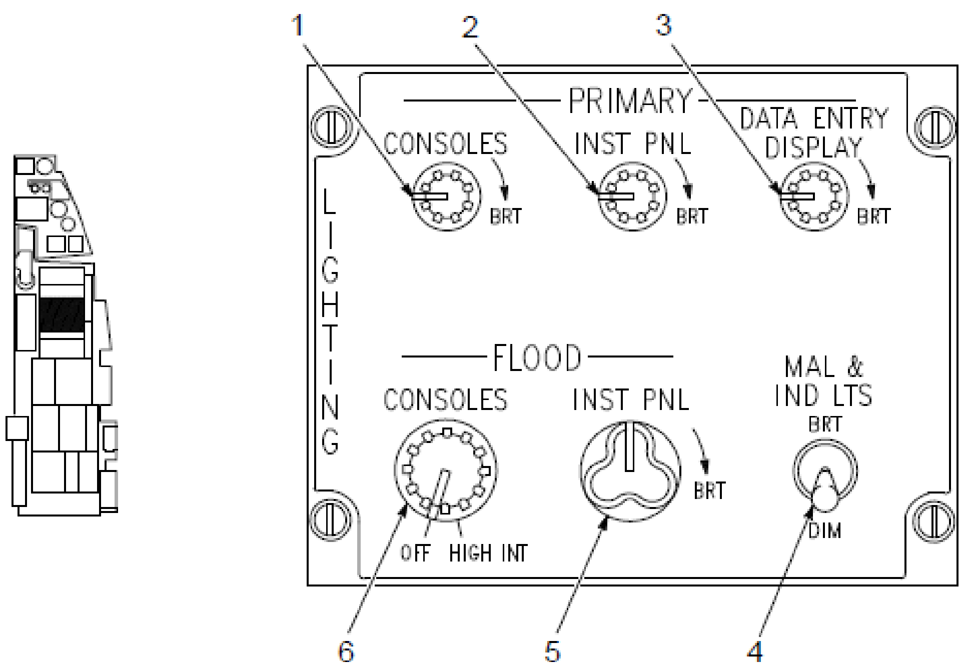
A white light is mounted on the upper leading edge of the vertical tail and is directed forward to flood the AR receptacle and upper fuselage. The light illuminates by the OPEN position of the AIR REFUEL switch. The floodlight is not NVIS friendly.

20.6 Landing and Taxi Lights

A white landing light and taxi light assembly is located on the NLG door. The landing light is angled to illuminate the landing area. The lights are turned on by the three-position LANDING TAXI lights switch located on the LG control panel. The switch has positions of LANDING, OFF, and TAXI. The light goes off during LG retraction if the switch is left in either the LANDING or TAXI position. The landing and taxi lights are not NVIS friendly.

20.7 Interior Lighting

The interior LIGHTING control panel contains the power and intensity controls for the primary (console and instrument) and secondary (flood) lighting systems for the cockpit. The HIGH INT position of the FLOOD CONSOLES knob provides thunderstorm lighting. The interior lighting system, with the exception of the utility light, functions normally except all lighting is NVIS green. Internal instrument lighting has been disabled and replaced with post and bezel NVIS friendly lighting. Secondary lighting has been equipped with NVIS green filters to eliminate IR light. Caution and warning lights have filters which limit IR emissions to be compatible with night vision goggles. All interior lighting (except for one position on the utility light) is NVIS friendly and invisible through the night vision goggles. Cockpit instruments must be viewed beneath the goggles.



1. PRIMARY CONSOLES Knob
2. PRIMARY INST PNL Knob
3. DATA ENTRY DISPLAY Knob
4. MAL & IND LTS Intensity Switch
5. FLOOD INST PNL Knob
6. FLOOD CONSOLES Knob

20.7.1 PRIMARY INST PNL KNOB

The PRIMARY INST PNL knob has a cw arrow pointing toward BRT. Rotating the knob cw varies the intensity of the forward instrument panel and right auxiliary console lighting from off to bright.

20.7.2 DATA ENTRY DISPLAY KNOB

The DATA ENTRY DISPLAY knob has a cw arrow pointing toward BRT. The knob controls the lighting of the Data Entry Display (DED) and PFLD from dim to bright.

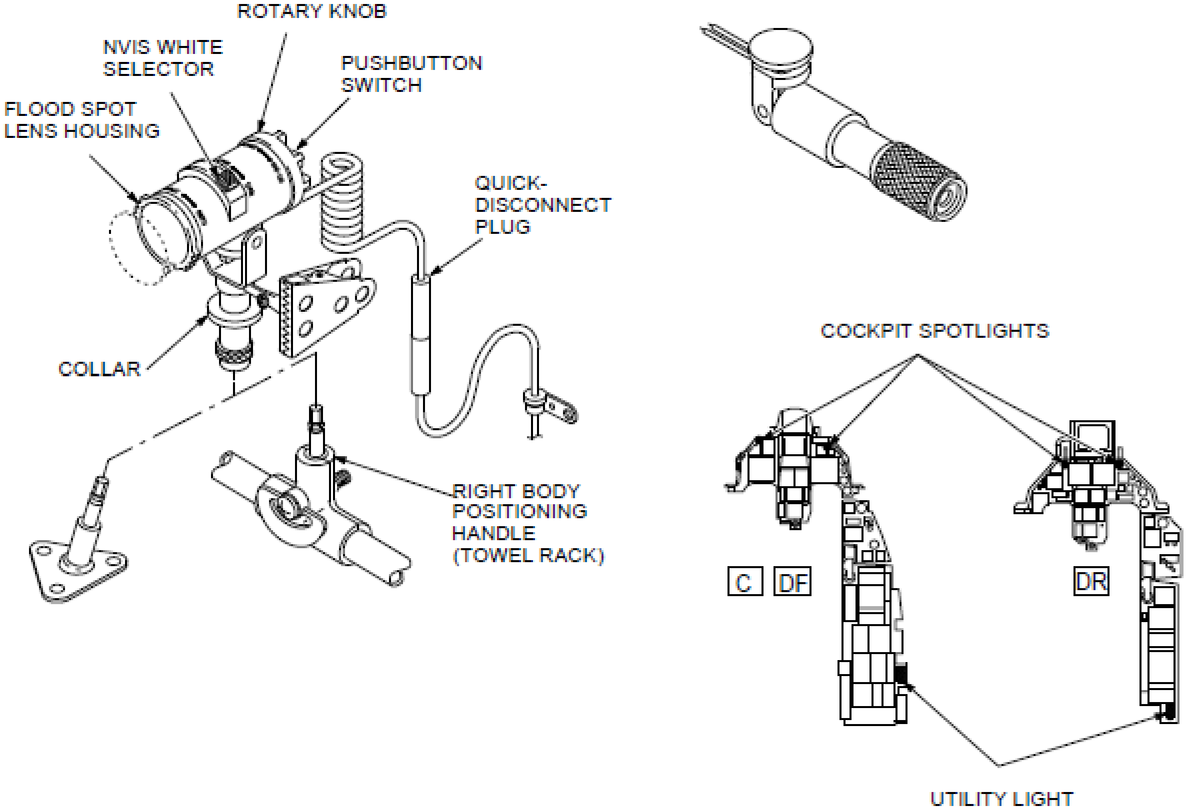
20.7.3 FLOOD INST PNL KNOB

The FLOOD INST PNL knob has a cw arrow pointing toward BRT. Rotating the knob cw varies the floodlights intensity from off to bright.

20.7.4 Cockpit Spotlights

The cockpit spotlights are located under the upper left and right glareshields. In the stowed position (horizontal, facing forward), the spotlight is off. The spotlight is turned on by pulling the spotlight barrel downward. Illumination intensity is controlled by turning the knurled barrel (dimmer). To turn the spotlight off, return it to the stowed position. Overrotation of the knurled barrel may cause breakage of the bulb or rheostat. The lights are powered by battery bus No. 1.

Utility Light and Spotlights (Typical)



21 ESCAPE SYSTEM

21.1 CANOPY

The canopy is a two-piece, plastic, bubble-type, transparent enclosure. The forward part is a single-piece windshield canopy transparency which is hinged at the aft end and is unlatched, opened, or closed/latched by an electrically operated actuator with a manual backup. A smaller fixed transparency fairs to the fuselage aft of the seat. The canopy may be jettisoned by internal controls for in-flight or ground escape and by external controls for ground rescue. An inflatable pressurization seal on the cockpit sill mates with the edge of the movable canopy. A noninflatable rubber seal on the canopy prevents the entry of water when the cockpit is not pressurized.

Bird Strikes are not implemented yet in BMS.

The canopy provides some bird strike protection. Bird strikes on centerline at approximately eye level may produce enough canopy deflection to shatter the HUD combiner glass and cause rearward propagation of a deflection wave. Deflection of the canopy in the area of the pilot's helmet has been observed to be 1 to 2 inches during bird strike tests that were considered successful. Successful completion of canopy bird strike testing (4-pound bird at 350 or 550 knots, depending on canopy) requires that the canopy not deflect more than 2 ¼ inches in the area of the pilot's helmet. This may be a consideration for adjusting seat height, especially while flying at lower altitudes with helmet-mounted equipment. Impacts off center may not shatter the HUD glass. High energy bird strikes may cause canopy penetration or larger deflection waves.

21.2 CANOPY CONTROLS AND INDICATORS

21.2.1 Manual Canopy Control Handcrank

An internal MANUAL CANOPY CONTROL handcrank manually performs the same function as the canopy switch. Due to the strength required to open the canopy with the handcrank, the method should be considered a last resort. An external flush-mounted CANOPY handcrank receptacle just opposite the inside manual drive is used for ground crew manual operation of the canopy.

21.2.2 Canopy Handle

The canopy handle, located on the canopy sill just forward of the throttle, hinges down to cover and protect the internal canopy switch. The handle also functions to inflate/deflate the canopy pressure seal, to turn the CANOPY warning light off/ on, and to mechanically prevent the canopy actuator from unlatching. The canopy handle should be in the up (unlock) position prior to lowering the canopy.

21.2.3 Ejection Seat

The ACES II ejection seat is a fully automatic emergency escape system. One of three ejection modes is automatically selected. Mode 1 is a low airspeed, low altitude mode during which the recovery parachute assembly is deployed almost immediately after the ejection seat departs the aircraft. Mode 2 is an intermediate airspeed, low altitude mode during which a drogue chute is first deployed to slow the ejection seat followed by the deployment of the recovery parachute assembly. Mode 3 is a high airspeed/high altitude mode in which the sequence of events is the same as mode 2, except that automatic pilot/seat separation and deployment of the recovery parachute assembly are delayed until safe airspeed and altitude are reached. Controls are provided to adjust seat height and lock shoulder harness.

21.2.4 Ejection Handle

The ejection handle (PULL TO EJECT) is sized for onehanded or two-handed operation and requires a pull of 40-50 pounds to activate. The handle remains attached to the seat by a wire cable after activation.

21.2.5 Ejection Safety Lever

The ejection safety lever mechanically safeties (in the up/ vertical position) or arms (in the down/horizontal position) the seat ejection handle.

21.2.6 SEAT NOT ARMED Caution Light

The SEAT NOT ARMED caution light, located on the caution light panel, illuminates when the ejection safety lever is in the up (vertical) position.

21.2.7 SEAT ADJ Switch

The SEAT ADJ switch is located on the right cockpit sidewall outboard of the stick. Center position is spring-loaded off. The up position raises the seat, while the down position lowers the seat. The seat adjustment motor is protected by a thermal relay which interrupts electrical power when overheated. After a 1-minute cooling period, the motor should operate normally. The motor is powered by nonessential ac bus No. 1.

21.2.8 Survival Kit (Not visible)

The survival kit is stowed under the seat pan lid. The KIT DEPLOYMENT switch has a manual (aft) or automatic (forward) position which selects the mode of postejection survival kit deployment. Pulling the kit ripcord handle deploys the kit which remains attached by a 25-foot lanyard.

21.3 Ejection Seat operation

Seat ejection is initiated by pulling the ejection handle (PULL TO EJECT). This action retracts the shoulder harness straps and locks the inertia reel, fires the initiators for canopy jettison, and ignites two canopy removal rockets. As the canopy leaves the aircraft, lanyards fire two seat ejection initiators. A rocket catapult propels the seat from the cockpit exposing the seat environmental sensor pitots and activating the emergency oxygen. The recovery sequencer selects the correct ejection mode, ignites the stabilization package (STAPAC) rocket and the trajectory divergence rocket, and (if in mode 2 or 3) initiates the drogue gun. If the automatic pilot/seat separation and recovery parachute deployment system fails, pulling the EMERGENCY MANUAL CHUTE handle approximately 6 inches ballistically deploys the recovery parachute assembly and releases the lapbelt and inertia reel straps and unlatches the seat pan lid. The liferaft, survival kit, and radio beacon antenna are deployed following pilot/seat separation when the survival KIT DEPLOYMENT switch is in AUTO. If the parachute is equipped with UWARS, the parachute risers are automatically released approximately 2 seconds after entering saltwater. Seat ejection also automatically performs an escape zeroize operation by purging coded electronic information associated with the following equipment:

• DTC.

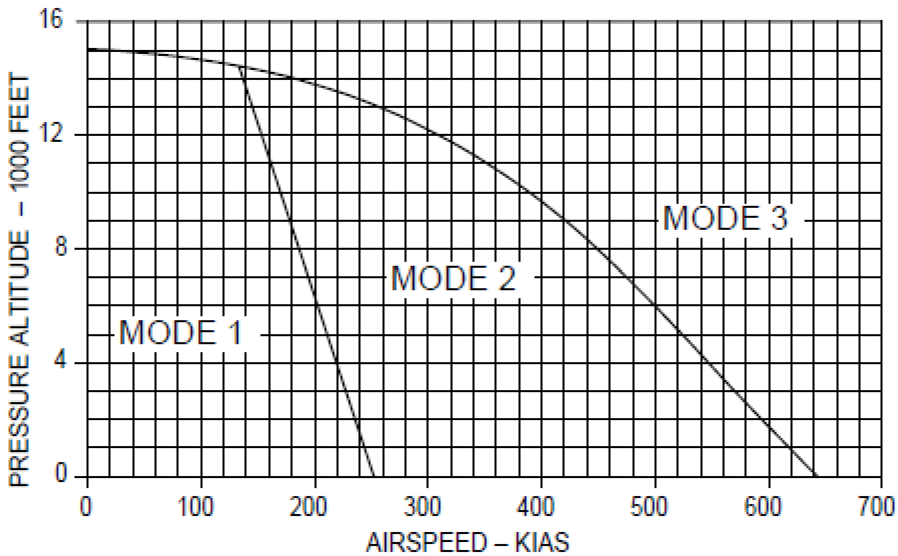
• MMC. - Secure voice.

• IFF mode 4. • IDM.

• 220 GPS/EGI. • RWR

21.4 Ejection Mode Envelopes

It is to be noted that although BMS won't simulate yet the whole real-life limitations on the pilot in the ejection sequence and the mechanical limitations, it is interesting for hardcore simulator users to implement the limitations and have a good knowledge on the operational envelope of the system.

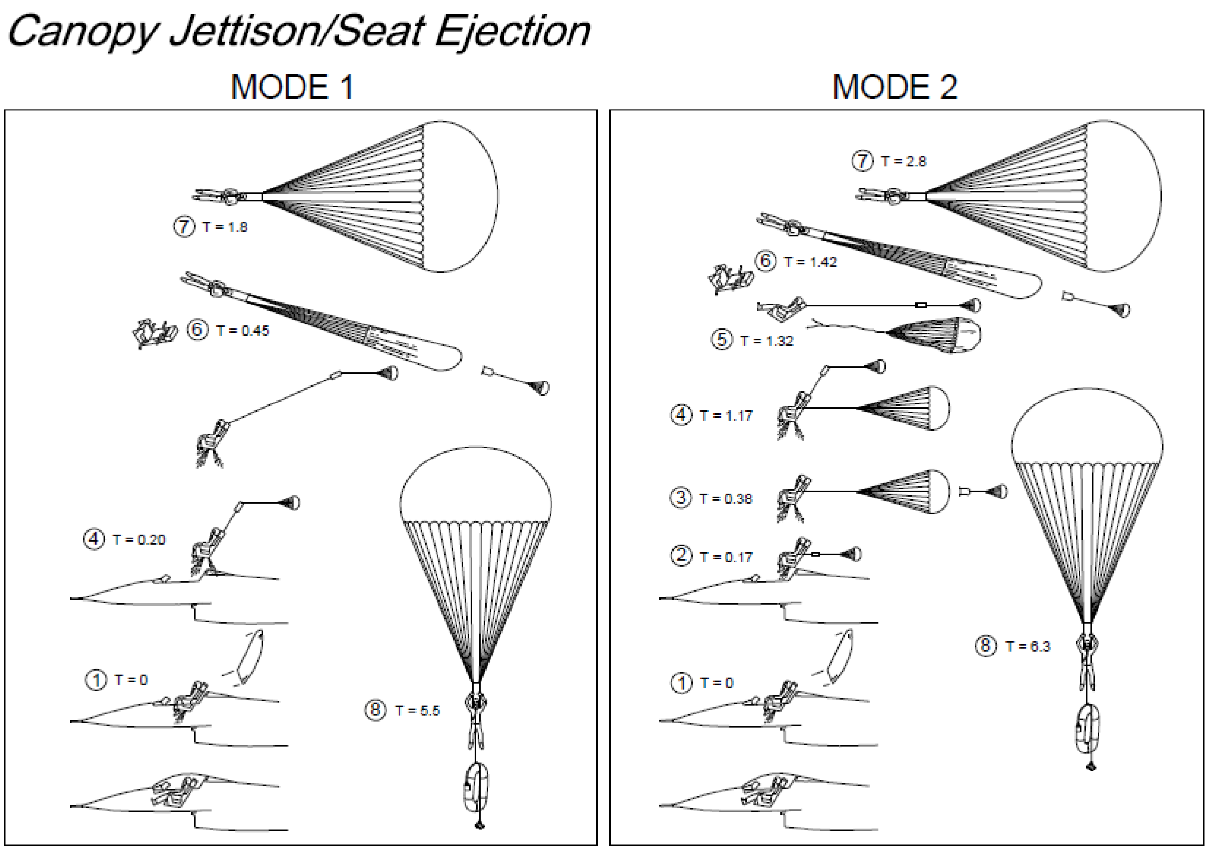


21.5 Ejection Sequence Times

Ejection Sequence Times

	EVENT	TIME (SECONDS) Mode 1	TIME (SECONDS) Mode 2
NOTE • In mode 3, events after drogue deployment are delayed until within mode 2 envelope. Recovery parachute deploys 1 second after entering mode 2 envelope. • [D] Times in the aft/forward sequence increase to include a 0.33-second delay for the rear seat and a 0.73-second delay for the forward seat. In SOLO, the forward seat is delayed 0.33 second. • Canopy jettison time varies from 0.75 second at 0 KIAS to 0.13 second at 600 KIAS. Ejection begins when canopy jettison initiates seat lanyards.	1. Catapult Initiation	0.0	0.0
	2. Drogue Gun Fired	NA	0.17
	3. Drogue Chute Inflated	NA	0.38
	4. Parachute Fired	0.20	1.17
	5. Seat/Drogue Separation	NA	1.32
	6. Pilot/Seat Separation	0.45	1.42
	7. Recovery Parachute Inflated	1.8	2.8
	8. Survival Kit Deployed	5.5	6.3

21.6 Canopy Jettison/Seat Ejection



22 OXYGEN SYSTEM

The oxygen system in BMS 4.37 is only partially implemented. The virtual pilot will experience hypoxia (visual cues) if the Oxygen system is not turned on. For now, there won't be any description of the Oxygen system for now in the BMS -1.

23 COMMUNICATIONS, NAVIGATION, AND IFF (CNI) EQUIPMENT

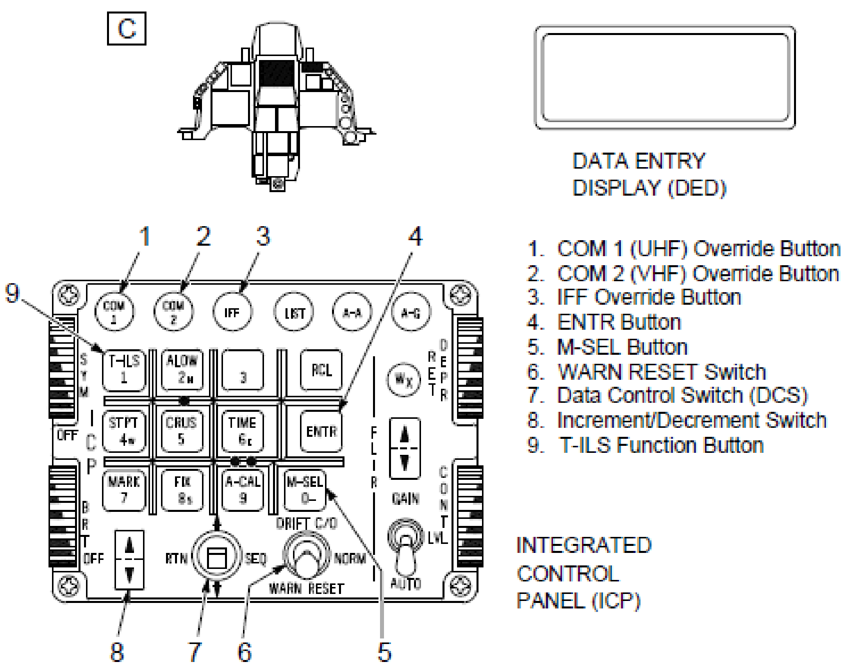
Cockpit controls for CNI equipment are divided between control units on the consoles and the upfront controls located on the instrument panel. Controls for less frequently used functions, such as power and audio volume, and essential functions, such as communications backup and guard, are located on console panels. Controls for frequently used functions are located on the upfront controls to permit head-up control during flight.

23.1 UPFRONT CONTROLS

The upfront controls provide a simplified, centralized, head-up means of controlling the most frequently used functions of the communications system, navigation systems, and IFF. The upfront controls consist of the data entry display (DED), **C** **DF** the integrated control panel (ICP), and **DR** the integrated keyboard panel (IKP). The upfront controls are powered by emergency dc bus No. 2 and emergency ac bus No.2.

23.2 DED/CNI READOUTS

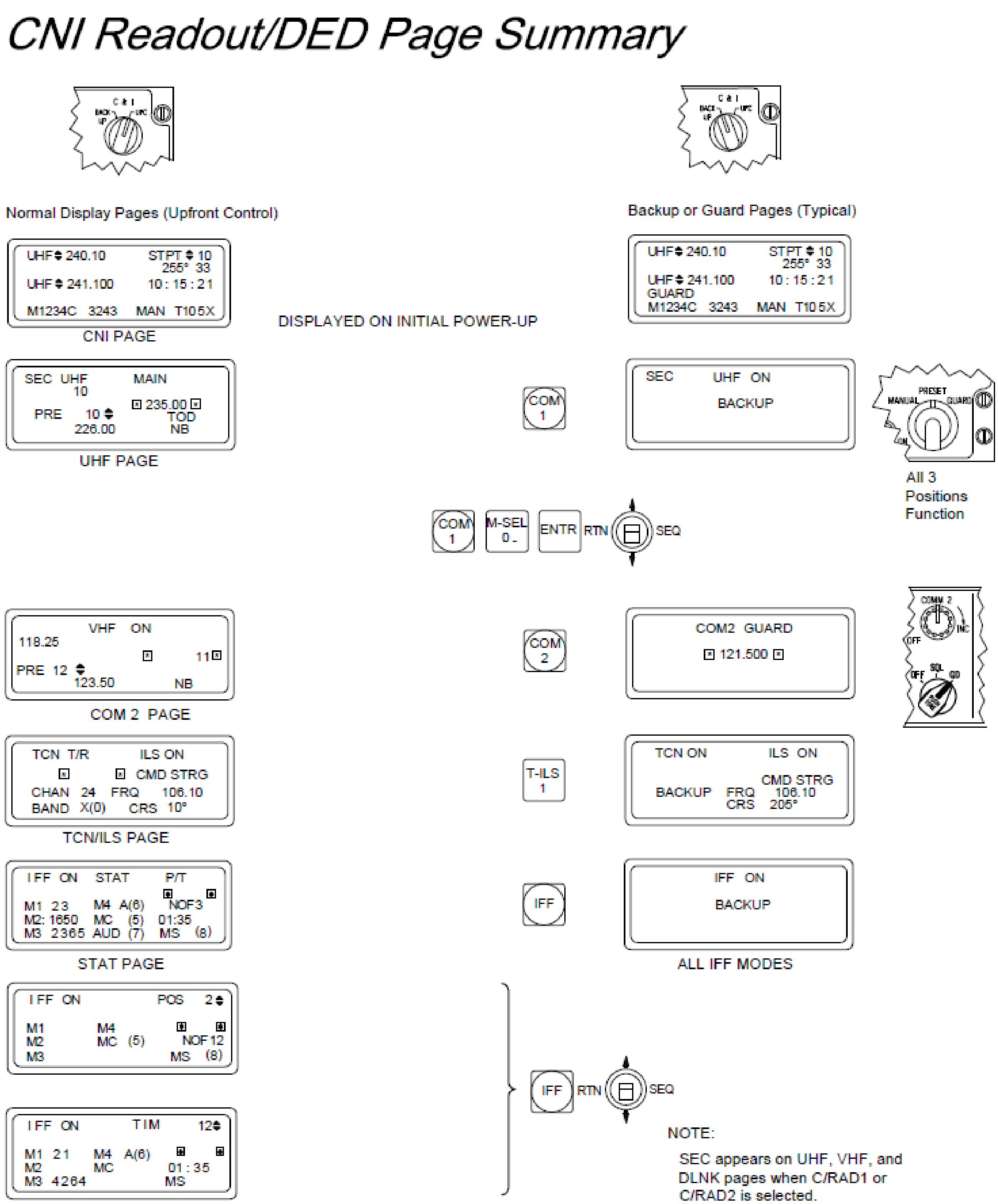
Upfront Controls (Typical)



The DED is an integral part of the upfront controls and provides a visual display of the switch actions made via upfront controls. The primary readouts of communication, navigation, and IFF systems are included in the page selections available for display on the DED. Channel, frequency, mode, and code selections of UHF, VHF, TACAN, ILS, and IFF are presented when the appropriate page is selected. INS/EGI present position and steerpoint data may be selected for display on the DED.

Displays for UHF, TACAN, and IFF show the word BACKUP when the C & I knob is in BACKUP. The word GUARD appears on UHF and VHF pages when guard is selected. The current state of CNI operation is shown on the DED and is automatically displayed on initial power up of the upfront controls or may be selected by positioning the data control switch (DCS) to RTN momentarily.

24 CNI READOUT/DED PAGE SUMMARY



The CNI page displays data concerning the UHF (COM 1), VHF (COM 2), steerpoints, IFF, system time, and TACAN.

The CNI page displays its data on five lines. The first line displays information concerning the UHF radio mode, preset channel or manual frequency, and current steerpoint number.

The label at the far left indicates the radio mode (either UHF or HQ). UHF is displayed when the normal mode is selected; HQ is displayed when the AJ mode is selected. The UHF/HQ label is highlighted when the UHF VHF IFF transmit switch is keyed to UHF. Adjacent to the mode label is the preset UHF channel if one is selected. If a preset channel is not selected, this area contains the manual frequency.

The right side of the first line displays navigation information. If a steerpoint is selected, STPT is displayed. If an initial point is selected, IP is displayed. Adjacent to the steerpoint label is the number of the current steerpoint.

The left side of the second line displays the status of the UHF radio and default value indication. During normal operation, this area is blank.

OFF, BUP, and GRD are other indications of UHF radio status. OFF is displayed when the power is turned off with the COMM 1 power knob. When BACKUP or GUARD is selected, BUP or GRD is displayed. The middle area of line two is blank during normal operation. If the upfront controls memory is lost, the upfront controls revert to default values and DFLT is displayed in the middle of line two.

DFLT is displayed if UFC memory is lost, and the UFC automatically uses default values. The right side of the second line can display wind direction and velocity. When the SEQ position of the DCS is activated, wind direction (referenced to magnetic north) and velocity, in knots, is displayed. When the SEQ position of the DCS is again activated, wind data is blanked. If wind data is displayed when the CNI page is exited, wind data is displayed when the CNI page is reentered. Wind data is not displayed upon UFC power-up.

The third line displays VHF (COM 2) function, preset channel or manual frequency, and system time. The left side of line three always displays the radio mode label VHF. When the UHF VHF IFF transmit, switch is keyed to VHF, the VHF label is highlighted. Adjacent to the VHF label is the active preset channel or manual frequency number. The right side of line three shows system time. The fourth line displays the status of the VHF radio. A blank area indicates normal operation. OFF indicates that the power is off, and GRD indicates that GUARD has been selected. The right side of the fourth line also displays hack time anytime the stopwatch is activated.

The fifth line displays IFF and TACAN information. The area at the far-left displays IFF modes selected. M, which stands for mode, is always displayed; 1, 2, 3/A, C, and 4 are displayed when the corresponding mode is selected. When a mode 4 reply is issued, the 4 is highlighted. The next area of line five displays the four-digit code associated with IFF mode 3/A.

The next area displays IFF status.

OFF, STBY, BUP, POS, TIM, P/T, MAN, and DEG are indications of IFF status.

OFF is displayed when the power is turned off with the IFF MASTER knob.

When STBY or BACKUP is selected, STBY or BUP is displayed.

POS, TIM, or P/T is displayed when an automatic transponder switching function is selected.

MAN is displayed when no automatic transponder switching function is selected. A blank space is displayed when no automatic transponder switching function is selected.

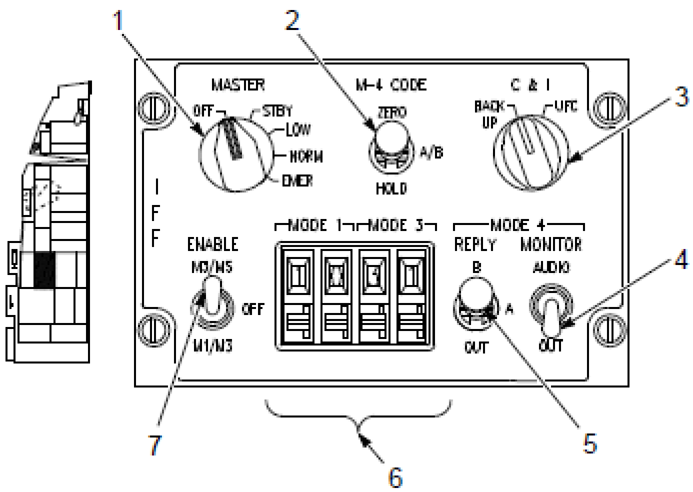
DEG is displayed when MUX BUS communication between the upfront controls and the MMC is lost. The right-side displays TACAN channel number and band.

TACAN channel number and band are not displayed when TACAN radio is off or in backup. The CNI readout/DED page summary displays IFF modes 1, 3, C, and 4 selected, 4264 (MODE 3 code), AUTO (automatic transponder switching function), T123 (TACAN channel number), and X (TACAN band). For a detailed description of air-to-air TACAN, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.4.

To change preset channels or steerpoint numbers, the up/down triangles must be next to the item to be changed. When the DCS is positioned up or down, the up/down triangles move between the steerpoint and the UHF and VHF preset channels. With the up/down triangles next to the desired item, the steerpoint/channel can be changed by depressing the increment/ decrement switch until the desired steerpoint or channel is selected. If a manual frequency is selected, the triangles are displayed but are not functional. The up/down triangles are displayed at the steerpoint number during initial upfront control power-up.

For a detailed description of UHF, VHF, IFF, TACAN, and ILS operation using the upfront controls, refer to COMMUNICATIONS SYSTEM, this section.

24.1 IFF CONTROL PANEL



1. IFF MASTER Knob
2. IFF M-4 CODE Switch
3. C & I Knob
4. IFF MODE 4 MONITOR Switch
5. IFF MODE 4 REPLY Switch
6. IFF MODE 1/MODE 3 Selector Levers
7. IFF ENABLE Switch

C & I (Communications and IFF) Knob

Functions are:

• BACKUP - In the event of failure of the upfront controls, the BACKUP position provides for alternate operation of the UHF and IFF. BACKUP may be selected, when desired, even when upfront controls are functioning.

• UFC - Provides for normal control of communications, navigation, and IFF primarily via upfront controls. Refer to UPFRONT CONTROLS, this section.

24.1.1 IFF MASTER KNOB

The IFF MASTER knob functions with the C & I knob in BACKUP or UFC.

Functions are:

• OFF - Removes power from the IFF equipment and zeroizes mode 4 settings unless HOLD function has been used. The knob must be lifted to position to or from OFF.

• STBY - The equipment is turned on and warmed up but does not transmit.

• LOW - Same as NORM.

• NORM - Full range recognition and reply occur.

• EMER - The knob must be lifted to position to EMER.

When so positioned, an emergency-indicating pulse group is transmitted each time a mode 1, 2, or 3/A interrogation is recognized. IFF replies to mode S interrogations with an alert condition.

IFF M-4 CODE Switch

The IFF M-4 CODE switch has three positions. It is spring-loaded to center (A/B) from HOLD and is lever locked in ZERO position.
Functions are:

• ZERO - Zeroizes mode 4 settings whenever IFF MASTER knob is not OFF.

• A/B - A/B position permits code selection via upfront controls or via IFF MODE 4 REPLY switch when C & I knob is in BACKUP.

• HOLD - Both code settings can be retained after flight by placing the IFF M4 CODE switch to HOLD momentarily prior to placing the IFF MASTER knob to OFF or removing power.

24.1.2 IFF MODE 4 REPLY SWITCH

The IFF MODE 4 REPLY switch has three positions and is used when the C & I knob is in BACKUP.
Functions are:

• OUT - Mode 4 operation is disabled.

• A - Enables mode 4 and selects the preset code for A.

• B - Enables mode 4 and selects the preset code for B.

24.1.3 IFF MODE 4 MONITOR SWITCH

The IFF MODE 4 MONITOR switch permits audio monitor of mode 4 replies when the C & I knob is in BACKUP.

Functions are:

• AUDIO – Monitoring of mode 4 interrogations is provided by an audio tone on the intercom. An audio tone of 0 to 1000 Hz is generated when the transponder is not replying to valid mode 4 interrogations. The frequency of the tone depends on the number of interrogations received. i.e., the higher the number of interrogations, the higher the frequency.

• OUT - Disables audio monitor.

24.1.4 IFF ENABLE SWITCH

The IFF ENABLE switch permits mode selection in BACKUP. Functions are:

• M3/MS - Modes 3/A and S enabled in backup.

• OFF - Modes 1, 3/A and S disabled in backup.

• M1/M3 - Modes 1 and 3/A enabled in backup.

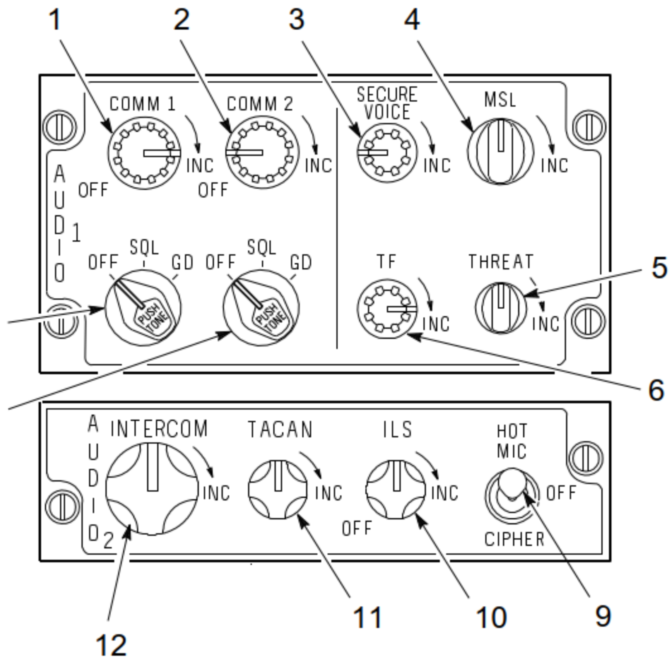
24.1.5 IFF MODE 1/MODE 3 SELECTOR LEVERS

The MODE 1 code selector levers are incremented/decremented to select the two-digit code displayed in the readout windows. The two left-most windows display the mode 1 code digits when the C & I knob is in BACKUP.

The Mode 3/A code selector levers are incremented/decremented to select the two-digit code displayed in the readout windows. The two right-most windows display the two most significant mode 3/A backup code digits when the C & I knob is in BACKUP. The two least significant digits are always set to zero. For example, if the windows are set to 77, the transmitted mode 3/A code is 7700.

24.2 AUDIO 1 & 2 CONTROL PANEL

The AUDIO 1 control panel provides control of less frequently used functions of the communications system. Except as noted, controls are active regardless of the position of the C & I knob.



1. COMM 1 (UHF) Power Knob
2. COMM 2 (VHF) Power Knob
3. SECURE VOICE Knob
4. MSL Tone Knob
5. THREAT Tone Knob
6. TF Tone Knob
7. COMM 2 (VHF) Mode Knob
8. COMM 1 (UHF) Mode Knob
9. HOT MIC CIPHER Switch
10. ILS Power Knob
11. TACAN Knob
12. INTERCOM Knob

24.2.1 COMM 1 (UHF) Power Knob

The COMM 1 power knob has an OFF position and a cw arrow pointing to INC. The OFF position removes power from the UHF,radio. Rotating the knob cw applies power and increases UHF audio volume.

24.2.2 COMM 1 (UHF) Mode Knob

The COMM 1 mode knob has three positions and may be depressed in any of the three positions. Depressing the knob interrupts reception and transmits a tone signal and TOD for
HQ on the selected frequency.
Functions are:

• OFF - Disables squelch circuit to permit reception of a weak signal.
• SQL - Enables squelch circuit to help reduce background noise in a normal operation.

• GD - The main receiver and transmitter are automatically tuned to the guard frequency and the guard receiver is disabled. GD position is not functional with C & I knob in BACKUP.

24.2.3 COMM 2 Power Knob

The COMM 2 power knob has an OFF position and a cw arrow pointing to INC. The OFF position removes power from the VHF radio. Rotating the knob cw applies power and increases VHF audio volume.

24.2.4 COMM 2 Mode Knob

The COMM 2 mode knob has three positions and may be depressed to transmit a VHF tone in any of the three positions. The COMM 2 mode knob may not function during certain failures of the upfront controls.

Functions are:

• OFF - Disables squelch circuit to permit reception of a weak signal.
• SQL - Enables squelch circuit to help reduce background noise in normal operation. (Not implemented yet)

• GD - The main receiver and transmitter are automatically tuned to the guard frequency.
• Monitoring and volume control of voice communication between pilot and ground crew or between pilot and tanker boom operator, monitoring and volume control of AIM-9 missile tone, TWS composite audio tone, and TWS missile launch tone.
• Monitoring of systems individually volume controlled from the audio control panels.
• Monitoring of fixed volume warning tones (LG and low speed warning tone, TWS missile launch tone, and IFF mode 4 audio monitor) and voice messages.

24.2.5 THREAT Tone Knob

The THREAT tone knob has a cw arrow pointing to INC. CW rotation increases the volume of the TWS composite tone.

24.2.6 ILS Power Knob

The ILS power knob has an OFF position and a cw arrow pointing to INC. The OFF position removes power from the ILS receiver. Rotating the knob cw applies power and increases the volume of the localizer identification signal. The ILS may not function during certain failures of the upfront controls.

24.2.7 TACAN Knob

The TACAN knob on the AUDIO 2 control panel has a cw arrow pointing to INC. Rotating the knob increases the volume of the TACAN station identification signal. TACAN power is applied through the MIDS LVT knob on the AVIONICS POWER panel. When the MIDS is not turned on, TACAN OFF will be displayed on the MFD TCN page and TCN OFF will be displayed on the T-ILS DED page.

24.2.8 INTERCOM Knob

The intercom provides the following functions:

- Monitoring and volume control of AIM-9 missile tone.
- TWS composite audio tone.
- TWS missile launch tone.

24.2.9 VHF RADIO

The VHF radio provides line-of-sight voice communication. VHF transmissions are made by holding the UHF VHF IFF transmit switch on the throttle to the VHF position. Transmission and reception are available for AM from 116.000–151.975 MHz and for FM from 30.000–87.975 MHz. Only reception is available from 108.000–115.975 MHz. Twenty channels may be preset. Operation may be either on narrow band or wide band. Narrow band is used for all normal operations. Power, volume, squelch, guard, and tone controls for the VHF radio are located on the AUDIO 1 control panel. Other VHF radio functions are controlled by the upfront controls. There are no backup controls. In the event of certain failures of the upfront controls, the VHF radio may remain on the last frequency set prior to the failure. The VHF radio is powered by emergency dc bus No. 1.

24.2.9.1 Operation of the VHF Radio on Upfront Controls

To change VHF preset channels on the CNI page, refer to CNI READOUT/DED PAGE SUMMARY, this section. The VHF page is selected by depressing the COM 2 override button on the upfront controls.

Functions available on the VHF page are:

• Changing preset channels and manual frequencies.

• Channelizing frequencies.

• Changing bandwidth.

The VHF page displays its data on five lines. The first line contains information about secure voice status, radio mode, and radio status. The display SEC appears when secure voice is selected. The radio mode always displays VHF for normal operation. The radio status is displayed as ON or OFF;

however, the ON and OFF functions can only be controlled via the AUDIO 1 control panel. The second line displays active frequency or preset channel. Line three displays the data entry scratchpad, which is a five-digit area highlighted by two asterisks. The scratchpad is used to change either channels or manual or active frequencies, and it displays the channel/ frequency not currently being used.

When the VHF page is first selected, the scratchpad is displayed in one of two ways:
If the radio is operating on manual frequency, the scratchpad displays preset channel entry or if the radio is operating on preset channels, the scratchpad displays manual or active frequency entry. The fourth line contains the label PRE and a preset channel number. The label PRE is highlighted when the radio is tuned to a preset channel. Line five displays the frequency associated with the preset channel. The fifth line also shows the selected bandwidth, which is displayed as either narrow band (NB) or wide band (WB). (Bandwidth selection is not implemented).

Changes on the VHF page are made by use of the asterisks and the keyboard or the increment/decrement switch, depending on the change. Asterisks (*135.00*) are moved by up/down movement of the DCS through the following locations:

scratchpad, bandwidth, manual frequency, preset channel number, preset channel frequency designation, and back to the scratchpad. Information enclosed with asterisks may be changed as described under OPERATION OF THE UHF RADIO ON UPFRONT CONTROLS, this section. The preset channel may be changed by using either the increment/ decrement switch (note the up/down triangles next to the preset channel number) or by use of the asterisks and the keyboard. When operating on guard frequency, AM or FM selections are available on the VHF page. To switch from AM to FM or FM to AM, depress any ICP/IKP key (1-9).

24.2.10 UHF/VHF RADIO

The UHF/VHF ARC-210 radio provides line-of-sight voice communication in normal, secure voice and anti-jam modes (HAVE QUICK, HAVE QUICK II and SINCGARS). Secure and Anti-Jam modes are not implemented for now in BMS.

UHF/ VHF transmissions are made by holding the UHF VHF IFF transmit switch on the throttle to the VHF position. UHF transmission and reception are available for AM from 225.000-399.975 MHz and FM from 400.000-511.975 MHz. VHF transmission and reception are available for AM from 118.000-155.975 MHz and for FM from 30.000-87.975 and from 156.000-173.975 MHz. Reception only in AM is available from 108.000-117.975 MHz. Twenty channels may be preset in MAN mode and twenty-five in AJ mode. Power, volume, squelch, guard, and tone controls for the UHF/VHF radio are located on the AUDIO 1 control panel. Other UHF/ VHF radio functions are controlled by the upfront controls. There are no backup controls. In the event of certain failures of the upfront controls, the UHF/VHF radio may remain on the last frequency set prior to the failure.

Until a software update is made, transmissions on UHF guard (243.000 MHz) are not readable; transmissions on VHF guard (121.500 MHz) are normal.

The UHF/VHF radio is powered by the nonessential dc bus and requires power from emergency ac bus No. 2 and emergency dc bus No. 2 for operation on upfront control.

24.2.10.1 Operation of the UHF/VHF Radio on Upfront Controls

To change UHF/VHF preset channels on the CNI page, refer to CNI READOUT/DED PAGE SUMMARY, this section. The COM 2 page is selected by depressing the COM 2 override button on the upfront controls.

Functions available on the COM 2 page are:

• Changing preset channels and manual frequencies.

• Channelizing frequencies.

• Changing bandwidth.

• Changing COMSEC mode.

• Changing COMSEC key.

• Changing Receiver mode.

• Changing Radio mode.

• Time of Day (TOD) selection
.
• Low Battery indication.

The COM 2 page displays its data on five lines:

The first line displays information about COMSEC, the COMSEC key, the UHF/VHF radio mode and status. The radio status is displayed as OFF, MAIN, or BOTH; however, the ON and OFF functions can only be controlled via the AUDIO 1 control panel.

The second line is divided into two areas. The first area displays active frequency or preset channel. The second area displays the AM/FM rotary. The third line is divided into two areas. The first area contains the label PRE and a preset channel number. The label PRE is highlighted when the radio is tuned to a preset channel. The second area contains the data entry scratchpad, which is a five or six-digit area highlighted by two asterisks. The scratchpad is used to change either channels or manual or active frequencies, and it displays the channel/frequency not currently being used. When the UHF/VHF page is first selected, the scratchpad is displayed in one of two ways: (1) If the radio is operating on manual frequency, the scratchpad displays preset channel entry. (2) If the radio is operating on preset channels, the scratchpad displays manual or active frequency entry.

The fourth line contains the preset frequency and the preset modulation. The fifth line is divided into three areas. The first area contains the preset frequency name. The second area contains the Low Battery Indication (LBI). The third area contains the Time of Day (TOD) selection.
Changes on the COM 2 page are made by use of the asterisks and the keyboard or the increment/decrement switch, depending on the change. Asterisks (*135.00*) are moved by up/down movement of the DCS through the following locations: scratchpad, bandwidth, manual frequency, preset channel number, preset channel frequency designation, and back to the scratchpad. The preset channel may be changed by using either the increment/decrement switch (note the up/ down triangles next to the preset channel number) or by use of the asterisks and the keyboard. When operating on guard frequency, AM or FM selections are available on the COM 2 page. To switch from AM to FM or FM to AM, depress any ICP/IKP key (1–9).

24.3 ANT SEL PANEL

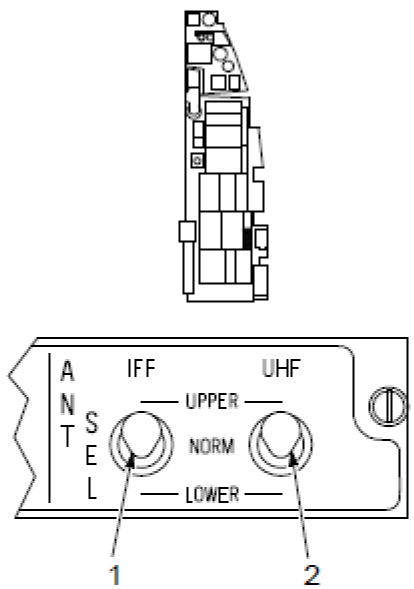
The ANT SEL panel allows selection of various antennas for optimum transmission and reception of IFF and UHF signals.

24.3.1 IFF ANT SEL SWITCH

The IFF ANT SEL switch is a three-position switch. Functions are:

• UPPER - Upper antenna is used to receive and reply to interrogation signals.

• LOWER - Lower antenna is used to receive and reply to interrogation signals.



1. IFF ANT SEL Switch
2. UHF ANT SEL Switch

24.3.2 UHF ANT SEL SWITCH

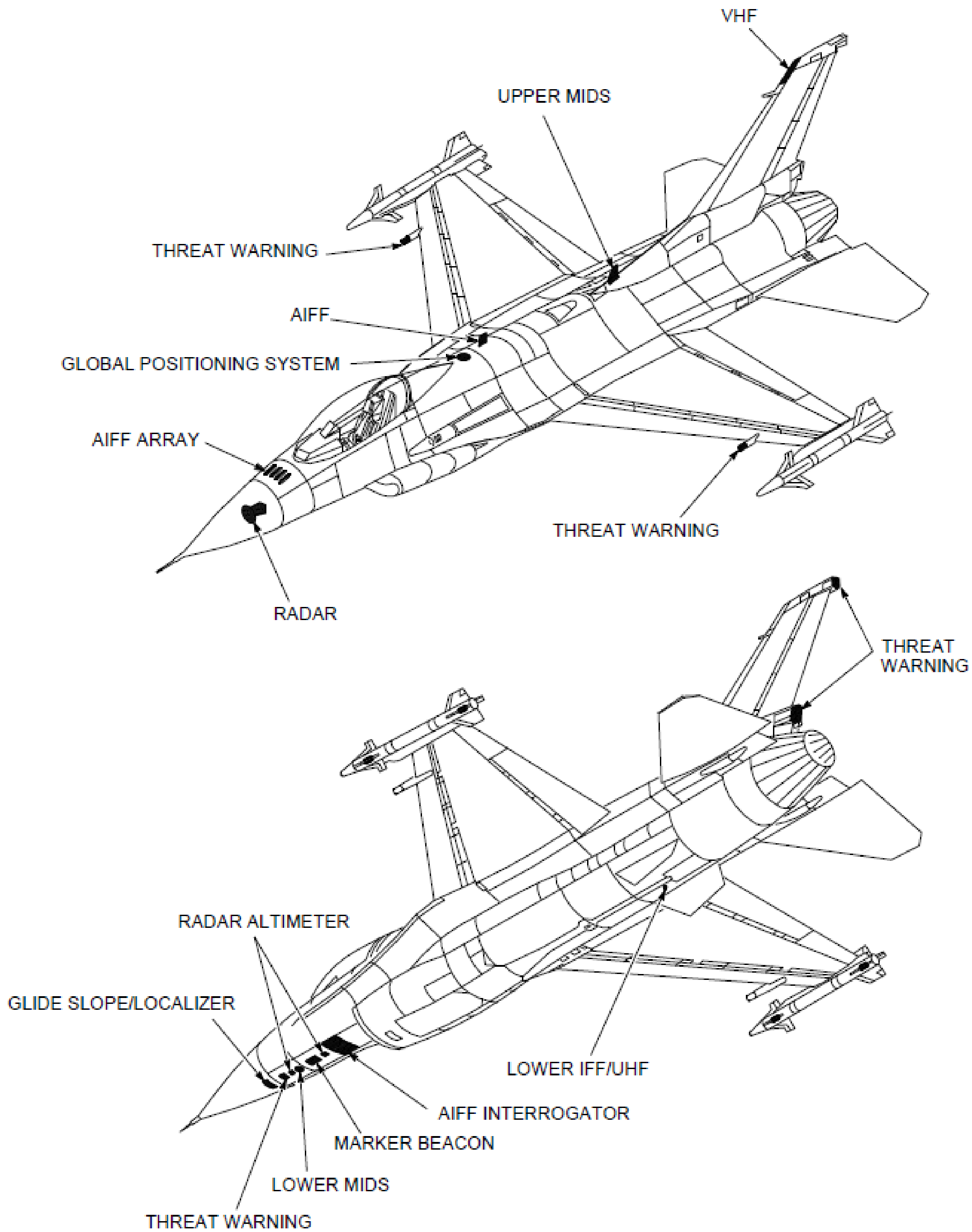
The UHF ANT SEL switch is a three-position switch.
Functions are:

• UPPER - Upper antenna is used to receive and transmit signals.

• NORM - The antennas cycle between upper and lower to provide omnidirectional antenna pattern.

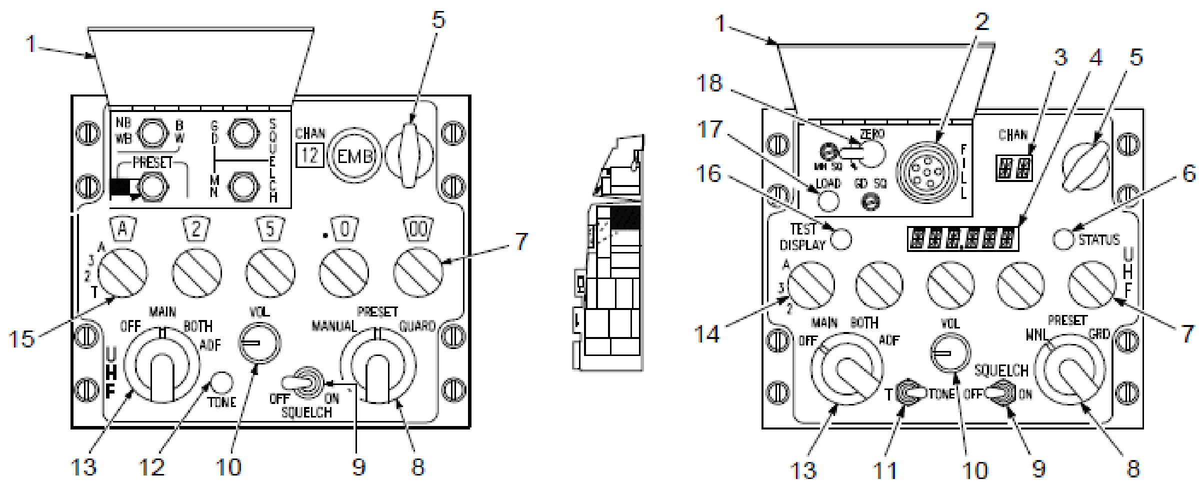
• LOWER - Lower antenna is used to receive and transmit signals.

Antenna Locations (Typical)



24.4 UHF Radio Backup Control Panel

The UHF radio backup control panel, located on the left console, controls the UHF radio, when required, by positioning the C & I knob to BACKUP (IFF control panel). When BACKUP is selected, the controls on the UHF radio backup control panel have the following functions:



HAVE QUICK II   HAVE QUICK II.2

1. Preset Channel Card and Access Door
2. FILL Connector
3. CHAN Display
4. Frequency/Status Display
5. CHAN Knob
6. STATUS Button
7. Manual Frequency Knobs
8. Mode Knob
9. SQUELCH Switch
10. VOL Knob (Inactive)
11. T-TONE Switch
12. TONE Button
13. Function Knob
14. A-3-2 Knob
15. A-3-2-T Knob
16. TEST DISPLAY Button
17. LOAD Button
18. ZERO Switch

24.4.1 Function Knob

Functions are:

- OFF - Power off.
- MAIN - With COMM 1 power switch on, UHF radio operates on selected frequency.
- BOTH - Normal operation plus receiving on guard frequency.
- ADF - Not operational.

24.4.2 Mode Knob

• MANUAL - UHF frequency is selected by manually setting the five frequency knobs.

• PRESET - UHF frequency is determined by the CHAN knob.

• GUARD - The main receiver and transmitter are automatically tuned to the guard frequency and the guard receiver is disabled.

24.4.3 CHAN Knob

The CHAN knob permits the selection of 1 of 19 (MWOD) or 14 (single WOD) preset frequencies (channels 1-19) with the mode knob at PRESET and the knob in either 2 or 3. Preset channels used for WOD storage cannot be used as preset channels for normal radio operation. Frequencies set for each channel can be manually written on a channel frequency card located on the access door.

Preset channel frequencies are set (or changed) as follows:

• Function knob - MAIN or BOTH.

• Mode knob - PRESET.

• Manual frequency knobs - Set to desired frequency.

• CHAN knob - Set to desired channel.

• Lift access door.

• Depress HQ II PRESET, HQ II.2 LOAD button under access door.

24.4.4 Manual Frequency Knobs

The five manual frequency knobs allow manual selection of frequencies in steps of 0.025 MHz from 225.000–399.975 MHz.

24.4.5 VOL Knob

The VOL knob is nonfunctional. Volume can only be controlled by the COMM 1 (UHF) power knob.

25 NAVIGATION SYSTEMS

25.1 EMBEDDED GLOBAL POSITIONING AND INERTIAL NAVIGATION SET (EGI)

The EGI is the prime system for aircraft velocity, attitude, heading, position, and navigation information. The EGI consists of an embedded GPS receiver and a fiber optic gyro based inertial navigation system. The blended solution is continuously corrected in the horizontal and vertical axes based on CADC data. Manual fix taking is available to update the system's navigation solution. For a detailed system description, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.2.3.1.

25.2 GLOBAL POSITIONING SYSTEM (GPS)

The GPS receives signals from orbiting satellites to determine accurate aircraft position, velocity, and time information. The MMC uses this data to reduce inertial navigation errors and enable accurate weapon delivery solutions. GPS data can also be used for in-flight alignment of the inertial platform and for HAVE QUICK time-of-day updates. Refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.2.3.2 for a detailed description of the GPS.

25.3 INERTIAL NAVIGATION SET (INS)

The INS is a prime sensor for aircraft velocity, attitude, and heading and is a source of navigation information. The INS consists of the INU. The INS, in conjunction with the upfront controls, GPS, CADC, and MMC provides:

- Present position with update and storage capability.
- Current winds.
- Groundspeed and drift angle.
- Great circle course computation.
- Instantaneous and maximum g data for display in the HUD.

25.4 TACTICAL AIR NAVIGATION (TACAN) SYSTEM

The TACAN system provides continuous bearing and distance information from any selected TACAN station within a line of- sight distance up to approximately 390 miles, depending upon terrain and aircraft altitude. Only distance information is presented when a DME navigational aid is selected. There are 252 channels available for selection. The TACAN bearing, selected course, range, and course deviation information are displayed on the HSI as determined by HSI M button.

TACAN is not available if the MMC is either failed or operating in a degraded mode. The upper antenna contains a filter to block the transmission of signals falling in the IFF transmit and receive bands. TACAN channels 1-13 and 59-73 fall in these bands; therefore, if the upper antenna is used, no DME information will be available for these TACAN channels until the aircraft is within approximately 5 nm of the station.

25.4.1 Operation of the TACAN on Upfront Controls

The TACAN is controlled by the upfront controls when the TACAN is powered and the C & I knob is in UFC. TACAN power is applied through the INS knob on the AVIONICS POWER panel. The TACAN knob on the AUDIO 2 panel only controls TACAN volume. The DED displays information about four TACAN items: operating mode, channel number, band, and TACAN station identifier. The operating mode is displayed (REC, T/R, or A/ A TR) and may be changed by positioning the DCS to SEQ until the desired mode is displayed. Channel (1–126) and band (X or Y) may be changed within the scratchpad with the keyboard.

TACAN operating modes are:

• REC - Receive mode.
The system receives signals which result in a bearing and course deviation display on the HSI and audio in the headset. TACAN range window (MILES) on HSI is shuttered.

• T/R - Transmit/receive mode.
Same as REC and, in addition, interrogates the TACAN ground station for DME information; distance (nm) is displayed in the HIS range window (MILES).

• A/A T/R - Air-to-air transmit-receive mode.

TACAN system interrogates and receives signals from aircraft having air-to-air capability, providing slant range (nm) distance between aircraft operating 63 TACAN channels apart.

(KC-10A also provides bearing information.) Up to five aircraft can determine distance from a sixth lead aircraft. Lead aircraft can only determine distance from one aircraft. Audio identification is not provided. Channels are selected by keying in the desired number on the scratchpad and then depressing the ENTR button. Asterisks remain about the scratchpad after channel change. TACAN band is selected by keying zero in the scratchpad and then depressing the ENTR button. The asterisks remain about the scratchpad after band change. While operating with the RF switch in SILENT, no changes to TACAN settings (mode or channel) can be made and the TACAN continues to operate on the previous settings regardless of inputs displayed on the TCN-ILS page until the RF switch is moved out of SILENT.

26 AIFF SYSTEM

The AIFF system provides selective identification feature (SIF), automatic altitude reporting, and encrypted mode 4 IFF. Normal operation is possible in any of six modes:

- Mode 1 - Security identity.
- Mode 2 - Personal identity.
- Mode 3/A - Traffic identity.
- Mode 4 - Encrypted identity.
- Mode C - Altitude reporting.
- Mode S - Air traffic control data link (includes mode 3/A and C functions). (Not implemented)

26.1 AIFF TRANSPONDER

The transponder only transmits coded replies to correctly coded interrogations. Backup control is provided for modes 1, 3/A, S, and 4 and EMER functions. Refer to IFF CONTROL PANEL, this section, for functions of IFF MASTER knob and modes 1, 3/A, S, and 4 backup controls. In the event of certain failures of upfront controls, IFF modes 1, 2, and 3/A may continue to reply on the last codes selected if modes are selected prior to failure. Mode C, if selected prior to failure, may continue to reply. When the C&I knob is placed in BACKUP, modes 2 and C are disabled. Modes 1, 3/A, 4, and S can be enabled via switches on the IFF control panel. When the C & I knob is placed in UFC, all modes are automatically enabled. Mode C provides altitude information from the CADC in 100-foot increments.

26.1.1 Operation of the Transponder on Upfront Controls

When the IFF MASTER knob, located on the IFF control panel, is placed to LOW or NORM and the C & I knob is in UFC, the AIFF transponder is controlled by the upfront controls.

The IFF page is selected by depressing the IFF override button on the upfront controls. Information is displayed on the IFF pages in five lines. The first line displays IFF and power status (OFF, STBY, DEGR, or ON). The next area displays either STAT for the IFF status page, POS for the position page, or TIM for the time page. The STAT page will be followed by a POS, TIM or P/T mnemonic to signify the selected automatic event type and will highlight with each occurrence. A blank space indicates manual mode.

The POS and TIM pages will be followed by a one or two digits that represent the active mode or code group. Line two on the STAT page contains the scratchpad. Line three displays four items. The first area at the left displays M1 and the enterable mode 1 code (STAT and TIM pages only).

The second area displays M4 and an A or a B (STAT and TIM pages only). M4 indicates that mode 4 is selected. A or B indicates the two mode 4 codes. The third area displays a 6, which represents the ICP/IKP key that alternates selection of the mode 4 code (A or B). The area at the far right displays the scratchpad (POS and TIM pages only), which is displayed only when values are being keyed in, provides on/off for each of the six IFF modes, code control for modes 1, 2, 3/A, C, 4, and S, and monitoring control for mode 4.

On the STAT page the far right displays the position criteria for mode group switching. The first area of line four displays M2 and the enterable mode 2 code (STAT and POS pages only). The next area displays MC and 5 (STAT and POS pages only). MC represents IFF mode C, and it is highlighted when mode C is selected (STAT and POS pages only). The 5 represents the ICP/IKP key that provides selection of mode C via the scratchpad. The last area displays the criteria used for position or time switching. Line five displays five items. The first area displays M3 and the enterable mode 3/A code (STAT and TIM pages only). The second area displays mode 4 monitoring modes (STAT page only). The third area displays a 7 (STAT page only), which represents the ICP/IKP key that rotates selection of mode 4 monitoring. The fourth area displays MS. The fifth area indicates the status of Mode S. A one character status window to the right of MS displays Mode S level 1 or 2 enabled and will only be displayed with Mode S selected. The sixth area displays an 8 (STAT and POS pages only), which represents the ICP/IKP key that provides selection of mode S via the scratchpad.

The initial IFF page display is always STAT. IFF pages are accessed by placing the DCS to SEQ. IFF manual mode switching is accomplished by verifying the IFF, STAT page is selected. With asterisks positioned about the scratchpad, depress appropriate ICP/IKP key and depress ENTR. ICP/IKP keys represent the following: 0 and 9 are invalid (scratchpad flashes); 1 for mode 1 selection; 2 for mode 2; 3 for mode 3/ A; 4 for mode 4; 5 for mode C; 6 for mode 4 A/B code; 7 for mode 4 monitoring (OUT, LIT, or AUD); 8 for mode S selection; any two digits (mode 1 code); three or four digits (mode 3/A code); 2 followed by 4 digits (mode 2 code). Automatic switching modes are activated by selecting POS, TIM or POS and TIM on the appropriate IFF page by positioning the asterisks around the dehighlighted label and depressing the mode select button on the ICP/IKP. The UFC displays the selected switching option on the first line of the STAT page. Whenever an event criterion for a mode or code group is reached the mnemonic will highlight. If none of the automatic switching options are selected the UFC shall blank the POS/TIM status window.

26.2 AIFF INTERROGATOR

The interrogator provides selective interrogation of IFF systems along a line-of-sight (LOS) or within a specific scan area. For a specific scan area, the interrogator may be selectively coupled or decoupled with the FCR. For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.2.4.4.2. Location and classification of a particular IFF system as a friend or unknown is possible by comparison SIF codes. During mode 4 interrogation, the interrogator is commanded to the modes 1, 2, 3/A, and 4 (A or B) code as programmed via the DTE or manually entered using the scratchpad. The mode 4 (A/B) interrogator code is independent of the mode 4 (A or B) transponder code as displayed on the CNI interrogator (INTG) page. Control of the interrogator is accomplished via the IFF control panel, the target management switch, the INTG page, and the MFDS FCR display. Interrogation of other IFF systems is possible when in any one of the following modes:

• Mode 1 - Security identity.

• Mode 2 - Personal identity.

• Mode 3/A - Traffic identity.

• Mode 4 - Encrypted identity.

26.2.1 Operation of the Interrogator on Upfront Controls

Selecting either the SCAN INTG page or the LOS INTG page displays the corresponding interrogator mode 1, 2, 3/A, and 4 (A/B) codes. After a DTU load for IFF codes, the SCAN and LOS interrogator mode 1, 2, 3/A, and 4 (A/B) codes are the same as the transponder mode 1, 2, 3/A, and 4 (A/B) codes. Modes and codes selected for SCAN are independent of the modes and codes selected for LOS. The interrogator continues to use the same codes until modified via the scratchpad. For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.2.4.4.2.

26.3 AIFF CONTROLS AND INDICATORS IFF IDENT Button

The IFF IDENT button, located on the instrument panel, provides the primary method of initiating the identification of position (I/P) function of the IFF system. Pushing the button momentarily causes the I/P timer to energize for 15-30 seconds. If a mode 3/A interrogation is recognized within this 15-30 second period, I/P replies are made.

26.3.1 IFF (Mode 4) Caution Light

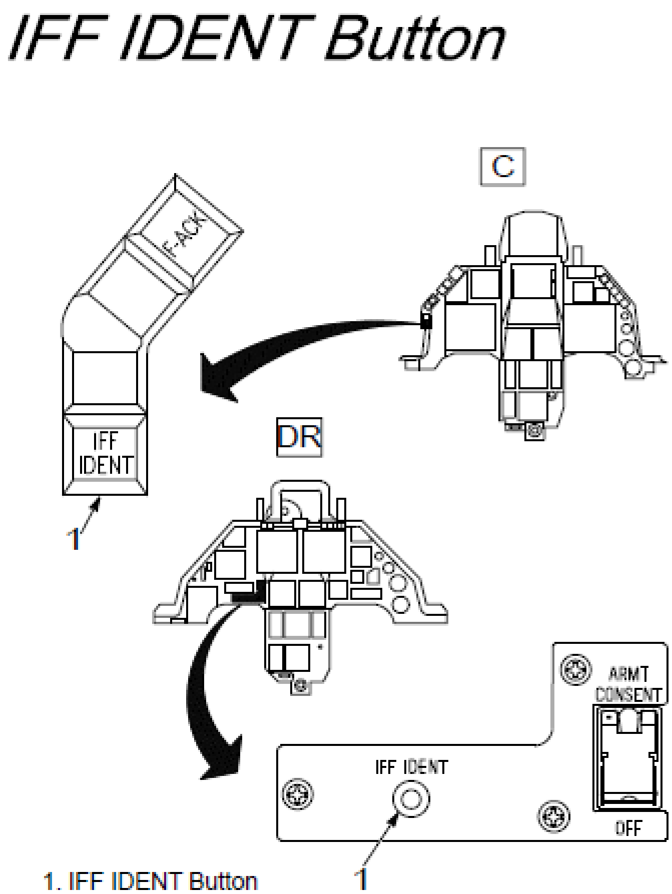
The IFF (mode 4) caution light, located on the caution light panel, indicates that the IFF system was interrogated on mode 4 and is unable to respond because the mode 4 codes (A and B) are zeroized or not coded, mode 4 is not enabled, or the RF switch is in QUIET or SILENT.

