PERSONAL EQUIPMENT HOOKUP - Shirt Sleeve Flight

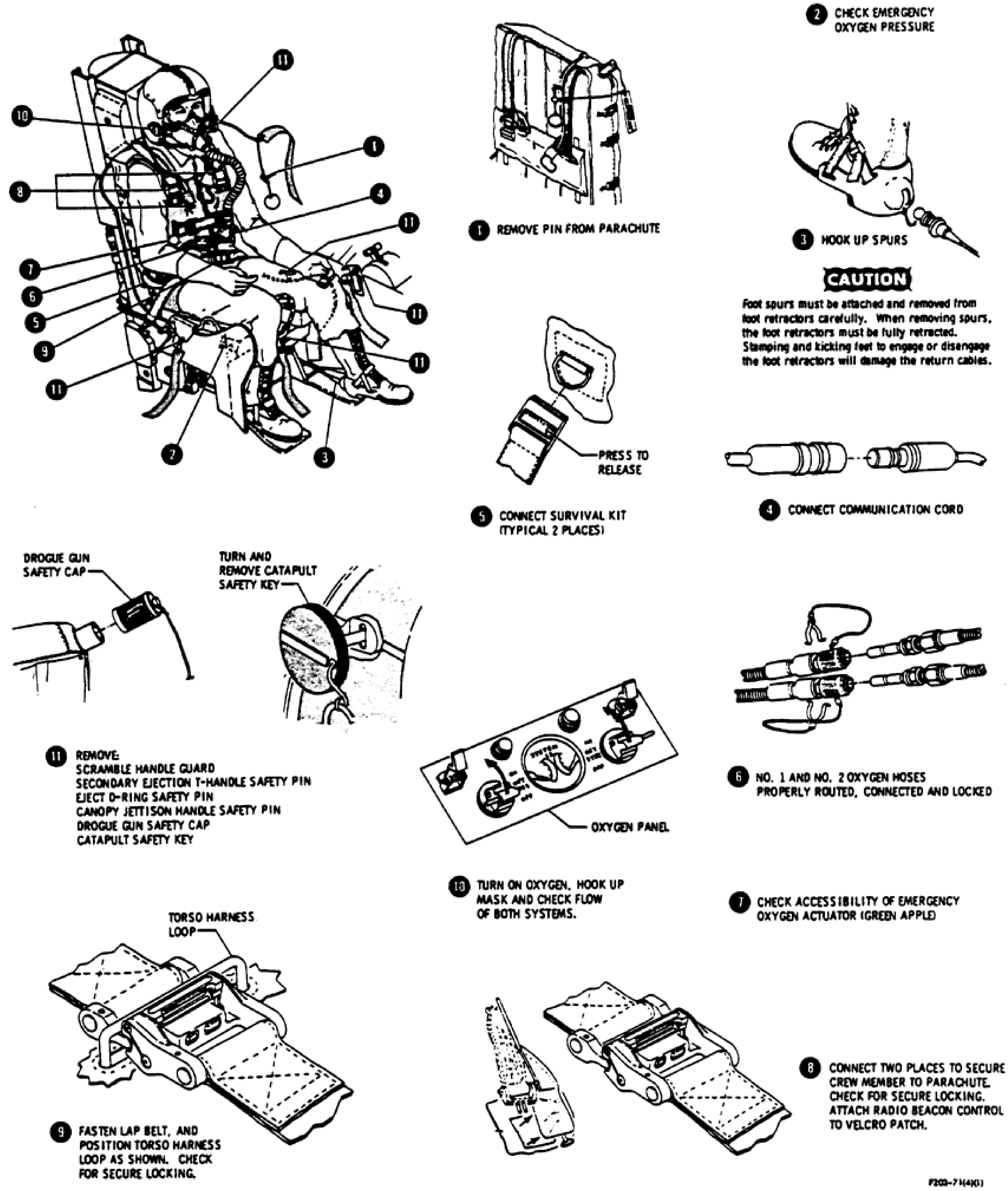


Figure 2-1 (Sheet 2 of 2)

Before each flight, check takeoff and anticipated landing gross weights and weight-and-balance clearance (Form 365F or local substitute). Note weight and moment values programmed for CG mode selector box.

NOTE

> Recommended weight and/or c.g. limits can be exceeded by seemingly normal loading arrangements. Check loading documents carefully.

AIRCRAFT STATUS

Refer to AF Form 781 for engineering, servicing, and equipment status.

PREFLIGHT CHECK - SR-71A/B

EXTERIOR INSPECTION

Because it is not practical for the flight crew to perform an exterior inspection while wearing pressure suits, the exterior inspection should be accomplished by other qualified personnel.

BEFORE ENTERING COCKPIT - SR-71A/B

▲1. Ejection seat and canopy pins -Installed

▲2. Circuit breakers - Checked in (set).

If any DAFICS computer circuit breakers are open, those in the aft cockpit should be reset approximately one minute prior to resetting those in the front cockpit.

▲3. Canopy handles - Checked.

Fwd cockpit - Locked forward.
Aft cockpit - Aft position.

4. Mode selector reference moment setting - Checked.

▲5. Publications - Checked.

FRONT COCKPIT INTERIOR CHECK - SR-71A/B

Check personal equipment hookup. (See Figure 2-1). Hookup will be performed by personal equipment personnel.

Left Console - Pilot

1. Throttle restart arming switch - NORM.

2. Liquid oxygen quantity indicators -Check SYS 1, SYS 2, and STANDBY.

   a. LOX QTY selector switch - SYS 1, IND 1.

   b. LOX quantity gage - Check both full.

   c. LOX QTY selector switch - STANDBY, IND. 1.

   d. LOX quantity gage - Check No. 1 full.

   e. LOX QTY selector switch - SYS 1, IND 1.

3. Light rheostat switches - Checked.

4. Thunderstorm lights switch - As desired.

   At night, use of these lights can facilitate the P.E. Hookup.

5. Emergency ICS switch - OFF. (Trainer only)

6. Standby oxygen system switches -OFF.

7. Control transfer panel lights - All on. (Trainer only)

Cycle control transfer switches if needed to obtain control in the forward cockpit and illuminate all four transfer lights.

8. UHF radio - ON and set.

   a. Mode - INT.

   b. VOL - Nearly full clockwise.

   c. PWR - Set.

   d. Frequency - Set.

   e. Function select - Set.

9. Oxygen control panel - Set.

10. Aft bypass position lights - Checked.

    Press to test.

11. L and R aft bypass switches -CLOSE.

12. EGT trim switches - AUTO.

13. Map projector controls - Set.

14. Throttles - OFF.

15. Throttle friction lever - Set.

16. Throttle restart switch - Cycle to OFF.

    Slide the switch to the forward bypass open and then to the restart position. Check that the MANUAL INLET and CAUTION lights illuminate. Return the switch to OFF.

17. TEB counters - 16.

Instrument Panel - Pilot

1. Cockpit pressure dump switch - OFF.

2. Bay Air switch - ON.

3. Manifold temperature switch - AUTO.

4. Landing/Taxi light switch - OFF.

5. Suit heat rheostat - OFF.

6. Face heat rheostat - Set.

   Use face heat at all times. Adjust for comfort.

CAUTION

- Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.
- The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

7. Cockpit temperature control rheostat - 12 o'clock position.

   Cockpit temperature control may have to be adjusted for varying ambient conditions.

8. Temperature indicator selector switch - R BAY.

9. L and R refrigeration switches - OFF.

10. Cockpit temperature mode selector and override switch - AUTO.

11. Defog switch - CLOSED.

12. Brake switches - Set.

    a. Set ANTI-SKID ON, or ALT STEER & BRAKES, respectively, depending on whether the left or right engine is to be started first.

    b. Set WET/DRY switch DRY.

13. Indicators and warning lights test button - Press.

    a. Spike and forward bypass position indicators full counterclockwise, (0 inches and 100% open).

b. LN_2 and LOX quantity indicators decrease to zero.

c. All cockpit caution and warning lights illuminate.

d. Gear warning tone sounds in headset.

e. All CIP indicator needles decrease to zero.

f. Fuel quantity indicator needle moves to zero. The c.g. indicator indicates 14%.

g. The annunciator panel C.G. warning light remains illuminated until c.g. indicator needle is above 17%.

14. Fuel derich switch - ARM.

15. Landing gear lever - DOWN.

16. Cabin altimeter - Field elevation.

17. Standby attitude indicator - Erecting.

If required, pull the cage knob to erect the instrument, then release the knob. The instrument will erect and then seek 7° nose-down and 0° roll (if the aircraft is level).

NOTE

A jitter of $\pm 1/2^\circ$ in the pitch axis is acceptable and may occur at any pitch angle.

18. Angle of attack indicator - Checked.

Check OFF flag out of view and AOA indicates zero.

19. Drag chute control - Checked in, light off.

Verify that the drag chute handle is in the full forward detent JETTISON position and that the DRAG CHUTE UNSAFE annunciator light is not illuminated.

WARNING

The red marking on the drag chute handle shaft must not be visible.

20. Compressor inlet temperature (CIT) gage - Checked.

Check needles together and ambient temperature indicated.

21. Airspeed/Mach Meter - Checked.

a. Limit hand setting - 460 KIAS.

b. Airspeed indication - 60 knots or less.

c. Mach number indication - Right half of window blanked. Disregard Mach reading in left half of window.

22. RSO EJECTED light - Press to test.

23. Compressor inlet pressure (CIP) gage - Checked.

L and R needles and reference pointer together and indicating barometric pressure.

24. APW switch - PUSHER/SHAKER.

With ANS, INS, or TACAN selected on the Display Mode Selector switch, the ADI glide slope pointer should deflect to the lowest dot on the glide slope displacement scale. The pointer may fluctuate if there is fuselage motion in the pitch axis.

25. Spike and forward bypass position indicators - Checked.

    a. Spikes - 0 in. aft.

    b. Forward bypass - Open 100%.

26. Accelerometer - Reset.

27. L and R spike and forward bypass controls - Cycle, then AUTO.

    Check knobs for security. Check that the MANUAL INLET and CAUTION lights are on when not in AUTO.

28. L and R restart switches - Cycle to RESTART ON, then off, individually.

    Check operation of the MANUAL INLET light when in RESTART ON.

29. Projector - Checked.

    a. Verify proper loading.

    b. Check controls and lights.

    c. Illumination as desired.

30. Surface limiter release handle - Pulled, and SURFACE LIMITER caution light off.

31. Pitot heat switch - OFF.

    Check that the PITOT HEAT caution light is on.

32. Windshield rain removal and de-ice switch - OFF.

33. Trim power switch - ON.

34. A, B and M CMPTR RESET switches - Normal (Guard down).

35. Clock - Set.

36. Altimeter - Set.

NOTE

It is possible to rotate the barometric set knob through full travel so that the 10,000-foot pointer is 10,000 feet in error. Check that the 10,000-foot pointer is reading correctly.

37. Vertical velocity indicator - Checked.

    Check for zero indication.

38. TACAN control transfer switch - CONT illuminated (SR-71A).

    Press to obtain control in the forward cockpit.

39. Engine instruments - Checked.

40. Igniter purge switch - Off.

41. Liquid nitrogen quantity gages -Checked.

42. Forward transfer switch - OFF.

43. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

44. Fuel dump switch - OFF (guard down).

45. Battery - BAT.

46. Emergency ac bus switch - NORM.

47. Generators - OFF.

48. Instrument inverter switch - NORM.

    Place switch to TEST and check that INST INVERTER ON light illuminates, then set to NORM.

<u>Right Console - Pilot</u>

1. PVD - OFF.

2. ILS power switch - ON.

3. SAS - OFF.

4. SAS lights - Test.

   All SAS panel warning lights should illuminate when the test switch is depressed including the DAFICS BIT TEST and FAIL lights.

5. Autopilot - OFF.

   Press the right console A/P OFF switch and check that the A/P OFF light is on.

6. TACAN mode selector - T/R.

7. Interphone control panel - Set.

8. IGV Lockout switches - NORM.

9. Cockpit pressure selector switch - Set.

   Select either the 10,000 or 26,000 foot setting. The 26,000 foot setting is normally desired.

10. VHF radio - TR and set.

    a. Mode select switch - As desired.

    b. Frequency control/Emergency select switch - PRE or MAN.

    c. Frequency - Set.

    d. Volume control - Nearly full clockwise.

11. Canopy seal - OFF.

TRAINER AFT COCKPIT INTERIOR CHECK

Left Console - Instructor Pilot

1. Thunderstorm lights switch - As desired.

   At night, use of these lights can facilitate the P.E. Hookup.

2. Light rheostat switches - Checked.

3. Throttle restart arming switch - NORM.

4. UHF modulator/demodulator (Modem) control - Set.

   a. Code selector switches - Set.

   b. Range address switch - Set.

5. Oxygen control panel - Set.

6. HF radio - OFF and set.

7. Interphone control panel - Set.

8. UHF radio - ON and set.

9. INS - Check aligning.

   a. Check present position.

   b. Function switch - NORM or STOR HDG.

   NOTE

   INS must be in NAV to obtain a valid mag heading.

   c. Check/enter desired DP's.

   d. Adjust INS segment lights as desired.

10. Aft bypass position lights - Checked.

    Press to test.

11. L and R aft bypass switches - FWD CONT.

12. EGT trim switches - HOLD & FWD CONT.

13. Map projector controls - Set.

14. Throttles - OFF.

15. Throttle friction lever - Set.

16. Throttle restart switch - Cycle to OFF.

    Check that the MANUAL INLET and CAUTION lights are on and the SPIKE DOOR transfer light on the control transfer panel is on when the throttle restart switch is not in the OFF position.

17. Emergency ICS switch - OFF.

18. UHF TRANS switch - Set.

19. Control transfer panel - Cycle to forward control.

    Verify lights illuminate when aft cockpit has control and then transfer to forward control.

20. Cockpit air handle - Off (forward).

<u>Instrument Panel - Instructor Pilot</u>

1. Indicators and warning lights test button - Press.

    a. Spike and forward bypass position indicators full counterclockwise (0 inches and 100% open).

    b. LOX quantity indicators decrease to zero.

    c. All cockpit caution and warning lights illuminate.

    d. Gear warning tone sounds in both headsets.

    e. All CIP indicator needles decrease to zero.

    f. Fuel quantity indicator needle moves to zero. The c.g. indicator indicates 14%.

2. Brake switch - OFF.

3. Landing gear switch - OFF.

4. Fuel derich switch - ARM.

5. Drag chute switch - OFF, light off.

    Check that the yellow dot in the end of the switch is visible with the guard down and the DRAG CHUTE UNSAFE annunciator light is not illuminated.

6. Airspeed/Mach Meter - Checked.

    a. Limit hand setting - 460 KIAS.

    b. Airspeed indication - 60 knots or less.

    c. Mach number indication - Right half of window blanked. Disregard Mach reading in left half of window.

7. Liquid oxygen quantity indicators -Check SYS 1, SYS 2 and STANDBY.

    Coordinate with forward cockpit to check System 1 and Standby system.

8. Clock - Set.

9. Cabin altimeter - Field elevation.

10. Accelerometer - Reset.

11. Compressor inlet pressure (CIP) gage - Checked.

    L and R needles and reference pointer together and indicating barometric pressure.

12. Compressor inlet temperature (CIT) gage - Checked.

    Check needles together and ambient temperature indicated.

13. Spike and forward bypass position indicators - Checked.

    a. Spikes - 0 in. aft.

b. Forward bypass - Open 100%.

14. L and R spike and forward bypass controls - Cycle, then AUTO.

Check knobs for security. MANUAL INLET and CAUTION lights will not illuminate when knobs are not in AUTO unless aft cockpit has SPIKE DOOR transfer light illuminated on control transfer panel.

15. L and R restart switches, - Cycle to RESTART ON, then off, individually.

Check that the MANUAL INLET and CAUTION lights are on and the SPIKE DOOR transfer light on the control transfer panel is on when in RESTART ON.

16. Projector - Checked.

a. Verify proper loading.

b. Check controls and lights.

c. Illumination as desired.

17. Surface limiter release handle - Pulled, and SURFACE LIMITER caution light off.

18. APW switch - CONT FWD.

19. Defog switch - CLOSED.

20. Trim power switch - ON.

21. Drag chute emergency deploy switch - Stowed and safetied.

22. A, B, and M CMPTR RESET switches - Normal (Guard down).

23. Standby attitude indicator - Erecting.

If required, pull the cage knob to erect the instrument, then release the knob. The instrument will erect and then seek 7° nose down and 0° roll (if the aircraft is level).

NOTE

A jitter of $\pm 1/2^{\circ}$ in the pitch axis is acceptable and may occur at any pitch angle.

24. Air refuel switch - OFF.

25. Altimeter - Set.

NOTE

It is possible to rotate the barometric set knob through full travel so that the 10,000-foot pointer is 10,000 feet in error. Check that the 10,000-foot pointer is reading correctly.

26. Vertical velocity indicator - Checked.

Check for zero indication.

27. Engine instruments - Checked.

28. Forward transfer switch - OFF.

29. Fuel dump switch - OFF (guard down).

30. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

Right Console - Instructor Pilot

1. SAS - OFF.

2. SAS lights - Test.

All SAS panel warning lights should illuminate when the test switch is depressed including the DAFICS BIT TEST and FAIL lights.

3. Autopilot - OFF.

Press the right console A/P OFF switch and check that the A/P OFF light is on.

4. TACAN mode selector - T/R.

5. Temperature indicator selector switch - R BAY.

6. Cockpit pressure selector switch - Set.

   Select either the 10,000 or 26,000 foot setting. The 26,000 foot setting is normally desired.

7. Face heat rheostat - Set.

   Use face heat at all times. Adjust for comfort.

   CAUTION

   - Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.

   - The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

8. ANS - Checked, MAG set.

   a. DATA Switch - TEST

      Press DISPLAY push-button switch to display data.

   b. Check mission tape number and Star Catalog number.

   c. DATA Switch - As required.

      Check Control and Display Panel readouts. Check mission modifications as required.

   d. MAG/GRID push-button switch - MAG.

9. ANS DATA Switch - NORMAL

   Press DISPLAY push-button switch to display selected data.

10. IFF - Set.

11. ILS power switch - ON.

12. MRS power switch - ON.

    Check green ON illuminated, red FAIL not illuminated.

13. Canopy seal - OFF.

AFT COCKPIT INTERIOR CHECK - SR-71A

<u>Left Console - Aft Cockpit</u>

1. Cockpit air handle - Off (forward).

2. Light rheostat switches - Set.

3. HF radio - OFF and set.

4. UHF radio - On and set.

   a. Mode - INT.

   b. Vol - Nearly full clockwise.

   c. PWR - Set.

   d. Frequency - Set.

   e. Function select - Set.

   f. UHF TRANS switch - Set.

5. Interphone control panel - Set.

6. INS - Check aligning.

   a. Check present position.

   b. Function switch - NORM or STOR HDG.

   NOTE

   INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

   c. Check/enter desired DP's.

d. Adjust INS segment lights as desired.

7. DEF systems - Off.

System A: System A power ON legend not illuminated.
System H: Warmup and standby lights extinguished and the mode switch MAN and AUTO legends off.

WARNING

Assure that the System H Mode Indicator lights for the H LO and H HI bands are extinguished. System H transmitter radiation while on the ground is hazardous to personnel if antenna hoods are not installed.

System M: System M power ON legend not illuminated.

8. UHF modulator/demodulator (Modem) control - Set.

   a. Code selector switches - Set.

   b. Range address switch - Set.

9. Oxygen control panel - Set.

10. DEF gating generator switch - Guard down.

This switch is nonfunctional.

Instrument Panel - Aft Cockpit

1. TACAN CONT transfer switch light -Off

2. TACAN mode selector - T/R.

3. IFF - Set.

4. G-Band Beacon switch - OFF.

5. RCD display brightness control - Full clockwise.

6. Egress lights - Press to test.

Press to test the ALERT, PILOT EJECTED and BAILOUT lights.

7. Cockpit pressure selector switch - Set.

Select either the 10,000 or 26,000-foot position. The 26,000-foot position is normally set.

8. Face heat rheostat - Set.

Use face heat at all times. Adjust for comfort.

CAUTION

- Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.

- The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

9. Camera exposure control - Checked and set.

   a. Rotate the exposure dial full clockwise to align the 90° index with the first high reflectivity dot.

   b. Set the briefed sun angle value.

NOTE

If the 90° index does not align with the first high reflectivity dot in the full clockwise position, the dial is not correctly installed. The corresponding electrical value on the sun dial will be incorrect.

10. Attitude indicator - Checked and set.

   a. Check indicator movement and set zero pitch angle.

   b. Attitude Reference Selector - ANS.

11. V/H indicator M pointer - Set.

12. Liquid oxygen quantity indicators - Check.

13. Clock - Set.

14. BDHI No. 1 needle select switch - ADF.

15. BDHI heading select switch - INS.

NOTE

INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

Viewsight Control Panel - Aft Cockpit

1. V/H select switch - BUS.
2. Map drive switch - Set.
3. Map rate control - Set.
4. MAP/DATA film select switch -Set.

Right Console - Aft Cockpit

1. Canopy seal - OFF.
2. OBC Power switch - Off.
3. ANS - Checked, MAG set.
   a. Check mission tape number.
   b. Normal Display - Check C&D panel readouts.
   c. Mission modifications - Check as required.
   d. MAG/GRID push-button switch - MAG.
4. Sensor power switches - STP then OFF (ON extinguished).
   a. RADAR
   b. ELINT
   c. RCDR
   d. LH and RH TECH
   e. TERRAIN
5. NAV RCDR power switch - ON.
6. MRS power switch - ON.
7. V/H power switch - ON.
8. VWSGT power switch - ON.
9. EXPOS power switch - ON.
10. Map projector - Checked.
    a. Verify proper loading.
    b. Check controls and lights.
    c. Illumination as desired.
11. LAMP TEST - Press to test.

    Check all instrument panel and console lights.
12. Left and right technical camera CONT switches - A (Auto).
13. FMC switches - V/R.
14. V/H SOURCE - NAV.

AFT COCKPIT CHECK (SOLO FLIGHT) - SR-71A/B

NOTE

Abbreviated checklists are not supplied for this procedure.

Before flight, check the following items in the rear cockpit. The trainer aircraft shall be flown solo only from the front cockpit.

1. Lap belt, shoulder harness and all personal leads - Secured.
2. All circuit breakers - In.

WARNING

For the SR-71B:

- o The following controls in the aft cockpit can override the forward cockpit:

  Aft bypass switches
  EGT Trim switches
  Throttle restart switch
  Brake switch
  Landing gear switch
  Drag chute switch
  Restart switches
  APW switch
  Air refuel switch
  Trim switches

- o Trim power must be ON in both cockpits to enable the trim system.

- o Fuel forward transfer switches, fuel dump switches, and emergency fuel shutoff switches must be off in both cockpits to turn the respective systems off.

<u>Left Console - SR-71A/B (Solo)</u>

1. Cockpit air handle - On (aft).
2. Panel, instrument, and thunderstorm light switches - OFF.
3. (T) Throttle restart arming switch - CUT-OUT.
4. UHF modulator/demodulator (Modem) control - Set.
5. Oxygen control panel - Sys 1 and 2 ON.
6. HF radio control panel - Set.
7. Interphone control panel - Set.
8. UHF radio - BOTH, frequency set.
9. INS - Checked, set to NAV.
   a. Check present position.
   b. Check alignment complete (NAV RDY light flashing).
   c. Check/enter desired DP.
   d. Set FUNCTION switch to NAV.

NOTE

INS must be in NAV to obtain a valid mag heading.

SR-71A:

10. DEF systems - Off.
11. (T) L and R aft bypass switches - FWD CONTROL.
12. (T) EGT trim switches - HOLD & FWD CONT.
13. (T) Throttle friction - OFF.
14. (T) Emergency ICS panel - OFF.
15. (T) UHF TRANS switch - OFF.

    Check UHF TRANS switch off to provide UHF-1 with ADF and external mode operating capability.
16. (T) Control transfer panel - Set (lights OFF).

<u>Instrument Panel - SR-71A (Solo)</u>

1. TACAN - T/R, frequency set.
2. IFF - NORMAL, modes and codes set.
3. Cockpit pressure switch - 26,000 FT.
4. Face heat switch - OFF.
5. UHF TRANS switch - OFF.

   Check UHF TRANS switch off to provide UHF-1 with ADF and external mode operating capability.

Instrument Panel - SR-71B (Solo)

1. Brake switch - OFF.
2. Landing gear switch - OFF; guard safety wired.
3. Drag chute switch - OFF.
4. S/P BAILOUT switch - OFF.
5. L and R spike and forward bypass controls - AUTO.
6. L and R restart switches - OFF.
7. APW shaker - CONT FWD.
8. Defog switch - CLOSED.
9. Trim power switch - ON.
10. Emergency chute deployment handle - Stowed and safetied.
11. A, B, and M CMPTR RESET switches - Normal (Guard down).
12. Bearing select switch - TAC/ADF.
13. Display mode select switch - ILS APCH.
14. Air refuel switch - OFF.
15. Forward transfer switch - OFF.
16. Fuel dump switch - OFF (guard down).
17. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

Right Console - SR-71A/B (Solo)

(T) 1. SAS - ON.

(T) 2. Autopilot - OFF.

(T) 3. TACAN - T/R, frequency set.

(T) 4. Cockpit pressure switch - 26,000 FT.

(T) 5. Face heat switch - OFF.

6. ANS - Checked and set.

SR-71A:

7. Sensor power - OFF.

(T) 8. IFF - NORMAL, modes and codes set.

(T) 9. ILS panel - ON, frequency set.

10. MRS power switch - ON.

    Check green ON illuminated, red FAIL not illuminated.

11. Canopy seal - ON.

    After the engines are started, the canopy seal will inflate and remain inflated until engine shutdown.

    Close rear cockpit canopy and lock externally immediately prior to engine start.