26.3.2 Target Management Switch

The target management switch, located on the stick, provides control of the area for interrogation (LOS or scan). For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.2.4.4.2.

26.3.3 UHF VHF IFF Transmit Switch

The UHF VHF IFF transmit switch, located on the throttle, when momentarily positioned to OUT provides control of the area for SCAN interrogations.
This panel serves no purpose in BMS as none of its functionality is implemented yet.



27 INSTRUMENT LANDING SYSTEM (ILS)

The ILS provides precision approaches to runways equipped with localizer, glide slope, and marker beacon equipment. Localizer identification signals are supplied to the headset for station identification. The glide slope and localizer receivers supply glide slope and localizer deviation data to the deviation bars on the ADI and HUD; the HSI also displays course or localizer deviation data. Two warning flags, designated LOC and GS, appear on the ADI when deviation data is invalid. A course deviation warning flag appears on the HSI if localizer deviation data is invalid. HUD symbology consists of localizer and glide slope deviation bars. Dashed deviation bars indicate invalid data. Deviation bars are roll stabilized with tic marks positioned at the one-dot and two-dot deflections. The symbology automatically displayed on the HUD with ILS selected is the same as LG down with the following exceptions:

• The great circle steering symbol is replaced by the ILS deviation bars.
• The lower HUD windows, except distance-to-destination, are not blanked unless the NLG is lowered, and inertial velocity exceeds 80 knots.
• The HUD altitude scale does not change from 100-foot increments to 20-foot increments until NLG is lowered.
• AOA bracket is not displayed until NLG is lowered.

The flight director displays command steering data on the HUD when selected on the upfront controls. Command steering symbology consists of a circle, a tic mark positioned at the top of the circle, and a reference mark/caret positioned at the heading/ground track scale.

The flight director circle is referenced to the FPM and appears when localizer data is valid. Proper use of the flight director requires that the localizer be intercepted from a heading no more than 45 degrees from the localizer course using bank angles of 30 degrees or less.

When the aircraft is within two dots deflection of the localizer deviation bar, the flight director commands a turn to roll out on the localizer course. The tic mark appears on the flight director circle when glide slope deviation nears center, indicating that pitch steering data is valid. The glide slope should be intercepted from a position that is wings level and on the localizer course.

If the pitch steering becomes invalid, the symbol X appears over the tic mark.

The reference caret indicates the heading required to maintain the course selected on the DED (magnetic heading scale displayed) or ground track error relative to the course selected (magnetic ground track scale displayed).

The course value may be changed only by entering the new value through the DED.

The ILS flight director is designed to intercept the glide slope from below while in approximately level flight.

If the aircraft approaches the glide slope from above, there is no pitch steering data.

The flight director symbol remains on the horizon, displaying bank steering data, and the symbol X appears over the tic mark, indicating that pitch steering data is invalid.

Valid pitch steering is provided after the glidepath is intercepted. The marker beacon receiver operates on a fixed frequency of 75 MHz. Refer to MRK BCN LIGHT, this section.

27.1 ILS CONTROLS

The ILS power knob, located on the AUDIO 2 panel, controls ILS power and audio volume. The ILS presentation on the HSI and ADI is controlled by the CRS set knob (HSI) and mode button (HSI). All other control functions are selected by the upfront controls. There are no backup controls. In the event of certain upfront control failures, the ILS may remain on the last frequency selected prior to failure.

27.2 OPERATION OF THE ILS ON UPFRONT CONTROLS

The ILS is controlled by the upfront controls when the ILS power knob on the AUDIO 2 control panel is placed to on (cw).

The ILS page is selected by verifying the CNI page is displayed on the DED and then depressing the T-ILS function button. Commanded ILS status (OFF or ON) and three changeable items appear: the ILS frequency, the localizer course for the ILS flight director cues on the HUD, and the selection of the flight director (CMD STRG).

The asterisks initialize over the scratchpad when the TCN/ILS page is selected. The ILS frequency is changed by ensuring that the asterisks are over the scratchpad, keying in the desired frequency, and then depressing the ENTR button.

The asterisks then automatically step to the ILS course for course entry. The flight director is selected/deselected by positioning the asterisks about the CMD STRG label and depressing the M-SEL button. (The flight director is automatically selected at ILS power up.) Selecting one of the PLS functions with the mode button is required before ILS deviation data (localizer and glide slope) can be displayed on the HSI, HUD, and ADI.

Three steps are required before the ILS flight director (command steering) HUD cues are usable: the localizer course is displayed on the DED, the flight director is mode-selected on the upfront controls, and a PLS selection is made with the HSI M button.

The HSI stores an ILS course for PLS/TACAN and PLS/NAV modes and a non-ILS course for the TACAN and NAV modes. The course displayed and used is based on the HIS mode selected. The ILS course can be entered either by using the UFC or by the CRS set knob.

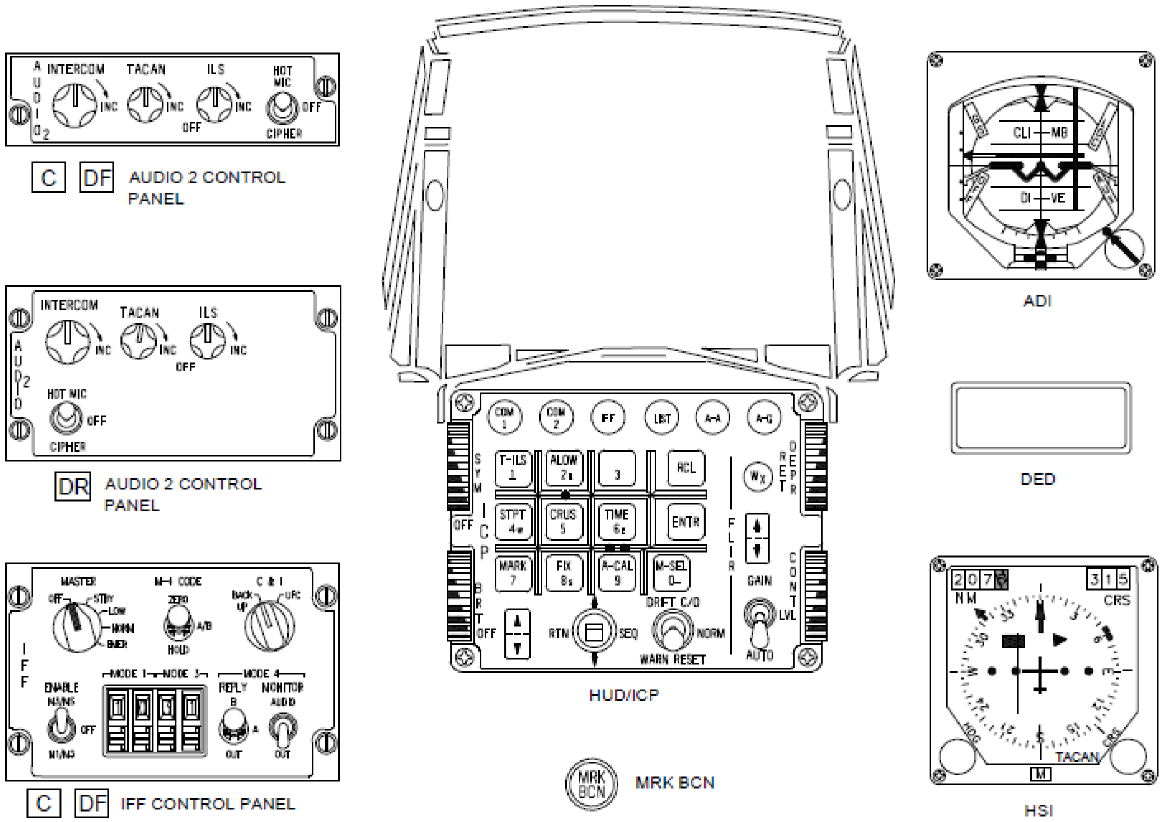
27.3 MRK BCN LIGHT

The MRK BCN light is located on the instrument panel. When the aircraft is over a marker beacon facility, the light illuminates green and blinks according to the code of the marker beacon.

28 INSTRUMENT MODE SELECTION AND DISPLAY

28.1 Navigation Aids and Display

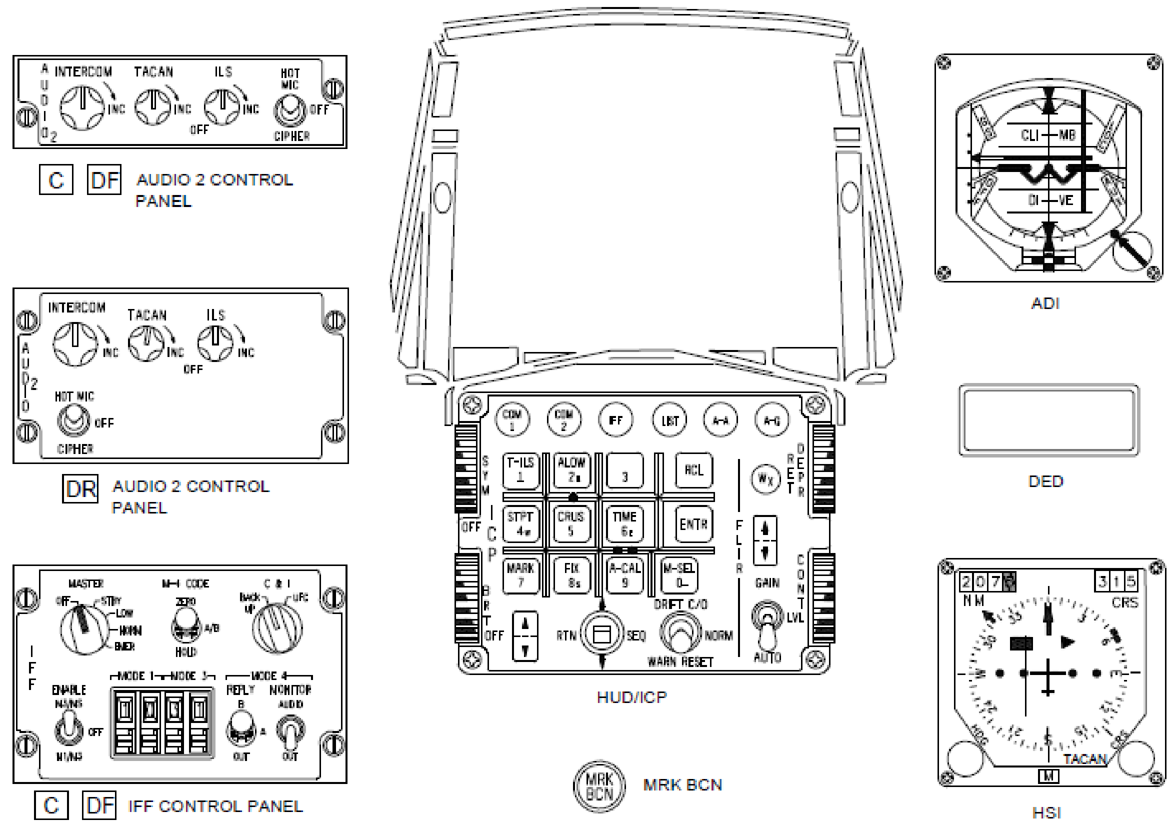
Navigation Aids and Display (Typical)



M	HSI					ADI		
INSTRU-MENT MODE SELECTED	RANGE INDICATOR	COURSE ARROW & COURSE SELECTED	COURSE DEVIATION INDICATOR	TO – FROM INDICATOR	BEARING POINTER	ATTI-TUDE SPHERE	LOCALIZER DEVIATION BAR	GLIDE SLOPE DEVIATION BAR
PLS/ TACAN	RANGE TO TACAN STATION OR DME NAV AID	MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION	OUT OF VIEW	BEARING TO TACAN STATION	INS ROLL AND PITCH ATTI-TUDE	LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION
TACAN		MANUALLY SELECTED COURSE	DEVIATION FROM SELECTED COURSE	IN VIEW			OUT OF VIEW	OUT OF VIEW
NAV	RANGE TO INS/EGI DESTINA-TION			OUT OF VIEW	BEARING TO INS DESTINA-TION			
PLS/NAV		MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION				LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION

28.2 Instrument Modes

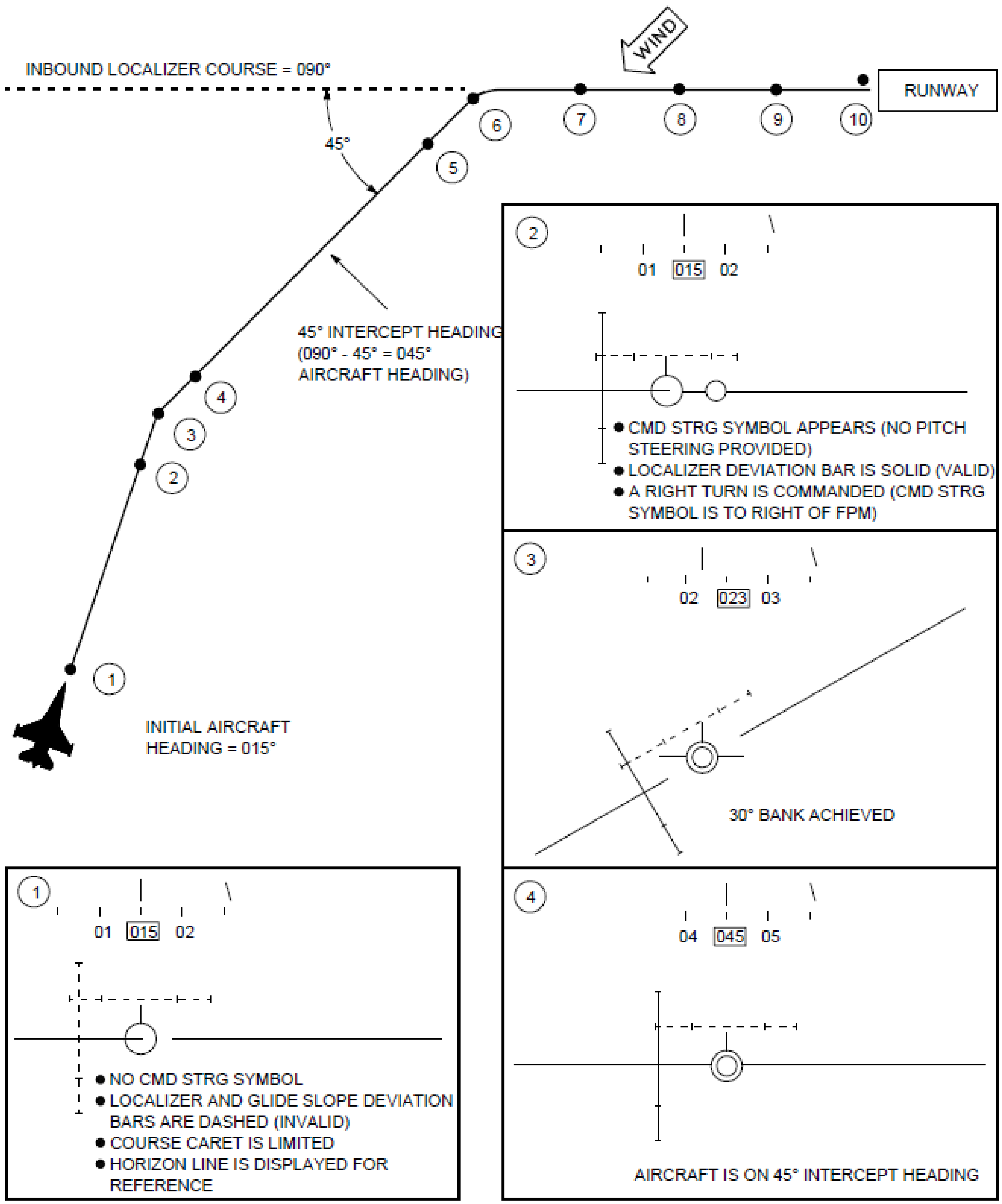
Navigation Aids and Display (Typical)



M	HSI					ADI		
INSTRU-MENT MODE SELECTED	RANGE INDICATOR	COURSE ARROW & COURSE SELECTED	COURSE DEVIATION INDICATOR	TO – FROM INDICATOR	BEARING POINTER	ATTI-TUDE SPHERE	LOCALIZER DEVIATION BAR	GLIDE SLOPE DEVIATION BAR
PLS/ TACAN	RANGE TO TACAN STATION OR DME NAV AID	MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION	OUT OF VIEW	BEARING TO TACAN STATION	INS ROLL AND PITCH ATTI-TUDE	LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION
TACAN		MANUALLY SELECTED COURSE	DEVIATION FROM SELECTED COURSE	IN VIEW			OUT OF VIEW	OUT OF VIEW
NAV	RANGE TO INS/EGI DESTINA-TION			OUT OF VIEW	BEARING TO INS DESTINA-TION			
PLS/NAV		MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION				LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION

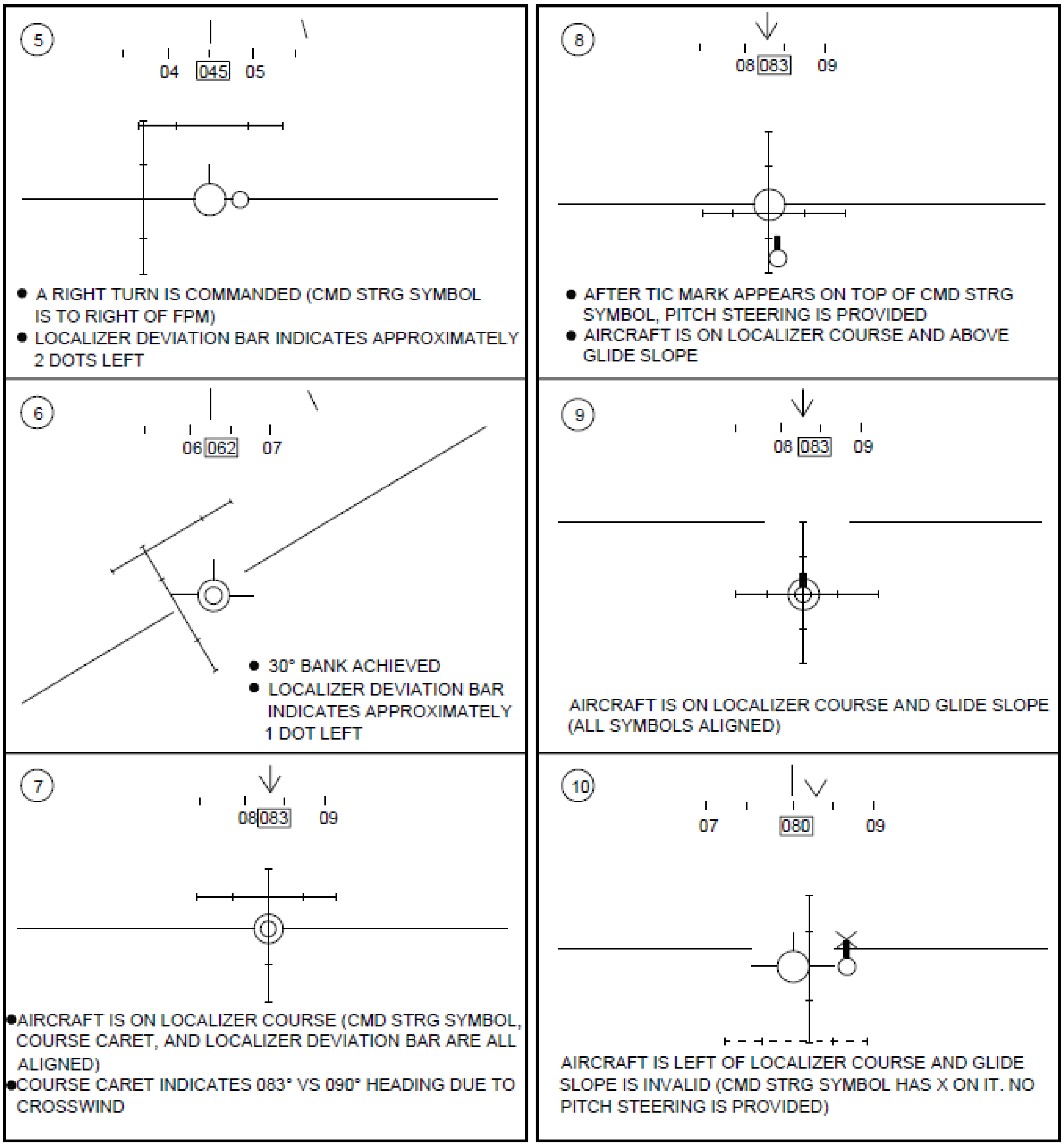
Instrument Modes (Typical)

ILS HUD DISPLAYS



Instrument Modes (Typical)

ILS HUD DISPLAYS



29 FLIGHT INSTRUMENTS

The flight instruments are located on the instrument panel. The instruments listed below are common and are not illustrated in detail.

- Airspeed/Mach Indicator.
- Clock.
- Magnetic Compass.
- Servo-Pneumatic Altimeter.
- Standby Attitude Indicator.
- Vertical Velocity Indicator.

29.1 Altimeter

The servo-pneumatic altimeter is a dual mode pressure altitude indicator with a range of -1000 to +80,000 feet. The operating mode is manually selected by the mode lever located at the lower right corner of the instrument. In the ELECT (primary) operating mode, the altimeter is electrically driven by the CADC. In the PNEU (secondary) operating mode, the altimeter is pneumatically operated by static pressure supplied by the pitot-static system. Should the CADC or altimeter servo malfunction, the altimeter automatically reverts to the pneumatic mode and the PNEU flag appears on the face of the altimeter. The PNEU flag may also appear when accelerating or decelerating through the transonic region or while performing high g maneuvers. The barometric setting knob, located at the lower left corner of the instrument, is used to set the desired altimeter setting. **C** **DF** The barometric setting of the altimeter is electrically transmitted to the CADC as a manual input correction for the pressure altitude display on the HUD. The barometric setting is shown in inches of mercury (Hg).

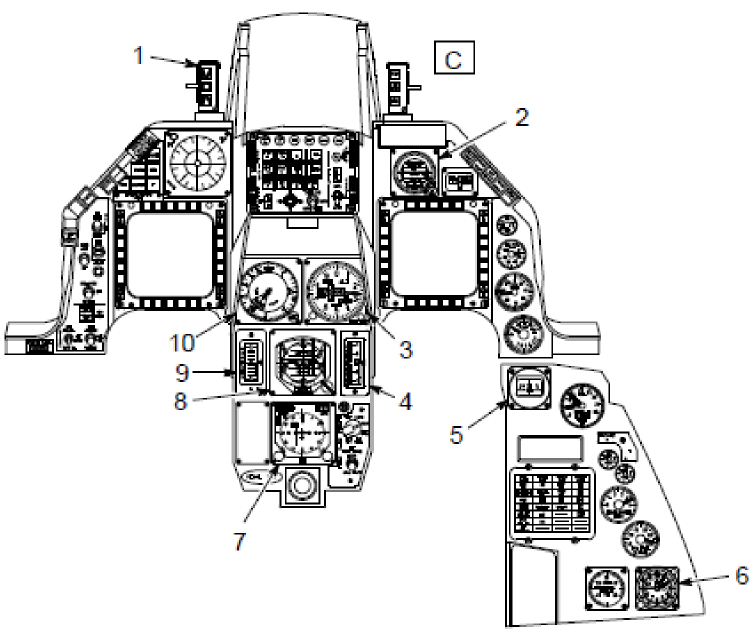
29.2 Airspeed/Mach Indicator

The airspeed/mach indicator is pneumatically operated by total and static pressure supplied by the pitot-static system. The indicator displays indicated airspeed and mach number. Indicated airspeed is displayed by a moving airspeed-mach pointer against a fixed airspeed scale. Mach number, which is read against the airspeed-mach pointer, is displayed by a rotating mach scale. The range of the indicator is from 80–850 knots and from 0.5–2.2 mach. The maximum allowable airspeed pointer indicates 800 knots at sea level. Higher airspeeds are indicated as altitude is increased. This indication is not a valid maximum allowable airspeed cue; it should be disregarded. Refer to MAXIMUM AIRSPEED OPERATING LIMITATIONS. The SET INDEX knob is used to set the airspeed reference index. (The set index is not modeled yet).

29.3 Standby Attitude Indicator (SAI)

The SAI is a self-contained, electrically powered vertical gyroscope that mechanically positions the attitude sphere of the indicator to display aircraft pitch and roll attitudes. Manual caging of the gyroscope is accomplished by pulling the PULL TO CAGE knob at the lower right corner of the indicator. The knob is held out until the sphere is caged to zero pitch and roll indication and then released. Adjustment of the miniature aircraft reference symbol is accomplished by rotation of the PULL TO CAGE knob. Since the SAI is mounted in the instrument panel at an angle, it indicates a pitch angle of 4 degrees less than the ADI when pitch trim knobs on both indicators are set at the pitch trim index. If caging is required, the aircraft should be flown wings level, constant altitude, and at an AOA of approximately +4 degrees. When caged on the ground, allow 2 minutes prior to taxi. An OFF-warning flag appears whenever electrical power is lost or whenever the PULL TO CAGE knob is pulled. After power loss, the indicator continues to provide usable attitude information for approximately 9 minutes. The gyroscope of the indicator is unrestricted in roll but is limited to approximately ±85 degrees in pitch. The indicator can develop errors during aerobatic maneuvering, primarily when pitch is near 90 degrees. If these errors exceed 7 degrees after returning to level flight, erection is cut off. If this occurs, the gyro does not automatically erect and must be manually caged to eliminate the error.

Flight Instruments



1. AOA Indexer
2. Standby Attitude Indicator
3. Altimeter
4. Vertical Velocity Indicator
5. Magnetic Compass
6. Clock
7. Horizontal Situation Indicator
8. Attitude Director Indicator
9. AOA Indicator
10. Airspeed/Mach Indicator

29.4 VERTICAL VELOCITY INDICATOR (VVI)

The VVI displays rate of climb/descent information provided by the CADC. The indicator has a vertically moving tape display with a range of 6000 fpm climb or dive. The VVI is powered by emergency ac bus No. 1.

29.5 MAGNETIC COMPASS

The magnetic compass is a self-contained indicator which shows the heading of the aircraft with respect to magnetic north. Adjustable compensating magnets in the compass provide the means for cancelling magnetic disturbances originating within the aircraft. A deviation correction card for the compass is located immediately below and aft of the compass.

29.6 ATTITUDE DIRECTOR INDICATOR (ADI)

The ADI displays pitch and roll attitude information supplied by the INS. The ADI is not limited in pitch or roll and displays any aircraft attitude accurately. The instrument displays turn rate which is presented in standard turn needle format. The turn rate needle is driven by the rate gyroscope transmitter which senses the aircraft turn rate and displaces one needle width in response to a 1-1/2-degree/second turn rate. The slip indicator (ball) is a self-contained item. The pitch trim knob is used to adjust the attitude sphere to the desired pitch attitude in reference to the miniature aircraft. In certain modes of operation, the indicator displays ILS glide slope and localizer deviation information.

The OFF-warning flag may indicate failure of either the INS or the ADI. A momentary OFF and/or AUX flag, even with proper attitude being displayed, may indicate impending failure of the ADI or INS data to the ADI. The GS warning flag indicates that the glide slope deviation bar is unreliable. The LOC warning flag indicates that the localizer signal is unreliable. The AUX warning flag signifies that the INS has failed or is operating in a less precise attitude condition and that HSI heading must be set to a known heading by the HDG knob on the HSI.

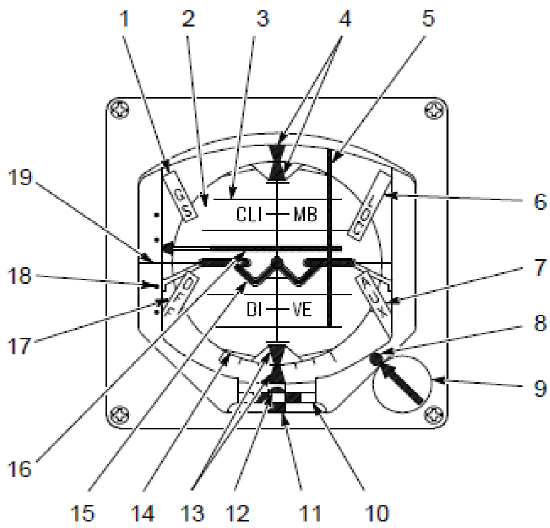
29.7 HORIZONTAL SITUATION INDICATOR (HSI)

The HSI displays a horizontal or plan view of the aircraft with respect to the navigation situation. The miniature aircraft symbol in the center of the HSI is fixed and comparable to an aircraft superimposed on a compass rose. The face of the HSI is a compass card driven by the INS so that aircraft magnetic heading is always read at the upper lubber line. The HDG set knob provides the means for rotating the heading reference marker to the desired heading. Once set, the heading reference marker rotates with the compass card. The heading reference marker provides a reference to the heading select mode of the autopilot.

When the INS/EGI is operating in the ATT mode, the ATT flag is displayed on the left side of the HSI. While in the ATT mode, pushing the HDG knob allows entry into the heading adjustment mode. When the HSI is in the heading adjustment mode, rotating the HDG knob drives the compass card to a desired heading, and ADJ HDG is displayed across the wings of the miniature aircraft symbol. To exit the heading adjustment mode, push the HDG knob. The CRS set knob provides the means for selecting any one of 360 courses. To select a desired course, rotate the head of the course arrow to the desired course on the compass card and check the course selector window for the precise setting. Once set, the course arrow rotates with the compass card. The HSI stores an ILS course for PLS/TACAN and PLS/NAV modes and a non-ILS course for the TACAN and NAV modes. The course displayed and used is based on the HIS mode selected. The ILS course can be entered either by using the UFC or by the CRS set knob. Pushing the CRS knob causes entry into the brightness adjustment mode. While in the brightness adjustment mode, rotating the CRS knob adjusts the brightness of the HIS display, and BRT is displayed across the wings of the miniature aircraft symbol. The brightness adjustment mode ends approximately 3 seconds after the pilot stops turning the knob.

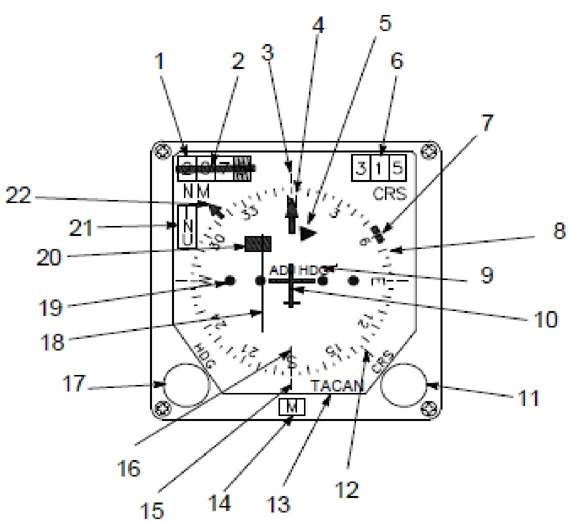
The EGI does not use slaved variation for course display for TACAN, VORTAC, and VOR points retrieved from the database. Rather, the magnetic variation at the aircraft present position is used for course computation and display. The bearing pointer provides bearing information to TACAN station or INS/EGI destination. Refer to NAVIGATION AIDS AND DISPLAY, this section. The range indicator provides a readout of distance in nm to a TACAN station, DME navigational aid, or INS/EGI destination. The fourth digit of the range indicator indicates tenths of a mile. Loss of TACAN or DME signal or an unreliable signal causes a warning flag to cover the range indication window when either ILS/TACAN or TACAN is selected. When NAV or PLS/NAV is selected, an INS/EGI failure causes the INU flag to display. Loss of power to the HSI causes the display to blank completely. The mode (M) button allows selection of the desired mode of the HSI. The operating mode of the HSI (TACAN, PLS/ TACAN, NAV, or PLS/NAV) is displayed momentarily across the wings of the miniature aircraft symbol when the mode button is pressed and continuously at the bottom of the indicator. HSI BIT can be initiated from the MFD TEST page. Ensure that the heading select mode of the autopilot is not engaged when BIT is performed.

Attitude Director Indicator (ADI)



1. GS Warning Flag – Glide Slope Unreliable
2. Attitude Sphere
3. Pitch Scale
4. Upper Bank Index Pointer
5. Localizer Deviation Bar
6. LOC Warning Flag – Localizer Signal Unreliable
7. AUX Warning Flag – INS Navigation and Heading Unavailable
8. Pitch Trim Index
9. Pitch Trim Knob
10. Rate-of-Turn Scale
11. Rate-of-Turn Needle
12. Slip Indicator (Ball)
13. Lower Bank Index Pointer
14. Lower Bank Scale
15. Miniature Aircraft Symbol
16. Glide Slope Deviation Bar and Pointer
17. OFF Warning Flag Attitude Sphere/INS Unreliable
18. Glide Slope Deviation Scale
19. Horizon Line

Horizontal Situation Indicator (HSI)



1. Range Indicator
2. Warning Flag – Range Indicator
3. Upper Lubber Line
4. Course Arrow
5. TO-FROM Indicator
6. Course Indication
7. Heading Reference Marker
8. Compass Card
9. Momentary Label
10. Miniature Aircraft Symbol
11. CRS Set Knob and Brightness Control
12. Bearing Pointer – Tail
13. Instrument Mode
14. Mode (M) Button
15. Lower Lubber Line
16. Course Arrow – Tail
17. HDG Set Knob
18. Course Deviation Indicator
19. Course Deviation Scale
20. Warning Flag – Course Deviation
21. INU Flag or ATT Flag
22. Bearing Pointer

29.8 CLOCK

The clock, located on the right auxiliary console, is an 8-day, manually wound clock with provisions for an elapsed time indication up to 60 minutes.

30 HELMET MOUNTED CUEING SYSTEM (HMCS)

The HMCS is an electro-optical device that serves as an extension of the HUD by displaying weapon, sensor, and flight information in front of the pilot's right eye. The HUD and HMCS are considered as one sensor-of-interest (SOI) (i.e., they share the same hands-on control switchology). For specific HMCS operational details, refer to TO 1F-16CM/AM-34-1-1 BMS, chapter 2.5.

30.1 HMCS COMPONENTS

The HMCS consists of a Helmet Display Unit (HDU), Helmet Vehicle Interface (HVI), electronics unit, cockpit unit, Magnetic Transmitter Unit (MTU), HMCS control panel, and seat position sensor.

30.2 Helmet Display Unit (HDU)

The HDU is a removable assembly that contains the CRT, optics, Magnetic Receiver Unit (MRU), Charge Coupled Device (CCD) camera, automatic brightness sensor, two up-look reticles with optics, and the helmet mounted portion of the HVI connector.

The HDU visor assembly is the final optical element displaying symbology to the pilot. The HMCS image is projected on the visor reflective patch in front of the right eye.

30.3 Helmet-Vehicle Interface (HVI)

The HVI provides the electrical cabling between the avionics and the helmet. The HVI consists of a universal connector mounted on the helmet, cabling, helmet release connector, QDC and an in-line release connector. The universal connector provides the capability to remove the HDU from the helmet shell.

30.4 Electronics Unit

The electronics unit provides communication with the host aircraft, interface for power, Line of Sight (LOS) computations, graphics generation, video/symbology overlay, equipment ready status, and support equipment requirements.

30.5 Cockpit Unit

The cockpit unit contains a high voltage power supply which powers the CRT display.

30.6 Magnetic Transmitter Unit (MTU)

The MTU is mounted on a bracket attached to the left side of the canopy frame and provides a pulsating energy field within the cockpit for each of three orthogonal axes.

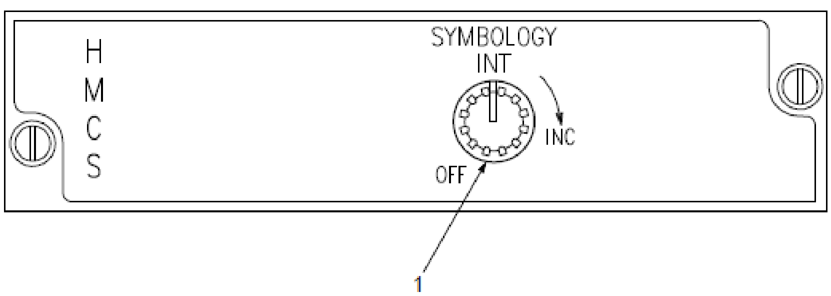
30.7 HMCS Control Panel

The HMCS control panel, located on the left auxiliary console, is used to power on the HMCS and to adjust the symbology intensity. The symbology intensity works in conjunction with the Day/Night/Auto switch on the HUD control panel.

30.8 Seat Position Sensor

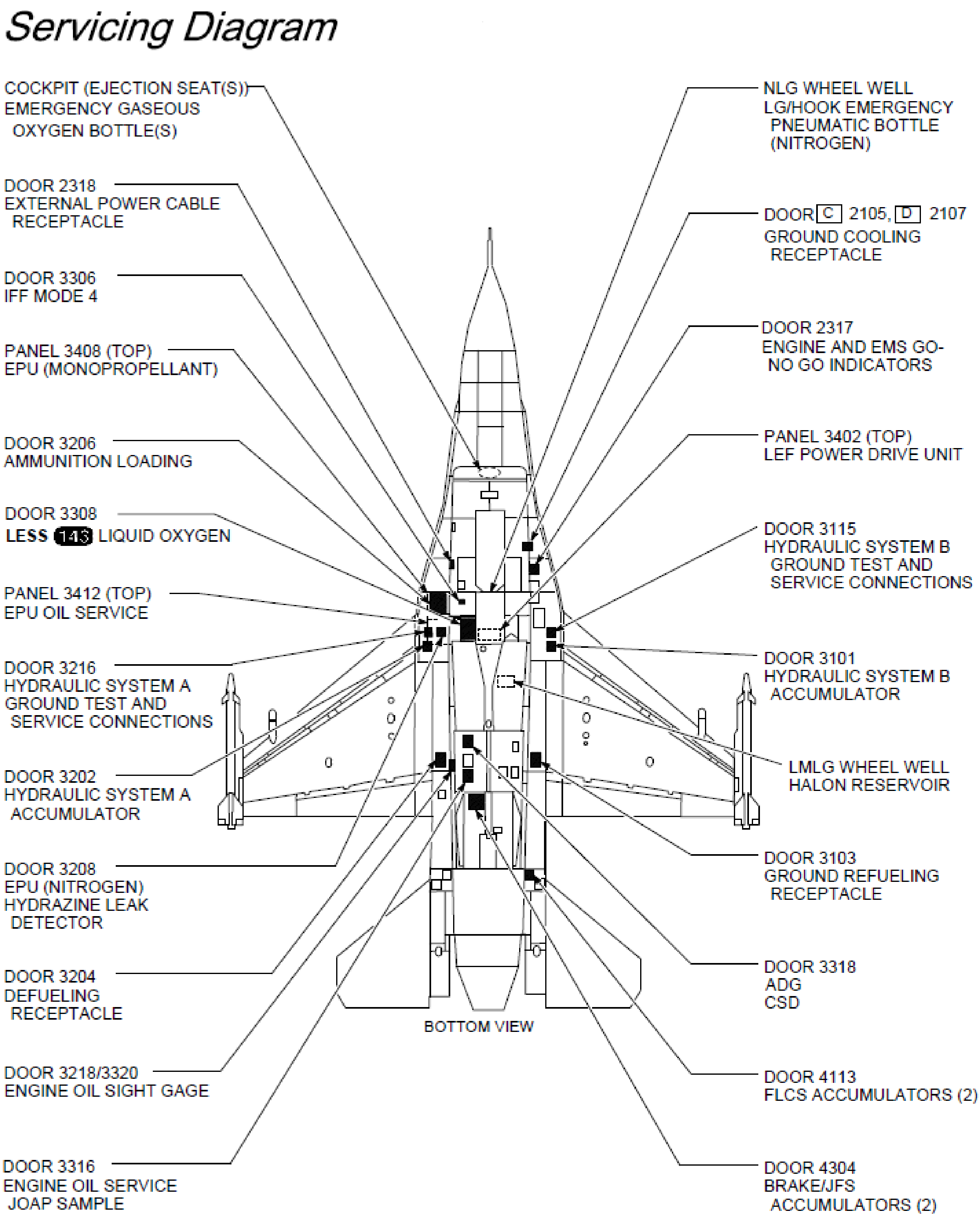
The seat position sensor measures the seat's position. The HMCS uses seat position to determine the proper cockpit magnetic map to accurately establish helmet LOS data.

HMCS Control Panel (Typical)



1. SYMBOLOGY INT KNOB

31 SERVICING DIAGRAM

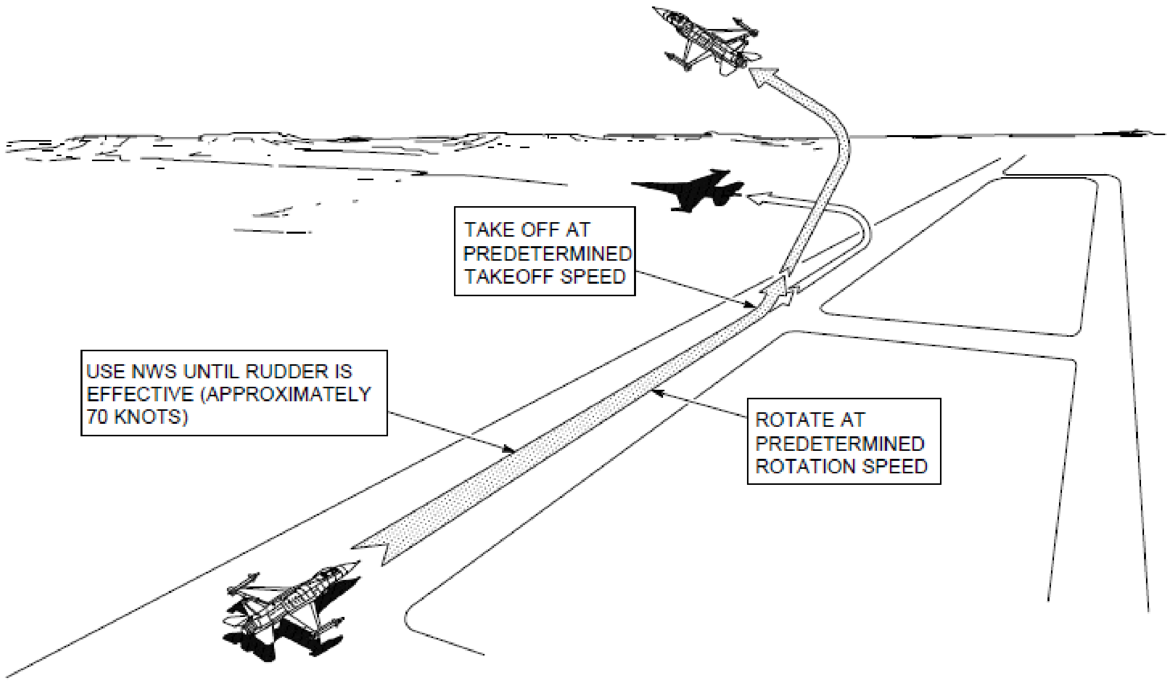


32 Normal procedures

This section provides the actions required for normal operation of the aircraft. Amplification is included only when special considerations or techniques should be observed. A complete knowledge of Section EMERGENCY PROCEDURES, and Section OPERATING LIMITATIONS, is required prior to flight.

Refer to the BMS checklists under *\Docs\02 Aircraft Manuals & Checklists\01 F-16\F-16 Checklists*, “SECTION N” for further details.

32.1 TAKEOFF



1. Retard the throttle to IDLE.

Check oil pressure to compute target for required oil pressure rise on throttle advance to MIL or MAX.

NOTE
For the PW229 engines, during the takeoff roll a 5 to 10 psi decrease in oil pressure may occur after achieving the required target oil pressure. This drop may cause oil pressure to momentarily drop slightly below 30 psi prior to recovering. Takeoff should be continued, and oil pressure should subsequently increase within approximately 3 to 5 seconds resulting in normal operation.

2. Advance the throttle to approximately 80% for **PW220** engines, 85% for **PW229** engines, or 90 % for **GE100** / **GE129** engines.

3. Verify parking brake disengaged.

4. Check engine instruments for normal indications.

5. Release brakes prior to exceeding **PW220** 80 percent, **PW229** 85 percent, or **GE100** / **GE129** 90 percent rpm.

6.Advance throttle to desired thrust.

NOTE

An engine runup check is not required if conditions require a rolling takeoff.

For PW220 and PW229 engines at MIL power and above, oil pressure must increase to 15 psi minimum above IDLE oil pressure. Once the oil system has achieved this pressure, a small drop in pressure may occur and should be considered normal (must remain within normal range). Maximum FTIT and rpm vary with temperature and pressure altitude but stabilize in 5 to15 seconds.

- **Normal engine operation during a MIL takeoff is indicated by a nozzle position of:**

  1. 30 % for **PW220** engines.
  2. 20% for **PW229** engines
  3. 15% or less for **GE100** and **GE129** engines after 5 seconds at MIL.

- **Normal engine operation during an Afterburner (AB) takeoff is indicated by:**

a) For **PW220** and **PW229** engines the nozzle will begin to open within 5 seconds after selecting Afterburner (AB).

b) For **GE100** and **GE129** engines the nozzle preopening up to 10 percent more than MIL nozzle position when Afterburner is selected (AB is first selected. AB light-off should occur within 5 seconds (greater than 40°F (4°C)) or 10 seconds (40°F (4°C) or less) after AB selection and is indicated by increasing fuel flow and nozzle position.

CAUTION

Crossing an arresting cable in a three-point attitude above 90 knots groundspeed with a centerline store may cause cable strike.

NOTE

Spacing of less than 15 seconds between aircraft when Afterburner (AB) is used by preceding aircraft increases the probability of an AB blowout or no light due to hot gas ingestion.

When airspeed is approximately 10 knots below computed takeoff speed for non-AB or 15 knots for AB, initiate rotation to establish takeoff attitude (8-12 degrees). Do not apply aft stick at airspeed lower than 10-15 knots below computed takeoff speed. Early rotation can lead to overrotation, skipping, wallowing due to early liftoff, and increased takeoff distance.
As aircraft lifts off, LEF’s extend downward. Retract LG when safely airborne. Ensure LG is up and locked before exceeding 300 knots. TEF’s retract when the LG handle is raised.

WARNING

Since LG and TEF retraction occurs simultaneously, LG retraction should not be rushed after takeoff. The reduction in lift may cause the aircraft to descend and contact the runway.

CAUTION

Due to low aft stick forces required for takeoff, use caution to avoid early rotation.

32.2 TAKEOFF WITH ASYMMETRIC STORES

Roll trim should be set prior to takeoff with asymmetric stores to prevent wing drop. The amount of roll trim If any FLCS PFL occurs during takeoff, a WOW switch problem may be indicated. If the fault clears, the mission may be continued.

Ensure that the LG handle is placed fully up. The handle can stop in an intermediate position (unless you have a full pit at home that won't be an issue in BMS) which retracts the LG; however, the handle is not locked and may lower under high g conditions.

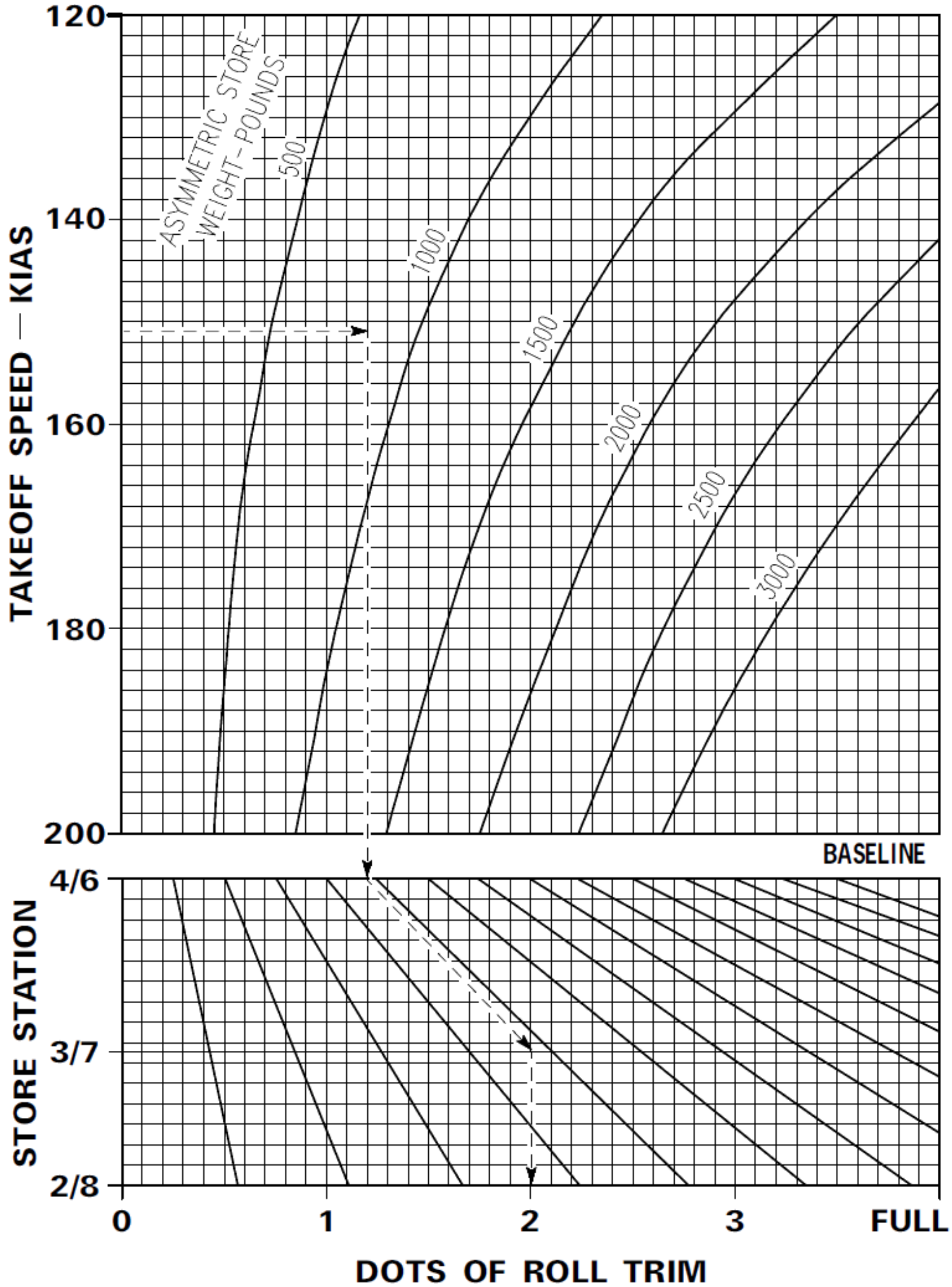
WARNING

Asymmetric loadings may cause an excessive load on one of the main gear tires, which could result in tire failure during taxi/takeoff. Ground operations are prohibited when the aircraft GW and CG exceed the maximum tire limit. Appropriate downloading, offloading, or partial fuel loading of the 370-gallon fuel tanks must be applied to any loading that exceeds asymmetric limits.

NOTE

It is possible to exceed the roll trim authority of the aircraft for an on-speed takeoff with a net asymmetric (rolling) moment less than aircraft takeoff limits.

When ARI activates after takeoff, roll trim for asymmetric stores causes a rudder input that can cause aircraft yaw away from the wing with the asymmetric store. This yaw is easily controllable by pilot rudder inputs.



Takeoff Roll trim with Asymmetric Stores

NOTE

INCREASE TAKEOFF SPEED 2 KTS FOR EACH DOT OF ROLL TRIM APPLIED TO COMPENSATE FOR REDUCED LIFT. TAKEOFF DISTANCE INCREASES PROPORTIONATELY TO THE SPEED INCREASE.

IT IS POSSIBLE TO EXCEED THE LATERAL TRIM AUTHORITY OF THE AIRCRAFT FOR ONSPEED TAKEOFF WITH A NET ASYMMETRIC (ROLLING) MOMENT LESS THAN AIRCRAFT TAKEOFF LIMITS.

32.3 OPERATING AIRSPEEDS BELOW 10,000 FEET MSL

Below 10,000 feet MSL, airspeeds for areas outside special use airspace are as follows:

300 to 350 KTS:

- Point-to-point navigation and formation rejoins that do not occur on departure.
- Descents into an MTR.
- Non-IAP descents into the terminal area.
- Tactical initial.
- If a route abort or unplanned climb causes the aircraft to exit the MTR.

350 to 400 KTS:

- Formation rejoins on departure.

400 to 450 KTS:

- Initial entry airspeed for g-awareness exercises.

32.4 CLIMB

The climb schedules are defined by airspeed/mach number or mach number only.

When airspeed/mach number is shown, climb at the scheduled airspeed to the scheduled mach number, then maintain the mach number to the desired altitude. When starting a climb at an altitude above the airspeed/mach transition point, climb at the scheduled mach number. Use the Weapon Delivery Planner to find the Mach number for the climb according to your weight.

32.4.1 CLIMB/IN-FLIGHT/OPERATIONAL CHECKS

At frequent intervals, check the aircraft systems, engine instruments, cockpit pressure, and oxygen flow indicator and system operation. Monitor fuel in each internal and external tank to verify that fuel is transferring properly by rotating the FUEL QTY SEL knob and **checking that the sum of the pointers and totalizer agree, and that fuel distribution is correct.**

WARNING

Maximum fuel transfer rate is 18,000 pph from the 300-gallon fuel tank or 30,000 pph from the 370/600-gallon fuel tanks. Maintaining fuel flow above these values while the external tank(s) is feeding results in a decrease of internal fuel. Prolonged operation under these conditions may result in the rapid depletion of fuselage fuel and render fuel transfer by siphoning action inoperative. Without siphoning action, fuel transfer to the fuselage tanks is provided by the wing turbine pumps at a maximum rate of 6000 pph. A fuel flow rate greater than 6000 pph continues to deplete fuselage fuel. Under these conditions, the external fuel tank(s) may appear slow to feed and a fuel imbalance may result. Prolonged AB operation in a three-tank configuration may result in engine flameout prior to depletion of external fuel.

1. Fuel Check: Check quantity/transfer/balance.

2. FUEL QTY SEL knob: Check knob in the NORM position.

NOTE
The FUEL QTY SEL knob must be in NORM for operation of the automatic forward fuel transfer system, trapped fuel warning, and for the BINGO fuel warning computation to be based on fuselage fuel.

3. Oxygen system: Check

4. Cockpit Pressurization: Check

WARNING
The CABIN PRESS caution light does not illuminate until cockpit pressure altitude is above 27,000 feet.

5. Engine instruments: Check

6. HYD PRESS A & B: Check

32.5 DESCENT/BEFORE LANDING checks

1. Fuel: Check quantity/ Transfer/Balance.

2. Final approach airspeed: Compute.
3. Defog lever/cockpit heat: As required (not implemented yet)

4. Landing Light: On
5. Altimeter and attitude indications: Check altimeter setting, ELECT versus PNEU mode altimeter readings, and ELECT mode altitude versus altitude displayed in HUD/ASHM.

(The ability to select between ELECT and PNEU mode for the altimeter is not implemented yet in BMS)

For subsonic flight below 20,000 feet MSL with vertical velocity less than 500 fpm, the difference between ELECT and PNEU mode altitudes should not exceed 270 feet and the difference between the ELECT mode altitude and the altitude displayed in the HUD should not exceed 75 feet.

WARNING
An erroneous ELECT mode altitude can be displayed without a CADC caution light or a transfer to PNEU mode. An erroneous altitude can be displayed in the HUD without a CADC caution light.

6. *Attitude references - Check ADI/HUD/SAI.

7. ANTI ICE switch - As required.

32.6 Landing

32.6.1 Normal Landing

Fly initial at 300 knots. At the break, retard throttle and open speedbrakes as required. On downwind leg, when airspeed is below 300 knots, lower the LG. During base turn, recheck the LG down and slow to computed final approach airspeed to arrive on final at 11- or 13-degrees AOA. Check speedbrakes open and maintain computed final approach airspeed/AOA on final. Rate of descent decreases slightly when entering ground effect. Reduce thrust gradually to continue the descent while applying back stick to reduce sink rate to the minimum practical. Thrust can be reduced sooner during an 11-degree approach than during a 13-degree approach. In either case, maintain a maximum of 13 degrees AOA while reducing sink rate to the minimum practical.

WARNING

Physically confirm that the LG handle is fully down. The LG handle may visually appear to be down when in an intermediate position. An intermediate position may allow LG extension and/or safe indications; however, the LG handle is not locked and LG retraction could occur during subsequent in-flight or ground operations.

Failure of the ANTI-SKID switch can allow it to be bumped/placed towards PARKING BRAKE while airborne. A very small movement out of ANTI-SKID is sufficient to engage the parking brake. Landing with the parking brake engaged will result in main tire failures upon touchdown.

CAUTION

Failure to depress the LG handle down permission button prior to attempting to lower the LG may result in damage to the electrical solenoid. Failure to reduce sink rate, particularly at heavier GW's, may cause a firm landing and structural damage or failure of the LG. Use of the paddle switch may cause pitch and/or roll transients as control is switched from one cockpit to the other.

Avoid landing directly on approach-end arresting cable to prevent possible cable strike damage to nozzle, speedbrakes, and ventral fins. Horizontal tail contact with the runway is possible if a large roll input is made at or near touchdown.

NOTE

The HUD AOA bracket and AOA indicator display the correct AOA until NLG WOW. Therefore, these indications are valid references for aircraft attitude throughout two-point aerodynamic braking. After NLG WOW, the AOA indicator displays zero. The LG warning horn and the TO/LDG CONFIG warning light are inhibited at approach airspeed above 190 (±4) knots. Aft CG approaches may be characterized by increased pitch sensitivity which will be most noticeable upon entering ground effect.

Use two-point aerodynamic braking until approximately 100 knots; then fly the nosewheel to runway. Maximum effective two-point aerodynamic braking is achieved at 13 degrees AOA. An AOA less than 11 degrees results in significantly reduced two-point aerodynamic braking. Although two-point aerodynamic braking is effective as low as 80 knots, runway length and condition should be used to determine when, after decelerating to 100 knots, to lower the nose to the three-point attitude.

CAUTION

Do not touch down with brake pedals depressed. A failure in either the touchdown protection circuitry or an MLG WOW switch can result in locked wheels and blown MLG tires.

Use a maximum of 13 degrees AOA for twopoint aerodynamic braking. Nozzle, speedbrakes, and ventral fins may contact runway if 15-degree pitch angle is exceeded.

During two-point aerodynamic braking, the speedbrakes (43 degrees or greater open) may contact the cable.

During the landing phase, large/rapid roll control inputs in reaction to turbulence or wake vortices will cause temporary retraction of one and sometimes both flaperons. This retraction will decrease lift and may induce a sink rate beyond the structural limit of the landing gear. During rapid reversal of roll inputs, both flaperons might move up to a position that will illuminate the TO/LDG CONFIG warning light. Display of ISA FAIL PFL's is also possible.

Be prepared to initiate a go-around if wake turbulence is encountered. After the nosewheel is on the runway, open the speedbrakes fully and maintain full aft stick for maximum three-point aerodynamic braking and wheel braking effectiveness.

CAUTION

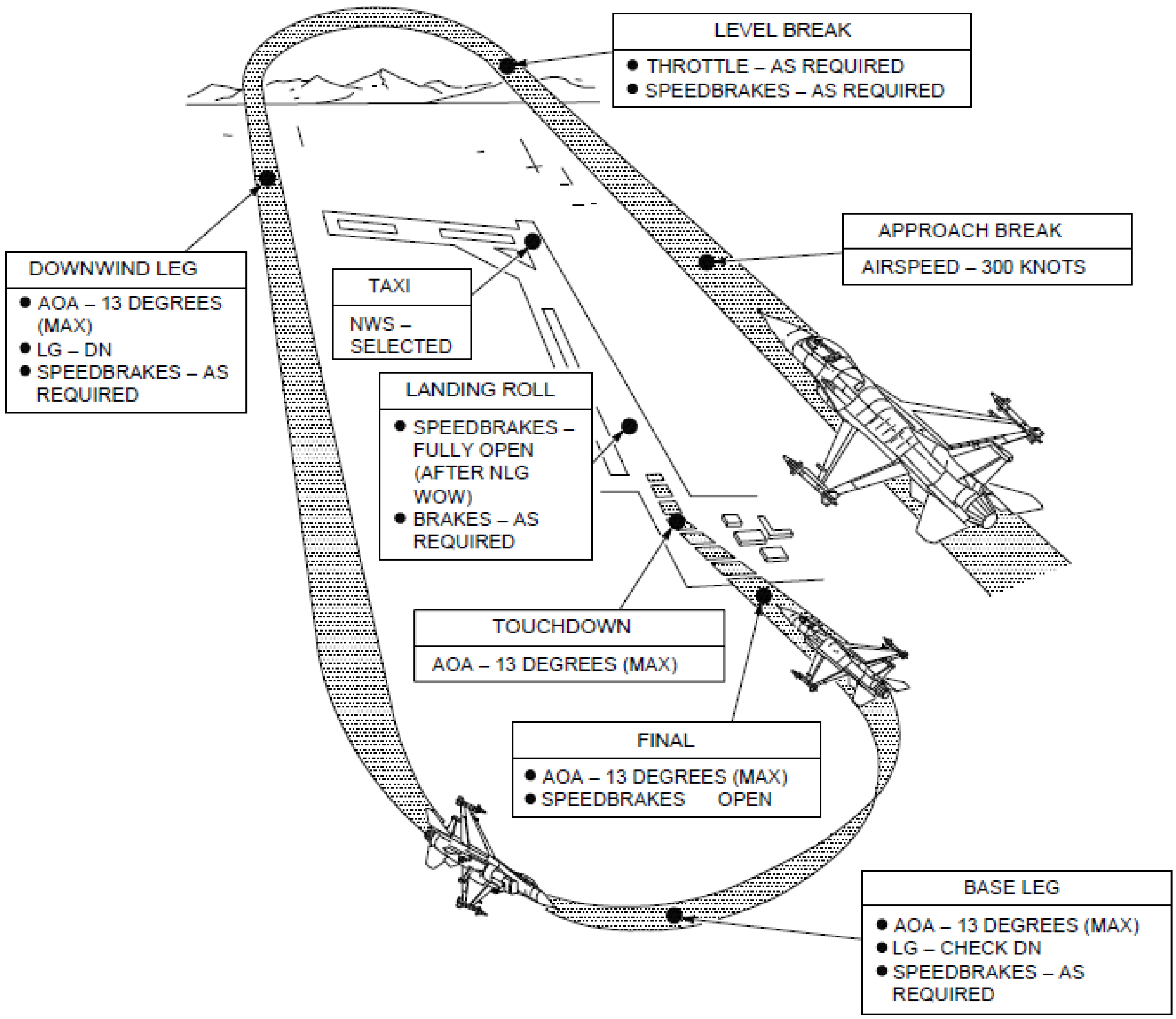
Crossing an arresting cable in a three-point attitude above 90 knots groundspeed with a centerline store may cause cable strike. Do not move SPD BRK switch to open until the nosewheel is on runway as speedbrakes may contact runway. Until WOW, forward stick pressure in excess of approximately 2 pounds results in full trailing edge down deflection of the horizontal tails. This horizontal tail deflection reduces wheel braking effectiveness. At high speeds in the three-point attitude, forward stick results in excessive loads on the NLG which can lead to nose tire failure and possibly cause structural failure of the NLG.

NOTE

The single fork design of the NLG causes the aircraft to drift right when NWS is not engaged. This drift is easily controlled with rudder or differential braking. Applying forward stick force during landing roll increases the load on the nose wheel which increases the right drift.

Smoothly apply moderate to heavy braking to decelerate to taxi speed. Using less than moderate braking increases the likelihood of a hot brake(s). NWS should not be engaged above taxi speed unless required to prevent departure from prepared runway surface.

WARNING
NWS malfunctions at any speed may cause an abrupt turn, tire skidding or blowout, aircraft tipping, and/or departure from the prepared surface.



NOTES:

- FINAL APPROACH AIRSPEED/13 DEGREES AOA CROSS-CHECK.
  - C PW220 134 PW229 135 GE100 / GE129 136 KNOTS + 4 KNOTS PER 1000 POUNDS OF FUEL/STORE WEIGHTS. ADD 8 KNOTS FOR 11 DEGREES AOA APPROACH.
  - D PW220 136 PW229 137 GE100 / GE129 138 KNOTS + 4 KNOTS PER 1000 POUNDS OF FUEL/STORE WEIGHTS. ADD 8 KNOTS FOR 11 DEGREES AOA APPROACH.
- THE PRECEDING BASELINE AIRSPEEDS ARE BASED ON THE BASIC OPERATING WEIGHT FROM T.O. 1F-16CM-1-1 PLUS FULL AMMO. ACTUAL FINAL APPROACH AIRSPEED AT 11/13 DEGREES AOA MAY DIFFER BY +/-5 KNOTS DUE TO VARIATIONS IN AIRCRAFT CG.

32.7 SHORT FIELD LANDING (DRY RUNWAY)

NOTE
The following procedures should be used any time stopping distance is critical, whether due to a long, fast, heavy weight, or short field landing.

When stopping distance is critical, a normal approach should be made. Select IDLE at or slightly before touchdown. Touch down as near as possible to the end of the runway at 13 degrees AOA. Two-point aerodynamic and wheel braking should be used with the nose held up at 13 degrees AOA until the nose falls. Pitch must be held at 13 degrees AOA if two-point aerodynamic braking is to be effective. Maximum effort braking is achieved by using the wheel brakes in conjunction with two-point aerodynamic braking. When the wheel brakes become effective, the nose automatically lowers. This occurs soon after brakes are applied.

After the nosewheel is on the runway, maintain full aft stick, open the speedbrakes fully, and use maximum wheel braking (antiskid on).

32.8 CROSSWIND LANDING

The recommended technique for landing in a crosswind is to use a wing level crab through touchdown. At touchdown, the ARI switches out. Undesirable yaw transients may occur if roll control is being applied at this time. After touchdown, perform two-point aerodynamic braking using the rudder to maintain aircraft track down the runway and flaperon to prevent wing rise. In crosswinds, the aircraft may drift downwind due to side loads imposed by the crosswinds or travel upwind due to insufficient directional control inputs/availability. As the airspeed decreases, increasing amounts of rudder are required to maintain track. Maintain two-point aerodynamic braking until approximately 100 knots or until roll or directional control becomes a problem. As the pitch attitude decreases, the nose tends to align itself with the ground track.