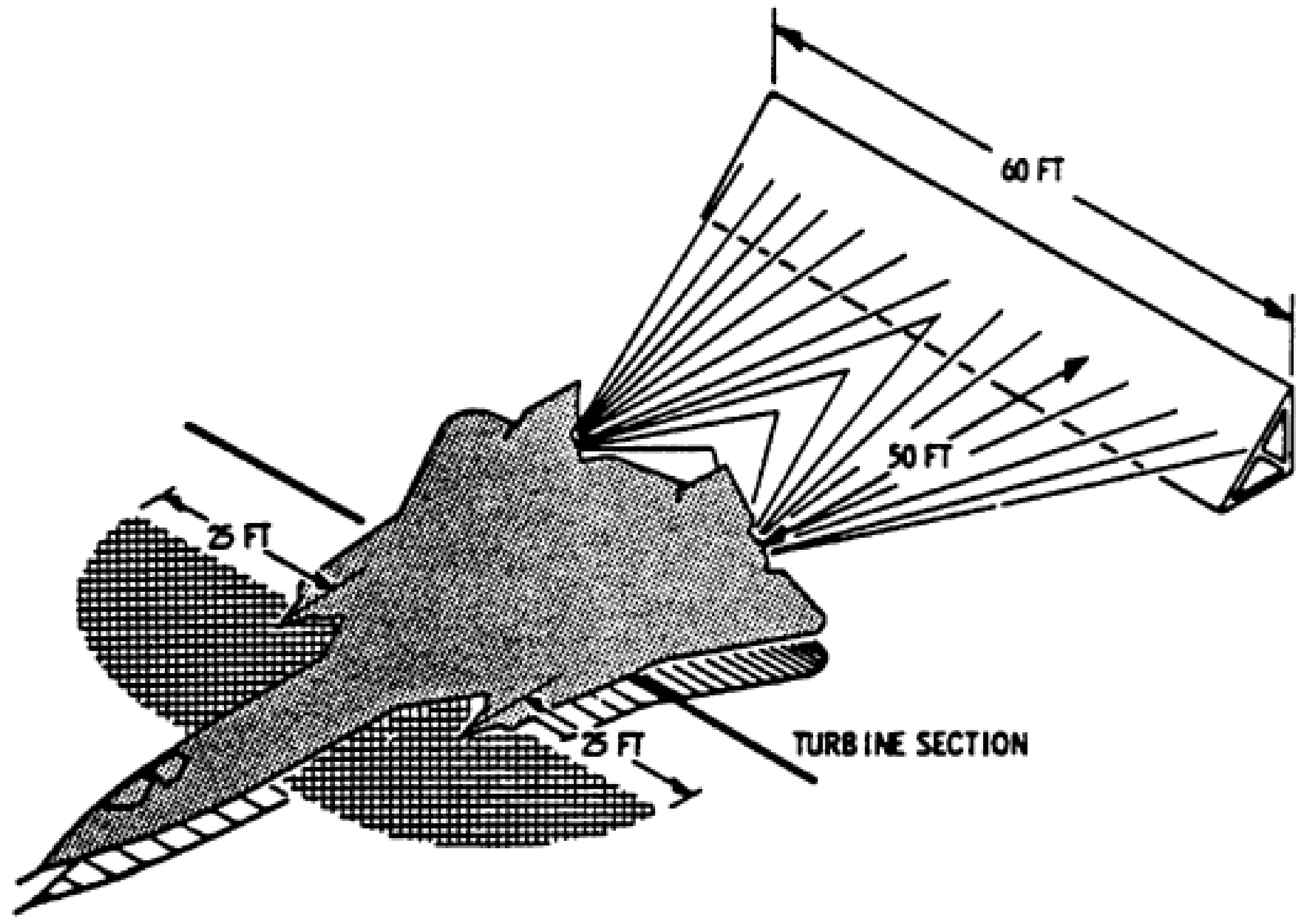
CAUTION

Leave the rear cockpit canopy open until just before engine start to maintain adequate cooling in the equipment bays. Close the front cockpit canopy followed by the rear cockpit canopy immediately prior to engine start.

DANGER AREAS - Engine Operation

WARNING

THE ENGINE TURBINE SECTION AND NACELLE INTAKE AND EXHAUST AREAS CAN BE DANGEROUS. KEEP CLEAR.
ENGINE NOISE CAN DAMAGE HEARING PERMANENTLY. DURING ENGINE RUNUP, USE EAR PLUGS AND MUFFS WITHIN 400 FEET DURING AFTERBURNER OPERATION AND WITHIN 200 FEET DURING MILITARY POWER OPERATION.



ESTIMATED JET WAKE DIAGRAMS

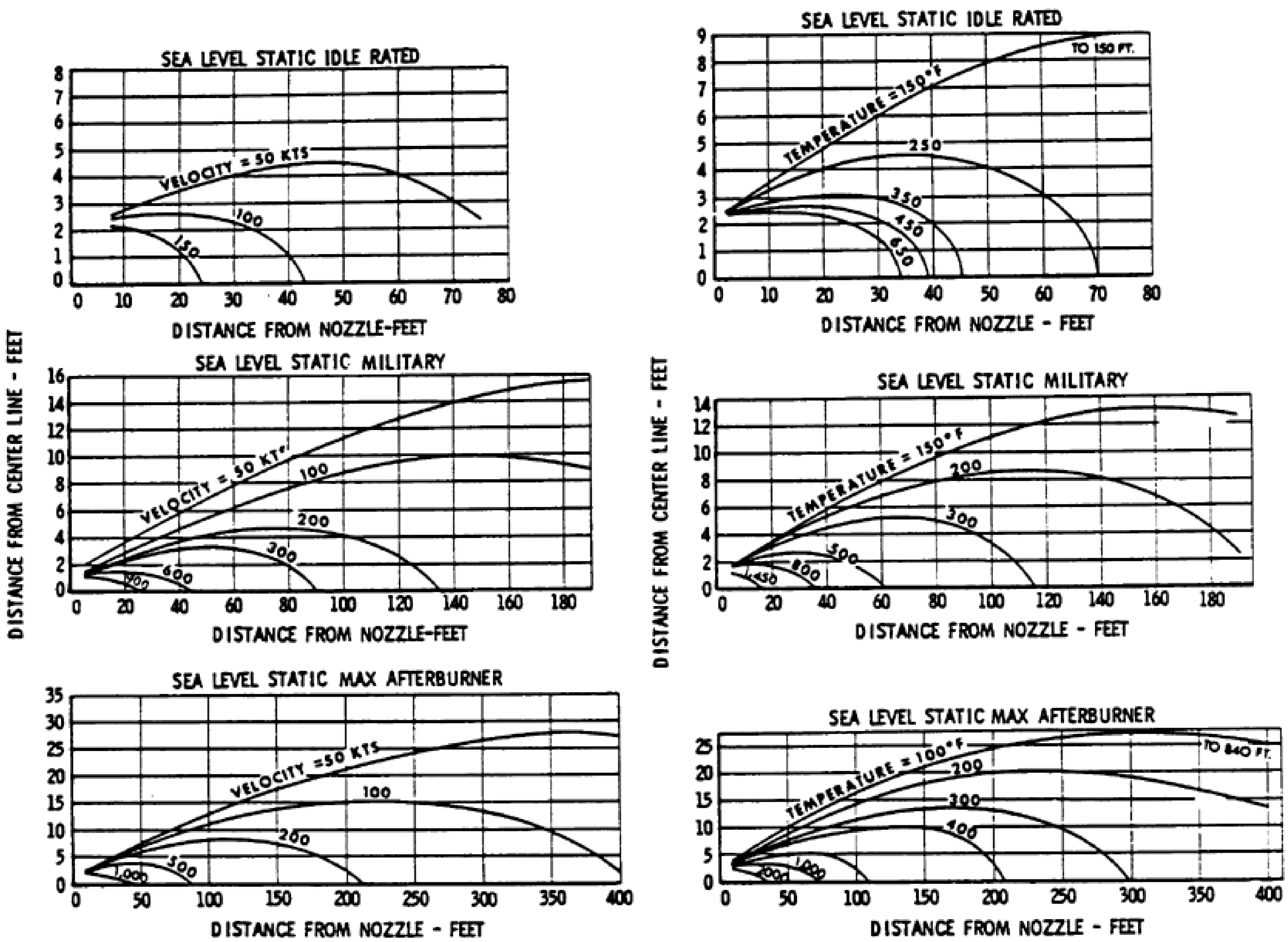


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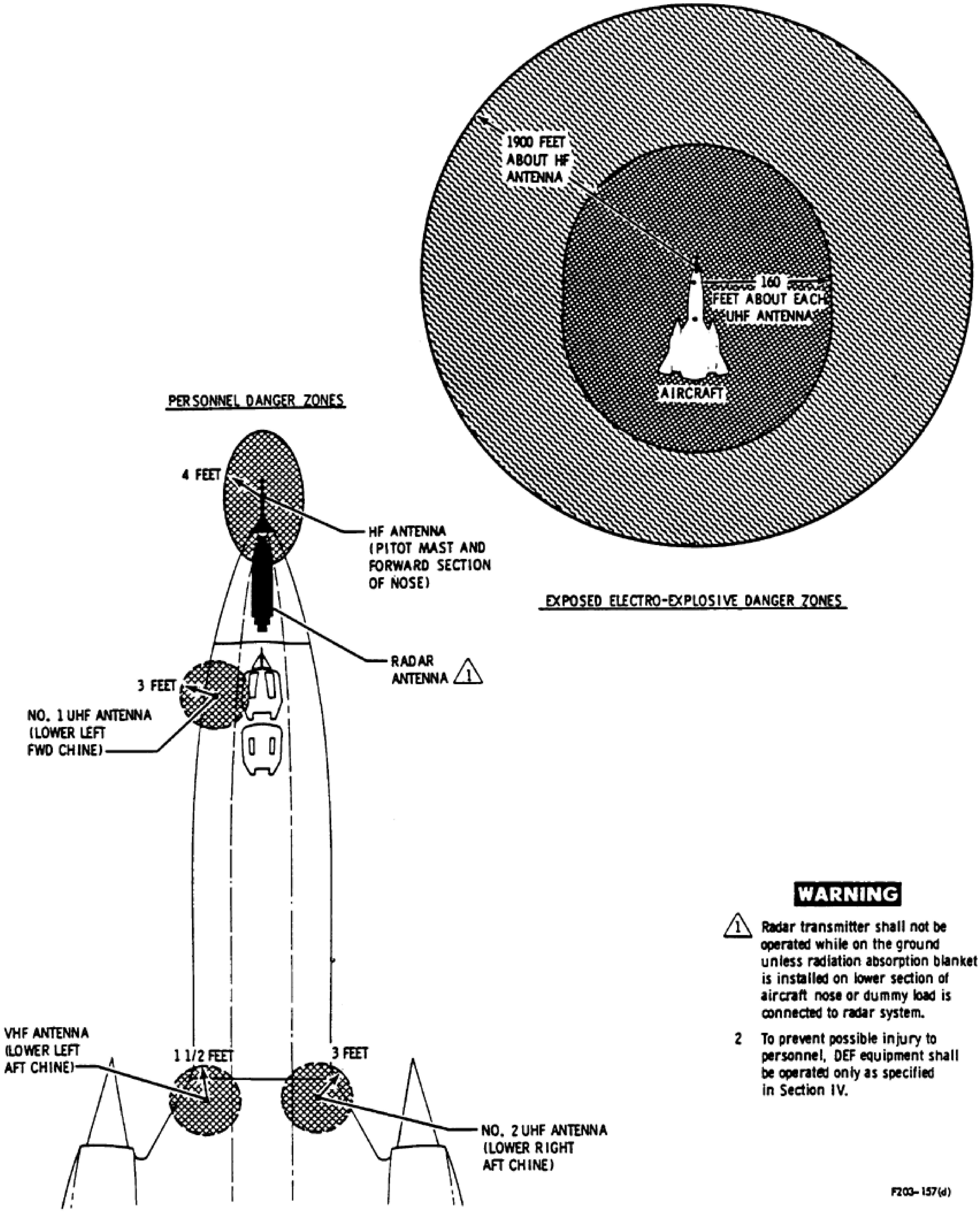
Figure 2-2 (Sheet 1 of 2)

DANGER AREAS - EMF Radiation



WARNING

1. Radar transmitter shall not be operated while on the ground unless radiation absorption blanket is installed on lower section of aircraft nose or dummy load is connected to radar system.
2. To prevent possible injury to personnel, DEF equipment shall be operated only as specified in Section IV.

Figure 2-2 (Sheet 2 of 2)

All subsequent checklists apply to both cockpits of the SR-71 A/B.

NOTE

Pilot and RSO (or IP) coordination is required. RSO (or IP) reads -Pilot responds. Alphabetized items need not be read.

STARTING ENGINES

▲1. Interphone - Checked.

Check CALL, HOT MIC, and normal functions (and emergency ICS in SR-71B).

▲2. BAILOUT light - Checked.

Coordinate ALERT and BAILOUT light illumination with switch position. Return switch to OFF (guard down).

▲3. Triple display indicator - Check.

a. Altitude - Within ±200 feet of pressure altimeter indication when altimeter is set at 29.92 inches Hg. Maximum difference between TDI's, fwd and aft cockpits, 100 feet.

b. Airspeed - 75 to 110 KEAS.

c. Mach - 0.11 to 0.2 normal.

▲4. Fuel quantity indicating system - Checked.

a. Individual tank quantities - Check. (within 550 lb between cockpits)

b. Sum of individual tank quantities - Check. (within 780 lb of TOTAL)

c. TOTAL fuel quantity - Check. (within 850 lb between cockpits)

▲5. Indicated and corrected computed c.g. - Within 0.5% MAC.

Check indicated c.g. reading between cockpits and compute c.g. with manual computer.

NOTE

While on the ground, c.g. computed using the manual c.g. computer should be corrected as follows to allow for the effect of level rather than flight attitude (with normal fuel distribution per T.O. 1-1B-40).

Total Fuel	Correction to MAC for computed c.g.*
Full tanks	-0.3%
70,000	-0.4%
65,000	-0.55%
60,000	-0.7%
55,000	-0.85%
55,000 (tank 6 empty)	-0.5%
50,000	-1.0%
45,000	-1.2%
45,000 (tank 6 empty)	-0.8%
40,000	-1.4%
35,000	-1.2%
30,000 (tank 6 empty)	-1.0%
25,000 (tank 6 empty)	-1.0%
20,000 (tank 6 empty)	-1.0%

*In level attitude, computed c.g. is aft of actual c.g. (The c.g. gage should read actual c.g.).

NOTE

When tank 6 is not full, use tank 6A and 6B scale. Fuel distribution must be obtained from mission loading form.

One minute before starting engines:

▲6. No. 1 and No. 2 oxygen systems - ON and checked.

Sys 1 and Sys 2 oxygen supply levers both latched ON and pressure checked.

▲7. Baylor bar - Latched and locked.

8. Exterior light switches - ON.

   a. FUS & TAIL switch - BRT.

   b. TAIL LT switch - STEADY.

   c. ANTI - COLLISION switch - ANTI-COLLISION.

9. Brake switch - Setting checked.

   Set ALT STEER & BRAKES if the right engine is to be started first.

10. First engine - Start.

   Although either engine can be started first, it is recommended that the left engine be started first (and shut down first) for odd numbered flights. Start the right engine first for even numbered flights. This enables a flight control system check to be made on alternate single-hydraulic systems immediately after starting.

   Ground personnel using interphone equipment will observe exhaust nozzle and nacelle inspection panels during start.

   WARNING

   Determine intake and exhaust areas are clear of personnel and ground equipment. Check fire guard(s) standing by.

   CAUTION

   o Before starting an engine, assure wheels are chocked. There is no parking brake.

   o Do not move control stick until at least 1500 psi can be maintained on the A or B hydraulic system.

   NOTE

   The crewchief will call the pilot when the starting unit is connected, and the pilot will instruct the crewchief to turn the unit on after verbally confirming that the engine combustion chamber drain valves are open and fuel is draining from each engine.

   a. Pilot - Signal for engine rotation.

   b. Throttle - IDLE at first indication of rpm increase.

      When necessary, an alternate technique of advancing the throttle at 1000 rpm may be used.

   c. Fuel flow - Checked for increase.

   d. IGV lights - Off.

   NOTE

   With pressurization of the engine fuel hydraulic system during start, the IGV position light must be extinguished (IGV cambered); if not, discontinue the start and determine the cause.

   e. Ignition - Verify within 15 seconds when using gas engine cart or within 20 seconds when using 3AG1100 air turbine starter. If no ignition indicated by an rpm increase and a rise in EGT within the allowable time, move throttle to off and continue cranking engine for 30 seconds at 1000 rpm.

CAUTION

- o In case of a false start, use Clearing Engine procedure, this section.
- o When using the 3AG1100 air turbine starter, do not exceed 5 seconds steady-state cranking operation between 1370 and 1470 rpm. Resonant frequency of the air turbine is in this range. No problems are encountered accelerating through this range, providing the transition period is less than 5 seconds.

f. Ground starting unit - Signal for disconnect at 3200 rpm.

g. If 565°C is exceeded, move throttle to OFF. If 649°C is exceeded, do not attempt to restart the engine.

NOTE

If the engine does not accelerate smoothly to idle rpm, but appears to "hang" in the 2600 to 2800 rpm range, retard the throttle to OFF and then quickly return it to IDLE. This "double clutching" procedure momentarily leans the fuel/air mixture and positions the flame front correctly in the burner cans so the engine can accelerate normally to idle rpm.

h. Idle rpm - Checked.

Engine idle speed is 3975 ± 50 rpm below 60C (140°F).

CAUTION

- o When using the MA-1A carts (or equivalent) abort start if Idle rpm is not obtained after 90 seconds.
- o When using the shelter airstart system, abort start if Idle rpm is not obtained after 120 seconds.

i. Engine and hydraulic instruments - Check normal indications.

(1) EGT - 350° to 565°C (start limit).

(2) Fuel flow - 4600 to 6300 lb/hr. A lower indication is evidence of heat sink system malfunction. If this occurs, shutdown and request investigation of circulating systems.

(3) Oil pressure - 35 psi minimum.

CAUTION

Discontinue start if oil pressure rise is not observed by the time IDLE rpm is obtained.

(4) Hydraulic system pressures - Checked.

(5) CIP should decrease to slightly below ambient.

Two minutes after engine start:

11. Flight controls - Steady neutral position.

Confirm with maintenance that the control surfaces arrive at a steady neutral position.

WARNING

Abort flight if maintenance detects surface movement without stick or rudder inputs.

12. Flight control system - Checked.

With nosewheel steering disengaged, individually check each axis for full deflection and freedom of travel in both directions. Confirm correct deflection and normal response by ground crew observation using the sequence: nose up, nose down, left roll, right roll, nose left, nose right.

If the right engine was started first and the elevon up travel is restricted, the pusher piston may be extended. Inform maintenance of the restriction, wait until the mixer access panel is removed, and then overpower the restriction. Check the flight control system after the left engine start.

If a restriction to rudder travel is felt and a force of approximately 10 pounds overpowers the restriction, the cause may be an extended rudder servo limiter piston due to the nonoperating engine. The rudders must be checked after the second engine is started to insure that the rudders are not restricted.

If nosewheel steering will not disengage, rudder control will be severely restricted in-flight with the gear down.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A or B HYD warning light. The light should extinguish when flow demands diminish and normal pressure is restored.

13. Second engine - Start.

    Use the same sequence as for items a thru i of step 11.

    If the right engine was started first and the elevon up travel was restricted, check the flight control system after left engine start.

    If a restriction to rudder travel occurred after the first engine start and a force of approximately 10 pounds overpowered the restriction, check the rudders again to insure that the rudders are not restricted. If a restriction to rudder travel occurs again, a flight control system problem exists.

14. TEB counters - Checked.

15. Generators - On (NORM), and lights off.

    Check R and L GEN OUT lights extinguish.

NOTE

With transfer of electrical power while on the ground, the DAFICS will undergo ground re-initialization indicated by momentary illumination of the A, B, and M CMPTR OUT caution lights, OFF flags in both TDIs, and TDI resynchronization to 55,000 ft., Mach 2.0, and 300 KEAS. If DAFICS indications are abnormal, notify maintenance.

16. Generator Bus Tie light - Off.

17. External power -Disconnected.

    Signal ground crew to disconnect.

T 18. Fuel system - Checked.

    a. Check all pump, tank empty, crossfeed and pump release lights are on when TEST is pressed.

    b. Press the crossfeed switch to obtain OPEN.

       Illumination of the OPEN portion of the switch confirms crossfeed is on.

    c. Press pump switches 1 through 6 ON in sequence.

    d. Press ON an additional tank containing fuel.

    e. Press pump release switch and check that the manually selected tank is released.

    f. Press crossfeed switch OFF.

    g. Tanks 1, 3, & 6 (or 5) boost pump lights on.

19. Left and right forward bypass - Both confirmed open.

Ground crew confirms doors open.

T 20. Spike and forward bypass position indicators - Check.

a. Spikes - 0 in. aft.
b. Forward bypass - 100% open.

T 21. Brakes - Normal & alternate systems checked, set ANTI SKID ON.

Pump brakes and check normal feel while crew chief visually confirms brake actuation on both trucks. Normal feel does not necessarily indicate braking action. Perform the check both in ANTI SKID ON and ALT STEER & BRAKE. While applying moderate brake pressure, cycle the brake switch and check for a slight pedal movement (thump) and small position change when shifting between hydraulic systems. The absence of the thump indicates only one braking system available.

Pause slightly while passing through the ANTI SKID OFF position and observe the ANTI-SKID OUT light illuminated. If the light does not illuminate, there may be an electrical/switch failure and only one braking system may be available.

With S/B R-2695, check the antiskid disconnect feature of the trigger switch. With the brake switch in ANTI SKID ON and/or ALT STEER & BRAKE, check the ANTI-SKID OUT annunciator caution light illuminates while the trigger is depressed and extinguishes when the trigger is released.

Set ANTI SKID ON at the conclusion of the check.

NOTE

If both engines must be shut down temporarily after start and it is necessary to retain ANS alignment, insure that ground air and power are connected and on, and turn generators off before shutting down the second engine.

CLEARING ENGINE

Cool the engine and remove trapped fuel and vapor as follows:

1. Throttle - OFF.

CAUTION

Allow a minimum of 1 minute for fuel drainage and coast down before motoring engine.

2. Starter - Engage and motor engine for at least 30 seconds and until EGT is below 150°C.

Signal ground crew to motor engine at 1000 rpm. Crew chief will advise pilot when engine is clear and ready for start.

CAUTION

Do not motor the engine with the fuel shut off switch in the fuel off position except in an emergency. Damage to the engine may result with the engine fuel-hydraulic system off.

NOTE

If an electrical power interruption has occurred, cycle the MRS power switch off (light extinguished) then ON to assure reestablishment of MRS operation. Fuel boost pump circuit breakers should also be checked after electrical power interruption.

AFT TOWING - ENGINE OPERATING

Aft towing of the aircraft with engines running is permitted with:

a. Engines at idle.

b. 120,000 pounds gross weight or less.

c. Interphone communications maintained between the pilot and tow operation observer.

d. All braking accomplished by the tow tractor.

WARNING

The pilot shall not use aircraft braking except in an emergency.

e. Aircraft steering accomplished by a ground crewmember, using a nose wheel tow bar.

WARNING

Do not move the rudder pedals during hookup of the nose steering linkage at completion of towing.

BEFORE TAXIING

(T1) IFF - STBY.

(T2) HF - On.

Refer to Danger Areas, Figure 2-2, for extent of danger to personnel and exposed electro-explosive devices.

WARNING

Do not transmit on ground until safe to do so.

(T3) INS - Checked, set to NAV

Check alignment complete (NAV RDY light flashing)

NOTE

INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

T 4. DAFICS Preflight BIT - Check.

a. SAS channel engage switches - ON.

b. SENSOR/SERVO lights - Checked off.

c. Cycle controls in pitch, roll and yaw and check for abnormal control surface oscillation or vibration.

d. Autopilot pitch and roll engage switches - ON.

e. Control stick trigger switch - Depress.

Check autopilot disengagement.

(T) f. Aft cockpit SAS channel engage switches - ON.

(T) g. AFCS control - Transfer to aft cockpit.

Check AFCS transfer light illuminated in aft cockpit.

(T) h. SAS Lights - Off.

Check SENSOR/SERVO lights remain off.

(T) i. Cycle aft cockpit controls in pitch, roll and yaw and check for abnormal control surface oscillation or vibration.

(T) j. Aft cockpit autopilot pitch and roll engage switches -ON.

(Note: Page 2-24A/(2-24B Blank) deleted)

Check autopilot disengagement.

(T) l. AFCS control - Transfer to forward cockpit.

m. Autopilot pitch and roll engage switches - ON.

Ⓣ k. Aft cockpit control stick trigger switch - Depress.

Check autopilot disengagement.

Ⓣ l. AFCS control - Transfer to forward cockpit.

m. Autopilot pitch and roll engage switches - ON.

n. Forward cockpit switch positions for DAFICS PREFLIGHT BIT - Set.

- ATT REF SELECT switch - INS
- KEAS HOLD switch - ON
- HEADING HOLD switch - ON

o. DAFICS PREFLIGHT BIT switch - ON.

The BIT TEST light illuminates steady green while the test is running. The BIT TEST light also illuminates when the function selector on the maintenance analyzer panel is not in the OFF position.

The PREFLIGHT BIT check can be terminated manually (once it is initiated) by stopping any DAFICS computer.

Pressure from A hydraulic system is required to engage the DAFICS PREFLIGHT BIT. Low pressure or flow from A, B, L or R hydraulic system will cause the DAFICS preflight BIT to fail.

If the DAFICS PREFLIGHT BIT switch will not engage, recheck:

1) CSC/NWS switch - Released.
2) ATT REF SELECT switch - INS
3) APW switch - PUSHER/SHAKER
4) SPIKES & FWD BYPASS doors - AUTO
5) RESTART switches - Off
6) Throttle Restart switch -Off
7) SAS channel engage switches - ON
8) AUTOPILOT PITCH & ROLL engage switches - ON
9) KEAS HOLD switch - ON
10) HEADING HOLD switch -ON

NOTE

If at BIT completion the FAIL light, any SENSOR light, any SERVO light, or any CMPTR OUT light illuminates, notify maintenance.

After one minute:

p. Check BIT TEST light flashing green, sensor and servo lights extinguished, BIT FAIL light extinguished, and OFF Flags in both TDI's. The CIP barber pole reads zero.

q. Check autopilot pitch and roll engage switches, KEAS HOLD switch, and HEADING HOLD switch-Off. AUTOPILOT OFF and SAS OUT lights illuminated.

The flashing BIT TEST light and SAS OUT light indicates that the SAS is still in the ground test mode.

r. Check DAFICS PREFLIGHT BIT switch - OFF (guard down).

s. SENSOR/SERVO recycle switches - Press one of the six.

Pressing one of the six SENSOR/SERVO recycle switches resets the DAFICS system to the flight mode. Check SENSOR/SERVO lights, BIT TEST light, and SAS OUT lights are out. Check both spikes have returned to the full forward position and the CIP barber pole has returned to normal. Both TDI's will initiate resynchronization and run up to 55,000 ft, Mach 2.0, and 300 KEAS. AOA will indicate 10°. AOA will return to 0° in approximately 1 min 15 sec and TDI indications will return to normal in approximately 2 min 15 sec after the DAFICS system has been reset to the flight mode. The A, B, and M CMPTR OUT annunciator panel lights will flash momentarily when the DAFICS system is reset.

WARNING

The SAS is non-functional while in the ground test mode. DAFICS will not operate normally until the system is reset. Failure to press a SENSOR/SERVO recycle switch after the DAFICS Preflight BIT is complete will cause the DAFICS to remain in the ground test mode.

T 5. Flight instruments and navigation equipment - Checked.

a. Turn display mode selector switch to:

(1) INS - Check that bearing pointer and DME display TACAN/ADF data with Bearing Select switch set to TAC/ADF. Check that bearing pointer and DME display INS data with Bearing Select switch in NORMAL. Adjust Course Set knob to check for proper CDI indications.

(2) TACAN/ADF - Tune and identify TACAN station. Check for bearing pointer and DME indication. Adjust Course Set knob to check proper CDI and To-From indications.

(3) ILS - Tune and identify ILS station. Set Course Set knob to final approach course and check CDI and glide slope indications in relation to present position.

(4) ILS/APPROACH - Adjust Course Set knob to align the course arrow with the top index. Depress ILS test buttons on ILS control panel and check for proper indications on steering bars, glide slope, and CDI.

(T6.) UHF-1 and UHF-2 radios - Checked.

Check external and internal operation. For external operation, using power level 4 or less, depress CONT and INT lights to confirm normal operation. The interrogate light should remain on for three to four seconds.

7. VHF radio - Checked.

T 8. SAS channel engage switches - OFF.

T 9. Trim - Checked.

Check pitch (full travel), roll, and yaw trim and set to zero. Confirm that direction of movement corresponds with indication in the sequence: nose up, nose down, left roll, right roll, nose left and nose right. Check RH rudder synchronizer.

T 10. Flight control system - Checked.

With nosewheel steering disengaged, check each axis for full deflection and freedom of travel in both directions, and confirm correct deflection of control surfaces in the sequence: nose up, nose down, left roll, right roll, nose left and nose right.

If nosewheel steering will not disengage, rudder control will be severely restricted in flight with the gear down.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A and/or B HYD warning light. The light should extinguish when flow demands diminish and normal pressure is restored.

11. Shotgun cartridge - Checked.

    Confirm left and right cartridges engaged.

12. Fuel derich system - Both checked and rearmed.

    a. Set both engines 400 rpm above idle speed.

    b. Actuate the derich test switch until 860°C EGT is exceeded with LEFT and then RIGHT selected.

    When the EGT indications exceed 860°C:

    c. Verify that the EGT gage warning lights are on and that the Fuel Derich lights are on.

    d. Note that engine speeds decrease between 50 and 400 rpm.

    e. Cycle the fuel derich switch to REARM then ARM.

       Verify that each engine returns to 400 rpm above idle, and EGT indications are normal.

    f. Reset the throttles to IDLE.

13. Air refueling system and drag chute doors - Checked.

    a. Air refuel switch - AIR REFUEL.

       Check READY light on. Confirm doors open and light on, toggles unlatched.

    b. Air refuel switch - MAN O'RIDE. Confirm door open, and light on, toggles latched.

    c. Actuate stick trigger, confirm toggles retract.

    d. Air refuel switch - OFF. Confirm light off, door closed.

    e. Confirm with ground crew that drag chute doors are locked. A paddle indicator on the drag chute door should be flush with the fuselage contour when viewed from alongside the cockpit at the level of the crew station.

(T14) ANS mode - Set.

    The ANS is normally placed in the INERTIAL ONLY mode.

▲15. ANS - Checked.

    a. Pilot set display mode select switch to ANS. Check true heading under HSI lubber line and programmed true course in HSI course window.

    b. RSO check ANS heading against INS heading. Check for proper DP code and coordinates, and crosscheck command course and distance to DP with pilot.

    c. Pilot check bearing select switch in both positions for normal operation of bearing pointer and DME.

    d. Pilot and RSO check for normal attitude indications in both attitude reference select switch positions.

    e. Pilot check standby attitude indicator.

▲16. INS - Checked.

a. Pilot set display mode select switch to INS, bearing select switch to NORMAL.

b. RSO set BDHI SEL HEADING and NO. 1 NDL switches to INS. Display distance to DP on Inertial Control Panel (Data switch set to STRG, distance is in left display).

c. Confirm INS DP bearing and distance are the same in both cockpits.

▲17. Ejection seat and canopy pins -Removed.

▲18. Canopy - Closed and locked.

Visually check engagement of canopy hooks.

CAUTION

To prevent overheating the ANS, the RSO canopy must not be closed and locked prior to the pilot's canopy unless the cockpit air handle is off (forward).

NOTE

Severe cockpit fogging may occur if cold cockpit temperature control settings are selected unless the RSO's cockpit air handle is off.

▲19. Canopy seal switch - ON.

(T20.) Cockpit air handle - On (aft).

21. L and R refrigeration switches - ON.

Minimize the time between locking the aft canopy and activation of a ship air-conditioning system. A delay increases the possibility of overheating equipment.

T 22. CANOPY UNSAFE, L and R AIR SYS OUT and CKPT AIR OFF caution lights - Off.

The RSO should recycle the cockpit air shutoff lever if the CKPT AIR OFF caution light is illuminated.

23. Ground air - Disconnect.

Signal ground crew for disconnect. Confirm the BAY AIR OFF light extinguishes.

(24.) OBC Power switch - ON.

25. PVD - On and set.

Up to 25 seconds may be required before laser line is visible.

a. Set ROLL to index.

b. Set PITCH to index or as desired.

c. Set intensity as desired.

d. Set SCALE to NORM or as desired.

WARNING

Do not look directly into the laser beam.

(T) 26. Angle of Attack indicator -Checked.

Check OFF flag out of view and AOA indicates zero.

T 27. Periscope - Checked.

T 28. Nosewheel steering - Engaged and checked.

Nose should swing as rudder pedals are moved slightly. Nosewheel STEER ON light should illuminate.

29. Panels and gear pins - Secured and removed.

Crewchief confirms all panels and doors secured. Crewchief disconnects interphone and displays landing gear downlock pins.

(30.) OBC self test - Completed, OPR/STP light on.

CAUTION

If installed, the Optical Bar Camera must always be operated in the standby or operate modes while in flight; if shut down, the optical bar may be damaged.

TAXIING

Observe crewchief for signal.

CAUTION

Taxi and turn at low speed to minimize side loads on the landing gear. Fast taxiing should also be avoided to prevent excessive brake and tire heating and wear.

T 1. Braking and nosewheel steering - Checked.

When clear of obstacles disengage nosewheel steering and check individual brake operation on L and R systems, and for dragging brakes. Release pedal pressure before changing hydraulic systems. Engage NWS and check steering operation.

NOTE

Rudder pedal feedback, due to nosewheel castering, indicates that nosewheel steering has not disengaged. The STEER ON light also remains on.

T 2. Turn-and-slip indicator - Checked.

Check turn needle deflection in the direction of turn and ball free in race.

T 3. SAS lights - Checked.

Check SAS control panel for PITCH, ROLL, or YAW SENSOR lights during turns or braking. Attempt to reset SENSOR lights. All SENSOR lights should be out prior to takeoff.

(T4.) ANS - As desired.

If the ANS is in the INERTIAL ONLY mode and NAVIGATE/ASTRO INERTIAL mode is desired for takeoff, place the ANS in NAVIGATE/ASTRO INERTIAL.

BEFORE TAKEOFF

▲1. Pilot's ANS distance display mode - DP/TURN.

(Ta.) ANS DATA switch - TEST.

Press DISPLAY push-button switch to display data.

(Tb.) DP/TURN push-button switch - As desired.

RSO will coordinate the pilot's desired ANS distance display mode.

2. Flight instruments - Set for takeoff.

a. Display Mode Select switch - Set.

b. Attitude Reference Select switch - INS.

c. For instrument departure, tune and identify TACAN station.

d. HSI Course Select knob - Set.

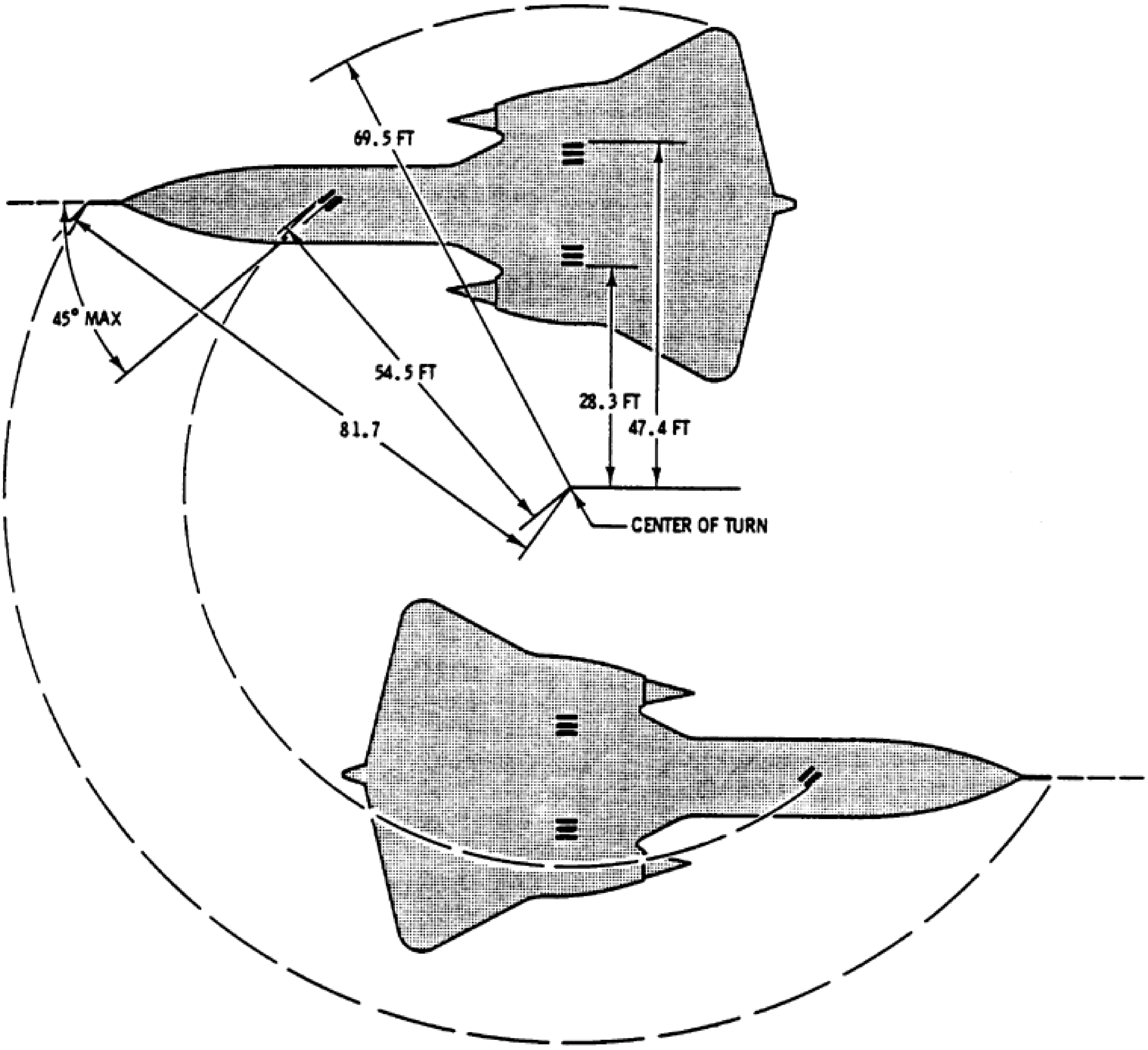
3. Engine run - Lockout and EGT trim checked.

a. Wheels - Chocked.

b. Brakes - Apply.

c. IGV switches - LOCKOUT.

MINIMUM TURNING RADIUS



NOTE

101.9 MINIMUM RUNWAY WIDTH REQUIRED FOR 180-DEGREE TURN (MAIN GEAR WHEELS ON EDGE OF RUNWAY AT START OF TURN).

F203-5d(a)

Figure 2-3

One engine at a time, with AUTO EGT selected:

d. Throttle - Military.

Move the throttle smoothly to the Military stop, observing ENP and EGT. EGT should increase and ENP indication should move toward zero. An EGT gage COLD flag will appear when the throttle reaches the Military position if EGT is below the nominal trim band.

NOTE

Automatic trimming does not occur until the throttle is positioned at or above the Military position.

e. Throttle - Retard approximately one-half inch aft of the Military position and return to Military rapidly. This removes hysteresis from the fuel control linkage. Hold the military power throttle setting for at least 30 seconds to allow MRS recording of engine parameters.

Note EGT gage COLD/HOT flag operation. If the throttle is retarded before EGT reaches the nominal trim band, disappearance of the COLD flag while the throttle is retarded confirms normal operation of the automatic EGT trim system permission circuit.

f. IGV light - Off.

The IGV position light should remain off.

g. IGV switch - NORM (as EGT approaches the nominal trim band).

h. IGV light - On.

The IGV position light should illuminate immediately when IGV NORM is selected, indicating an IGV shift to the axial position. The nozzle should open slightly at IGV shift.

NOTE

- Do not takeoff if the IGV position light fails to illuminate.
- An inoperative IGV lockout which is detected during the before takeoff trim check does not require aborting the flight.
- The engine IGV light should not illuminate on rpm increase with its IGV switch in the LOCKOUT position. With IGV NORM selected, the engine IGV light should illuminate during rpm increase (approximately 300 to 800 rpm below the Military rpm schedule) and extinguish when the guide vanes reach the cambered position as the throttle is retarded to idle.

i. EGT trim - As required.

Check automatic EGT trims to within the nominal band shown by Figure 2-4.

If a HOT flag appears and EGT approaches an overtemperature condition, retard the throttle, select manual EGT control, downtrim as required, then recheck trim at Military in AUTO EGT.

If no HOT or COLD flag is observed and EGT is normal at Military power, downtrim EGT momentarily in manual control, then select AUTO EGT. At Military, the COLD flag should appear temporarily, and the engine should retrim to the AUTO EGT deadband range.

If Auto EGT is unusable, trim manually as shown in Figure 2-4.

j. RPM - Check engine speed vs the schedule shown by Figure 2-4.

k. Engine and inlet instruments - Check.

EGT Auto Trim Check Schedule

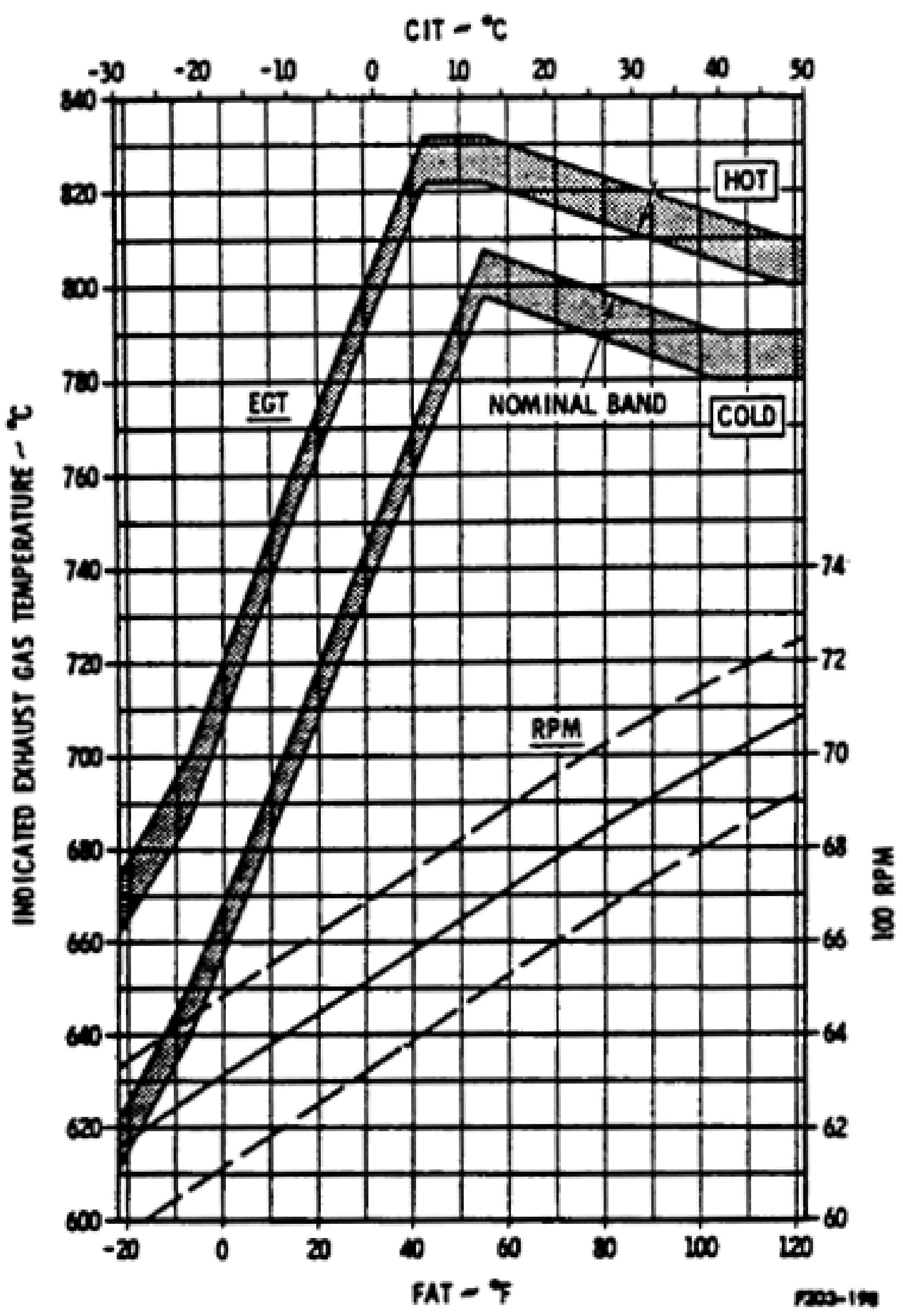


Figure 2-4

Check engine instruments for normal indications. Note ENP and fuel flow values (for engine comparison), and oil pressure values. Note L and R CIP; CIP indication should be less than at idle.

4. EGT trim switches - HOLD or AUTO

During cold temperature ground operations, engine surge (compressor stall) may occur at or above military power if EGT goes above the nominal trim band.

With EGT trim in AUTO, EGT uptrim starts when the throttle is advanced to the military position and continues until EGT increases into the deadband. Even if an engine was previously trimmed within the deadband, thermal lag results in a slight EGT overshoot when readvancing the throttle to military.

a. To avoid compressor stalls on takeoff when outside air temperature is below 15°C (59°F), position EGT trim to HOLD after stabilized in military power within the nominal EGT operating band. Select automatic trim, if desired, after takeoff.

Engine surge should not occur when ambient temperature is above 15°C (59°F).

If compressor stalls occur during engine run, retard throttle and downtrim EGT. Refer to Exhaust Gas Temperature Limits, Ground Operation, Section V.

b. Throttle - Retard smoothly to IDLE.

Check that ENP indication is normal during power reduction.

NOTE

After retarding from Military power to IDLE, do not readvance the throttle for at least ten seconds (for the engine to stablize at idle rpm). Otherwise, stall and dieout may occur. The stall may be inaudible, but dieout is indicated by decreasing rpm and, particularly, by increasing EGT. If dieout occurs, move the throttle to OFF to prevent overtemperature. The engine may be restarted as soon as a starter is available; accomplish Clearing Engine checklist. The stall and dieout occur only during ground static operation and is more likely when relatively high ambient temperatures exist.

c. IGV light - Off.

The IGV light should extinguish.

NOTE

If cockpit fog is encountered, increase cockpit temperature. Twelve-to-one o'clock auto-temperature control rheostat positions are normally sufficient.

T 5. Flight controls and trim settings -Check.

Cycle and check hydraulic pressure. Recheck trim settings zero.

▲6. Fuel sequencing - Checked.

a. Check tanks 1, 3, and 6 or 5 ON, depending on fuel load, and quantities decreasing. If less than full load, check tank 4 increasing.

NOTE

To check tank 3 pump operation, if no decrease in tank 3 fuel quantity has been noted, transfer fuel or increase left engine rpm.

▲7. CG - Checked.

Takeoff c.g. must be forward of 22%. (To check the c.g. which will occur in the flight attitude, increase the indicated c.g. value by the amount of the hand-held c.g. computer correction.) When the takeoff fuel load is above 70,000 pounds, the c.g. should be no further forward than 20%. With less than 70,000 pounds of fuel, c.g. should not be aft of 20% while level, to allow for the aft c.g. shift during takeoff.

NOTE

- A supersonic leg with less than a full fuel load may require manual control of the fuel system to achieve a desirable supersonic c.g.
- Press the Tank 5 or Tank 4 boost pumps on before transferring fuel forward. Otherwise, with crossfeed off, a reduction in fuel flow to approximately 3600 lb per hour will occur on the right side. This is less than the desired value for normal operation of the fuel heat sink system. Release the tank after completing fuel transfer.

T 8. Forward transfer - OFF.

T 9. Fuel Derich switch - ARM.

▲10. No. 1 and No. 2 oxygen systems - ON and pressure checked.

Verbally confirm oxygen latched ON with normal pressure.

▲11. Baylor bar - Latched and locked.

12. Brake switches - DRY or WET, and ANTI SKID ON.

Use the DRY position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume a wet runway condition if moisture is visible on the runway, particularly as evidenced by glare or reflections.

▲13. Takeoff data - Review.

a. Acceleration Check.

b. Refusal speed.

c. Rotation speed.

d. Takeoff speed.

e. Single-engine speed.

NOTE

If a tire cooling period has been required, do not takeoff until ground crew signals that tire condition is satisfactory.

14. Pitot heat switch - ON and checked.

Ground crew confirms heat on.

15. Battery switch - Checked BAT.

16. Instrument inverter switch - Checked NORM.

(T17) INS altitude - Update.

Update the INS altitude to the sustained or mid-altitude expected after takeoff, i.e. enter A/R altitude, or if climbing immediately to cruise conditions enter 35,000 or 40,000 feet.

18. VHF radio antenna cover - Removed.

Ground crew displays cover to pilot.

TAKEOFF

(T1) IFF - NORMAL

Set proper mode and code.

2. SAS - Engaged, lights off.

   a. Channel engage switches - ON.

   b. SENSOR/SERVO lights - Check off.

   c. BIT TEST light - Check off.

WARNING

The SAS is non-functional while in the ground test mode. DAFICS will not operate normally until the system is reset. Failure to press a SENSOR/SERVO recycle switch after the DAFICS Preflight BIT is complete will cause the DAFICS to remain in the ground test mode.

(T)3. Aft cockpit SAS - ON.

Channel engage switches all ON.

NOTE

For normal operations, all SAS channel engage switches should remain ON in both cockpits for entire flight regardless of which cockpit has AFCS control.

(T)4. AFCS control - Transfer to other cockpit.

Check AFCS transfer light illuminated in cockpit not previously in control.

(T)5. SAS Lights - Off.

Check SENSOR/SERVO lights remain off.

(T)6. AFCS control - As desired.

WARNING

In the SR-71B, only the positions of the SAS channel engage switches in the cockpit that has the AFCS transfer light illuminated on the control transfer panel effect the SENSOR/SERVO and SAS OUT caution lights. No warning is displayed if the SAS channel engage switches are not ON in the cockpit that does not have AFCS control. If the SAS engage switch(es) are OFF in the cockpit that does not have AFCS control, transferring AFCS control to that cockpit results in loss of SAS until the SAS switch(es) are engaged.

▲7. Warning and caution lights - Checked.

Any amber caution lights (autopilot, cockpit air, etc.) which remain on must be justified by an intentional and acceptable operating situation. Do not start a takeoff if any red warning lights are on.

▲8. Circuit breakers - Checked.

9. Tank 4 boost pump switch - Press on.

▲10. Compass - Checked.

Check INS and standby compass against runway heading. Start ANS runway heading alignment when required.

11. Nosewheel steering -Engaged.

Confirm STEER ON light illuminated.

Refer to Figure 2-5 for illustration of the typical sequence of events during takeoff.

a. Brakes - Release when IGV lights illuminate (approximately 6000 rpm) as the throttles are advanced.

CAUTION

The tires may skid if the brakes are held at high thrust.

NOTE

Abort takeoff if IGV position lights fail to illuminate with Military rpm during engine acceleration.

b. At Military power - Check engine instruments for values at or approaching those observed during trim.

(1) Tachometer.
(2) EGT.
(3) Nozzle Position.
(4) Oil Pressure.

c. Throttles - Advance to mid afterburner range for A/B ignition, then smoothly advance to maximum afterburner.

CAUTION

- To prevent overspeed, afterburners must not be ignited before engines reach Military rpm.
- Abort the takeoff if an afterburner fails to ignite within 3 seconds.
- Advancing the throttle will result in momentary nozzle excursion, and engine transient speed oscillation may approach 250 rpm.

d. Maximum A/B - Check engine instruments.

Exact readout of these instruments is time consuming. The readouts should be anticipated and needle position checked against a clock position. If there is any indication of deficient engine performance during throttle advancement, abort the takeoff. If possible, any abort decision should be made before the aircraft has reached high speed. Refer to takeoff performance data in the Appendix. Directional control should be maintained with nosewheel steering up to nosewheel lift-off speed.

e. Acceleration - Check.

Check KIAS against computed acceleration check speed at selected acceleration check distance. Refer to takeoff performance data in the Appendix.

NOTE

Failure of the IGV lights to remain illuminated during takeoff results in inability to develop full rated thrust; unless a more serious malfunction is indicated, the takeoff may be continued if the acceleration check speed has been reached satisfactorily.

ROTATION TECHNIQUE

In general, the tires are more vulnerable to blowouts during takeoff than at landing because of the higher groundspeeds and gross weights involved. Wing lift quickly relieves the gear load as the nose is raised. Apply smooth, constant back pressure 15 to 25 knots below computed rotation speed. Lift the nosewheel off at rotation speed, using the rotation rate required to leave the ground at computed takeoff speed. Depending on gross weight, normal takeoff attitude is 8° to 10°

TAKEOFF - Typical

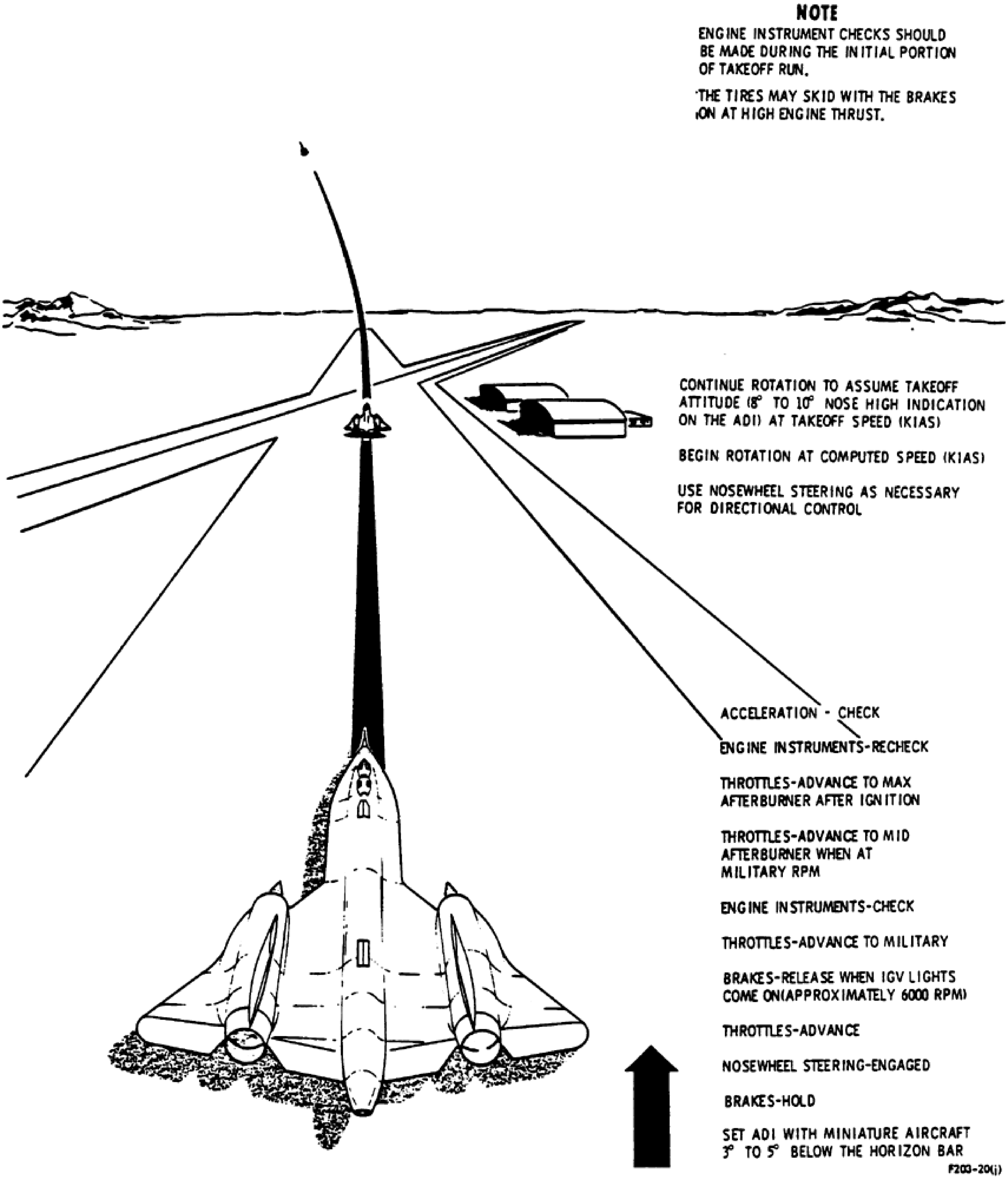


Figure 2-5

nose high indication on the ADI. The transition from start of rotation to takeoff requires approximately 5 seconds when using the normal takeoff technique. Refer to Takeoff Speed Schedule in Part II of the Appendix for rotation and takeoff speeds.