Aft stick and fully opened speedbrakes reduce stopping distance. Apply brakes after nosewheel is on the runway; however, if stopping distance is a factor, refer to SHORT FIELD LANDING, this section. With all LG on the runway, maintain directional control with rudder, differential braking, and NWS if required.

During landing rollout, the main concerns are wing rise (roll control), weather vanning (directional control), and downwind drift. Wing rise is controlled by flaperon into the crosswind. Excessive flaperon deflection degrades directional control. Use rudder and differential braking to control ground track, especially on wet or icy runways. Engage NWS if required to maintain directional control and to prevent departure from the runway. Excessive differential braking may result in a hot brake condition. High rudder pedal force may result in a yaw transient when NWS is engaged. NLG strut compression is required to engage NWS but sustained forward stick may result in full horizontal tail deflection which decreases weight on the
MLG and thus reduces wheel braking effectiveness.

32.9 TOUCH-AND-GO LANDING

Perform a normal approach and landing. After touchdown, maintain landing attitude, advance the throttle, close the speedbrakes, and perform a normal takeoff.

32.10 AFTER LANDING

WARNING
Do not use parking brake within 30 minutes after a normal landing. Use only chocks, if available, or minimum possible toe brake pressure to hold the aircraft stationary. Parking brake use may cause residual heat damage to brakes and may increase the probability of subsequent brake fire.

NOTE
Avoid heavy braking below 20 knots at light GW's. Heavy braking during these conditions may cause both MLG WOW switches to momentarily go to the air position, which causes the antiskid system to deactivate the toe brakes. The WOW switches return to the ground position after 1-1.5 seconds, restoring braking capability. If heavy braking resumes, the cycle may be repeated. NWS disengagements are possible when taxiing with CG near the in-flight aft limit.

1. Probe Heat Switch: OFF.

WARNING
If probe heat is on or has been on, heat in probes may be sufficient to cause injury if touched.

CAUTION
Prolonged ground operation of probe heat may cause failure of AOA probe heaters.

2. ECM Power: OFF.

CAUTION
Positively identify switch prior to activation. During ground operations, if the MAIN PWR switch is moved from MAIN PWR to OFF without a delay of one second in BATT, the EPU does not activate and electrical power for braking, NWS, hook, and radios is lost. Placing the MAIN PWR switch back to BATT or MAIN PWR should restore electrical power.

3. Speedbrake: Close.
4. Ejection Safety Lever: Safe (Up position).
5. IFF MASTER knob: STBY.
6. IFF M-4 CODE switch: HOLD.
7. LANDING TAXI lights switch: As required.
8. ZEROIZE switch: As required.

NOTE

If any FLCS single failures occurred while airborne, they are reported in the PFL 2 minutes after WOW. The FLCS FAULT caution light also illuminates. If a FLCS SNGL FAIL PFL occurs and FLCS 049 and 070 MFL's are the only MFL's present on the MFD test page, perform up to three additional FLCS BIT's and MFL clear actions. If these FLCS MFL's clear, no writeup is required. If these FLCS MFL's do not clear, inform maintenance.

9. Canopy handle - Up.

NOTE

Unlock the canopy to ensure that the canopy seal is deflated before the canopy is opened. (Not visible in BMS yet). If the canopy handle is placed to up within 2 minutes of WOW, an FDR 024 MFL is generated.

10. Armament switches - Off, safe, or normal.

32.11 PRIOR TO ENGINE SHUTDOWN

NOTE

If a flight control related problem was experienced during the flight, coordinate with maintenance to determine if the contents of the FLCC fault history table are desired before shut down of FLCS power.

1. EPU Safety pin: request In. (comm menu).

NOTE

Installation of the EPU safety pin should be delayed until after engine shutdown under the following conditions:

- The ground crew recovering the aircraft is not familiar with F-16 danger areas
- The aircraft is being recovered by emergency response personnel (landing with activated EPU, hot brakes, etc.)

Place the EPU switch to OFF prior to engine shutdown if the EPU safety pin is not installed.

2. EGI/INS: Check.

- Steerpoint of Current Location: Select.
- Miscellaneous data: Record (as required).

NOTE

EGI or INS velocity (VX or VY) greater than 5 fps is considered out of tolerance.

3. MFL: Record (as required) / not applicable in BMS.

4. AVTR power switch: UNTHRD.

NOTE

Place the AVTR power switch to UNTHRD at least 15 seconds prior to engine shutdown to allow the tapes to unthread.

5. C & I knob: BACKUP.

6. TWS switches: OFF.

7. EGI/INS knob: OFF.

NOTE

The INS requires aircraft power for 10 seconds after the INS is turned off to insure flight data is stored in memory.

8. Avionics: OFF:
   - HUD thumbwheels.
   - SNSR PWR switches.
   - AVIONICS POWER switches.
   - HMCS SYMBOLOGY INT knob.
   - COMM radios.

NOTE

Position MMC switch to OFF last to insure complete MFL processing and proper operation of the DED CMDS page on the next sortie.

32.12 ENGINE SHUTDOWN

> **WARNING**
>
> For PW229 / GE100 / GE129 engines, a postshutdown engine tailpipe fire is possible. Ignition may be indicated by a mild bang, followed by smoke, fumes, or a small fire in the combustion/turbine area. Potentially hazardous inlet and exhaust areas should be avoided within PW229 10, GE100 / GE129 engines 5 minutes after engine shutdown.
>
> This phenomenon does not cause damage to the engine or aircraft. If a postshutdown fire occurs, the engine may be motored with the JFS for approximately 1 minute to extinguish the fire. If motoring the JFS is not possible, the fire extinguishes on its own within a few minutes.
>
> For PW220 engines, when ready to shut down the engine, oil scavenge should be performed, conditions permitting.

1. For PW220 engines, position the Throttle to: 75% rpm to 78% rpm maximum (let it stabilize for 5 to 10 seconds).
2. For PW220 engines, place the Throttle to: IDLE for 1 to 2 seconds.

> **NOTE**
>
> For PW220 engines, do not wait for the engine to stabilize in idle prior to shutdown. Timing begins when the throttle reaches IDLE. Waiting longer than 1 to 2 seconds after the throttle reaches IDLE negates the effects of the scavenge shutdown.

3. Throttle: OFF.

4. JFS RUN light: Check.

   Notify maintenance if the JFS RUN light is flashing after the throttle is placed to OFF. After main generator drops offline:

5. EPU GEN and EPU PMG lights: Confirm off.

> **WARNING**
>
> If either light is illuminated, turn the MAIN PWR switch to OFF. Ensure that the EPU safety pin remains installed and notify maintenance.

6. MAIN PWR switch: OFF.

NOTE

GE100 / **GE129** Delay placing MAIN PWR switch to OFF until after engine rpm decreases through 20 percent. This delay should allow the exhaust nozzle to remain open and makes it easier for maintenance to accomplish the postflight inspection.

7. Oxygen hose, survival kit straps, lapbelt, g-suit hose, and vest hose - Disconnect, stow.
    - Stow oxygen connector in bracket on right sidewall. Ensure oxygen hose does not protrude beyond console edge.
    - Stow lapbelt and survival kit straps on seat cushion.
    - Use both hands to disconnect g-suit hose to avoid excessive force on the hose-to-console connection.
    - Disconnect HMCS Quick Disconnect from QMB on flight harness. Disconnect upper HVI from lower HVI and stow lower HVI in bracket aft of left console.

CAUTION

One-handed or brute force disconnects of the g-suit connection will cause internal damage to the hose at the hose-to-console connection. Failure to properly stow lapbelt, survival kit straps, oxygen connector, g-suit hose, oxygen hose, and HMCS lower HVI may cause damage to consoles and to the ejection seat during seat adjustment. Failure to properly stow and secure HMCS QDC may result in damage to the QDC, seat, and other equipment.

8. OXYGEN regulator: OFF and 100%.

CAUTION

Failure to position the oxygen regulator to OFF and 100% may result in particulate contamination of the regulator and subsequent damage. To avoid damage to the oxygen regulator, do not pull the knob on the end of the mode lever when moving the mode lever from ON to OFF.

9. HUD glareshield: Stow vertically.

CAUTION

The HUD glareshield is of frangible design and easily damaged during cockpit ingress or egress. The glareshield should not be used as a hand hold or storage shelf.

10. Canopy: Open.

WARNING

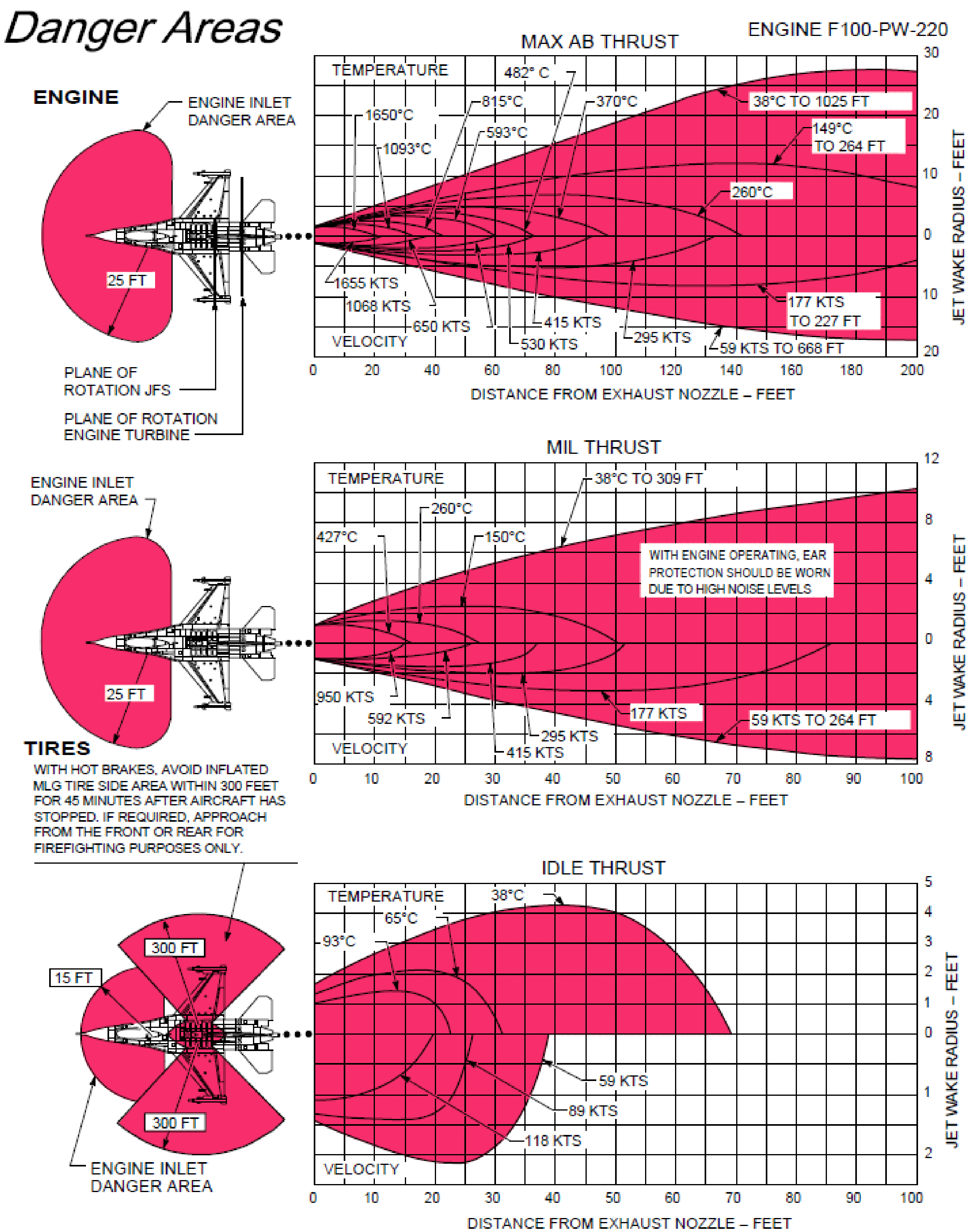
If winds exceed 30 knots, open the canopy only as far as needed to enter/exit the cockpit. Decreasing the canopy angle reduces the possibility that the canopy can be blown past full open.

A failure of the canopy actuator could allow the canopy to fall during transit. Keep hands and arms out of the path of canopy travel during opening or closing.

NOTE

If the internal canopy switch is left in the up position, the canopy automatically opens following a command in the closed direction from the outside.

33 Jet Danger Areas



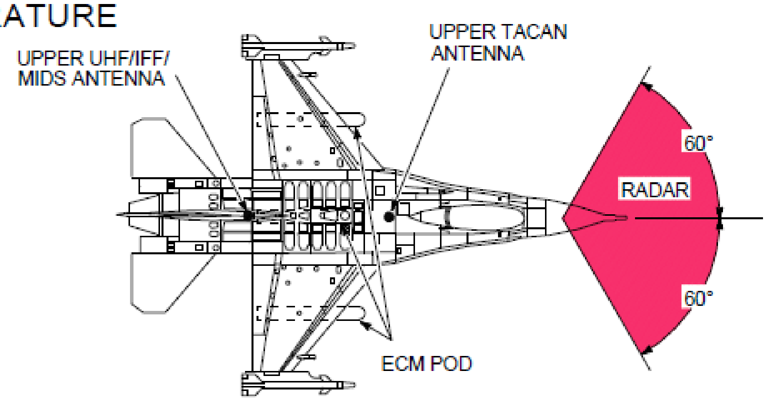
Danger Areas

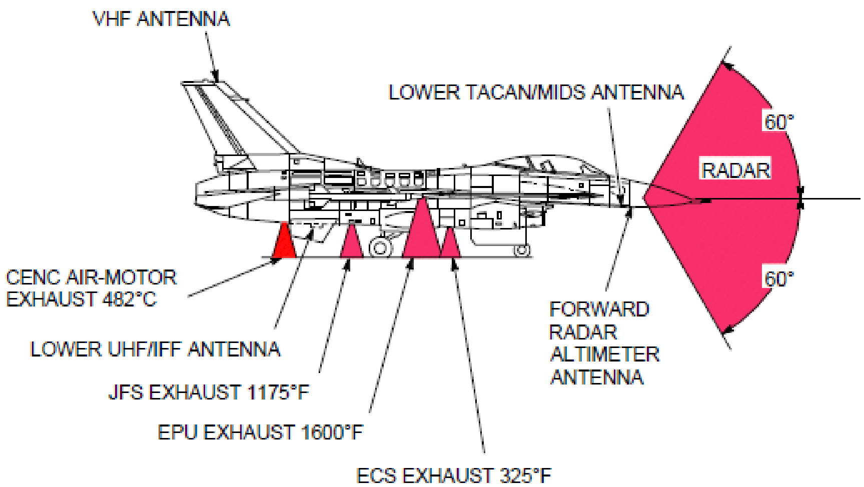
RADIATION AND TEMPERATURE

ENGINE F100-PW-220

NOTES:

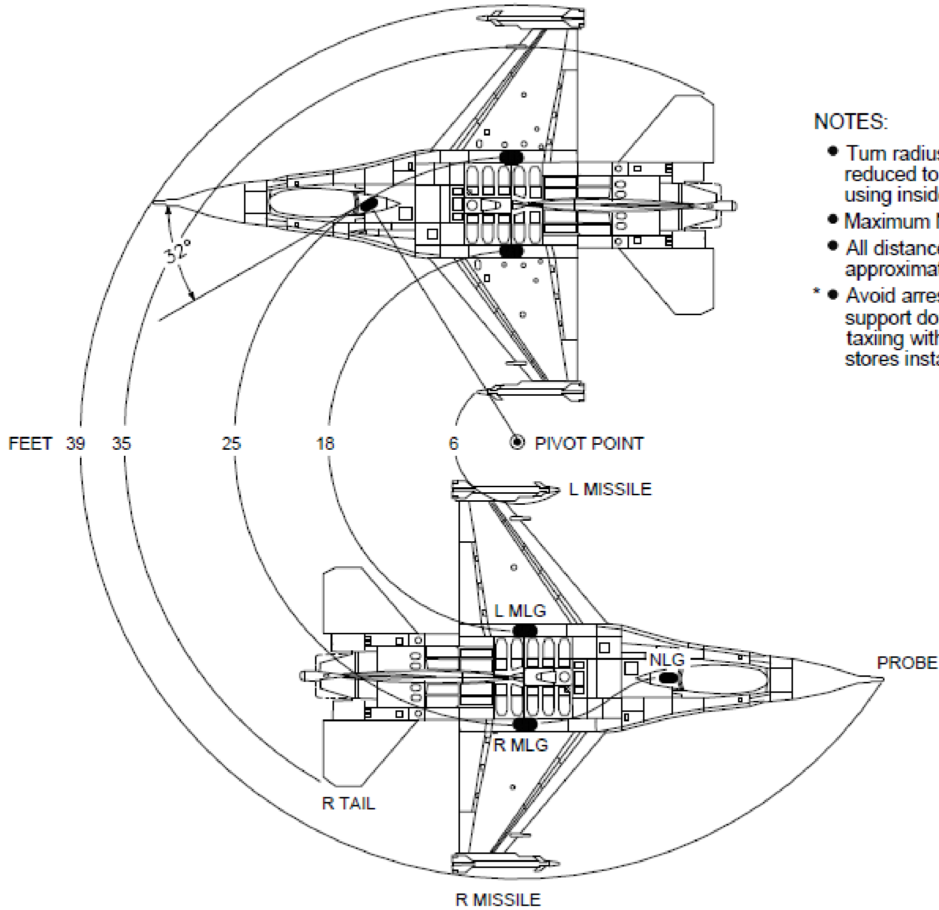
- Distance from radar disc to forward tip of radome = 5 feet.
- ECM pods radiate in a fan pattern fore and aft.





OPERATING TRANSMITTERS	MINIMUM SAFE DISTANCE FROM ANTENNAS IN FEET		
	VOLATILE FLUIDS	PERSONNEL	EED
UPPER AND LOWER UHF/IFF	—	1	—
UPPER AND LOWER TACAN/MIDS	—	1	2
VHF	—	1	—
RADAR ALTIMETER	—	1	—
FIRE CONTROL RADAR	30	120	120
AN/ALQ-119	—	6	6
AN/ALQ-131	—	15	15
AN/ALQ-176	—	6	6
AN/ALQ-184	—	31	6
AN/ALQ-188	—	6	6
QRC-80-01	—	6	6

Turning Radius and Ground Clearance (Typical)

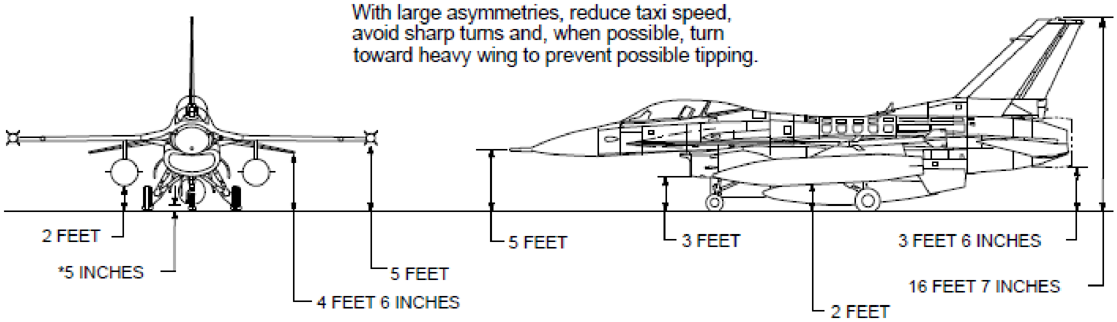


NOTES:

- Turn radius can be reduced to 38 feet by using inside brake.
- Maximum NWS deflection.
- All distances are approximate.
- * Avoid arresting cable support donuts when taxiing with centerline stores installed.

WARNING

With large asymmetries, reduce taxi speed, avoid sharp turns and, when possible, turn toward heavy wing to prevent possible tipping.

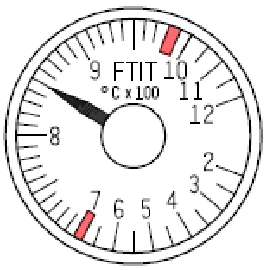


34 Operating Limitations

The aircraft and system limitations that must be observed during normal operations are presented in this section.

34.1 Instrument Markings

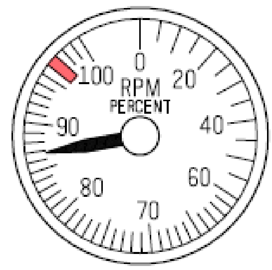
ENGINE F100-PW-220



680°C GROUND ENGINE START

980°C MAXIMUM STEADY STATE

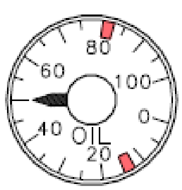
FTIT



96% MAXIMUM STEADY STATE

NOTE: RPM is limited to 94 percent on takeoff roll.

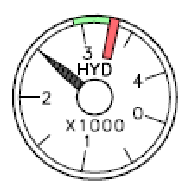
RPM



15 PSI MINIMUM

80 PSI MAXIMUM

OIL PRESSURE



2850-3250 PSI NORMAL

3250 PSI MAXIMUM

HYDRAULIC PRESSURE

34.2 Engine Limitations

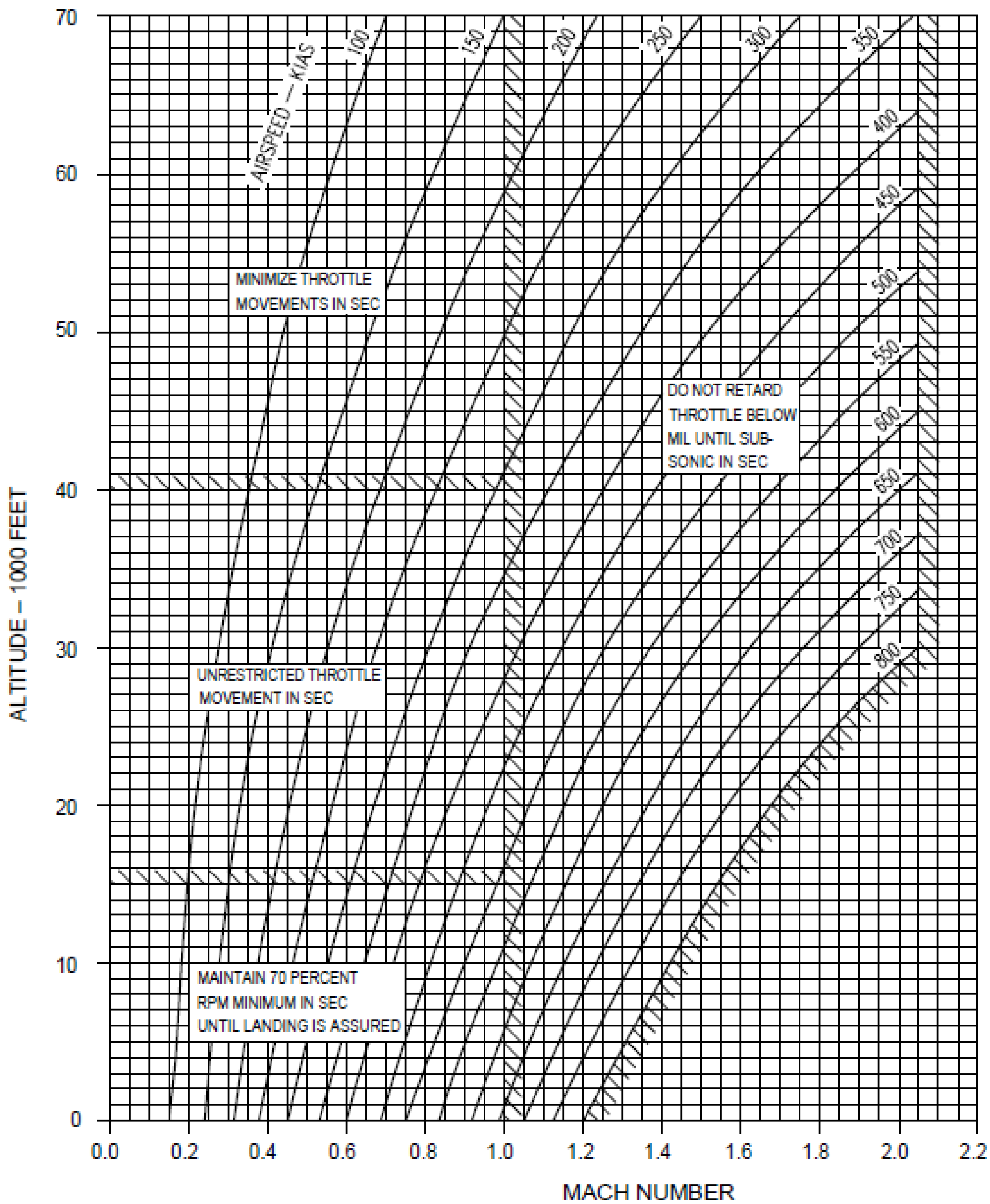
				ENGINE F100-PW-220
		GROUND		
CONDITION	FTIT°C	RPM%	OIL PSI	REMARKS
START	680	–	–	During cold start, oil pressure may be 100 psi for up to 1 minute
IDLE	575	60-76	15 (min)	Maximum FTIT in SEC is 650°C
MIL/AB	965	94	30-80	At MIL and above, oil pressure must increase 15 psi minimum above IDLE oil pressure
TRANSIENT	980	94	30-80	Maximum temperature limited to 30 seconds
FLUCTUA-TION	±10	±1	±5 IDLE ±10 above IDLE	Must remain within steady-state limits. In-phase fluctuations of more than one instrument or fluctuations accompanied by thrust surges indicate engine control problems Nozzle fluctuations limited to ±2% at and above MIL. Fluctuations not permitted below MIL
		IN FLIGHT		
CONDITION	FTIT°C	RPM%	OIL PSI	REMARKS
AIRSTART	800	–	–	–
IDLE	–	–	15 (min)	–
MIL/AB	980	96	30-80	Oil pressure must increase as rpm increases
MAX POWER	1000	96	30-80	Do not use MAX POWER except in actual combat. Use of MAX POWER limited to 6 minutes per application. Total of 60 minutes allowed before turbine inspection/overhaul.
TRANSIENT	1000	96	30-80	Maximum temperature limited to 10 seconds.
FLUCTUA-TION	±10	±1	±5 IDLE ±10 above IDLE	Same as ground operation. Zero oil pressure is allowable for periods up to 1 minute during flight at less than +1g

34.3 Engine Operational Envelope

ENGINE F100-PW-220

NOTES:

- Transfers to SEC when subsonic below 40,000 feet MSL should be performed with the throttle at midrange or above.
- Transfers from SEC to PRI should be performed with the throttle at MIL or below.
- Transfers to SEC above 40,000 feet below 300 knots may result in a self-recovering stall.
- For supersonic transfers to SEC, do not retard throttle below MIL until subsonic.



34.4 System Restrictions

34.4.1 Jet Fuel Starter Limits

Jet Fuel Starter Limits

CONDITION	LIMITS
Normal Ground Operation	* Continuous motoring of the engine shall not exceed 4 minutes. After 4 minutes of continuous motoring, a normal engine start may be initiated after 5 minutes of cooling
	A minimum wait of 1 minute is required after each JFS start attempt to allow fuel drainage from the JFS
Hot Start of Engine	Motor until FTIT is below 200°C
Airstart/In Flight	Below 20,000 feet MSL and 400 knots. 3-minute maximum run time when the engine is operating satisfactorily above 60 percent rpm; otherwise, unlimited

*Motoring is defined as JFS rotating the engine with the throttle in OFF PW220/PW229 at 22 percent rpm, GE100/GE129 25 percent rpm minimum if ambient temperature is less than or equal to 100°F (38°C) or PW220/PW229 20 percent rpm, GE100/GE129 23 percent rpm minimum if ambient temperature is greater than 100°F (38°C).

NOTES:

- OAT between 20°F (-6°C) and 100°F (38°C). A minimum brake/JFS accumulator pressure of 3000 psi is required for START 1 and 2800 psi is required for START 2.
- OAT between -25°F (-32°C) and 20°F (-6°C) or OAT above 100°F (38°C). START 2 and a minimum brake/JFS accumulator pressure of 2800 psi are required.
- OAT below -25°F (-32°C). START 2 and a minimum brake/JFS accumulator pressure of 3200 psi are required.
- If one brake/JFS accumulator is depleted, verify a minimum pressure of 3000 psi in the remaining brake/JFS accumulator before attempting START 2.

34.4.2 Tire Speed limit

The MLG tires are certified for use to 225 knots groundspeed.
The NLG tire is certified for use to 217 knots groundspeed.

34.4.3 Brake Energy Limits

For brake energy limits for maximum effort braking, taxi, aborted takeoff, landing, and the effect on turnaround capability. The actual energy per brake may differ considerably from the value found in Part 2. This is caused by unequal energy distribution between the brakes or residual heat from previous braking. Maximum brake application speed is the maximum speed from which the aircraft can be stopped using maximum braking. This speed is based on the capability of each brake to absorb a maximum of 23.5 million foot-pounds of energy.

CAUTION

- Initiating maximum effort braking above maximum brake application speed may result in loss of braking before the aircraft is stopped.
- Danger zone procedures should be followed for any event which requires excessive braking.
- If brake energy absorption is in the danger zone, wheel fusible plugs release tire pressure within 3-15 minutes after the stop.

34.5 Fuel System Limitations

34.5.1 One Reservoir Empty

The maximum allowable fuel flow with one reservoir empty is 25,000 pph.

34.6 Negative G Flight

Negative g flight with both reservoir tanks full is limited to:

- AB Thrust: 10 seconds
- MIL thrust or below: 30 seconds

NOTE

Negative g flight should be avoided when a low fuel condition exists (forward or aft reservoir not full) or ENG FEED knob out of NORM.

34.7 Miscellaneous Limitations

34.7.1 Cable/Net Arrestment Limit

Cable/Net Arrestment Limits

Compatible Cable Systems With Established Aircraft Limits

- BAK-6
- BAK-9
- BAK-12 (Standard, Extended, and Dual)
- BAK-13 (Navy designation is E-28)
- BAK-14
- BAK-15 (NI) (Net barrier with cable for hook)
- MAAS
- *44B-2L

ROUTINE ARRESTMENT LIMIT - 150 KNOTS (*156 KNOTS).

A planned event. Operational conditions are such that each landing requires arrestment. Such operational conditions include operating from highways or from runways that are too short for normal landings. The standard factor of safety is used to determine the maximum engagement speed.

EMERGENCY ARRESTMENT LIMIT - 160 KNOTS (*171 KNOTS).

An unplanned event. A reduced factor of safety is accepted and the corresponding maximum engagement speed is slightly higher than for a routine arrestment. With a ground level ejection capability, a reduced factor of safety for the arrestment is possible since the pilot can still eject if the arrestment fails.

Compatible Cable Systems Without Established Aircraft Limits

CAUTION

Use of arresting systems without established aircraft limits may result in failure of the hook, hook backup structure, or nose landing gear.

- BLISS 500S-6
- TAGS BLISS 500S-6B Transportable
- 44B-3H/SP/WR
- MAGS 44B-3H/SP/WR Mobile
- RHAG MK-1
- RHAG MK-2
- PUAG
- PAAG
- P-IV/BAK-12 Portable
- Aerazur Textile Braking System (MB 60.9.9 C, MB 100.10 C)

34.8 Airspeed Limitations

Airspeed Limitations

(Systems)

SYSTEM OR CONDITION	KIAS/MACH
Canopy Open or in Transit	70 (Includes ground wind velocity)
LG Extended or in Transit	300/0.65, whichever is less
AR Door Opening/Closing	400/0.85, whichever is less
AR Door Open	400/0.95, whichever is less
Flight in Severe Turbulence (+/-3g)	500

WARNING

Maximum airspeed operating limitations may be easily exceeded in level flight due to the improved performance engine excess thrust capabilities.

34.8.1 Maximum Airspeed Operating Limitations

Maximum operating airspeed is 800 knots from sea level to 30,000 feet MSL. Above 30,000 feet MSL, the aircraft is limited to 2.05 mach.

Maximum operating airspeed/Mach may be reduced as a result of system restrictions or stores limitations.

34.8.2 Low Airspeed Operating Limitations

Recovery should be initiated no later than activation of the low-speed warning tone.

WARNING

For CAT I configurations with drag indices greater than 120, delaying recovery until activation of the low-speed warning tone may result in departure regardless of recovery technique. Rapid airspeed decay may reduce control authority to the point that recovery inputs have no effect. Low thrust settings, external fuel tanks, or inlet pods increase the possibility of a departure.

To avoid departures due to roll coupling, do not operate with category III loadings below 200 knots unless in takeoff and landing gains.

WARNING

Departures from controlled flight with asymmetric category III loadings may result in fast, flat (possibly nonrecoverable) spins.

34.9 Prohibited Maneuvers

The following maneuvers are prohibited:

a) Intentional departures and spins with any of the following:

- Symmetric category I loading with suspension equipment or missiles at station 3, 4, 6, or 7.
- Asymmetric category I loading.
- Category III loading.
- Altitude below 30,000 feet AGL.
- CG aft of aft limit for the configuration being flown.
- Lateral fuel (internal and external) imbalance greater than 200 pounds.

b) Repeated Intentional rudder reversals
c) Maximum command rolls exceeding 360 degrees of bank angle change.
d) Maximum command rolling maneuvers above 1.8 mach and either above 3g or below 35,000 feet MSL.
e) Rudder rolls or rudder-assisted rolls of more than 90 degrees of bank angle change with any store on station 3, 4, 6, or 7.
f) With LG and/or TEF’s down:

- Flight above 15 degrees AOA with stores at station 3, 4, 6, or 7.
- Maximum command rolls of more than 90 degrees of bank angle change.

g) Abrupt roll reversals above 550 knots and below 20,000 feet MSL with the STORES CONFIG switch in CAT I.
h) Rapid rudder release or reversal above 300 knots/0.6 mach.

34.10 Gross Weight Limitations

The maximum allowable GW for ground handling, taxi, takeoff, in-flight, and landing is 42,300 pounds.

34.11 CG Limitations

Generally, the aircraft is within CG limits when the red portion of the AL pointer is not visible (FUEL QTY SEL knob in NORM).

34.12 Acceleration Limitations

Load factor limits should not be intentionally exceeded. Notify maintenance of a possible over-g if symmetric maneuvering on the g limiter results in a load factor greater than or equal to 9.5g/-3.2g or if symmetric non-g limiter maneuvering or asymmetric maneuvering exceeds a positive or negative g limit specified in this section. Provide details of the occurrence (maximum g indication, airspeed, altitude, description of maneuver, fuel weight and distribution, etc.) and HUD videotape if it is available.

NOTE

- SYM G limits apply to maneuvers resulting from less than abrupt roll stick inputs and in which roll rate does not exceed 20 degrees/ second. ROLL G limits apply to maneuvers resulting from abrupt roll stick inputs or maneuvers in which roll rate exceeds 20 degrees/ second.

- The maximum g experienced can be higher than 9.5 g depending on flight conditions, type of maneuver flown, stores configuration, gross weight, and CG. Full aft stick maneuvers started above 500 KCAS are more susceptible to over-g. In some cases, aerodynamic changes occur rapidly, and the g limiter cannot prevent a brief increase in g. Similarly, a brief increase in g can occur if an inadvertent roll input is made.

- A false maximum g indication may be displayed in the HUD due to INU vibration while the aircraft is at maximum g. G indications above 10 (e.g., 0.2 for 10.2g) have been observed.

- G’s experienced during a wingtip vortex/wake turbulence encounter should be considered as asymmetrical when determining if a g limit has been exceeded.

34.13 Acceleration Limitations

Acceleration Limitations		
CONFIGURATION	LOAD FACTOR (g)	
	SYMMETRIC	ASYMMETRIC
Takeoff	+4.0, 0.0	+2.0, 0.0
Landing		
LG Retraction*	+2.0, 0.0	+2.0, 0.0
LG Extension		
* If the LG handle is raised near 2g's approaching 300 knots, actuator power may be insufficient to completely retract the LG until g is reduced.		

34.14 AOA and Roll Limitations

AOA and Rolling Limitations			
LOADING CATEGORY	STORES CONFIG SWITCH	MAX AOA	MAX BANK ANGLE CHANGE FOR MAX ROLL MANEUVER
I	I	LIMITER	360°
III	III	LIMITER	360°
NOTES: 1. Determine loading category from the appropriate line in TO 1F-16CM-1-2, Figure 5-2, Stores Limitations. 2. The roll command should be released in sufficient time to avoid overshooting the indicated bank angle change limits.			

With heavy wing loadings, it may be necessary to cancel the roll command up to 90 degrees early to avoid exceeding the maximum bank angle limit. Except for emergency conditions, do not fly category III loadings with the STORES CONFIG switch in CAT I.

WARNING
• Category III loadings are not protected from AOA or roll-induced departures with the STORES CONFIG switch in CAT I. • Damage to or failure of wing internal structure can occur if rolling maneuvers are performed with the STORES CONFIG switch in CAT I while carrying a category III loading. An asymmetric loading is any asymmetry that requires roll and/or yaw trim. Refer to ASYMMETRIC LOADINGS. • Nose slice and yaw departure may occur during maximum command rolls on the CAT I AOA limiter at high altitude when carrying a centerline tank. Refer to YAW DEPARTURE.

WARNING

- If the aircraft CG is near the aft limit, departure may occur while performing low airspeed, high AOA, maximum command rolling maneuvers with either of the following:
- Asymmetric category I missile loadings (station 2, 3, 7, or 8).
- Speedbrakes opened.
- The indicated bank angle change limit is particularly critical for category I loadings with 370-gallon fuel tanks plus suspension equipment on stations 3 and 7. Care is required with these loadings to check the roll so as not to exceed the indicated bank angle change limit.

34.15 Stores Limitations

34.15.1 Asymmetric Store Loading

The maximum allowable asymmetric (rolling) moment for ground handling, taxi, takeoff, in-flight, and landing is 25,020 foot-pounds. Takeoff is prohibited when the roll trim necessary to compensate for an asymmetric loading exceeds the maximum roll trim available.

35 Flight characteristics

Information presented in this section reflects the flight characteristics with category I and III loadings. Refer to AOA AND ROLLING LIMITATIONS, for information regarding specific categories.

35.1 Flight Control System

The FLCS is a four-channel fly-by-wire system. The FLCC combines pilot commands along with aircraft motion and flight conditions to command position of the flight control surfaces. Artificial stability provided by the FLCS allows for relaxed static stability which increases performance and maneuverability by reducing trim drag and increasing maximum lift. Refer to FLIGHT CONTROL SYSTEM (FLCS).

35.2 FLCS Limiters

FLCS limiters may be defeated if maneuvering limits are not strictly observed. Departure may result from maximum maneuvering combined with maximum permissible aft CG. The most critical maneuvers are maximum command rolls coupled with either maximum aft stick ormexceeding the maximum bank angle change limits. The AOA/g limiter depends on the horizontal tails to control g and AOA. If the airspeed decreases until there is not enough airflow over the tails to provide this control, the limiter is defeated, and a departure or deep stall may result. This condition may occur in a nose-high, decreasing speed maneuver. Refer to LOW AIRSPEED OPERATING LIMITATIONS.

35.3 Leading Edge Flaps

The LEF system is designed to optimize wing airflow. It also provides special functions in the takeoff and landing configurations.

At subsonic speeds, the LEFs move from 2 degrees up to 25 degrees down as a function of mach number, AOA, and altitude. This automatic operation significantly reduces buffet and drag and improves high AOA directional stability. If the LEFs fail to schedule properly during maneuvering flight, higher than normal buffet levels occur and, in the high AOA region, reduced directional and longitudinal stability may also be noted. At supersonic speeds, the LEFs are scheduled to minimize drag.

35.4 Speedbrakes

The speedbrakes provide deceleration over the entire flight envelope. There are no trim changes associated with speedbrake operation and induced buffet is negligible. A yaw oscillation may occur at approximately 1.4 mach with speedbrakes opened. The oscillation is neutrally damped, and no action is required. The oscillation may be eliminated by either closing the speedbrakes, reducing mach, or increasing the g level.

35.5 Autopilot

With the HDG SEL and ALT HOLD modes engaged, the aircraft turns, climbs, or dives within the limits of the autopilot to capture the heading reference and the altitude reference regardless of aircraft attitude. This autopilot commanded flight may eventually return the aircraft to a preselected heading and altitude if airspeed and altitude permit. If the ALT HOLD remains engaged as airspeed transits 1.0 mach, a mild pitch transient may occur and can be eliminated by depressing the paddle switch until the altimeter has stabilized. Use of pitch altitude or altitude hold during decelerating flight can produce either autopilot disengagement and the FLCS A/P FAIL PFL or descent from the referenced altitude if AOA increases above certain values. In CAT I, the autopilot disengages and the FLCS A/P FAIL PFL occurs when 15 degrees AOA is exceeded. In CAT III, the aircraft starts descending from the referenced altitude at approximately 8-10 degrees AOA. If the descent is not corrected within 5 seconds, the FLCS A/P DEGR PFL occurs.

CAUTION
Since the autopilot command is additive to stick commands, use of ALT HOLD in conjunction with high g maneuvering may result in aircraft over-g.

35.6 Trim

The aircraft can be trimmed about all three axes. With pitch trim centered in cruise gains and no input to the stick, the aircraft attempts to maintain 1g flight regardless of flight condition unless AOA exceeds 15 degrees. Full noseup/full nosedown trim corresponds to +3.4g or -1.4g in cruise gains.

NOTE
Airspeed must be closely monitored because there is little aerodynamic indication of large changes in airspeed. Cues which normally indicate airspeed changes, such as stick movement or trim changes, are absent.

Above 15 degrees, the FLCS commands an increasing nose down pitch attitude as a warning of decreasing airspeed. A specific force applied to the stick commands a specific g increment from the trim condition. Moving the PITCH TRIM wheel changes the hands-off trim condition. In takeoff and landing gains, zero pitch trim commands zero pitch rate until 10 degrees AOA. A slight amount of noseup trim is required to zero stick forces during an 11–13-degree AOA approach. When properly trimmed and no command is applied to the stick, the aircraft attempts to maintain zero roll rate. Moving the ROLL TRIM wheel changes the hands-off trim condition. Maximum roll trim authority is approximately one-fifth of maximum stick command of cruise gains. However, precise trimming is difficult using the stick TRIM button. Roll trim requirements may change with stores, particularly at supersonic speeds. For asymmetric configurations (asymmetrical stores or rudder mistrim), roll retrimming may be required as flight conditions change. Roll trim inputs also command rudder deflection through the ARI. The ARI switches out with wheel spin up upon landing. Likewise, the ARI switches in following takeoff as the wheels spin down. This switching may cause abrupt rudder inputs to occur if roll (due to asymmetries or crosswind) is being input via the stick or trim. Rudder trim inputs command rudder deflection. Rudder trim is required with asymmetrical configurations and frequently during supersonic flight, especially with stores. Maximum trim authority is 12 degrees.

35.7 Normal Flight Characteristics

The FLCS provides constant response for specific inputs regardless of flight conditions. Commanded pitch responses are in g increments per stick force for AOA below 15 degrees. Above 15 degrees AOA, stick force increases as a cue of increasing AOA. Conventional cues such as aircraft buffeting forces are not always present as AOA and g limits are approached. The commanded lateral response is roll rate per stick force. Rudder position is commanded by rudder pedal force.

The ARI provides coordinated rudder commands and reduces sideslip during rolling maneuvers. Additional pilot rudder commands do not improve roll performance but do increase departure susceptibility. When ARI is not available during takeoff and landing (MLG wheel speed above 60 knots), pilot rudder commands may be required to provide coordinated flight and to control yaw.

WARNING
• The capability of the aircraft to rapidly attain and sustain high g levels, which may cause g induced loss of consciousness, should be considered during heavy maneuvering. • Rolling g limits are not protected by the FLCS and must be observed.

35.8 CATEGORY I LOADINGS

The FLCS minimizes the possibility of departures or spins. Roll rate inputs command flaperons and horizontal tails for roll power to provide a relatively constant roll response. Maximum command 360-degree rolls at subsonic speeds may cause a slight g reduction on termination. At supersonic speeds, maximum roll rates may cause a slight increase in g. At high AOA and low airspeed conditions, roll performance is reduced by the FLCS to minimize pitch/roll coupling. Aft CG’s, open speedbrakes, asymmetric missiles, or centerline stores decrease departure resistance.

35.9 CATEGORY III LOADINGS

Aircraft response with most category III loadings remains similar to that of the clean aircraft; however, large stores significantly increase total aircraft drag and reduce performance. Light buffeting may occur during level flight at approximately 0.92 mach. In addition, surging may occur near the store limit airspeed, especially at low altitude. Neither condition requires specific action. With STORES CONFIG switch in CAT III, the AOA/g limiter provides departure resistance for all category loadings. Except for the requirement to avoid structural overstress, pilot workload is reduced to a level comparable to that with category I loadings.

35.10 FLIGHT WITH LG DOWN

With the LG handle down, LG and TEFs are extended and the FLCS operates in takeoff and landing gains. Normally, this mode of flight is limited to takeoff, approach, and landing; however, circumstances can arise which require flight for an extended distance with the LG down. If so, the LG should be left pinned, but the streamers should be removed to prevent damage. With the LG pins installed, it is preferable to raise the LG handle once airborne. This action retracts the TEFs and significantly reduces drag and the FLCS switches to cruise gains.

For cruise with only the LG down, the best airspeed is 230- 250 knots. A clean aircraft can be flown at 25,000-30,000 feet with the LG down and TEFs up and fuel flow is 3000-3400 pph. If the LG handle is left down, the TEFs remain down, and the best cruise altitude is less than 20,000 feet with significantly higher fuel flows.

35.11 LANDING CONFIGURATION

Two distinct techniques may be used when landing. One technique is to trim for approximately 11 degrees AOA and to fly that airspeed throughout the final approach. Attitude/ glidepath is controlled by the stick, and airspeed/AOA is controlled by the throttle. This technique allows better pitch control, better over-the-nose visibility, and a more stable HUD presentation. In gusty wind conditions, the aircraft wallows less, and during the flare, the sink rate is easier to control. The aircraft floats approximately 800-1200 feet from flare initiation to touchdown. Another technique is to trim for 13 degrees AOA and to fly that airspeed throughout the final approach. The throttle is used primarily to control glidepath, and the stick controls airspeed through control of AOA and direction through bank angle. This type of approach primarily allows better control of touchdown point and more efficient energy dissipation; however, since the aircraft is already at 13 degrees AOA, the flare is more difficult, and care must be exercised to avoid scraping the speedbrakes or landing firm. The aircraft floats approximately 500-700 feet from flare initiation to touchdown.

Regardless of the technique used, establish computed final approach airspeed for the desired AOA early on final and trim the aircraft. Airspeed changes result in pitch changes, which may require retrimming and make glidepath control more difficult. **PW220** / **PW229** Small throttle adjustments may be required as the DEEC retrims the engine.

On short final, avoid premature or large thrust reductions which may cause increased sink rates and a hard landing. Use thrust rather than back stick to control undesirable sink rates. Increased back stick may result in a tail strike in this situation. AOA decreases slightly as the aircraft enters ground effect. All normal landings should be made with speedbrakes opened to the 43-degree position to avoid a floating tendency when entering ground effect. A touchdown at the desired point at 13 degrees AOA can be achieved when flying final at either 11- or 13-degrees AOA by adjusting the initial aimpoint.

Increased control inputs to achieve normal aircraft response as airspeed decreases are unnecessary. Control inputs should be kept small to avoid overcontrol.

Due to the aircraft light wing loading and the floating tendency associated with ground effect, wake turbulence on final approach and during touchdown presents a significant hazard. Increased spacing between landing aircraft should be used when there is little or no effective crosswind. Exercise caution and be ready to initiate a go-around when wake turbulence is encountered. An early go-around decision may help avoid the need for a large roll control input. Such an input retracts a flaperon, causing decreased lift and possibly a sink rate as well as a roll. A large roll input at slow airspeed also causes a large horizontal tail split. A horizontal tail surface could contact the runway while trying to counter wake turbulence effects during touchdown.

If pitch trim is used during the turn to final, forward stick/trim will be required upon rollout on final approach to counter noseup motion. Floating tendencies following a high flare or aircraft bounce may be increased. Slight forward stick force may be required to prevent a long or slow landing. Stick force per degree AOA change is reduced and should not be relied upon as a slow speed cue.

35.12 FACTORS AFFECTING FLYING CHARACTERISTICS

- Pitch sensitivity and pilot induced oscillations (a maximum of ± 0.5g) may occur above 0.80 mach when flying with 600-gallon fuel tanks. This behavior can be minimized by avoiding large pitch-stick inputs and rapid pitch-stick reversal. If this behavior becomes objectionable, reduce airspeed and pitch-stick inputs.
- Momentary uncommanded pitch changes (a maximum increase of 1g) and/or bank angle changes (a maximum increase of 15 degrees) may occur above 0.85 mach when flying with 600-gallon fuel tanks. This behavior is known to occur with loaded TER racks but may occur with other store loadings. Avoid overresponding to the changes and use smooth stick input to minimize pilot induced oscillations. Airspeed should be reduced if this behavior becomes objectionable. If flying within normal load factor carriage (MAX ACCEL G) limits defined in TO 1F-16CM-1-2, STORES LIMITATIONS, an incremental 1g uncommanded pitch change will not exceed structural limits.
- A mild pitch oscillation (a maximum of ± 0.15g at 3 cycles per second) may occur at 0.75-0.90 mach while in cruise gains or at 330- 400 knots while in takeoff and landing gains. The oscillation is caused by the normal response of the aircraft and FLCS and does not cause a significant tracking problem.
- Momentary roll hesitations may occur when commanding low to moderate roll rates (Generally, less than 100 degrees per second) when airspeed is above 350 knots, and altitude is 20,000 feet or less. This behavior is most noticeable when flying without stores.
- A short duration (less than 3 seconds) series of rapid wing rocks (less than 10 degrees of bank angle change) may occur when terminating a high roll rate maneuver at airspeeds above 400 knots. This behavior is most noticeable when flying without stores.

- Minor AOA oscillations (less than ± 2 degrees) may be noticed during elevated-g maneuvering on or near the AOA/g limiter with certain loadings. This behavior is most noticeable between 250 and 350 knots when flying above 25,000 feet MSL.

- Momentary roll hesitations may occur during elevated-g maneuvering on or near the AOA/g limiter with certain loadings. This behavior is most noticeable between 250 and 350 knots when flying above 25,000 feet MSL.

35.13 Center-of-Gravity Considerations

Monitoring the forward and aft fuel distribution provides an indication of the aircraft CG. As CG moves aft, higher pitch rates are obtainable and susceptibility to departure and deep stall increases.

35.14 Effect of Thrust

Thrust changes result in little or no change in aircraft trim or stability at all operational load factors and for all store loadings.

35.15 Effect of Low Airspeed Maneuvering

Departures are possible at low airspeeds and low pitch angles if large, simultaneous pitch and roll inputs are made. The FLCS requires adequate airflow over the control surfaces to be effective, which means that airspeed is a critical factor in departure susceptibility during maneuvering. Low airspeeds should, therefore, be avoided during maximum performance maneuvering.

WARNING
• FLCS limiters can be defeated at low airspeeds (below 200 knots in a CAT I configuration) during maximum pitch and roll commands initiated from below limiter AOAs. • The aircraft can be departed (from parameters outside the tone on area of with no low airspeed warning tone present, if abrupt or uncoordinated FLCS commands are made.

35.16 High Pitch, Low Airspeed

The low airspeed warning tone sounds to aid in recognizing that critical high pitch, low airspeed flight conditions are reached.

WARNING
Proper assessment of flight path angle (not pitch angle) is key to determining the nearest horizon and performing a proper recovery. Differences between flight path and pitch angle of up to 25 degrees, combined with the visual illusion caused by a reclined seat can lead to an incorrect decision to continue the maneuver through the vertical. The risk of a departure/ deep stall in this instance is very high.

Avoiding a departure under these conditions requires specific control techniques. To recover, first release aft stick pressure. This action unloads the aircraft and reduces AOA so that the flightpath more closely coincides with the longitudinal axis of the aircraft. Smoothly roll inverted to the nearest horizon. After the roll, smoothly apply the aft stick pressure required to keep the nose moving toward the horizon. As airspeed continues to decrease during the recovery, more aft stick pressure may be required to keep the nose moving. Continue to smoothly increase aft stick pressure up to the AOA/g limiter. If full aft stick is inadvertently released, do not reapply it unless required to keep the nose moving.

WARNING
Avoid large, simultaneous pitch and roll commands to preclude a roll-coupled departure. Small lateral commands can be made as required to maintain wings level, inverted flight. Do not abruptly apply aft stick pressure at anytime during the recovery. Rapid aft stick pressure will generate excessive AOA, overshooting the AOA limiter and causing departure.

During a recovery where full aft stick is required, nose movement toward the horizon may slow down markedly as the AOA/g limiter tries to limit AOA. As long as the nose continues to move, no further action is required. If the nose of the aircraft does not continue to move toward the horizon, the aircraft has departed, and out-of-control recovery procedures should be initiated. After attaining a nose down attitude with airspeed increasing, continue to avoid abrupt commands. The aircraft may either be unloaded and rolled upright, or a split-s recovery can be made at airspeed above 200 knots, altitude permitting, before continuing to maneuver. The split-s recovery is the simplest way to recover the aircraft. However, if altitude is a factor, allow airspeed to increase to a minimum of 150 knots, unload the aircraft to less than 1g, smoothly roll upright, and recover to level flight.

35.17 Flight with Stores

The major effects of stores are increased weight and inertia. A reduction in aircraft response and damping should be expected as GW increases, particularly when stores are carried. Stores generally reduce longitudinal and directional stability and increase inertial effects so that the pilot must anticipate initiation and termination of maneuvers based on the loadings. High roll and pitch rates are attainable with full force application of the stick. Avoid abrupt control commands which may cause AOA overshoots in excess of the limitations.

Bank angle change limits must not be exceeded. During rolling maneuvers with category III loadings, the roll rate must be stopped prior to 360-degree bank angle change. Removing the roll input is not always sufficient (opposite stick may be required).

Certain store loadings may exhibit decreased yaw/roll damping in supersonic flight and result in mild yawing oscillations. Neutral and divergent yaw and roll oscillations may occur during sideslip maneuvers at supersonic airspeed. These oscillations are aggravated when pods and/or large stores are carried. Excessive vertical tail loads may be generated if oscillations become sufficiently large. If oscillations are encountered during rudder inputs, release the rudder input. Additionally, buffeting may occur in transonic flight with certain store loadings.

NOTE

- A mild airframe vibration may be experienced while supersonic when carrying a centerline store.
- When performing rolls or steady heading side slips while carrying single TGP or large centerline pods above 1.2 mach, the aircraft may report the following PFL's: FLCS ADC FAIL, FLCS AOA FAIL, and BRK PWR DEG.

35.18 Limit Cycle Oscillation and Aeroservo-Elastic Oscillation

A limited amplitude constant frequency oscillation (commonly referred to as limit cycle oscillation or LCO) may occur with certain stores loadings. The LCO (typically 5-10 cycles per second) may occur in level flight or during elevated g maneuvers. The LCO may appear as buffeting or turbulence similar to that experienced during normal transonic buffet, but the buffeting is a constant frequency, lateral acceleration from side-to-side or, in some cases, vertical accelerations up and down. The magnitude generally increases with increasing airspeed and/or load factor. Other cues of LCO include significant vertical movement of the forward area of wing stores, especially wingtip launchers and missiles; this motion is typically up and down but may also follow a circular pattern. In addition, cockpit instruments may become difficult to read as the LCO amplitude increases from moderate to severe. Within published carriage limits, LCO is not detrimental to the aircraft. LCO susceptible loadings include air-to-surface and airto- air loadings and associated downloadings. If LCO is encountered and is uncomfortable or distracting, reduce airspeed and/or load factor.

An aeroservoelastic (ASE) oscillation is similar to LCO. Wing and store oscillation and cockpit vibration may be indistinguishable from those caused by LCO. However, ASE oscillation is driven by the FLCS, resulting in key differences. ASE oscillation (typically at 4-5 cycles per second) is most likely to occur within a narrow range between 0.9 and 0.95 mach. The magnitude is strongly dependent on mach, but not strongly dependent on load factor, and increases in severity as altitude decreases. ASE oscillation will probably occur when carrying wingtip AIM-120 missiles. The presence of stores at stations 3 and/or 7 may dampen the oscillation. Within published carriage limits, ASE oscillation is not detrimental to the aircraft. If ASE oscillation is encountered and is uncomfortable or distracting, change airspeed by at least 0.05 mach.

NOTE

LCO and ASE oscillation may be indistinguishable to the pilot. Either may produce severe oscillation at the most critical flight condition. While not detrimental to the aircraft within published carriage limits, the motions may be extremely uncomfortable or impact mission accomplishment. The most effective way to reduce LCO or ASE is to reduce airspeed.

35.19 Store Separation

Symmetrical store releases and wingtip AIM-9 missile launches can be accomplished with no unusual aircraft responses. Separation of the 300-gallon fuel tank produces negative g on the aircraft. The magnitude of this response depends on the amount of fuel remaining in the tank and the mach number at release. Separating a full 300-gallon fuel tank at supersonic speeds produces the worst response (up to - 1.5g). Separation of 370-gallon fuel tanks produces a minimal aircraft
response. Separation of a single 370-gallon fuel tank will initially produce aircraft positive g response and roll away from the separated tank (up to +1g and 15 degrees of bank).

35.20 DIVE RECOVERY CHARACTERISTICS

Dive recovery capability is given as altitude lost during pullout and is a function of pullout load factor, dive angle, true airspeed, and FLCS limiting. Plots to convert indicated airspeed or mach number into true airspeed are provided on the chart. Dive recovery during constant load factor pullout may be on the AOA limiter prior to recovery, under certain initial conditions, as airspeed is reduced. Dive recovery capability at constant load factor is nearly independent of store drag. The dive recovery chart is applicable to GWs between 20,000-30,000 pounds. The dive recovery chart becomes increasingly conservative for GWs less than 25,000 pounds and decreasingly conservative for GWs greater than 25,000 pounds. Increase altitude lost during full aft stick pullout by 4 percent for each 1000 pounds in excess of 25,000 pounds GW if initial dive angle is ≥ 45 degrees and initial airspeed is less than 500 knots.

Dive Recovery

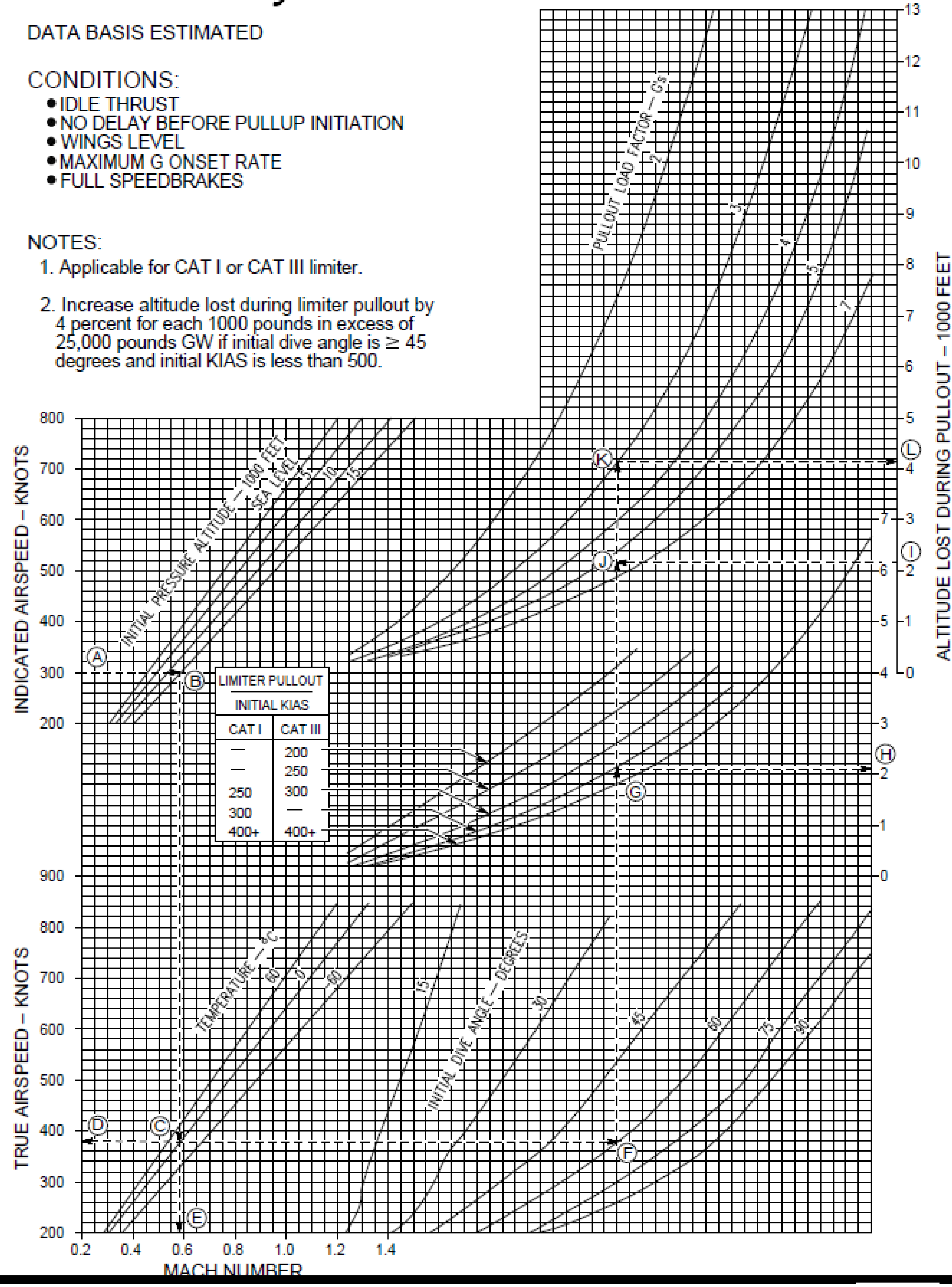
DATA BASIS ESTIMATED

CONDITIONS:

- IDLE THRUST
- NO DELAY BEFORE PULLUP INITIATION
- WINGS LEVEL
- MAXIMUM G ONSET RATE
- FULL SPEEDBRAKES

NOTES:

1. Applicable for CAT I or CAT III limiter.
2. Increase altitude lost during limiter pullout by 4 percent for each 1000 pounds in excess of 25,000 pounds GW if initial dive angle is $\geq$ 45 degrees and initial KIAS is less than 500.



For a constant g pullout, use the greater of constant g or limiter pullout altitude lost.

NOTE

The dive recovery chart is based on an idle thrust, wings level, speedbrakes fully open recovery. However, if airspeed is below 350 knots, altitude loss is minimized by selecting/ maintaining MIL/AB thrust and closing speedbrakes. If airspeed is 350 knots or above, selecting/ maintaining idle thrust and opening speedbrakes minimize altitude loss. In either case, best dive recovery performance is obtained by making an ADI referenced wings level pull.

35.21 FLIGHT WITH ASYMMETRIC LOADS

If roll trim is used to hold up a heavy wing, the ARI adds rudder in the direction of the roll trim, causing a yaw away from the heavy wing. If roll trim is used for takeoff, yaw occurs when the wheel speed drops below 60 knots groundspeed after takeoff, activating the ARI. This yaw is easily controllable by rudder inputs. Yaw and roll trim requirements change for different flight conditions.

Asymmetric loads increase departure and spin susceptibility. Roll commands/trim away from the heavy wing is required to maintain the desired roll attitude. Increasing g requires additional roll commands/trim. Therefore, aft stick commands result in increased roll requirements which, in turn, produce yaw away from the heavy wing due to ARI action.

WARNING

With certain asymmetric category III loadings (2000 pounds or greater on station 3 or 7 with stores on stations 4, 6, and/or 5), rapid or abrupt aft stick commands may result in sudden nose slicing departures. Departure with an asymmetric category III loading may result in a fast, flat (possibly nonrecoverable) spin.

NOTE

Left-wing heavy asymmetries are more susceptible to departure. At high airspeeds, asymmetric loads exhibit some unusual flight characteristics. Frequent trim reversals may occur during supersonic acceleration. At airspeeds greater than 700 knots, yaw oscillation may occur with significant lateral accelerations. During supersonic flight, negative-g maneuvers are highly susceptible to pilot induced yaw oscillations. Lateral stick commands will result in significant proverse yawing moments that excite lightly damped yaw oscillations. A constant lateral stick input and increasing the AOA above 0 degrees will dampen the oscillations. Small lateral stick inputs (2 to 3 pounds force) result in small, damped yaw oscillations. Keep lateral stick commands to a minimum during negative-g supersonic flight.

CAUTION

Yaw oscillations may occur as a result of lateral stick commands during negative-g supersonic flight. Keep lateral stick commands to a minimum and make AOA positive if yaw oscillations are encountered during this flight regime.

Over 750 knots, a high frequency directional shaking may occur with loadings such as the ECM pod.

35.22 ABNORMAL FLIGHT CHARACTERISTICS

Loss of any component of the flight control system or surfaces, through system degradation or damage, may significantly alter the normal flying characteristics and procedures.

35.23 FLCS DBU

Flight characteristics for cruise and landing are not significantly affected by operation in DBU. Although airspeed should be maintained below 500 knots/0.9 mach while in DBU, transitions to DBU at higher airspeeds do not produce adverse handling characteristics. Minimal pitch transients occur if transition to DBU occurs at 1g. At higher g levels, transition to DBU is accompanied by an initial reduction in g. If the aft stick input is continued, g level again increases, but may be less than that which was available prior to the transition. The STORES CONFIG switch is inoperative in DBU and AOA/g force available is similar to that in CAT III.
If LG are lowered below 200 knots, a mild noseup transient of approximately 2 degrees occurs. A similar nosedown movement occurs if LG is raised below 200 knots. If an automatic transition to DBU occurs when in ATF, the FLCS initiates a 3g incremental no roll to wings level fly-up.
This fly up can be interrupted using the paddle switch. All ATF indications are turned off (active light, TF FAIL warning light, ATF NOT ENGAGED caution light, and autopilot PITCH switch). HUD TF symbology is also removed.

35.24 LEADING EDGE FLAPS LOCKED (SYMMETRIC)

Flight characteristics for landing and low AOA maneuvering are not significantly affected by locked LEFs. At high airspeeds, LEFs locked down cause increased buffet. At high AOA, LEFs locked up reduce stability, increase departure susceptibility significantly, and cause increased buffet. Above 16-18 degrees AOA, an abrupt yaw departure may occur, producing an uncommanded roll with little or no forewarning. Do not exceed 12 degrees AOA with the LEFs inoperative. Locked down LEFs significantly reduce cruise range. During landing, floating may also be noticeable if LEFs are locked at or near full down. The aircraft may float, sink rate may decrease, and a slight forward stick pressure may be needed to fly through the ground effect.

35.25 STANDBY GAINS

When operating on standby gains, aircraft response is normal at low AOA. Because the LEFs are at zero degrees (LG handle in UP and ALT FLAPS switch in NORM) with a dual air data failure, buffet and departure susceptibility will be increased at higher AOA (above 18 degrees). At flight conditions higher/slower than the fixed gain conditions, aircraft response is more sluggish requiring larger control commands for a given response. Landing the aircraft should present no special problems.

35.26 ONE HYDRAULIC SYSTEM

Flight characteristics with one hydraulic system should be normal unless extremely large, rapid control surface deflections are commanded. Under these conditions, the hydraulic flow rate from the one system may be inadequate which slows down control surface movement rates and possibly causes sluggish aircraft response.

35.27 SPEEDBRAKES

Speedbrakes may stick fully open or open asymmetrically. If a yawing moment is noted when the speedbrakes are opened, close the speedbrakes. If the speedbrakes fail to close, a significant increase in drag results. Fully opened speedbrakes significantly reduce cruise range.

35.28 AIRCRAFT DAMAGE

In BMS for now the damage is general or may affect certain systems, but you visually won't be able yet to see a damage to a specific structural part of the airplane. Therefore, this section is left as is and will be updated accordingly when the damage model of the F-16 will be integrated.

35.29 Stalls

The AOA/g limiter depends on the horizontal tails to control g and AOA. Conventional cues such as aircraft buffeting forces are not always present as AOA and g limits are approached. If the airspeed decreases until there is not enough airflow over the tails to provide this control, the limiter is defeated and a departure or deep stall may result. This condition may occur in a nose-high, decreasing speed maneuver.

35.30 DEEP STALL

If the aircraft does not self-recover following a departure, a deep stall may have developed. A deep stall is an out-of control flight condition in which the aircraft stabilizes at an AOA of approximately 60 degrees (upright) or -60 degrees (inverted) with low yaw rates. The FLCS attempts to return AOA to the normal range by commanding full horizontal tail deflection. However, the full horizontal tail deflection is insufficient to return AOA to the controllable range. The aircraft has entered a deep stall if the AOA remains outside the controllable range. In a deep stall the AOA will be pegged at 32 or -5 degrees. Recovery to controlled flight requires that the pilot pitch rock the aircraft with the MPO switch in OVRD. The MPO switch allows the pilot to override the FLCS and to manually control the horizontal tails.

Airspeed indications are erroneous in a deep stall and fluctuate between 0-150 knots. Altimeter indications should be considered reliable; however, aircraft oscillations may cause momentary stabilized or even slightly increased altitude indications. Sink rate in a deep stall is usually between 10,000 and 15,000 feet per minute. The normal load factor is approximately 1g or -1g for upright and inverted deep stalls, respectively.

Upright deep stalls may be very stable with little or no pitch, roll, and yaw motions or may be very oscillatory with large pitch, roll, and yaw motions. Generally, a clean configuration results in a deep stall with a near wings-level pitching motion. If stores are being carried, especially a 300-gallon fuel tank or 370-gallon fuel tanks, the deep stall may be very oscillatory, masking the pitch motions.

In an upright deep stall, the nose of the aircraft usually oscillates ±15 degrees about a slightly nose-low pitch attitude. Pitch oscillations may be as high as ±40 degrees and normally reverse direction approximately every 3 seconds. Roll reversals up to ±90 degrees from wings level may occur and the yaw rate tends to cyclically reverse back and forth and may be as high as 40 degrees per second. A slow net heading change, usually to the left, may occur.

Inverted deep stalls may be either stable or highly oscillatory in pitch, depending upon the CG. If there is little or no pitch motion, the nose is slightly above the horizon and the wings are generally level. If the deep stall is oscillatory in pitch, the nose may oscillate above and below the horizon by as much as ±20 degrees. Yaw and roll oscillations in an inverted deep stall are normally smaller than those during an upright deep stall.

The aircraft is most likely to stabilize in a deep stall if it does not self-recover within two post departure pitch oscillations.

The likelihood of a deep stall occurring after a departure is also dependent upon the aircraft CG and configuration. An inverted deep stall can occur at a more forward CG than an upright one. The likelihood of a deep stall developing after a departure increases as the CG moves farther aft and if stores (especially 370-gallon fuel tanks) are loaded.

35.31 Deep Stall Recovery

The aircraft should be allowed the opportunity to self-recover if altitude permits. Initiating pitch rocking too soon should be avoided because it can aggravate post departure roll and yaw motions, which can significantly lengthen recovery time.

If recovery is not apparent after two post departure pitch oscillations (10-20 seconds), the aircraft must be rocked out of a deep stall. To pitch rock the aircraft, the MPO switch must be firmly held in OVRD until recovery is complete. Recognize any pitching motions and begin stick cycling in-phase with these motions. If no pitch motions are apparent, an abrupt maximum command stick input to pitch the nose away from the ground (full aft stick for an upright deep stall, full forward for an inverted deep stall) will reverse the horizontal tail deflection and should generate a noticeable pitch rate. The best indicator for timing stick cycles is the nose position relative to the horizon, or if no outside references are available, the ADI may be useful. In an upright deep stall, an aft stick command increases the AOA and pitch angle. When the nose reaches its highest point and reverses direction, a full forward stick command reinforces the nosedown pitch rate. One complete pitch rocking cycle takes approximately 6 seconds, during which time the aircraft descends 1000 to 1500 feet.

If the nosedown pitch rate is large enough, the upright deep stall is broken and AOA returns to the normal range (below +25 degrees). If the nose down pitch rate is insufficient, the nose stops its downward motion and either begins to rise or stabilizes. Promptly reapply the full aft stick command when the nose reverses or after 2-3 seconds if reversal is not apparent. Holding full forward stick more than 2-3 seconds with the nose stabilized can generate a rapid yaw rate and delay recovery. If the aircraft has not recovered after 2-3 seconds or if a yaw rate develops, reapply full aft stick and complete another in-phase pitch rocking cycle.

Just prior to breaking the deep stall, the nose down pitch rate may decrease or even stop. Unless the nose either definitely starts back up or stabilizes for longer than 2-3 seconds, another pitch up cycle should not be started. On the pitch down cycle, the stick should be held full forward (upright) or aft (inverted) while the nose hesitates as the stall breaks. Following a short hesitation (less than 2-3 seconds), the nose continues down to near vertical. There is frequently a distinct, low magnitude airframe shudder which occurs as the stall is breaking. This shudder is a favorable indication that recovery is occurring.

Once the deep stall is broken, aggressive pilot commands are usually required to stop the pitch rate in a steep dive. If possible, find and track a feature on the ground. Maintain firm pressure on the MPO switch until airspeed reaches 200 knots. If a transition to an opposite AOA deep stall does occur, reinforce the already present pitch motion with the MPO still engaged and recovery should be rapid. Transitions during upright deep stall recoveries are most likely to occur with 370-gallon fuel tank configurations.

Recovery to controlled flight is recognized by a steep pitch attitude (usually within 30 degrees of vertical), pitch rate stopping and AOA in the normal range (-5 to +25 degrees). As airspeed increases above 200 knots, release the MPO switch, maintain neutral roll and yaw commands, and recover from the resulting dive.

Stick commands during pitch rocking should be abrupt and full command and should reverse after pitch motion reverses. Stick commands that are not abrupt and full command may not be effective. Rapid fore and aft cycling of the stick out of phase with the aircraft motion is also not effective.

The number of pitch rocking cycles required for recovery from an upright deep stall is dependent on aircraft configuration. Generally, recovery occurs in one or two pitch rocking cycles. However, configurations with a centerline store (particularly a 300-gallon fuel tank) or with 370-gallon fuel tanks may require more pitch rocking cycles for recovery. These loadings usually have more oscillatory deep stalls, and the roll and yaw motions make it more difficult to determine proper stick cycling. Pitch attitude is still the best indication for proper stick cycling.

During upright deep stalls with a centerline store, particularly a 300-gallon fuel tank, the aircraft tends to roll and yaw right while pitching up and roll and yaw left while pitching down. During deep stalls with 370-gallon fuel tanks, the aircraft nose motion appears triangular. This motion is characterized by a roll and yaw right while pitching up, followed by a pitch down, a hesitation, and a yaw to the left. These alternating yaw oscillations should not be confused with a sustained yaw rotation in one direction indicating the aircraft is in a spin.

An inverted deep stall recovery is similar to an upright recovery. In an inverted deep stall, the yaw rate limiter automatically provides rudder against the yaw rate. Pilot roll and rudder commands should be avoided. Pilot roll and rudder commands are inhibited when the MPO switch is in OVRD. Yaw oscillations may be noticed but do not affect recovery.

To recover from an inverted deep stall, position the MPO switch to OVRD and begin stick cycling in-phase with pitch motions. If no pitch motions are apparent, make the first pitch input away from the ground by pushing full forward and monitor pitch motion. One or two pitch rocking cycles are usually sufficient to recover from an inverted deep stall.

During recovery from an inverted deep stall, a transition to an upright deep stall is likely to occur if large pitch motions are present during inverted pitch rocking and the MPO switch is released too early. Early release of the MPO switch reduces the horizontal tail authority available and delays recovery. The MPO switch must be held in OVRD until the deep stall is positively broken as evidenced by the pitch rate stopping, AOA in normal range (-5 to +25 degrees), and a steep pitch attitude (usually within 30 degrees of the vertical). As airspeed increases above 200 knots, release the MPO switch, maintain neutral roll and yaw commands, and recover from the resulting dive.

NOTE

For GE100 / GE129 engines, the aircraft has demonstrated a strong tendency to transition to an upright deep stall during recovery from an inverted deep stall. Aggressive pilot inputs are required as the nose pitches down to the vertical during recovery to preclude a transition.

35.32 DEPARTURES

A departure is a loss of aircraft control that is characterized primarily by uncommanded aircraft motions or failure of the aircraft to respond to control commands. In a pitch departure, the AOA increases beyond the normal controllable range. In a yaw departure, the sideslip angle increases beyond the normal controllable range first, although a pitch departure may immediately follow. The automatic features of the FLCS normally prevent departures. However, departures may occur when limitations are exceeded or in certain circumstances when the FLCS provides only marginal protection.

With a lateral asymmetry in excess of 300 pounds (including wing tip missile and internal/external fuel), abrupt maneuvering on or near the CAT I AOA limiter can result in a departure if the aircraft is configured with any of the following:

- 300-gallon fuel tank.
- 370-gallon fuel tanks.
- Inlet mounted pod(s).
- Combination of a centerline store plus stores (or suspension equipment) at stations 3 and/or 7.

With these loadings, maneuvering at high altitude (above 25,000 feet) increases the probability of a yaw departure. Even moderate control commands may cause aircraft with some CAT I loadings to depart above 25,000 feet.

Abrupt maneuvering on or near the CAT I AOA limiter at slow airspeeds (less than 200 knots) may result in a departure.

35.33 YAW DEPARTURE

A yaw departure occurs when sideslip increases beyond the normal controllable range (i.e., beyond about 15 degrees). The primary indication of most yaw departures is an abrupt nose slice. The aircraft then fails to respond properly to pilot commands and exhibits uncommanded motions. AOA is in the normal range (-5 to +25 degrees) during the initial phase of the nose slice. Immediately following a yaw departure, a pitch departure usually occurs resulting in AOA indication of -5 or +32.

It is possible for the sideslip to briefly exceed the normal controllable range without the aircraft experiencing uncommanded motions. In this situation, the pilot’s only indication of a departure may be noticeable sideforces. These brief departures typically self-recover within 5 seconds. A yaw departure may occur while maneuvering on or near the CAT I AOA limiter in the 0.80 to 0.95 mach range, especially at high altitude (above 25,000 feet). Maneuvering at high altitude is more critical than low altitude because mach effects reduce directional stability. These yaw departures usually result from maximum command left rolls; but they may also occur during symmetric maneuvering.

The possibility of a yaw departure is increased whenever the aircraft is configured with stores or suspension equipment,especially a centerline store. In general, the possibility of departure increases as the number, weight, and size of such equipment or stores increases. Susceptibility to a yaw departure increases significantly with lateral asymmetry, with left-wing-heavy loadings being more likely to depart than right-wing-heavy loadings. In addition, a heavier GW aircraft is generally more likely to experience yaw departures. CAT I loadings most susceptible to yaw departures have one or more of the following characteristics:

- Centerline store.
- Inlet mounted pod(s).
- Lateral asymmetry greater than 300 pounds at stations 1,2, or 3.

Yaw departures can be minimized by avoiding abrupt maneuvers in the 0.80 to 0.95 mach range with a centerline store, especially above 25,000 feet. Either unload the aircraft prior to making roll commands or command only minimum required roll rate when operating near the CAT I AOA limiter. With centerline store loadings having lateral asymmetries greater than 300 pounds and inlet mounted pod(s), avoid abrupt aft stick commands above 25,000 feet.

WARNING
The probability of a yaw departure significantly increases above 25,000 feet for CAT I loadings having a centerline store, a lateral asymmetry greater than 300 pounds, and inlet mounted pod(s). With these loadings, moderate, full-aft-stick inputs at 35,000 feet and 300 knots have caused yaw departures and spins.

A yaw departure may also occur with large air-to-surface lateral asymmetries with the STORES CONFIG switch in the CAT III position. These departures can be avoided if abrupt control commands are not used with lateral asymmetries in excess of 1500 pounds at station 3 (or equivalent).

A yaw departure results in one of the following:

- A self-recovery. The self-recovery may occur quickly (within approximately 5 seconds). If a pitch departure follows the yaw departure, the self-recovery may require 10-20 seconds. Random and possibly abrupt pitch, roll, and yaw rates may occur.

- A deep stall.

- An upright spin.

35.33.1 PITCH DEPARTURE

A pitch departure occurs when the AOA exceeds the AOA/g limiter. A pitch departure is classified either as upright if the AOA is positive or as inverted if the AOA is negative. Although the AOA indicator displays a maximum of 32 degrees and a minimum of -5 degrees, the actual AOA during a departure will exceed these values. In highly oscillatory departures, the AOA may momentarily indicate an AOA below 32 degrees. Airspeed indications are erroneous and generally oscillate between the minimum value and approximately 150 knots.

An upright pitch departure occurs when the AOA exceeds the positive AOA/g limiter. Above limiter AOA, both horizontal tails are commanded to full trailing edge down by the pitch axis of the FLCS to try to reduce the AOA. If AOA exceeds 35 degrees, the yaw rate limiter provides antispin commands to the rudder, flaperons, and horizontal tails. Pilot roll and rudder commands are inhibited, and pitch stick commands are ineffective without use of the MPO switch.

An inverted pitch departure can occur when the AOA exceeds –5 degrees and the aircraft is at low airspeed. During the departure, the pitch axis of the FLCS commands the horizontal tails to full trailing edge up to try to return AOA to the normal range. Pitch stick commands are ineffective without use of the MPO switch.

If AOA is below -5 degrees and airspeed is less than 170 knots, the yaw rate limiter provides antispin commands to the rudder. During an inverted departure, roll and rudder commands should be avoided. Pilot roll and rudder commands are inhibited when the MPO switch is engaged.

An upright or inverted pitch departure can occur when the aircraft is flown to airspeeds below that indicated by the low speed warning tone. Inverted pitch departures usually result from inverted flight at high pitch attitudes and low airspeeds, such as those often encountered by going over the top at too slow an airspeed. An upright or inverted pitch departure may also occur at any pitch attitude if abrupt stick commands are made at airspeeds below 200 knots. Simultaneous abrupt roll and aft stick commands are especially likely to cause an upright pitch departure. However, the aircraft can be safely flown to the AOA/g and roll limiters below 200 knots with smooth commands.

An upright pitch departure may also result from a yaw departure. In addition, recovery from an inverted pitch departure may cause the aircraft to pendulum into an upright departure and vice versa.

The likelihood of a pitch departure increases if the aircraft is configured with stores (especially 370-gallon fuel tanks), if the speedbrakes are opened, or if the CG is near the aft limit.

Pitch departure characteristics are strongly influenced by the airspeed and aircraft rates present at departure. A low airspeed departure (below 200 knots) may have relatively benign uncommanded pitch, roll, and yaw motions. Higher airspeed departures are usually very dramatic with large uncommanded pitch, roll, and yaw motions which may persist for 10 seconds

or more. It is possible for the AOA to briefly exceed the AOA/g limiter without the aircraft experiencing uncommanded motions. In this situation, the pilot's only indication of a departure may be
a failure of the aircraft to respond to control commands. These brief departures typically self-recover within 5 seconds.

A pitch departure results in one of the following:

- A self-recovery which occurs within 5-20 seconds. Random and possibly abrupt pitch, roll, and yaw rates may occur.
- A deep stall.
- A spin.

35.34 SELF RECOVERY

Recovery from most departures is automatic, requiring only release of the controls. Once the controls are released, self-recoveries usually occur within the first two post departure pitch oscillations (10-20 seconds). Recovery is characterized by the nose pitching down to a steep dive angle, increasing airspeed, and AOA and sideslip returning to the normal range. Some post departure yaw and roll oscillations may be evident, particularly if the departure was in yaw. To prevent departure reentry, the airspeed should be allowed to increase to 200 knots prior to dive recovery. Flight control failure indications may be present after recovery from any departure.

35.35 SPINS

A spin is a deep stall with a significant sustained yaw rate in one direction (greater than 30 degrees per second). The pitch, roll, and yaw oscillations associated with a deep stall should not be confused with the continuous yaw rotation associated with a spin. AOA, airspeed indications, and altitude loss are similar to those during deep stalls. Spins can be either upright or inverted, although inverted spins are much less likely to occur than upright spins.

The yaw rate limiter is effective in preventing an upright spin with most CAT I loadings. However, following a yaw departure above 25,000 feet, aircraft with CAT I loadings that have all the following characteristics may spin:

- Centerline store.
- Inlet mounted pod(s).
- Lateral asymmetry greater than 300 pounds at stations 1, 2, or 3.

Upright spins following a yaw departure can be disorienting. The initial portion of the spin is characterized by highly oscillatory pitch and roll motions and a high yaw rate (70 to 100 degrees per second). Initially, the aircraft spins roughly around the aircraft's flight path at departure. As the spin continues, the rotation axis eventually becomes vertical. Very noticeable forward g (eyeballs out) and sideforces are present.
Yaw rate usually decreases to near zero within 10 to 25 seconds. The g forces decrease noticeably as yaw rate decreases, which may give the sensation that yaw rate is lower than it actually is. Use outside references to determine when the yaw rate has stopped. If unable to determine yaw rate or direction via outside references (i.e., IMC or night), reference the ADI, HSI, and turn needle. A recovery may occur after yaw rate has decreased to near zero. If recovery does not occur, the aircraft has settled into a deep stall and pitch rocking must be used to recover the aircraft to controlled flight. However, because pitch rocking is less effective when a yaw rate is present, pitch rocking should not begin until yaw rotation stops or is minimized (if altitude permits).

A spin may also occur following any departure with a CAT III loading that has a large lateral asymmetry from air-tosurface stores. These spins may be fast, flat, and possibly unrecoverable.

An inverted spin can be caused by pilot rudder and roll commands if they are not released following an inverted departure. The yaw rate limiter is effective in preventing an inverted spin with all CAT I loadings. However, large lateral asymmetries from air-to-surface stores on CAT III loadings may overpower the yaw rate limiter and cause unrecoverable inverted spins.

35.36 SPIN RECOVERY

To recover from a spin, yaw rate must be stopped or minimized before the aircraft can be recovered. Due to large nose-up moments caused by the inertial properties of the aircraft and decreased horizontal tail pitch effectiveness with sideslip, attempts to pitch rock out of a spin are usually not effective. Pitch rocking during a spin is also likely to aggravate roll and yaw oscillations, which make recovery more difficult.

When the FLCS has sensed the increased yaw rate of a spin, it commands flaperon and differential horizontal tail deflection into the yaw, and rudder opposite the yaw. Since activation of MPO commands the horizontal tails to the neutral position, attempts at pitch rocking before the yaw rotation stops or is minimized limit the effectiveness of the antispin controls and will delay recovery.

The large forward g (eyeballs out) and sideforces present during the initial portion of an upright spin decrease noticeably as yaw rate decreases, which may give the sensation that yaw rate is lower than it actually is. Use outside references to determine when the yaw rotation has stopped. If unable to determine yaw rate or direction via outside references (i.e., IMC or night), reference the ADI, HSI, and turn needle. Pitch rocking should not begin until the yaw rotation stops or is minimized. Pitch rocking with a steady yaw rate greater than 30 degrees per second may prevent recovery.

Waiting for yaw rotation to stop or minimize may require from 20 to 30 seconds. When the yaw rotation stops or is minimized, the aircraft will either self-recover or will settle into an upright deep stall. If recovery is not apparent after yaw rate has stopped, perform the appropriate recovery procedures described in the Deep Stall Recovery section. Pitch, roll, and yaw oscillations associated with a deep stall should not be confused with the continuous yaw rotation associated with a spin. Once the continuous yaw rotation of a
spin has been arrested and pitch rocking has begun, pitch rocking should continue until a recovery is achieved.

Upright spins with CAT III loadings that have large lateral asymmetries from air-to-surface stores may be fast, flat, and possibly unrecoverable. There is an option to jettison an asymmetric store as a last-ditch effort in case of a fast, flat spin. However, aircraft-store collision may occur.

Inverted spins with CAT I loadings are effectively prevented by the yaw rate limiter. The yaw rate limiter automatically provides rudder against the yaw rate. Pilot roll and rudder commands should be avoided.

If recovery is not apparent after yaw rate has stopped or is minimized in an inverted spin, the aircraft has settled into an inverted deep stall. Perform the inverted deep stall recovery procedures.

35.37 ENGINE OPERATIONS

35.37.1ENGINE OPERATION DURING DEPARTURES/OUTOF- CONTROL

PW220 Departures at high altitude may result in an engine stall or stagnation. Retard the throttle to IDLE. Do not advance the throttle until beginning the dive recovery.

If the engine stalls during a departure or out-of-control situation, refer to ENGINE STALLS, Section III, after recovery is complete. The engine should be left running during an out-of-control situation to insure adequate hydraulic pressure to flight control surfaces for recovery. Recover from the out-of-control condition; then concentrate on the engine. If the engine does not recover, accomplish the AIRSTART PROCEDURES.

36 ADVERSE WEATHER OPERATION

36.1 INSTRUMENT FLIGHT PROCEDURES

The HUD may be used as a primary reference for instrument flight. Frequent crosschecks with other instruments will be performed to maintain proper flight orientation and detect failures that are not directly communicated to the pilot.

WARNING
The HUD should not be used as the sole reference for instrument flight due to the lack of adequate failure warning but should be crosschecked with the primary/basic instruments. The displays generated for the HMCS helmet are not approved for use as a reference during instrument meteorological conditions (IMC) or for course guidance during landing. A delayed selection of PLS/TACAN or PLS/ NAV until the aircraft is nearly on the ILS glide slope may cause the flight director circle to be positioned incorrectly (full up or full down) for up to 90 seconds. If the flight director circle is positioned incorrectly when an ILS mode is selected, select TACAN or NAV, then reselect the desired ILS mode. This action enables the flight director to operate properly. Certain RLG INUs may indicate a failure of the altitude and vertical velocity data during supersonic flight or high rates of climb/descent. This condition will blank the HUD FPM and disable ground collision warning functions with no other failure indications or advisories. It is possible for the MMC to position the ILS glideslope bar full down without being dashed even though the ILS glideslope signal may be valid. Care must be taken during precision approaches to cross check ILS information on the ADI if the HUD glideslope bar drives full down and is not dashed. It is possible for the displayed ADI and/or HUD attitude to be in error with no ADI OFF or AUX warning flags in view and without an INS, EGI or HUD PFL. Displayed HSI and/or HUD headings may also be in error with no HSI OFF or ADI AUX warning flags in view and without an INS, EGI or HUD PFL. Momentary warning flags may indicate impending failure. To detect these failures and maintain proper flight orientation, basic and backup instruments shall be cross-checked. With certain failures of the INS with ILS selected, a fixed aircraft reference symbol is displayed at zero degrees azimuth, 11 degrees below the boresight symbol. This symbol is for ILS deviation reference in conjunction with the horizontal and vertical deviation bars. The aircraft reference symbol should not be used for attitude reference. Avoid touching the canopy transparency, canopy frame or placing arms on the canopy body positioning handles during IMC. Contact may produce severe shock as a result of static discharge.

NOTE

TACAN is only functional with INS turned on.

Electrical transients (particularly during the EPU check) may cause the INS to revert to use of the last manually entered magnetic variation. Under these conditions, the accuracy of heading information displayed on the HSI and HUD depends upon the manual magnetic variation value entered. If magnetic heading error is suspected, confirm that automagnetic variation is in use or that the correct local magnetic variation is entered.

Interference effects from the scanning of the FCR antenna may degrade ILS glideslope reception range and cause intermittent loss of signal indications. The interference can be eliminated by stowing the FCR antenna (select STBY or depress OVRD OSB). If FCR use is required, interference may be reduced or eliminated by positioning the FCR antenna tilt as high as practical, preferably above the horizon.

36.2 HOLDING

Recommended holding airspeed is maximum endurance.

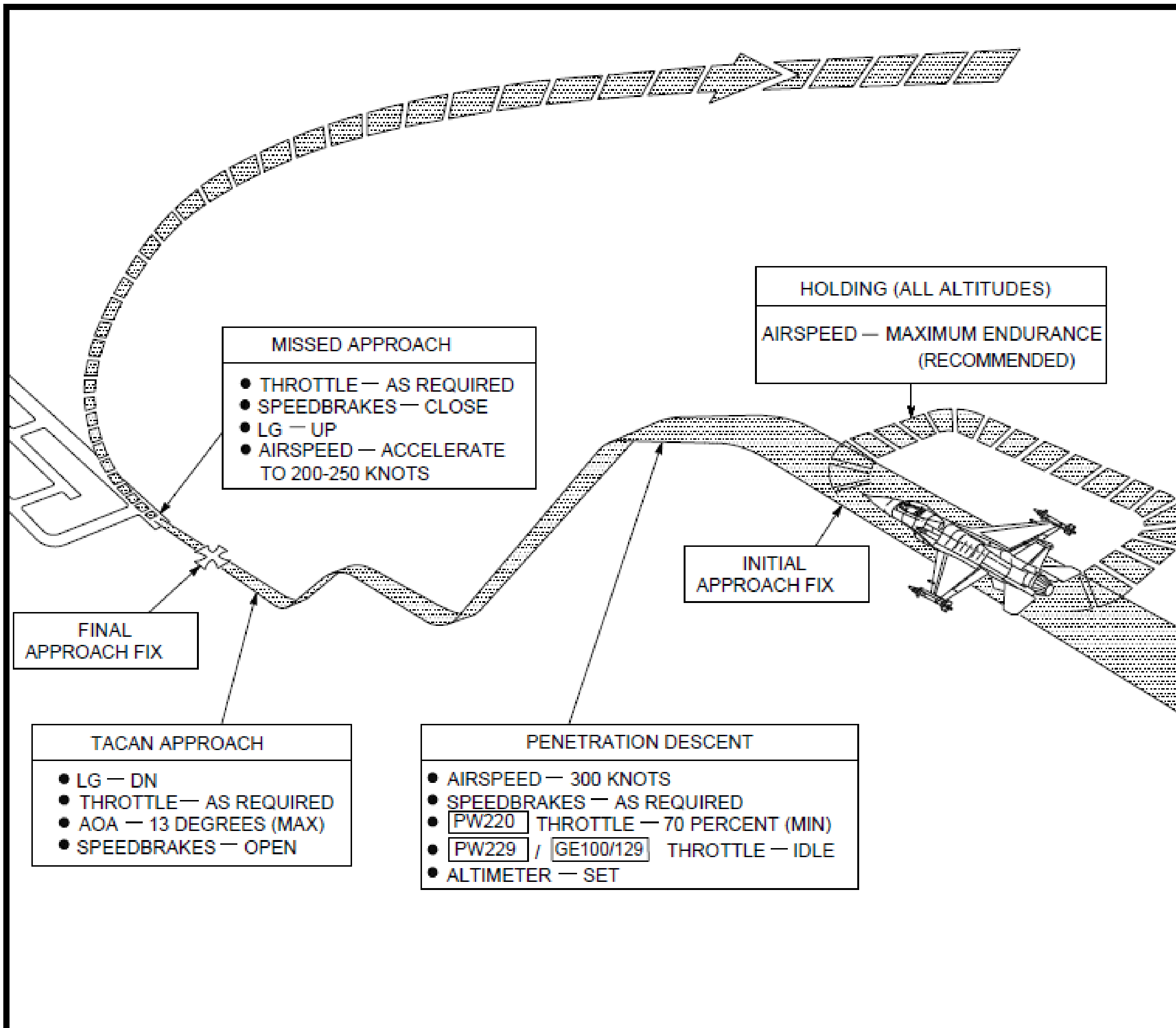
36.3 PENETRATION

Penetrations are normally flown at 300 knots, speedbrakes as required, and throttle at PW220 70 percent rpm minimum, PW229 / GE100/GE129 IDLE.

36.4 INSTRUMENT PATTERN/APPROACHES

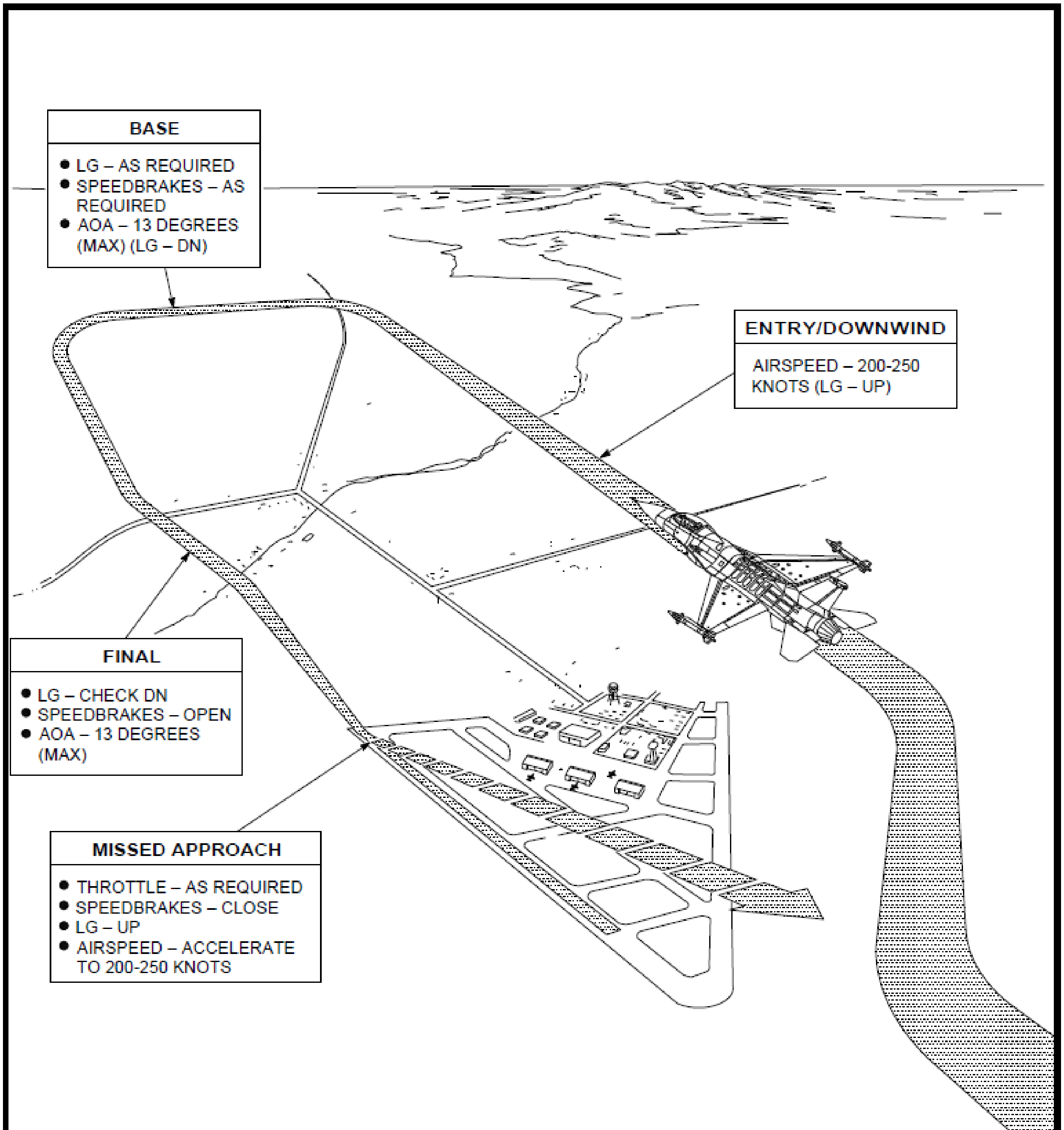
For a typical TACAN holding pattern, penetration and approach. Refer to Tacan holding pattern Typical for a typical GCA. Instrument patterns are normally flown at 200-250 knots clean. Approaching final, lower the LG, slow the aircraft, and fly final approach at 13 degrees AOA maximum.

36.4.1 TACAN HOLDING PATTERN TYPICAL



NOTE:

A typical straight-in penetration and approach require approximately 400 pounds of fuel for a drag index of 0 and 600 pounds of fuel for a drag index of 200.



NOTE:

A typical GCA pattern requires approximately 400 pounds of fuel for a drag index of 0 and 700 pounds of fuel for a drag index of 200.

36.5 Missed Approach

Advance throttle as required, close speedbrakes, and retract LG after a positive climb is established. Adjust throttle to maintain between 200-250 knots. Pitch transients resulting from LG and TEF changes are mild and require minimum control compensation.

36.6 TURBULENCE AND THUNDERSTORMS

Avoid flight in turbulent air, hailstorms, and thunderstorms. There is a high probability of damage to airframe and components from impact ice, hail, and lightning. Thunderstorm penetration airspeed is 300 knots or optimum cruise airspeed, whichever is lower. At high airspeeds, personal discomfort and structural stress are greater. At slower airspeeds, controllability is reduced and inlet airflow distortion due to turbulence may cause compressor stall and/or engine stagnation.

The GM mode of the radar can be used as an aid in navigation between or around storm cells. (This is not implemented yet).

If entry into adverse weather cannot be avoided, the following procedures should be used:

- PROBE HEAT switch - Check PROBE HEAT.
- FLOOD CONSOLES knob - HIGH INT.
- ANTI ICE switch - ON.
- Airspeed - 300 knots or optimum cruise, whichever is lower.

NOTE

- Severe turbulence causes variations in airspeed and altitude. Do not change throttle setting except for extreme airspeed variations.

- An extremely loud screeching noise may be heard in the headset while flying in cirrus clouds or in the vicinity of thunderstorms. The noise may be eliminated by turning the UHF or VHF radio off, by turning the volume(s) down, or by changing UHF antenna positions (Not implemented yet).

- When flying in heavy rain, water tends to be aerodynamically held on the forward portion of the canopy.

- At higher airspeeds, this condition may obscure visibility as much as 30 degrees back on each side of the canopy. On final approach, the water is generally confined to the position of the canopy immediately in front of the HUD. It may be necessary to look out the side of the canopy to acquire the runway and to flare and land the aircraft.

36.7 COLD WEATHER OPERATION

Engine operation under the following conditions may result in engine damage due to icing:

CAUTION
• Ambient temperatures between 20°F (-7°C) and 45°F (7°C) with precipitation (rain, fog, sleet, or snow).
• Dewpoint within 9°F (5°C) of ambient temperatures between 25°F (-4°C) and 45°F(7°C).
• Ambient temperature below 45°F (7°C) with standing water or a mixture of water with ice or snow within the immediate proximity of the engine inlet.

36.8 BEFORE ENTERING COCKPIT

All accumulated ice and snow must be removed from the aircraft before flight is attempted. Insure that water does not accumulate on control surfaces or other critical areas where refreezing may cause damage or binding.

36.9 BEFORE STARTING ENGINE

Extreme cold temperature may require cockpit preheating to ease operation of rotary-type switches. D The canopy may not latch on battery power alone. Start the engine with the canopy closed as much as possible.

If there is visible moisture and ambient temperature is 45°F (7°C) or less, place the ANTI ICE switch to ON. This reduces ice buildup on the engine front face, eliminates ice on the heated inlet strut, and reduces the possibility of ice ingestion.

36.10 STARTING ENGINE

Different oils are not implemented but it is nice to know info.

If the aircraft is serviced with MIL-H-5606 hydraulic fluid and the aircraft has cold soaked for more than 1 hour at temperatures below -40°F (-40°C), do not start the JFS until ambient temperature increases to above -40°F (-40°C) for at least 2 hours or until the engine bay is preheated. For temperatures above -40°F (-40°C), refer to JET FUEL STARTER LIMITS.

If the aircraft is serviced with MIL-H-83282 hydraulic fluid and the aircraft has cold soaked for more than 1 hour at temperatures below -20°F (-29°C), do not start the JFS until ambient temperature increases above -20°F (-29°C) for at least 2 hours or until the engine bay is preheated. For temperatures above -20°F (-29°C), refer to JET FUEL STARTER LIMITS.

During cold start, oil pressure may be 100 psi for up to 1 minute for PW220 and PW229 engines and 2 minutes for GE100 / GE129 engines.

36.11 AFTER ENGINE START

EPU fuel quantity can indicate as low as 90 percent at temperatures below 40°F (4°C). For rapid cockpit warming, position the TEMP knob to the desired MAN WARM range. Position the RADAR to off and the DEFOG lever as required to clear fogging. After the cockpit reaches a comfortable temperature, select a setting within the AUTO range. If the engine was started with the canopy unlatched, wait approximately 10 minutes to warm the canopy before fully closing it.
If probe icing is evident or suspected, turn the PROBE HEAT switch to PROBE HEAT at least 2 minutes prior to accomplishing the FLCS BIT.

WARNING
If probe heat is on or has been on, heat in probes may be sufficient to cause injury if touched.

CAUTION
If the aircraft has cold soaked at temperatures below -20°F (-29°C), repeated brake applications (25-30) may be required before the brakes work effectively.

36.12 TAXI

To avoid brake icing, do not taxi in deep water, slush, or deep snow. When taxiing on ice or hard packed snow, NWS may not be completely effective. Use a combination of NWS and differential braking to maintain directional control. Taxi at a safe speed considering surface condition, GW, slope, and thrust. If the aircraft has cold soaked at temperatures below -20°F (-29°C), the NWS may initially be sluggish, but controllable.

WARNING
Probe internal icing must be suspected anytime the aircraft has been exposed to near or below freezing conditions on the ground. Internal icing may be difficult to see and may remain present even when current conditions do not appear conducive to ice formation. Turn probe heat on at least 2 minutes prior to takeoff anytime icing of probes is possible.

CAUTION
If unable to control taxi speed or direction, immediately shut down the engine.

NOTE
After cold soaking at temperatures below 0°F (-18°C), be alert for flat MLG struts.

36.13 TAKEOFF

If the aircraft has cold soaked at temperatures below -20°F (- 29°C), LG retraction times may be significantly increased. In addition, the nose gear door may fail to close. If the nose gear door can be visually confirmed as the only LG component that has failed to retract/close, then up to two extend/retract cycles can be made in an attempt to achieve a normal LG up condition. Observe LG extended or in transit limitations.

36.14 IN FLIGHT

Flight in areas of icing should be avoided whenever possible. If icing conditions are anticipated or cannot be avoided, turn ANTI ICE switch to ON and PROBE HEAT switch to PROBE HEAT. Frequently check the aircraft leading edges for indication of ice buildup. Make all throttle movements slower than normal when in potential icing conditions to reduce possibility of engine stalls and/or stagnation. Consider diverting to an alternate field if required to avoid icing conditions.

WARNING
Flight in icing conditions can result in ice accumulation on the AOA probes even with probe heat operating. Icing of the AOA probes with probe heat operating can cause them to remain frozen in one position. Probes frozen in one position will result in a fixed AOA indication in the cockpit. A FLCS AOA FAIL PFL occurs if actual AOA differs by six degrees from the fixed AOA indication when in takeoff and landing gains. Refer to AOA PROBE ICING.

36.15 LANDING IN ICY OR WET CONDITIONS

Icy or wet runway conditions may pose severe problems in directional control and braking effectiveness due to hydroplaning. Although possible, total hydroplaning is not expected below 130 knots groundspeed. Partial hydroplaning can occur to varying degrees below 130 knots. Once hydroplaning occurs, it can continue to speeds well below the onset speed. Wheel spinup must occur to permit normal antiskid braking. Hydroplaning can prevent wheel spinup and can occur on runways which only appear damp if heavy braking is applied at high speeds. Hydroplaning tendency increases with water depth and with smooth runway surfaces such as rubber deposits or paint stripes.

Approach and touchdown are the same as for a short field landing on a dry runway. Immediately after touchdown, make a deliberate effort to be sure brakes are not applied while using the rudder. Use two-point aerodynamic braking until approximately 100 knots; then fly the nosewheel to the runway. Maximum effective two-point aerodynamic braking is achieved at 13 degrees AOA. After the nosewheel is on the runway, open the speedbrakes fully and maintain full aft stick for maximum three-point aerodynamic braking and wheel braking effectiveness. When wheel brakes are used, they should be continuously applied.

When stopping distance is critical, continuous maximum wheel braking should be initiated in the two-point attitude. Wheel braking effectiveness at high speeds is very low compared to two-point aerodynamic braking effectiveness. Low deceleration at high speed may be mistakenly interpreted as a brake or anti-skid failure. When the wheel brakes become effective, the nose will automatically lower. Do not hesitate to lower the hook, if required.

CAUTION
Rubber deposits on the last 2000 feet of a wet runway make directional control a difficult problem even at very low speeds. Braking should be started in sufficient time to avoid excessive braking on the last portion of the runway.

37 Air Refuelling Procedures

This section contains information and procedures for F-16 air refueling (AR) with KC-135 and KC-10/KDC-10 aircraft. For basic flight crew air refueling procedures, refer to the BMS Training Manual.

Refer to the BMS checklists under *Docs**02 Aircraft Manuals & Checklists**01 F-16**F-16 Checklists* "SECTION EP" for further details.

37.1 WINGMAN RECEIVER RESPONSIBILITIES

To assist the cell leader in insuring the safety and integrity of the flight, the wingman receiver will:

- Keep the leader in visual or electronic contact at all times.
- Maintain briefed position at all times.
- Anticipate corrections/changes and plan accordingly.
- Monitor all aspects of formation operations and advise the cell leader if an unsafe condition is noted.

37.2 AIRSPEED AND ALTITUDES

Cruise and air refueling KCAS is 310 knots at 30,000 feet unless specifically directed otherwise. Lower altitudes may be required for abnormally high free air temperatures. The controlling agency directing the mission will be responsible for obtaining enroute and air refueling altitude clearance for training and operational missions.

37.3 WEATHER

Weather minimums are prescribed by command guidance. Buddy departure minimums are 1500 feet and 3 NM for day and 2500 feet and 3 NM for night takeoffs. Rendezvous and air refueling will not be attempted when inflight visibility is deemed insufficient for safe air refueling operations; however, the aircraft may close to the lock-on limits of the radar provided that the required altitude separation is maintained until visual contact has been established. Without lock-on capability, minimum visibility for rendezvous is 1 NM.

37.4 REFUELING TRANSFER RATE

The air refueling transfer rate averages 2,000 pounds per minute with two tanker A/R pumps operating with a KC-135 and 3000 pounds per minute with a KC-10/KDC-10.

37.5 WAKE TURBULENCE

Wake turbulence caused by wide-bodied (heavy) jets can affect a considerable area and precautions are necessary to ensure that AR formations are not subject to disturbance while refueling is in progress. If an aircraft is reported by radar or sighted visually whose track will coincide with or cross within 10 NM of the track of an AR formation and whose vertical position is within the 2000-foot band above the formation, the following actions are to be taken:

- Attempt to establish if the contact is heavy.
- If the contact is identified as heavy or if identity cannot be established, order any receivers in contact position to disconnect.
- Do not bring receivers into contact position until the aircraft has traversed the affected area.

NOTE

Multi-tanker formations that includes KC-10 should be particularly aware of wake turbulence, especially if the KC-10 is leading or takes the lead.

37.6 RADAR

It is the responsibility of the receiver to ensure that the aircraft radar is not radiating. Normally, the radar should be set to standby once the receiver is visual with the tanker (Nose Cold). During conditions of EMCON constraint (EMCON 3 and 4), radio calls between tanker and receiver to check on the radar states are inappropriate and impractical.

37.7 Receiver Director Lights KC-135

The receiver director lights do not give true vertical and horizontal information. The up and down lights change because of angular movement of the boom and the fore-and-aft lights change because of in-and-out movements of the boom. The axis of the director lights system is inclined at a 30 degree angle to the fuselage. This angle causes an interaction in both lights when a true vertical or horizontal movement is made by the receiver. For example, flying straight forward while in contact will cause the boom to compress and also increase its angle with the tanker fuselage. The lights will show that the aircraft is flying forward and down. If a true up movement is made, the boom will both compress and lessen its angle with the tanker fuselage and the director lights will indicate that an up and forward movement has been made. Small fore and aft corrections can be made with little or no power change by moving vertically.

Receiver director lights are on the bottom of the fuselage directly aft of the nose landing gear. They consist of two rows of lights: the left row for elevation and the right row for telescoping.

The elevation lights consist of five colored panels with a green stripe, green and red colors, and two illuminated letters, D and U, for down and up respectively. The colored panels are illuminated by lights that are controlled by boom elevation during contact. There is an illuminated white panel between each panel to serve as a reference. The letters A, for aft, and F, for forward, augment the colored panels on the telescope side. The receiver pilot director lights will remain illuminated and follow boom movements in both the contact made and disconnect conditions. There are no lights for azimuth position. A fluorescent yellow strip on the bottom center of the tanker fuselage may be used as centerline reference by the pilot. The triangular-shaped panels are for elevation and the rectangular-shaped panels are for forward and back movement.

37.8 Receiver Director Lights KC-10/KDC-10

The receiver director lights consist of two rows of lights located forward of the wing root. Relative elevation position is provided by the left row and the right row provides telescoping position. The elevation row contains one striped, green, two amber and two red triangular panels, and two white letters: U at the forward end for UP, and D at the aft end for DOWN. The colored panels and letters are dimly illuminated by background lights. The telescoping row contains one striped, green, two amber, two red, and four white rectangular panels, and two white letters: A at the forward end for AFT, and F at the aft end for FORWARD. The colored panels are not background lighted; however, the letter at each end of the row is dimly illuminated. Separation is provided by the white panels. The pilot director lights are adjusted by the boom operator to the size air refueling envelope for each receiver and provide guidance during contact. To provide more response time, the appropriate panel and letter are illuminated in anticipation of receiver movement. The director lights provide commands based on both receiver position and rate of movement. With rapid motions of the receiver, the lights can show a correction required even though the receiver is in the center of the envelope. The red panel and letter at the ends of each row can be illuminated by the boom operator to aid the receiver in attaining the contact position.

37.9 Post Air Refueling

WARNING
Receiver will ensure a safe clearance from the tanker(s) as they proceed on their assigned missions. Receiver(s) required to accelerate past the tanker(s) and climb on the refueling heading will maneuver either left or right (a minimum of 1 NM) of track to preclude climbing directly in front of the tanker(s) remaining receiver(s). Aircraft flying through departing receivers’ jet wash may experience damage to the aircraft and injury to personnel.

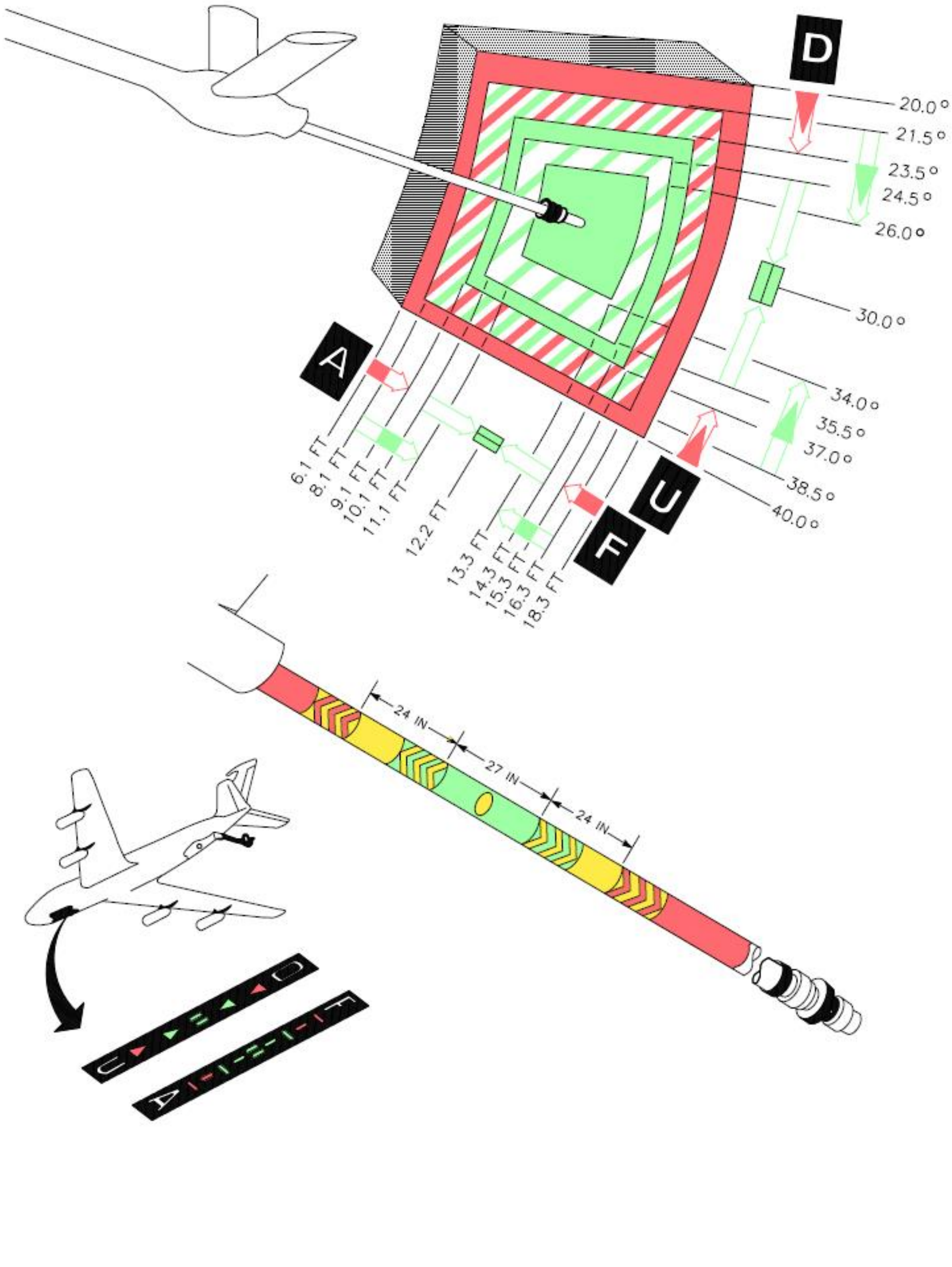
37.10 Flying Safely

37.10.1BOOM ENVELOPE LIMITS

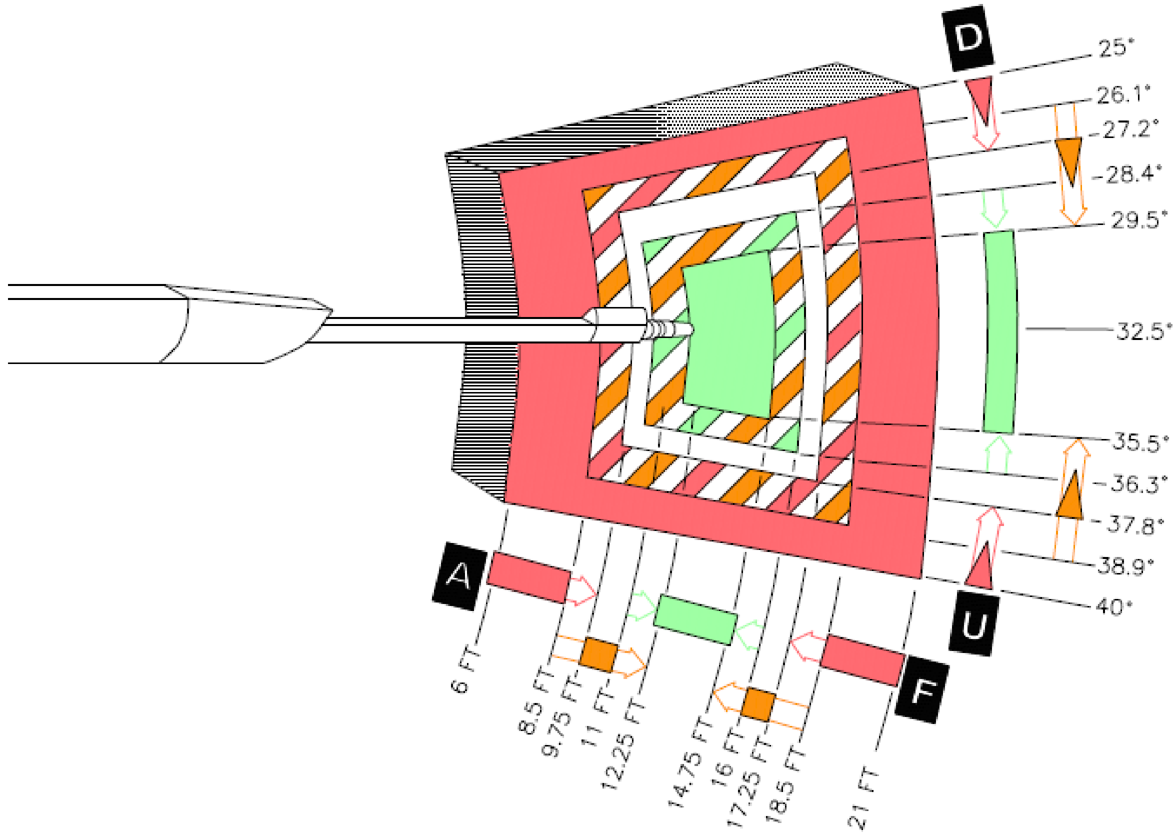
The refueling envelope is limited by the refueling receptacle location. As long as the receiver is positioned within these limits, contact can be maintained despite rolling, yawing, or pitching.

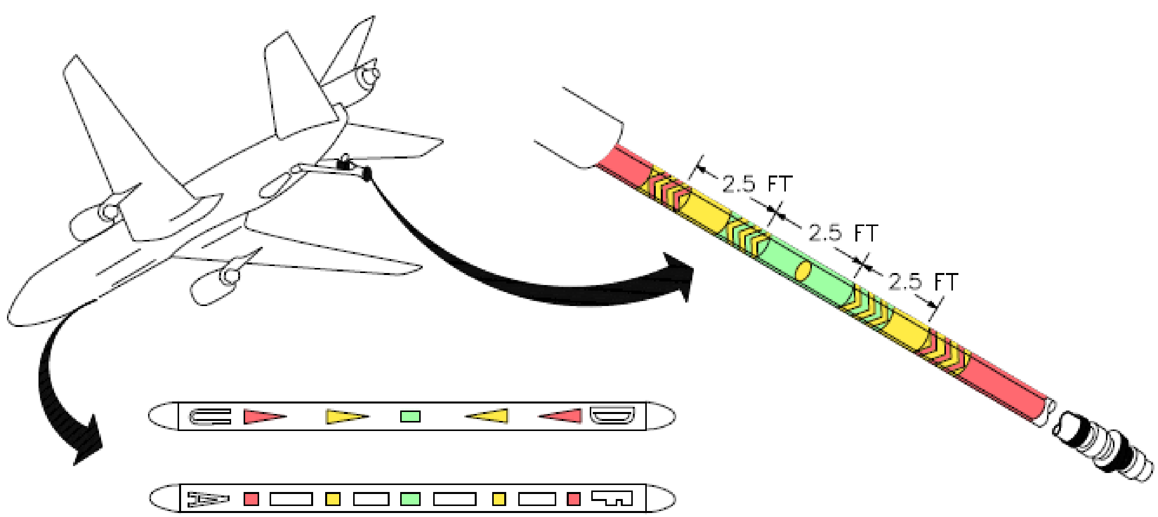
CAUTION
Approaching boom limits at a relatively high velocity can cause structural damage as a result of an inability to disconnect due to binding of the boom nozzle. **Due to the restricted refueling envelope, boom limit switch protection is not provided in up elevation for KC-135 aircraft.**

Receiver Director Lights (KC-135)

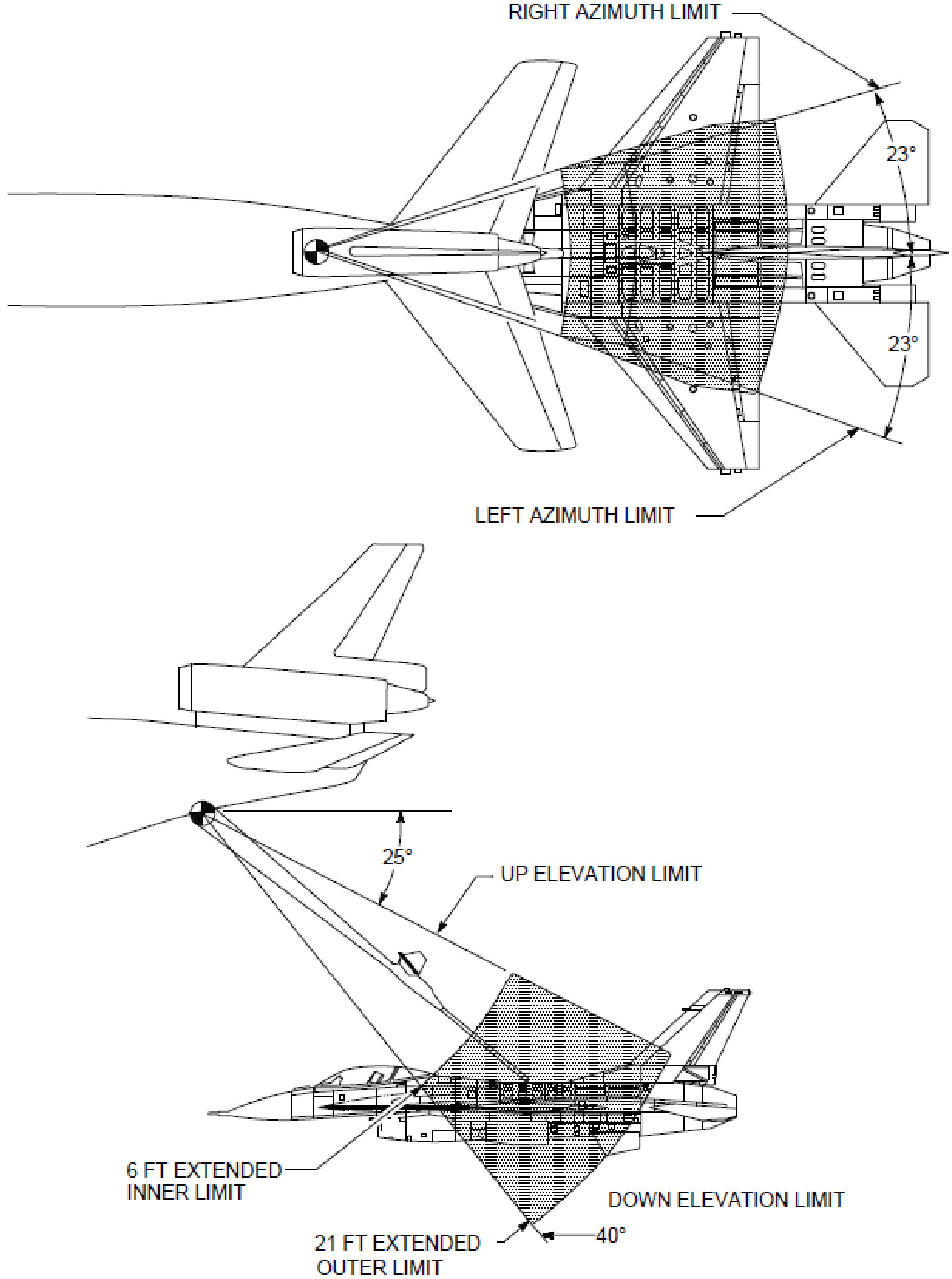


Receiver Director Lights (KC-10/KDC-10)

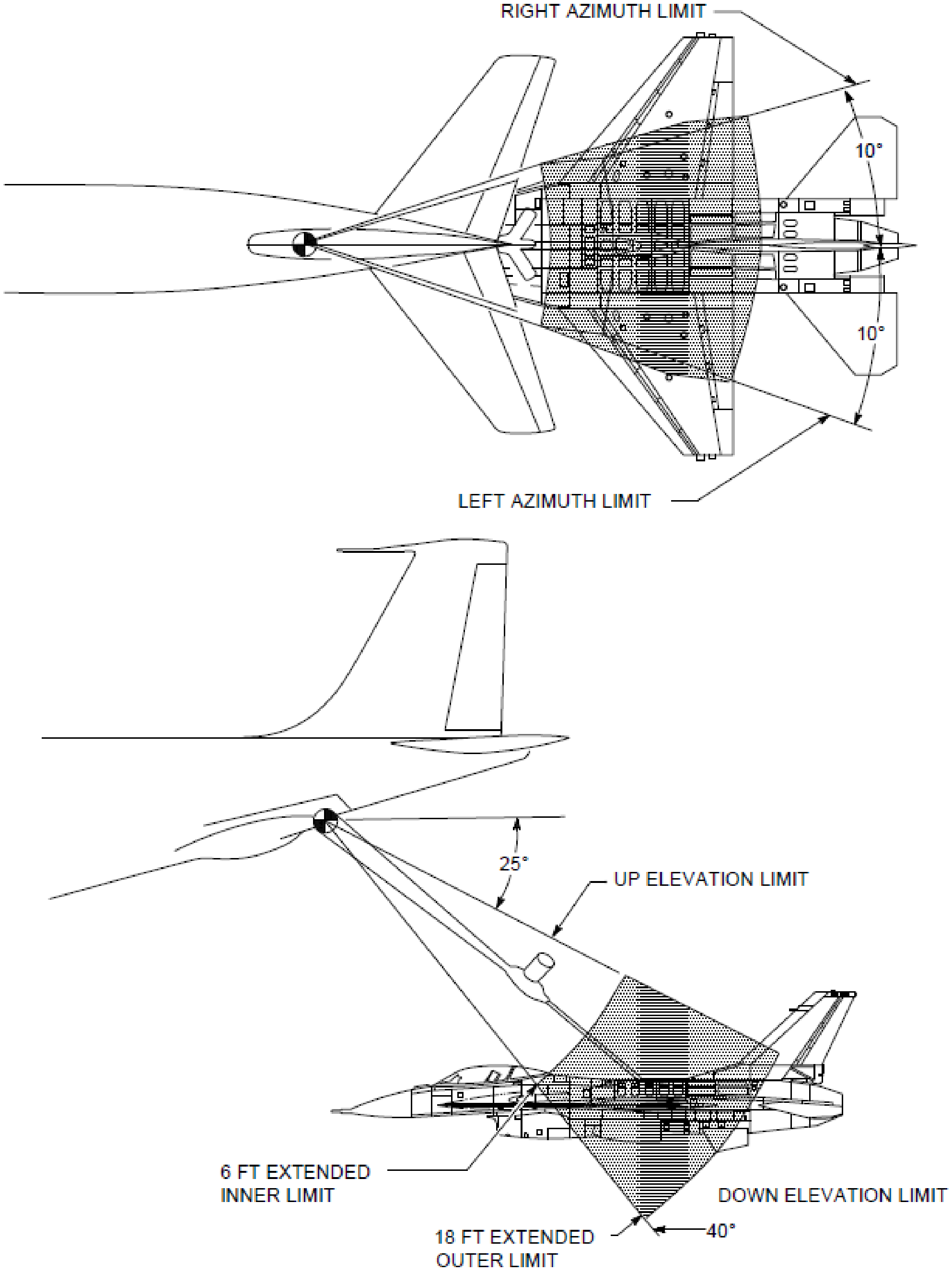




Boom Envelope Limits (KC-10/KDC-10)



Boom Envelope Limits (KC-135)



37.11 AIR REFUELING PROCEDURES

NOTE
Some procedures described here are only possible with a human piloted Tanker. As there are some hardcore users in the BMS community and Familly, the in dept procedures are for those ones.

37.11.1 ALTIMETER SETTINGS

Unless otherwise directed, an altimeter setting of 29.92 inches Hg will be used for air refueling operations at or above transition altitude or when over water and operating in accordance with ICAO procedures. For all other air refueling operations, the briefed altimeter setting will be used.

37.11.2 TANKER RENDEZVOUS EQUIPMENT

Tanker rendezvous equipment consists of the following:

- KC-135
  - A/A TACAN - DME only
  - Radar beacon - AN/APN-69 (all aircraft) and AN/APN-134 (some aircraft)
  - Automatic Direction Finder - AN/ARA-25

- KC-10
  - A/A TACAN - Range and Bearing
  - Radar beacon - APX-78 (Two Pulse, Variable Width)
  - UHF/DF
  - INS

37.11.3 RECEIVER FORMATION DURING RENDEZVOUS

Formation procedures after level-off or from the RVIP until join-up with the tankers will be as follows:

Formation lead changes and join-ups will normally be completed prior to departure from the RVIP. Should such maneuvers be required subsequent to departure and prior to join-up on the tanker(s), the rendezvous will not be continued unless the flight leader is positive of his position in relation to the tanker(s) and the published AR track.

Day VMC (visibility five miles or greater). Flights will be in trail, offset to the right of the preceding flight. When all aircraft are in visual contact with the tanker(s), each aircraft/flight will join with its respective tanker as briefed.

IMC or Night. The receiver formation will be formed into flight(s) of four aircraft in close or route formation. Succeeding flights will be in a like formation, positioned 1500 feet astern of the first flight or 2-3 NM radar trail, depending on weather conditions. When the tankers are established on the on-course track, the receiver leader will position his flight 3 NM astern of the last tanker. When all tankers in the cell are in positive radar contact, receivers will climb to 1000 feet below base altitude. If visual contact has been established, the flight/element leader will initiate join-up on the last tanker.

When the appropriate wingmen have visual contact and are within1 NM of their tanker, the leader will drop them off and proceed to the next tanker. The receiver leader will continue as above until all wingmen are on their appropriate tanker, then join the lead tanker. If not in visual contact at 3 NM, the receiver flight/element leader will clear the last receiver flight to join on the last tanker. The last receiver flight will then turn to the right and join on the last tanker while climbing to 500 feet below base altitude, then maintain this altitude until visual contact with the tanker is established. The first receiver flight will join on the number 2 tanker, maintaining 1000 feet below base altitude until visual contact is established. Each receiver leader will offset his tanker target 15 degrees to the left and close at approximately 50 knots above the tanker KCAS. Aircraft with operable airborne radar equipment will close no closer than 1500 feet. Receivers losing radar lock between 1 NM and minimum range will ensure 1000 feet altitude separation is maintained and discontinue rendezvous attempts until adequate range separation (1 NM) is achieved or radar lockon is regained. Range closure limitation for non-radar equipped receiver(s) or receiver(s) without radar lock-on is 1 NM.