Premature nosewheel liftoff should be avoided because the unnecessary drag extends the ground run and may result in excessive tire loads.

NOTE

AOA indicates zero at airspeeds less than 100 KEAS and actual AOA at higher airspeeds.

CROSSWIND TAKEOFF

The aircraft weathervanes into the wind during crosswind takeoffs when the nosewheel lifts off and nosewheel steering is no longer available. Rudder pressure must be held to counteract the crosswind. A definite correction must be made as the aircraft breaks ground. Apply lateral control as necessary for wings-level flight. Both the directional and lateral control applications are normal and no problems should be encountered when taking off during reasonable crosswind conditions.

AFTER TAKEOFF

When definitely airborne:

1. Landing gear lever - UP.

   Gear retraction requires 12 to 16 seconds.

WARNING

- Single engine operation is critical immediately after takeoff. Increasing airspeed and decreasing angle of attack have greater benefits than gaining altitude at a maximum rate. Single engine flight capability is presented in Part II of the Appendix. With gear down, the minimum safe speed out of ground effect is approximately 30 knots greater than in ground effect.
- Immediately depress the control stick trigger switch to deactivate APW System stick pusher operation if a false stick pusher warning occurs. If the stick pusher is not deactivated by the trigger, use a pull force of 30 to 35 pounds in addition to normal stick forces to overcome the stick pusher spring. Use pitch trim to relieve stick force.

After gear retraction is completed and single engine flying speed is obtained, establish climb power as desired. A military power climb conserves fuel.

2. Engine instruments - Check.

At Mach 0.5:

3. Surface limiter - Engaged, SURFACE LIMITER light off.

   Rotate handle counterclockwise and release to engage limiters.

4. Attitude Reference - ANS (pilot).

   The RSO will crosscheck attitude sources before the pilot selects the opposite reference. This is especially critical for night or instrument flight conditions.

   NOTE

   The RSO should vigilantly monitor attitude during takeoff/climb out and crosscheck his attitude indicator references by alternately selecting ANS/INS. He will notify the pilot immediately if any abnormal attitude is suspected.

5. EGT trim switches - AUTO

CLIMB

NOTE

If the cockpit air handle was positioned OFF for takeoff, wait until a safe altitude out of the moist air before positioning the handle to on. Approximately 5000 feet above ground level should be sufficient.

Normal climb is 400 KEAS until Mach 0.90 is intercepted, then hold Mach 0.90.

WARNING

If moderate turbulence is encountered, reduce airspeed to 300 - 350 KEAS while subsonic. Climb at 400 KEAS if supersonic, or decelerate to subsonic speeds at 350 KEAS if the climb cannot be continued. Refer to Section VII, Operation in Turbulence.

NOTE

The pilot must advise the RSO of autopilot engagement or disengagement and the mode(s) affected.

1. PUMP REL switch - Press, Tank 4 released, light out.

   During climb at maximum power when the right-hand shut-off float switches in tank 1 have been actuated because of tank depletion or flight attitude, illumination of the L and/or R FUEL PRESS warning light(s) (a fuel low pressure warning) may occur if tank 4 is released. At maximum power, do not release tank 4 at low altitude.

T 2. Altimeter - Set.

   Set 29.92 as required.

(3.) Sensor power - As briefed.

   All sensor power switches except DEF may be turned on at this time. The RCD or IPD power switch ON legend should illuminate when Radar power is applied. The OBC should be in STBY before takeoff.

   Sensor warmup times are:

RADAR	-	6 min.
RCD	-	1 to 3 min.
EIP/EMR	-	2 min.
TECH	-	20 to 40 sec.

   Ensure TECHs and radar in AUTO or MANUAL modes as required.

(T) 4. HF radio - Retune (618-T-only).

   Recycle HF tuning to in-flight antenna impedance by momentarily placing freq control knob off-frequency, then back to original position. Recycle antenna coupler by keying transmitter.

WARNING

Rf energy from the HF radio during tuning or transmission has caused erroneous light and instrument indications.

5. DEF system power - As briefed.

Depress DEF System A power switch to illuminate the ON legend. After two minutes warm-up, the S (standby) legend should illuminate.

Depress the DEF F/H power switch. The W (warm-up) legend illuminates immediately. In approximately five minutes, the W legend extinguishes and the S (standby) legend illuminates.

Depress the DEF M power switch to illuminate the W and ON legends. After three minutes warmup, the W legend extinguishes.

6. DEF systems - Checked.

Refer to the DEF System Procedures, Section IV.

CAUTION

To avoid DEF system damage due to overheating, do not exceed the transmission time periods scheduled for the checks while testing in the manual mode below FL 500.

NOTE

These tests can be finished after transonic acceleration if the system warm-up time requirement does not allow earlier completion.

7. G-band Beacon switch - As required.

Attitude Control

Each crew member must be aware of attitude reference operating characteristics and be alert for failures. The RSO should select INS attitude reference when the pilot has ANS selected, and vice versa. The pilot should crosscheck attitude with the standby attitude indicator. The RSO should periodically cross check attitude reference sources by alternately selecting INS and ANS.

If the ANS nav-ready signal is lost, the pilot's ANS REF annunciator caution light illuminates, and the RSO's ANS FAIL annunciator caution light illuminates. If the pilot's ATT REF select switch is in ANS: the autopilot disengages, the DAFICS ANR light flashes (flashing DAFICS Preflight BIT FAIL light), the PVD is inhibited, and the power OFF flag appears in the ADI. If the RSO's ATT IND switch is in ANS, the power OFF flag appears in the attitude indicator.

If the INS is operating in the attitude mode, the pilot's INS REF annunciator caution light illuminates. If the pilot's DISPLAY MODE SEL switch is in any position other than ANS, the course warning flag comes into view.

If the INS platform fails, the pilot's INS REF annunciator caution light illuminates. If the pilot's ATT REF SELECT switch is in INS: the autopilot disengages, the DAFICS ANR light flashes (flashing DAFICS Preflight BIT FAIL light), the PVD is inhibited, and the power OFF flag appears in the ADI. If the RSO's ATT IND switch is in INS, the power OFF flag appears in the attitude indicator.

ACCELERATION

The TDI is the primary speed and altitude reference for acceleration to, during, and for deceleration from supersonic flight. The pilot should crosscheck TDI indications with the pitot-static instruments. The RSO should monitor altitude, attitude, and speed. Crosscheck navigation system ground speed against aircraft speed indications.

SUPERSONIC AIRSPEED SCHEDULES

The optimum supersonic airspeed is 450 KEAS while climbing between Mach 1.25 and

NORMAL EVENTS AFTER TAKEOFF OR REFUELING DURING TRANSITION TO SUPERSONIC CRUISE

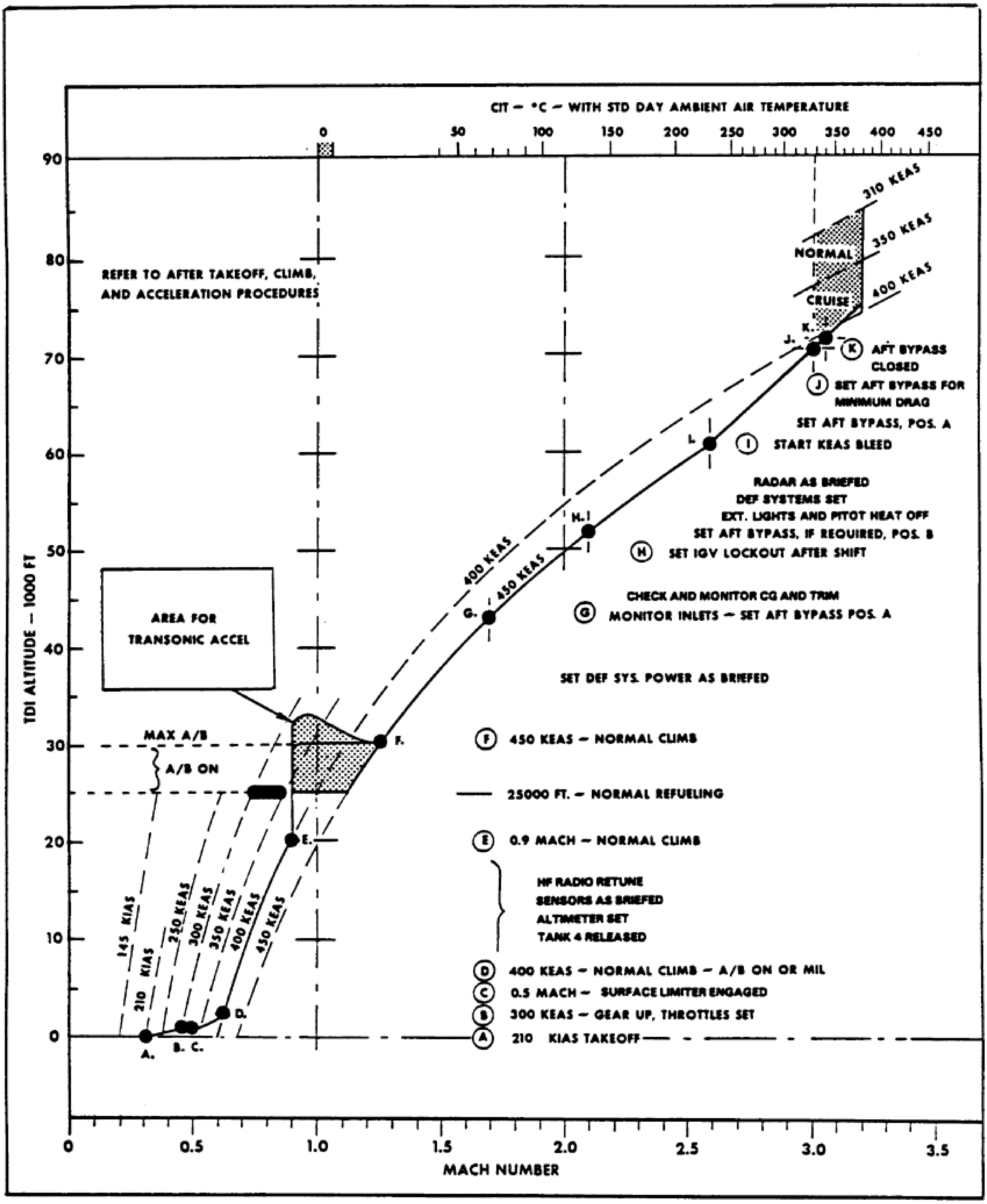


Figure 2-6

Mach 2.6. Lower airspeeds such as 400 or 375 KEAS may be used, as when turbulence is encountered, but performance is considerably degraded.

TRANSONIC ACCELERATION PROCEDURE

Transonic acceleration is accomplished at either a level altitude or during a climb-and-descent maneuver.

NOTE

> The climb-and-descent acceleration is recommended for best specific range (NM per pound of fuel used).

Level Acceleration

A level acceleration to intercept the supersonic climb speed schedule can be made at refueling altitude, normally 25,000 feet. When ambient temperatures are near or lower than standard, less time and distance are required to intercept the climb speed schedule than the climb-and-descent procedure. The total range penalty is small under these conditions.

Start the acceleration with minimum afterburner. Complete course changes while subsonic so that the additional power required for turning will not diminish the power available for transonic acceleration. Set maximum power at Mach 0.9. Gently increase pitch to climb attitude near 430 KEAS. A smooth technique is required, as 450 KEAS is only slightly more than Mach 1.1 at 25,000 feet and is still within the critical thrust/drag speed range which begins near Mach 1.05.

WARNING

> Airspeed may increase rapidly after Mach 1.1 is reached. Reduce power (below Military, if necessary) to avoid high airspeeds. Do not use excessive load factors to prevent exceeding 450 KEAS.

The procedure can be used at another altitude; however, when lower, the transition to 450 KEAS climb attitude must be made in the unfavorable speed range from Mach 1.05 to 1.10. At higher altitudes, the transition through this speed range can be completed before starting the climb, but less thrust is available. If ambient temperature increases, thrust decreases and the time, fuel and distance penalty for using the level acceleration procedure is greater.

Climb-And-Descent Acceleration

The climb-and-descent procedure requires less fuel to intercept the climb speed schedule than the level acceleration when ambient temperatures are warmer than standard.

NOTE

> The climb-and-descent procedure is recommended for best specific range (NM per pound of fuel used) at all temperatures.

WARNING

> Although angle of attack increases during the subsonic climb, pitch attitude must decrease to avoid dangerous flight conditions. Failure to monitor and control attitude, speed, and angle of attack can result in approach to pitch-up conditions.

Start the acceleration with minimum afterburner power. Intercept 0.9 Mach. Set maximum afterburner at 30,000 feet for the remainder of the acceleration, observing the 300 KEAS restriction. At 33,000 feet, increase speed to at least Mach 0.95. This speed is slightly above the start of the drag rise region. Make a smooth transition to establish a 2500 to 3000 fpm rate of descent.

NOTE

Engine stalls during the subsonic climb may indicate a potentially dangerous flight situation. Stalls can result from low CIP or high distortion in the inlet associated with aircraft operation beyond established flight limits. Refer to Subsonic Compressor Stalls, Section III.

After establishing the descent rate, maintain attitude until initiating climb. Avoid higher rates of descent since the usual result is altitude penetration below 29,000 feet and high fuel consumption.

When using the climb-and-descent procedure, it is important to exceed Mach 1.05 early in the descent, and to avoid turning until the climb is established. Begin the transition to climb near 435 KEAS so as to intercept 450 KEAS while climbing.

WARNING

- Airspeed may increase rapidly after Mach 1.1 is reached. Reduce power (below Military, if necessary) to avoid high airspeeds. Do not use excessive load factors to prevent exceeding 450 KEAS.
- In turbulence, reduce climb speed as specified in Section VII, Operation in Turbulence.

Transonic Acceleration Performance Comparison

Figure 2-7 is provided for convenience only. Refer to the appendix for detailed performance values.

TRANSONIC ACCELERATION PERFORMANCE COMPARISON
140,000 initial gross weight
Initial speed = Mach 0.75 at 25,000 feet

Temp difference from Std.		$-10^{\circ}C$	Std	$+10^{\circ}C$	$+20^{\circ}C$	
Level Accel. at 25,000 Ft.	Fuel	4800	5500	6800	8800	lb
	Time	3.1	3.6	4.4	5.8	min
	Dist.	30	36	47	63	nmi
Level Accel. at 30,000 Ft.	Fuel	4900	5600	6600	8300	lb
	Time	4.0	4.6	5.4	6.7	min
	Dist.	38	44	54	69	nmi
Climb to 33,000 Ft.	Fuel	4900	5400	6100	7200	lb
	Time	4.3	4.7	5.3	6.2	min
	Dist.	39	44	51	62	nmi

Std. Temp. = $-34.5^{\circ}C$ @ 25,000 Ft., $-44.4^{\circ}C$ @ 30,000 Ft.
Min. A/B to Mach 0.9 and for subsonic climb to FL 300.
Max. A/B for level accel. above Mach 0.9 and above FL 300.

Figure 2-7

SUPERSONIC ACCELERATION PROCEDURE

1. Throttles - A/B

   Use minimum or maximum afterburner, as desired.

   Intercept Mach 0.90 and climb at that speed until starting the transition to the supersonic schedule.

   If the pitch autopilot is used during subsonic climb, the Mach Hold function must be engaged to climb at constant Mach.

   Refer to appendix Figure A1-4 for approximate differences between IAS and EAS indications. At Mach 0.9, correct airspeed indications at 30,000 feet are 324 KEAS and 347 KIAS. The TDI can be monitored by comparing TDI Mach with indicated Mach.

At start of transonic acceleration:

2. Throttles - Maximum A/B.

   Advance both throttles smoothly to maximum power and advise the RSO.

   Use either the level acceleration procedure or the climb-and-descent procedure.

   NOTE

   - o The Auto-Nav feature of the autopilot is normally used if the roll autopilot is engaged.
   - o If the autopilot KEAS hold mode is used, engage the pitch autopilot and stabilize KEAS for a few seconds before engaging KEAS hold.

After reaching speeds above Mach 1.25 when operating without the automatic EGT control engaged, trim as necessary to maintain nominal EGT as shown in Figure 2-4. EGT must not exceed 830°C below 40°C CIT and 805°C above 40°C CIT. Maintain EGT between 775 and 805°C after climb is established.

At Mach 1.7:

3. Inlet parameters - Monitor.

   Monitor spike and forward door positions and CIP.

4. Aft bypass controls - Set.

   Normally set Position A at Mach 1.7, but wait until the forward bypass doors move out of full closed to set the aft bypass.

5. C.G. and trim - Monitor.

   NOTE

   - Manual boost pump selection for the purpose of shifting c.g. is not normally necessary with a full fuel load. With reduced fuel loads, manual control of the fuel system may be required to achieve a desirable supersonic c.g. position. (See Cruise Fuel Management, this section.) The c.g. normally moves aft 1% per 5000 lb of fuel used until the right-hand shutoff switch in tank 1 operates.
   - While at maximum power with high fuel flows, press tank 5 (or tank 4) boost pumps on before using fuel forward transfer to prevent an R FUEL PRESS warning. Release the tank after completing fuel transfer.

At IGV shift (CIT limit is 150°C):

6. IGV switches - LOCKOUT.

CAUTION

> Decelerate to 125°C CIT or less (approximately Mach 2.0) if the IGV lights are not extinguished upon reaching 150°C CIT (approximately Mach 2.2 with ambient temperature near standard).

The IGV lights should extinguish on completion of IGV shift at 85° to 115°C CIT (approximately Mach 1.7 to 2.3, depending on ambient temperature). The lights must be out at 150°C CIT. When the guide vanes shift, forward bypass opening will increase and fuel flow and thrust will decrease. The engines may not shift simultaneously due to tolerances in fuel control schedules.

NOTE

> If the IGV lights extinguish (IGV shift to cambered) while below the normal shift range, land when practical.

7. Aft bypass controls - Position B, if required.
   a. Set Position B when the lights extinguish if forward bypass opening exceeds 20%. Drag increases noticeably if the forward bypass schedules in excess of 20% open.
   b. Monitor forward bypass door position. Shift the aft bypass from position B to A when the forward bypass approaches closed. Allowing the forward bypass doors to schedule less than 5% open with the aft bypass doors in position B reduces inlet stability and increases the probability of an unstart without appreciably increasing overall inlet efficiency.

8. Exterior lights - Off.
   a. Anticollision/fuselage lights switch - OFF.
   b. TAIL LT switch - Off (center position).

9. Pitot heat switch - OFF.

(10.) DEF systems - Set and checked.

NOTE

> Set DEF system operating conditions as briefed when above FL 500.

(11.) Radar - As briefed.

At FL 600:

(T12.) IFF - Mode C OUT.

This prevents automatic altitude reporting.

At Mach 2.6:

13. Aft bypass controls - Set position A, when required.

    Shift from the B to the A position when the forward bypass approaches closed.

    Allowing the forward bypass doors to schedule less than 5% open with the aft bypass doors in position B reduces inlet stability and increases the probability of an unstart without appreciably increasing overall inlet efficiency.

14. KEAS bleed - Monitor.

    For normal climb at 450 KEAS, decrease KEAS 10 knots per 0.1 Mach number increase above Mach 2.6.

NOTE

The minimum pitch trim indication to be expected at Mach 2.6 is +0.5°. At higher Mach, the minimum limit depends on KEAS, aircraft weight and c.g. Assure trim is at or above 0° except for the specific high Mach, high KEAS conditions at 25% c.g. depicted on Figure 6-7. Check the c.g. if less nose-up trim is indicated.

(T15) INS altitude - Update as required.

Update the INS altitude to the mid-leg altitude between level off and start of descent.

At Mach 3.0:

16. Aft bypass controls - Set.

Maintain position A or use the CLOSE setting for cruise near Mach 3.0. If the forward doors are not closed with position A selected,maintain position A for best performance.

The optimum setting for cruise near Mach 3.0 may be determined by setting the aft doors to CLOSE individually. If drag increase on the closed side is noted, cruise with aft bypass in position A.

At Mach 3.05:

17. Aft bypass controls - Set CLOSE.

Set CLOSE position for cruise above Mach 3.05.

CRUISE

Cross-check the TDI altitude, KEAS, and Mach displays with IAS, indicated Mach, and altimeter, periodically, to detect discrepancies in the TDI. If Mach number appears to be inaccurate, make appropriate adjustments so that flight limits will not be exceeded.

The checklist Mach-KEAS-Altitude Relationship chart and the Mach-Airspeed-Temperature Conversion chart can be used to check the TDI and ANS true airspeed. Indicated spike position vs. the TDI and indicated Mach provides another cross-check on Mach number, as spike position is based on DAFICS Mach output.

WARNING

In the SR-71B, no warning is displayed if the SAS channel engage switches are not ON in the cockpit that does not have AFCS control. If the SAS engage switch(es) are OFF in the cockpit that does not have AFCS control, transferring AFCS control to that cockpit results in loss of SAS until the SAS switch(es) are engaged. Verbally confirm the position of the SAS channel engage switches before transferring AFCS control.

Flight will not be extended into night or IFR conditions if the pilot's standby attitude indicator and either the ANS or INS reference for the ADI are inoperative or erroneous. Climb and penetration through overcast is permitted. If already operating in night or IFR conditions, land when practical.

Pitot Static Reference - Subsonic Operation

The pressure altimeter is the primary altitude reference for subsonic flight operation; to fly an assigned altitude, use the altimeter correction card.

IFF Mode C uses DAFICS (TDI) altitude for automatic altitude reporting.

Operation at Supersonic Speeds

Avoid sustained operation at speeds between Mach 2.5 and 2.7 when convenient. This area is normally more susceptible to inlet duct roughness than higher or lower speeds. Refer to Climb, Section VI.

Autopilot Operation, Cruise or Climb

Manual trim in the yaw and roll axes may be used while the roll autopilot is engaged in Heading Hold or Auto Nav modes to minimize track error (course hang-off). When only attitude-hold mode (pitch or roll autopilot) is engaged, use the trim wheel on the function selector panel to adjust attitude. (Manual trim inputs at this time will only cause control transients.) If Mach hold is desired, engage the pitch autopilot and stabilize the aircraft at the desired Mach before engaging the Mach hold mode.

Optimizing Trim

Trim should be optimized during cruise to minimize drag. With the autopilot on, match fuel flows then apply yaw trim as needed to center the turn-and-slip ball. The periscope may be used to visually confirm rudder trim symmetry. With the roll autopilot engaged, check for off-center displacement of the roll autopilot alignment needle. "Beep" roll trim in the direction of needle displacement until the needle is centered. It may be necessary to repeat the procedure if KEAS or Mach changes.

The max range loss factors for rudder, sideslip, or c.g. deviation (based on symmetrical power and supersonic cruise) are:

rudder: 1° - 3 nm 2° - 12 nm

sideslip: 1° - 12 nm 2° - 48 nm

c.g.: 50 nm/% c.g. fwd of 25% MAC

Turning, in Auto Nav Mode

While in the Auto Nav mode, anticipate turn entry. Use manual stick inputs, if necessary, to avoid excessive roll rates and bank angles. It is unlikely that the stick shaker warning will be encountered during the roll-in to a normal turn. If shaker warning occurs while rolling into a steep turn, manually reduce the roll rate.

Steep Turns

The pitch autopilot can be used for turns with bank angles up to 45°. Pitch and roll attitude must be monitored when making steep turns.

C.G. Crosscheck

Since center of gravity control is important for optimum cruise performance and safety, crosscheck the c.g. indication with pitch trim and, occasionally, by computation.

During climb, the c.g. normally moves aft approximately 1% per 5000 pounds of fuel used and can be expected to reach 24% to 25% when the fuel in tank 1 reaches the right-hand shutoff setting. This should occur near the level-off point in a supersonic flight profile after air refueling to full tanks. After right-hand shutoff, the automatic sequencing provides a center of gravity which will approach 25%. This minimizes elevon deflection and trim drag during supersonic operation. If c.g. should exceed 25%, transfer fuel forward (C.G. annunciator panel warning light illuminates when c.g. reaches 25.3 to 25.6%). During subsonic mission legs, successive forward transfers may be necessary to keep the c.g. forward of the subsonic aft limit (22%).

NOTE

The optimum supersonic c.g. position may not be reached automatically with a partial fuel load. Manual fuel management may be required.

Fuel Management

Maintain c.g. forward of the center of gravity limit by using forward transfer. Forward transfer should also be used for an electrical system or SAS emergency.

Select fuel crossfeed OPEN any time tanks 5 and 6 are empty with both engines operating normally, and any time the FUEL QTY LOW caution light or an L or R FUEL PRESS warning light illuminates. Even though symmetrical thrust conditions exist, the use of crossfeed during afterburner operation can result in mismatched fuel flow indications of as much as 7000 lb per hour, due to fuel crossflow through the fuel heat sink system.

With crossfeed closed, should fuel flows to the engines be mismatched, c.g. may move out of the desired range. If the right fuel flow is higher, c.g. will not move aft as fast as the normal schedule and if the left fuel flow is higher, the converse is true. If fuel flows are mismatched, c.g. should be closely monitored as the full capabilities of the transfer system may be needed to obtain optimum c.g.

Manual aft transfer is provided to augment the automatic aft transfer system. Manual aft transfer is only effective if tank 5 is less than full.

The following three methods are designed to move the c.g. aft. Early manual fuel management is especially important with a less-than-full fuel load during supersonic acceleration. Manual aft transfer has a lower rate of c.g. movement than Method a only, being equal to 71% of Method a rate.

Method a

Press tank 1 on to override the RHSO until the fuel level in tank 1 reaches 3000 pounds.

CAUTION

Do not manually select tank 1 with less than 3000 pounds remaining in that tank. The forward pumps would be operating without fuel cooling and lubrication.

Method b

Pressing tank 2 on and opening the crossfeed valve is effective until tank 3 is empty. The rate of c.g. movement of this method will vary depending on the amounts of fuel remaining in tanks 1 and 2.

NOTE

Using this method eliminates automatic aft transfer. Increased aft c.g. movement can be obtained by depressing the manual aft transfer switch once tank 5 starts to operate.

Method c

Depressing the manual aft transfer switch is the primary means for moving the c.g. aft when tank 2 and 5 are supplying fuel during normal fuel sequencing.

NOTE

With the crossfeed valve open and only one forward tank supplying fuel, the c.g. may move forward.

Engine Operation

Exhaust gas temperature and engine speed limits vary with compressor inlet temperature. Refer to Engine Operating Limits, Section V. When encountered, slow fluctuations in EGT, fuel flow and rpm should be reported for maintenance evaluation; however, fluctuations of ±1% are expected and are not detrimental to engine operation. Random fluctuations of ±4% are expected in nozzle position indication and are not detrimental to engine operation.