When visual contact with the tanker has been established, the receiver element will form in the precontact position, and the receiver flight leader will turn left, then right back to track heading and join on the lead tanker in the cell using the same procedures. The flight leader's wingmen, after flight separation, will echelon to the right. If visual contact with the tankers is not established, receivers will maintain 15 degrees offset, applicable altitude, and minimum slant range until cell termination procedures are accomplished.

37.11.4 Early Arrival

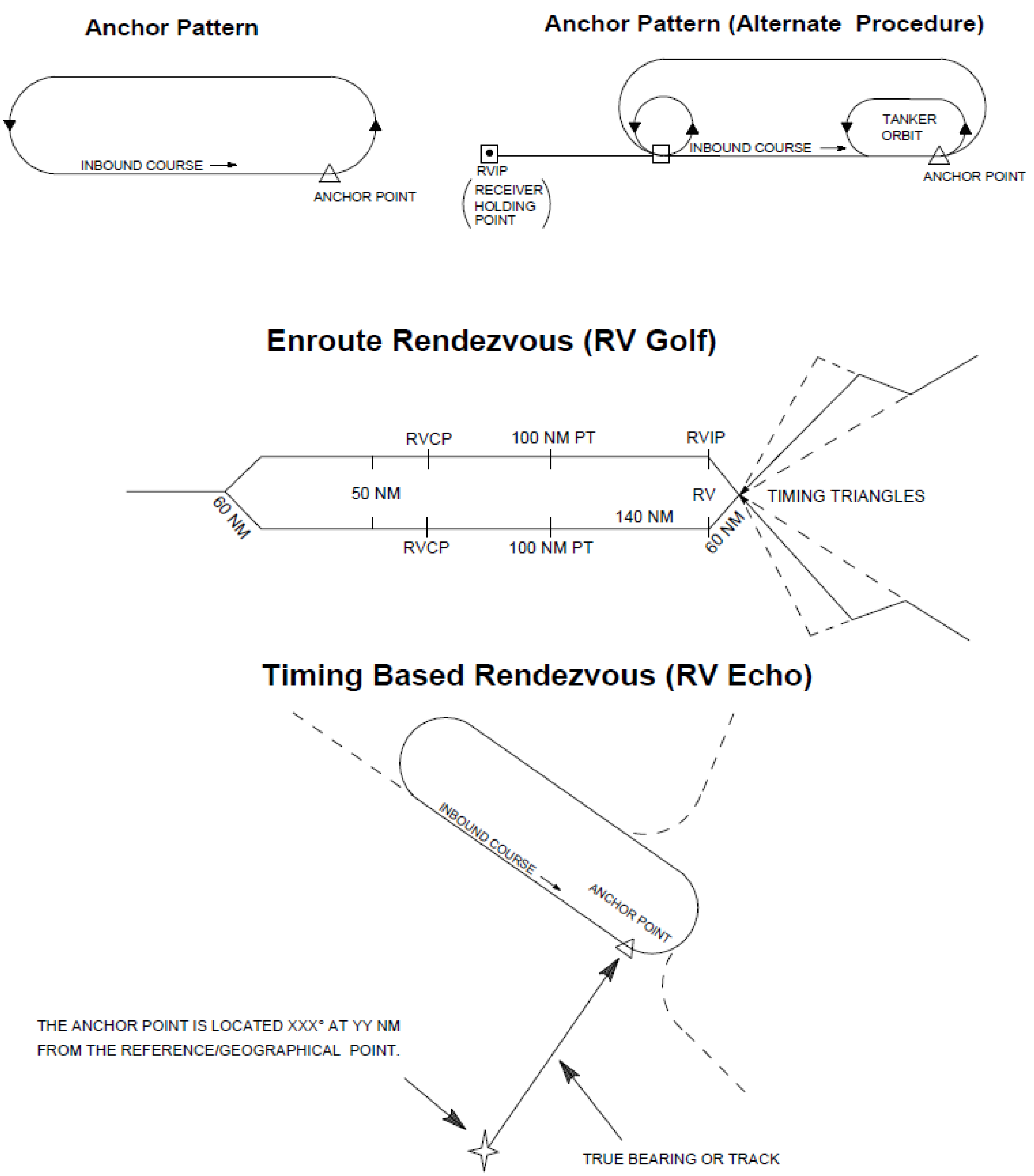
Once a join-up is initiated, and it is necessary for the joining receivers to hold while waiting for a preceding flight to complete their operations, the joining flight will join in a position 600-800 feet out (laterally) from the receivers in the observation position if in VMC; or fly offset laterally 1-3 NM in trail if in IMC and maintain 1000 feet below tanker base altitude. The decision on which side to join will be based on the direction of orbit of the tanker, departure intentions of the receiver flight refueling, and the presence of additional holding receiver flights.

In the event the receiver(s) arrives ahead of the tanker at the RVIP or ARCP point, the receiver will orbit at an altitude that ensures at least 1000 feet separation between tanker and receiver or any elements of tanker and receiver cells. If receivers hold at the ARCP, they will normally enter a left-hand holding pattern using 2-minute legs at 1000 feet below air refueling altitude.

37.11.5 Tanker Identification

Tanker identification is critical in congested refueling airspace. Available aids used in any combination should be used to confirm tanker location/identification prior to and during the rendezvous. These aids include ground radar, tanker/receiver radar, INS, A/A TACAN, UHF/DF steers, common ground TACAN stations, and radar beacons/IFF/SIF interrogation systems for receivers so equipped.

Racetrack Patterns (Typical)



37.12 Point Parallel Rendezvous (RV Delta)

The point parallel rendezvous is used to effect a rapid join-up between the tanker and receiver with minimum receiver maneuvering. The tanker and receiver approach on reciprocal headings offset, left or right, a distance equal to the tanker turn diameter. At a predetermined turn range, the tanker executes a turn to the receiver heading to roll out approximately 1-3 NM ahead of the receiver. Normally, the tanker aircrew has responsibility for the overall refueling operation and rendezvous and establishes the offset and turn point. When tanker systems are degraded, the situation dictates, or for training, the Tactical Air Controller or receiver may be responsible for the execution of the rendezvous. Specific rendezvous responsibilities will be in accordance with command guidance. Receivers will monitor the air refueling frequency and attempt to establish contact as nose-to-nose separation, stacked up at 500-foot intervals during the final turn to the air refueling track. When the receivers are inbound, the rendezvous will be directed by the Tactical Air Controller or the receiver leader. The Tactical Air Controller or the receiver leader (as appropriate) will determine the type rendezvous to be made. The tanker will adjust to refueling airspeed when directed by receiver leader. Receivers will rendezvous 1000 feet below refueling base altitude until visual contact is established. In the event Tactical Air Control radar is not available to control anchor refueling operations, the following alternate procedure will be used:

The tanker will establish a normal point parallel rendezvous at the anchor point. Receiver flights will proceed to an anchor RVIP a minimum of 70 NM upstream from the anchor point. Receivers will rendezvous 1000 feet below the refueling base altitude until visual contact is established. Normal point parallel rendezvous orbit (fighter) procedures will be used for the rendezvous.

After the receiver flight is joined up, the anchor pattern will be used for refueling. If cleared by the tanker commander, subsequent receiver flights may depart the RVIP prior to the previous receiver flights departing the anchor area when the receivers have the capability to assure safe aircraft separation and to join on the tanker using receiver turn-on rendezvous procedures. Ensure at least 1000 feet separation is provided between each joining flight, and between the highest flight and the lowest refueling element until visual contact is established. Use of secondary frequency is recommended. To preclude conflict with receivers clearing the tanker or during a breakaway, ensure fighters maintain adequate in-trail spacing from the refueling formation.

37.12.1 Timing Based Anchor Point Procedure (RV Echo)

This procedure, commonly referred to as RV Echo, utilizes a timing-based anchor orbit and may be used in tactical situations where it is necessary to have a tanker available with which receivers can rendezvous in a known area on an op-portunity basis. This procedure may be used to support Combat Air Patrols (CAPs) and is particularly appropriate when EMCON procedures are in effect. This procedure begins at a point located on an inbound track to the anchor point. With this procedure two points can be used as the initial point of the inbound track to the anchor point.

The two choices are:

- Range/true bearing – a range and true bearing from a reference point with the inbound track to the anchor point orientated at right angles and to the left of the radial from the reference point.
- Geographic point/true track – a geographic point and a true track which is to be flown towards the anchor point.

Although the normal duration for this type of rendezvous is 15 minutes, to allow for limitations in airspace reservations or operational requirements, the rendezvous may be defined as an RV Echo XX, where XX is the anchor duration in minutes. It is vital that the anchor duration is briefed prior to the mission, as the receiver will use the information to predict the approximate position of the tanker. The tanker will aim to fly through the anchor point at the RV refueling altitude on the hour and then at intervals as dictated by the RV Echo duration. Each receiver navigates independently to the tanker using all available aids. The receiver is to join the pattern 1000 ft below the RV refueling altitude. Receivers with A/A radar or visual contact may join at any suitable point along the anchor. Receivers without A/A radar should aim to fly the inbound track to the anchor point and adjust their timing to arrive 30 seconds after the tanker. EMCON procedures may be used in conjunction with the RV Echo. However, in such circumstances, the receivers should be aware that several other receivers/formations may be approaching the tanker from different directions. Therefore, it is essential that all receivers maintain a good lookout and strict adherence to AR procedures. Within the limitations of the tactical situation, the tanker pilot is to adjust the refueling altitude and/or position of the racetrack to maintain good VMC. Subject to the EMCON policy in effect, all available aids should be employed to achieve the rendezvous. If available, A/A TACAN should be used as follows:

- The tanker should select the A/A TACAN channel appropriate to the towline or as directed in the tasking order throughout its time on station.
- The tanker may select air to ground mode as necessary to obtain a position for a navigational fix.

37.12.2 Receiver Turn-On Rendezvous

Receiver turn-on rendezvous will be conducted in accordance with the procedures established in command guidance. Receivers will maintain required vertical separation until visual contact is made with the tanker(s).

37.12.3 Rendezvous Overrun

In the event of an overrun by fighters, the receiver(s) will pass 1000 feet below the tanker to ensure positive vertical separation. The receiver will decelerate to 290 KCAS and maintain air refueling heading. The tanker will accelerate to 355 KIAS (350 KCAS) or Mach 0.90, whichever is lower, and maintain air refueling heading. When the tanker is in positive visual contact ahead of the receiver, the tanker will decelerate to air refueling airspeed and normal closure procedures will be employed to establish contact.

37.12.4ENROUTE RENDEZVOUS PROCEDURES (RV GOLF)

An enroute rendezvous may be used when the tanker(s) and receiver(s) fly individual flight plans to a common rendezvous point (RV), where join-up is accomplished, and continue enroute cell formation to the ARCP.

These procedures may provide an orbit delay or timing triangle enroute to the ARCP. It is not appropriate to accomplish a point parallel rendezvous at the RV because the length of the orbit legs cannot be extended. Tankers will depart the RV to make good the RVCT or the receiver's ETA to the ARCP.

Either tanker(s) or receiver(s) may be scheduled to arrive at the RV first, orbit if necessary, and then depart at a preplanned time.

WARNING
When close interval stream operations are being conducted, do not use orbit delays to control timing.

The RV will be located a minimum of 50 NM prior to the RVIP/SD. Tracks from the RVIP/SD may be established from any direction and need not necessarily be an extension of the air refueling track. If orbit delays are required, they will be accomplished by orbiting at the RV point along an extension of the track from the RV to the RVIP/SD. Orbit in a racetrack pattern using 30-degree banked turns and a maximum of 15 NM straight legs (unless operational directives specify longer straight legs). Tanker(s) and receiver(s) will join-up at the RV by controlling timing, so they arrive at the RV at the same time. Timing to the RV may be adjusted using differential airspeeds, orbit delays or timing triangles. If a planned orbit delay is used, receiver(s) and tanker(s) may accomplish join-up in the orbit. Assigned altitudes at the RV will provide at least 1000 feet separation between affected aircraft (highest tanker and lowest receiver), with the receivers normally at the highest altitude. If the receiver(s) planned level off altitude is within 30 minutes flying time from the RVIP, the receiver(s) may level off below the tanker and maintain an altitude which provides a minimum of 1000 feet vertical separation between the highest receiver(s) and the lowest tanker(s). Communications will be in accordance with specified emission option. If radio contact between the aircraft has not been established prior to the rendezvous control time, or the adjusted rendezvous control time, aircraft will maintain altitude If prebriefed, tanker(s) and receiver(s) may adjust to air refueling airspeed and begin air refueling after passing the RV. Once departing the RV/RVIP, the tanker(s) should fly centerline. The receiver is the maneuvering aircraft. If the tanker is behind the receiver, the tanker should accelerate and pass slightly off the left wing of the receiver. and depart the RV to cross the ARCP at the RVCT. Delays at the ARCP will use normal orbit procedures unless otherwise directed. If there is minimal separation between following aircraft or cells using the same track, orbits at the ARCP will require close coordination and a thorough crew briefing to ensure altitude separation. When the aircraft or cells pass the RVIP/SD, the tanker(s) and receiver(s) will echelon, and the receiver(s) will begin descent to the base air refueling altitude. Receiver(s) will descend to be at the base altitude 80

NM prior to the ARCP. Tanker(s) will maintain published buddy cruise KCAS and adjust to air refueling airspeed crossing the ARCP.

If prebriefed, tanker(s) and receiver(s) may adjust to air refueling airspeed and begin air refueling after passing the RV. Once departing the RV/RVIP, the tanker(s) should fly centerline. The receiver is the maneuvering aircraft. If the tanker is behind the receiver, the tanker should accelerate and pass slightly off the left wing of the receiver.

37.12.5 ALTERNATE RENDEZVOUS PROCEDURES

Tanker and receiver crews must be prepared at all times to accomplish the rendezvous using whatever resources are available. When rendezvous equipment is degraded, tankers and receivers will fly the same profiles as described in previous paragraphs. The following are some suggested alternate rendezvous procedures which should be used in any combination to ensure a successful rendezvous:

NOTE

Radar/Rendezvous Beacons. The receiver/tanker beacons may be used for range and offset information with suitably equipped aircraft. Depending on equipment capability, one aircraft should maintain the planned outbound or inbound track while the other maneuvers to establish the planned offset. The tanker will clearly establish which aircraft will be maneuvering.

Common Ground Station. If A/A TACAN is not available, switching to a common ground TACAN/VORTAC station for range information may be necessary. The final turn to refueling track is made when the DME difference equals proper turn range.

UHF/DF. For DF steers, receivers will be requested to use the MIC switch without talking. The receiver will transmit on the air refueling frequency approximately 10 seconds out of every 20 second period, ending each transmission with the receiver’s call sign. When the receiver position shows proper turn range bearing (No Wind) from the tanker heading, the tanker will turn to the refueling track. Notify the receiver when the turn is started. At the receiver’s request, the tanker will transmit a homing signal.

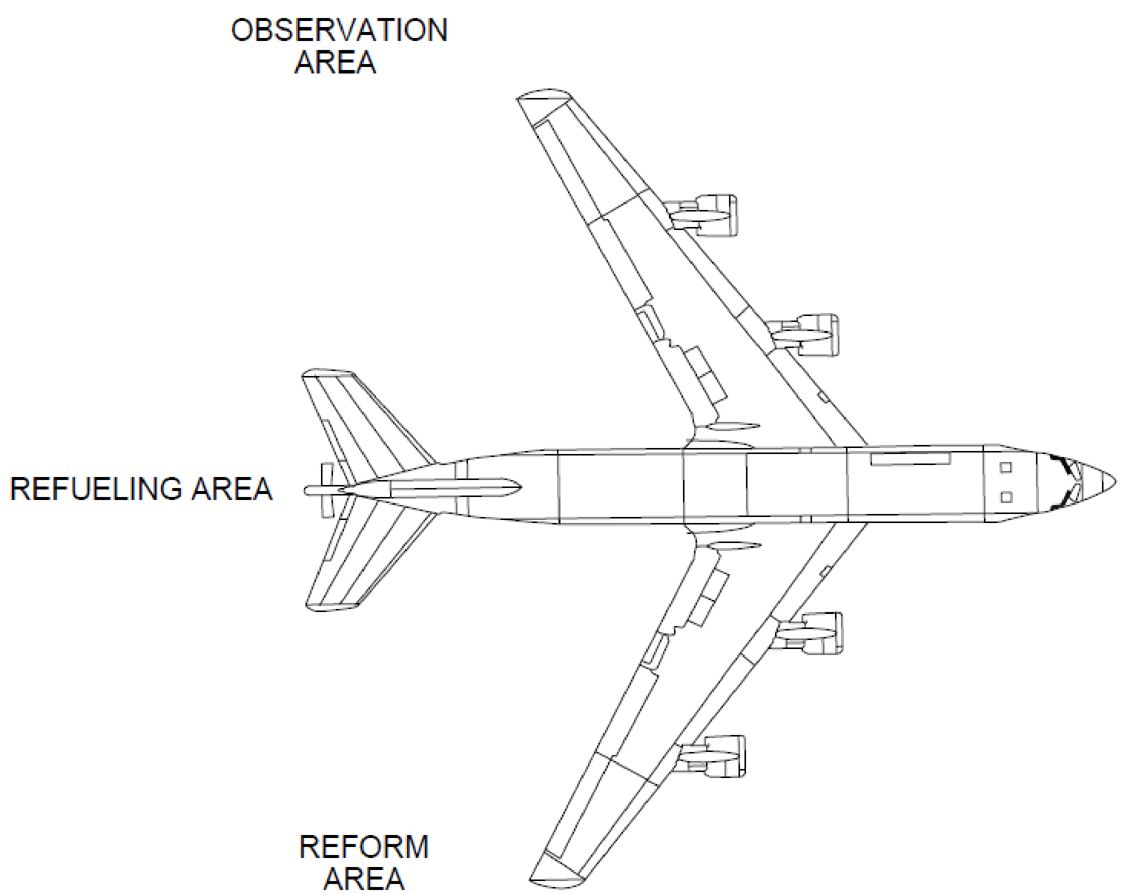
ETA. When adequate navigational check points are available, the tanker may adjust final orbit pattern to arrive over the ARCP on the air refueling heading at the receiver(s) ETA to the ARCP.

Ground Radar Assistance. Ground radar facilities may be used for vector and separation advisories. Ground radar assistance will be used to the maximum when conducting rendezvous with significantly degraded equipment to ensure a successful rendezvous.

37.12.6 MISSED RENDEZVOUS PROCEDURES

If contact is not established at the RV/RVIP, the tanker will arrive at the ARCP at the RVCT. This procedure begins when either aircraft arrives at the ARCP and does not have visual contact with the other. In this case, a left-hand orbit should be entered, and orbit controlled so as to be over the ARCP at intervals of every eight minutes (RVCT plus 8, plus 16, etc.). While in the orbit, every attempt should be made to establish visual contact with the other aircraft. The length of the delay and decision as to how long to continue radio silence should be determined during mission planning/development prior to flight.

Formation Positions



37.12.7 Fuel Management

The ENG FEED switch should be in the NORM or proper position, and the fuel distribution will be checked within flight manual tolerances on the fuel quantity indicator prior to contact with the tanker. The fuel system operation is automatic (fuel being distributed to internal and external tanks simultaneously).

NOTE
If a partial fuel load is onloaded, a fuel spread in excess of flight manual limits should be anticipated.

Disconnect from the boom may occur before all tanks are full if the external fuel tank configuration consists of only a centerline fuel tank. Such a disconnect typically occurs when refueling with an initial internal fuel load of 4000 pounds or more and the centerline tank empty. At disconnect, the aircraft total fuel may be up to 1600 pounds less than full, with many occurrences resulting in approximately 1000 pounds less than full.

37.12.8 Receiver's Radar Selection During Refueling

It is the responsibility of the receiver to ensure that the aircraft's radar is not radiating during the receivers refueling. This does not preclude the use of radar prior to or after the refueling. Normally, after the receiver as be directed to reposition from the observation area to the precontact position and is visual with the tanker, the receiver's radar should be set to standby (Nose Cold). After the receiver has completed refueling and has repositioned to the reform area, the receiver's radar should be reactivated.

37.12.9 Precontact

All precontact air refueling checks will be completed in the observation position or prior to reaching 1 NM in trail, except for final exterior light adjustment. After the receiver has stabilized in the precontact position, the receiver will move to the contact position.

WARNING

- The receiver will stabilize in the precontact position and attain a zero rate of closure. If the receiver fails to attain a stabilized position, or it becomes apparent that a closure overrun will occur, a breakaway will be initiated. Failure to initiate a breakaway under closure overrun conditions can result in a midair collision.
- Upwash and downwash effects may occur, drawing the aircraft together. Low pressure areas created by an overrunning receiver flying under the tanker will affect static ports, causing possible erroneous airspeed and altitude indications to both aircraft. The tanker autopilot altitude hold function may sense the low pressure as a climbing indication and initiate a descent into the lower aircraft.

37.12.10 BOOM AND RECEPTACLE PROCEDURES

NOTE

For night operations, prior to closing for contact with the tanker, coordinate with the boom operator on exterior lighting to avoid impairing night vision.

When cleared, move forward to the contact position and the boom operator will make contact. The receiver may request assistance from the boom operator in obtaining and maintaining position. From the precontact position, the receiver moves slowly with a 2-3 knot closure until reaching the contact position. When closing on the boom, constant cross reference between the boom and the tanker fuselage will alleviate any tendency to "chase" variations of boom trail position due to turbulence. When stabilized in the contact position, maintain this position. The boom operator will then make the contact.

CAUTION

- If the receiver director lights fail to illuminate when contact is established, the receiver pilot will inform the boom operator if he wishes to continue refueling operations. If refueling is continued, verbal corrections from the boom operator may be requested.
- Attempts to affect a contact during loss of any air refueling lighting that results in less than desired illumination will be at the discretion of the boom operator.

To maintain proper contact elevation and boom extension, refer to the director lights located on the bottom of the fuselage of the tanker.

If, for any reason, fuel is not transferring or is transferring at less than normal rate, the receiver pilot will disconnect and monitor the aerial refueling status indicator. The bottom lamp (DISC) lights amber when a disconnect has been accomplished. The system will automatically reset to ready, and the top lamp (RDY) relights blue after a 3-second delay. A second contact may then be accomplished. If this does not resolve the problem, the pilot may then disconnect, confirm disconnect with the boom operator, and recycle the system by closing and opening the slipway door using the AIR REFUEL switch.

37.12.11 DISCONNECT KC-135

In the event of failure to obtain a contact and after each disconnect, the receiver will move aft and stabilize in a position in trail of the boom or in precontact position and await clearance from the boom operator to return to the contact position.

CAUTION
• Remain stabilized in the contact position until visually confirming a disconnect has been made. This will prevent damage to the boom and/or receptacle through a brute force disconnect. • Brute force disconnects can occur unintentionally as the result of rapidly exceeding boom limits or failure of the receptacle toggles to release when a disconnect is initiated.

37.12.12 DISCONNECT KC-10/KDC-10

The KC-10/KDC-10 aerial refueling boom is controlled by a digital fly-by-wire system. Certain failure conditions of this system may cause one or more axes of the boom control system to become inoperative. Should this occur, the boom operator may not be able to maneuver the boom to avoid striking the receiver aircraft. In this situation, the boom operator will issue instruction to direct the receiver to a position where a safe disconnect can be carried out.

WARNING
• When notified that a KC-10/KDC-10 boom flight control system failure has occurred, do not initiate a disconnect unless directed by the boom operator. • Follow the boom operator's instruction explicitly. To reduce the probability of boom strike after disconnect, it may be necessary to remain in a stabilized position to allow for aerodynamic fairing of the boom control surfaces.

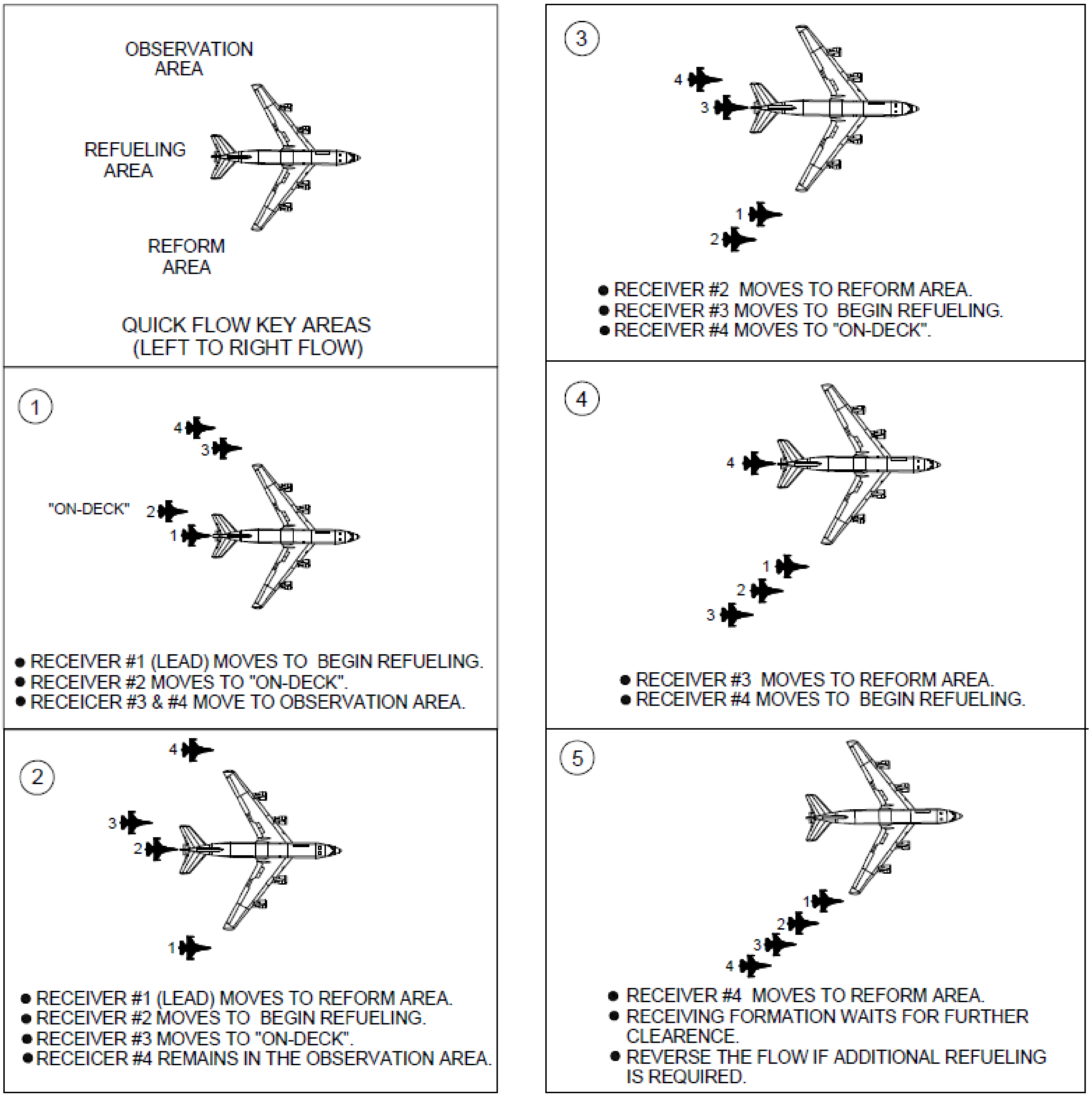
37.12.13 QUICK FLOW AIR REFUELING PROCEDURES

Fighter type receivers may use Quick Flow procedures to expedite air refueling operations. Quick Flow allows receivers to minimize refueling time with maximum fuel transfer. Quick Flow may be used during day or night operations, in VMC conditions only. If it appears that the flight may encounter adverse weather conditions, standard IMC procedures will be used. Coordination between tanker(s) and receivers prior to initiation of Quick Flow procedures is required. Air tasking guidance, direct communication with the tanker unit, or adding the term "Quick Flow" to the initial radio call will satisfy coordination requirements. Tanker lead is the final authority for Quick Flow operations. Left echelon formation is normally used for Quick Flow; however, variations are authorized with flight lead coordination and tanker lead approval.

Normally, the receiver flight will join on the tanker with the flight lead moving to the precontact position. Remaining aircraft will proceed to the left observation position. Once the flight lead commences refueling, the second aircraft in the air refueling sequence will move to the on-deck position. The ondeck position is normally flown as a route formation with approximately 10' spacing. When the flight lead completes refueling, the leader's aircraft moves to a position on the
tanker's right wing. The second receiver moves from the ondeck position to the precontact and contact position. With three or more receivers, the third receiver moves to the ondeck position. The left to right flow continues until all fighters have refueled. When the air refueling operation is complete, the flight may depart the tanker or, if additional refueling is required, remain in echelon formation on the tanker's right wing and reverse the Quick Flow procedures, with a right to left flow. The second receiver will assume a right on-deck position and Quick Flow will continue in order. Additional receivers arriving prior to the first flight completing refueling operations will remain in trail position until they are cleared by the tanker or observe the first flight departing the tanker.

In the event of a breakaway, the on-deck receiver follows the receiver that was on the boom. Any receivers on the wing will remain with the tanker. In the event a breakaway is initiated while a receiver is transitioning from the observation position to the on-deck position, that receiver will follow the receiver that was on the boom.

Quick Flow Air Refueling



37.12.14 SEPARATION/TERMINATION PROCEDURES

Following completion of air refueling, the receiver(s) will maneuver to the prescribed formation position, obtain tanker post air refueling report, and return to the primary refueling frequency (if applicable). After the receivers have reformed, the tanker leader will provide the receiver leader with present position in relation to the planned completion point. Additional information will be provided if requested, i.e., weather information, nearest abort bases, etc. The receiver leader will request the no wind heading and distance to the next checkpoint unless he has a positive fix from which to navigate.

37.13 EMERGENCY AIR REFUELING PROCEDURES

37.13.1BREAKAWAY PROCEDURES

Relative position of both aircraft must be closely monitored by all crew members during all phases of air refueling. When either a tanker or receiver crewmember determines that an abnormal condition exists which requires an immediate separation of the aircraft, that crewmember will transmit the breakaway call on air refueling frequency. Abnormal conditions include excessive rate of closure, closure overrun, and engine failure. The receiver does not have to be in the contact position to call a breakaway. For all breakaways, transmit the tanker's call sign and the word "breakaway" three times (Example: "Chevy 2, breakaway, breakaway, breakaway") and simultaneously take the following actions:

- Actuate disconnect switches as applicable.
- Retard throttle and establish a definite rate of descent, using speed break if necessary.
- If possible, drop aft of tanker until entire tanker is in sight and monitor flight instruments.
- In the event that the receiver loses visual contact with the tanker during the breakaway, it is to descend at least 500 ft below the tanker.

The tanker pilot will increase power to obtain forward separation. Unless lateral separation cannot be assured, the tanker will accelerate in level flight and will not climb. The lower rotating beacon will be turned on, the pilot director lights will be flashed, and the Radar/Rendezvous Beacon will be turned to operate, if appropriate. When the receiver is well clear, the breakaway may be terminated. The receiver pilot will be notified of and will acknowledge any reduction in power by the tanker to resume air refueling speed. If a climb is required, the tanker pilot will disengage the autopilot and climb straight ahead. If in a turn, the tanker will maintain the established bank angle until the receiver is well clear.

NOTE

If a breakaway is called prior to any receiver reaching the observation position, the entire receiver flight will execute the breakaway procedure. If a breakaway is called after receiver (s) have reached the observation position, only the receiver in the contact or precontact position will execute the breakaway procedure. The receiver(s) in the observation position will maintain formation on the tanker.

With certain gross weights and aircraft configurations, the tanker rate of acceleration on a breakaway may exceed the rate of acceleration for the receiver aircraft in the observation position.

37.14 SYSTEM MALFUNCTIONS

When any system malfunction or condition exists which could jeopardize safety, air refueling will not be accomplished except during fuel emergencies or when continuance of fueling is dictated by operational necessity. At any time, fuel siphoning is noticed, fuel transfer will be stopped and the receiver notified. The requirement to continue fuel transfer will be at the discretion of the receiver pilot.

NOTE

A small amount of fuel spray from the nozzle and receptacle during fuel transfer does not require fuel transfer to be terminated. The receiver pilot should be notified if this condition exists and the air refueling operations will be continued or discontinued at his discretion.

37.14.1SLIPWAY DOOR WILL NOT OPEN

No back-up system is provided to open or close the slipway door if hydraulic system B fails.

37.14.2SLIPWAY DOOR WILL NOT CLOSE

If the slipway door will not close, perform the following:

1. AR switch - CLOSE. Normal FLCS gains and tank pressures will be regained.

NOTE

The RDY, AR/NWS, and DISC lights will not indicate normally. The NWS light will not illuminate when nosewheel steering is engaged.

37.14.3INOPERATIVE BOOM/RECEPTACLE LATCHING

When all other recognized means of fuel transfer have failed, and an actual fuel shortage emergency aboard the receiver aircraft exists, fuel can be transferred by maintaining boom/receptacle contact using a slight extend pressure on the boom telescope lever. Unusual and varying trim changes may be required of both tanker and receiver aircraft.

If a fuel shortage emergency requires:

1. Boom operator - Inform of the need to accomplish manual boom/receptacle pressure refueling.

WARNING
The receiver pilot must inform the tanker he is ready to receive fuel and coordinate the disconnect cycle for the conclusion of refueling.

CAUTION
Prior to attempting this method of transferring fuel, the boom operator will brief the receiver pilot and thoroughly coordinate the procedures to be used. Both tanker and receiver crews will monitor the refueling with extreme caution.

37.14.4KC-10/KDC-10 BOOM FLCS FAILURE

Do not disconnect until cleared by boom operator.

WARNING
• When notified that a KC-10/KDC-10 boom flight control system failure has occurred, do not initiate a disconnect unless directed by the boom operator. • Follow the boom operator’s instruction explicitly. To reduce the probability of boom strike after disconnect, it may be necessary to remain in a stabilized position to allow for aerodynamic fairing of the boom control surfaces.

37.14.5BRUTE FORCE DISCONNECT

There are two types of brute force disconnects: Inadvertent and Controlled Tension.

37.14.6 INADVERTENT DISCONNECT

An inadvertent brute force disconnect is defined as any unplanned disconnect which is the result of one of the following:

- The receiver aircraft moving rapidly to the aft limit, causing mechanical tanker/receiver separation.
- Boom pullout occurs at 38 degrees elevation or below.

37.14.7 CONTROLLED TENSION DISCONNECT

A controlled tension brute force disconnect is defined as an intentional, coordinated disconnect occurring above 38 degrees elevation, accomplished by gradual movement of the receiver aircraft to the aft limit, and ending with a smooth tension boom pullout. Coordination between the receiver pilot and the boom operator is required to ensure as smooth a disconnect as possible.

1. Slide out boom with gradual power reduction.
2. When at full boom extension, tension disconnect will occur with slight power reduction.

CAUTION
• A controlled tension brute force disconnect will be accomplished only as a last resort, after all other normal and emergency methods of disconnect have failed. • The receiver pilot must not jerk the boom out with rapid thrust change toward IDLE or by using speed brakes; to do so may cause serious structural damage. Gradual power reduction will suffice to effect a disconnect. • Fly stabilized at contact altitude until certain the nozzle is clear of the receptacle and slipway. • Air refueling for the receiver which required controlled tension disconnect will be terminated except during fuel emergencies or when continuation of air refueling is dictated by operational necessity.

38 Emergency Procedures

This section covers the operation of the aircraft during emergency/ abnormal conditions. It includes a discussion of problem indications and corrective actions as well as procedural steps when applicable. Adherence to these guidelines insures maximum safety for the pilot and/or aircraft. The situations covered are representative of the most probable malfunctions. However, multiple emergencies, adverse weather, or other factors may require modification of the recommended procedures. Only those steps required to correct or manage the problem should be accomplished. When dealing with emergency/ abnormal conditions, it is essential to determine the most correct course of action by using sound judgment and a full understanding of the applicable system(s). When practical, other concerned agencies (i.e., flight lead, tower, etc.) should be advised of the problem and intended course of action. When a voice WARNING or CAUTION message is heard, check cockpit indications; then refer to the appropriate emergency procedure for corrective action.

When structural damage or any other failure that may adversely affect aircraft handling characteristics is known or suspected, a controllability check should be performed. Certain steps (e.g., MASTER CAUTION reset, ELEC CAUTION reset) are intentionally omitted from the numbered procedures. Pilots are expected to perform these actions without prompting, when warranted. Three basic rules, which apply to all emergencies, are established:

1. MAINTAIN AIRCRAFT CONTROL.
2. ANALYZE THE SITUATION AND TAKE PROPER ACTION.
3. LAND AS THE SITUATION DICTATES.

The following information provides general landing guidance:

Land As Soon As Possible

An emergency will be declared. A landing should be accomplished at the nearest suitable airfield considering the severity of the emergency, weather conditions, airfield facilities, lighting, aircraft GW, and command guidance.

Land As Soon As Practical

Emergency conditions are less urgent and, although the flight is to be terminated, the degree of the emergency is such that an immediate landing at the nearest suitable airfield may not be necessary.

WARNING
The canopy should remain closed during all emergencies that could result in a crash or fire such as crash landings, aborted takeoffs, and arrestments. The protection the canopy affords far outweighs the isolated risk of entrapment due to a canopy malfunction or overturn. **Ejection is preferable to sliding into an arrestment cable with the NLG collapsed. The cable may slide up over the nose with unpredictable and potentially dangerous consequences to anyone in the cockpit(s).** **If it appears that the aircraft will depart a prepared surface above normal taxi speed during an aborted takeoff or a landing and go around is not possible, eject since breakup of cockpit structure may occur. Retracting the LG to prevent departure from a prepared surface is not recommended since the MLG will probably not retract symmetrically.** **If remaining with an aircraft that will depart a prepared surface, shut down the engine, if feasible. This action reduces the potential for fire, reduces engine damage, and permits EPU turnoff if an MLG WOW signal is lost.**

CAUTION
For known or suspected landing gear malfunctions or failures (i.e., tires or struts), stopping straight ahead is recommended.

38.1 FORMAT

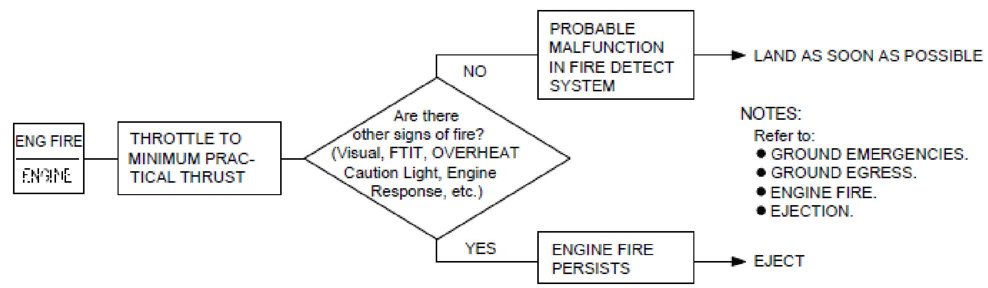
The format of Emergency Procedures differs slightly between the Checklist and the Flight Manual. Procedures in the Checklist have been grouped by malfunction category (engine, electrical, etc.) to provide maximum in-flight utility. In the Flight Manual, procedures are listed by the phase of flight in which the emergency may occur. In the Checklist, some procedures are split into two independent side-by-side series of steps and are separated by a straight line; in the Flight Manual, these side-by-side steps appear in a continuous column and can be identified by repeat numbering of steps following conditional statements beginning with the word if. Amplification following procedural steps in the Flight Manual is repeated in the Checklist under the heading Inoperative Equipment, Other Indications, or Other Considerations. A thorough review of the layout and content of the Checklist and Flight Manual is recommended prior to in-flight use.

38.2 WARNING AND CAUTION LIGHT AND PILOT FAULT LIST ANALYSIS

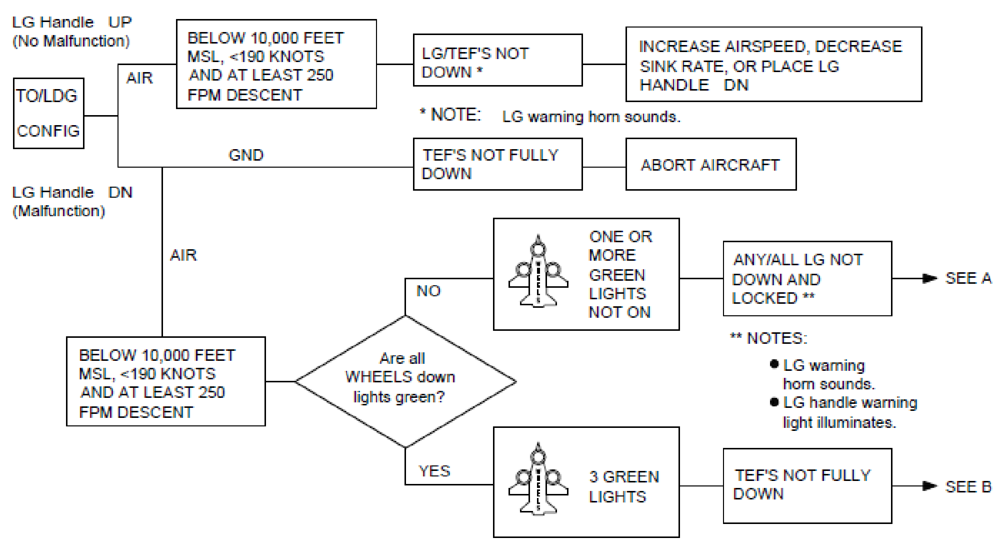
Fault trees show interrelationships with examples of problem events and corrective action.

Warning Light Analysis

WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
ENG FIRE / ENGINE	Engine compartment fire	Refer to ENGINE FIRE

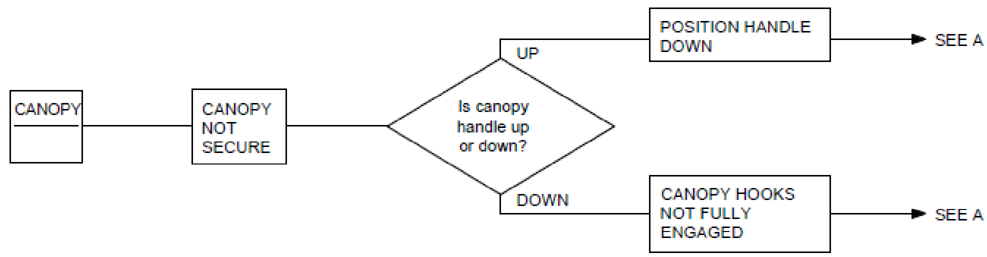


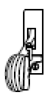
WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
TO/LDG CONFIG	Aircraft configuration wrong for takeoff or landing Any of the following: 1. LG not down and locked 2. TEF's not fully down	A. For in-flight LG problems, refer to LANDING EMERGENCIES B. If TEF's do not extend, execute landing using normal AOA (approximately 20 knots faster than normal)

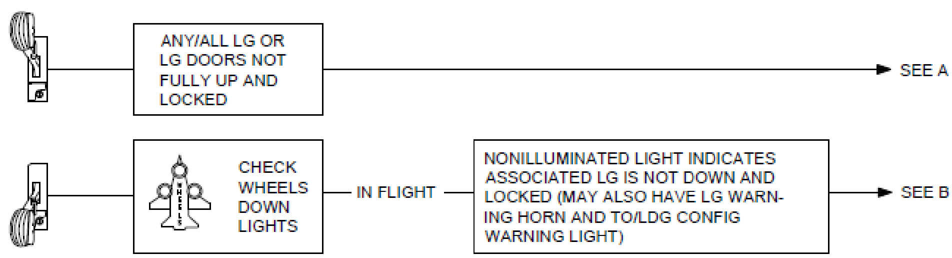


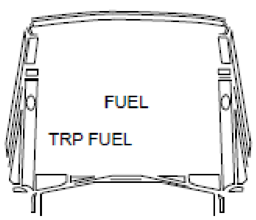
Warning Light Analysis

WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
CANOPY	Canopy hooks or lock not secure	A. • Push handle down farther into locked (outboard) position or if on the ground, inform maintenance • Refer to CANOPY DAMAGE/LOSS IN FLIGHT



WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
 LG handle warning light illuminated	LG or LG door not in position commanded by LG handle	A. Refer to LG FAILS TO RETRACT
		B. Refer to LG FAILS TO EXTEND/ ABNORMAL INDICATIONS



WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
TF FAIL	Not used	None
FLCS	One or more malfunctions	Note PFL(s) displayed and refer to PILOT FAULT LIST – FLCS
DBU ON	FLCC operating with backup software program	Refer to DBU ON WARNING LIGHT
OXY LOW	Partial pressure oxygen low BIT has detected fault Regulator pressure below 5 psi	Refer to OBOGS MALFUNCTION , this section
Flashing WARN symbol 	One or more red glareshield warning lights illuminated	Check for specific illuminated warning light Reset by toggling WARN RESET switch on ICP
Flashing TRP FUEL and FUEL warning symbols 	A trapped fuel condition is detected.	Reset FUEL by toggling WARN RESET switch on ICP Check fuel tank quantities and refer to TRAPPED EXTERNAL FUEL

Caution Light Analysis

CAUTION LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
MASTER CAUTION PRESS TO RESET	One or more caution lights on NOTE The MASTER CAUTION light does not illuminate for the IFF caution light.	Check for specific caution light on caution light panel Reset MASTER CAUTION light NOTE The MASTER CAUTION light does not reset when the ELEC SYS caution light is illuminated. The ELEC CAUTION RESET button must be depressed or the electrical malfunction cleared to extinguish ELEC SYS and MASTER CAUTION lights.

FLCS FAULT	ENGINE FAULT	AVIONICS FAULT	SEAT NOT ARMED
ELEC SYS	SEC	EQUIP HOT	NWS FAIL
PROBE HEAT	FUEL/OIL HOT	RADAR ALT	ANTI SKID
CADC	INLET ICING	IFF	HOOK
STORES CONFIG	OVERHEAT	NUCLEAR	*
ATF NOT ENGAGED	EEC		CABIN PRESS
FWD FUEL LOW	BUC		
AFT FUEL LOW			

Pilot Fault List – Engine PW220

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
ENG A/I TEMP/ENG 084	Anti-ice valve failed open and/or bleed air temperature greater than 850°F	Reduce throttle setting to midrange unless required to sustain flight. Operating the engine above midrange with anti-ice system failed on may result in engine stall. Land as soon as practical
ENG A/I FAIL/ENG 085	Engine anti-ice valve failed in closed position	Avoid areas of known or suspected icing conditions
ENG MACH FAIL/ENG 086	The CADC supplied mach number to the DEEC is no longer available	Supersonic stall protection is inoperative. Do not retard throttle below MIL while supersonic. If CADC caution light is also on, refer to CADC MALFUNCTION, this section
ENG A/B FAIL/ENG 087	AB system failure detected	AB RESET switch - AB RESET. Land as soon as practical if fault does not clear. AB operation is partially or fully inhibited
ENG THST LOW/ENG 088	Loss of redundant FTIT signals received by DEEC	MIL rpm is reduced 7 percent by DEEC
	DEEC has detected a failed open or missing nozzle	If a failed open or missing nozzle is suspected, refer to NOZZLE FAILURE, this section
ENG BUS FAIL/ENG 003	Communication lost between engine and aircraft MUX bus	Illuminates AVIONICS FAULT caution light. A subsequent engine fault causes a nonresettable ENGINE FAULT caution light and is not displayed on the PFLD
ENG PFL DEGR/ENG 089	Communication lost between diagnostic and control portions of the engine	Do not retard throttle below MIL while supersonic. May be accompanied by an auto transfer to SEC. After ENG PFL DEGR/ENG 089, only ENG A/I TEMP/ENG 084 can be subsequently displayed

Pilot Fault List – FLCS

(FLCS warning light illuminated)

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
FLCS AOA WARN	Dual AOA failure	Refer to AOA MALFUNCTIONS
FLCS DUAL FAIL	Dual electronic, sensor, or power failure in one or more axes	Refer to AIRCRAFT NON-RESPONSIVE IN PITCH OR FLCS DUAL ELECTRONIC FAILURE
FLCS LEF LOCK	LEF's are locked due to multiple failures, LE FLAPS switch position, or asymmetry	Refer to LEF MALFUNCTIONS
STBY GAIN	Dual air data failure	Refer to AIR DATA MALFUNCTIONS
FLCS BIT FAIL	FLCS BIT has detected a failure	Perform a second FLCS BIT. If fault does not clear, notify maintenance. Fault only occurs on ground

Pilot Fault List – FLCS

(FLCS FAULT caution light illuminated for all except FLCS BUS FAIL)

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
FLCS ADC FAIL	First failure of triplex air data input signal	Refer to AIR DATA MALFUNCTIONS
FLCS AOA FAIL	First failure of triplex AOA input signal	Refer to AOA MALFUNCTIONS
FLCS AOS FAIL	AOS feedback function is inoperative due to failure	Perform FLCS reset to attempt to clear fault; fault cannot be reset if INS or CADC is failed. If fault does not clear, the autopilot cannot be engaged. Position the STORES CONFIG switch to CAT III*
FLCS FLUP OFF	MANUAL TF FLYUP switch moved to DISABLE FLCS BIT detects MANUAL TF FLYUP switch in DISABLE	Position the MANUAL TF FLYUP switch as required. A FLCS reset extinguishes FLCS FAULT caution light. Position MANUAL TF FLYUP switch to ENABLE. Rerun FLCS BIT
FLCS A/P DEGR	Autopilot operating outside of attitude limits or unable to hold commanded mode	Refer to AUTOPILOT MALFUNCTIONS
FLCS A/P FAIL	Autopilot has disconnected or cannot be engaged due to loss of needed data	Refer to AUTOPILOT MALFUNCTIONS
FLCS BUS FAIL	Communication lost between FLCC and MUX bus	Illuminates AVIONICS FAULT caution light. Other FLCS PFL's may not be displayed on the PFLD. Refer to FLCS page on MFD for FLCS PFL's
BRK PWR DEGR	Power supply failure detected in one or more branches	Refer to FLCS SINGLE ELECTRONIC FAILURE
FLCS CCM FAIL	Erroneous output command detected by CCM	Refer to FLCS SINGLE ELECTRONIC FAILURE
FLCS HOT TEMP	FLCC sensors detect two branches in excess of 75°C	Refer to FLCS TEMPERATURE MALFUNCTIONS
ISA ALL FAIL	Two or more ISA's have reported a first servo valve failure	Refer to SERVO MALFUNCTIONS
ISA LHT FAIL ISA RHT FAIL ISA LF FAIL ISA RF FAIL ISA RUD FAIL	Indicated ISA has reported a first servo valve failure	Refer to SERVO MALFUNCTIONS
FLCS SNGL FAIL	Indicates single electronic or sensor failure in one or more axes	Notify maintenance. Fault only occurs on ground
FLCS MUX DEGR	BIT detected degradation of FLCC MUX interface	FLCS reset will not clear fault. Perform a second FLCS BIT. If fault does not clear and no other faults are reported, the system redundancy is adequate for flight. Notify maintenance after flight. Fault only occurs on ground

NOTE: *The potential for a departure from controlled flight is significantly increased if the AOS feedback function is inoperative and maneuvering occurs with the STORES CONFIG switch in CAT I.

38.3 Ground Emergencies

Refer to the BMS checklists under *Docs**02 Aircraft Manuals & Checklists**01 F-16**F-16 Checklists*, "SECTION EP GROUND" for further details.

38.3.1 FIRE/OVERHEAT/FUEL LEAK (GROUND)

An engine or JFS fire/overheat can be detected by flames, smoke, explosion, signal from ground crew, or radio call. FTIT may exceed 680°C for PW220 engines, if ac power is available, ENG FIRE warning or OVERHEAT caution light may illuminate.

1. Throttle - OFF.
2. JFS switch - OFF.
3. FUEL MASTER switch - OFF.
4. ENG FEED knob - OFF (if external power applied).

If Fire Continues:

5. Abandon aircraft.

38.3.2 HOT START (GROUND)

PW220 Hot start - FTIT over 680°C. During engine start, if the FTIT increases at an abnormally rapid rate through 575°C, a hot start can be anticipated.

1. Throttle - OFF.
2. FTIT indicator - Monitor.

If FTIT remains above 500°C:

3. JFS switch - START 2. Motor engine with JFS until FTIT is below 200°C.

38.3.3 HUNG START/NO START PW220

Hung start - RPM has stopped increasing below IDLE and FTIT is stabilized at less than 680°C.

No start - Light-off does not occur within 20 seconds.

1. Throttle - OFF. Notify maintenance.

38.3.4 ENGINE AUTOACCELERATION (GROUND)

If the engine auto accelerates on the ground, primary consideration should be given to shutting the engine down as quickly as possible. With engine shut down, only the brake/JFS accumulators are available to supply hydraulic pressure for braking. Stop the aircraft by making one steady brake application. When the aircraft is fully stopped, have chocks installed or engage parking brake. Leave the battery on until chocks are installed.

1. Throttle - OFF.
2. FUEL MASTER switch - OFF.

38.3.5 ANTISKID MALFUNCTION (GROUND)

If a failure affecting braking performance is detected while the aircraft is moving above 5 knots, the ANTI SKID caution light illuminates. In most cases this represents the loss of a wheel speed sensor signal, and the system switches to an alternate braking mode. In this mode, if differential braking is applied (15 percent or greater difference between pedals), both brakes oscillate between pressure as metered and no pressure. Braking effectiveness is reduced by 50 percent or greater. If brake pedals are within 15 percent, the system uses the information from the remaining good wheel speed sensor and stopping distance is increased by approximately 25 percent on both wet and dry runways. An ANTI SKID caution light which only illuminates below 5 knots indicates a malfunction that does not affect braking performance. Normal braking and antiskid are available; however, system redundancy may have been lost. Below 20 knots groundspeed the alternate braking mode is less effective than manual braking. To select manual braking, place BRAKES channel switch to CHAN 2 and ANTI-SKID switch to OFF. If the ANTI SKID caution light illuminates (with the ANTISKID switch in ANTI-SKID):

1. Brakes - Apply as needed.

NOTE

Use of maximum symmetric pedal pressure provides the best stopping performance. Differential brake only when essential for directional control. If the ANTI SKID caution light illuminated above 5 knots groundspeed, the aircraft may oscillate due to pulsating brake pressure (if 15 percent or greater differential pedal pressure is applied).

If braking performance is degraded:

2. BRAKES channel switch - CHAN 2.

WARNING
• Release brake pressure before switching to CHAN 2. • With certain failures, no antiskid protection is available with the ANTI-SKID switch in ANTI-SKID and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

3. HOOK switch - DN (if required).
4. NWS - Engage (if required).

If manual braking is desired:

5. ANTI-SKID switch - OFF.

CAUTION
Release brake pressure before switching antiskid off. No antiskid protection is available with the ANTI-SKID switch in OFF and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

38.3.6 BRAKE FAILURE

Malfunctions in systems which affect normal braking are described in the emergency procedure which addresses each specific system. One of the brake failure modes is the loss of one brake circuit. With this failure, both brakes are still available; however, significantly more pedal force than normal is required to achieve a specific braking effectiveness.

Another failure mode is loss of brakes on one or both MLG. Changing brake channels may return the system to normal operation. Turning the ANTI-SKID switch to OFF and confirming BRAKES channel switch in CHAN 2 may also restore braking; however, the system reverts to manual control and antiskid protection is lost. Status of the power source for toe brake transducers can be determined by testing the FLCS PWR lights on the TEST switch panel. Release brake pedal pressure before changing channels or turning off the ANTI-SKID switch to avoid immediate brake lockup if braking returns. When moving the ANTI-SKID switch, be very careful not to select the PARKING BRAKE unless that is what is intended. If directional control is a problem (such as with one brake inoperative on landing roll), do not hesitate to use NWS. If conditions permit, consider a go-around if the brakes are found to be inoperative on landing. Lower hook if a cable is available. If normal brakes cannot be restored, do not hesitate to use the parking brake if a cable is not available. The lower the groundspeed, the less chance there is for aircraft damage when using the parking brake. If the aircraft is accelerating, use the parking brake early.

It may be possible to cycle the parking brake on and off and stop the aircraft; however, regardless of technique, use of the parking brake may result in blown tires. Another failure mode is a hydraulic leak in the brake itself, which might not be apparent until after two-point aerodynamic braking. In this case, if a cable is not available, the aircraft should be stopped using the good brake
and NWS for directional control. Once the aircraft is stopped, do not engage the parking brake; use continuous pedal pressure on the good brake only. Failure to do so could deplete the hydraulic system and result in total brake failure prior to chock installation.

Accomplish as many steps as required:

NOTE
If conditions permit, consider a go-around if the brakes are found to be inoperative on landing. An approach-end cable arrestment is recommended.

1. BRAKES channel switch - CHAN 2.

CAUTION
Release brakes prior to changing brake channels or turning antiskid off.

2. HOOK switch - DN.
3. ANTI-SKID switch - OFF.

CAUTION
Release brakes prior to changing brake channels or turning antiskid off. No antiskid protection is available with the ANTI-SKID switch in OFF and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

4. NWS - Engage (if required).

If arresting cable is not available or if at low groundspeed:

5. ANTI-SKID switch - Intermittent PARKING BRAKE, then ANTI-SKID.

CAUTION
If in a congested area, use the parking brake immediately to stop.

When stopped:

6. Parking brake - Set as required.

WARNING
If hot brakes are suspected, do not use then parking brake and refer to HOT BRAKES, this section. Do not taxi the aircraft except for emergency movement. Do not set the parking brake with single brake failure. Single brake failure may indicate a hydraulic leak in the brake itself. In this case, application of the parking brake could deplete the hydraulic system and result in total brake failure. Use continuous pedal pressure on the good brake only.

38.3.7 HOT BRAKES

The pilot has the responsibility to determine when a hot brake condition exists. The pilot evaluates the situation by analyzing the variables that influence brake temperature:

GW, pressure altitude, OAT, speed at brake application, etc. Refer to TO 1F-16CM/AM-1BMS, BRAKE ENERGY LIMITS - MAXIMUM EFFORT BRAKING. Observations by ground crewmembers should also be used as certain malfunctions that result in overheated brakes, such as dragging brakes, may not be readily apparent to the pilot. Perform hot brake procedures anytime hot brakes are suspected.

1. Request firefighting equipment and proceed directly to the designated hot brake area or nearest area clear of other aircraft and personnel.

When in the hot brake area:

2. Align aircraft with nose into wind if possible.
3. EPU switch - OFF.
4. Throttle - OFF.
5. Nose wheel - Chocked.
6. MAIN PWR switch - OFF.
7. Exit toward the front of the aircraft.
8. Go to GROUND EGRESS, this section

It is impossible for the ground crew to avoid the hot brake and engine intake danger areas while pinning the EPU or chocking the aircraft. Therefore, if conditions permit, the aircraft should be shut down without pinning the EPU or chocking the wheels. Release brake pressure as soon as possible to minimize heat transfer between the brake surfaces and the wheel. This action also relieves hydraulic pressure to the brakes, which if leaking, could feed a hydraulic fire.

38.3.8 MAIN GENERATOR FAILURE (GROUND)

If the main generator fails on the ground, the standby generator provides power for full normal braking (both channels) and NWS. Abort the aircraft. Taxiing is permissible.

38.3.9 MAIN AND STANDBY GENERATOR FAILURE (GROUND)

FLCS PMG and aircraft battery provide power for full normal braking (both channels). The EPU should activate and provide power for NWS. Stop and engage the parking brake prior to attempting to reset the generators. If main or standby generator resets and further taxiing is required, brakes should be checked carefully. Allow the aircraft to begin rolling slowly and check for normal braking. If normal braking is inoperative, immediately engage the parking brake.

If MAIN GEN and STBY GEN lights illuminate:

1. Stop the aircraft.

Turn EPU on, if required, to obtain NWS.

2. ANTI-SKID switch - PARKING BRAKE
3. OXYGEN - 100%.
4. EPU switch - OFF.
5. ELEC CAUTION RESET button – Depress
6. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

CAUTION
If chocks are not installed, be prepared to immediately engage the parking brake if it disengages when the EPU is shut off.

CAUTION
If main or standby generator cannot be reset, NWS is inoperative unless the EPU is activated.

38.3.10ACTIVATED EPU/HYDRAZINE LEAK

If landing with an activated EPU or a hydrazine leak is detected while the engine is running: Inform landing base of hydrazine leak or EPU operation and request bioenvironmental services support.

WARNING
Treat any leak as a hydrazine leak until investigation proves otherwise.

1. OXYGEN - 100%.

When on the ground:

2. AIR SOURCE knob - OFF (if required).

Consider turning the ECS off to prevent the possibility of hydrazine fumes or EPU exhaust gases entering the cockpit.

CAUTION
If AIR SOURCE knob is placed to turn off nonessential avionic equipment as electronic equipment OFF, also may be damaged.

3. Taxi to designated isolated parking area (if required) and park aircraft with left wing into wind if possible.
4. Insure all nonessential personnel are clear.
5. EPU switch - OFF.
6. Shut down the engine (after left main wheel is chocked).

NOTE
To prevent sitting in a sealed cockpit (hot) without ECS, consider waiting for ground crew to arrive with ladder and oxygen bottle prior to shutting down the engine.

38.3.11 NWS FAILURE/HARDOVER

NWS failure may be detected by the NWS FAIL caution light or uncommanded NWS inputs with no caution light. If NWS FAIL caution light is on, do not engage NWS. If the NLG strut is overextended, the NWS cannot engage. If the NLG strut overextends after NWS engagement, NWS becomes disengaged, and the AR/NWS light goes off.

WARNING
NWS malfunctions at any speed may cause an abrupt turn, tire skidding or blowout, aircraft tipping, and/or departure from the prepared surface.

1. NWS - Disengage.
2. AR/NWS light - Verify off.
3. Rudder and brakes - As required.

38.4 Takeoff Emergencies

Refer to the BMS checklists under *\Docs\02 Aircraft Manuals & Checklists\01 F-16\F-16 Checklists*, “SECTION EP TAKEOFF” for further details.

38.4.1 DELAYED ROTATION

Several factors can cause the airspeed at which rotation occurs to be greater than that determined from the weapon delivery planner. As the weight of external stores carried increases, more nose down moment must be overcome to rotate for takeoff. Another factor is the application of roll stick force in addition to aft stick force. Applying a roll input reduces the maximum trailing edge up position for one horizontal tail and increased airspeed may be required to compensate. The last and most significant factor is improper servicing of the nose gear strut. Improper servicing may not be detectable during preflight inspection and may cause rotation speed to increase by up to 15 knots. All of these factors combined may add up to 25 knots to the computed airspeed for rotation. If pre-takeoff flight control checks were normal and the engine is operating normally (acceleration check normal), the aircraft will rotate above computed rotation speed. Therefore, takeoff should not be aborted due to delayed rotation until at least takeoff speed is attained. Notify maintenance after flight if a significantly delayed rotation occurred.

38.4.2 ABORT

The decision to abort or continue takeoff depends on many factors. Considerations should include, but not be limited to, the following:

Runway factors: Runway remaining, surface condition (wet, dry, etc.), type and/or number of barriers/ cables available, obstructions alongside or at the departure end, wind direction and velocity, and weather and visibility.

Aircraft factors: GW, stores, nature of the emergency, speed at decision point, and importance of becoming airborne.

Stopping factors: Maximum antiskid braking, speedbrakes, aerodynamic braking, and hook.

WARNING
Aborting takeoff at high speed with a blown tire may be more dangerous than continuing takeoff. For heavy GW takeoffs, an abort at high speed with a blown tire is extremely dangerous because braking and directional control are impaired.

CAUTION
At high speed (prior to WOW), forward stick pressure in excess of approximately 2 pounds results in full trailing edge down deflection of the horizontal tails. This causes excessive loads on the NLG which can lead to nose tire failure and possible structural failure of the NLG. Failure to use full antiskid braking or applying brakes with engine above idle thrust significantly increases the wheel brake temperature and probability of a wheel brake fire.

Normally, with the short takeoff distances of the aircraft, abort is not a problem unless directional control is a factor (e.g., blown tire). An early decision to abort provides the most favorable circumstances. If there is any doubt about the ability to stop on the runway, lower the hook. Consider aborting after becoming airborne only when sufficient runway is available and flight to a key position is not possible. Aborts above 100 KCAS require diligent adherence to the procedures in this section for the abort to be successful. If aborting after rotation, retard throttle to IDLE and maintain two-point attitude while applying maximum wheel braking (maximum pedal pressure (antiskid on) consistent with maintaining directional control). When wheel brakes become effective, the nose automatically lowers. After the nosewheel is on the runway, use maximum effort braking (full aft stick, full open speedbrakes, and maximum wheel braking). If aborting before rotation, retard throttle to IDLE, maintain three-point attitude and apply maximum effort braking if stopping distance is critical. NWS should be engaged if directional control is a problem. Consider following hot brake procedures after any abort. Taxiing after an abort will further increase brake temperature.

WARNING
When braking absorbs a high amount of energy, do not shut down engine until firefighting equipment is available and do not use the parking brake. Hot wheels and brakes may ignite leaking hydraulic fluid for PW220 engines or fuel drained overboard during engine shutdown. Wheel fusible plugs may relieve tire pressure within 15 minutes after stop.

1. Throttle – IDLE

WARNING
When the throttle is retarded to IDLE from MAX AB, the thrust and rpm decay to idle can take up to 2-4 seconds. Do not mistake high thrust/rpm for failure of the engine to respond to the idle command. Engine shutdown from MAX AB may result in a tailpipe fire.

2. Wheel brakes - Apply (as required).
3. HOOK switch - DN (if required).
   - The hook should be lowered at least 1500 feet from the cable to allow adequate time for hook to stabilize and for full holddown force to be developed by the hook actuator.

   - Refer to CABLE ARRESTMENT, this section.

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

If on fire:

4. Throttle - OFF.

NOTE
With engine shut down, NWS is lost and EPU does not activate automatically. After hydraulic pressure drops, braking is available using the brake/JFS accumulators only. Stop straight ahead and engage parking brake.

5. FUEL MASTER switch - OFF.

38.4.3 ENGINE FAILURE ON TAKEOFF

An engine malfunction on takeoff presents a demanding situation where critical actions must be accomplished quickly with little time for analysis. If takeoff is continued, a straight ahead climb is generally preferred over an immediate turn to low key. This action provides more favorable ejection parameters and an increase in analysis time. If necessary, use only shallow turns to avoid aggravating the situation. Jettison stores if required to reduce GW.

38.4.4 ENGINE MALFUNCTION ON TAKEOFF

Engine failure shortly after lift-off may not permit time for analysis or corrective action. The primary concern should be to trade any excess airspeed for altitude and to eject prior to allowing a sink rate to develop. Jettisoning stores may aid in gaining altitude but must not delay the ejection decision. If the failure occurs later in the takeoff phase, time may be available for analysis or corrective action.

If conditions permit:

1. Abort.

If conditions do not permit an abort:

1. Zoom.
2. Stores - Jettison (if possible).
3. Eject.

38.4.5 AB MALFUNCTION ON TAKEOFF

An AB malfunction can be detected by a thrust loss and nozzle closure or failure of AB to light within allowed time or stalls accompanied by a loud bang or pop. An AB failure (other than a slow/no light) may indicate other engine problems. If possible, abort the takeoff. If takeoff is continued, the throttle should be retarded to MIL. If normal thrust is not available in MIL, refer to LOW THRUST ON TAKEOFF OR AT LOW ALTITUDE (NON-AB), this section. AB operation should not be reattempted unless required to sustain flight.

If decision is made to stop:

1. Abort.

If takeoff is continued:

1. Throttle - MIL.
2. Stores - Jettison (if required).

38.4.6 LOW THRUST ON TAKEOFF OR AT LOW ALTITUDE (NON-AB) PW220 PW229

Low altitude, for engine malfunction purposes, is generally defined as 10,000 feet AGL or below. Low thrust can be the result of DEEC-related malfunctions, bird strike, malfunction in the nozzle control system, a failed open, damaged, or missing nozzle, engine start bleed strap failure, or an engine rpm rollback. A failed open, damaged, or missing nozzle may result in significant thrust loss and the inability to takeoff, or maintain level flight depending on pressure altitude and stores configuration. Low thrust can also be the result of the start bleed strap failing to close during the normal start cycle.

If low thrust occurs during takeoff and conditions permit, the takeoff should be aborted. If the takeoff must be continued or in any critical phase of flight and MIL thrust is not sufficient, AB should be used. An excessively open nozzle may reduce the chance for successful AB light.

If the AB does not light (allow the DEEC to automatically re-sequence the AB if conditions permit), consider jettisoning stores. In most failure situations, PRI should provide adequate thrust to maintain level flight at low altitude depending on stores loading. Therefore, allow the DEEC to select the initial control mode.

If thrust is still insufficient while operating in PRI, place the ENG CONT switch to SEC. SEC should only be selected when it becomes apparent that sufficient thrust cannot be achieved in PRI. In some cases, manual selection of SEC may result in full SEC MIL thrust (80-100% of PRI MIL thrust). Operating in SEC at prolonged throttle settings above 850°C FTIT with a nozzle missing or failed open may result in engine failure and fire.

Certain engine control system failures result in the DEEC commanding an auto transfer to SEC. If an auto transfer to SEC occurs, full MIL SEC thrust should result.

If on takeoff and the decision is made to stop:

1. Abort.

If takeoff is continued and/or thrust is insufficient:

1. Throttle - AB.

The chances for a successful AB light with the nozzle open more than 30 percent are reduced.

2. Stores - Jettison (if required).

NOTE

In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

If PRI thrust is insufficient to maintain level flight at a safe altitude:

3. ENG CONT switch - SEC.

WARNING

With the nozzle missing or failed open, catastrophic engine failure and fire are probable with prolonged power settings above 850°C FTIT while in SEC.

NOTE

SEC should only be selected when it becomes apparent that sufficient thrust cannot be achieved in PRI. SEC eliminates the additional thrust and the engine protection benefits provided by the DEEC in PRI.

38.4.7 LOW THRUST ON TAKEOFF OR AT LOW ALTITUDE (NON-AB) GE100 GE129

Low altitude, for engine malfunction purposes, is generally defined as 10,000 feet AGL or below. Low thrust can be the result of DEC-related failures, the nozzle failing, or an rpm rollback. These situations may result in significant thrust loss and the inability to takeoff or maintain level flight. If low thrust occurs during takeoff and conditions permit, the takeoff should be aborted.

If the takeoff must be continued or in any critical phase of flight, when MIL thrust is insufficient, AB should be used.

An automatic transfer to HYBRID or SEC may occur resulting in less than MIL thrust with limited or no AB capability. An exhaust nozzle problem may prevent the use of AB and will be indicated by an ENG AB FAIL PFL.
If an automatic transfer to SEC occurs or SEC is selected manually, resulting thrust is 70-95 percent of normal MIL thrust with no AB capability. If thrust is still low, consider jettisoning stores.

If on takeoff and the decision is made to stop:

1. Abort.

If takeoff is continued and/or thrust is insufficient:

1. Throttle - AB.

Nozzle problems may inhibit AB capability as indicated by presence of the ENG AB FAIL PFL.

2. Stores - Jettison (if required).

NOTE
In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

If PRI thrust is insufficient to maintain level flight at a safe altitude:

3. ENG CONT switch - SEC (even if SEC caution light is on), then immediately back to PRI.

CAUTION
Position the ENG CONT switch to SEC for a minimum of 1/2 second, then immediately back to PRI.

38.4.8 ENGINE FIRE ON TAKEOFF

An engine fire may be indicated by the ENG FIRE warning and/or OVERHEAT caution lights, high FTIT, smoke, or fumes.

38.4.9 LG FAILS TO RETRACT

If the LG handle warning light remains on after the LG handle is placed to UP, the LG or LG doors are not fully up and locked.

1. Airspeed - 300 knots maximum.

2. LG handle - DN. (Use DN LOCK REL button if required.)

WARNING
If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. PW229 Nozzle remains closed, resulting in higher than normal landing thrust.

38.4.10 LG HANDLE WILL NOT RAISE

If the left MLG WOW switch fails to the ground position, the LG handle does not move out of the DN position. In addition, the TO/LDG CONFIG warning light and touchdown skid control system are affected. The LG handle may be raised by first depressing the LG handle downlock release button.

If conditions permit:

1. Airspeed - 300 knots maximum.
2. GW - Reduce prior to landing.

If LG must be raised:

1. LG handle DN LOCK REL button - Depress.
2. LG handle - UP.

TO/LDG CONFIG light is on if left MLG WOW switch has failed.

When desired:

3. LG handle - DN. (Use DN LOCK REL button if required.)

WARNING
If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. PW229 Nozzle remains closed, resulting in higher than normal landing thrust.

After touchdown:

4. Brakes - Apply after wheels spin up.

CAUTION
Touchdown antiskid protection is not available. Landing with feet on the brake pedals may result in blown tire(s).

38.4.11 BLOWN TIRE ON TAKEOFF

Tire failure on takeoff is difficult to recognize and may not be noticed in the cockpit.

A blown nose tire can easily be confused with an engine malfunction. Possible indications of a nose tire failure include a loud explosion, slight deceleration, vibrations, flying debris, and at night, a flash or flame. These characteristics can be mistaken for an engine stall. Although rubber debris may cause damage to the engine, NWS wiring harness, WOW switch assembly and/or gear position sensor wiring, historically, the chance of catastrophic engine damage is remote. NWS may not be available even though the AR/NWS light is on and the NWS FAIL light is off.

WARNING
Aborting takeoff at high speed with a blown tire may be more dangerous than continuing takeoff. For heavy weight takeoffs, an abort at high speed with a blown tire is extremely dangerous because braking and directional control are impaired. The primary response to a blown tire at high speed (i.e., greater than 100 knots) should be to check engine instruments and continue the takeoff if the engine is operating normally. If takeoff is continued, do not retract the LG, reduce GW if practical, and prepare to land as soon as practical.

NOTE
The decision to takeoff or abort depends on the speed at the time of the failure, GW, stopping distance required, and arresting gear availability.

Directional control during stopping is the primary concern when aborting with a blown tire. Heavy GW and high speed aborts place greater demands on the brakes and tires. This may cause damage to the NWS, wheels, and struts which may result in loss of directional control. In addition, heavy differential braking may result in MLG tire failure.

If aborting with a blown MLG tire, leave antiskid on to minimize possibility of skidding the good tire. If the wheel with the blown tire does not turn, the antiskid system switches to the alternate braking mode. Use roll control to relieve pressure on the blown tire and NWS to maintain directional control.

If aborting with a blown NLG tire, hold the nosewheel off the runway (if able) and use two-point aerodynamic braking until control effectiveness begins to decay. Lower the nosewheel to the runway and immediately engage NWS, if available, to maintain directional control. Use aft stick to reduce load on the NLG after brakes are applied. If NWS is not available, the aircraft tends to drift right. Attempt to move to the left side of the runway before rudder effectiveness is lost and maintain directional control with rudder and differential braking. Stop short of the departure-end arresting cable if possible. The small nosewheel rolling radius with the tire missing may allow

the cable to pass over top of the nosewheel and cause NLG collapse. A NLG tire failure accompanied by complete tire separation from the wheel may cause reverse castering.
The conditions for this to occur are the NWS disengaged or inoperative; the nose wheel rim rolling on a deformable surface (i.e., asphalt); and lateral force applied to the nose wheel from either a rudder input or differential braking. If reverse castering occurs the nose wheel will turn in the opposite direction of rudder and brake inputs making it extremely difficult to maintain directional control.

WARNING
If a blown NLG tire occurred and NWS is not available, it may not be possible to prevent departure from the runway. A reverse castering effect may occur in which the nosewheel moves opposite to the rudder or differential braking input.

CAUTION
With a blown tire, avoid centerline lights as they may cause wheel damage and subsequent loss of directional control. Failure to use full aft stick with a blown NLG tire may lead to wheel failure and directional control problems. Stop straight ahead and shut down the engine as soon as firefighting equipment is available. Do not attempt to taxi unless an emergency situation exists.

If takeoff is continued:

1. LG - Do not retract.
2. Airspeed - 300 knots maximum.
3. Refer to LANDING WITH A BLOWN TIRE, this section.

If takeoff is not feasible:

1. Abort.

38.5 In-Flight Emergencies

When preparing to activate backup systems which rely on stored nitrogen pressure to function, consider the potential for time-related failures and do not activate the system earlier than required. For example, the hydrazine mode of the EPU requires nitrogen pressure to force hydrazine to the EPU. If a nitrogen leak exists, turning the EPU on early could lead to an inability of the EPU to function on hydrazine. Similarly, alternate LG and hook extension use stored nitrogen pressure. If alternate LG extension is used early and a nitrogen leak exists, hydraulic system B could subsequently fail. Such a leak could also result in insufficient pressure to maintain proper hook holddown force. Since nitrogen leaks are not apparent prior to system activation, consider their potential existence and activate the backup system when needed, but not excessively early.

Voltage transients associated with manual EPU activation (main generator still on line) or main generator failure may cause the HSI to be blank or display NO DATA. Performing a BIT of the HSI may restore normal operation if the display is blank. If normal HSI operation is not restored, notify maintenance after landing.

Refer to the BMS checklists under *\Docs\02 Aircraft Manuals & Checklists\01 F-16\F-16 Checklists,* "SECTION EP INFLIGHT" for further details.

38.5.1 CANOPY WARNING LIGHT ON

If CANOPY warning light illuminates:

1. Canopy handle - Push outboard.

If CANOPY warning light remains on:

2. Go to CANOPY DAMAGE/LOSS IN FLIGHT, this section.

38.5.2 CANOPY DAMAGE/LOSS IN FLIGHT

Canopy loss/penetration in flight results in disorientation and may result in structural damage caused by the canopy striking the aircraft. Due to the possibility of severe disorientation, vision loss, injury, or incapacitation at high airspeed, immediate ejection may be the only option. Slow to 180 knots or less and check for controllability. Wind blasts up to 180 knots can be coped with by leaning forward and down behind the glareshield and HUD.

WARNING
Arms must be kept close to the body to avoid letting wind blast pull arms out of the cockpit. • HUD glass disintegration can be expected following a medium to high energy bird strike with or without canopy penetration. • Canopy damage may cause loss of the canopy without warning.

Wind buffet increases slightly with increased AOA. Therefore, if fuel is not critical, TEF's should be extended using the ALT FLAPS switch or by placing the LG handle to DN.

A canopy crack may occur during flight. Spontaneous canopy cracks are typically in the non-structural ply of the transparency. If a canopy crack occurs, maintain the lowest practical altitude and airspeed and land as soon as practical.

1. Airspeed - 180 knots maximum.
2. Seat - Full down.
3. ALT FLAPS switch - EXTEND.
4. Land as soon as possible.

If a canopy crack has occurred:

5. Airspeed and altitude - Minimum practical.
6. Land as soon as practical.

NOTE
Spontaneous canopy cracks are typically in the nonstructural ply of the transparency.

38.5.3 COCKPIT PRESSURE/TEMPERATURE MALFUNCTION

Loss of cockpit pressurization could be caused by canopy seal, air-conditioning system, or cockpit pressure regulator safety valve malfunctions or ECS shutdown or failure.
Low ram airflow or certain ECS equipment malfunctions can result in temporary shutdown of the ECS. These shutdowns are more prevalent at high altitude during low speed flight with high engine thrust settings. An ECS shutdown is characterized by an oily, smokey smell, followed by loss of cockpit noise and airflow and gradual loss of pressurization. These temporary shutdowns typically last from 20-45 seconds or, on occasion, up to 2 minutes. The EQUIP HOT caution light may illuminate if the shutdown lasts longer than 20 seconds.

WARNING
• With the ECS shut down or the AIR SOURCE knob in OFF or RAM, the g-suite does not inflate and PBG is disabled. • With the ECS shut down or the AIR SOURCE knob in OFF or RAM, OBOGS is inoperative. Activate EOS if OXY LOW warning light

Short duration (approximately 15 seconds) losses of cockpit airflow when operating above 35,000 feet MSL should not be confused with an ECS shutdown. These are the result of an automatic ECS cutback which is designed to prevent total system shutdown.

NOTE
The OBOGS caution light may illuminate as a result of ECS cycling or temporary ECS shutdown. This is normal as long as the OXY LOW warning light does not illuminate.

Most AUTO position temperature failures can be corrected by use of the MAN position.

If cockpit pressure altitude exceeds 27,000 feet, the CABIN PRESS caution light illuminates.

If the cockpit temperature is excessive and does not respond to AUTO, MAN, or OFF temperature commands or cockpit pressure is lost, proceed as follows:

1. OXYGEN - 100%.
2. Altitude - 25,000 feet maximum (18,000 feet if conditions permit).
3. Airspeed - 500 knots maximum.
4. AIR SOURCE knob - OFF (10-15 seconds), then NORM.

The OBOGS caution light illuminates while AIR SOURCE knob is in OFF.

If cockpit pressure is not regained but all other systems dependent on the ECS are operational:

5. Flight may be continued below 25,000 feet (18,000 feet if conditions permit).

If ECS has failed or cockpit temperature control is not regained:

5. AIR SOURCE knob - OFF.

WARNING
With the ECS shut down or the AIR SOURCE knob in OFF or RAM, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates

NOTE
• The External fuel cannot be transferred in OFF or RAM. Consider jettisoning tank(s) to decrease drag if range is critical and ECS cannot be turned on for short periods of time to transfer fuel. • With OBOGS inoperative, the BOS will supply oxygen for approximately C 3-5 minutes, D 2-3.5 minutes with both cockpits occupied or 4-7 minutes with one cockpit occupied. The EOS will supply oxygen for 8-12 minutes.

WARNING
With the ECS shut down or the AIR SOURCE knob in OFF or RAM, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates above 10,000 feet cockpit altitude.

6. Nonessential electrical equipment - Off.
7. Land as soon as practical.
8. Check for failed emergency dc bus(es).

Refer to EMERGENCY POWER DISTRIBUTION, this section.

38.5.4 EQUIP HOT CAUTION LIGHT

If EQUIP HOT caution light illuminates:

NOTE

- Certain ECS equipment malfunctions result in temporary shutdown of the ECS and illumination of the EQUIP HOT caution light.

- An ECS shutdown and EQUIP HOT caution light illumination for up to 2 minutes can occur during operation above a line from 42,000 feet MSL at 0.2 mach to 50,000 feet MSL at 0.95 mach. This shutdown is normal, but may still require additional action if the EQUIP HOT light remains on for more than 1 minute.

- If cockpit temperature is excessive, refer to COCKPIT PRESSURE/TEMPERATURE MALFUNCTION, this section.

1. AIR SOURCE knob - Confirm in NORM if smoke or fumes are not present.
2. Throttle - 80 percent rpm minimum (in flight).

If EQUIP HOT caution light remains on after 1 minute:

3. Nonessential avionics - Off.
4. Land as soon as practical.

38.5.5 EJECTION

Ejection should be accomplished at the lowest practical airspeed.

38.5.6 EJECTION (TIME PERMITTING)

If time permits, descend to avoid the hazards of high altitude ejection. Stow all loose equipment and direct the aircraft away from populated areas. Sit with head against headrest, buttocks against back of seat, and feet on rudder pedals.

1. IFF MASTER knob - EMER.
2. ZEROIZE switch (combat status) - ZEROIZE.
3. Loose equipment and checklist - Stow.
4. Lapbelt and helmet chin strap - Tighten.
5. Night vision devices - Remove (if appropriate).

WARNING
Failure to remove night vision goggles (NVG) prior to ejection may cause serious injury. If unable to remove NVG, a proper ejection body position (head back against the seat headrest) reduces the chance of injury from the NVG.

6. HMCS - Manually disengage QDC (if necessary).
7. Visor - Down.
8. Throttle - IDLE.

Slow to lowest practical airspeed.

9. Speedbrakes - Open.
10. Assume ejection position.
11. Ejection handle - Pull.

38.5.7 FAILURE OF CANOPY TO SEPARATE

If canopy fails to separate, remain in position for ejection while keeping arms inboard and perform the following:

WARNING
If canopy is jettisoned or manually released/ opened after pulling the ejection handle, the ejection seat functions immediately after canopy separation. Be prepared to immediately put arm back in ejection position when the canopy starts to separate.

1. Canopy - Open normally.
2. Canopy - Jettison.

WARNING
Pulling the CANOPY JETTISON T-handle other than straight out may cause the handle to jam.

3. MANUAL CANOPY CONTROL handcrank - Push in and rotate ccw.

WARNING
Use of the CANOPY JETTISON T-handle or MANUAL CANOPY CONTROL handcrank may result in serious injury. To minimize chances of injury, immediately release the handle when the canopy starts to separate.

38.5.8 EJECTION SEAT FALIURE

If the ejection seat fails to function after the ejection handle is pulled and the canopy has separated from the aircraft, there are no provisions designed into the escape system for manual bailout.

38.5.9 ELECTRICAL SYSTEM FAILURES

Electrical system failures are indicated by illumination of the ELEC SYS caution light and one or more ELEC control panel lights (in any combination). After accomplishing the appropriate emergency procedures, refer to EMERGENCY POWER DISTRIBUTION, this section, to determine inoperative equipment for any remaining ELEC control panel lights.

38.5.9.1 FLCS PMG FAILURE

FLCS PMG light illuminates. The converter/regulator automatically selects the power source with the highest voltage from the available alternate sources. Other FLCS power sources are the main generator, the standby generator, the EPU generator, the EPU PMG, and the aircraft battery.

If FLCS PMG light illuminates:

1. Land as soon as practical.

38.5.9.2 SINGLE GENERATOR FAILURES (INFLIGHT) 40/42

A single generator failure is indicated by illumination of either the MAIN GEN or STBY GEN light. A mechanical failure which affects the standby generator may also affect the FLCS PMG causing illumination of both the STBY GEN and FLCS PMG lights. Actions required in this circumstance are the same as those for illumination of the MAIN GEN or STBY GEN light; thus, this failure is also categorized as a single generator failure.

Illumination of the MAIN GEN light indicates that one or both nonessential ac buses are not being powered by the main generator. The light may illuminate if the main generator fails or if a bus contactor trips off one or both nonessential ac buses. In either case, the standby generator automatically comes on line to power the essential and emergency buses which are not being powered by the main generator. The nonessential dc bus is not powered. The main generator may be reset by depressing the ELEC CAUTION RESET button or cycling the MAIN PWR switch; however, moving the switch out of MAIN PWR removes standby generator power and causes the EPU to activate. Refer to EMERGENCY POWER DISTRIBUTION, this section, for a list of inoperative equipment if the main generator does not reset.

Illumination of the STBY GEN light indicates that standby generator power is not available for the essential and emergency buses. The STBY GEN light illuminates for standby generator system failure or for failure of the essential bus relay(s). No bus loses power if the STBY GEN light illuminates when the main generator is still on line. The standby generator may only be reset by depressing the ELEC CAUTION RESET button.

Illumination of both STBY GEN and FLCS PMG lights indicates that standby generator and FLCS PMG power is not available. If the main generator is on line, no buses lose power and the EPU does not automatically activate.

NOTE
• With standby generator failure and the MAL & IND LTS switch in DIM, the ELEC SYS caution light may not appear to illuminate when the MASTER CAUTION and STBY GEN lights illuminate. • The TACAN is not powered when the main generator is off line.

If the MAIN GEN, STBY GEN, or STBY GEN and FLCS PMG lights illuminate:

1. ELEC CAUTION RESET button - Depress.

This action may reset the main or standby generator. Cycling the MAIN PWR switch may also reset the main generator; however, this action momentarily removes standby generator power and activates the EPU.

2. Land as soon as practical.

CAUTION
While operating on standby generator with NVP powered, do not exceed 5000 feet MSL and do not exceed 25 minutes NVP operating time.

38.5.9.3 SINGLE GENERATOR FAILURES (INFLIGHT) 50/52

A single generator failure is indicated by illumination of either the MAIN GEN or STBY GEN light. A mechanical failure which affects the standby generator may also affect the FLCS PMG causing illumination of both the STBY GEN and FLCS PMG lights. Actions required in this circumstance are the same as those for illumination of the MAIN GEN or STBY GEN light; thus, this failure is also categorized as a single generator failure.

Illumination of the MAIN GEN light indicates that one or both nonessential ac buses are not being powered by the main generator. The light may illuminate if the main generator fails, if a main power contactor trips off one or both nonessential ac buses, or if a shorting failure of an overcurrent sensing contactor (OCSC) or other wiring/ equipment occurs. Refer to PARTIAL ELECTRICAL POWER LOSS, this section, for discussion of OCSC failures. In all cases, the standby generator should automatically come on line to power the essential and emergency buses which are not being powered by the main generator. The nonessential dc bus is not powered.

The main generator may be reset by depressing the ELEC CAUTION RESET button or cycling the MAIN PWR switch; however, moving the switch out of MAIN PWR removes standby generator power and causes the EPU to activate. A reset attempt should not be made if the MAIN GEN light was preceded by a 2-3 second loss of power to the HUD, MFD's, and other cockpit equipment. Refer to EMERGENCY POWER DISTRIBUTION, this section, for a list of inoperative equipment if the main generator is/ does not reset. Certain aircraft could experience main generator auto-cycling on the ground beginning 7 seconds after weight-on-wheels. The main generator comes back on line automatically and another 2-3 second period of degraded power could occur until the main generator is again taken off line. Seven seconds later the cycle can repeat. This auto cycling (and the resulting over current damage) can be prevented by activating the EPU and moving the MAIN PWR switch to BATT before landing.

Illumination of the STBY GEN light indicates that standby generator power is not available for the essential and emergency buses. The STBY GEN light illuminates for standby generator system failure or for failure of the essential bus relay(s). No bus loses power if the STBY GEN light illuminates when the main generator is still on line. The standby generator may only be reset by depressing the ELEC CAUTION RESET button. Illumination of both STBY GEN and FLCS PMG lights indicates that standby generator and FLCS PMG power is not available. If the main generator is on line, no buses lose power and the EPU does not automatically activate.

CAUTION
Illumination of the MAIN GEN light after a 2-3 second loss of power to the HUD, MFD's, and other cockpit instruments indicates shorting failure of an OCSC or other wiring/equipment.

NOTE
• With standby generator failure and the MAL & IND LTS switch in DIM, the ELEC SYS caution light may not appear to illuminate when the MASTER CAUTION and STBY GEN lights illuminate. • TACAN is not powered when the main generator is off line.

If MAIN GEN light illuminated after a 2-3 second loss of the HUD and MFD's was observed:

1. Land as soon as practical.

When ready to land:

2. EPU switch - ON.

After verifying EPU run light is on and EPU PMG and EPU GEN lights are off.

3. MAIN PWR switch - BATT.
4. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.
5. If hydrazine depletes or EPU run light goes off at low thrust - Go to ABNORMAL EPU OPERATION, this section.

If MAIN GEN light illuminated and a 2-3 second loss of the HUD and MFD's was not observed, or if STBY GEN or STBY GEN and FLCS PMG lights illuminate:

1. ELEC CAUTION RESET button - Depress.

This action may reset the main or standby generator. Cycling the MAIN PWR switch may also reset the main generator; however, this action momentarily removes standby generator power and activates the EPU.

2. Land as soon as practical.

38.5.9.4 MAIN AND STANDBY GENERATOR FAILURE (IN FLIGHT)

Illumination of the MAIN GEN and STBY GEN lights indicates that power is lost from at least one nonessential ac bus and that the standby generator also failed. The EPU should start automatically at the time of the second failure as indicated by the EPU AIR and EPU run lights. Additional lights, such as HYDRAZN, AVIONICS FAULT, and ENGINE FAULT, may also illuminate. If both generators fail, power to all essential and nonessential buses (ac and dc) is lost. Refer to EMERGENCY POWER DISTRIBUTION, this section, for list of inoperative equipment. The EPU generator powers the emergency ac and dc buses and both battery buses. Depressing the ELEC CAUTION RESET button may reset the main and/or standby generator.

NOTE
The TACAN is not powered when the main generator is off line.

If MAIN GEN and STBY GEN lights illuminate:

1. EPU switch - ON (if EPU run light is off).
2. PW220 Throttle - Do not retard below MIL if supersonic.

CAUTION
DEEC stall protection may be lost. Do not retard throttle below MIL until subsonic.

3. ELEC CAUTION RESET button - Depress.

This action may reset the main and/or standby generator. The MAIN PWR switch may also be cycled to reset the main generator.

If MAIN GEN or STBY GEN light goes off:

4. EPU switch - OFF, then NORM.
5. ADI - Check for presence of OFF and/or AUX warning flags.

If warning flag(s) is in view, refer to TOTAL INS FAILURE LESS or EGI FAILURE, this section.

WARNING
If only AUX flag is in view, pitch and roll attitude information is likely to be erroneous due to INS autorestart in the attitude mode when other than straight and level, unaccelerated flight conditions existed.

6. Land as soon as practical.
7. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If MAIN GEN and STBY GEN lights remain on:

4. ADI - Check for presence of OFF and/or AUX warning flags.

If warning flag(s) is in view, refer to TOTAL INS FAILURE LESS or EGI FAILURE, this section.

WARNING
If only AUX flag is in view, pitch and roll attitude information is likely to be erroneous due to INS autorestart in the attitude mode when other than straight and level, unaccelerated flight conditions existed.

5. Land as soon as possible.
6. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.
7. If hydrazine depletes or EPU run light goes off at low thrust - Go to ABNORMAL EPU OPERATION, this section.

After landing and aircraft is stopped:

8. Chocks - Installed (or parking brake engaged).
9. EPU switch - OFF.

CAUTION
If chocks are not installed, be prepared to immediately engage the parking brake if it disengages when the EPU is shut off.

10. MAIN PWR switch - MAIN PWR (until chocks are installed).

38.5.9.5 MAIN, STANDBY, AND EPU GENERATOR FAILURE

A main, standby, and EPU generator failure is indicated by illumination of the MAIN GEN and STBY GEN lights without an EPU run light. Other indications include loss of all avionics, ADI OFF and AUX warning flags, uncontrollable cold airflow into the cockpit or reduced airflow to the cockpit if the water separator coalescer freezes up, and loss of OBOGS. The caution lights which illuminate for a failure of just the main and standby generators (e.g., AVIONICS FAULT, ENGINE FAULT) do not illuminate. Refer to EMERGENCY POWER DISTRIBUTION, this section, for a list of inoperative equipment. The primary concerns during multiple generator failures are maintaining power to the FLCS and maintaining/ regaining power to the emergency buses.

The EPU generator may be inoperative for several reasons, two of which may be remedied from the cockpit. If the EPU AIR light is off, the EPU may not have received an automatic start command; manually turning the EPU on may correct this failure. If the EPU GEN, EPU AIR, and HYDRAZN lights are illuminated but the EPU run light is off, the EPU may be underspeeding. If the EPU PMG underspeed could be caused by failure of hydrazine to power the EPU in conjunction with a low thrust setting and may be corrected by advancing the throttle. If the EPU generator operates, refer to MAIN AND STANDBY GENERATOR FAILURE (IN FLIGHT), this section.

If the EPU generator is still inoperative and the main and standby generators do not reset, power cannot be restored to the emergency buses. The aircraft battery supplies power to battery buses No. 1 and No. 2. As long as the ACFT BATT TO FLCS light remains off, the EPU PMG and/or FLCS PMG is supplying adequate FLCS power. The primary concern is aircraft battery life for communications, brakes, and hook. UHF communications are available on the frequency in use at power loss with UFC selected. BACKUP must be selected if a frequency change is desired.

If the FLCS PMG light illuminates when the MAIN GEN, STBY GEN, and EPU GEN lights are on, there are two possible sources of FLCS power (EPU PMG and aircraft battery). If the EPU PMG and ACFT BATT TO FLCS lights are off, the EPU PMG is supplying power to the FLCS whether the EPU run light is on or off.

If the ACFT BATT TO FLCS light is on, the aircraft battery is supplying power to the FLCS. The aircraft battery supplies power for FLCS operation for 3-14 minutes (depending on state of battery charge) after total generator failure. As the aircraft battery depletes, the flight controls either become unresponsive or uncommanded maneuvers occur.

WARNING
Imminent loss of electrical power to the FLCS is indicated by increasingly degraded flight control response and uncommanded motions. Total loss of FLCS power results in a pitching motion and complete loss of control. At high airspeeds, the pitching motion could be excessive and interfere with the ability to eject.

NOTE
If total loss of FLCS power occurs in the landing configuration and near final approach airspeed, the pitching motion is gradual and in the noseup direction for all configurations.

The ACFT BATT FAIL light indicates battery voltage less than 20 volts. Brake operation is doubtful during total generator failure with the ACFT BATT FAIL light on. As aircraft battery voltage continues to decrease, the capability to operate the brakes and lower the hook is lost. Lower the hook early since significantly higher battery voltage is required to lower the hook than is required to keep it fully extended. Once lowered, the hook remains full down well past the point at which the brakes are lost. An approach-end arrestment is recommended, if conditions permit, because it is difficult to ascertain brake operation. Relative intensity of the warning and caution lights is not a positive indication of battery voltage level.

If MAIN GEN, STBY GEN, and EPU GEN lights illuminate:

WARNING
With a main, standby, and EPU generator failure, OBOGS and the OXY LOW warning light are inoperative. Activate EOS if above 10,000 feet cockpit altitude.

NOTE
The TACAN is not powered when the main generator is off line.

1. AOA - 12 degrees maximum (200 knots minimum).

WARNING
LEF's are inoperative and departure susceptibility may be increased. Near 1g flight, 200 knots should keep AOA less than 12 degrees. Limit rolling maneuvers to a maximum bank angle change of 90 degrees and avoid rapid roll rates.

2. EPU switch - ON (if EPU run light is off).
3. PW220 Throttle - Do not retard below MIL if supersonic.

CAUTION
DEEC stall protection may be lost. Do not retard throttle below MIL until subsonic.

4. Climb if necessary.
5. Throttle - As required to extinguish the HYDRAZN light.

If EPU GEN light goes off:

6. Go to MAIN AND STANDBY GENERATOR FAILURE (IN FLIGHT), this section.

If EPU GEN light is still on:

7. ELEC CAUTION RESET button - Depress.

This action may reset the main and/or standby generator.

If both MAIN GEN and STBY GEN lights remain on:

8. MAIN PWR switch - BATT, then MAIN PWR.

   This action may reset the main generator.

If either MAIN GEN or STBY GEN light goes off:

9. EPU switch - OFF, then NORM.
10. Land as soon as possible.
11. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If MAIN GEN, STBY GEN, and EPU GEN lights all remain on or all come on again:

WARNING
• Plan to land within 30 minutes to insure adequate electrical power for communications, brakes, and hook. • If the FLCS PMG and EPU PMG lights are on in combination with the ACFT BATT TO FLCS light, the aircraft battery is powering the FLCS. With the aircraft battery powering the FLCS in addition to the battery buses, approximately 3-14 minutes flight time is available. • When the FLCS is powered by the aircraft battery, remain alert for degraded flight controls. At the first indication of degraded response, reduce airspeed and climb to safe ejection altitude. Eject prior to complete loss of control.

8. HOOK switch - DN.
9. C & I knob - BACKUP.
10. Minimize UHF, COM1 transmissions.

If conditions permit:

11. Land as soon as possible.

Fly airspeed for 11 degrees AOA approach using fuelstate when power was lost.

12. LG handle - DN. (Use DN LOCK REL button.)

WARNING
If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. PW220 / PW229 Nozzle remains closed, resulting in higher than normal landing thrust.

13. ALT GEAR handle - Pull (190 knots maximum).

• Alternate LG extension can be used up to 300 knots; however, the NLG may not fully extend until 190 knots. Time above 190 knots should be minimized in case there is a leak in the pneumatic lines.

• WHEELS down lights and TO/LDG CONFIG warning light function are inoperative. Monitor LG handle warning light to verify that LG is down.

CAUTION
• NWS is not available following alternate LG extension. • Do not depress the ALT GEAR reset button while pulling the ALT GEAR handle. This action may preclude successful LG extension. • Pulling the ALT GEAR handle with normal system B hydraulic pressure may result in system B hydraulic failure within 15 minutes.

14. Consider an approach-end arrestment, if conditions permit. Refer to CABLE ARRESTMENT, this section.
15. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

After landing:

16. Stop straight ahead and have chocks installed (or engage parking brake).
17. MAIN PWR switch - MAIN PWR (until chocks are installed).

38.5.9.6 EPU MALFUNCTIONS

38.5.9.6.1 UNCOMMANDED EPU OPERATION

Failures can occur which allow engine bleed air to spin the EPU turbine even though the EPU has not been commanded on. This may not be apparent if the thrust turning above or below the speed range which turns on the EPU run light. During uncommanded EPU operation on bleed air, EPU speed varies directly with throttle position. High thrust settings are likely to result in EPU failure.
The EPU may also activate for reasons not apparent to the pilot. Although this is not an EPU malfunction, it may be interpreted as uncommanded EPU operation. If uncommanded EPU operation occurs and AIR light is off (bleed air valve failure):

NOTE

The nonessential dc buses and the essential dc bus may lose power. If so, this results in loss of power to the 40/42 ASHM, fuel boost and transfer pumps, CARA, ECM, TWS, and FCR and power for normal weapon arming/re lease including selective jettison.

1. Throttle - Minimum practical thrust.
2. Stores - Jettison (if required).

Only if required to maintain low thrust.

3. Land as soon as possible.

If AIR light is on (and EPU is operating normally):

NOTE

• The nonessential dc buses and the essential dcbus lose power. This results in loss of power to the fuel boost and transfer pumps, 40/42 ASHM, CARA, ECM, TWS, and FCR and power for normal weapon arming/release including selective jettison.

• If the affected systems are required for the safe recovery of the aircraft, consider delaying/terminating EPU operation until the systems are no longer required.

1. EPU - Leave running.
2. Land as soon as possible.
3. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.9.6.2 ABNORMAL EPU OPERATION

Abnormal EPU operation after a normal start command is indicated by one or more of the following: EPU run light flashes, indicating EPU operation in tertiary speed control mode; EPU run light does not come on or goes off after initial illumination, indicating sustained underspeed or overspeed operation; EPU HYDRAZN light does no go off or EPU fuel quantity continues to deplete when the throttle is advanced to assure adequate bleed air, indicating an EPU bleed air or fuel control system problem.

When tertiary speed control is functioning, the EPU run light alternately cycles on and off (one to three times per second) as a function of EPU speed fluctuating between the normal and slightly above normal speed ranges. The MASTER CAUTION and the EPU HYDRAZN lights may illuminate. Hydrazine use occurs regardless of available engine bleed air. The hydrazine supply depletes in approximately 10 minutes. After hydrazine depletion, the EPU continues to operate with available bleed air on tertiary speed control.

If tertiary speed control cannot control EPU speed (constant overspeed), total EPU failure is imminent. Excessive voltage generated by the EPU generator or its PMG is regulated by the converter/regulators before going to the FLCC. Other electrical and avionic equipment may be damaged by the overvoltage condition. When EPU failure occurs, FLCS power is provided by the FLCS PMG, main generator, standby generator, or the aircraft battery (whichever has the higher voltage).
Under some failure conditions, hydrazine may not be available to the EPU or it may continue to deplete even with adequate bleed air. If a hydrazine malfunction or depletion occurs, landing must be accomplished using an engine thrust setting sufficient to maintain an adequate bleed air supply to the EPU. Failure to maintain minimum engine rpm can result in hydraulic pressure fluctuations or electrical bus cycling. Advance throttle as required to maintain adequate bleed air supply. (If the EPU is the sole source of hydraulic pressure, the throttle should be set so as to keep the EPU run light on during mild flight control inputs.) This action may result in a thrust level that is higher than required for a normal straight-in approach. Fully open speedbrakes or a shallower than normal approach may be required. A straight-in approach followed by an approach-end arrestment is recommended.

If EPU was turned on for an ACFT BATT FAIL or a FLCS RLY light:

1. EPU switch - OFF, then NORM.
2. Land as soon as possible.
3. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If EPU was activated for other reasons:

1. Throttle - As required (PW220 / PW229 75-80, GE100 / GE129 82-90 percent rpm).

Keep thrust high enough to assure adequate bleed air if EPU fuel usage continues above PW220 / PW229 80, GE100 / GE129 90 percent rpm or if EPU run light is flashing. If EPU fuel is depleted or if EPU run light goes off at low thrust, set throttle to keep EPU, run light on.

2. EPU FUEL quantity - Monitor.
3. Land as soon as possible.

Make an approach-end arrestment, if practical, if EPU fuel depletes before landing or if EPU run light goes off at low thrust settings. Refer to CABLE ARRESTMENT, this section.

WARNING
Before landing, confirm that the EPU operates (EPU run light is on) with the throttle in IDLE. If the EPU run light goes off, immediately advance the throttle and maintain a throttle setting which keeps EPU run light on until after touchdown.

CAUTION
If EPU underspeeds, electrical bus cycling may affect brake operation. For a missed engagement, attempt CHAN 1 then CHAN 2 brakes. If no braking is available, consider going around for another engagement or making a departure-end arrestment. The parking brake still operates.

4. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.9.7 FLCS RLY LIGHT

Illumination of the FLCS RLY light indicates that voltage on one or more of the four FLCC branches connected to the aircraft battery is inadequate (below 20V). Therefore, should main generator, standby generator, and FLCS PMG power be lost (engine shutdown, PTO shaft failure, ADG failure), power would not be available to one or more FLCS branches until the EPU is on line. The EPU must be turned on if the FLCS RLY light cannot be extinguished.

1. FLCS PWR TEST switch - TEST, momentarily.

If FLCS RLY light goes off:

2. Land as soon as practical.

If FLCS RLY light remains on:

2. EPU switch - ON.

NOTE

- The nonessential dc buses and the essential dc bus lose power. This results in loss of power to the fuel boost and transfer pumps, 40/42 ASHM, CARA, ECM, TWS, and FCR and power for normal weapon arming/release including selective jettison.

- If the affected systems are required for the safe recovery of the aircraft, consider delaying/terminating EPU operation until the systems are no longer required.

3. Land as soon as practical.
4. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If EPU runs abnormally:

3. EPU switch - OFF, then NORM.
4. Land as soon as possible.

38.5.9.8 PARTIAL ELECTRICAL POWER LOSS 40/42 RLY LIGHT

Loss of power to several systems or indicators without any indications on the ELEC control panel may be the result of wire harness chafing or the loss of power to one or more ac or dc buses. Refer to EMERGENCY POWER DISTRIBUTION, this section, to determine affected buses and equipment. If one item on a bus is powered, then that bus should be considered powered. Wire harness chafing can affect numerous items on more than one bus without causing loss of power to a bus.

The ELEC CAUTION RESET button on the ELEC control panel is used to reset a tripped overcurrent protection unit; however, the unit may not remain reset if the fault persists.
The buses with resettable overcurrent protection units are nonessential ac bus No. 1 and the nacelle nonessential ac bus.

The items with nonresettable overcurrent protection units are the radar ac bus; stations 3, 5, and 7; and left and right inlet stations.

1. ELEC CAUTION RESET button - Depress.

May reset overcurrent protection unit(s). If power is restored:

2. Land as soon as practical.

If power is not restored:

2. Determine the power status of electrical buses.

Refer to EMERGENCY POWER DISTRIBUTION, this section, to determine the power status of individual buses. If one item on a bus is powered, then that bus should be considered powered.

NOTE

Determining the status of the battery buses is critical for a safe recovery of the aircraft.

If one or both emergency ac buses are not powered:

3. EPU switch - ON.

NOTE

• The nonessential dc buses and the essential dc bus lose power. This results in loss of power to the fuel boost and transfer pumps, ASHM, CARA, ECM, TWS, and FCR and power for normal weapon arming/release including selective jettison.

• If the affected systems are required for the safe recovery of the aircraft, consider delaying/terminating EPU operation until the systems are no longer required. the status of the battery buses is critical for a safe recovery of the aircraft.

If the battery buses are not powered:

4. Consider a net arrestment, refer to NET ARRESTMENT, this section.

If net arrestment is not available:

5. Consider a gear up landing, refer to LANDING WITH LG UNSAFE/UP, this section.

If power to the battery buses is lost after the landing gear has been extended, the landing gear cannot be raised.

6. Refer to EMERGENCY POWER DISTRIBUTION, this section.
7. Land as soon as possible

If EPU was activated:

8. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.9.9 PARTIAL ELECTRICAL POWER LOSS 50/52 RLY LIGHT

Loss of power to several systems or indicators without any indications on the ELEC control panel may be the result of wire harness chafing or the loss of power to one or more ac or dc buses. Refer to EMERGENCY POWER DISTRIBUTION, this section, to determine affected buses and equipment. If one item on a bus is powered, then that bus should be considered powered. Wire harness chafing can affect numerous items on more than one bus without causing loss of power to a bus.

A failed overcurrent sensing contactor (OCSC) may be the cause of the partial power loss. If the OCSC failure involves electrical shorting, power from the main generator is degraded while the short is present. An obvious effect of this degraded power is loss of the HUD and MFD's. If the short quickly burns itself open, only the system(s) which receives power through the failed OCSC is lost. Power to the nonessential ac No. 1, emergency ac No. 1, emergency dc No. 1, and nonessential dc buses goes through one OCSC. Failure of this OCSC results in a loss of power to many items, including the FCR, CADC, stick trim, TACAN, VHF radio, DED, FUEL FLOW indicator, primary instrument and console lights, VVI, and AOA. The MMC enters a degraded mode that includes loss of the HUD. Failure effects for the other OCSC's are limited to individual store stations, the FCR, or the nacelle ac buses. If the short persists for 2-3 seconds, the main generator goes off line and power is removed from all eight overcurrent sensing contactors. The standby generator should automatically come on line to power the essential, emergency, and battery buses. Refer to SINGLE GENERATOR FAILURES (IN FLIGHT) 50/52 , this section, if the MAIN GEN light is on.

OCSC's can also fail open without electrical shorting. These failures do not result in degraded power from the main generator but do cause loss of power to the buses/ items protected by the OCSC.

The ELEC CAUTION RESET button can be used to rset a failed open OCSC; however, the OCSC may not remain reset if the fault persists.

The buses with a resettable overcurrent sensing contactor are nonessential ac bus No. 1 and the nacelle nonessential ac bus.

The items with a nonresettable overcurrent sensing contactor are the radar ac bus; stations 3, 5, and 7; and left and right inlet stations.

1. ELEC CAUTION RESET button - Depress.

The failed open OCSC may reset.

If power is restored:

2. Land as soon as practical.

If power is not restored:

2. Determine the power status of electrical buses.

Refer to EMERGENCY POWER DISTRIBUTION, this section, to determine the power status of individual buses. If one item on a bus is powered, then that bus should be considered powered.

NOTE
Determining the status of the battery buses is critical for a safe recovery of the aircraft.

If one or both emergency ac buses are not powered:

3. EPU switch - ON.

NOTE
• The nonessential dc buses and essential dc bus lose power. This results in loss of power to fuel boost and transfer pumps, 40/42 ASHM, CARA, ECM, TWS, and FCR and power for normal weapon arming/release including selective jettison. • If the affected systems are required for the safe recovery of the aircraft, consider delaying/terminating EPU operation until the systems are no longer required.

If the battery buses are not powered:

4. Consider a net arrestment, refer to NET ARRESTMENT, this section.

If net arrestment is not available:

5. Consider a gear up landing, refer to LANDING WITH LG UNSAFE/UP, this section.

If power to the battery buses is lost after the landing gear has been extended, the landing gear cannot be raised.

6. Refer to EMERGENCY POWER DISTRIBUTION, this section.
7. Land as soon as possible.

If EPU was activated:

8. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.9.10 ELECTRICAL POWER CYCLING

An electrical power overload at station 3, 5, or 7, or in the wiring to one of these stations, may cause cockpit displays and lights to cycle on and off approximately once every 3 seconds. This cycling may be the result of a wire harness chafing condition. A fire at the chafing location can occur and can adversely affect other wire harness/aircraft systems. Removing SMS power should stop the cycling. Depending on where and how long the overload occurred, the damage and system effects could range from minimal to significant.

If cycling occurs:

1. ST STA switch - OFF.
2. Monitor aircraft systems.
3. Land as soon as possible.

If possible, verify the status of aircraft systems required for landing in advance.

38.5.9.11 AIRCRAFT BATTERY FAILURE

Aircraft battery system failure is indicated by the ELEC SYS and ACFT BATT FAIL lights. The FLCS RLY light also illuminates if the failure involves low battery voltage. The ELEC SYS caution light may not be resettable. If the battery fails and both main and standby generators subsequently drop off line, power is not available to activate the EPU. If the battery fails and subsequent loss of main generator, standby generator, and FLCS PMG power occurs (e.g., engine shutdown, PTO shaft failure, ADG failure), power is not available to activate the EPU or control the aircraft. Thus, it is necessary to turn the EPU on after battery failure is indicated. The ACFT BATT FAIL light illuminates only for low battery voltage while in flight (approximately 20 volts). If a battery charger failure occurs in flight and is still present after landing, the ACFT BATT FAIL light illuminates 60 seconds after WOW.

The ACFT BATT FAIL light illuminates only for low battery voltage while in flight (approximately 20 volts). If a battery cell imbalance occurs in flight and is still present after landing, the ACFT BATT FAIL light illuminates 60 seconds after WOW.

CAUTION
If the aircraft battery has failed (and EPU is off), do not taxi except to clear runway. Subsequent loss of the main generator results in loss of all braking, NWS, hook, and radios.

1. EPU switch - ON.

NOTE

• The nonessential dc buses and the essential dc bus lose power. This results in loss of power to the fuel boost and transfer pumps, 40/42 ASHM, CARA, ECM, TWS, and FCR and power for normal weapon arming/release including selective jettison.

• If the affected systems are required for the safe recovery of the aircraft, consider delaying/terminating EPU operation until the systems are no longer required.

• If both radios become inoperative after an aircraft battery failure indication, refer to PARTIAL ELECTRICAL POWER LOSS, this section.

• The ACFT BATT FAIL light may subsequently extinguish. This should not be interpreted to mean that the battery has recharged. It may indicate that the battery voltage is so low that the light cannot remain illuminated.

2. Land as soon as practical.
3. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If EPU runs abnormally:

4. EPU switch - OFF, then NORM.
5. Land as soon as possible.
6. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

Prior to shutdown:

7. Loose items - Secure.
8. Canopy - Open.

38.5.9.12 EMERGENCY POWER DISTRIBUTION

Emergency Power Distribution

MAIN GENERATOR FAILED

SYSTEM	**INOPERATIVEEQUIPMENT**	**BUS ASSIGNMENT**			
		NONESS AC		**NACELLE NONESS DC**	
		NO. 1	**NO. 2**	**NO. 1**	**NO. 2**
ENGINE	**PW 220** MAX POWER Sw				X
	PW 229 GIT (LG handle down)	X(FCC)			
	GE 100 / **GE 129** EMSC				X
NAV/COMM	MIDS LVT (including TACAN)	X		*	
FUEL	Pumps l, 2, 4 & 5		X	*	
	GE 100 / **GE 129** FUEL/OIL HOT Caution Light (oil hot signal)				X
STORES MGT	AIM–9/–120	* * *			
	Stations 3, 5, & 7 – ECM, EO, Radar - Guided Weapons	* *			
	Stations 4 & 6 – EO, Radar - Guided Weapons		X		
AVIONICS	DTU		X		
	FCR	Radar		*	
	GPS	X			
	Right Inlet Station				X
	HMCS	X			
	TWS	X		X	
LIGHTS	Flood Console		X		
	Flood Instrument		X		
	Formation		X		
	Taxi		X		
OTHER	ECM Control			*	
	Halon Heater		X		
	Inlet Strut heater		X		
	INS Heater	X			
	Nacelle Ejector Shutoff				X
	Seat Adjustment	X			
	Total Tamp Probe Heater	X			

NOTE: Equipment On nonessential ac bus NO. 1 or nonessential ac bus NO. 2 may be functional with the MAIN GEN light On (bus contactor failure).

* Aft equipment bay nonessential dc bus.
** **Block 40/42** Overcurrent protection panel No. 1.
** **Block 50/52** Overcurrent sensing contactors.
*** Nacelle nonessential ac bus.
**** Not implemented in BMS.

Emergency Power Distribution

MAIN GENERATOR FAILED

SYSTEM	INOPERATIVE EQUIPMENT	BUS ASSIGNMENT	
		ESS AC	ESS DC
FUEL	Pump 3 & 5	X	X
	Tank Inerting		X
NAV/COM	Secure Voice		X
STORES MGT	AIM–9	*	
	Arm and Release Power- Station's 1 Thru 9		X
AVIONICS	**40/42** ASHM		X
	MFD's	X	
	Left Inlet Station	**	
	PFLD	*	
	Radar Altimeter		X
OTHER	Air Data Probe Heater (fuselage)	*	
	Battery Charger	X	

NOTE: Equipment on this sheet may operate if MAIN GEN light was caused by bus-contactor failure at nonessential bus No. 1.

*Nacelle essential ac bus.
**Overcurrent protection panel No. 2.

Emergency Power Distribution

MAIN, STANDBY, AND EPU GENERATORS FAILED

SYSTEM	INOPERATIVE EQUIPMENT	BUS ASSIGNMENT			
		EMER AC		EMER DC	
		NO. 1	NO. 2	NO. 1	NO. 2
ENGINE	Engine ANTI ICE Sw				X
	ENGINE FAULT Caution Light				X
	Engine Ice Detector		X		
	Fire/Overheat Detect and Test		X		
	HYD PRESS Indicators		X		
	GE100 / GE129 Low Energy Ignition Power	X			
	NOZ POS Indicator		X		
	OIL Pressure Indicator		X		
FLIGHT INSTRUMENT	ADI		X		
	Altimeter (ELECT)	X			
	AOA Indexer			X	
	AOA Indicator	X			
	HIS		X		
	Turn Needle			X	
	INSTR MODE Sel Sw			X	
	VVI	X			
FUEL	Automatic Forward Fuel Transfer				X
	FUEL FLOW Indicator	X			
	FUEL LOW Caution Lights			X	
	FUEL Quantity Indicator		X		
FLT CONT	Autopilot				X
	DBU ON Warning light (branches A & B)			X	
	DBU ON Warning Light (branches C & D)				X
	C DF FLCS FAULT Caution Light (branches A & B)			X	
	DR FLCS FAULT Caution Light (branches C & D)				X
	FLCS RESET Switch (branches A & B)			X	
	FLCS RESET Switch (branches C & D)				X
	FLCS Power Source (branches A & B)			X	
	FLCS Power Source (branches C & D)				X
	FLCS Warning Light (branches A & B)			X	

Emergency Power Distribution

MAIN, STANDBY, AND EPU GENERATORS FAILED — CONT

SYSTEM	INOPERATIVE EQUIPMENT	BUS ASSIGNMENT			
		EMER AC		EMER DC	
		NO. 1	NO. 2	NO. 1	NO. 2
FLT CONT (cont)	FLCS Warning Light (branches C & D)				X
	LEF's	X			
	Speedbrakes			X	
	Stick Trim			X	
NAV/COMM	IFF		X	X	
	ILS				X
	INS	X		X	
	TACAN		X	X	
	VHF			X	
STORES MANAGEMENT	C ALT REL Button			X	
	Chaff/Flare Dispensers				X
	EMER JETT Button*			X	X
	Gun		X		X
	MASTER ARM Switch			X	
	MSL STEP Switch			X	
	NUCLEAR CONSENT Switch				X
	STORES CONFIG Caution Light				X
	C DF WPN REL Button				X
	DR WPN REL Button			X	
AVIONICS	CADC	X			
	CADC Caution Light			X	
	ICP/IKP				X
	MFD Video Control				X
	MMC/CTVS		X		
	MMC*			X	X
	Upfront Controls		X		X
LIGHTS	ANTICOLLISION Strobe		X		
	AR (flood)		X		
	AR (slipway)				X
	Landing		X		
	LANDING/TAXI/External Sw				X
	MAL & IND LTS TEST/BRT DIM			X	
	POSITION		X		
	PRIMARY CONSOLES	X			
	PRIMARY INST PNL	X			

*Indicates redundancy.

Emergency Power Distribution

MAIN, STANDBY, AND EPU GENERATORS FAILED -CONT

SYSTEM	INOPERATIVE EQUIPMENT	BUS ASSIGNMENT			
		EMER AC		EMER DC	
		NO. 1	NO. 2	NO. 1	NO. 2
LG/NWS/BRAKES	LG Hydraulic Isolation				X
	LG Sequence (doors)				X
	LG UP–DN Command				X
	NWS			X	
	WHEELS DOWN Lights			X	
OTHER	Air Data Probe Heater (nose)	X			
	AOA Probe Heaters	X			
	AR System			X	
	AVTR/CTVS				X
	CABIN PRESS Caution Light				X
	CAMERA/GUN Trigger				X
	Cockpit Pressure Dump Capability				X
	Cockpit Temperature Control			X	
	Engine Bleed Air Valves (close capability)				X
	EQUIP HOT Caution Light				X
	INLET ICING Caution Light				X
	C DF LIQUID OXYGEN Quantity Indicator				
	OXYGEN Quantity Indicator				
	OXY LOW Caution Light				X
	OXY LOW Warning Light				X
	OBOGS Caution Light				X
	OBOGS Concentrator		X		
	OBOGS Monitor			X	
	Probe Heat Monitor			X	
	PROBE HEAT Switch			X	
	SEAT NOT ARMED Caution Light				X

*Indicates redundancy.

Emergency Power Distribution

OPERATING EQUIPMENT — MAIN, STANDBY, AND EPU GENERATORS FAILED

SYSTEM	OPERATING EQUIPMENT	BUS ASSIGNMENT BATTERY NO. 1	BUS ASSIGNMENT BATTERY NO. 2
ENGINE	GE100 / GE129 Electrical Throttle Position		X
	PRI (no supersonic stall protection)*		
	PRI/SEC Transfer Circuit*		
INSTRU-MENTS	Airspeed/Mach Indicator*		
	Altimeter (PNEU)*		
	FTIT Indicator	X	
	RPM Indicator	X	
	SAI		X
FUEL	External Fuel Transfer*		
	FUEL MASTER Switch		X
	FFP*		
FLIGHT CONTROLS	Functional (except LEF's, speedbrakes, autopilot, and stick trim)*		
NAV/COMM	Intercom	X	
	Magnetic Compass*		
	UHF Radio	X	
LIGHTS	Spotlights	X	
	Utility Light	X	
LG/NWS/ BRAKES	Alternate LG Extension*		
	Antiskid/Channel 1 Brakes	X	
	Antiskid/Channel 2 Brakes		X
	LG Uplock/Downlock	X	
	MLG WOW (branches A & B)	X	
	MLG WOW (branches C & D)		X
	NLG WOW (branches A & B)	X	
	NLG WOW (branches C & D)		X
	Parking Brake		X
YARNING LIGHTS	CANOPY	X	
	ENGINE	X	
	HYD/OIL PRESS	X	
	LG Yarning (handle)		X

*Indicates items that do not require power through the battery buses.

Emergency Power Distribution

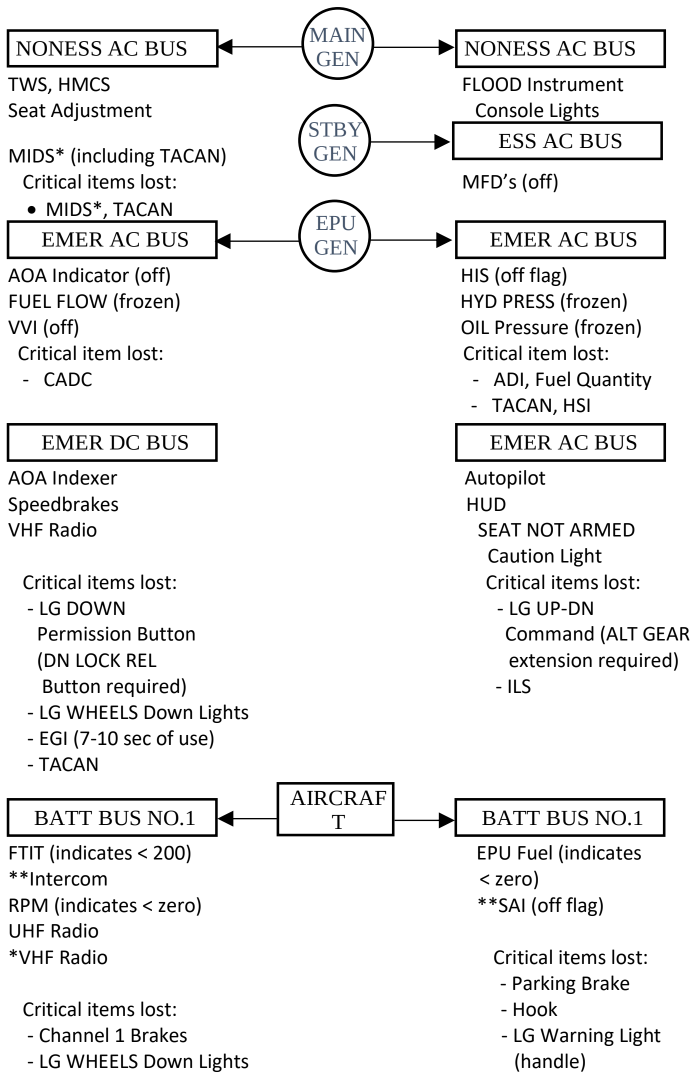
OPERATING EQUIPMENT — MAIN, STANDBY, AND EPU GENERATORS FAILED – CONT

SYSTEM	OPERATING EQUIPMENT	BUS ASSIGNMENT BATTERY NO. 1	BUS ASSIGNMENT BATTERY NO. 2
CAUTION LIGHTS	ANTI SKID		X
	ELEC SYS		X
	HOOK		X
	MASTER CAUTION	X	
	SEC		X
OTHER	Canopy Activation*		
	EPU	X	X
	Hook		X
	JFS	X	
	MAIN PWR Switch		X
	VMS	X	

* Indicates items that do not require power through the battery buses.

Emergency Power Distribution

PARTIAL ELECTRICAL POWER LOSS



*VHF radio is also inoperative
because the intercom is not powered.
** (Not implemented in BMS).

38.5.10 ENGINE MALFUNCTIONS PW220 / PW229

The LESS EDU, DEEC compares expected versus actual engine operation. The purpose of the LESS EDU, DEEC MFL is to provide maintenance personnel with an early indication of an engine condition which requires correction. No action is required for an engine MFL at anytime during a flight.

Low altitude, for engine malfunction purposes, is generally defined as 10,000 feet AGL or below. If an engine malfunction is suspected, the initial reaction should be to trade excess airspeed for altitude. Unless a suitable airfield is within gliding distance, turns should be avoided as they decrease the amount of time/altitude available to successfully recover engine performance or prepare for ejection. Optimizing the exchange of airspeed for altitude must be a priority action for any engine malfunction. Above 350 knots, more time is available by performing a zoom climb using a 3g pullup to 30-degree climb until approaching the desired airspeed (use approximately 50 knots lead point) and then initiating a zero-g pushover. Below 350 knots and above the minimum recommended ejection altitude, more time is available by performing a constant altitude deceleration to the desired airspeed. If below the minimum recommended ejection altitude and below 350 knots, primary concern should be to trade excess airspeed for altitude in preparation for ejection. If appropriate, jettison stores as soon as possible.

For any situation where automatic activation of the EPU is relied upon, verify that the EPU run light is on to insure that the EPU has started. If the EPU run light is off, position the EPU switch to ON.

Idle thrust in SEC during ground operation is approximately twice that in PRI. After landing in SEC, consider minimizing taxi distance and consider following HOT BRAKES procedures, this section.

38.5.10.1 ENGINE FIRE PW220 / PW229

Generally, the first indication of fire in the engine compartment is the ENG FIRE warning light. Abnormal fuel indications (quantity/flow) may also be present. FTIT probably will not be higher than normal. Explosions, vibrations, or engine instrument fluctuations are usually indicative of a serious engine problem; engine failure may be imminent. Immediate action should be taken to reduce thrust to the minimum practical level after attaining safe ejection parameters. If within gliding distance of a suitable runway, consider shutting the engine down. Sufficient time should exist to analyze the situation and make an ejection versus land decision. The ejection decision should be based on visual and/or cockpit indications that the fire is persisting. Cockpit indications include continued illumination of the ENG FIRE warning light and subsequent illumination of FLCS status lights/degraded flight controls or subsequent loss of either hydraulic system.

An in-flight fire may cause the degradation or failure of multiple systems. If time and conditions permit, attempt to determine the status of individual flight controls, speedbrakes, FLCS branches, and available thrust.

Fires can also occur in the exhaust nozzle area when using AB. These fires are the result of portions of the nozzle failing which allows the AB plume to burn through the nozzle. Ventilation should inhibit forward movement of the fire into and through the engine bay. Since these fires are aft of the detection circuit, the ENG FIRE warning light will not illuminate. Additionally, the nozzle position indications are normal, and there are no vibrations or instrument fluctuations. In most cases, these AB-related nozzle fires are detected by someone outside the aircraft (wingman, tower, etc.). When operating in AB and a fire is reported at the rear of the aircraft, retard throttle below AB immediately. This action should extinguish a nozzle fire within approximately 30-45 seconds and minimize damage to the aircraft skin, speedbrakes, nozzle, and flight controls; however, nozzle damage may result in a noticeable thrust loss.

A failure that causes an oil leak may also result in an oilfed fire in the AB section. The fire may continue for several minutes after the engine fails or is shut down (until the oil supply is exhausted). Since this fire is likely to be contained within the engine, the ENG FIRE warning light does not illuminate.

If on takeoff and the conditions permit:

1. Abort.

If takeoff is continued:

1. Climb.

Maintain takeoff thrust until minimum recommended ejection altitude is attained and then throttle to minimum practical.

2. Stores - Jettison (if required).

At a safe altitude:

3. Throttle - Minimum practical.

If fire occurred in AB, ENG FIRE warning light may not illuminate. Fire should extinguish after throttle is retarded; however, nozzle damage may result in lower than normal thrust.

If within gliding distance of a suitable runway, consider shutting the engine down.

If ENG FIRE warning light goes off:

4. FIRE & OHEAT DETECT button - Depress.

Determine if fire and overheat detection circuits are functional.

If fire persists:

5. Eject.

If fire indications cease:

5. Land as soon as possible.

WARNING
An in-flight fire may cause the degradation or failure of multiple systems. If time and conditions permit, attempt to determine the status of individual flight controls, speedbrakes, FLCS branches, and available thrust.

38.5.10.2 OVERHEAT CAUTION LIGHT PW220 / PW229

Detection of an overheat condition in the engine compartment, ECS bay, MLG wheel wells, or EPU bays illuminates the OVERHEAT caution light.

Accomplish as many of the following as required to extinguish the caution light. If the light goes off, verify the integrity of the detection circuit by depressing the FIRE & OHEAT DETECT button and land as soon as possible.

1. Throttle - Minimum practical.
2. FIRE & OHEAT DETECT button - Depress.

Determine if fire and overheat detection circuits are functional.

If OVERHEAT caution light goes off and detect circuit checks good:

3. Land as soon as possible.

If OVERHEAT caution light remains on (or detect circuit checks bad) and EPU is running:

3. EPU switch - OFF (if feasible).

If the EPU was manually turned on, consider turning it off to determine if it is the source of the overheat condition. If the OVERHEAT caution light remains on, the EPU should be turned back on.

If OVERHEAT caution light remains on (or detect circuit checks bad):

4. OXYGEN - 100%.
5. AIR SOURCE knob - OFF.

External fuel cannot be transferred in OFF or RAM. Consider jettisoning tank(s) to decrease drag if range is critical and the ECS cannot be turned on for short periods of time to transfer fuel.

WARNING
With the ECS shut down or the AIR SOURCE knob in OFF or RAM, the g-suit does not inflate and PBG is disabled.

6. Descend to below 25,000 feet (18,000 feet if conditions permit) and reduce airspeed to below 500 knots.

When airspeed is reduced and cockpit is depressurized:

7. AIR SOURCE knob - RAM (below 25,000 feet).

External fuel cannot be transferred in OFF or RAM. Consider jettisoning tank(s) to decrease drag if range is critical and the ECS cannot be turned on for short periods of time to transfer fuel.

WARNING
With the ECS shut down or the AIR SOURCE knob in OFF or RAM, the g-suit does not inflate and PBG is disabled..

8. Nonessential electrical equipment - Off.

NOTE
If in VMC and the ADI and HSI are not required for flight, the INS should be considered nonessential.

If OVERHEAT caution light still remains on (or detect circuit checks bad):

9. TANK INERTING switch - TANK INERTING even if Halon is not available.
10. LG handle - DN (300 knots/0.65 mach maximum). (Use DN LOCK REL button if required.)

WARNING
If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. Nozzle remains closed, resulting in higher than normal landing thrust.

11. Land as soon as possible.

38.5.10.3 ENGINE VIBRATIONS PW220 / PW229

Some engines exhibit low frequency vibrations which are non-damaging to both the airframe and engine. The vibrations should disappear if engine rpm is either increased or decreased. Vibrations that change in intensity with throttle movement and are present across the throttle/rpm range may indicate a potential engine malfunction.

If vibrations persist:

1. Throttle - Minimum practical.
2. Land as soon as possible.

38.5.10.4 OIL SYSTEM MALFUNCTION PW220 / PW229

An oil system malfunction is characterized by a pressure (including fluctuations) below 15 psi at IDLE or 30 psi at MIL, a pressure above 80 psi at any thrust setting, pressure fluctuations greater than ±5 psi at IDLE or ±10 psi above IDLE, or by a lack of oil pressure rise when the throttle is advanced. The OIL pressure indicator can be used as an early indication of oil loss. An indication of excessive oil loss is the lack of oil pressure rise when the throttle is advanced in the IDLE to MIL range. These conditions may not occur until approximately one-half the usable oil is lost. The HYD/OIL PRESS warning light may not illuminate until most of the usable oil is lost. At the first indication of an oil system malfunction, take immediate action to land as soon as possible.