EFFECT OF ASYMMETRIC ENGINE FUEL FLOW ON AUTOMATIC CG SCHEDULING

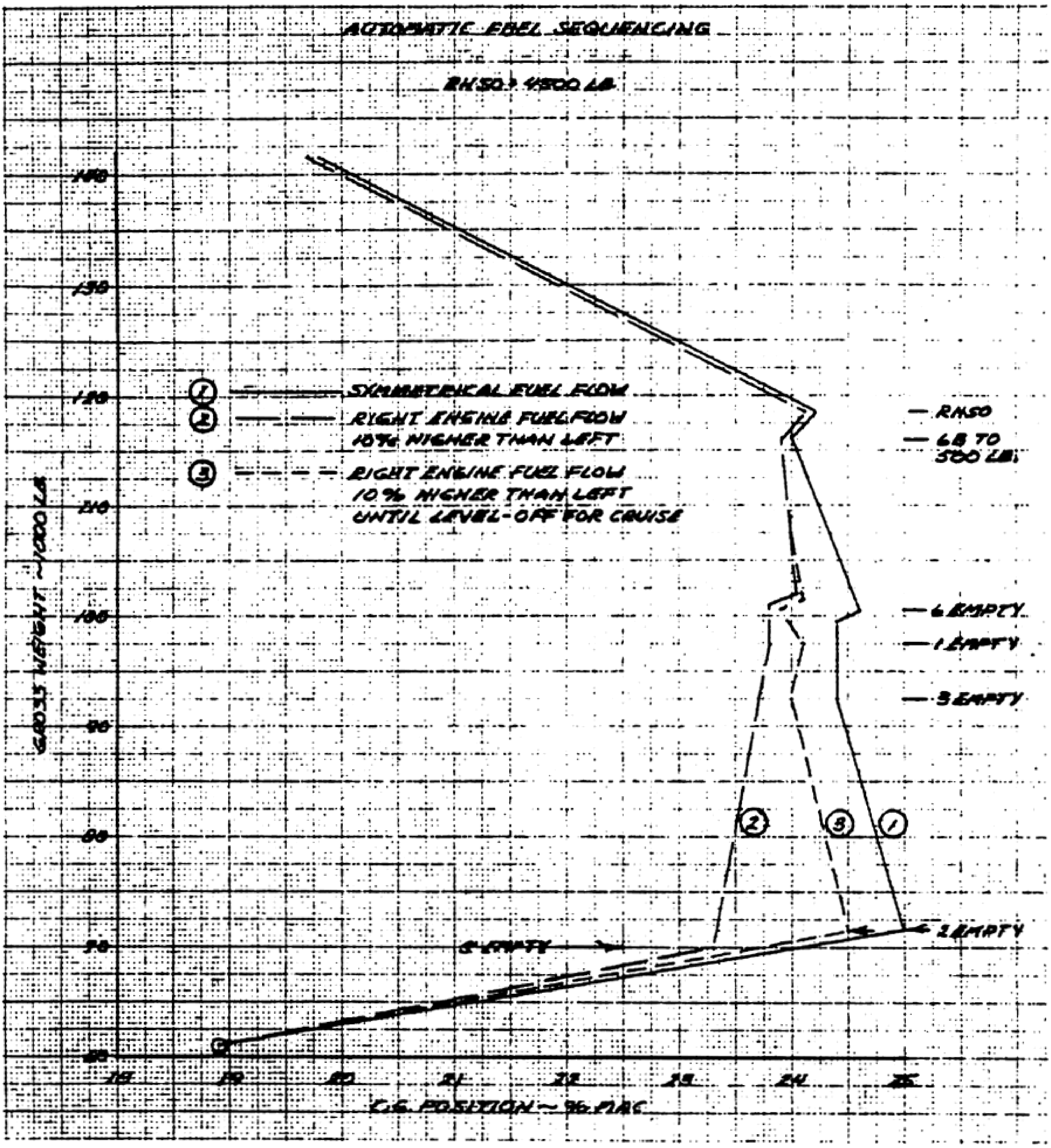


Figure 2-8

EFFECT OF AUTOMATIC AND MANUAL FUEL MANAGEMENT ON C.G. SHIFT RATE*

TANKS ON	PROCEDURE	Percent of Base C.G. Aft Shift Rate
1-3-6 to RHSO	HANDS OFF (NO ALTERNATE AVAILABLE)	+100%** (Base Rate)
HANDS OFF 1-3-6 after RHSO, >3000 lb in tank 1		-19%
	Press on tank 1	+100%
	Press on tank 2, open crossfeed	+67%
	Open crossfeed	+41%
	Tank 5 on after tank 6 is empty	+35%
1-3-6 after RHSO <3000 lb in tank 1, before tank 5 on	HANDS OFF	+7%
	Press on tank 1 (See Note)	+100%
	Press on tank 2, open crossfeed	+67%
	Open crossfeed	+41%
tank 5 on, before tank 2 on	HANDS OFF	+0.8%
	Press on tank 2, open crossfeed	+11.3%
	Open crossfeed	-28.8%
	Press on tank 2	-28.8%
	Press on tank 2, manual aft transfer held on	+34.6%
	Press on tank 2, open crossfeed, manual aft transfer held on	+49.7%
tank 2 on, before tank 4 on	HANDS OFF	+3.3%
	Open crossfeed	-14.1%
	Manual aft transfer held on	+92.0%
	Open crossfeed, manual aft transfer held on	+29.7%

* Based on nominal, matched fuel flow consumption to each engine.

** This rate, which is 1% of C.G. movement for every 5000 lbs of fuel consumption, is used for comparison throughout all stages of tank sequencing. A (+) or (-) sign indicates that the C.G. is moving aft or fwd.

Note: Do not manually select tank 1 with less than 3000 lbs remaining in that tank. The forward pumps would be operating without fuel cooling and lubrication.

Figure 2-9

Effect of Engine Thrust Variation with EGT

For a given level of thrust, higher throttle settings and increased fuel flow are required as EGT is decreased, because combined burning efficiency of the engine and AB decreases with lowered EGT. Full throttle ceilings are therefore reduced. The degradation in thrust for all throttle settings, at Mach 3.2 and 80,000 feet, is approximately 1.3 percent per 10°C of EGT decrease. The trend is the same for other flight conditions.

Effect of RPM Suppression on Maximum Thrust

As EGT decreases, the engine nozzle opens to maintain scheduled rpm. At high Mach and maximum power, the nozzle may open fully and any EGT decrease will result in rpm suppression below schedule. When this occurs, engine speed will suppress approximately 50 rpm for each 10°C of EGT decrease. The airflow through the engine decreases due to the suppressed rpm, leading to a higher inlet bypass requirement and opening of the forward bypass doors. At Mach 3.2 this results in a thrust degradation and drag increase of approximately 3.5 percent per 10°C of EGT decrease for each engine. If Mach number decreases as a result of the change in thrust and drag, the spikes schedule more forward and the forward bypass doors open further. Performance will deteriorate rapidly under these cumulative effects. Cruise EGT should be maintained between 775°C and 805°C to avoid this situation.

Crew Comfort

Pressure suit ventilation air temperature tends to increase and flow decreases while approaching the end of long cruise periods at maximum speed. The increase in temperature is associated with increasing fuel manifold temperature as tank 3 empties and the quantity remaining is exposed to high skin temperatures. This results in less cooling of the engine bleed air as it passes through the fuel-air heat exhangers in the environmental control system. Comfortable suit vent temperatures are restored as soon as tank 2 is scheduled on.

If uncomfortably warm suit vent temperatures are encountered, insure that the suit heat rheostat in the forward cockpit is OFF. Each crewmember can open his air controller valve to increase flow through the suits. If this is not sufficient, the pilot can manually select the tank 2 boost pumps on if the condition can be associated with depletion of tank 3. The c.g. indication must be monitored and kept within limits. Premature use of tank 4 is not recommended as an alternate to using tank 2 fuel.

PRIOR TO DESCENT

▲1. Pilot's ANS distance display mode - DP/TURN.

   a. Display Mode Select Switch - ANS.

   b. Bearing Select switch - NORMAL.

   (Tc) ANS DATA switch - TEST.

   Press DISPLAY push-button switch to display data.

   (Td) DP/TURN push-button switch - As desired.

   RSO will coordinate the pilot's desired ANS distance display mode and will read the backset from DP or distance to turn, as applicable, over interphone.

2. IGV switches - LOCKOUT checked.

3. LN_2 quantity - Checked.

   Check total liquid nitrogen quantity. If not sufficient for normal descent, refer to Fuel Tank Pressurization emergency procedure, Section III.

4. Inlet Controls - AUTO & CLOSE.

   Inlet spike and forward bypass controls will be placed in AUTO and the aft bypass controls set at CLOSE unless manual inlet procedures are used. Refer to Section III, Figure 3-5 for manual inlet schedule.

(T5) INS altitude - Update as required.

Update to the after descent condition (air refueling, penetration or field elevation).

DESCENT

1. For inlet(s) in manual control, restart(s) - ON.

2. Throttles - 720°C EGT to Military.

   Slowly retard both throttles to 720°C EGT to Military. 720°C EGT results in approximately 10 nm less descent distance than Military.

   Expect a fuel vapor trail to occur while the afterburner fuel lines clear.

   NOTE

   - Pause at minimum A/B approximately 5 seconds if retarding from a high power setting.
   - If 720°C EGT is selected, monitor EGT, RPM, and nozzle position. Expect EGT to decrease as Mach decreases. 700°C EGT should hold rpm at the Military schedule and maintain nozzle governing.

   With IGV lockout inoperative:

   a. Set Military.

   For inlet(s) in restart:

   b. Set 720°C EGT to Military.

   For inlet(s) in restart with IGV lockout inoperative:

   c. Set Military.

   Refer to Schedule for Manual Inlet Control, Section III.

3. Airspeed - 365 KEAS (350 minimum).

   Maintain cruise altitude while decelerating, or maintain cruise Mach number while descending, until approximately 365 KEAS. If KEAS hold is desired, engage the pitch autopilot and stabilize the aircraft at the desired KEAS for a few seconds before engaging KEAS hold. Maintain 350 KEAS minimum while decelerating to reduce the probability of unstart and minimize the possibility of engine stall or flameout.

4. Fuel tank pressure - Monitor.

   Descend so that minimum tank pressure (-0.5) is not exceeded.

At Mach 2.5:

5. Throttles - Set 6900 rpm.

   Retard throttles simultaneously. Some throttle misalignment may be required. An rpm decrease of 400-500 rpm can be expected from Mach 2.5 to 1.3. Maintain at least 6500 rpm while above Mach 2.0.

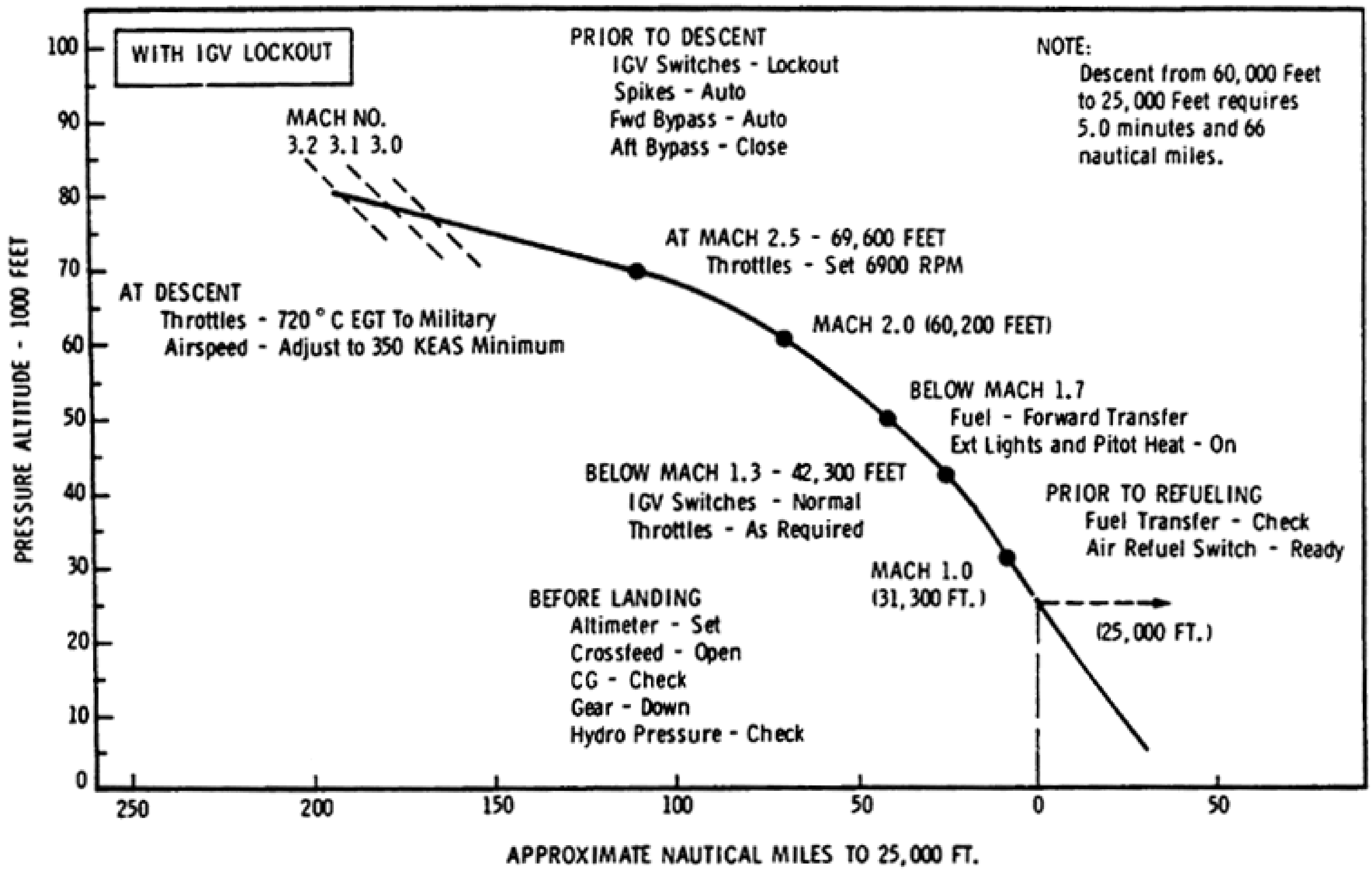
   With IGV lockout inoperative:

   a. Set 720°C EGT and maintain 700°C EGT minimum.

      This procedure will increase descent distance approximately 25 - 30 nm. Maintain at least 700°C EGT while above Mach 1.3 to hold the military rpm schedule and maintain nozzle governing. ENP greater than 70% open will result in less than military rpm; in this event, advance the throttle as necessary to maintain military rpm. Maximum rpm occurs near 100°C CIT, as during climb. Mild compressor stalls may be encountered when near 85°C CIT (approximately Mach 1.8) as the IGV and internal bleeds shift.

   For inlet(s) in restart:

DESCENT PROFILE



350 KEAS DESCENT

ALT	DISTANCE (NM) CRUISE MACH 3.2	3.15	3.1	3.0	2.9	2.8	2.6	2.4	PROFILE CHECK 350 KEAS DIST	IAS	ETE
84K	238	232	226								
82K	236	229	223	211							
80K	234	227	220	208	198	187			234	422	:15.5
78K	231	224	218	206	195	184					
76K	228	221	215	204	193	182	165		196	440	:14.0
74K	225	218	212	202	191	180	162				
72K			209	200	189	177	159	141			
70K				198	187	175	157	139	148	437	:12.0
68K					185	173	154	136			
66K						171	151	134			
64K						169	149	132	120	432	:11.0
62K							147	130			
60K								128	106	428	:10.0
55K									92	422	:09.5
50K									80	416	:08.5
45K	WITH LOCKOUT			W/O LOCKOUT					71	409	:08.0
40K	720° EGT ABOVE M2.5			MIL PWR ABOVE M2.5					63	401	:07.5
35K	6900 RPM AT M2.5			720° EGT BELOW M2.5 (700° MIN)					56	391	:06.5
30K									50	376	:06.0
25K									40	370	:05.0

NOTE

1. Distance and time includes 40 NM L/O prior to ARCP.
2. Add 35 NM for each IGV not locked out.
3. Subtract 25 NM for each restart on.
4. Subtract 30 NM for each inlet in restart w/o lockout.
5. Subtract 51 NM and :06 to FL 310 (IAF).
6. Subtract 40 NM and :05 to FL 250 (IAF).
7. Subtract 25 NM and :03 to FL 160.
8. Subtract 1 NM for each 10° of turn in descent.
9. 5500-6100 RPM below M 1.0.

F203-315(c)

Figure 2-10

b. Set 6500 rpm.

If the forward bypass doors are nearly full open (for any reason) and the engine internal bleeds shift before rpm is reduced, engine stall and flameout are possible.

Refer to Schedule for Manual Inlet Control, Section III.

For inlet(s) in restart with IGV lockout inoperative:

c. Set 6500 rpm. At Mach 2.0, set idle.

Refer to Schedule for Manual Inlet Control, Section III.

CAUTION

If protracted or non self-clearing stalls are encountered, follow procedures in Section III, Compressor Stall In Descent. Use restart and retard throttle to Idle on the affected engine only. Restarts on between Mach 2.5 and 1.3 near Military rpm may result in compressor stall. Check aft bypass doors closed.

At FL 600:

(T6) IFF Mode C - Set as briefed.

(7.) DEF systems - As required.

The DEF systems may be turned off if descending to land, or placed in standby. If the systems are turned off, check that all System H automatic and manual mode legends and the W and S legends are off. Avoid operating System H below FL 500. The other systems should be in standby before reaching FL 500.

NOTE

System H can be maintained in the standby mode below FL 500 if immediate availability of the system is desirable. In this event, perform an automatic self test each half hour with transmit modes selected. Shut down the system when immediate availability is not required.

Below Mach 1.7:

8. Fuel forward transfer switch -On.

Transfer fuel to obtain c.g. within subsonic limits. Check tank 1 fuel quantity increasing.

9. Pitot heat switch - ON.

10. Exterior lights - On.

a. Anticollision/fuselage lights switch - ANTICOLLISION.

b. TAIL LT switch - STEADY.

Below Mach 1.3:

11. Inlet controls - Checked.

Check spike and forward bypass controls AUTO and aft bypass controls at CLOSE unless manual inlet control procedures are required.

12. IGV switches - NORMAL.

De-energizing the IGV Lockout System restores the engine to maximum thrust capability. The IGV should shift to axial and IGV lights illuminate if RPM is above 5500-6000 rpm. (See Figure 1-11.)

13. Throttles - As required.

Adjust descent profile as required. Reduce rate of descent, if necessary, to avoid low fuel tank pressure below FL 400.

When the desired c.g. is obtained:

14. Fuel forward transfer switch -OFF.

15. Crossfeed switch - Set.

    Crossfeed OPEN should be selected if immediate penetration for landing is to be accomplished, if tanks 5 and 6 are empty, or if the FUEL QTY LOW light illuminates.

AIR REFUELING DATA CARD			
TKR TCS			
AREA			
ARCP			
DP #			
TRACK			
ARCT			
ALT BLOCK			
A/R ALT			
A/A TAC			
HF FREQ			
UHF Prim.			
UHF Backup			
EXT. CODE			
ON LOAD			
FULL TANK CG			
MISSED A/R ALT	DP CH	DP CH	DP CH
BINGO FUEL			
PLANNED RES			

Figure 2-11

AIR REFUELING

The pitot-static flight instruments will be used for tanker rendezvous and in-flight refueling procedures. Check that the altimeter is set at 29.92 in. Hg.

Air Refueling Data Card

Air refueling data is recorded on checklist cards similar to Figure 2-11.

Pilot Director Lights (On Tanker)

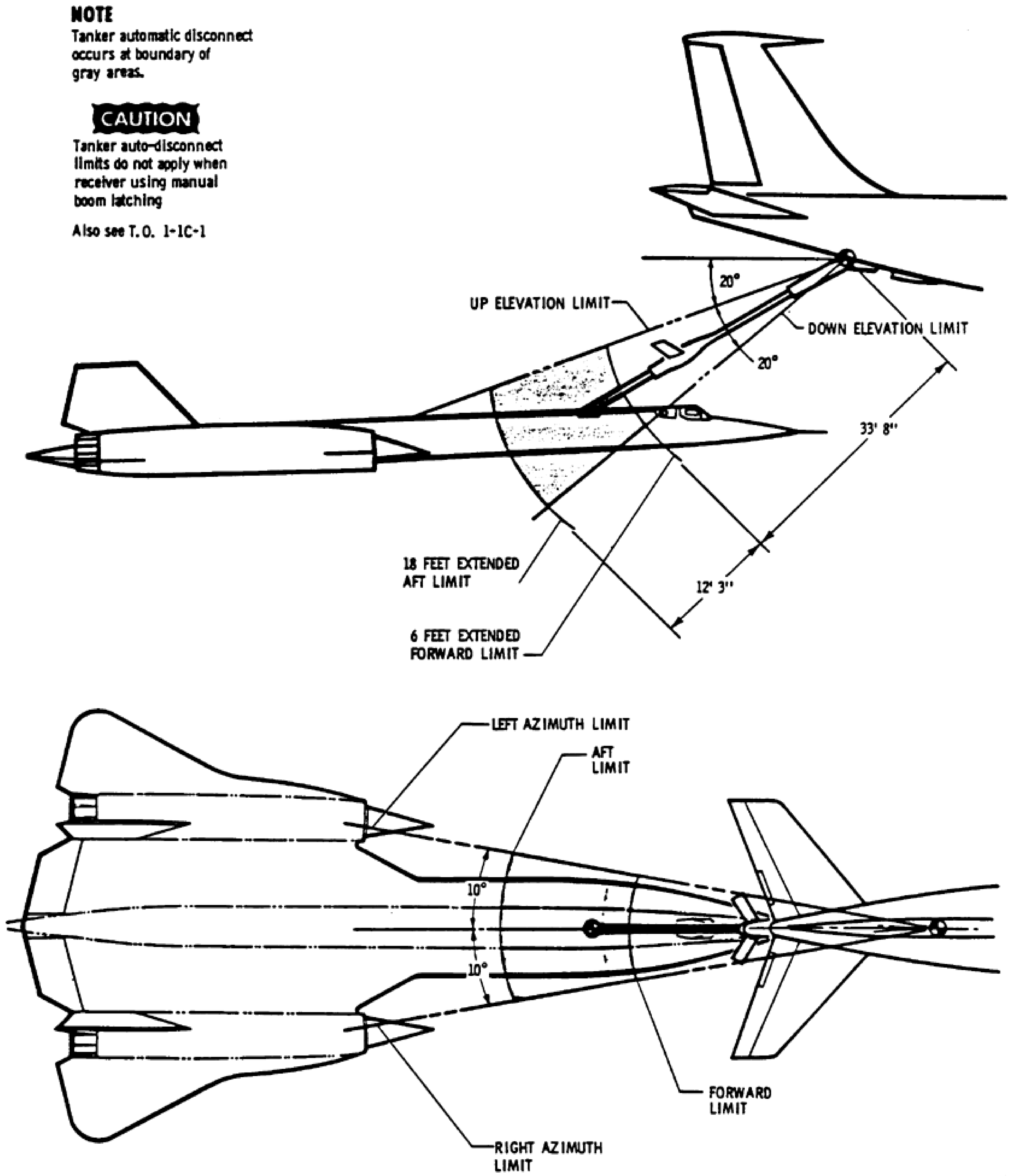
For the KC-135, refer to Figures 2-12 and 2-13. Receiver director lights are located on the bottom of the tanker fuselage between the nose gear and the main gear. They consist of two rows of lights, the left row for elevation and the right row for boom telescoping.

The elevation lights consist of five colored panels with green strips, green triangles, and red triangles to indicate relative position. Two illuminated letters, D and U for down and up movement, respectively, indicate elevation corrections. Background lights are located behind the panels. The elevation lights are controlled by boom elevation during contact.

KC-10 pilot director lights, Figure 2-14, are similar to the KC-135 director lights. The KC-10 elevation director lights consist of a green square, amber triangles, red triangles, and amber D and U letters. The lights are controlled by boom elevation plus boom elevation rate during contact.

The colored panels which indicate KC-135 boom telescoping are not illuminated by background lights. An illuminated white panel between each colored panel serves as a reference. The letters A for aft and F for forward are visible at the ends of the boom telescoping panel. Figure 2-13 shows the panel illumination at various boom nozzle positions within the boom envelope. When contact is made, the lights are controlled by boom extension. There are no lights to indicate azimuth; however, a yellow line on the tanker indicates the centerline.