Climbing to a higher altitude allows higher cruise airspeed and increases glide range. However, if the oil malfunction is caused by an internal engine oil leak, the rate of oil loss is decreased at low altitude and low throttle settings. Usually it is advisable to climb to a reasonable cruise altitude. Once at altitude, retard throttle to approximately 80 percent rpm and do not move the throttle unless absolutely required. With zero oil pressure, any throttle movement may cause the engine to seize. Minimize maneuvering g to minimize loads. Plan an approach which allows a flameout landing from any position should engine seize. Refer to SIMULATED FLAMEOUT (SFO) LANDING and FLAMEOUT LANDING, this section.

The EPU should be manually activated; otherwise, if the EPU does not start automatically when the engine seizes, the short time remaining before loss of control may be inadequate for recognition of the EPU failure and corrective action. Monitor hydrazine use after activating the EPU. If consumption rate is too high, cycle EPU switch to OFF, and then NORM to conserve hydrazine. Be prepared to place the EPU switch back to ON if the engine seizes.

If an oil pressure malfunction is suspected:

1. Attain desired cruise altitude.

The rate of oil loss is decreased at low altitudes and low throttle settings.

2. Stores - Jettison (if required).
3. Throttle - Approximately 80 percent rpm.
4. EPU switch - ON.

Monitor hydrazine use. If consumption rate is too high, cycle EPU switch to OFF, and then NORM to conserve hydrazine. Be prepared to place EPU switch back to ON if the engine seizes.

5. Throttle - Do not move until landing is assured.

CAUTION
Throttle movement/rpm change may cause engine seizure.

6. Land as soon as possible.

Plan to fly an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING and FLAMEOUT LANDING, this section.

7. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.10.5 ENGINE FAULT CAUTION LIGHT PW220 / PW229

Illumination of the ENGINE FAULT caution light indicates that an engine PFL item was detected. If ENGINE FAULT caution light illuminates:

1. PFLD - Note PFL(s) displayed.

NOTE
If ENG BUS FAIL PFL is displayed or has been displayed, MUX communication with the engine is no longer possible. Subsequently, if an engine PFL occurs, the ENGINE FAULT caution light illuminates but cannot be reset and that PFL cannot be displayed on the PFLD.

2. C DF F-ACK, DR FAULT ACK button – Depress to acknowledge fault.

If ENGINE FAULT caution light does not reset when the fault is acknowledged:

3. Throttle - Midrange.
4. Land as soon as practical.

If ENGINE FAULT caution light resets when the fault is acknowledged:

3. Refer to PILOT FAULT LIST - ENGINE, this section.
4. AB RESET switch - AB RESET, then NORM.

This action resets the DEEC and may clear the failure condition.

5. C DF F-ACK, DR FAULT ACK button – Depress to perform fault recall.

The failure condition no longer exists if the PFL is not present during the fault recall.

38.5.10.6 SEC CAUTION LIGHT PW220 / PW229

Illumination of the SEC caution light indicates that the engine is operating in SEC. If the ENG CONT switch is in C DF PRI, DR NORM and the SEC caution light is on, an automatic transfer to SEC has occurred. The transfer may be due to a DEEC malfunction, the DEEC sensing the loss of a critical input signal to the DEEC, or loss of power to the DEEC (engine alternator failure).

Automatic transfers to SEC after an engine alternator failure may also cause engine stalls. The combination of stalls and an erroneously low rpm indication may be incorrectly interpreted as a stagnation. Confirm that a stagnation actually exists before shutting down the engine.

If the SEC caution light illuminates above 40,000 feet MSL, minimize throttle movement until below 40,000 feet MSL. If the SEC caution light illuminates below 15,000 feet MSL and engine rpm is below 70 percent, slowly advance the throttle to achieve a minimum of 70 percent rpm.

If the SEC caution light illuminates while supersonic, do not retard throttle below MIL until subsonic. During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle because the nozzle is closed.

NOTE
The ENG CONT switch should not be returned to C DF PRI, DR NORM after landing in an attempt to open the nozzle and decrease thrust.

If SEC caution light illuminates while supersonic:

1. Throttle - Do not retard below MIL until subsonic.

CAUTION
Retarding the throttle below MIL while supersonic may induce inlet buzz which produces severe cockpit vibration and probable engine stalls.

When subsonic or if SEC caution light illuminates while subsonic:

2. Throttle - Verify engine responds normally to throttle movement; set as required.

AB operation is inhibited. Above 40,000 feet MSL, minimize throttle movement. Below 15,000 feet MSL, if rpm is below 70 percent, slowly advance throttle to achieve a minimum of 70 percent rpm.

WARNING
If the rpm indication is also zero or erroneously low, the engine alternator may have failed. If the engine is shut down, an airstart may not be possible.

3. ENG CONT switch - SEC.
4. Land as soon as practical.

During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle. Minimize taxi distance after landing to prevent overheating the brakes due to increased thrust.

CAUTION
An SFO is not recommended if engine is operating satisfactorily in SEC.

If engine is operating abnormally in SEC:

5. Refer to ABNORMAL OR NO ENGINE RESPONSE PW220 PW229 , this section.

38.5.10.7 FTIT INDICATOR FAILURE PW220 / PW229

Certain failures can cause erroneous FTIT indications above 1000°C and illumination of the ENGINE warning light. If all other engine indications are normal and the engine responds normally to throttle movement, the engine should not be shut down. Routine missions should not be continued since FTIT cannot be monitored.

38.5.10.8 ZERO RPM/ERRONEOUS RPM INDICATION PW220 / PW229

If the RPM indicator displays a zero or erroneous indication while other engine instruments indicate normal operation, the cause is loss of power to the indicator or indicator failure. Loss of power to the indicator causes the ENGINE warning light to illuminate. RPM indicator failure may not cause ENGINE warning light illumination.

WARNING
Assume engine alternator is inoperative or malfunctioning. If the engine is shut down, an airstart may not be possible.

If the RPM indicator displays a zero or erroneously low indication accompanied by an automatic transfer to SEC (SEC caution light illuminated), the engine alternator may have failed. Since rpm cannot be monitored, routine missions should not be continued.

If SEC caution light is illuminated:

1. Go to SEC CAUTION LIGHT PW220 PW229, this section.

If SEC caution light is not illuminated:

1. Land as soon as practical.

38.5.10.9 ABNORMAL OR NO ENGINE RESPONSE PW220 / PW229

Refer to LOW THRUST ON TAKEOFF OR AT LOW ALTITUDE (NON-AB) PW220 , this section, if appropriate.
Abnormal engine response is varied and generally indicated by abnormal thrust in relation to throttle position, engine oscillations (either continuous, momentary, or recurring), a complete lack of engine response to throttle movement, autoacceleration/deceleration, exhaust nozzle failure, or insufficient thrust. The DEEC detects and automatically attempts to take corrective action for engine malfunctions. This action may result in partially or totally inhibited AB operation or in engine control being transferred to SEC. The action taken by the DEEC may be indicated by illumination of either or both the ENGINE FAULT and SEC caution lights.

If thrust is too low to sustain level flight, turn immediately toward the nearest suitable runway and establish 250 knots airspeed. Consider jettisoning stores to increase flying time available to complete actions designed to restore usable thrust and improve range in the event those actions are unsuccessful.

NOTE

In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

A throttle linkage problem should be suspected if throttle movements in both PRI and SEC produce either no rpm change or an rpm increase but no rpm decrease. In either case, the OFF position does not shut down the engine.

The engine may roll back, which prevents the engine from reaching normal rpm and FTIT levels when the throttle is advanced. This rollback is generally caused by the DEEC sensing an out-of-limits condition and may not be accompanied by a SEC caution light. For this situation or any abnormal engine response below AB, follow the procedures of this section until the situation is corrected.

If thrust is too high to permit a safe landing, use excess thrust to climb and maneuver toward the nearest suitable airfield. Once high key for a flameout landing is assured, follow procedures as outlined in FLAMEOUT LANDING, this section. Activate the JFS and EPU and then shut down the engine as soon as landing is assured (normally high key) by placing the throttle to OFF or, if necessary, by placing the FUEL MASTER switch to OFF.

If the decision is made to manually select SEC while subsonic below 40,000 feet MSL, set the throttle to midrange or above before positioning the ENG CONT switch to SEC. If autotransfer to SEC occurs below 15,000 feet MSL and rpm is below 70 percent, slowly advance the throttle to achieve a minimum of 70 percent rpm. During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle because the nozzle is closed.

WARNING
• Failure to monitor sink rate and height above terrain while applying low thrust recovery procedures can result in ejection outside ejection seat performance envelope. • Jettison stores when necessary to increase flying time available to accomplish actions designed to restore thrust.

NOTE
• Transfer to SEC removes stall recovery logic. If SEC is selected while the engine is stalling, a stagnation may occur. • The ENG CONT switch should not be returned to C DF PRI, DR NORM after landing in an attempt to open the nozzle and decrease thrust.

If in AB or supersonic:

1. Throttle - MIL.

CAUTION
Retarding the throttle below MIL while supersonic may induce inlet buzz which produces severe cockpit vibration and probable engine stalls.

If thrust is low and nozzle is suspected to be failed open, damaged, or missing:

2. Refer to NOZZLE FAILURE PW220 PW229, this section.

If problem still exists:

3. AB RESET switch - AB RESET, then NORM.
4. Airspeed - 250 knots (if thrust is too low to sustain level flight).

If problem still exists:

5. Throttle - IDLE.
6. ANTI ICE switch - OFF.

Stalls may be caused by the anti-ice valve failing to close at high throttle settings (above midrange).

7. Throttle - Slowly advance to minimum practical.

Attempts to establish a minimum practical throttle setting that provides sufficient thrust may result in repeated stalls that clear when the throttle is retarded. Note stalled RPM/throttle position and attempt to establish a lower throttle setting that provides sufficient thrust.

If current thrust will allow a safe landing:

8. Land as soon as possible.

NOTE
Consider an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING, this section.

If suitable thrust cannot be attained or thrust is too high to permit a safe landing:

8. Throttle - Midrange.
9. ENG CONT switch - SEC.

Transfer to SEC while supersonic should be accomplished with the throttle at MIL. Subsonic transfers to SEC below 40,000 feet MSL should be accomplished with the throttle at midrange or above.

CAUTION
Below 15,000 feet MSL, maintain 70 percent rpm minimum until landing is assured.

10. Throttle - Minimum practical.

If current SEC thrust will allow a safe landing:

11. Land as soon as practical.

During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle. Minimize taxi distance after landing to prevent overheating the brakes due to increased thrust.

CAUTION
An SFO is not recommended if engine is operating satisfactorily in SEC.

When landing is assured:

12. Throttle - Verify engine responds normally to throttle movement; set as required.

If suitable thrust cannot be attained:

11. ENG CONT switch - C DF PRI, DR NORM.
12. Throttle - AB (if required to sustain level flight).
13. Land as soon as possible.

If thrust is too high to permit a safe landing:

11. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section.

When prepared to land (normally high key):

WARNING
Delaying engine shutdown can result in a long, fast landing. Wheel braking is less effective due to lack of WOW and there is an increased probability of a missed cable engagement.

12. Throttle - OFF.

If engine does not respond, shut down the engine with the FUEL MASTER switch. At MIL, the engine flames out in approximately 6 seconds; at IDLE, the engine flames out in approximately 45 seconds.

13. HOOK switch - DN (if required).

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

38.5.10.10 STUCK THROTTLE PW220 / PW229

A stuck throttle can be the result of a failure within the throttle cable/sleeve mechanism, throttle grip foot interference with the throttle track, or an object obstructing the path of the throttle or throttle linkage.
If thrust is too low to sustain level flight, turn immediately toward the nearest suitable runway and establish 250 knots which approximates the airspeed at which thrust required for level flight is the lowest. Consider jettisoning stores to increase flying time available to complete actions designed to restore usable thrust and improve range in the event those actions are unsuccessful.

NOTE

In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

If throttle is stuck in AB, placing the ENG CONT switch to SEC terminates AB and provides SEC MIL thrust. Selecting SEC also reduces fuel flow and maximizes remaining flight time. Consider delaying selection of SEC with the throttle stuck in AB until sufficient altitude is gained to perform a flameout landing in case an engine stall and flameout occur on transfer to SEC. Extended AB use may result in unrecoverable trapped external fuel. Monitor internal fuel quantities to preclude unexpected engine flameout due to fuel starvation.
If the throttle is stuck and thrust is suitable for sustained flight, attempts to free the throttle should be delayed until within gliding distance of a suitable landing field.
If the throttle is stuck at MIL or below, there is no significant thrust reduction by transferring engine control to SEC; remain in PRI.
If an object is blocking the throttle or throttle linkage, applying positive and negative g and sideslip maneuvers in both right and left directions may dislodge the obstruction.

If the throttle remains stuck and thrust is too high to permit a safe landing, a flameout landing is required. Follow procedures as outlined in FLAMEOUT LANDING, this section. Activate the JFS and EPU, and then shut down the engine when within gliding distance of a suitable landing field by placing the FUEL MASTER switch to OFF. At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds. The engine will likely experience a stall and brief overtemperature after the FUEL MASTER switch is placed to OFF.

If throttle is stuck in AB:

1. ENG CONT switch - SEC.

Consider delaying selection of SEC with the throttle stuck in AB until sufficient altitude is gained to perform a flameout landing in case an engine stall and flameout occur on transfer to SEC.

After engine is operating in SEC or if throttle is stuck below AB:

WARNING
• If the throttle is stuck and thrust is suitable for sustained flight, attempts to free the throttle should be delayed until within gliding distance of a suitable landing field. • Extended AB use may result in unrecoverable trapped external fuel. Monitor internal fuel quantities to preclude unexpected engine flameout due to fuel starvation.

2. Stores - Jettison (if required).

3. Throttle - Depress cutoff release, rotate throttle grip outboard and apply necessary force.

If throttle is still stuck:

4. Perform positive and negative g and sideslip maneuvers and attempt to move throttle.

If throttle is still stuck and thrust is too high to permit a safe landing:

5. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section, prior to placing FUEL MASTER switch off.

When prepared to land:

6. EPU switch - ON.
7. JFS switch - START 2.

When at high key or within gliding distance of a suitablelanding field:

WARNING
Delaying engine shutdown can result in a long, fast landing. Wheel braking is less effective due to lack of WOW and there is an increased probability of a missed cable engagement.

8. FUEL MASTER switch - OFF.

At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds. The engine will likely experience a stall and brief overtemperature after the FUEL MASTER switch is placed to OFF.

9. HOOK switch - DN (if required).

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

38.5.10.11 NOZZLE FAILURE PW220 / PW229

Exhaust nozzle malfunctions and nozzle control system malfunctions can result in the nozzle being too far open or too far closed. These malfunctions can result in loss of AB capability, engine stalls, or low thrust. Separation of the nozzle assembly from the engine is also possible and results in low thrust. The ENG THST LOW PFL is displayed for failed open/missing nozzle events.

A failed closed nozzle results in normal thrust below AB and stalls when AB is attempted.

Low or insufficient thrust can be caused by a failed open, damaged, or missing nozzle or a nozzle control system malfunction. If thrust is too low to sustain level flight, turn immediately toward the nearest suitable runway and establish 250 knots. With a missing nozzle, level flight may not be possible above 8000 feet MSL with the ENG CONT switch in PRI or 5000 feet MSL in SEC.

Thrust available should increase as altitude decreases. The airspeed at which thrust required for level flight is the lowest is approximately 250 knots.

Indications of a nozzle loss are as follows:

• An initial loud bang or pop, similar to a compressor stall, but rpm is stable above 60 percent; in PRI MIL, engine rpm is approximately 5 percent lower than normal and FTIT is approximately 250°C lower than normal; fuel flow is lower than normal; the nozzle is likely indicated in the full closed position; and thrust is decreased. Malfunctions of the exhaust nozzle control system may have symptoms similar to a missing nozzle, but the nozzle may indicate full open since the nozzle actuation system is intact.

• Presence of the ENG THST LOW PFL indicates that the DEEC has detected the malfunction and has activated logic to increase the thrust available in PRI. AB is inhibited. Remain in PRI if possible, as it should provide a sufficient level of thrust while also maintaining safe engine operation.

• If level flight cannot be attained by 1000 feet above minimum safe ejection altitude or minimum safe altitude with the ENG CONT switch in PRI, select SEC. Set the throttle as required to maintain 250 knots. Continuous operation above 850°C in SEC is likely to result in catastrophic engine failure and fire in as little as 5 minutes.

If thrust is low and a failed open, damaged, or missing nozzle is suspected:

1. Throttle - MIL or below
2. Stores - Jettison (if required).
3. Airspeed - 250 knots.

If thrust is sufficient to reach a suitable landing field:

4. Land as soon as possible. Plan a flameout landing.

Refer to FLAMEOUT LANDING, this section. If unable to reach a suitable landing field and level flight cannot be maintained by 1000 feet above minimum recommended ejection altitude or minimum safe altitude, whichever is appropriate:

5. ENG CONT switch - SEC.

NOTE
SEC should only be selected when it becomes apparent that sufficient thrust cannot be achieved in PRI. SEC eliminates the additional thrust and the engine protection benefits provided by the DEEC in PRI. The nozzle loss logic holds the engine in PRI for these reasons.

6. Throttle - As required to maintain 250 knots in level flight above minimum recommended ejection altitude or minimum safe altitude, whichever is appropriate.

WARNING
With nozzle loss, catastrophic engine failure and fire are probable with prolonged high power settings above 850°C FTIT while in SEC.

CAUTION
If airspeed drops below 250 knots, trade altitude to reacquire 250 knots. Do not descend below minimum recommended ejection altitude or minimum safe altitude, whichever is appropriate.

7. Land as soon as possible. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section.

38.5.10.12 AB BLOWOUT/FAILURE TO LIGHT PW220 / PW229

An AB blowout is indicated by the nozzle opening then closing after the throttle is advanced to AB. If an AB blowout occurs and the throttle is left in AB, the DEEC automatically recycles the AB up to three additional times (each cycle indicated by the nozzle opening and closing). An AB no-light is indicated by the nozzle failing to start open within 5 seconds of advancing the throttle to AB (nozzle remains closed or shows minimal movement). If an AB no light occurs and the throttle is left in AB, the DEEC automatically attempts to relight the AB up to 3 times. The initial attempt and 3 subsequent no lights could take up to 20 seconds. A combination of no lights and blowout recycles could take longer. If further AB attempts are required and the DEEC has completed all recycle attempts, then the throttle must be retarded to MIL or below and advanced to AB.

If the AB blowout/failure to light was not accompanied by an ENGINE FAULT caution light, flight may be continued. If an ENGINE FAULT caution light also occurred, refer to ENGINE FAULT CAUTION LIGHT PW220 PW220 ,this section.

38.5.10.13 ENGINE STALLS PW220 / PW229

The three primary causes of a stall are inlet flow distortion, AB instabilities, and hardware malfunctions. During normal aircraft operation, inlet flow distortion severe enough to cause engine stall is not expected. However, under some departure conditions, inlet flow distortion may induce engine stalls. Hardware-associated stalls may result from a failed nozzle, control system malfunctions, anti-ice system failed on, or FOD. Stalls may also result if rapid engine acceleration is attempted from an abnormally low SEC idle rpm (less than 70 percent).
Stalls may be caused by an anti-ice valve failed in the open position at high thrust settings (throttle above midrange). The engine should be operable with this condition by limiting throttle position to midrange or below. If flight conditions permit, place the ANTI ICE switch to OFF.

The first indication of an engine stall at high thrust settings may be a loud bang or pop. At lower thrust settings, the first indication may be loss of thrust, lack of throttle response, or decreasing engine rpm. When a stall is sensed, the DEEC cancels the AB (if throttle is in AB range), opens the nozzle, and decreases fuel flow until the stall clears. FTIT and NOZ POS may fluctuate in response to the stall recovery signal. If the engine auto transfers to SEC, automatic stall recovery and overtemp protection are not available. A malfunction such as engine internal damage, or primary control system failure could result in a stall, an automatic SEC transfer, and possible FTIT overtemp. Throttle reduction is appropriate as a first response to clear any engine stall.
If the engine stalls at low altitude, an immediate climb should be initiated, and stores jettison should be considered. Retarding the throttle may clear the stall. During a high thrust stall that is self recovering, there will be an immediate thrust loss. In PRI, the DEEC gradually restores thrust to the original level. If engine response at low altitude is not sufficient to maintain or gain altitude and a suitable landing field is not available, ejection may be required.
If a stall occurs at MIL or below, retarding the throttle may clear the stall. Further throttle movement should be limited to midrange or below.

38.5.10.14 AB-ASSOCIATED ENGINE STALLS PW220 / PW229

AB-associated stalls are normally accompanied by a loud bang or pop and a series of fireballs from the engine exhaust and occasionally the engine inlet. This is followed by an erratic flame from the engine exhaust if the stall is nonrecoverable. These characteristics could be mistaken for an aircraft fire. Whenever a stall occurs while operating in AB, the DEEC automatically cancels AB and activates stall recovery. This may be accompanied by a nozzle swing to full open for a few seconds and an associated temporary reduction of thrust. The throttle should be snapped out of AB to MIL. This action usually clears the stall and restores normal operation; however, stalls may continue at MIL and can be severe. They may be characterized by bangs or pops of low intensity or engine vibrations severe enough to preclude reading engine instruments. Refer to NON-AB ENGINE STALLS PW220, this section.
If a self-recovering AB sequencing stall occurs when transitioning from region 3 while operating with approved fuels other than JP-4, NATO F-40, or JET B and no otherabnormal engine indication is observed, the engine is safe to operate from IDLE to MAX AB.

38.5.10.15 NON-AB ENGINE STALLS PW220 / PW229

Non-AB stalls may occur if the engine is malfunctioning, particularly during throttle transients near IDLE. Non-AB stalls are often a symptom of a serious engine problem. Non-AB stalls may be inaudible; the first indication may be a lack of throttle response which may be difficult to differentiate from abnormal engine response. However, non-AB stalls can also be severe. They may be characterized by bangs, pops, low intensity or severe engine rumble or vibration. A momentary nozzle swing to near full open may occur, causing a temporary reduction in thrust, as the DEEC activates stall recovery. An erratic orange-yellow flame from the engine exhaust may be present. This exhaust flame should not be mistaken for an engine fire. If the stall is confirmed, the throttle should be immediately retarded to IDLE which may clear the stall. Further throttle movement should be limited to midrange or below. If a stall occurs while operating in SEC, do not advance the throttle until engine rpm is stable at SEC idle.

A self-recovering engine stall may occur due to hot gas ingestion from firing missiles. The probability increases as airspeed decreases and altitude increases. The indications might not be noticeable; however the pilot will receive an ENG 028 MFL. The stall automatically clears and normal engine operation is expected. If the pilot believes the stall was caused by missile exhaust, it is safe to operate the engine from IDLE to AB.

38.5.10.16 ENGINE STAGNATION PW220 / PW229

Stagnations are usually characterized by either rising FTIT and decreasing rpm or rpm less than 60 percent and a lack of rpm response to throttle commands or illumination of the ENGINE warning light. These indications are usually accompanied by bangs, pops, low intensity engine rumble or vibration, and/or an erratic orange-yellow flame from the engine exhaust. This exhaust flame should not be mistaken for an engine fire. FTIT can either spike, steadily increase, or even decrease immediately following a high thrust stagnation. During low thrust stagnation, FTIT can stabilize in the engine normal operating range of less than 980°C. Since FTIT can be deceptive, low rpm (less than 60 percent) is generally the best indication. Once a stagnation occurs, there is no way to recover normal engine operation except to shut down the engine and perform an airstart. Allowing a stagnated engine to run results in decreasing rpm, increasing FTIT, a loss of thrust, loss of altitude, and engine damage. As soon as stagnation is confirmed, immediately retard the throttle to OFF. Allowing FTIT to remain at high temperatures for an extended period decreases the probability of a successful airstart and normal engine operation.

WARNING
Prolonged engine operation with FTIT in excess of 1000°C can result in significant engine damage and may cause a non-recoverable engine failure.

38.5.10.17 NON-AB ENGINE STALLS PW220 / PW229

If an AB stall(s) occurs:

1. Throttle - Snap to MIL.

If AB stalls do not clear or stall(s) occurs below AB:

NOTE
Non-AB stalls may be inaudible.

2. Throttle - IDLE.
3. ANTI ICE switch - OFF when conditions permit.

NOTE
Stalls may be caused by anti-ice valve failing to close at high thrust setting (throttle above midrange).

If stalls continue at idle and progress to a stagnation (engine rpm less than 60 percent with no rpm response to throttle movement):

4. Throttle - OFF. Initiate airstart. Refer to AIRSTART PROCEDURES PW220/229, this section.

WARNING
Shutting down the engine with an engine alternator failure (indicated by zero or erroneously low rpm, illuminated SEC caution light, illuminated ENGINE warning light, and normal thrust) results in no ignition for an airstart.

If non-AB stall(s) clears:

5. Throttle - Midrange or below.

If a non-AB stall clears, maintain throttle at midrange or below unless required to sustain flight, and jettison stores (if required).

6. Land as soon as possible.

If AB stall(s) clears:

2. Throttle - As required.

• If a self-recovering AB sequencing stall occurs when transitioning from region 3 while operating with approved fuels other than JP-4, NATO F-40, or JET B and no other abnormal engine indication is observed, the engine is safe to operate from IDLE to MAX AB.

• If an AB stall clears under conditions other than described in the preceding bullet, the engine is safe to operate in the IDLE to MIL range, provided no other abnormal indication is observed. Attempt further AB operation only if needed to sustain flight.

38.5.10.18 INLET BUZZ PW220 / PW229

Inlet buzz occurs at supersonic airspeeds if the engine control system fails to maintain adequate engine rpm when the throttle is retarded below MIL. Inlet buzz causes moderate to severe vibration within the cockpit and probably results in multiple engine stalls.

If inlet buzz occurs, the throttle should not be moved until subsonic. Decrease airspeed to subsonic as quickly as possible by opening the speedbrakes and increasing g. If engine stalls occur and persist, the throttle should be retarded to IDLE when subsonic. If the stalls do not clear, the engine must be shut down and restarted.

38.5.10.19 ENGINE FAILURE OR FLAMEOUT PW220 / PW229

Engine failures can result in rpm decrease with no abnormal vibration or sound (flameout), rpm decrease with abnormal vibration and/or stalls, or stable rpm with abnormal vibration and/or low thrust.

If the engine flames out, fuel starvation or mechanical failure has occurred. A flameout is indicated by a decrease in FTIT and engine rpm decaying below approximately 60 percent. Loss of thrust and lack of response to throttle movement confirm the flameout. The ENGINE warning light illuminates when engine rpm is below 55 percent. Additionally, the MAIN GEN light illuminates below 45 percent rpm and the EPU should start running. Do not mistake a loss of ECS noise as an engine flameout.

If the reservoir tanks do not contain fuel, an airstart is impossible. If fuel starvation was due to a temporary lack of fuel, restart should be possible. If fuel quantities appear normal, the flameout may have been caused by fuel contamination. In this case, retarding the throttle to OFF may clear the contaminated fuel and allow an airstart.

Main fuel pump failure or tower shaft geartrain failure also causes flameout. Both present similar symptoms: an abrupt decrease of indicated fuel flow to less than 500 pph; loss of main generator, standby generator, FLCS PMG, and EPU activation; no throttle response; and illumination of the SEC caution light even though the ENG CONT switch is in C DF PRI, DR NORM.

If only the main fuel pump has failed, the rpm indication reflects a gradual spooldown. The JFS can be started and the engine can be motored at approximately 25 percent rpm. If the SEC caution light remains illuminated (with ENG CONT switch in C DF PRI, DR NORM and engine rpm at 12 percent or above), the engine probably cannot be restarted; therefore, place primary emphasis on a flameout landing while continuing airstart attempts. If unable to make a flameout landing, refer to EJECTION, this section.

38.5.10.20 TOWER SHAFT FAILURE PW220 / PW229

Failure of the engine tower shaft or its associated geartrain results in loss of all rotation to the engine gearbox and the ADG. Loss of rotation to the engine gearbox renders the engine alternator, main fuel pump, and oil pump inoperative resulting in a zero rpm indication, zero oil pressure, illumination of the ENGINE warning and SEC caution lights, and engine flameout due to fuel starvation. The initial symptoms are similar to main fuel pump failure; however, the primary difference is that the rpm and oil pressure indications drop immediately to zero with a tower shaft failure since the engine alternator is not being driven. Additional symptoms caused by loss of rotation to the ADG include loss of hydraulic systems A and B, main and standby generators, and FLCS PMG and subsequent activation of the EPU. It may be possible to regain engine operation using the JFS and performing a SEC airstart.

The JFS drives the ADG and the engine gearbox (through the PTO shaft), restoring rotation to both hydraulic pumps, FLCS PMG (at a reduced output), main fuel pump (SEC caution light goes off in PRI until SEC is selected), engine alternator (cockpit rpm signal, DEEC power, and engine ignition), and oil pump (oil pressure increases). Without the load of the engine, the JFS produces an rpm indication fluctuating between 3050 percent which is the speed of the engine alternator, not the actual engine rpm. This rpm may be high enough to restore standby generator power; however, main generator power may cycle on and off line with the rpm fluctuations. If the ENG CONT switch is still in C DF PRI, DR NORM, the SEC caution light goes off when fuel pump pressure is restored; however, a PRI airstart is not possible since the rpm signal to the DEEC is in error. Perform a SEC airstart. Since the JFS is not preserving rpm, maintain 275 knots minimum during the airstart attempt, which should assure adequate actual engine rpm for the airstart.

38.5.10.21 LOW ALTITUDE ENGINE FAILURE OR FLAMEOUT PW220 / PW229

Initial reaction to any malfunction at low altitude should be to trade excess airspeed for altitude. Higher altitude translates directly to either additional time to achieve an airstart or to additional glide range to reach a suitable landing field. At low airspeed, the climb may be only enough to insure a safe ejection altitude. Above 350 knots, more time is available by performing a zoom climb using a 3g pullup to 30- degree climb until approaching the desired airspeed (use approximately 50 knots lead point) and then initiating a zero g pushover. Below 350 knots and above the minimum recommended ejection altitude, more time is available by performing a constant altitude deceleration to the desired airspeed. If below the minimum recommended ejection altitude and below 350 knots, primary concern should be to trade excess airspeed for altitude in preparation for ejection.

If required, jettison stores as soon as possible to aid in gaining or maintaining altitude and maneuver toward a suitable landing field, if available. If the zoom results in an altitude below 5000 feet AGL, there will probably be insufficient time to achieve an airstart prior to minimum recommended ejection altitude. In that case, primary consideration should be given to preparing for ejection; do not delay ejection below 2000 feet AGL. If the zoom results in an altitude between 5000-10,000 feet AGL, there is probably time for one airstart attempt prior to minimum recommended ejection altitude. This attempt shall be performed in the control mode selected by the DEEC.

If low altitude engine failure or flameout occurs:

1. Zoom.
2. Stores - Jettison (if required).

If stores jettison is attempted after main and standby generators drop off line but before EPU generator powers the SMS (approximately 5 seconds delay), stores will not jettison.

NOTE

Visually confirm the stores have jettisoned and jettison again if required.

3. Perform airstart (if altitude permits). Refer to AIRSTART PROCEDURES PW220, this section.

WARNING
Below 5000 feet AGL, there may be insufficient time to perform an airstart prior to minimum recommended ejection altitude.

38.5.10.22 AIRSTARTS PW220 / PW229

Factors such as altitude, airspeed, weather, etc., must be considered in determining whether to try an airstart, accomplish a flameout landing, or eject. Jettisoning of stores reduces altitude loss during an airstart and improves glide ratio during a flameout landing.

Oil pressure is directly related to rpm. Do not confuse a low oil pressure indication due to windmilling rpm as an oil system malfunction.

If the engine has seized due to an oil system malfunction or flamed out due to fuel starvation or mechanical failure, a flameout landing or ejection is required.

The most likely reason to perform an airstart is that the engine has shut down due to a PRI system failure, hardware failure, or stagnation. The DEEC assesses any faults or internal failures and automatically transfers to SEC, if required. The first airstart attempt should be made in the engine control mode selected by the DEEC. When a tower shaft failure is suspected, perform the airstart in SEC. Procedures for SEC and PRI airstarts are identical except for ENG CONT switch position and airspeed.

There are two airstart options available. The primary option is a spooldown airstart, for which the throttle is advanced from OFF to IDLE as rpm is decreasing between 50-25 percent. The recommended spooldown airspeed is 250 knots minimum for PRI or 275 knots minimum for SEC airstarts. The secondary option is a JFS assisted airstart which differs from a spooldown airstart in that once the JFS RUN light is on, airspeed can be reduced to achieve maximum range or maximum endurance (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 1000, D zero pounds). Under normal conditions the JFS will motor the engine at a minimum of 22 percent. The minimum airspeed for PRI and SEC JFS-assisted airstarts is 170 knots and 200 knots, respectively.

CAUTION
Do not fly slower than 200 knots for SEC JFS assisted airstarts.

There are critical requirements which apply to any airstart attempt. The most important is engine rpm. During a spooldown airstart, if the throttle is advanced from OFF to IDLE after rpm goes below 25 percent, light-off may not occur before rpm decreases through 12 percent. Below 12 percent, the main fuel pump does not supply sufficient fuel to effect an airstart and engine ignition is not available. In general, rpm spooldown rate can be decreased with increased airspeed. As much as 350 knots or more is required to prevent rpm from decaying below 12 percent. If rpm is allowed to drop to near zero, 400-450 knots for 20-25 seconds may be required to regain 12 percent. If this situation occurs and the aircraft is not within gliding distance of a suitable landing field, a 50-degree dive angle or greater should be established to accelerate to 450 knots. Once at 450 knots, the dive angle may be reduced to approximately 20 degrees to maintain airspeed. As the engine rpm increases to near 12 percent, an airstart may be attempted. If the dive is started from 20,000 feet MSL at 200 knots and zero engine rpm, 16,000-18,000 feet is required to regain 12 percent engine rpm. If the engine is allowed to stop rotating, it may thermally seize after which it will not rotate even with high airspeeds or by engaging the JFS. The second requirement is engine temperature. High temperatures may result if the airstart is initiated before the FTIT is allowed to decrease below 700°C.

To meet these requirements, an airstart should be initiated at 50-25 percent rpm with FTIT below 700°C. These parameters can usually be achieved by maintaining 250 knots minimum for PRI or 275 knots minimum for SEC below 40,000 feet MSL. This airspeed will not maintain rpm above 12 percent; however, it provides the best tradeoff between the rate of rpm spooldown and loss of altitude. If it appears that engine rpm will drop below 25 percent, increase airspeed if feasible and advance the throttle to initiate the airstart even if FTIT is above 700°C. A hot start may result; however, rpm is preserved. If a hot start does result, retard the throttle to OFF and reattempt the airstart when rpm and FTIT are within limits. Generally, higher airspeeds increase airstart reliability by slowing rpm decay which allows the FTIT to decrease more rapidly.

At low altitudes, however, higher airspeeds do not significantly affect the rpm decay. Maintain airspeed at 250 knots minimum for PRI or 275 knots minimum for SEC for spooldown airstarts and at maximum range or maximum endurance airspeed for JFS-assisted airstarts (200 knots minimum for SEC).

38.5.10.23 HIGH ALTITUDE AIRSTART CONSIDERATIONS PW220 / PW229

At high altitudes, dive at approximately 30 degrees to gain or maintain 250 knots in PRI or 275 knots in SEC below 40,000 feet. Once established, approximately 5-10 degrees of dive should maintain airspeed. Note that airspeed cannot be reduced to less than 250 knots for PRI or 275 knots for SEC until the JFS RUN light is on. Unless an airstart is obviously impossible (total lack of fuel, engine seizure, etc.), do not become tempted to establish a maximum range or maximum endurance glide. The first consideration should be an immediate spooldown airstart attempt even if the engine failed for no apparent reason. If airstart airspeed is not maintained, rpm decreases at a faster rate. The only airstart option available is then a JFS-assisted airstart. Time constraints due to EPU fuel consumption must be considered. A maximum range or maximum endurance glide from above approximately 35,000 feet may exhaust EPU fuel prior to landing.

If the first attempt is in the control mode selected by the DEEC and all parameters (FTIT, rpm, and airspeed) are met and the start is unsuccessful, reattempt airstart with the ENG CONT switch in SEC.

When below 20,000 feet MSL, turn the JFS on. Activating the JFS above 20,000 feet is prohibited since successful JFS start/motoring of engine is unlikely and the brake/JFS accumulators will be depleted. If the JFS RUN light is on, airspeed may be reduced to achieve maximum range or maximum endurance (200 knots minimum for SEC airstarts). With the JFS running, EPU fuel consumption is also reduced.

38.5.10.24 LOW ALTITUDE AIRSTART CONSIDERATIONS PW220 / PW229

Due to the limited time available and the rapid rpm spooldown rate at low altitude, some additional considerations are required. Below approximately 10,000 feet MSL, rpm decreases rapidly regardless of airspeed and remains between 50-25 percent for only 5-10 seconds; therefore, rpm should be closely monitored. Advance the throttle to initiate the airstart before rpm goes below 25 percent regardless of FTIT indication. This action should insure that light-off occurs prior to 12 percent rpm. Start the JFS immediately after advancing the throttle (if airspeed is below 400 knots).

Following a zoom climb, plan to arrive at 250 knots for PRI or 275 knots for SEC; airspeed may be reduced to achieve maximum range or maximum endurance (200 knots minimum for SEC airstarts) only after the JFS RUN light is on. Maintain 275 knots minimum with tower shaft failure. If a higher airspeed is maintained or an attempt is made to gain airspeed to delay the rpm decay, available time may be reduced to the point that an airstart is not possible. During any low altitude airstart attempt, constantly evaluate altitude above the ground relative to airstart success. Do not delay ejection below 2000 feet AGL unless the engine is producing thrust capable of maintaining level flight or safely controlling the sink rate or unless a flameout landing can be accomplished.

38.5.10.25 AIRSTART PROCEDURES PW220 / PW229

To perform an airstart, retard throttle to OFF, obtain airstart conditions, and advance the throttle to IDLE.

If the throttle is retarded to OFF to clear a stagnation, the rpm decreases rapidly and the FTIT decreases. The throttle should be maintained in OFF for a few seconds to allow the stagnation to clear. If the airstart attempt is not due to a stagnation, FTIT may be well below 700°C when the throttle is retarded to OFF.

If it appears that rpm will drop below 25 percent, the throttle must be advanced to IDLE to preserve rpm regardless of FTIT or airspeed. If FTIT was above 700°C, a hot start will probably occur, and the throttle must again be retarded to OFF. However, rpm is preserved permitting a subsequent airstart within parameters.

Regardless of altitude, all initial airstart attempts shall be performed in the control mode selected by the DEEC. In PRI, maintain 250 knots minimum for a spooldown airstart or maximum range or maximum endurance airspeed with the JFS RUN light on. In SEC, maintain 275 knots minimum for a spooldown airstart or 200 knots minimum with the JFS RUN light on.

Start the JFS below 20,000 feet MSL and below 400 knots immediately after the throttle is advanced to IDLE to initiate the spooldown airstart.

When the throttle is advanced to IDLE, rpm and FTIT may continue to decrease until light-off occurs which takes up to 15 seconds. Increasing rpm is normally the first indication of an airstart. The light-off is subtle since rpm and FTIT turnaround are very slow. If light-off is not attained within 20 seconds, retard the throttle to OFF and reattempt an airstart with the ENG CONT switch in SEC. From the time the throttle is advanced from OFF, the engine takes approximately 45 seconds to reach idle rpm. Engine acceleration may be slow around 40-50 percent rpm during the airstart attempt. Do not confuse the slow acceleration with a hung start. DEEC airstart overtemperature protection logic attempts to limit FTIT to approximately 700°C, which results in hung, decreasing, or slowly increasing rpm. If FTIT is stabilized between 700°C and 800°C and rpm is slowly increasing, a successful airstart results.

If FTIT is stabilized between 700°C and 800°C and rpm is definitely hung or decreasing, retard the throttle to OFF and reattempt the airstart. If all airstart parameters were in limits, increase airspeed (275 knots minimum), and reattempt an airstart with the ENG CONT switch in SEC; if not, attain airstart parameters and reattempt in the control mode selected by the DEEC. If airstart was still unsuccessful with the airstart conditions met and the ENG CONT switch in SEC, place the ENG CONT switch back to PRI, maintain the airstart parameters and reattempt the airstart. If the engine auto transferred to SEC, repositioning the ENG CONT switch to PRI will have no effect.
However, if SEC was selected manually and not selected by the DEEC, the engine should transfer back to PRI.

If a hot start occurs (FTIT above 800°C) and start parameters were met and altitude is still sufficient, increase airspeed (if possible) and reattempt an airstart with the ENG CONT switch in SEC. If a hot start occurs and start parameters were not met and maintained, attain airstart parameters and reattempt airstart in the control mode selected by the DEEC.

If the JFS stops running or fails to run within 30 seconds, do not reattempt a JFS star until the rake/JFS accumulators have time to recharge. Allow 1 minute of engine rotation (either windmilling or JFS assisted) at 12 percent rpm or above to insure that the brake/JFS accumulators are fully recharged. Recharging begins 3-4 seconds before the JFS RUN light illuminates or 30 seconds after selecting a start position (in the event of a JFS failure to run). Recharging begins regardless of JFS switch position.

In the event of a JFS shutdown, the JFS switch does not relatch in either start position while the JFS is spooling down. Spooldown from full governed speed takes approximately 17 seconds. The JFS switch must be cycled to OFF and then to START 2 to reinitiate a JFS start. It is possible to complete the spooldown before the brake/JFS accumulators are recharged if the JFS ran for only a short time.
When the airstart is completed, turn the JFS off (if tower shaft failure is not suspected). Reset the main generator using the ELEC CAUTION RESET button and verify MAIN GEN and STBY GEN lights are off. Cycle the EPU switch to OFF, then back to NORM.

To accomplish an airstart:

1. Throttle - OFF.

CAUTION
FTIT should decrease rapidly when throttle is OFF. If FTIT does not decrease rapidly, verify that the throttle is OFF.

2. Airspeed - As required.

Maintain 250 knots minimum for PRI or 275 knots minimum for SEC below 40,000 feet for a spooldown airstart.

NOTE
If RPM snaps to zero and tower shaft failure is suspected, place ENG CONT switch to SEC and maintain 275 knots minimum throughout airstart attempt.

When rpm is 50-25 percent with FTIT below 700°C.

3. Throttle - IDLE.

CAUTION
If it appears rpm will go below 25 percent, advance throttle to IDLE regardless of FTIT or airspeed.

4. JFS switch - START 2 below 20,000 feet MSL and below 400 knots.

Maintain maximum range or maximum endurance airspeed (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 1000, D zero pounds) with the JFS RUN light on (200 knots minimum for SEC airstarts).

CAUTION
Do not fly slower than 200 knots for SEC JFS assisted airstarts.

NOTE
• If maximum gliding range is not a factor, consider maintaining 250 knots minimum for PRI or 275 knots minimum for SEC above 10,000 feet AGL to reduce rpm spooldown rate (in case of JFS failure). Below 10,000 feet AGL with the JFS RUN light on (where only one airstart attempt is likely), maintain maximum range or maximum endurance airspeed (200 knots minimum for SEC airstarts). • If the JFS switch is erroneously placed to START 1, leave it there.

• If the JFS RUN light does not illuminate or goes out once illuminated, place the JFS switch to OFF and reattempt START 2 when the brake/JFS accumulators are recharged.
The JFS switch does not relatch in either start position while the JFS is spooling down. RPM naps to zero and tower shaft failure is suspected, place ENG CONT switch to SEC and maintain 275 knots minimum throughout airstart attempt.

5. Stores - Jettison (if required).

If stores jettison is attempted after main generator drops off line but before EPU generator powers the SMS (approximately 5 seconds delay), stores will not jettison.

NOTE

Visually confirm the stores have jettisoned and jettison again if required.

If hung/hot/no start and airstart conditions were not met:

NOTE

• Hung start is indicated by the FTIT stabilized below 800°C and rpm has stopped increasing.

• Hot start is indicated by an FTIT above 800°C.

• No start is indicated when light-off does not occur within 20 seconds.

6. Throttle - OFF.
7. Reattempt airstart in mode selected by the DEEC.

If hung/hot/no start and airstart conditions were met:

NOTE

• Hung start is indicated by the FTIT stabilized below 800°C and rpm has stopped increasing.

• Hot start is indicated by an FTIT above 800°C.

• No start is indicated when light-off does not occur within 20 seconds.

8. Throttle - OFF.
9. ENG CONT switch - SEC.

NOTE

• Place the ENG CONT switch to SEC prior to placing the throttle to IDLE, otherwise a start anomaly may result.

• The proximity of the ENG CONT switch to the JFS switch makes the JFS switch susceptible to being bumped to OFF when selecting SEC.

If still hung/hot/no start and airstart conditions were met:

11. Throttle - OFF.
12. ENG CONT switch - PRI.
13. Throttle - IDLE.

If engine does not respond normally after airstart is completed:

14. Refer to FLAMEOUT LANDING, this section.

If engine responds normally:

CAUTION

Do not turn JFS or EPU off if indicated rpm is below 60 percent with adequate thrust (e.g., tower shaft failure).

14. JFS switch - OFF.
15. ELEC CAUTION RESET button - Depress.

Verify MAIN GEN and STBY GEN lights are off.

16. EPU switch - OFF, then NORM.
17. ADI - Check for presence of OFF and/or AUX warning flags.

If warning flag(s) is in view, refer to TOTAL INS FAILURE LESS or EGI FAILURE, this section.

WARNING

If only AUX flag is in view, pitch and roll attitude information is likely to be erroneous due to INS autorestart in the attitude mode when other than straight and level, unaccelerated flight conditions existed.

18. Throttle - As required.

NOTE

If the SEC caution light is on, refer to SEC CAUTION LIGHT PW220/229 , this section.

19. Land as soon as possible.

NOTE

Consider an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING, this section.

20. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.5.11 ENGINE MALFUNCTIONS GE100 / GE129

The EMS compares expected versus actual engine operation. The purpose of the EMS MFL is to provide maintenance personnel with an early indication of an engine condition which requires correction. No action is required for an engine MFL at anytime during a flight.

Low altitude, for engine malfunction purposes, is generally defined as 10,000 feet AGL or below. If an engine malfunction is suspected, the initial reaction should be to trade excess airspeed for altitude. Unless a suitable airfield is within gliding distance, turns should be avoided as they decrease the amount of time/altitude available to successfully recover engine performance or prepare for ejection. Optimizing the exchange of airspeed for altitude must be a priority action for any engine malfunction. Above 310 knots, more time is available by performing a zoom climb using a 3g pullup to 30-degree climb until approaching the desired airspeed (use approximately 50 knots lead point) and then initiating a zero-g pushover. Below 310 knots and above the minimum recommended ejection altitude, more time is available by performing a constant altitude deceleration to the desired airspeed. If below the minimum recommended ejection altitude and below 310 knots, primary concern should be to trade excess airspeed for altitude in preparation for ejection. If appropriate, jettison stores as soon as possible.

WARNING
With engine failure or flameout, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates above 10,000 feet cockpit altitude.

NOTE
With OBOGS inoperative, the BOS will supply oxygen for approximately C 3-5 minutes, D 2-3.5 minutes with both cockpits occupied or 4-7 minutes with one cockpit occupied. The EOS will supply oxygen for 8-12 minutes.

For any situation where automatic activation of the EPU is relied upon, verify that the EPU run light is on to insure that the EPU has started. If the EPU run light is off, position the EPU switch to ON.

SEC is a highly reliable backup engine operating mode. However, in certain circumstances the engine may malfunction in SEC following an auto transfer, or continue to malfunction in SEC following a manual transfer. Returning to PRI may result in proper engine response, due to either the resetting of internal hydromechanical control pressures or to the resetting of digital engine control logic.

Idle thrust in SEC during ground operation is approximately twice that in PRI. After landing in SEC, consider minimizing taxi distance and consider following HOT BRAKES procedures, this section.

38.5.11.1 ENGINE FIRE GE100 / GE129

Generally, the first indication of fire in the engine compartment is the ENG FIRE warning light. Abnormal fuel indications (quantity/flow) may also be present. FTIT probably will not be higher than normal. Explosions, vibrations, or engine instrument fluctuations are usually indicative of a serious engine problem; engine failure may be imminent. Immediate action should be taken to reduce thrust to the minimum practical level after attaining safe ejection parameters. If within gliding distance of a suitable runway, consider shutting the engine down. Sufficient time should exist to analyze the situation and make an ejection versus land decision. The ejection decision should be based on visual and/or cockpit indications that the fire is persisting. Cockpit indications include continued illumination of the ENG FIRE warning light and subsequent illumination of FLCS status lights/degraded flight controls or subsequent loss of either hydraulic system.

An in-flight fire may cause the degradation or failure of multiple systems. If time and conditions permit, attempt to determine the status of individual flight controls, speedbrakes, FLCS branches, and available thrust.

Fires can also occur in the nozzle area when using AB. These fires are the result of portions of the nozzle failing which allows the AB plume to burn through the nozzle. Ventilation should inhibit forward movement of the fire into and through the engine bay. Since these fires are aft of the detection circuit, the ENG FIRE warning light will not illuminate. Additionally, the nozzle position indications are normal, and there are no vibrations or instrument fluctuations. In most cases, these AB-related nozzle fires are detected by someone outside the aircraft (wingman, tower, etc.). When operating in AB and a fire is reported at the rear of the aircraft, retard throttle below AB immediately. This action should extinguish a nozzle fire within approximately 30-45 seconds and minimize damage to the aircraft skin, speedbrakes, nozzle, and flight controls; however, nozzle damage may result in a noticeable thrust loss as well as an oil leak.

If on takeoff and the conditions permit:

1. Abort.

If takeoff is continued:

1. Climb.

Maintain takeoff thrust until minimum recommended ejection altitude is attained and then throttle to minimum practical.

2. Stores - Jettison (if required).

At a safe altitude:

3. Throttle - Minimum practical.

If fire occurred in AB, ENG FIRE warning light may not illuminate. Fire should extinguish after throttle is retarded; however, nozzle damage may result in lower than normal thrust as well as an oil leak.

If within gliding distance of a suitable runway, consider shutting the engine down.

If ENG FIRE warning light goes off:

4. FIRE & OHEAT DETECT button - Depress.

Determine if fire and overheat detection circuits are functional.

If fire persists:

5. Eject.

If fire indications cease:

5. Land as soon as possible.

WARNING
An in-flight fire may cause the degradation or failure of multiple systems. If time and conditions permit, attempt to determine the status of individual flight controls, speedbrakes, FLCS branches, and available thrust.

38.5.11.2 OVERHEAT CAUTION LIGHT GE100 / GE129

Detection of an overheat condition in the engine compartment, ECS bay, MLG wheel wells, or EPU bay illuminates the OVERHEAT caution light.

Accomplish as many of the following as required to extinguish the caution light. If the light goes off, verify the integrity of the detection circuit by depressing the FIRE & OHEAT DETECT button and land as soon as possible.

1. Throttle - Minimum practical.
2. FIRE & OHEAT DETECT button - Depress.

Determine if fire and overheat detection circuits are functional.

If OVERHEAT caution light goes off and detect circuit checks good:

3. Land as soon as possible.

If OVERHEAT caution light remains on (or detect circuit checks bad) and EPU is running:

3. EPU switch - OFF (if feasible).

If the EPU was manually turned on, consider turning it off to determine if it is the source of the overheat condition. If the OVERHEAT caution light remains on, the EPU should be turned back on.

If OVERHEAT caution light remains on (or detect circuit checks bad):

4. OXYGEN - 100%.
5. AIR SOURCE knob - OFF.

External fuel cannot be transferred in OFF or RAM. Consider jettisoning tank(s) to decrease drag if range is critical and the ECS cannot be turned on for short periods of time to transfer fuel.

WARNING
• With the ECS shut down or the AIR SOURCE knob in OFF or RAM, the g-suit does not inflate and PBG is disabled. • With the AIR SOURCE knob in OFF or RAM, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates above 10,000 feet cockpit altitude.

6. Descend to below 25,000 feet (18,000 feet if conditions permit) and reduce airspeed to below 500 knots.

When airspeed is reduced and cockpit is depressurized:

7. AIR SOURCE knob - RAM (below 25,000 feet).

External fuel cannot be transferred in OFF or RAM. Consider jettisoning tank(s) to decrease drag if range is critical and the ECS cannot be turned on for short periods of time to transfer fuel.

WARNING
• With the ECS shut down or the AIR SOURCE knob in OFF or RAM, the g-suit does not inflate and PBG is disabled. • With the AIR SOURCE knob in OFF or RAM, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates above 10,000 feet cockpit altitude.

8. When practical, descend below 10,000 feet.

With OBOGS inoperative, the BOS will supply oxygen for approximately C 3-5 minutes, D 2-3.5 minutes with both cockpits occupied or 4-7 minutes with one cockpit occupied. The EOS will supply oxygen for 8-12 minutes.

9. Nonessential electrical equipment - Off.

If OVERHEAT caution light still remains on (or detect circuit checks bad):

10. TANK INERTING switch - TANK INERTING even if Halon is not available.
11. LG handle - DN (300 knots/0.65 mach maximum).
(Use DN LOCK REL button if required.)

WARNING
If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND.

12. Land as soon as possible.

38.5.11.3 ENGINE VIBRATIONS GE100 / GE129

Some engines exhibit low frequency vibrations which are non-damaging to both the airframe and engine. The vibrations should disappear if engine rpm is either increased or decreased.
Vibrations that change in intensity with throttle movement and are present across the throttle/rpm range may indicate a potential engine malfunction.

If vibrations persist:

1. Throttle - Minimum practical.
2. Land as soon as possible.

38.5.11.4 OIL SYSTEM MALFUNCTION GE100 / GE129

An oil system malfunction may be indicated by the EMS, the OIL pressure indicator, the NOZ POS indicator, and the HYD/OIL PRESS warning light.
An oil system malfunction is characterized by a pressure (including fluctuations) below 15 psi at IDLE or 25 psi at MIL, pressure above 65 psi at any throttle setting, pressure fluctuations greater than ±5 psi, or continuous presence of the ENG LUBE LOW PFL.

The following situations require landing as soon as possible:

• Presence of ENG LUBE LOW PFL
• Presence of a HYD/OIL PRESS warning light with either oil pressure fluctuating out of limits or steadily indicating below minimum

The ENG LUBE LOW PFL will precede most oil system pressure problems. If this PFL is present with or without a low oil pressure indication, it indicates a land as soon as possible situation. Oil pressure fluctuating or steadily indicating below minimum, accompanied by illumination of the HYD/OIL PRESS warning light should also be treated as a land as soon as possible situation. While high oil pressure and fluctuating oil pressure (without an ENG LUBE LOW PFL) are classified as oil system malfunctions, their occurrence is of less concern than low oil pressure or low oil quantity. Historically, low, high or fluctuating pressure without illumination of the HYD/OIL PRESS warning light or the presence of the ENG LUBE LOW PFL have been directly attributed to a failed oil pressure transmitter, a failed cockpit indicator, or other failed parts associated with the pressure indication. Though these indications are most likely caused by the previously mentioned malfunction(s), it is still possible that the indication reflects the actual condition; therefore, landing as soon as practical via a straight-in approach at a suitably configured airfield is recommended as a precaution.

Engine oil level decreasing below approximately 40 percent of normal capacity for 30 seconds results in activation of an ENG LUBE LOW PFL. Further oil level decrease may cause the exhaust nozzle to fail to an aerodynamically balanced position and there may be a decrease in thrust and a larger than normal NOZ POS indication. The HYD/OIL PRESS warning light may not illuminate until most of the usable oil is lost.

High airspeeds (especially at low altitude), high throttle settings, and/or throttle movements are undesirable when oil pressure is abnormally low.

Initial reaction to an oil system malfunction at low altitude should be to gain altitude and proceed to the nearestsuitable airfield. The remainder of this discussion assumes that the ENG LUBE LOW PFL and/or the HYD/OIL PRESS warning light is illuminated. If oil pressure is low, reduce airspeed. If oil pressure is 10 psi or above, consider using MIL or AB thrust to quickly attain desired cruise altitude. If oil pressure is below 10 psi, increase altitude and reduce airspeed by performing a fixed throttle climb. If the altitude gained is insufficient for a safe cruise, a slow throttle advance followed by a slow throttle reduction, when at a sufficient cruise altitude, may be performed.
Do not make subsequent throttle movements unless required to sustain flight.

Anticipate engine seizure approximately 5 minutes after oil pressure drops below 10 psi with the ENG LUBE LOW PFL and/or the HYD/OIL PRESS warning light illuminated. Use minimal throttle movement and reduced thrust settings to maximize time. Minimize maneuvering g to minimize loads. Plan an approach which allows a flameout landing from any position should engine seize. Refer to SIMULATED FLAMEOUT (SFO) LANDING and FLAMEOUT LANDING, this section.

The EPU should be manually activated if engine seizure is anticipated (i.e., oil pressure decreases below 10 psi and the ENG LUBE LOW PFL and/or the HYD/OIL PRESS warning light illuminated); otherwise, if the EPU does not start automatically when the engine seizes, the short time remaining before loss of control may be inadequate for recognition of the EPU failure and corrective action. Monitor hydrazine use after activating the EPU. If consumption rate is too high, cycle EPU switch to OFF, then NORM to conserve hydrazine. Be prepared to place the EPU switch back to ON if the engine seizes.

If an oil system malfunction is suspected:

1. Range - Maximize.

If oil pressure is 10 psi or above with the ENG LUBE LOW PFL present and/or the HYD/OIL PRESS warning light illuminated, and the nearest suitable airfield is not within gliding distance, consider using MIL or AB thrust to quickly gain altitude and/or decrease distance to the nearest suitable airfield. If oil pressure is below 10 psi with the ENG LUBE LOW PFL present and/or the HYD/OIL PRESS warning light illuminated, attain desired cruise conditions using minimum throttle movement and then slowly retard to the minimum setting required.

CAUTION
When oil pressure is below 10 psi with the ENG LUBE LOW PFL present and/or the HYD/OIL PRESS warning light illuminated, throttle movement, high throttle settings, or high airspeeds may accelerate or cause engine seizure.

If the ENG LUBE LOW PFL occurs or oil pressure is low with the HYD/OIL PRESS warning light illuminated:

2. Stores - Jettison (if required).
3. EPU switch - ON, if oil pressure decreases below 10 psi.

Monitor hydrazine use. If consumption rate is too high, cycle EPU switch to OFF, then NORM to conserve hydrazine. Be prepared to place EPU switch back to ON if the engine seizes.

4. Land as soon as possible.

Plan to fly an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING and FLAMEOUT LANDING, this section.

5. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

If oil pressure is out of normal operating limits without an ENG LUBE LOW PFL present or the HYD/OIL PRESS warning light illuminated:

2. Land as soon as practical.

NOTE
Though this is most likely a faulty indication, it is still possible that the indication reflects the actual condition; therefore, landing as soon as practical via a straight-in approach at a suitably configured airfield is recommended as a precaution.

38.5.11.5 ENGINE FAULT CAUTION LIGHT GE100 / GE129

Illumination of the ENGINE FAULT caution light indicates that an engine PFL item was detected.

If ENGINE FAULT caution light illuminates:

1. PFLD - Note PFL(s) displayed.
2. C DF F-ACK, DR FAULT ACK button – Depress to acknowledge fault.
3. Refer to PILOT FAULT LIST – ENGINE, this section.
4. C DF F-ACK, DR FAULT ACK button – Depress to perform fault recall.

The failure condition no longer exists if the PFL is not present during the fault recall.

38.5.11.6 SEC CAUTION LIGHT GE100 / GE129

Illumination of the SEC caution light indicates that the engine is operating in SEC. If the ENG CONT switch is in C DF PRI, DR NORM and the SEC caution light illuminates, an automatic transfer to SEC has likely occurred. Normal SEC operation is characterized by the SEC caution light, a fixed closed exhaust nozzle, and AB unavailable. The ENG CONT switch does not have to be positioned to SEC.

NOTE
If the rpm indication is also zero, the engine alternator has failed.

There are no throttle restrictions while operating subsonic in SEC. If supersonic when transfer to SEC occurs, the throttle must remain at MIL or above until subsonic.

The thrust level at MIL, while operating in SEC, is 70-95 percent of that provided (for the same throttle position and flight condition) in PRI. During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle because the nozzle is closed.

A throttle cable internal failure or a throttle linkage disconnect results in an automatic transfer to SEC; however, control of the engine with a failed throttle cable or linkage disconnect is not possible in SEC. In SEC, a throttle cable internal failure is characterized by a possible rpm increase but no decrease with throttle movements; a throttle linkage disconnect results in no engine response to throttle movements. In this situation, control of the engine at idle and above can be regained in PRI by cycling the ENG CONT switch to SEC, then back to C DF PRI, DR NORM. The engine logic for this failure is such that the engine remains in PRI after cycling the ENG CONT switch. After landing, shutdown of the engine must be accomplished with the FUEL MASTER switch.

If SEC caution light illuminates when supersonic:

1. Throttle - Do not retard below MIL until subsonic.

CAUTION
Retarding throttle below MIL while supersonic may induce inlet buzz which produces severe cockpit vibration and probable engine stalls.

When subsonic or if SEC caution light illuminates when subsonic:

2. Throttle - Verify engine responds normally to throttle movement from IDLE to MIL; set as desired.

AB operation is inhibited and exhaust nozzle is closed.

If the engine is operating normally in SEC:

3. ENG CONT switch - SEC.
4. Land as soon as practical.

During landing in SEC, idle thrust is approximately twice that in PRI with a normal nozzle. Minimize taxi distance after landing to prevent overheating the brakes due to increased thrust.

CAUTION
An SFO is not recommended if engine is operating satisfactorily in SEC.

If the engine is operating abnormally in SEC:

WARNING
Failure to monitor sink rate and height above terrain while applying low thrust recover procedures can result in ejection outside ejection seat performance envelope.

3. ENG CONT switch - Position to SEC, then back to C DF PRI, DR NORM.
4. Airspeed - 250 knots (if thrust is too low to sustain level flight).
5. Land as soon as possible.

NOTE
A broken throttle cable or throttle linkage disconnect causes a transfer to SEC and abnormal engine response in SEC. Reselecting PRI restores normal engine operation for flight; however, engine shutdown after flight requires use of the FUEL MASTER switch.

If thrust is too high to permit a safe landing:

6. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section.

WARNING
Do not start the JFS if engine seizure has occurred or is anticipated or if engine failure is a result of fuel starvation. Starting the JFS may result in no brake/JFS accumulator pressure for the brakes.to monitor sink rate and height above terrain while applying low thrust recover procedures can result in ejection outside ejection seat performance envelope.

When landing is assured (normally high key):

WARNING
Delaying engine shutdown can result in a long, fast landing. Wheel braking is less effective due to lack of WOW and there is an increased probability of a missed cable engagement.

7. Throttle - OFF.

If engine does not respond, shut down the engine with the FUEL MASTER switch. At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds.

8. HOOK switch - DN (if required).

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

38.5.11.7 FTIT INDICATOR FAILURE GE100 / GE129

The engine does not use FTIT as a control parameter. However, routine missions should not be continued since FTIT cannot be monitored.

38.5.11.8 ZERO RPM/ERRONEOUS RPM INDICATION GE100 / GE129

If the RPM indicator fails to zero or displays erroneous rpm indication, it indicates either a malfunction within the indicator itself or within the engine alternator. Total alternator failure also causes an automatic transfer to SEC. The ENGINE warning light also illuminates for engine alternator or RPM indicator failure. Engine transfer to SEC due to certain partial or total alternator failures results in loss of most engine fault reporting. Partial alternator failure may not result in automatic transfer to SEC. If the engine does not transfer to SEC, fault reporting continues. Partial alternator failure may also result in transfer to hybrid operation with AB operation inhibited. In this case, ENG HYB MODE and ENG A/B FAIL PFL's occur. Routine missions should not be continued without a functional RPM indicator.

If SEC caution light is illuminated:

1. Go to SEC CAUTION LIGHT GE100/129, this section.

If SEC caution light is not illuminated:

1. Land as soon as practical.

38.5.11.9 ABNORMAL OR NO ENGINE RESPONSE GE100 / GE129

Refer to LOW THRUST ON TAKEOFF OR AT LOW ALTITUDE (NON-AB) GE100/129 , this section, if appropriate.

If thrust is too low to sustain level flight, turn immediately toward the nearest suitable runway and establish 250 knots airspeed. Consider jettisoning stores to increase flying time available to complete actions designed to restore usable thrust and improve range in the event those actions are unsuccessful.

NOTE

In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

Abnormal engine response is varied and generally indicated by abnormal thrust in relation to throttle position, engine oscillations (either continuous, momentary, or recurring), a complete lack of engine response to throttle movement, auto acceleration/deceleration, exhaust nozzle failure, or insufficient thrust. A PRI malfunction can cause these abnormal engine responses as well as overtemperature or overspeed indications. During AB operation, if engine anomalies occur in region 1, the throttle should be moved out of the AB range and AB should not be selected again for the remainder of the flight.

Exhaust nozzle control or oil system malfunctions can result in the nozzle being too far open, too far closed, or unstable. Insufficient thrust may result if the nozzle is more open than normal. SEC should be selected and, if the nozzle goes fully closed, engine operation should be continued in SEC. If the nozzle does not close in SEC, the ENG CONT switch should be moved back to C DF PRI, DR NORM as more thrust results and AB light-off may be attainable at lower altitudes. AB should only be used when required to sustain flight.

If the exhaust nozzle is positioned more closed than normal, thrust is adequate, but engine stall may occur if AB is selected. The AB is inhibited in PRI for exhaust nozzle malfunctions.

NOTE
Certain PRI malfunctions may not result in an autotransfer to SEC. If the engine operates abnormally, do not rely upon an autotransfer to SEC. Timely selection of SEC may preclude further engine problems.

If thrust is still insufficient to make a safe landing after selecting SEC or abnormal engine response is still present, reattempt PRI.

If thrust is too high to permit a safe landing, use excess thrust to climb and maneuver toward the nearest suitable airfield. Once high key for a flameout landing is assured, follow procedures as outlined in FLAMEOUT LANDING, this section. Activate the JFS and EPU and then shut down the engine as soon as landing is assured (normally high key) by placing the throttle to OFF or, if necessary, by placing the FUEL MASTER switch to OFF.

If abnormal engine response occurs:

WARNING
Failure to monitor sink rate and height above terrain while applying low thrust recovery procedures can result in an ejection outside ejection seat performance envelope.

CAUTION
If SEC caution light is on, refer to SEC CAUTION LIGHT GE129 , this section.

If in AB or if supersonic:

1. Throttle - Retard to MIL.

CAUTION
Retarding throttle below MIL while supersonic may induce inlet buzz which produces severe cockpit vibration and probable engine stalls.

If subsonic or problem still exists:

CAUTION
Idle PRI thrust with nozzle stuck closed is approximately 50 percent greater than idle SEC thrust.

2. ENG CONT switch - SEC.

NOTE
Transfer to SEC may be accomplished while supersonic if the throttle remains at MIL.

3. Airspeed - 250 knots (if thrust is too low to sustain level flight).
4. Throttle - Verify engine responds normally to throttle movement from IDLE to MIL; set as desired.

AB operation is inhibited and exhaust nozzle is closed.

If a safe landing can be made with the current thrust:

5. Land as soon as practical.

During landing in SEC, idle thrust is higher than normal. Minimize taxi distance after landing to prevent overheating the brakes due to increased thrust.

CAUTION
An SFO is not recommended if engine is operating satisfactorily in SEC.

If thrust is insufficient to make a safe landing or abnormal engine response is still present:

5. ENG CONT switch - C DF PRI, DR NORM.
6. Land as soon as possible.

NOTE
Consider an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING, this section.

If thrust is too high to permit a safe landing:

5. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section.

When landing is assured (normally high key):

WARNING
Delaying engine shutdown can result in a long, fast landing. Wheel braking is less effective due to lack of WOW and there is an increased probability of a missed cable engagement.

6. Throttle - OFF.

If engine does not respond, shut down the engine with the FUEL MASTER switch. At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds.

7. HOOK switch - DN (if required).

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

38.5.11.10 STUCK THROTTLE GE100 / GE129

A stuck throttle can be the result of a failure within the throttle cable/sleeve mechanism, throttle grip foot interference with the throttle track, or an object obstructing the path of the throttle or throttle linkage.

If thrust is too low to sustain level flight, turn immediately toward the nearest suitable runway and establish 250 knots which approximates the airspeed at which thrust required for level flight is the lowest. Consider jettisoning stores to increase flying time available to complete actions designed to restore usable thrust and improve range in the event those actions are unsuccessful.

NOTE
In a partial thrust situation, thrust available may increase as altitude decreases. 250 knots approximates the airspeed at which thrust required for level flight is the lowest.

If throttle is stuck in AB, placing the ENG CONT switch to SEC terminates AB and provides SEC MIL thrust. Selecting SEC also reduces fuel flow and maximizes remaining flight time. Extended AB use may result in unrecoverable trapped external fuel. Monitor internal fuel quantities to preclude unexpected engine flameout due to fuel starvation.

If the throttle is stuck and thrust is suitable for sustained flight, attempts to free the throttle should be delayed until within gliding distance of a suitable landing field.

If the throttle is stuck at MIL or below, there is no significant thrust reduction by transferring engine control to SEC; remain in PRI.

If an object is blocking the throttle or throttle linkage, applying positive and negative g and sideslip maneuvers in both right and left directions may dislodge the obstruction.

If the throttle remains stuck and thrust is too high to permit a safe landing, a flameout landing is required. Follow procedures as outlined in FLAMEOUT LANDING, this section. Activate the JFS and EPU, and then shut down the engine when within gliding distance of a suitable landing field by placing the FUEL MASTER switch to OFF. At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds.

If throttle is stuck in AB:

1. ENG CONT switch - SEC.

After engine is operating in SEC or if throttle is stuck below AB:

WARNING
• If the throttle is stuck and thrust is suitable for sustained flight, attempts to free the throttle should be delayed until within gliding distance of a suitable landing field. • Extended AB use may result in unrecoverable trapped external fuel. Monitor internal fuel quantities to preclude unexpected engine flameout due to fuel starvation.

2. Stores - Jettison (if required).
3. Throttle - Depress cutoff release, rotate throttle grip outboard and apply necessary force.

If throttle is still stuck:

4. Perform positive and negative g and sideslip maneuvers and attempt to move throttle.

If throttle is still stuck and thrust is too high to permit a safe landing:

5. Plan a flameout landing. Refer to FLAMEOUT LANDING, this section, prior to placing FUEL MASTER switch off.

When prepared to land:

6. EPU switch - ON.
7. JFS switch - START 2.

When at high key or within gliding distance of a suitable landing field:

WARNING
Delaying engine shutdown can result in a long, fast landing. Wheel braking is less effective due to lack of WOW and there is an increased probability of a missed cable engagement.

8. FUEL MASTER switch - OFF.

At MIL, the engine flames out in approximately 6 seconds. At IDLE, the engine flames out in approximately 45 seconds.

9. HOOK switch - DN (if required).

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

38.5.11.11 AB BLOWOUT/FAILURE TO LIGHT GE100 / GE129

AB blowouts are characterized by a thrust loss, a fuel flow decrease, and nozzle closure. The DEC attempts to relight the AB as long as the throttle remains in AB.

If AB is selected in region 1 and fails to light within 10 seconds or if the AB blows out in any region, retard throttle out of AB. AB operation should not be reattempted for the remainder of the flight.

AB operation in region 2 may include AB no lights or delayed lights if unfavorable AB light-off conditions exist. If these are encountered, the throttle may be left in AB. If the throttle is retarded, an AB light may be attempted.

38.5.11.12 ENGINE STALLS GE100 / GE129

The three primary causes of a stall are inlet flow distortion, AB instabilities, and hardware malfunctions. During normal aircraft operation, inlet flow distortion severe enough to cause engine stall is not expected. However, under some departure conditions, inlet flow distortion may induce engine stalls. Hardware-associated stalls may result from a failed nozzle, control system malfunctions, or FOD.

The first indication of a stall at high thrust settings may be a loud bang or pop. At lower thrust settings, the first indication may be loss of thrust, lack of throttle response, or decreasing rpm. The throttle should be retarded at the first indication of a stall. Engine stalls are divided into two types: AB-associated engine stalls and non-AB engine stalls.

38.5.11.13 AB-ASSOCIATED ENGINE STALLS GE100 / GE129

Types of AB-associated engine stalls are:

• AB initiation - Stall at AB light-off.
• AB sequencing - Stall during AB sequencing as the AB fuel flow increases with the throttle in AB.
• AB cancellation - Stall during throttle retard from AB.
• AB blowout/relight - Stall occurs during relight after a blowout in stabilized AB. May be preceded by AB rumble.

AB-associated engine stalls are normally accompanied by a loud bang or pop and a possible fireball from the engine exhaust and occasionally the engine inlet. These characteristics could be mistaken for an aircraft fire. Whenever a stall occurs while operating in AB, the throttle should be snapped out of AB to MIL. This usually clears the stall and restores normal operation. The stalls may continue at MIL and are characterized by bangs or pops of lower intensity than AB stalls. If stall condition persists, refer to NON-AB ENGINE STALLS GE100/129, this section.

CAUTION
If an AB-associated engine stall occurs below 30,000 feet MSL or while supersonic, IGV system damage may occur. Throttle movements after the stall clears should not be rapid.

FTIT fluctuation and decreasing rpm will probably accompany stalls. The throttle should be retarded to IDLE if the stall continues for a few seconds. The engine may continue to stall at IDLE but may not be audible, particularly at high altitudes. The engine instruments should be monitored for indications of stall. FTIT may rise while rpm decreases.

If the engine stalls at low altitude, an immediate climb should be initiated. Retarding the throttle o MIL may clear the stall. If engine response at low altitude is not sufficient to maintain or gain altitude and a suitable field is not immediately available, ejection may be required.

38.5.11.14 NON-AB ENGINE STALLS GE100 / GE129

Non-AB engine stalls may occur if the control system is malfunctioning, particularly during throttle transients. Non-AB engine stalls are often a symptom of a serious engine problem. Non-AB engine stalls may be inaudible; the first indication may be a lack of engine response to throttle movement which may be difficult to differentiate from abnormal engine response. However, non-AB engine stalls may be characterized by bangs, pops, low intensity engine rumble or vibration, and/or erratic orange-yellow flame from the engine exhaust.

This exhaust flame could be mistaken for an engine fire. FTIT fluctuation and decreasing rpm will probably accompany stalls. If a stall is confirmed, the throttle should be immediately retarded to IDLE. The engine may continue to stall at IDLE but the stall may not be audible, particularly at high altitudes. The engine instruments should be monitored for indications of stall. FTIT may increase while rpm decreases. If the engine recovers, throttle movements should be minimized and made slowly until landing is assured.

If stall continues, initiate airstart. Refer to AIRSTARTS GE100/129, this section. If the stalls continue after the airstart, the engine may have a serious hardware problem. The focus should shift to using available thrust to land at the nearest suitable airfield.

WARNING
Prolonged engine operation with FTIT in excess of 980°C can result in significant engine damage and may cause a non-recoverable engine failure.

A self-recovering engine stall may occur due to hot gas ingestion from firing missiles. The probability increases as airspeed decreases and altitude increases. The indications might not be noticeable; however the pilot will receive an ENG 020 MFL. The stall automatically clears and normal engine operation is expected. If the pilot believes the stall was caused by missile exhaust, it is safe to operate the engine from IDLE to AB.

38.5.11.15 ENGINE STALL RECOVERY GE100 / GE129

If an AB stall(s) occurs:

1. Throttle - Snap to MIL.

If AB stalls do not clear or stall(s) occurs below AB:

2. Throttle - IDLE.

NOTE
For serious hardware problems, the engine may operate normally at idle rpm but exhibit stall/ vibration conditions at thrust settings above idle rpm. Use the highest thrust setting below the stall/vibration condition to sustain flight and jettison stores (if required).

If stalls continue, or thrust is insufficient for a safe recovery:

3. Initiate AIRSTART PROCEDURES GE100/129 , this section.

If stall(s) clears:

3. Throttle - MIL or below. Minimize throttle movements and make necessary movements slowly.

NOTE

If stall(s) occurred in AB at 30,000 feet MSL or above and while subsonic, the engine is safe to operate in the IDLE to MIL range provided no other abnormal engine indications are observed.

If stall(s) occurred at MIL or below, or in AB below 30,000 feet MSL or while supersonic:

4. Land as soon as possible.

38.5.11.16 INLET BUZZ GE100 / GE129

Inlet buzz occurs at supersonic airspeeds if an engine control system failure or a CADC mach signal failure results in insufficient airflow or if the throttle is retarded below MIL while operating in HYB or SEC. Inlet buzz causes moderate to severe vibration within the cockpit and may result in multiple engine stalls.

If inlet buzz occurs, the throttle should not be moved until subsonic. Decrease airspeed to subsonic as quickly as possible by opening the speedbrakes and increasing g. If engine stalls occur and persist, the throttle should be retarded to IDLE when subsonic. If the stalls do not clear, refer to AIRSTART PROCEDURES GE100/129, this section.

38.5.11.17 ENGINE OVERSPEED GE100 / GE129

An overspeed occurs when engine rpm exceeds 109.5 percent. If an overspeed condition occurs, an MFL is recorded and the engine control attempts to reduce rpm below maximum limit. However, if the DEC malfunctions and engine rpm reaches 113 percent, the overspeed protection in the MEC closes the overspeed fuel shutoff valve resulting in a flameout. The overspeed fuel shutoff valve will reset to open when the rpm decreases through 55 percent. Refer to AIRSTART PROCEDURES GE100/129, this section.

38.5.11.18 ENGINE FAILURE OR FLAMEOUT GE100 / GE129

If the engine flames out, fuel starvation or mechanical failure has occurred.

A flameout is indicated by a decrease in FTIT and engine rpm decaying below in-flight idle (approximately 70 percent rpm). Loss of thrust and lack of response to throttle movement confirm the flameout. The ENGINE warning light illuminates when engine rpm is below 60 percent. Additionally, the MAIN GEN and STBY GEN lights illuminate below 50 percent rpm and the EPU should start running. Do not mistake a loss of ECS noise as an engine flameout.

A flameout indicates an engine control failure, fuel starvation, fuel system malfunction, or fuel cutoff due to engine overspeed protection. If the engine flames out, two features may instantly restart the engine. There is an autorelight feature and the capability to automatically transfer to SEC if certain faults are detected in PRI. If these features work, the restart may take place instantly and the flameout may not be noticeable (except for the illumination of the SEC caution light). In this situation, remain in SEC. (Refer to SEC CAUTION LIGHT GE100/129 , this section.)

If the flameout progresses to the point that it is noticeable, initiate AIRSTART PROCEDURES GE100/129, this section.

38.5.11.19 LOW ALTITUDE ENGINE FAILURE OR FLAMEOUT GE100 / GE129

Initial reaction to any malfunction at low altitude should be to trade excess airspeed for altitude. Higher altitude translates directly to either additional time to achieve an airstart or to additional glide range to reach a suitable landing field. Above 310 knots, more time is available by performing a zoom climb using a 3g pullup to 30-degree climb until approaching the desired airspeed (use approximately 50 knots lead point) and then initiating a zero-g pushover. Below 310 knots, more time is available by performing a constant altitude deceleration to the desired airspeed; if required, climb to achieve minimum recommended ejection altitude.

If the zoom results in an altitude below 4000 feet AGL, there may be insufficient time to achieve an airstart prior to reaching minimum recommended ejection altitude. In that case, primary consideration should be given to preparing for ejection; do not delay ejection below 2000 feet AGL.

If low altitude engine failure or flameout occurs:

1. Zoom.
2. Stores - Jettison (if required).

If stores jettison is attempted after main and standby generators drop off line but before EPU generator powers the SMS (approximately 5 seconds delay), stores will not jettison.

NOTE
Visually confirm the stores have jettisoned and jettison again if required

3. Perform airstart (if altitude permits). Refer to AIRSTART PROCEDURES GE100/129, this section.

WARNING
Below 4000 feet AGL, there may be insufficient time to perform an airstart prior to minimum recommended ejection altitude.

38.5.11.20 AIRSTARTS GE100 / GE129

CAUTION

Prior to initiating airstart procedures, verify lack of thrust response to throttle movement to ensure the problem is an actual engine malfunction and not just an engine instrument problem.

NOTE

The term airstart for the GE engine is defined as the procedure to restore engine operation primarily by using the ENG CONT switch. Cycling the ENG CONT switch from PRI to SEC and, if necessary back to PRI, is the most effective corrective action that can be accomplished. Shutting the engine down by cycling the throttle to OFF is reserved for engine overtemperature.

Airstarting the engine does not require exact airspeeds or rpm ranges, but there are key events that must be performed in a timely manner in order to have the best chance for obtaining sufficient thrust. The key events are initiating the recovery while engine rpm is still high and selecting SEC immediately. If conditions permit, allow up to 10 seconds to observe if selecting SEC recovered the engine (increasing thrust or rpm/FTIT). If the engine does not recover during this time in SEC, then return the ENG CONT switch to PRI.

Returning the ENG CONT switch to PRI from SEC is an attempt to reset the DEC logic. In order for this reset to occur, a minimum pause of 1/2 second is required in SEC. If the fault cannot be corrected by the control logic reset (PRI-SEC-PRI), the DEC will auto transfer again to SEC or hybrid.

In a low altitude situation, the priorities are zooming the aircraft and jettisoning stores, if required. The pilot should then select SEC and, after a minimum pause of 1/2 second, immediately reselect PRI in an attempt to regain useable thrust. Exact throttle position is not important during an airstart for either PRI or SEC, so any position between IDLE and MAX AB is acceptable. Multiple PRISEC- PRI attempts are authorized, but be sure to allow enough time (up to 10 seconds, time and conditions permitting) for the engine to begin recovering before making subsequent PRI-SEC-PRI attempts.

In flight, the only reason the throttle must be retarded to OFF then back to the operating range (midrange position preferred) is to terminate a hot start. This provides a fuel stop switch function only and does not change fuel scheduling nor turn on either main or auxiliary ignition. These are a function of rpm only. Shutting down the engine for reasons other than a hot start is not recommended as this terminates any recovery attempt which may be in progress.

Oil pressure is directly related to rpm. Do not confuse a low oil pressure indication due to windmilling rpm as an oil system malfunction.

Factors such as altitude, airspeed, weather, etc., must be considered in determining whether to perform airstart procedures, to accomplish a flameout landing, or to eject. Jettisoning stores reduces altitude loss during an airstart and improves glide ratio during flameout landing.

If gliding distance is not a factor, maintain 250 knots or more in order to reduce rpm rate of decay until the JFS can be started. The engine can be recovered with airspeeds from 170-400 knots/0.9 mach; however, 250 knots provides the best tradeoff of altitude loss, range, and airflow for the engine.

A successful engine recovery depends on many variables: cause of flameout, type of fuel, altitude, airspeed, and engine rpm when the recovery is attempted. High engine rpm is the most important variable and provides the best chance of a successful restart. Therefore, do not delay the initiation of an airstart (PRI-SEC-PRI) in an attempt to reach a particular flight condition. Initiate the airstart as soon as it becomes apparent that engine rpm has decayed below in-flight idle (approximately 70 percent rpm) or illumination of the ENGINE warning light, engine instrument indications, and no response to throttle movement confirm a flameout. The best conditions for engine recovery in either PRI or SEC are below 30,000 feet MSL, at 250 knots or more, and with high engine rpm.

Of equal importance to selecting SEC when required is preserving engine rpm. The JFS should be started as soon as the aircraft is in the JFS envelope. The advantage of using the JFS to assist the airstart is that once the JFS RUN light is on, airspeed can be reduced. Under normal conditions the JFS will motor the engine at a minimum of 25 percent.

In the event that the ENG CONT switch movements do not reverse the rpm spooldown, or FTIT exceeds 935°C and the engine fuel is shut off temporarily with the throttle, be aware that throttle advances made between 25-50 percent engine rpm are slow to light-off and may take up to 90 seconds to regain usable thrust. If altitude is available, increasing airspeed can assist engine acceleration and decrease the time to regain usable thrust once a lightoff is achieved. As long as engine rpm continues to increase, this condition should not be considered as a hung/no start. Spooldown airstarts initiated below 25 percent rpm have been successful during flight tests, but spool up to usable thrust may take more time than is available. Keep engine rpm at 25 percent or above during spooldown airstarts, if possible.

Following the potential rapid FTIT rise and peak of a light-off, FTIT slowly decreases approximately 50°C. Therefore, do not confuse a drop in FTIT as an unsuccessful airstart unless accompanied by decreasing rpm as well.

If the engine recovers normally, turn the JFS off, depress the ELEC CAUTION RESET button to reset the main generator, cycle the EPU switch OFF then back to NORM, and check for the presence of OFF and/or AUX warning flags in the ADI. If the ADI warning flags are present, refer to TOTAL INS FAILURE LESS or EGI FAILURE, this section.

38.5.11.21 HIGH ALTITUDE AIRSTART CONSIDERATIONS GE100 / GE129

As altitude is increased above 30,000 feet MSL, the probability of a successful airstart/engine recovery can be improved by selecting SEC as soon as possible and by quickly descending to altitudes below 30,000 feet MSL. If engine recovery is not apparent after 10 seconds in SEC, re-select PRI. Airspeeds above 250 knots (400 knots/0.9 mach maximum) should be considered as a means to reduce altitude and increase the probability of a successful airstart. Do not become tempted to shut down the engine with the throttle unless FTIT exceeds 935°C. If the engine is restartable, fuel and ignition will be automatically scheduled. A lightoff will occur when inlet conditions become more favorable and/or the JFS envelope is attained and rpm can be increased. Spooldown airstarts can be achieved with rpm as low as 25 percent, but not at all airspeeds and altitudes.

NOTE

Engine shutdown and restarts initiated above 30,000 feet MSL and below 250 knots have a higher probability of either a no-start or a hot start.

At high altitudes, dive as required to maintain speed in the 250-400 knot/0.9 mach range. Unless an airstart is obviously impossible (total lack of fuel, tower shaft failure, engine seizure, etc.), do not become tempted to establish a maximum range or maximum endurance glide.

When below 20,000 feet MSL, turn JFS on. Activating the JFS above 20,000 feet MSL is prohibited since successful JFS start/motoring of engine is unlikely and the brake/JFS accumulators will be depleted. If the JFS RUN light is on, airspeed may be reduced to achieve maximum range or maximum endurance (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 1000, D zero pounds). Time constraints due to EPU fuel consumption must also be considered. A maximum range or maximum endurance glide from above approximately 35,000 feet MSL may exhaust EPU fuel prior to landing. With the JFS running, EPU fuel consumption is also reduced.

38.5.11.22 LOW ALTITUDE AIRSTART CONSIDERATIONS GE100 / GE129

After zooming the aircraft and jettisoning stores, if required, initiate the airstart procedure as soon as possible. Place the ENG CONT switch to SEC for a minimum of 1/ 2 second, immediately reselect PRI, and turn on the JFS (START 2) to assist the airstart.

Following a zoom climb, plan to arrive at 250 knots until the JFS RUN light is on; airspeed may then be reduced to achieve maximum range or maximum endurance (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 1000, D zero pounds). If a higher airspeed is maintained or an attempt is made to gain airspeed to delay the rpm decay, available time may be reduced to the point that an airstart is not possible.

During any low altitude airstart attempt, constantly evaluate altitude above the ground relative to airstart success. Do not delay ejection below 2000 feet AGL unless the engine is producing thrust capable of maintaining level flight or safely controlling the sink rate or unless a flameout landing can be accomplished.

38.5.11.23 AIRSTART PROCEDURES GE100 / GE129

To begin the airstart procedure, place the ENG CONT switch to SEC. If the engine does not show signs of recovery, (increasing thrust or rpm/FTIT), within approximately 10 seconds, return the ENG CONT switch to PRI. If time and conditions do not permit observing if a recovery has occurred in SEC, reselecting PRI immediately after a minimum of 1/2 second delay in SEC offers the best chance of engine recovery.

Monitor for signs of a light-off, which are characterized by a rapid rise in FTIT, accompanied by a slow increase in rpm.

If a hot start occurs, retard the throttle to OFF and allow the FTIT to drop to below 700°C before advancing the throttle to midrange. Increasing the airspeed (maximum of 400 knots/0.9 mach) should help the next airstart to be cooler. If a second hot start occurs, retard the throttle to OFF, select the opposite ENG CONT switch position, and allow the FTIT to decrease below 700°C before advancing the throttle.

After entering the JFS envelope, start the JFS to assist in preserving rpm. With the JFS RUN light on, airspeed may be reduced to achieve maximum range/endurance.

If the JFS stops running or fails to run within 30 seconds, do not reattempt a JFS start until the brake/JFS accumulators have had time to recharge. Allow 1 minute of engine rotation (either windmilling or JFS-assisted) at 12 percent rpm or above to insure that the brake/JFS accumulators are fully recharged. Recharging begins 3-4 seconds before the JFS RUN light illuminates or 30 seconds after selecting a start position (in the event of a JFS failure to run). Recharging occurs regardless of JFS switch position.

In the event of a JFS shutdown, the JFS switch does not relatch in either start position while the JFS is spooling down. Spooldown from full governed speed takes approximately 17 seconds. The JFS switch must be cycled to OFF and then START 2 to reinitiate a JFS start. It is possible to complete the spooldown before the brake/JFS accumulators are recharged if the JFS ran for only a short time.

It is possible the engine may not respond properly to throttle movement following an otherwise successful airstart. If this occurs or if thrust is insufficient to ensure a safe landing, refer to FLAMEOUT LANDING, this section.

When the airstart is completed and usable thrust is regained, turn the JFS off. Reset the main generator using the ELEC CAUTION RESET button and verify MAIN GEN and STBY GEN lights are off. Cycle the EPU switch to OFF and then back to NORM.

WARNING
With engine failure or flameout, OBOGS is inoperative. Activate EOS if OXY LOW warning light illuminates above 10,000 feet cockpit altitude.

To accomplish an airstart:

1. ENG CONT switch - SEC (even if SEC caution light is on), then PRI.

CAUTION
If at low altitude, position the ENG CONT switch to SEC for a minimum of 1/2 second, then immediately back to PRI.

NOTE
If not at low altitude, position the ENG CONT switch to SEC. If the engine does not show signs of recovery (increasing thrust or rpm/ FTIT) within 10 seconds, time and conditions permitting, return the ENG CONT switch to PRI.

2. Airspeed - Attain approximately 250 knots or establish maximum range or endurance airspeed (200 or 170 knots, respectively, plus 5 knots per 1000 pounds of fuel/store weights over C 1000, D zero pounds) with JFS RUN light on.

Above 30,000 feet MSL, airspeeds in the 250-400 knot/0.9 mach range should be considered to reduce altitude and increase the probability of a successful airstart.

NOTE
If maximum gliding range is not a factor, consider maintaining 250 knots or more above 10,000 feet AGL to provide best restart conditions (in case of JFS failure). Below 10,000 feet AGL with the JFS RUN light on, maintain maximum range or maximum endurance airspeed.

3. JFS switch - START 2 below 20,000 feet MSL and below 400 knots.

NOTE
• If the JFS switch is erroneously placed to START 1, leave it there. • If the JFS RUN light does not illuminate or goes off once illuminated, place the JFS switch to OFF and reattempt START 2 when the brake/JFS accumulators are recharged. The JFS switch does not relatch in either start position while the JFS is spooling down.

4. Stores - Jettison (if required).

If stores jettison is attempted after main generator drops off line but before EPU generator powers the SMS (approximately 5 seconds delay), stores will not jettison.

NOTE
Visually confirm the stores have jettisoned and jettison again if required.

If engine FTIT exceeds 935°C:

5. Throttle - OFF, then midrange.

Allow FTIT to drop below 700°C before advancing the throttle.

CAUTION
• FTIT should decrease rapidly when throttle is OFF. If FTIT does not decrease rapidly, verify the throttle is OFF. • Do not mistake a rapid initial FTIT increase during an airstart as an indication of a hot start.

NOTE
Typically, airstarts are characterized by rapidly increasing FTIT with a slow increase in rpm.

6. Airspeed - Increase (400 knots/0.9 mach maximum).

If a second hot start occurs:

7. Throttle - OFF.
8. ENG CONT switch - SEC.
9. Throttle - Midrange after FTIT drops below 700°C.

If hung start occurs:

NOTE
Hung start is indicated by the FTIT stabilized below 935°C and rpm has stopped increasing.

10. ENG CONT switch - SEC, if in PRI; PRI, if in SEC.

NOTE
• Stay in the mode that successfully restarts the engine. • The proximity of the ENG CONT switch to the JFS switch makes the JFS switch susceptible to being bumped to OFF when selecting SEC.

If engine does not recover or if thrust is still insufficient to make a safe landing:

11. Refer to FLAMEOUT LANDING, this section.

If engine responds normally:

11. JFS switch - OFF.
12. ELEC CAUTION RESET button - Depress.

Verify MAIN GEN and STBY GEN lights are off.

13. EPU switch - OFF, then NORM.
14. ADI - Check for presence of OFF and/or AUX warning flags.

If warning flag(s) is in view, refer to TOTAL INS FAILURE LESS, or EGI FAILURE this section.

CAUTION
If only AUX flag is in view, pitch and roll attitude information is likely to be erroneous due to INS autorestart in the attitude mode when other than straight and level, unaccelerated flight conditions existed.

15. Land as soon as possible.

NOTE
Consider an SFO. Refer to SIMULATED FLAMEOUT (SFO) LANDING, this section.

16. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

38.6 Landing Emergencies

Refer to the BMS checklists under *Docs\02 Aircraft Manuals & Checklists\01 F-16\F-16 Checklists*, "SECTION EP LANDING" for further details.

38.6.1 FLAMEOUT LANDING

The decision to eject or make a flameout landing rests with the pilot. Considerations for attempting a flameout landing must include:

1. Nature of the emergency.
2. Weather conditions.
3. Day or night.

NOTE

A flameout approach at night should be treated as an IMC penetration if the landing runway is not visible at the initiation of the approach.

- Proximity of a suitable landing runway.
- Proficiency in performing simulated flameout (SFO) landings.

Due to the capabilities of the ejection seat, the entire approach is within the ejection envelope; however, ejection should not be delayed in an attempt to salvage a questionable approach. When performing a flameout landing, the aircraft can safely stop (dry runway without arresting gear) in approximately twice the computed ground roll distance (8000-foot minimum runway length recommended), assuming a touchdown no more than 1/3 of the way down the runway at 11-13 degrees AOA. To perform a flameout landing, turn immediately toward the desired runway. Jettison stores (if required) and establish maximum range airspeed. Maximum range airspeed may be less than the minimum airstart airspeed. If range to the desired runway is critical, the decision to attempt an airstart or a flameout landing rests with the pilot.

NOTE

During an airstart attempt, do not slow below the minimum airstart airspeed.

- If the engine is still running, but thrust is insufficient to sustain level flight, treat it as a flameout situation.
- The TACAN is not powered when the main generator is off line.

Maximum range airspeed varies only with GW and is not affected by drag index. Maximum range airspeed is 200 knots for a GW of 20,000 pounds and increases 5 knots per 1000 pounds of actual GW above 20,000 pounds. For most circumstances, sufficient accuracy is obtained by adding 5 knots per 1000 pounds of fuel/store weights over 1000 pounds.

NOTE

• If range to desired runway is critical, maximum range airspeed may be calculated using actual GW in excess of 20,000 pounds.

• For a 10,000-foot descent (LG up), each 10 knots above or below maximum range airspeed decreases glide range up to 1/4 nm. an airstart attempt, do not slow below the minimum airstart airspeed.

The maximum range airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm per 5000 feet AGL (a no wind condition). Retaining stores or flying into a headwind decreases glide range significantly.

The EPU should be on and, if aircraft fuel is available, the JFS should be started using START 2 when below 20,000 feet MSL and below 400 knots unless the engine is either seized or anticipated to seize. The EPU should provide a minimum operation of 10 minutes (HYDRAZN light on) with normal flight control demands before EPU fuel depletion. Operating time can be extended to as much as 15 minutes if the JFS is running and flight control inputs are minimized. If expected time to landing exceeds expected EPU operating time and excess energy is available, a steeper/faster descent may be flown. The JFS also provides hydraulic pressure for normal LG extension, normal braking, and NWS after landing. If the JFS is not running, alternate LG extension will be required, accumulator braking will be required, and NWS will be inoperative.

When bleed air is no longer available to operate the EPU, confirm that the EPU is operating on hydrazine (EPU run and HYDRAZN lights on) since the JFS alone does not provide adequate hydraulic pressure to land the aircraft. If the EPU is inoperative, maneuver the aircraft as necessary on JFS-assisted hydraulic pressure to a more favorable ejection envelope and initiate ejection.

There are two basic types of flameout landing patterns: the overhead approach or the straight-in approach. The overhead approach is preferred as it affords the most opportunities to properly manage available energy while providing the best visual cues for pattern corrections. The overhead approach may be entered at any position, provided the proper altitude for that point in the pattern can be obtained. The main concern is to reach high key, low key, or base key at or above the recommended minimum key altitudes. A straight-in approach is an alternate approach when the overhead approach cannot be attained. For both approaches, the initial aimpoint should be approximately 1/3 of the way down the runway.

38.6.2 OVERHEAD APPROACH

Plan to arrive over the landing runway (high key) at 7000-10,000 feet AGL. The high key position may be approached from any direction.

The recommended key altitudes are based on flying a 360- degree descending turn from high key with the LG down. The altitudes vary with GW and with additional drag due to stores. The recommended high key altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over 1000 pounds The recommended low-key altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over 1000 pounds. These formulas include compensation for stores drag effects; thus, no additional correction is required.

If altitude will be significantly higher at high key, some form of altitude dissipating maneuver such as a dive, gentle S-turns, or a 360-degree descending turn should be used. Speedbrakes also may be used to lose excess altitude. However, if the speedbrakes are not closed when a satisfactory flightpath is reached, the added drag may preclude a successful flameout approach.

After departing high key, all attention should be directed toward a successful landing. If actual altitude at high key was below the recommended altitude, fly maximum range airspeed with the LG up until a satisfactory flightpath is reached and then lower the LG. Optimum LG down airspeed is 10 knots less than maximum range (LG up) airspeed. Minimum LG down airspeed is 20 knots less than maximum range (LG up) airspeed and provides sufficient maneuverability to arrest the high sink rate associated with a flameout approach. Optimum angle of bank is 50 degrees with the LG up and 55 degrees with the LG down. Bank angles more than 10 degrees above/ below optimum result in a significant increase in altitude loss per degree of turn and may preclude a successful flameout approach.

NOTE

- Delaying LG extension until low key allows successful completion of the overhead approach from as low as 1500 feet below the recommended high key altitude.
- Altitude loss for a 360-degree descending turn with the LG down increases up to 500 feet for every 10 knots above optimum LG down airspeed.
- Altitude loss for a 360-degree descending turn with the LG down increases up to 500 feet for each 5 degrees above/below the optimum bank angle.

The ground track of a flameout/SFO overhead approach is approximately the same as that of a normal overhead approach except the final approach is approximately ¾ nm long. Avoid rapid flight control inputs which use excessive EPU fuel and may exceed the emergency hydraulic pump capability.

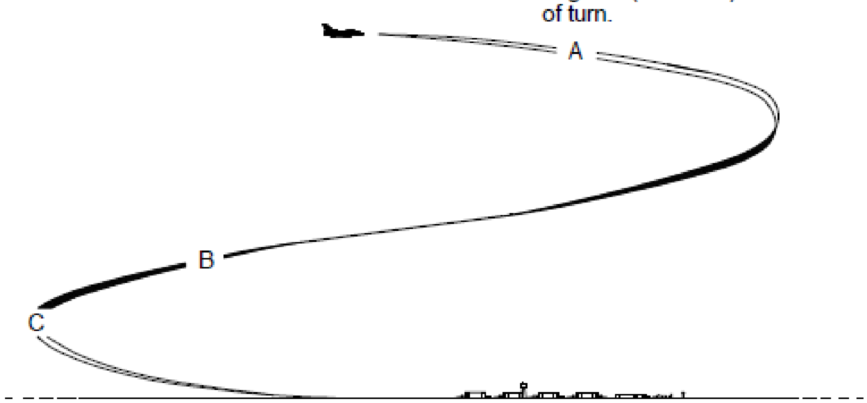
WARNING

If EPU fuel quantity is below 25 percent at high key (20 percent with the JFS running), a flameout landing should not be attempted since adequate hydraulic pressure may not be available through the landing.

(OVERHEAD APPROACH)

NOTES:

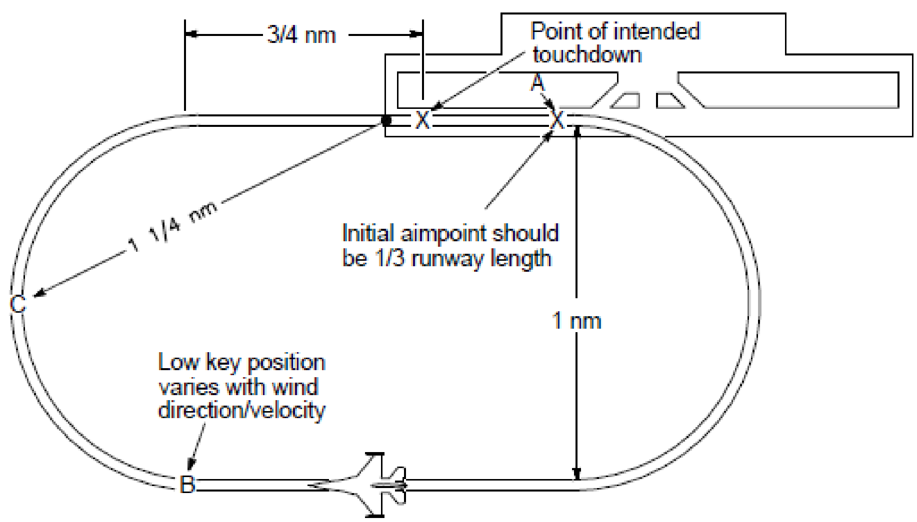
1. Jettison stores (if required).
2. Maximum range (LG up) airspeed is 200 knots. Optimum airspeed (LG down) is 190 knots. Minimum LG down airspeed is 180 knots. Increase airspeeds by 5 knots per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
3. Maximum range (LG up) airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm per 5000 feet AGL. If stores are retained, glide ratio decreases.
4. Altitudes:
   - High Key – 7000-10,000 feet AGL
     Recommended altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
   - Low Key – 3000-5000 feet AGL
     Recommended altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
   - Base Key – 2000 feet AGL minimum
5. Optimum bank angles are 50 degrees (LG up) and 55 degrees (LG down) for least altitude lost per degree of turn.



A. HIGH KEY – Above a point approximately 1/3 of the way down the runway

B. LOW KEY – Abeam point of rollout on final

C. BASE KEY – Midpoint of turn from downwind to final



38.6.3 STRAIGHT-IN APPROACH

If one of the overhead approach key positions cannot be reached, a straight-in approach may be flown. The clean glide at maximum range airspeed should be continued until the initial aimpoint is 11-17 degrees below the horizon; then the LG should be lowered. Seventeen degrees is below the forward field of view. A good visual reference for 15 degrees is when the initial aimpoint is at the bottom of the HUD (just above the radome). Optimum LG down airspeed is 10 knots less than maximum range (LG up) airspeed. Minimum LG down airspeed is 20 knots less than maximum range (LG up) airspeed and provides sufficient maneuverability to arrest the high sink rate associated with a flameout approach.

NOTE
For a 10,000-foot descent (LG down), each 10 knots above optimum LG down airspeed decreases glide range up to 1/2 nm.

38.6.3.1 IMC PENETRATION

Should IMC be encountered during a flameout approach to the intended runway and no alternate runway is available, an alternate descent/penetration may be flown which should allow maneuvering airspeed after penetrating the undercast.

WARNING
IMC penetration should not be attempted unless present position is known and navigation can be performed throughout the descent, and high terrain or other hazards are not a factor.

The stores should be jettisoned, and the aircraft glided at maximum range airspeed until a 1:1 ratio between altitude in thousands of feet and range to the runway (e.g., 20,000 feet AGL at 20 nm, 15,000 feet AGL at 15 nm, etc.) is attained. The descent angle should then be increased, and airspeed allowed to increase to maintain the 1:1 ratio. This equates to a 9–10-degree descent angle. This 1:1 glide ratio must be maintained until sufficient airspeed is attained to maneuver after penetrating the undercast.

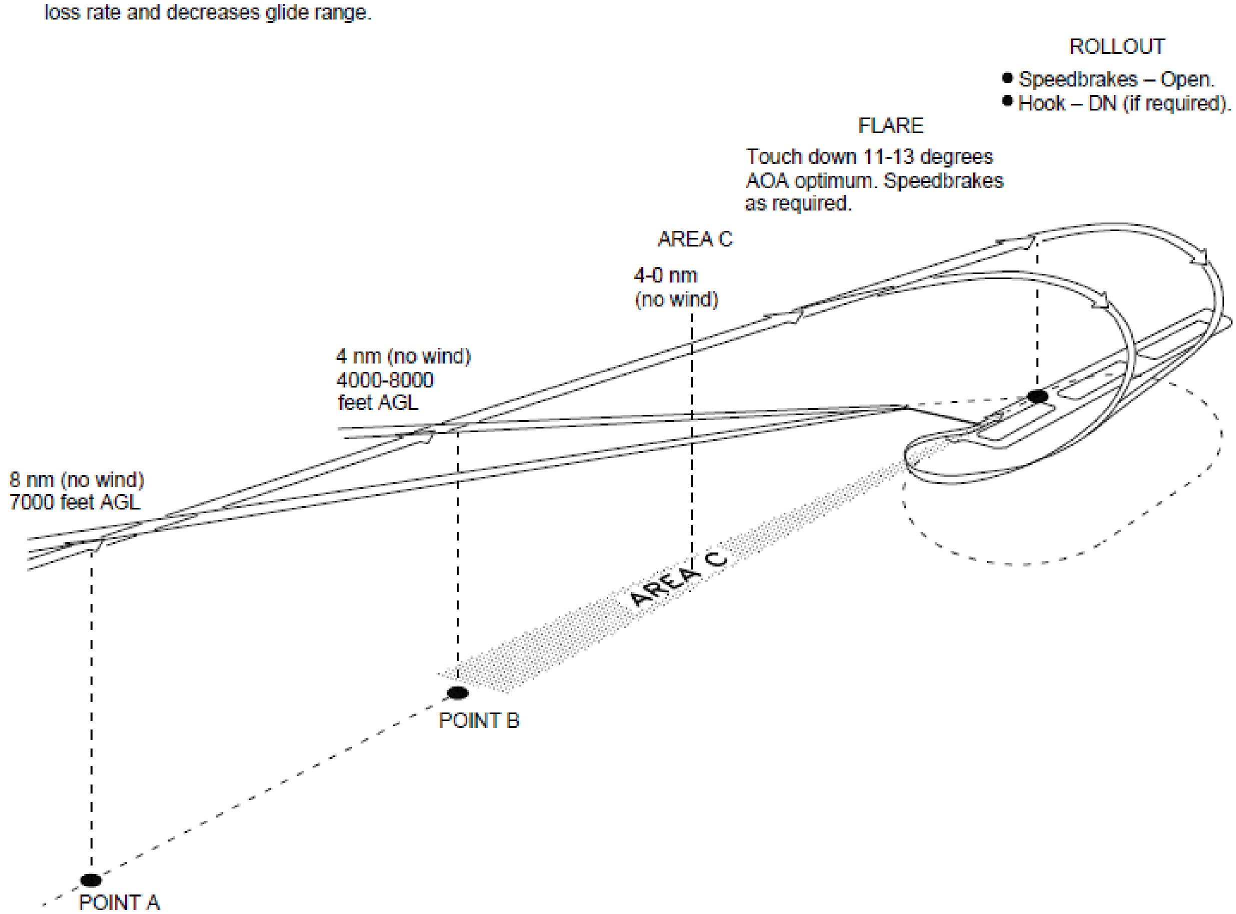
NOTE
A 90-degree level turn at 50 degrees bank angle with the LG and speedbrakes retracted will dissipate 65-85 knots. A 180-degree turn will dissipate 145-250 knots. Airspeed dissipation increases with increasing GW and DI. A glide angle at a 1:1 ratio begun from maximum range airspeed will result in an airspeed of 260- 320 knots after a 10,000-foot descent. Higher airspeed at the start of the glide, additional descent altitude, heavier gross weight, or lower drag index will result in higher airspeed at the completion of the glide

At 3000 feet AGL, the aircraft should be 3 nm from the touchdown point. If the runway is not in sight by base key altitude, the aircraft may be zoomed for a controlled ejection. When VMC is attained and the runway is in sight, the aircraft should be glided to an attainable key position for an overhead approach or to a straight-in approach and the LG should be lowered. Excess airspeed above optimum LG down airspeed not required to maneuver to the flameout landing approach should be dissipated by use of speedbrakes or early LG extension.

(STRAIGHT-IN APPROACH)

NOTES:

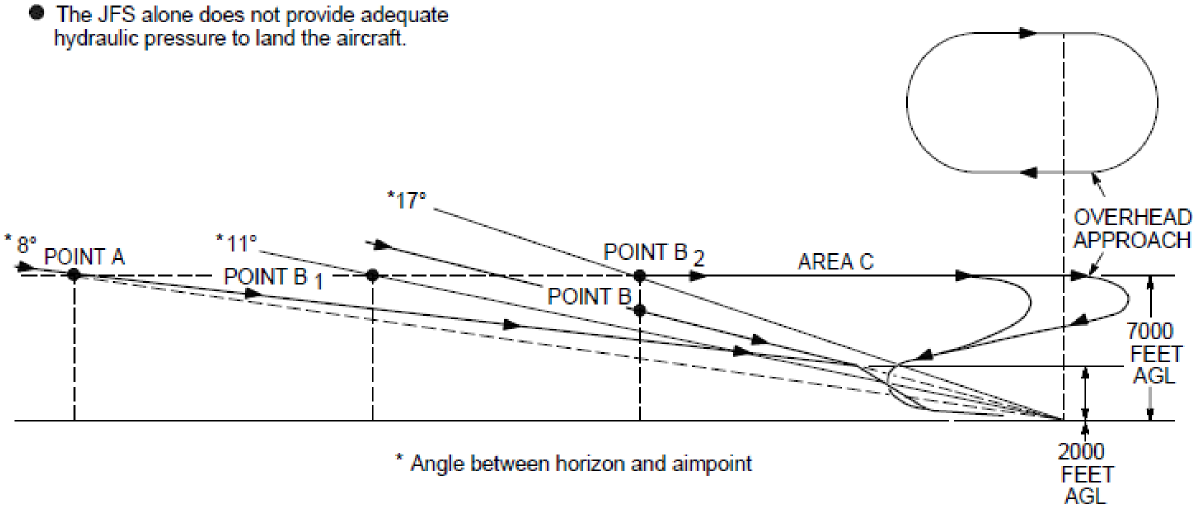
1. Jettison stores (if required).
2. Maximum range (LG up) airspeed is 200 knots. Optimum airspeed (LG down) is 190 knots. Minimum LG down airspeed is 180 knots. Increase airspeeds by 5 knots per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
3. Maximum range (LG up) airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm for each 5000 feet AGL. If stores are retained, glide ratio decreases.
4. Minimum altitudes are based on an LG up glide at maximum range airspeed to 2000 feet AGL followed by an LG down glide at optimum LG down airspeed to the runway for a drag index of 100.
5. After lowering LG, glide range decreases by approximately 30 percent. Airspeed greater than optimum LG down airspeed significantly increases energy loss rate and decreases glide range.
6. Frost or condensation on the canopy could restrict visibility during flameout approach. Place AIR SOURCE knob to RAM and place DEFOG lever forward below 25,000 feet MSL.
7. Time constraints due to EPU fuel consumption must be considered as well as distance to be covered. To estimate required EPU fuel for a nonstandard approach, use 15 percent per minute as a basis for computation.
8. Starting JFS reduces load on EPU, conserves EPU fuel, and partially restores hydraulic system B.
9. If alternate LG extension is used, the NLG may not indicate down until airspeed is reduced below 190 knots.



(STRAIGHT-IN APPROACH)

WARNING

- Do not allow airspeed to decrease below minimum LG down airspeed.
- If the aimpoint on the runway moves up in the field of view while maintaining maximum range (LG up) airspeed, the runway probably cannot be reached. This path corresponds to a glide angle of about 7 degrees between the horizon and the aimpoint.
- The JFS alone does not provide adequate hydraulic pressure to land the aircraft.
- EPU fuel quantity (points A, B_1, and B_2) should be sufficient to insure adequate hydraulic pressure through landing.
- Eject if it becomes obvious that a safe landing cannot be made. Ejection can be accomplished at any point in the approach; however, do not delay ejection below 2000 feet AGL in an attempt to salvage a questionable approach.



* Angle between horizon and aimpoint

POINT A

8 nm (no wind), 7000 feet AGL, continue glide until initial aimpoint is 11-17 degrees below horizon. Then lower LG and establish optimum LG down airspeed. As a guide, no wind minimum EPU fuel is 45 percent (40 percent with JFS running).

POINT B

4 nm (no wind), 4000-8000 feet AGL, airspeed and LG as required. As a guide, no wind minimum EPU fuel is:

POINT B 1

6 nm - 35 percent (30 percent with JFS running).

POINT B 2

4 nm - 25 percent (20 percent with JFS running).

WARNING

Do not delay lowering LG below 2000 feet AGL.

AREA C

4-0 nm (no wind), initial aimpoint is more than 17 degrees below horizon (under nose of aircraft and not visible). Normal straight-in approach is not feasible.

Options are:

- Delay LG lowering. Plan an overhead approach from a high key altitude but below the normal recommended altitude.
- Delay LG lowering. Plan a modified flightpath to low key.
- Lower LG, open speedbrakes, and dive and maneuver aircraft to intercept a point on the normal straight-in glidepath.

38.6.4 LANDING PHASE

The LG should be lowered no later than 2000 feet AGL to allow adequate time for alternate LG extension. Establish a glidepath to achieve the initial aimpoint while maintaining optimum LG down airspeed. Once wings level on final approach, be aware of the tendency to slow below minimum LG down airspeed.

WARNING
Do not attempt to stretch a glide by allowing the airspeed to decrease below minimum LG down airspeed. A slower airspeed decreases the maneuverability available to arrest the high sink rate associated with the flameout approach and may preclude a successful flameout landing.

Once landing is assured, the recommended procedure is to shift the aimpoint from 1/3 of the way down the runway to a position short of the intended touchdown point. Speedbrakes may be used to help control airspeed. The higher the airspeed, the shorter the aimpoint should be to allow for additional float (from flare to touchdown). The aircraft is easiest to control in the flare if the flare is begun between optimum and minimum LG down airspeeds. The point at which the flare is begun depends upon airspeed, sink rate, and glide angle. The flare should be started high enough to allow a smooth gradual reduction in glide angle but not so high as to run out of airspeed prior to touchdown. Under a no wind condition, the aircraft floats 3000-4000 feet after beginning the flare, if the flare is begun at the optimum LG down airspeed. Once the sink rate is arrested, attempt to slow to a normal touchdown airspeed and AOA. If excess airspeed exists after arresting the sink rate, the best method to slow the aircraft is to stay airborne until normal touchdown airspeed is reached.

38.6.5 AFTER TOUCHDOWN

After touchdown from a flameout landing, use a normal or short field stopping technique as required by the stopping distance available. If the JFS and EPU are running, normal braking and NWS are available (NWS is inoperative if the LG was lowered with the alternate LG system). If the JFS is not running, only the brake/JFS accumulators are available to supply hydraulic pressure for braking. Stop the aircraft by making one steady brake application just short of antiskid cycling. If there is any doubt about stopping on the remaining runway, lower the hook. When the aircraft is fully stopped, have chocks installed or engage parking brake. Leave the battery online until chocks are installed. If JFS START 2 was attempted but was unsuccessful, no braking is available for stopping or directional control unless the brake/JFS accumulators are recharged. Use flaperons and rudder as required to maintain directional control. As the aircraft slows below 70 knots, directional control is reduced and the aircraft may drift right.

38.6.6 FLAMEOUT LANDING PROCEDURES

If the engine has flamed out or if flameout is imminent, turn toward a suitable runway and accomplish either an overhead approach or a straight-in approach, as appropriate.

- Altitudes (overhead approach):

- High key - 7000-10,000 feet AGL – Recommended altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over 1000 pounds.
- Low key - 3000-5000 feet AGL – Recommended altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over 1000 pounds.
- Base key - 2000 feet AGL minimum.

- Altitudes (straight-in approach):

- 8 nm - 7000 feet AGL minimum – The minimum altitude is based on an LG up glide at maximum range airspeed to 2000 feet AGL followed by an LG down glide at optimum LG down airspeed to the runway for a drag index of 100. A lower drag index slightly reduces the minimum altitude required. A higher drag index slightly increases the minimum altitude required.

- 4 nm - 4000-8000 feet AGL – Delay lowering the LG until the initial aimpoint is 11-17 degrees below the horizon.

WARNING
Eject if a safe landing cannot be made. Ejection can be accomplished at any point in the pattern but do not delay ejection below 2000 feet AGL in an attempt to salvage a questionable approach.

1. Stores - Jettison (if required).

2. Airspeed - 200 knots.

Increase airspeed 5 knots per 1000 pounds of fuel/ store weights over C 1000. This airspeed equates to approximately 7 degrees AOA.

NOTE
During an airstart attempt, do not slow below the minimum airstart airspeed.

3. EPU switch - ON.

4. JFS switch - START 2 (below 20,000 feet MSL and below 400 knots).

WARNING

- EPU fuel quantity should be at least 25 percent (20 percent with JFS running) at high key for an overhead approach or 45 percent (40 percent with JFS running) at 8 nm for a straight-in approach to insure adequate hydraulic pressure through landing.

- The JFS alone does not provide adequate hydraulic pressure to land the aircraft.

- Do not start the JFS if engine seizure has occurred or is anticipated or if engine failure is a result of fuel starvation. Starting the JFS may result in no brake/JFS accumulator pressure for the brakes.

NOTE

- If engine is not operating, consider placing the FUEL MASTER switch to OFF if a fuel leak exists. This action may conserve fuel for the JFS.

- If the JFS is erroneously placed to START 1, leave it there.

- If the JFS RUN light does not illuminate or goes off once illuminated, place the JFS switch to OFF and reattempt START 2 when the brake/JFS accumulators are recharged. The JFS switch does not relatch in either start position while the JFS is spooling down.

5. AIR SOURCE knob - RAM (below 25,000 feet MSL,18,000 feet if conditions permit).

6. DEFOG lever - Forward.

7. LG handle - DN. (Use DN LOCK REL button if required.)

WARNING

- Do not delay lowering LG below 2000 feet AGL.
- If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. PW220 Nozzle remains closed, resulting in higher-than-normal thrust.

8. ALT GEAR handle - Pull (if required) (190 knots maximum, if practical).

CAUTION

- NWS is not available following alternate LG extension.
- Do not depress the ALT GEAR reset button while pulling the ALT GEAR handle. This action may preclude successful LG extension.

9. Airspeed - 190 knots optimum in pattern.

Increase airspeed by 5 knots per 1000 pounds of fuel/ store weights over 1000 pounds.

WARNING
Do not allow airspeed to decrease below 180plus 5 knots per 1000 pounds of fuel/store weights over 1000 pounds.

After touchdown:

10. HOOK switch - DN (if required).

11. Stop straight ahead and engage parking brake.

CAUTION

- Brakes should be applied in a single, moderate, and steady application without cycling the antiskid.
- Touchdown skid control prevents brake application prior to wheel spin-up; however, brake pedal deflection of 1/16 inch causes a small flow of hydraulic fluid from the brake/JFS accumulators.
- To avoid depleting brake/JFS accumulator pressure, do not rest feet on the brake pedals.
- Do not attempt to taxi clear of the runway. Loss of brake/JFS accumulator pressure results in the inability to stop or steer the aircraft.

12. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

39 Glossary

A

A/A, AA	Air-to-Air
AAM	Air-to-Air Missile
AB	Afterburner
ac, AC	Alternating Current
A/C, ACFT	Aircraft
A/C GW	Aircraft Gross Weight
ACM	Air Combat Maneuvering
ACMI	Air Combat Maneuvering Instrumentation
ADC	Air Data Converter
ADG	Accessory Drive Gearbox
ADI	Attitude Director Indicator
AERP	Aircrew Eye/Respiratory Protection
AFC	Afterburner Fuel Control
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AG/IFF	Air-to-Ground Identification Friend or Foe
AGL	Above Ground Level
AGM	Air-to-Ground Missile
AIFF	Advanced Identification Friend or Foe
AIM	Air Intercept Missile
AL	Aft/Left
ALOW	Automatic Low Altitude Warning
ALT	Altitude, Altimeter, or Alternate
ALTRV	Altitude Reservation
AM	Amplitude Modulation
AMMO	Ammunition
ANT	Antenna
AOA	Angle of Attack
AOS	Angle of Sideslip
AP	Autopilot
A/R, AR	As Required, Air Refueling
ARCP	Air Refueling Control Point
ARI	Aileron-Rudder Interconnect
ARMT	Armament
ARS	Analog Recovery Sequencer
ASE	Aeroservoelastic
ATT, ATTD	Attitude
AUX	Auxiliary
AVTR	Airborne Videotape Recorder

B

BAK-	Arresting Cable Prefix (e.g., BAK-9)
BARO	Barometric
BATT	Battery
BDU	Bomb Dummy Unit
BIT	Built-in-Test or Binary Digit
BL	Buttock Line
BLU	Bomb Live Unit
BRU	Bomb Rack Unit
BSU	Bomb Stabilization Unit

C

CADC	Central Air Data Computer
CARA	Combined Altitude Radar
CAT	Category
CBU	Cluster Bomb Unit
CCIP	Continuously Computed Impact Point
CCM	Coil Current Monitor
CCRP	Continuously Computed Release Point
CCW	Counterclockwise
CDI	Course Deviation Indicator
CENC	Convergent Exhaust Nozzle Control
CG/C.G.	Center of Gravity
CHAN	Channel
CIU	Central Interface Unit
CMDS	Countermeasures Dispensing System
CO2	Carbon Dioxide
CIVV's	Compressor Inlet Variable Vanes
CONFIG	Configuration
CONT	Control
CRS	Course
CRT	Cathode Ray Tube
CRV	Canadian Rocket Vehicle
CSD	Constant Speed Drive
CSFDR	Crash Survivable Flight Data Recorder
CTR	Center
CTVS	Cockpit Television Sensor
CW	Clockwise

D

dBA	Adjusted (Human Ear Response) Decibels
DBU	Digital Backup
dc, DC	Direct Current
DEC	Digital Engine Control
DED	Data Entry Display
DEEC	Digital Electronic Engine Control
DEEU	Data Entry Electronic Unit
DEGR	Degraded

DF	Direction Finding
DI	Drag Index
DIA	Diameter
DIFF	Differential
DIM	Dimension
DIS	Disable
DISC	Disconnect
DME	Distance Measuring Equipment
DN	Down
DNS	Doppler Navigation System
DOI	Display of Interest
DRS	Digital Recovery Sequencer
DSG RS	Designate/Return to Search
DTC	Data Transfer Cartridge
DTOS	Dive Toss
DTU	Data Transfer Unit
DVAL	D-Value
DWAT	Descent Warning After Takeoff

E

EAS	Equivalent Airspeed
ECM	Electronic Countermeasures
ECP	Engineering Change Proposal
ECS	Environmental Control System
EDU	Engine Diagnostic Unit
EED	Electroexplosive Device
EGT	Exhaust Gas Temperature
ELECT	Electronic (primary altimeter operating mode)
ELEV	Elevation
EMCON	Emission Control Option
EMER/ EMERG	Emergency
ENDUR	Endurance
ENG	Engine
EO	Electro Optical
EPU	Emergency Power Unit
EQUIP	Equipment
EST	Estimate
ETA	Estimated Time of Arrival
EXT	Exterior/External

F

F-ACK/ FAULT ACK	Fault Acknowledge
FC	Flight Control
FCC	Fire Control Computer
FCR	Fire Control Radar
FFAR	Folding Fin Aircraft Rocket
FFP	Fuel Flow Proportioner
FLCC	Flight Control Computer
FLCP	Flight Control Panel
FLCS	Flight Control System
FLIR	Forward Looking Infrared Radar
FM	Frequency Modulation
FO	Foldout
FOD	Foreign Object Damage
FORM	Formation
FOV	Field of View
fpm, FPM	Feet per Minute/Flightpath Marker
FR	Forward/Right
FS	Fuselage Station
FT, ft	Feet
FTIT	Fan Turbine Inlet Temperature
FUS	Fuselage
FWD	Forward

G

g, G	Force of Gravity
GAAF	Ground Avoidance Advisory Function
gal, GAL	Gallon
GBU	Guided Bomb Unit
GCA	Ground Controlled Approach
GCAS	Ground Collision Avoidance System
GCI	Ground Control Intercept
GCU	Generator Control Unit
GD	Gear Down/Guard
GEN	Generator
GM	Ground Map
GND	Ground
GP	General Purpose/Group
GS	Glide Slope
GU	Gear Up
GW	Gross Weight

H

HDG	Heading
HDG SEL	Heading Select
HDPT	Hard Point
HF	High Frequency
Hg	Mercury
HMCS	Helmet Mounted Cueing System
HMD	Helmet Mounted Display
HRC	Helmet Release Connector
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
HTS	Harm Targeting System

HVI	Helmet Vehicle Interface
HYD	Hydraulic
HYDRAZN	Hydrazine
Hz	Hertz

I

IAS	Indicated Airspeed
IAW	In Accordance With
ICAO	International Civil Aviation Organization
ICP	Integrated Control Panel
ID	Identification
IFF	Identification, Friend or Foe
IKP	Integrated Keyboard Panel
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IMSP	Instrument Mode Select Panel
In., IN.	Inches
INBD	Inboard
INC	Increase
INCL	Including
IND	Indicator
INOP	Inoperative
INS	Inertial Navigation Set (or System)
INST, IN-STR	Instrument
INT	Intensity, Internal, or Interval
INU	Inertial Navigation Unit
I/P	Identification of Position
IRC	In-Line Release Connector
ISA	Integrated Servoactuator

J

JETT\JTSN	Jettison
JFS	Jet Fuel Starter
JG	Job Guide
JOAP	Joint Oil Analysis Program

K

K	Thousand (e.g., 40K = 40,000)
KCAS	Knots Calibrated Airspeed
KEAS	Knots Equivalent Airspeed
KIAS	Knots Indicated Airspeed
KT(S)	Knot(s)
KTAS	Knots True Airspeed
KVA	Kilovolt Ampere

L

L	Left
LADD	Low Altitude Drogue Delivery
LAU	Launcher Armament Unit
lb, LB	Pounds
LB/HR	Pounds per Hour
LB/MIN	Pounds per Minute
LCO	Limit Cycle Oscillation
LCOS	Lead Computing Optical Sight
LD	Load or Low Drag
LDGP	Low Drag General Purpose
LE	Leading Edge
LEF's	Leading Edge Flaps
LEMAC	Leading Edge of Mean Aerodynamic Chord
LG	Landing Gear
LH	Left Hand
LMLG	Left Main Landing Gear
LOC	Localizer
LOD	Light-Off Detector
LOX	Liquid Oxygen
LPU	Life Preserver Unit
LRES	Left Hand Reservoir
LRU	Line Replaceable Unit
LTS	Lights
LVT	Low Volume Terminal
LWD	Left Wing Down

M

M	Mach
MAAS	Mobile Aircraft Arrestment System
MAC	Mean Aerodynamic Chord
MACL	Mean Aerodynamic Chord Length
MAJCOM	Major Command
MAL	Malfunction
MAL & IND	Malfunction and Indicator
MAN	Manual
MAU	Miscellaneous Armament Unit
MAX	Maximum
MAX AB	Maximum Afterburner
Mb	Millibar
MEC	Main Engine Control
MECH	Mechanical
MEM	Memory
MFC	Main Fuel Control
MFD	Multifunction Display
MFDS	Multifunction Display Set
MFL	Maintenance Fault List
MFP	Main Fuel Pump
MHz	Megahertz
MIC	Microphone

MIDS	Multifunction Information Distribution System
MIL	Military
MIN	Minute or Minimum
MK	Mark (equivalent of model)
MLG	Main Landing Gear
mm, MM	Millimeter
MMC	Modular Mission Computer
MPO	Manual Pitch Override
MRK BCN	Marker Beacon
msec	Milliseconds
MSL	Missile or Mean Sea Level
MUX BUS	Multiplex Bus

N

NA	Not Applicable
NAM	Nautical Air Miles
NAVAID	Navigation Aid
NFOV	Narrow Field of View
NLG	Nose Landing Gear
NM, nm	Nautical Miles
No., NO	Number
NORM	Normal
NOZ POS	Nozzle Position
NVG	Night Vision Goggles
NWS	Nose Wheel Steering

O

OAT	Outside Air Temperature
OBOGS	Onboard Oxygen Generating System
OCP	Organic Change Proposal
OCSC	Overcurrent Sensing Contactor
OHEAT	Overheat
OP	Operational or Optimum
OPT	Optional
OSB	Option Select Button
OTBD	Outboard
OVRD	Override
OW, (OW)	Operating Weight
OXY, O_2	Oxygen

P

PBG	Pressure Breathing for g
PDG	Programmable Display Generator
PFL	Pilot Fault List
PFLD	Pilot Fault List Display
PLD	Personnel Lowering Device
PLS	Precission Landing System
PMEL	Precision Measuring Equipment Laboratory
PMG	Permanent Magnet Generator
PNEU	Pneumatic (secondary altimeter operating mode)
PNL	Panel
pph, PPH	Pounds per Hour
PRE	Preset
PRESS	Pressure
PRI	Primary
PROV	Provisions
PSA	Pneumatic Sensor Assembly
psi, PSI	Pounds per Square Inch
PTO	Power Takeoff (shaft from engine gearbox to ADG)
PWR	Power

Q

QDC	Quick Disconnect Connector
QMB	Quick Disconnect Mounting Bracket
QTY	Quantity

R

R	Retard, Retarded
RAD	Radio (e.g., RAD 1 or RAD 2)
RCR	Runway Condition Reading
RCVV	Rear Compressor Variable Vanes
RDR	Radar
RDY	Ready
REF	Reference
REL	Release
RER	Radial Error Rate
RES(L)	Reservoir (Left)
RES(R)	Reservoir (Right)
RET	Return
RET SRCH	Return to Search
RH	Right Hand
RIT	Reduced Idle Thrust
RIU	Remote Interface Unit
RM	Rocket Motor, Right Main
RMLG	Right Main Landing Gear
RNDS	Rounds (gun)
RNG	Ranging
rpm, RPM	Revolutions per Minute
RS	Return to Search
RSE	Reduced Speed Excursion
RSVR	Reservoir
RSVRS	Reservoirs
RT	Retarded
RV	Receive Variable/Rendezvous

RVCT	Rendezvous Control Time
RVIP	Rendezvous Initial Point
RWD	Right Wing Down
RWR	Radar Warning Receiver

S

SAI	Standby Attitude Indicator
SD	Start Descent Point
SEAWARS	Seawater Activated Release System
SEC	Secondary Engine Control
SEL	Select
SEQ	Sequence
SFO	Simulated Flameout Landing
SIF	Selective Identification Feature
SL	Sea Level
SMS	Store Management System
SNSR	Sensor
SOR	Set-On Receiver
SPD BRK	Speedbrake
SPL	Sound Pressure Level
SQ	Square
SQL	Squelch
STA	Station
STAPAC	Stabilization Package
STBY	Standby
STD	Standard
ST STA	Stores Station
SURV	Survival/Survivable
SUU	Suspension Utility Unit
SW	Switch
SYM	Symmetrical
SYS	System

T

TACAN	Tactical Air Navigation
TAS	True Airspeed
TCN	TACAN
TCTO	Time Compliance Technical Order
TEF's	Trailing Edge Flaps
TEMP	Temperature
TER	Triple Ejection Rack Unit
TEU	Trailing Edge Up
TF	Terrain Following
TGM	Training Guided Missile
TGT	Target
THEO	Theory
TISL	Target Identification Set, Laser
TM	Technical Manual
TO	Technical Order
T.O.	Takeoff
TOD	Time of Day
TOGW	Takeoff Gross Weight
TR, T/R	Transmit/Receive
TRV	Travel
TT	Total Temperature
TV	Television
TVS	Television Sensor
TWS	Threat Warning System

U

UFC	Upfront Controls
UHF	Ultra High Frequency
UNK	Unknown

V

VAC	Volts Alternating Current
VDC	Volts Direct Current
VHF	Very High Frequency
VIP	Visual Initial Point
VMC	Visual Meteorological Conditions
VMS	Voice Message System
VOL	Volume
VVI	Vertical Velocity Indicator

W

W/	With
WB	Wideband
WDU	Weapon(s) Delivery Unit
WH	Warhead
WL	Waterline
W/O	Without
WOD	Word of Day
WOW	Weight on Wheels
WPN	Weapon
WPN REL	Weapon Release
wt, WT	Weight

X

XMTR	Transmitter

Y

Y	Yaw
YY/MM/DD	Year, Month, Day

TERMS/SYMBOLS

An	Normal Acceleration

a_o	Speed of Sound at Sea Level, Standard Day
&	And
Φ	Roll Rate (Deg/Sec)
ψ	Yaw Rate (Deg/Sec)
Ay	Lateral Acceleration (Ft/Sec2)
θ	Pitch Rate (Deg/Sec)
α	Angle of Attack (Deg)
P_o	Pressure at Sea Level, Standard Day
Pt	Total Pressure
Ps	Static Pressure or Specific Energy Rate
qc	Impact Pressure (Pt – Ps)
ρ_o	Density at Sea Level, Standard Day
δ	Density Ratio
β	Angle of Sideslip
Fe	Elevator Stick Force (lb)
Fa	Aileron Stick Force (lb)
Fp	Rudder Stick Force (lb)
N2	Engine Compressor RPM or Nitrogen
P	Pressure
T	Absolute Air Temperature
W	Specific Weight (lb/Ft 3)
Vc	Calibrated Airspeed
Vt	True Airspeed
ΔH	Delta Change Altitude (Ft)
H	Altitude Rate (FPS)