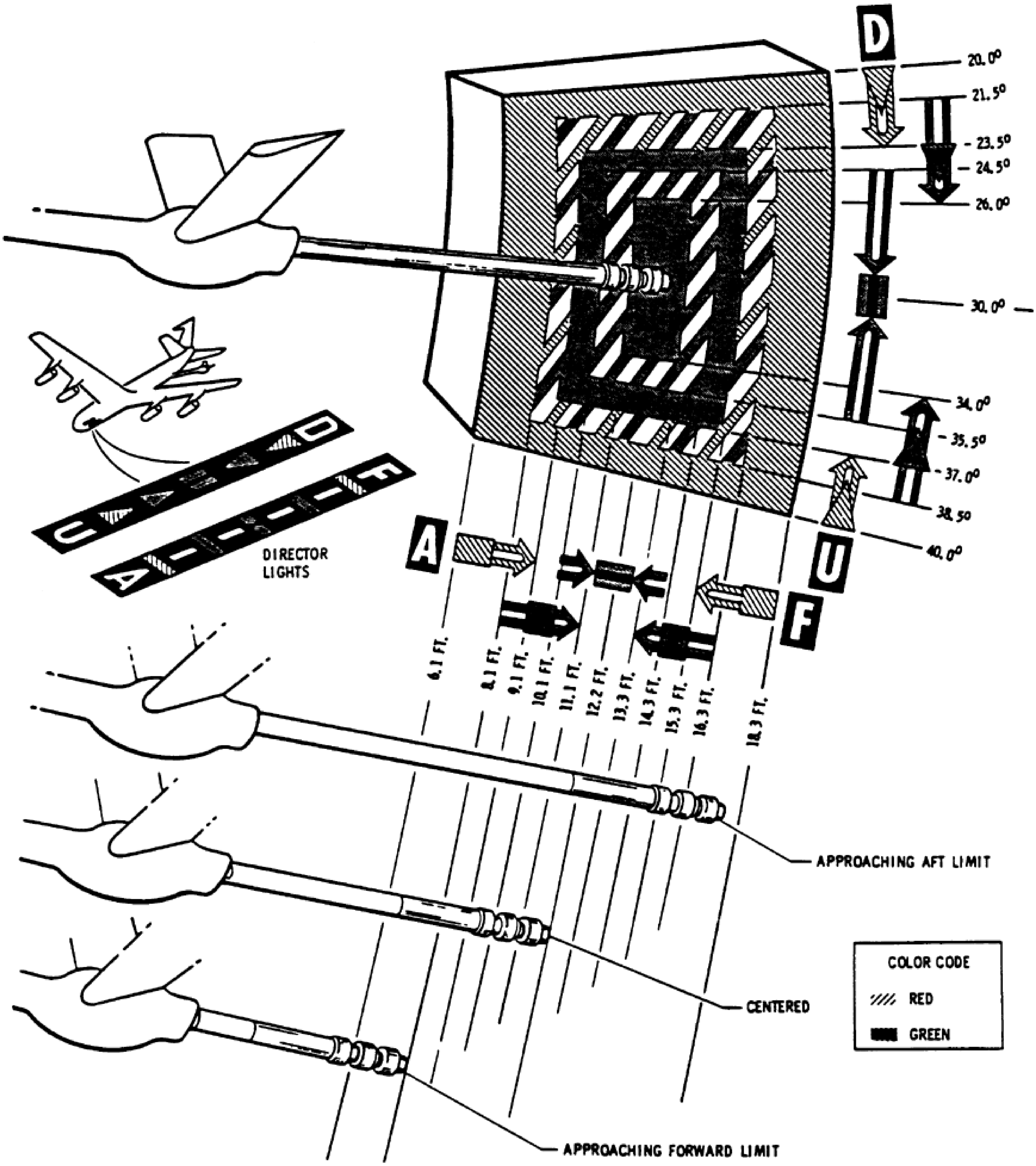
KC-135 AIR REFUELING BOOM LIMITS



F203-28(a)

Figure 2-12

RECEIVER DIRECTOR LIGHTS AND ILLUMINATION PROFILE (KC-135)
(Also see T.O. 1-1C-1)



F203-29(b)

Figure 2-13

RECEIVER DIRECTOR LIGHTS AND ILLUMINATION PROFILE (KC-10)
(Also See T.O. 1-1C-1)

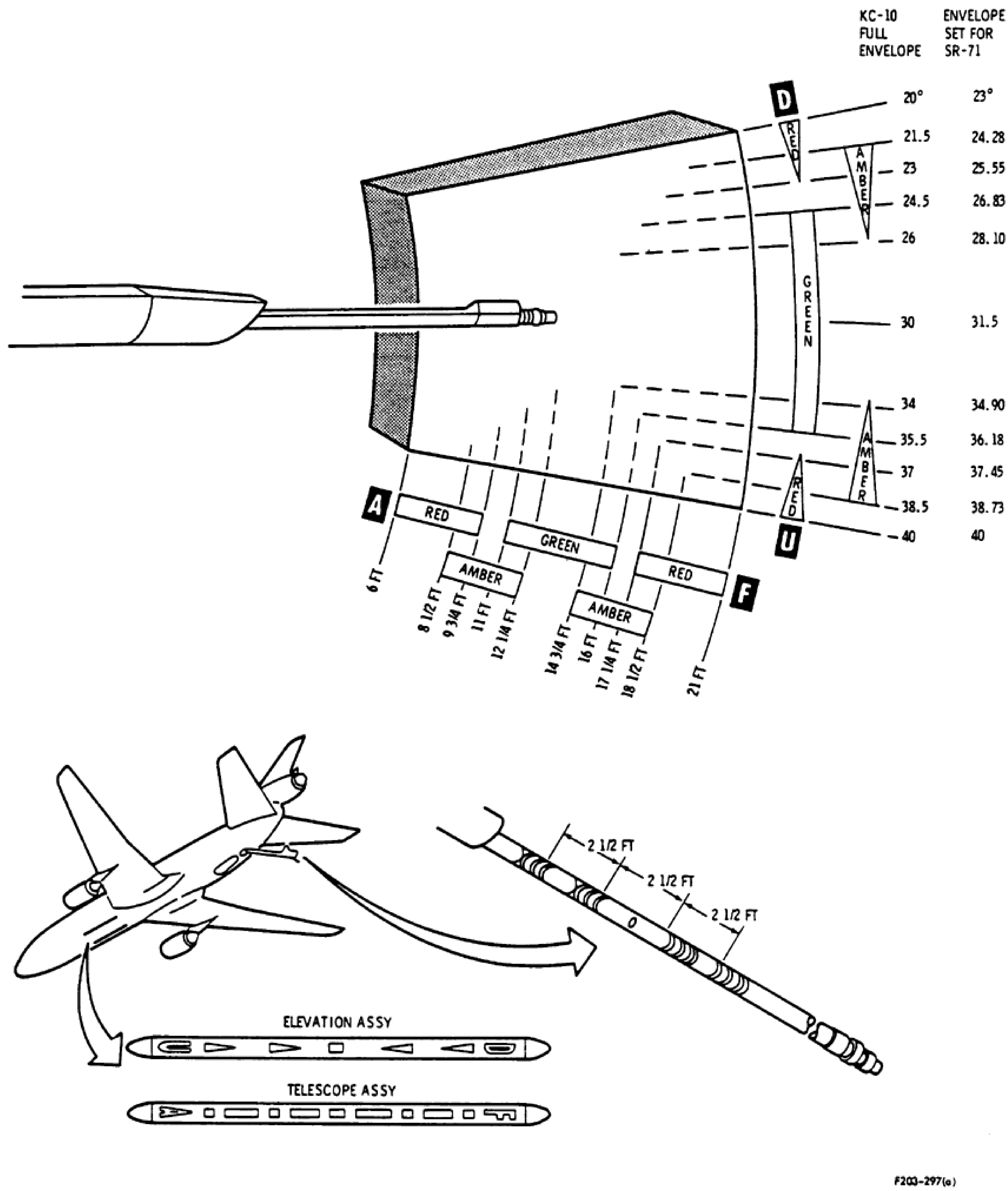
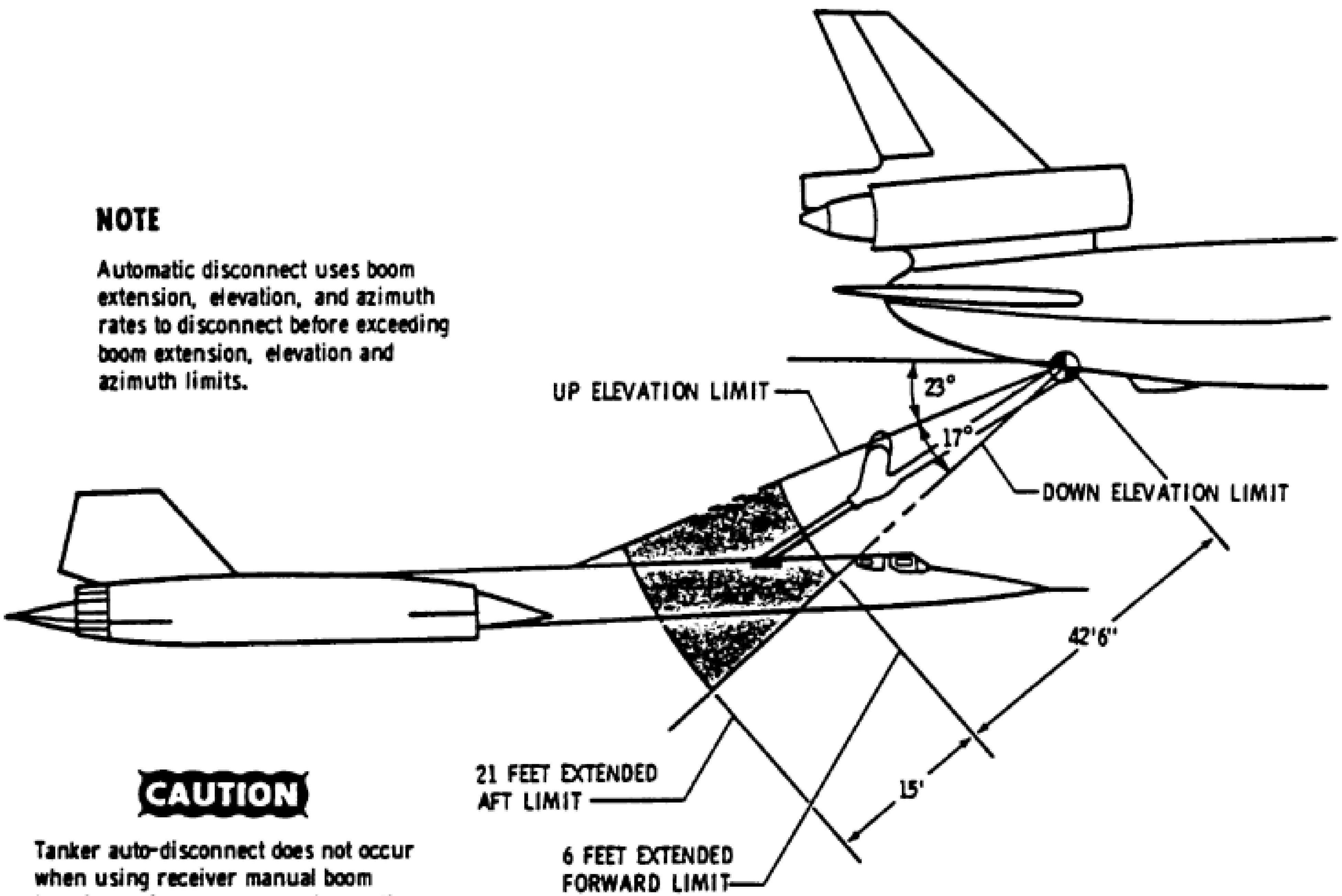


Figure 2-14

KC-10 AIR REFUELING BOOM LIMITS

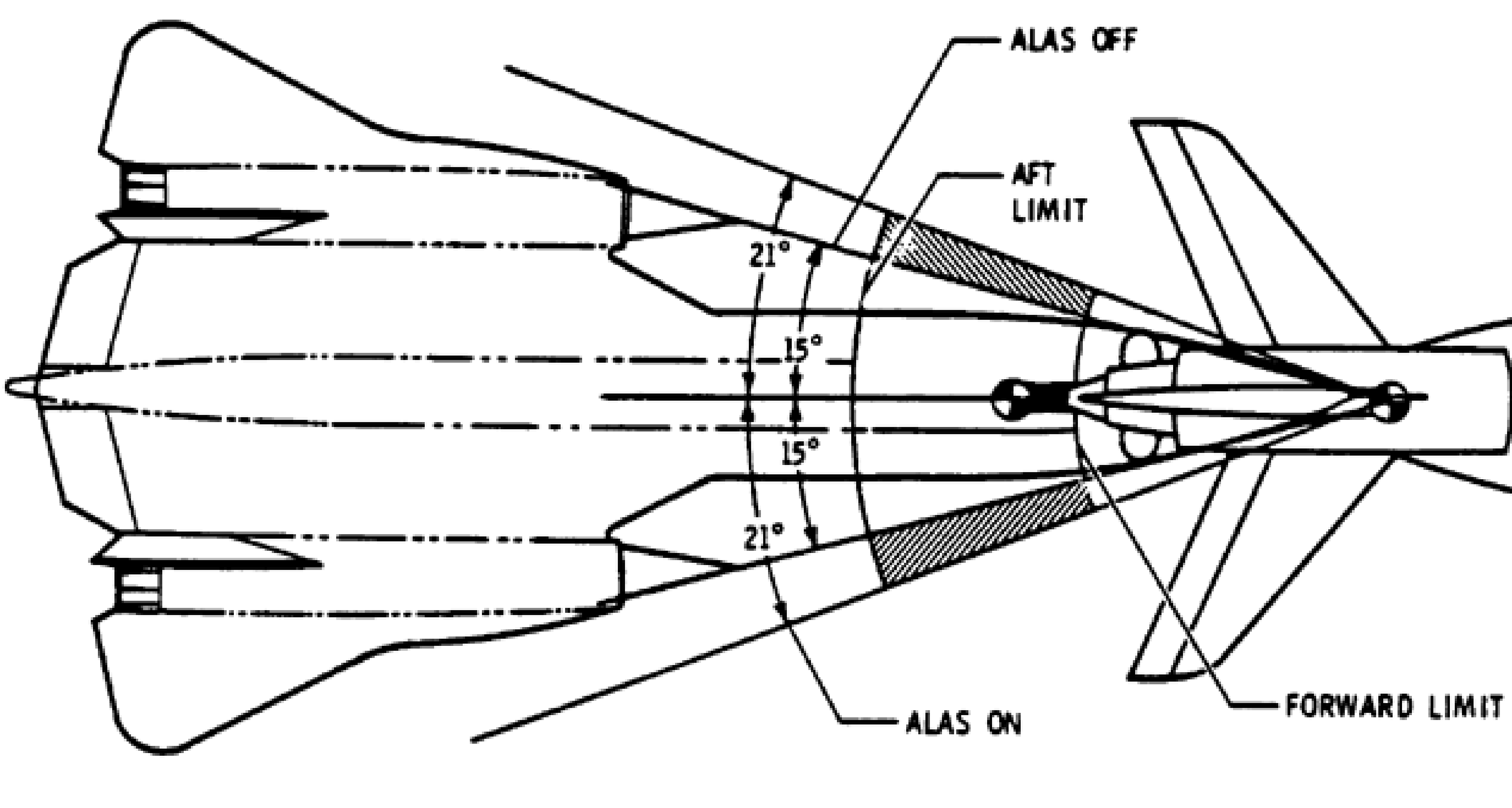
NOTE

Automatic disconnect uses boom extension, elevation, and azimuth rates to disconnect before exceeding boom extension, elevation and azimuth limits.



CAUTION

Tanker auto-disconnect does not occur when using receiver manual boom latching or in tanker manual operation (TMO).



NOTE

Automatic azimuth disconnect set at ±21 degrees with the boom ALAS operating or ±15 degrees with ALAS off.

F203-298

Figure 2-15

The KC-10 lights which indicate boom telescoping are shown in Figure 2-14. When contact is made, the panels are controlled by boom extension plus extension rate.

During radio silence, when in the ready condition, the boom operator actuates the red panels of the receiver director lights to direct the receiver pilot. Illumination of the triangular panels nearest the U and D letters directs the pilot to move up or down respectively. The rectangular panels nearest the F and A letters direct the pilot to move forward or aft respectively. A steady red light indicates that a relatively large correction is desired in the indicated direction. A flashing red light indicates that relatively small correction is necessary.

Fuel Management Prior to Refueling

Transfer fuel as necessary to maintain c.g. within the subsonic limits and manually energize the tank 4 fuel pumps. Reducing the quantity in tank 4 provides more space for cool fuel from the tanker to reduce the temperature of tank 4 fuel and prevents the ullage pumps from cycling due to fuel level fluctuations during refueling. Forward transfer provides a more desirable center of gravity for unaugmented pitch stability and also replenishes tank 1 so that its boost pumps will supply the left fuel manifold during refueling. Fuel is also supplied to the right manifold when tank 4 is below 3600 ± 1200 pounds, or tank 1 is pressed on manually, or the tank 1 fuel level is above the right hand shutoff level. Forward transfer should be repeated if there is any appreciable delay before initial refueling contact or between subsequent refueling contacts. Do not transfer excessive amounts to tank 1, however, as cg forward of 17% reduces load factor limits. Forward transfer should be shut off before making contact.

NOTE

Crossfeed should be used if the FUEL QTY LOW light illuminates or tanks 5 and 6 are empty.

Approach For Refueling

Make the approach from behind and below. Deicing is only provided on the left windshield panel. The seat should be lowered prior to reaching the observation position. Upon completion of the Before Refueling procedure, maneuver to the pre-contact position about 50 feet to the rear and 10 feet below the refueling position. Stabilize and trim the aircraft. Maneuver as indicated by director light signals or by verbal instructions of the boom operator.

NOTE

- COMNAV 50 range and bearing information may be lost when below the tanker if the tanker has not switched to lower antenna.
- The air-to-air mode of the TACAN provides both range and bearing with all KC-10 and some KC-135Q aircraft, but range only with other KC-135Qs. TACAN information may be lost within one mile due to antenna blanking. TACAN signals are not resistant to meaconing, interference, and jamming.

Refueling Hookup

A successful hookup is confirmed by steady illumination of the director light panel and extinguishing of the ready light. Hookup can be maintained between the aircraft and tanker during a turn or in a descent. No adverse flight characteristics result from tanker downwash. Clear away aft and down along the axis of the refueling boom after disconnect.

Boom Elevation Limits

The KC-135 boom upper elevation limit is 20 degrees and the lower elevation limit is 40 degrees. For the SR-71 receiver, refueling above 25 degrees (green triangle) is not recommended. Any illumination of the red "down" triangle is outside the recommended SR-71 receiver envelope.

The upper disconnect limit of the KC-10 boom can be varied. Although the KC-10 can refuel between 20 degrees and 40 degrees, the upper limit for the SR-71 has been set at 23 degrees. With the 23 degree upper limit set, the director lights will show the center of the envelope at 31.5 degrees (Figure 2-14). During refueling, the KC-10 director lights are higher in the pilot's field of view than the KC-135 director lights. Below 36 degrees elevation, the SR-71 pilot may not be able to see the KC-10 director lights even with the seat full down.

Boom Extension Limits

	KC-135	KC-10
Range of Travel	12.2 ft.	15.0 ft.
Inner Disconnect	6.1 ft.	6.0 ft.
Outer Disconnect	18.3 ft.	21.0 ft.
Mid Boom	12.2 ft.	13.5 ft.

Boom Azimuth Limits

The KC-135 azimuth limit is ± 10 degrees. No automatic disconnect is provided in azimuth.

The KC-10 ALAS (Automatic Load Alleviation System) positions the boom elevator and rudders to reduce boom loading after contact. For the SR-71, the automatic disconnect azimuth limit is set to ±21 degrees with ALAS operating and ±15 degrees with ALAS off.

EGT Trimming

Manual EGT trimming may be used in lieu of the automatic trim system, if desired. This will avoid the possibility of "ratcheting." Manual trimming to temperatures above the nominal deadband schedule depicted in Figure 2-4 is permitted. If the engine should stall, or if EGT exceeds 830°C, downtrim immediately.

Disconnect

A disconnect may be accomplished:

1. Automatically.

   a. If boom envelope limits are exceeded.

   b. When fuel pressure exceeds 70 psi.

Pressure disconnects do not usually occur with the KC-10 since the refueling system reduces flow to maintain normal refueling pressure.

2. Manually.

   a. By the boom operator.

   b. By depressing the A/R DISC trigger on the control stick grip.

   c. By the KC-10 boom operator activating the Independent Disconnect System (IDS). The IDS retracts the KC-10 boom latch surface inward and frees the boom even with the SR-71 boom latches still extended.

   d. When pull on the boom becomes excessive ("tension" or "brute force" disconnect).

NOTE

The latch toggle hydraulic system incorporates a pressure relief valve which will permit the boom to be pulled out when a pullout force of approximately 5400 pounds is applied. Therefore, if a malfunction occurs which prevents disconnecting the boom, place the air refuel switch in the MAN O'RIDE position, depress the A/R DISC trigger switch, and proceed with brute-force pullout.

CAUTION

Disconnect in an aft and downward direction, and avoid forward relative motion during disconnect. Disconnect maneuvers which tend to pry the boom out of the receptacle will damage the receptacle or airframe.

Boom Control Failure (KC-10)

The KC-10 boom control system is a dual channel fly-by-wire system. If the two control channels disagree, the boom fails passive with controls in their last position.

CAUTION

If KC-10 boom control failure occurs, the receiver pilot should follow the boom operator's instructions. The boom operator will direct the receiver to a position that will allow a safe disconnect with the boom loaded slightly away from the receiver.

NORMAL AIR REFUELING PROCEDURE

Refueling can be accomplished from either cockpit of the SR-71B.

1. Center of gravity - Checked.

   Transfer fuel to maintain subsonic c.g.; the c.g. will tend to travel aft slightly during the initial portion of the refueling. After c.g. adjustment, the pitch trim should indicate at least 0° to 1° nose up. CG forward of 17% reduces load factor limits.

2. Windshield Deice switch - Set.

   If icing conditions are anticipated, set the Windshield Deice switch ON (down) to start hot air flow across the outside of the left windshield panel. Check that the WINDSHIELD DEICE ON caution light illuminates if deicing is selected.

3. Air refuel switch - AIR REFUEL, READY light on.

4. Tank 4 boost pump switch - Press on.

(T5.) IFF - As required.

6. Forward transfer - OFF.

▲7. Interphone - Set.

   a. Pull and set HOT MIC.
   b. Pull and set IFR COMM.

   NOTE

   If the tanker is not equipped with boom interphone, or if the tanker interphone is off, actuation of either cockpit INPH switch will result in disconnect.

▲8. TACAN Mode selector switch - T/R.

▲9. Radios - Set.

   Check UHF/VHF frequencies. Set UHF Mode switch to INT and power as required. Set interphone selector to radio with primary refueling frequency.

10. Anticollision lights switch - FUS.

11. (Night only) FUS & TAIL switch - DIM.

   For night refuelings, boom operators may request lights off.

   CAUTION

   While refueling, do not transmit on HF radio as the tanker HF transceiver may be damaged.

   NOTE

   After tanker hook-up the air refuel READY light should extinguish.

Total fuel quantity, pitch trim, and c.g. should be monitored.

CAUTION

Under normal conditions, if trimming is required, disconnect and retrim in the precontact position. If trimming on the boom, be alert for runaway trim. To avoid runaway trim due to a sticking trim switch, assure positive switch movement to neutral after each actuation.

Disconnect is indicated by illumination of the DISC light.

When refueling is complete:

12. Air refuel switch - OFF.

▲13. Speeds - Crosscheck and monitor.

Use the ANS ground speed to confirm speed is increasing and as a systems crosscheck.

WARNING

Monitor airspeed and angle of attack after refueling and adjust attitude as necessary to remain within limits. A minimum of 300 KEAS is required.

(T14.) Precomputed c.g. - Check.

Compare c.g. precomputed for the end of refueling with actual c.g. Cross-check tank quantity indications if c.g. is not as expected.

15. Pump release switch - Press and confirm normal tank lights on.

After releasing the tank 4 pumps, only tanks 1,3, and 6 fuel tank boost pump switches remain illuminated.

NOTE

The tank 4 boost pumps must be released after refueling or premature depletion of that tank will occur.

16. Crossfeed - Closed.

(T17.) IFF - Set.

18. EGT trim switches - As required.

19. Windshield Deice switch - OFF.

Check the WINDSHIELD DEICE ON caution light extinguished.

20. Anticollision lights - ANTI COLLISION.

21. (Night Only) FUS & TAIL switch -Bright.

▲22. Interphone control panel - Set.

▲23. Pilot's ANS distance display mode - DP/TURN.

(Ta) ANS DATA switch - TEST.

Press DISPLAY push-button to display data.

(Tb) DP/TURN push-button switch - As desired.

RSO will coordinate the desired pilot's ANS distance display mode.

POWER LIMITED REFUELING

Engine EGT may be manually uptrimmed. Uptrimming should be done prior to establishing tanker contact, but is permissible during contact. If CIT is below 5°C, the nominal EGT schedule in Figure 2-4 decreases rapidly and compressor surge (stall) is possible if the schedule is exceeded. Downtrim immediately if EGT exceeds 830°C or if the engine stalls.

If military power limit is reached prior to completion of fuel transfer, the receiver may request the tanker to initiate a "toboggan" maneuver, or may elect to use one afterburner. If afterburner is used, set one throttle in Minimum A/B. Left afterburner is recommended. A slightly downtrimmed EGT on the afterburning engine helps minimize power asymmetry. Use the opposite throttle to vary thrust. For actual and simulated single engine air refueling procedures, see Section III, Single Engine Air Refueling.

BREAKAWAY PROCEDURE

Any tanker or receiver crewmember, if an emergency arises, will transmit on the air refueling frequency the tanker aircraft call sign followed by "breakaway, breakaway, breakaway." The boom operator may signal breakaway by rapidly flashing the receiver director lights. The receiver pilot will actuate the A/R DISC trigger. Retard throttles and drop aft and down until the entire tanker is in sight.

WARNING

The pilot should use care not to overrun the tanker. If overrunning does occur, under no conditions should a turn be made until breakaway has been completed.

Breakaway Signal

To visually signal emergency breakaway, the tanker turns on the rotating beacon and rapidly flashes the director lights.

AIR REFUELING ALTERNATE PROCEDURE

If L hydraulic pressure is lost, R pressure may be utilized for refueling by moving the brake switch to ALT STEER & BRAKE.

Normal and manual boom latching air refueling procedures apply with ALT STEER & BRAKE selected.

CAUTION

Do not leave the brake switch in ALT STEER & BRAKE after refueling. R hydraulic pressure may be lost also if L system fluid loss is due to a malfunction of the steering or refueling system.

MANUAL BOOM LATCHING

A manual refueling procedure may be used if the signal amplifier fails. This procedure requires manual control of the refueling boom latches. The refueling boom latches are open with the air refuel switch in MAN O'RIDE and the A/R DISC trigger on the control stick grip depressed. The receiver pilot can usually feel the boom nozzle bottom in the receptacle. The READY light will extinguish when the boom nozzle is properly seated; then the pilot should latch the boom in the receptacle by releasing the trigger switch. When latching the boom manually:

1. Air refuel switch - MAN O'RIDE, READY light on.
2. Trigger switch - Press and hold.

After nozzle is seated in receptacle and READY light is off:

3. Trigger switch - Release.

When refueling is completed:

4. Trigger switch - Press and hold until boom is clear.

   READY light illuminates when boom is not seated. DISC light will not illuminate.

Subsequent procedures are the same as after normal refueling.

CAUTION

- If the A/R DISC trigger switch is released when the nozzle is not in the bottom of the receptacle (READY light is off), it is possible for the nozzle to damage or break the extended nozzle latches, preventing any further refueling.
- The boom limit switches are deactivated when using manual boom latching. The receiver pilot must initiate disconnect before exceeding the boom limits since the boom operator will be unable to release the nozzle latches. KC-10 boom operators can still use the Independent Disconnect System.

NOTE

There will not be a pressure disconnect when using manual boom latching, but the refuel manifold accepts tanker pressure with ample margin after tanks shut off automatically. The fuel vent manifold releases excess tank pressure if the tank shutoff valves malfunction.

RADIO SILENCE REFUELING PROCEDURE

Radio silence air refueling can be conducted if the following procedures are observed and both crews are experienced in normal air refueling procedures. The method, time, and place of rendezvous, and amount of fuel to be transferred, must be coordinated.

a. Air refueling checks will be completed before moving to the precontact position.

b. Before contact, maneuver as directed by tanker director lights. A steady red light indicates a large correction and a flashing red light indicates a small correction in the direction indicated by the red director lights. When contact is made, boom interphone may be used.

AIR REFUELING VISUAL SIGNALS

The following visual signals will be used for radio communication failure or radio silence.

Signals From Tanker

With boom in trail:

a. Ten foot extension of the probe means that the tanker is ready for contact.

When the ready signal is received, move from the observation position and stabilize in the precontact position, then move to the contact position.

b. Full extension of the probe means that the tanker is ready for contact but that he is in manual control, without disconnect control capability.

Close and open the Air Refueling door to acknowledge this signal.

NOTE

Boom interphone is inoperative when the tanker is in manual operation.

c. Full retraction of the boom indicates that offload has been completed.

Boom stowed:

a. Full retraction of the probe means that the tanker air refueling system is inoperative.

b. Five foot extension of the probe indicates that there is an air refueling system malfunction.

Check the air refueling system.

Director lights off:

A request to disconnect is signalled by turning the director lights off. Return to the precontact position after disconnecting.

Director lights flashing:

The BREAKAWAY command is signalled by turning the lower rotating beacon on and rapid flashing of the director lights.

Signal From Receiver

Cycle the Air Refueling Door:

Cycling the A/R door while in the precontact position indicates that the Manual Boom Latching procedure will be used. The tanker should signal acknowledgement by full extension of the refueling probe with the boom in trail, and then retract the probe to the ready position.

CAUTION

During manual boom latching, the receiver pilot must initiate all disconnects. KC-10 boom operators can still use the Independent Disconnect System.

Rock wings (daytime) and turn rotating beacon on/off at ten second intervals:

This signal indicates that the receiver must refuel. If not at a scheduled time or place for refueling (when the boom operator might not be in place) take a position where the signals are visible from the tanker cockpit.

FUEL DUMPING

Fuel dumping provides a means of reducing gross weight rapidly. The nominal dump rate is 2500 pounds per minute for both FUEL DUMP and EMER switch positions, but the rate varies with the amount of fuel remaining and the number of boost pumps operating.

Normally, fuel is dumped in the automatic fuel sequence. An additional tank can be selected in each tank group to increase the dump rate.

To dump fuel:

1. Fuel dump switch - FUEL DUMP.

   All tanks containing fuel will empty in the normal usage sequence except tank 1. Tank 1 will dump automatically with the other tanks until its fuel level reaches approximately 4700 pounds, depending on aircraft attitude (see Fig. 1-36), then it will stop. The other tanks will continue dumping until the fuel level in tank 4 reaches 3700 pounds (again depending on aircraft attitude), then normal dumping is terminated automatically regardless of the fuel quantities remaining in the other tanks.

2. C.G. - Monitor.

   Transfer fuel as necessary to maintain c.g. within limits. At heavy weight, with more than 40,000 pounds of fuel remaining, consider pressing tank 2 on manually to avoid any abnormal forward c.g. condition during dumping. Crossfeed can also be used and will tend to shift c.g. aft.

3. Fuel quantity - Monitor total and tank 4.

   a. Tank 1 dumping should terminate automatically when 4700 pounds remain in that tank.

   b. All dumping should terminate automatically when 3700 pounds remain in tank 4.

When the desired fuel quantity remains:

4. Fuel dump switch - OFF.

To dump fuel when tank 4 contains less than 4000 pounds, or if the FUEL DUMP switch position is inoperative:

5. Fuel dump switch - EMER.

   Selection of the fuel dump switch emergency position overrides the stop-dump feature of the normal dump system.

6. Fuel quantities - Monitor tanks 1 and 4.

   WARNING

   Emergency fuel dumping must be terminated by positioning the dump switch to OFF (or FUEL DUMP), or all tanks will empty.

When tank 1 is below 5000 pounds:

7. Fuel crossfeed switch - Press to OPEN.

When the desired fuel quantity remains:

8. Fuel dump switch - OFF.

BEFORE PENETRATION

The pitot-static flight instruments will be used when subsonic.

1. Display mode selector switch - Set.

T 2. Defog switch - Set.

T 3. Altimeter - Set.

(4.) DEF systems power - Off.

(5.) Sensor operate switches -STP.

(6.) Sensor power switches -Off.

(7.) V/H power switch - Off.

(8.) Exposure power switch - Off.

(9.) G-band Beacon switch - OFF.

NOTE

Do not shut down the MRS.

(T10.) INS altitude - Update.

Update to the field elevation.

PENETRATION

1. Crossfeed switch - OPEN.

CAUTION

Leave crossfeed open to assure fuel supply to both engines during landing and possible go-around operations.

2. Brake switches - DRY or WET, and ANTI SKID ON.

Use the DRY position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume a wet runway condition if moisture is visible on the runway, particularly as evidenced by glare or reflections.

(T) a. Brake switch - OFF.

Below Mach 0.5:

3. Surface limiter control handle - Pulled, SURFACE LIMITER light out.

Pull and rotate the surface limiter handle 90 degrees to disengage the surface limiters, lock the handle, and extinguish the SURFACE LIMITER caution light.

▲4. UHF power selector - Set.

Set power 4 or lower, if making an ILS approach.

WARNING

ILS reception can be affected by UHF transmission at high power settings.

T 5. Defog switch - Set.

To dissipate fog in the windshield area, hold the defog switch OPEN for several seconds to provide hot air to the windshield, then select HOLD.

NOTE

Fog usually occurs in the rear cockpit first.

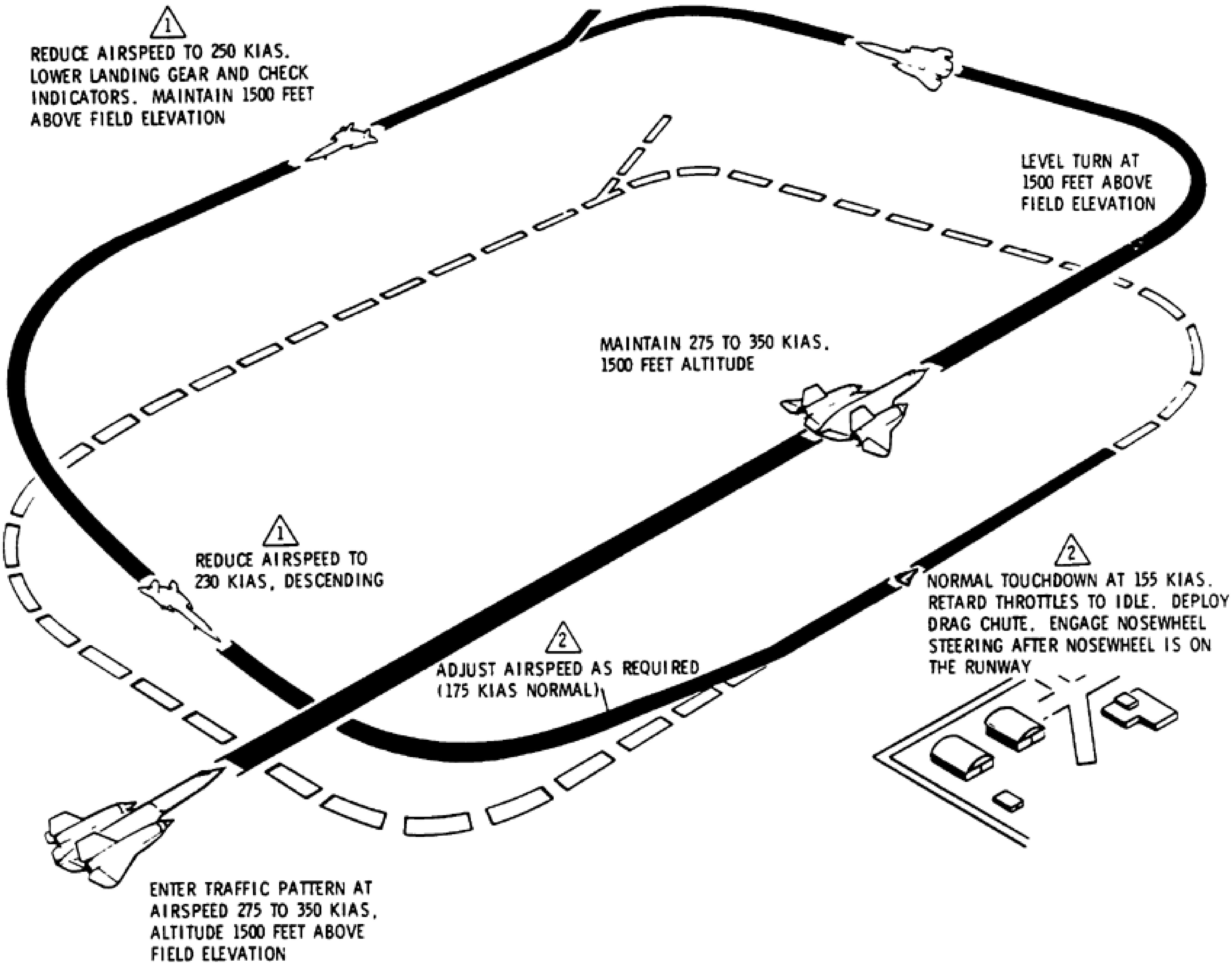
6. Landing light switch - On

BEFORE LANDING

Figure 2-16 depicts a typical landing pattern. At heavy weights, increase airspeed if necessary to maintain angle of attack less than 8 degrees for turns to base leg and 9 degrees for turns to final approach.

The design landing weight is 68,000 pounds with 10 fps sink rate. When landing at higher weights is required, the following speed and sink rate schedule applies.

LANDING PATTERN - Typical



NOTE

1. For aircraft over 100,000 lbs. (more than 40,000 lb. fuel remaining), maintain 275 KIAS on downwind leg and 250 KIAS on base leg; and use an angle of attack of approximately 10.5° for final approach and landing.

2. Increase normal speed for final approach (175 KIAS) and landing (155 KIAS) by 1 knot per 1000 lb of fuel over 10,000 lb remaining. For maximum performance, the minimum landing speed is 10 KIAS less than the speed determined by this rule. See Appendix figure A2-15. The minimum final approach speed is 20 KIAS above the intended landing speed.

Figure 2-16

NORMAL LANDING SPEED SCHEDULES

Approx Fuel Remaining	Final Approach KIAS	Landing Speed KIAS	Max Sink Rate Allowable
10,000 lb or less	175	155	10 fps (600 fpm)
20,000 lb	185	165	9 fps (540 fpm)
25,000 lb	190	170	8.7 fps (522 fpm)
30,000 lb	195	175	8.5 fps (510 fpm)
40,000 lb	205	185	7.75 fps (465 fpm)
With over 40,000 lb remaining, observe Section V landing sink rate limits.			

Figure 2-17

CAUTION

When feasible, routine full stop landings should be made with no more than 10,000 pounds of fuel.

For heavyweight landings: With over 40,000 lb of fuel remaining, use the normal final approach speed schedule and maximum performance landing speed (10 KIAS less than normal landing speed). See Figure 2-17. Use the maximum performance landing technique for stopping.

NOTE

Maximum performance landing speeds result in touchdown angles of attack 1/2 to 1 degree greater than for normal landing speeds.

▲1. Approach and landing speeds -Computed.

Final approach and landing speeds are based on weight. Angle of attack will be approximately 10 degrees for a normal final approach.

Use the maximum performance landing speed schedule when conditions such as wet runway or short field length require minimum roll after touch down.

▲2. Center of gravity - Checked.

Transfer fuel as necessary to maintain subsonic c.g. limits. CG forward of 17% reduces load factor limits. If cg is forward of 17%, insure that no more than half the fuel remaining is in tank 1.

3. Landing gear lever - DOWN and checked.

Check gear warning lights.

CAUTION

Do not extend the landing gear more than 10 times each flight.

NOTE

- Normal gear extension time is 12 to 16 seconds.
- When at heavy weights, gear extension may be delayed until after turn to final approach course, if desired.

4. Hydraulic pressure - Checked.

5. Right refrigeration switch - OFF.

The pilot's R AIR SYS OUT caution light illuminates. Monitor E and R Bay temperatures and suit vent flow for adequate flow from the operating refrigeration unit. Turn the right refrigeration system on and the left refrigeration system off if flow is inadequate.

(T6.) Cockpit air handle - OFF

Place the cockpit air handle in the forward (valve closed) position to prevent cockpit fogging. The pilot's CKPT AIR OFF caution light illuminates.

NOTE

Refrigeration system shutoff and cockpit air shutoff are not normally required for low approaches.

7. Annunciator panel - Checked.

NOTE

Lowering the vision splitter during night landings reduces glare from reflections off the inside of the windshield.

NORMAL LANDING

Touchdown is made with the throttles in IDLE, and at approximately 9.5 degrees angle of attack. (Due to ground effect, angle of attack is nearly the same as for final approach.) Pitch angle is approximately 10.5 degrees, with the nose almost on the horizon. A high rate of sink will develop if airspeed becomes excessively low on final approach, and result in a hard landing.

NOTE

- Throttle movement should follow the quadrant curvature so that the hidden ledge at the IDLE position can prevent inadvertent engine cutoff.
- With cockpit air on, sudden fogging can occur when the throttles are retarded during the landing flare. Use the Cockpit Fog emergency procedure in this event.

NOTE

- Angle of attack at touchdown must not exceed 14 degrees to avoid scraping the tail.

Use the maximum performance landing touchdown speed when wet or slippery runway conditions exist which degrade braking capability.

AFTER TOUCHDOWN

1. Drag chute - Deploy.

Deploy the chute when the main gear is on the runway and angle of attack is 10 degrees or less.

CAUTION

Deploying the drag chute at greater than 10 degrees angle of attack may result in the chute canopy contacting the runway and receiving scuff damage.

Pull the drag chute handle straight aft to the limit of its travel (approximately one inch).

WARNING

Avoid resting the hand on or near the drag chute handle after pulling it aft for normal deployment. Otherwise, the chute will be jettisoned if the handle is pushed forward inadvertently when the chute opens.

The initial forces caused by chute opening normally approximate one-half "g" deceleration. See Section VI, Figure 6-11.

If the chute does not deploy normally in approximately five seconds, turn the chute handle 90 degrees counterclockwise and pull aft, approximately six inches, to the limit of its travel.

NOTE

The drag chute switch in the aft cockpit of the SR-71B must be OFF to deploy from the forward cockpit; otherwise, the handle in the forward cockpit is inoperative.

Start the nose down at touchdown. Excessive nose gear loads may result on contact if a high angle of attack is maintained until airspeed is too low for positive control of attitude.

2. Nosewheel steering - Engage.

   Engage nosewheel steering when the nosewheel is on the runway. Steering will not engage until the rudder pedals and nosewheel are aligned and aircraft weight is on any one gear.

   Illumination of the nosewheel steering STEER ON light is a positive indication that steering has engaged.

   It may be necessary to move the rudder pedals through a small range on each side of neutral to assure alignment with the nosewheel castering angle. In a crosswind, engagement will probably require momentarily moving the pedals in a direction opposite to that desired for steering.

   Although the steering system includes a holding relay in the engagement circuit, the recommended method for positive engagement is to hold the nosewheel steering (CSC/NWS) button on the control stick depressed until steering is engaged. The button may be released after engagement.

   Nosewheel steering is released by pressing and releasing the button a second time (whether actually engaged or not). If steering is inadvertently released, depress the button again and reengage steering as before.

3. Brakes - Checked.

   Check for normal brake operation by light application prior to jettisoning the drag chute.

   Anti-skid braking is available when aircraft weight is on at least one main gear; however, delay braking until the nosewheel is on the runway.

   The normal performance procedure should be used on a dry runway or on a grooved runway with braking equivalent to a dry runway. (Refer to Wet/Slippery Runway Landings, this section, if landing on a runway where braking may be degraded). Apply brakes as required. Light braking is sufficient if the drag chute deploys normally. If the drag chute does not deploy, moderate braking force is necessary at normal landing weight.

4. Drag chute - Jettison.

   Push the drag chute handle fully forward from the deploy position to jettison the chute.

   The drag chute is normally jettisoned at or above 55 KIAS when on a dry runway or with equivalent braking action available; however, do not jettison the chute if the crosswind component exceeds 12 knots or if braking action is unsatisfactory.

   (T) a. Drag chute switch - OFF.

   WARNING

   In the SR-71B, if the aft cockpit deploys the drag chute and the forward cockpit handle remains stowed, returning the aft cockpit drag chute switch to OFF will jettison the drag chute.

CAUTION

If the drag chute is not jettisoned, the elevons should not be moved during taxiing as the shroud lines may jam between the inboard elevons and fuselage and cause structural damage.

NOTE

The drag chute can not be jettisoned after using the emergency deployment system.

CROSSWIND LANDING

Refer to Landing Gear System, Crosswind Limits in Section V. Also refer to the Crosswind Component chart in the Appendix, Figure A2-1.

Runway alignment on final approach can be maintained by crabbing and/or dropping one wing. Remove any crab before touchdown, and use the wing-low technique to align the aircraft with the runway and prevent side drift.

Reduce sink rate to a minimum to accomplish a smooth touchdown. As crosswind components increase, sink rate must be minimized due to the increased side loads imposed on the landing gear.

CAUTION

It is essential to remove all crab before touchdown to minimize scuffing damage to the tires.

Crosswind Condition With Dry or Grooved Runway

Touchdown and try to remain on the upwind side of the runway. This provides more runway space on the downwind side, and puts the crosswind and runway "crown" effects in opposition. Deploy the drag chute early in the landing roll, as for a normal landing, but lower the nosewheel first and engage steering if the crosswind component is over 15 knots.

The chute's tendency to pull the aircraft off the runway in a crosswind decreases as speed is reduced, and the effect is easily controllable with nosewheel steering. Keep the stick forward to improve nosewheel steering effectiveness. Increasing rudder deflection and/or increasing elevon differential is required as speed decreases.

Do not shut down either engine when on a dry runway, or on a grooved runway which provides equivalent braking.

Crosswind Condition With Slippery Runway

For landing on a slippery runway with a crosswind, start the nose down immediately on landing and engage nosewheel steering before deploying the drag chute. After the nose is lowered, use lateral stick deflection and/or rudders to increase directional control. Use roll inputs in the same direction as rudder/nosewheel steering. This also increases braking on that side when combined with neutral or aft stick.

With a slippery runway, shutdown of one engine to assist in stopping is permissible if required due to drag chute failure. Shutdown the upwind engine when under 100 KIAS, and select ALT STEER & BRAKE if continuing on the right engine alone. Shutdown is not recommended if barrier engagement is available.

The nosewheel steering system provides adequate control in allowable crosswinds on slippery runways, even with damaged main gear tires. However, be careful not to overcontrol the aircraft and start a lateral skid. The nosewheel steering force can be very large and this force, combined with the reduced side reaction force capability of the main gear tires, may cause the main gear tires to "break away" and slide. The nosewheel steering force reaches a maximum at a 13-1/2 degree angle between the tires and the ground track. This corresponds to 6 degrees rudder deflection with the aircraft heading along the ground track.

WET/SLIPPERY RUNWAY LANDINGS

When landing on a runway where degraded braking is expected (i.e., on a wet runway without grooves), select the WET anti-skid braking mode. When crosswind is not a factor, use the maximum performance touchdown speed schedule and lower the nose while deploying the drag chute. Apply maximum braking as soon as the nosewheel is on the runway and engage nosewheel steering. Frequent anti-skid cycling may be felt. Retain the drag chute if stopping distance is critical. The chute can be jettisoned if a control problem or a lateral skid develops.

If the drag chute fails to deploy, use moderate up-elevon to increase drag and the load on the main gear. The WET anti-skid mode provides the best braking capability with or without the drag chute unless tire failure has occurred; in this event, it may be necessary to complete the stop with anti-skid OFF and the wheels locked. Refer to Flat Tire Landing emergency procedure, Section III. If the chute fails, shutdown of one engine is permissible when under 100 <u>KIAS</u> if required to assist in stopping, but shutdown is not recommended if barrier engagement is available.

Icy Runway Procedure

Use the same techniques as for the Wet/Slippery Runway landing.

MAXIMUM PERFORMANCE LANDING

Use the maximum performance schedule whenever minimum landing distance is desirable. Maximum performance touchdown speed is 10 KIAS less than normal touchdown speed. Start drag chute deployment as soon as the main gear is on the runway and angle of attack is 10 degrees or less.

WARNING

Do not deploy the chute in flight.

CAUTION

Deploying the drag chute at greater than 10 degrees angle of attack may result in the canopy contacting the runway and receiving scuff damage.

Lower the nose and apply maximum braking as soon as the nosewheel is on the runway. Engage nosewheel steering. Retain the drag chute. One engine may be shutdown after touchdown to reduce thrust and shorten the landing roll.

WARNING

Do not shutdown both engines, as it may result in the loss of brakes. Nosewheel steering will be lost when engine speed decays.

MINIMUM ROLL

Reduce fuel weight to 5000 pounds, if possible, and use the maximum performance landing procedure.

HEAVYWEIGHT LANDING

Landings with more than 40,000 pounds of fuel remaining should be avoided, but can be accomplished if necessary. Use normal final approach speeds, but do not exceed 11 degrees angle of attack. Use the maximum performance touchdown speed schedule and observe touchdown rate of sink limits from Section V. When touchdown speed is less than the chute deploy limit speed (210 KIAS), lower the nose and deploy the drag chute as soon as the main gear is on the runway. If touchdown speed is higher than 210 KIAS, hold the nose off until 210 KIAS is reached, then lower the nose and deploy the drag chute. To minimize the possibility of tire

GO AROUND - Typical

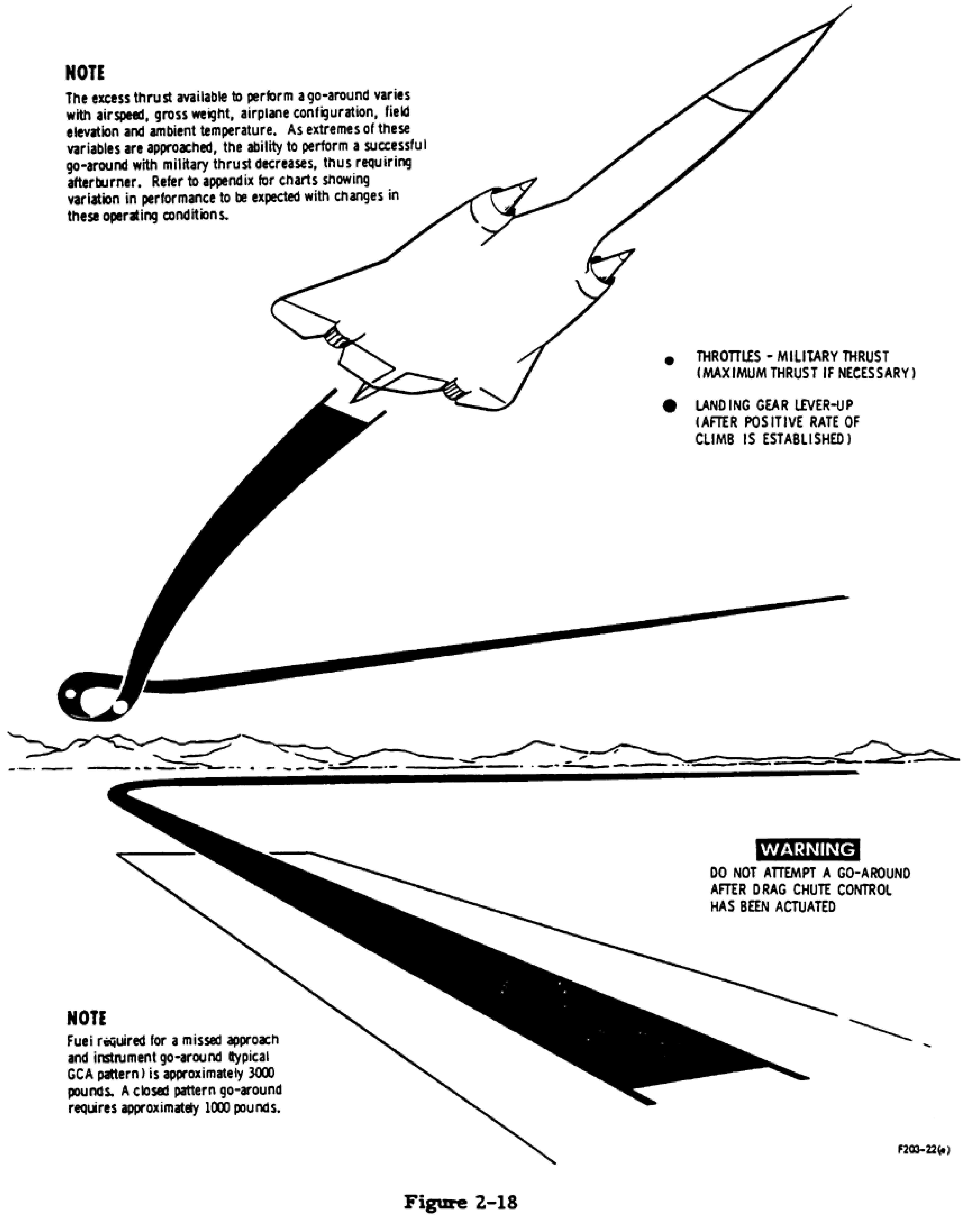


Figure 2-18

failure at heavy weight, the brakes should be applied early in the landing roll. This reduces the distance travelled at high speed. Retain the drag chute. Barrier engagement should be anticipated, since the brake energy rating may be exceeded. Refer to Figure 5-9, Section V.

GO-AROUND

A go-around may be initiated at any time during the approach or landing roll when sufficient runway remains for takeoff and no attempt to deploy the drag chute has been made. (See Figure 2-18.) For go-around after touchdown, reduce pitch attitude to approximately 5 degrees pitch angle (5 degrees above what the attitude would be with the nose on the ground) then adjust attitude to takeoff at 210 KIAS.

TOUCH-AND-GO LANDING

Normal Before Landing and After Takeoff procedures apply to touch-and-go operations. The maximum fuel load recommended is 25,000 pounds remaining and cg aft of 17%. The limit sink rate is 8.7 fps (522 fpm) with 25,000 pounds of fuel.

CAUTION

Do not extend the landing gear more than 10 times each flight.

At least ten complete retract and extend cycles of the gear can be made with normal hydraulic quantity and reservoir nitrogen pressure servicing. If reservoir nitrogen pressure is depleted, cycling the landing gear may cavitate the L hydraulic system pump and cause complete loss of L hydraulic system pressure.

NOTE

Manual EGT trim may be used when making successive low approaches or touch and go landings. This prevents auto EGT up-trim "ratcheting" which could occur because of power manipulation during approach, and which might result in EGT overtemperature while at or above Military power during go-around.

1. Throttles - IDLE.
2. Touchdown speed - As required.

   Base touchdown speed on fuel remaining.

After touchdown:

3. Pitch angle - Approximately +5°

   Reduce pitch attitude to approximately 5 degrees pitch angle (5 degrees above what the attitude would be with the nose on the ground). The nosewheel should not touch the runway.

4. Throttles - Military
5. Pitch attitude - Adjust to fly off at 210 KIAS.

AFTER LANDING

T 1. SAS channel engage switches - Off.

2. Landing light - OFF.

   Select TAXI LT if lighting is required; otherwise, select OFF. The landing light should not be operated without airstream cooling or it will burn out prematurely.

3. Right refrigeration switch - ON.

(T4) Cockpit air shutoff handle - ON.

(T5) HF radio - OFF.

(T6) IFF - OFF.

When clear of the runway:

7. Pitot heat switch - OFF.

8. Crossfeed - Closed.

T 9. EGT trim switches - HOLD.

T 10. Periscope - Stowed.

(11) Viewsight power - Off.

ENGINE SHUTDOWN

1. Wheel chocks - Installed.

2. Nosewheel steering - Disengaged.

(3.) OBC Power Control switch - OFF.

4. C.G. - Forward of 17%.

Transfer fuel forward of 17% for easier downloading of sensor equipment.

NOTE

If Tank 4 is not on, press Tank 4 boost pumps on before transferring fuel forward. Otherwise, with crossfeed off, a reduction in fuel flow to approximately 3600 lb per hour will occur on the right side. This is less than the desired value for normal operation of the fuel heat sink system. Release the tank after completing fuel transfer.

In the SR-71B, use the DAFICS BIT check after landing to check aft cockpit switch inputs to DAFICS.

(T) 5. APW switch - PUSHER/SHAKER.
APW switch position in the cockpit that does not have APW switch control does not affect the DAFICS BIT.

(T) 6. SPIKE DOOR control transfer - Take control.
Check SPIKE DOOR transfer light illuminated on aft cockpit control transfer panel. Inlet switches in the cockpit that does not have SPIKE DOOR control are not functional and do not affect the DAFICS BIT.

(T) 7. AFCS control transfer - Take control.

T 8. DAFICS Preflight BIT - Check.

T a. SAS channel engage switches - ON.

T b. SENSOR/SERVO lights - Check off.

T c. Forward cockpit (aft cockpit in SR-71B) switch positions for DAFICS PREFLIGHT BIT - Set.

- Autopilot pitch and roll engage switches - ON.
- ATT REF SELECT switch - ANS
- KEAS HOLD switch - ON
- HEADING HOLD switch - ON

T d. DAFICS PREFLIGHT BIT switch - ON.

The BIT TEST light illuminates steady green while the test is running.

Pressure from A hydraulic system is required to engage the DAFICS PREFLIGHT BIT. Low pressure or flow from A, B, L or R hydraulic system will cause the DAFICS preflight BIT to fail.

If the DAFICS PREFLIGHT BIT switch will not engage, recheck:

1) CSC/NWS switch - Released.
2) ATT REF SELECT switch - ANS
3) APW switch - PUSHER/SHAKER
4) SPIKES & FWD BYPASS doors - AUTO
5) RESTART switches - Off
6) Throttle Restart switch - Off
7) SAS channel engage switches - ON.
8) AUTOPILOT PITCH & ROLL engage switches - ON
9) KEAS HOLD switch - ON
10) HEADING HOLD switch - ON

NOTE

If at BIT completion the FAIL light, any SENSOR light, any SERVO light, or any CMPTR OUT light illuminates, notify maintenance.

After one minute:

e. Check BIT TEST light flashing green, sensor and servo lights extinguished, BIT FAIL light extinguished, and OFF flags in both TDI's. The CIP barber pole reads zero.

f. Check autopilot pitch and roll engage switches, KEAS HOLD switch, and HEADING HOLD switch -Off. AUTOPILOT OFF and SAS OUT lights illuminated.

g. Check DAFICS PREFLIGHT BIT switch - OFF (guard down).

h. SENSOR/SERVO recycle switches - Press one of the six.

Pressing one of the six SENSOR/SERVO recycle switches resets the DAFICS system to the flight mode. Check SENSOR/SERVO lights, BIT TEST light, and SAS OUT lights are out. Check both spikes have returned to the full forward position and the CIP barber pole has returned to normal. Both TDI's will initiate resynchronization and run up to 55,000 ft., Mach 2.0, and 300 KEAS. AOA will indicate 10°. AOA will return to 0° in approximately 1 min 15 sec and TDI indications will return to normal in approximately 2 min 15 sec after the DAFICS system has been reset to the flight mode. The A, B, and M CMPTR OUT annunciator panel lights flash momentarily when the DAFICS system is reset.

9. Exterior lights - OFF.

▲10. TACAN and ILS - OFF.

11. PVD - OFF.

▲12. Loose items - Secured.

▲13. Canopy seal pressure lever - OFF.

▲14. Canopy - Open

CAUTION

The pilot should notify the RSO when he opens the canopy. If either canopy is open, the aft canopy latch handle must be in the aft position or the cockpit air handle must be in the forward (off) position for adequate equipment cooling. Otherwise, most of the cooling air would exit through the cockpit openings instead of the bays.

15. SENSOR/SERVO lights - Check off.

All pitch, yaw, and roll SAS channels should be engaged before checking the effects of generator switching.

(T16.) ANS MODE switch - OFF.

Prior to ANS shutdown, place system in DEAD RECKON MODE and record LAT/LONG from Present Position Display. Coordinates will be used for system evaluation.

17. Right generator switch - OFF.

NOTE

With transfer of electrical power while on the ground, the DAFICS may undergo ground reinitialization indicated by momentary illumination of the A, B, and M CMPTR OUT caution lights, OFF flags in both TDIs, and TDI resynchronization to 55,000 ft., Mach 2.0, and 300 KEAS.

18. Bus tie pushbutton - Press.

Split the buses to obtain satisfactory MRS records.

NOTE

The tank 4 boost pump indicator light may extinguish.

The tank 4 boost pump indicator light is associated with the power supply to pumps 4-3 and 4-4 only. If pumps 4-2 and 4-4 are on and pumps 4-1 and 4-3 are off (tank 5 empty, tank 2 feeding, tank 4 not manually selected), when the right generator is turned off and the buses are split, the tank 4 boost pump indicator light will extinguish as pump 4-4 is de-energized. In this condition, pumps 2-1 and 4-2 continue to supply the engines. The tank 4 boost pump indicator light should illuminate again when the right generator is returned to service.

19. Right generator switch - NORM.

Check the GEN BUS TIE OPEN caution light on and the R GEN OUT caution light extinguished.

20. APW System switch - OFF.

(T) a. Aft cockpit - CONT FWD.

21. Fuel derich system - Both checked, rearmed, and OFF.

a. Set both engines 400 rpm above idle speed.

b. Actuate the derich test switch until 860°C EGT is exceeded with LEFT and then RIGHT selected.

When the EGT indications exceed 860°C:

c. Verify that the EGT gage warning lights are on and that the Fuel Derich lights are on.

d. Note that engine speeds decrease between 50 and 400 rpm.

e. Cycle the fuel derich switch to REARM, and then OFF.

Verify that each engine returns to 400 rpm above idle, and EGT indications are normal.

f. Reset the throttles to IDLE.

22. Tanks No. 1 & 4 boost pump switches - Press on.

23. Left generator switch - OFF.

After fifteen seconds for MRS recording:

24. Left generator switch - NORM.

25. Right generator switch - OFF.

After fifteen seconds:

26. Left generator switch - OFF.

Check that both GEN OUT caution lights are on. DAFICS computers should automatically reset after power transfer, and no SAS SENSOR or SERVO lights should illuminate.

Check that the following lights are off:

SAS OUT
MRS power switch (RSO)

Check that the following lights are on:

INSTR INVERTER ON
GEN BUS TIE OPEN
L and R GEN OUT
L and R XFMR RECT OUT

CAUTION

This step should be completed and ac power restored to the fuel system boost pumps without delay. An engine fuel-hydraulic pump can be damaged by cavitation if operation is continued for any significant period with a low fuel pressure condition.

27. Left and right generator switches - EMER.

The following annunciator panel lights should not be illuminated:

L and R GEN OUT
L and R XFMR RECT OUT
EMER BAT ON

Fuel panel lights for empty tanks should illuminate EMPTY.

▲28. INS - Check normal operation.

INS continues to operate on aircraft battery and instrument inverter power with both generators OFF or in EMER.

a. INS REF annunciator light - Check not illuminated.

b. ADI - Check attitude indication is unchanged and no OFF flags in view.

(c.) RSO attitude indicator:

With S/B R-2595 check attitude is unchanged and no OFF flag.

Without S/B R-2595 attitude not valid and OFF flag is in view.

(Td.) INS FUNCTION switch - Set ATT and check heading slew.

Set the INS Function switch to ATT, INS REF annunciator light illuminates, flag at top of ADI comes in view (heading not valid), ADI attitude remains valid. Push and turn the heading slew knob and confirm HSI and BDHI compass card rotation.

(T29.) INS FUNCTION switch - OFF.

(T30.) INS PWR switch - Press (off).

31. One generator switch - NORM.

Resume normal operation with the generator corresponding to the engine which is to be shut down last.

32. Remaining generator switch - OFF.

Turn off generator corresponding to the engine which is to be shut down first (usually the engine that was started first). Check that the L and R FUEL PRESS warning lights are off to assure that normal pressure exists in the fuel supply manifolds.

T 33. SAS channel engage switches - Off.

34. Brake switch - Set.

Set ALT STEER & BRAKES if the left engine is to be shut down first.

35. First engine throttle - OFF.

Confirm with ground personnel that area under engine is clear before shutting down the engine.

36. Flight control system - Checked.

Check nosewheel disengaged. After flight control (A or B) hydraulic steady-state pressure from the first engine is below 1500 psi, individually check each axis for full deflection and freedom of travel in both directions. Confirm correct ground crew observation, using the following sequence: nose up, nose down, left roll, right roll, nose left and nose right.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A or B HYD warning light. The light should extinguish when flow demands on the system diminish and normal pressure is restored.

37. Brakes and steering - Checked.

Check brakes and nosewheel steering operate with only one hydraulic system (L or R) operating. Pump brakes and check normal pressure while crew chief visually confirms brake actuation on both trucks. Nosewheel STEER ON light illuminates when nosewheel steering engaged. Nose should swing as rudder pedals are moved slightly.

+38. Second generator switch - OFF.

Confirm with ground personnel that area under engine is clear.

CAUTION

Do not delay engine shutdown after generator power to the boost pumps is removed.

39. Second engine throttle - OFF.

40. Instrument inverter - Checked and OFF.

Check that the following lights are on:

INSTR INVERTER ON
EMER BAT ON

NOTE

A relay delays EMER BAT ON light illumination for 10 seconds after loss of T-Rs (Step 38).

Press the Indicator and Lights Test switch to check AØ and BØ (bright illumination of the left and right FIRE lights, respectively) of the instrument inverter. TDI off flag (Pilot and RSO) remaining out of view with normal TDI indications (or TDI values increasing or decreasing in response to DAFICS resynchronization) is a check of CØ instrument inverter power.

▲41. Seat and canopy safety pins -Installed.

▲42. UHF and VHF radios - OFF

43. Battery switch - OFF.

NORMAL GROUND EGRESS - Pressure Suit

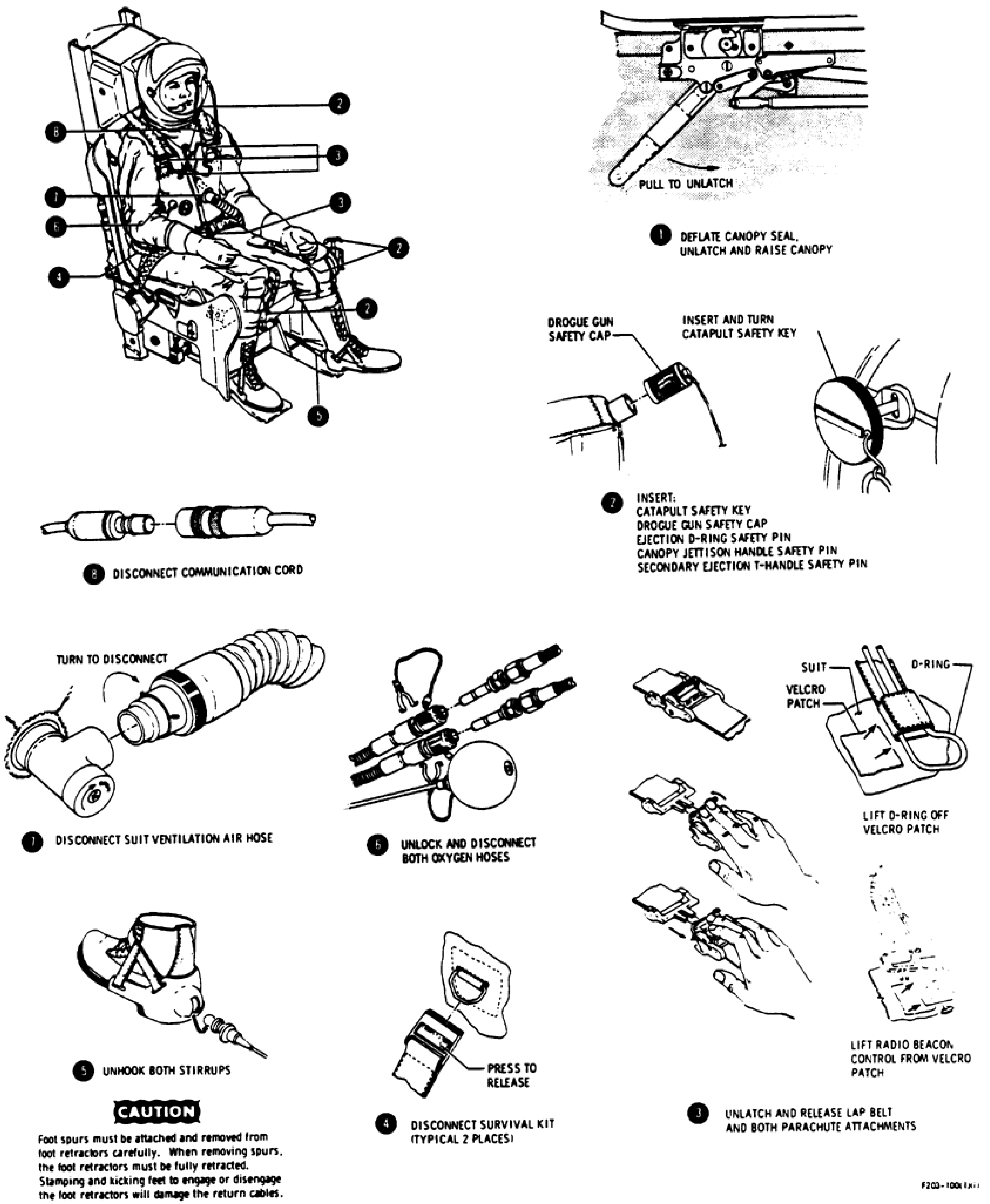


Figure 2-19

SURVIVAL QUICK LAUNCH

WARNING

Quick Launch procedures are not intended for normal operations. Quick Launch procedures will only be used when directed by the commander.

Takeoff using Survival Quick Launch procedures should be used only to avoid destruction of the aircraft.

QUICK LAUNCH SETUP

The Quick Launch Setup procedures require that all normal procedures through Before Taxiing (or Before Takeoff) have been completed before the Quick Launch Setup checklist is initiated.

QUICK LAUNCH SETUP PROCEDURE

After Before Taxiing (or Before Takeoff) checks complete:

(T1.) HF Radio - OFF.

(T2.) IFF mode 4 code select switch - HOLD.

Place the switch in the momentary HOLD position for 15 seconds, then wait another 15 seconds before turning equipment OFF.

After 15 seconds:

(T3.) IFF - OFF.

(4.) Sensor and OBC power - Off.

5. Pitot heat switch - OFF.

6. EGT trim switches - Downtrim, if desired, then AUTO.

If engine run to check automatic EGT trim has not been completed, consider downtrimming EGT slightly. Return EGT trim switch to AUTO so that automatic EGT trimming will trim EGT into the nominal band during takeoff.

7. C. G. - 18%.

Transfer fuel to 18% so that c.g. will be at 18% to 20% for takeoff.

8. PVD - OFF.

▲9. Loose items - Secured.

(T10.) Cockpit air - Off (forward).

▲11. Canopy seal switch - OFF.

▲12. Canopy - Open.

(T13.) ANS MODE switch - OFF.

(T14.) INS FUNCTION switch - OFF.

(T15.) INS PWR switch - Press (Off).

16. Right generator switch - OFF.

17. Right throttle - OFF.

Confirm with ground personnel that area under engine is clear before shutting down the engine.

18. Left generator switch - OFF.

Confirm with ground personnel that area under engine is clear.

CAUTION

Do not delay engine shutdown after generator power to the boost pumps is removed.

19. Left throttle - OFF.

20. Instrument inverter - Checked and NORM.

21. Cabin pressure switch - 10,000 FT, if desired.

▲22. Seat and canopy pins - Installed.

23. Pilot's A, B, and M CMPTR circuit breakers (3 total) - Pull.

T24. RSO's A, B, and M COMPUTER circuit breakers (9 total) - Pull.

T25. INS FUNCTION switch - STOR HDG.

▲26. Oxygen - OFF.

27. Battery switch - OFF.

QUICK LAUNCH START

While subject to Quick Launch, ensure that nobody has access to the aircraft unless authorized by the aircrew.

If Quick Launch Setup procedures were not completed prior to start or if the aircraft is removed from Quick Launch status, use normal procedures for launch.

When routine aircraft servicing is required, cockpit access requires crew authorization and the crew should accompany maintenance personnel (to remain aware of aircraft status and confirm that cockpit setup is not changed).

Quick Launch Setup and Quick Launch Start procedures require ANS Ground Hot Start and INS Stored Heading procedures. If the aircraft is moved after the ANS and INS are shutdown, these alignments are invalidated and normal procedures for ANS and INS alignment should be used.

Survival Quick Launch procedures assume external power is available for start. If external power fails the engines can be started but engine instrument indications, except for rpm, will not be available until a generator is turned on. If the crew chief does not use a headset during start, the aircrew must coordinate the hand signals to be used prior to assuming Quick Launch status.

QUICK LAUNCH START PROCEDURES

After external power applied:

T1. INS PWR switch - Press (On).

2. Battery switch - BAT.

3. Right engine - Start.

T4. RSO's A, B, and M COMPUTER circuit breakers (9 total) - Push in.

These circuit breakers are pulled to keep the PTAs from being powered until cooling air is available. The circuit breakers may be reset as soon as the start procedures are in progress. Since the left and right refrigeration switches are still on (from Before Taxiing checks), cooling air to the PTAs will be available as soon as the right engine starts.

The DAFICS circuit breakers in the front cockpit are reset after the DAFICS circuit breakers in the aft cockpit to prevent the DAFICS computers from operating (sensing and storing power faults) until DAFICS has proper power. If the forward cockpit circuit breakers are reset first, DAFICS memory will indicate transient power faults, however DAFICS operation and reliability is <u>not</u> degraded.

After right engine is started:

5. Right generator - On (NORM), light off.

Check R GEN OUT light extinguishes

T6. ANS Mode switch - INERTIAL ONLY.

The ANS is not turned on until after the right engine is started so that the ANS has cooling and the LIMIT light will not flash.

The MAL light will flash until the HOT switch is pressed.

T7. ANS HOT switch - Press.

8. External power - Disconnected.

9. Left engine - Start.

10. Left generator - On (NORM), light off.

Check L GEN OUT light extinguishes.

11. Pilot's A, B, and M CMPTR circuit breakers (3) - Push In.

Setting the 3 dc CMPTR circuit breakers in the forward cockpit starts the DAFICS computers. Check the A, B, and M CMPTR OUT annunciator lights extinguish.

▲12. Ejection seat and canopy pins - Removed.

▲13. Canopy - Closed and locked.

▲14. Canopy seal switch - ON.

(T15.) Cockpit air - On (aft).

16. Nosewheel steering - Engaged.

With NAV RDY light flashing:

(T17.) INS FUNCTION switch - NAV.

With F/A in mode window:

(T18.) ANS MODE START switch - Press.

The chronometer may not be charged for Quick Launch procedures; if not, the ANS will not star track if Astro-Inertial mode is selected.

(T19.) MRS - ON.

QUICK LAUNCH TAXI

1. Brakes - DRY or WET and ANTI SKID ON.

▲2. Circuit breakers - Checked.

3. Flight controls and trim setting - Check.

4. Fuel - Check tanks 1, 3, and 5 (or 6) on.

▲5. CG - Checked.

▲6. Oxygen - ON and pressure checked.

7. Pitot heat switch - ON.

(T8.) IFF - NORMAL.

(T9.) HF radio - On.

QUICK LAUNCH TAKEOFF

T 1. SAS - Engaged, lights off.

▲2. Warning and caution lights - Checked.

3. Tank 4 - Press on.

SECTION III

The following summary of bold print steps is provided as a training aid. The amplified procedures should be reviewed to assure complete understanding of the meaning and intent of the bold print steps.

GROUND OPERATION

GROUND EMERGENCY EGRESS

▲ 1. **CANOPY OPEN OR JETTISON**
▲ 2. **SCRAMBLE HANDLE**
▲ 3. **KIT HANDLE**
▲ 4. **CHUTE RELEASE**

ENGINE FIRE

1. **THROTTLES OFF**
2. **FUEL OFF**

BRAKE OR STEERING FAILURE

If normal brakes/steering not effective or if L hydro out:

1. **ALT STEER & BRAKE**

If alternate brakes ineffective:

2. **ANTISKID OFF**

TAKEOFF EMERGENCIES

ENGINE FAILURE

If conditions permit and gear down:

1. **ABORT**

After takeoff,
If unable to hold altitude and accel:

▲ 1. **EJECT**

If able to hold altitude or accel:

1. **THROTTLES MAX**
2. **GEAR UP**

BARRIER ENGAGEMENT

1. **NOSE DOWN**
2. **BRAKES RELEASE**

ABORT

1. **THROTTLES IDLE**
2. **BRAKES**
3. **CHUTE DEPLOY**

If tire failure occurs and braking abnormal:

4. **ANTISKID OFF**

TIRE FAILURE

Before accel check speed:

1. **ABORT**

If takeoff continued:

1. **DON'T RETRACT GEAR**
2. **ANTISKID OFF**
3. **BRAKE WHEELS**

IN-FLIGHT EMERGENCIES

BAILOUT

1. **ALERT RSO**

▲ 2. **EJECTION D-RING**

If seat fails to eject:

▲ 3. **CANOPY JETTISON**
▲ 4. **EJECTION T-HANDLE**

EMERGENCY DESCENT

1. **RESTARTS ON**
2. **THROTTLES IDLE**

Propulsion System Emergencies

INLET UNSTART

For inlet A/D:
1. α WITHIN LIMIT

If either inlet in manual before A/D, or autorestart not effective (unstart recurs, inlet does not clear, or CIP does not recover):

2. RESTARTS ON
3. AFT BYPASS
4. CHECK EGT
5. 350 KEAS

AIRSTART

Affected side:
1. RESTART ON
2. AFT BYPASS OPEN
3. ☆ DERICH
4. ☆ X-FEED OPEN
5. ☆ THROTTLE OFF, THEN 1/3 TO 1/2 MIL

After engine starts:

6. AFT BYPASS SET

If subsonic — only do ☆ items

SUBSONIC COMPRESSOR STALL

1. α WITHIN LIMIT

DOUBLE ENGINE FLAMEOUT

With both L & R GEN OUT lights on:
1. ▲ ATTITUDE REFERENCE INS
2. BOTH GENS EMER
3. PRESS TANK 4 ON

Engine(s):

4. AIRSTART

ENGINE FIRE/SHUTDOWN

1. ☆ THROTTLE MIL/IDLE

To shut down engine:

2. RESTART ON
3. ☆ THROTTLE OFF
4. ☆ AFT BYPASS OPEN
5. ☆ FUEL OFF FOR FIRE

ACCESSORY DRIVE SYSTEM

1. ☆ THROTTLE RESTART ON

Other Aircraft System Emergencies

FUEL PRESSURE LOW

1. X-FEED OPEN
2. PRESS TANK 4 ON

L AND/OR R HYDRAULIC SYSTEM FAILURE

With low quantity, or pressure below 2200 psi:
1. ☆ RESTART ON

FLIGHT CONTROL SYSTEM TRIM FAILURE

1. TRIGGER HOLD

DOUBLE GENERATOR FAILURE

1. ▲ ATTITUDE REFERENCE INS
2. BOTH GENS EMER
3. PRESS TANK 4 ON

APW SYSTEM

For false stick pusher:
1. TRIGGER HOLD

LANDING EMERGENCIES

COCKPIT FOG

(T1.) COCKPIT AIR OFF

BLOWN TIRE AFTER LANDING

If main gear tire fails and braking abnormal:
1. ANTISKID OFF

INTRODUCTION

The emergency procedures recommended in this section should be followed unless circumstances such as weather, fuel, or other reasons dictate otherwise. The safest region for continued operation is subsonic unless altitude or aircraft range is a factor.

Checklists have been provided where specific corrective steps can be enumerated. A narrative format has been used where an analysis is necessary to determine the correct course of action. In some cases, where a decision-tree analysis is possible, the forms have been combined.

MULTIPLE EMERGENCIES

Procedures are based on the assumption that each crewmember understands normal systems operation. Procedures usually cover single emergencies. Crewmembers must recognize that single malfunctions often affect operation of other aircraft systems and may require actions beyond those contained in a specific emergency procedure.

ASSUMPTIONS

Three basic assumptions are made which are not reiterated in each individual procedure. These are: (1) Aircraft control is paramount. (2) Circuit breakers associated with a malfunctioning system must be checked. (3) The other crewmember must be advised of any emergency situation.

SYMBOL CODING

Symbols used to identify crew responsibility are the same as normal procedures. These are:

1. Steps without special notation apply to the forward cockpit of all aircraft.

(2.) Steps with an enclosed step number apply to the aft cockpit of the SR-71A.

▲3. Steps preceded by the ▲ symbol apply to both cockpits of all aircraft.

T 4. Steps preceded by a T apply to the forward cockpit of all aircraft as well as the aft cockpit of the SR-71B.

(T5.) Steps with an enclosed T <u>and</u> step number apply to the aft cockpit of SR-71A/B.

(T) 6. Steps preceded by an enclosed T apply only to the aft cockpit of the SR-71B.

DEFINITIONS OF LANDING SITUATIONS

The terms "land when practical" and "land as soon as possible" are not interchangeable.

<u>Land when practical</u> means land at home base or other suitable alternate, with air refueling as necessary.

<u>Land as soon as possible</u> means land at the nearest suitable facility.

USE OF CHECKLISTS

Critical emergency checklist steps appear in capital bold print. The <u>actions</u> required must be committed to memory. In an emergency, the crewmember(s) must be able to accomplish these steps immediately without reference to the abbreviated checklist. This prevents any delay which might aggravate the emergency. Other checklist steps should be accomplished using the challenge and response method when time and circumstance permit. The most important consideration is to maintain aircraft control. Where an emergency situation requires more than one procedure, a reference to the other procedure(s) is included.

GROUND EMERGENCY EGRESS

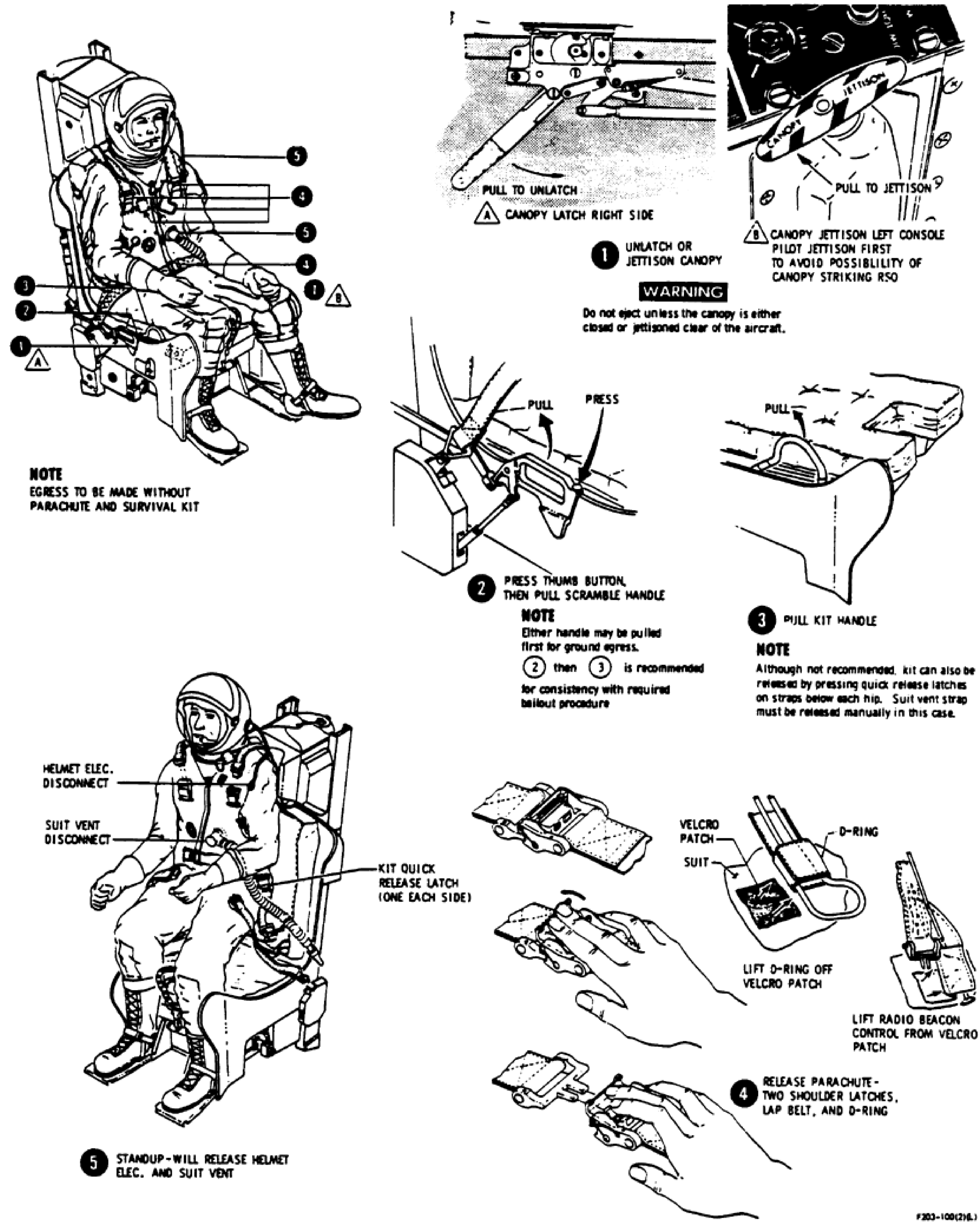


Figure 3-1

GROUND OPERATION

GROUND EMERGENCY EGRESS

In an emergency requiring ground abandonment, the primary concern is to leave the immediate area of the aircraft as soon as possible. The following procedure provides the fastest means of escape. The lap belt should not be released until the aircraft has stopped.

Aircraft On Fire

When the aircraft or the surrounding area is engulfed in flames, the crew may abandon the aircraft (relying on the faceplate, helmet, and suit for protection) or eject.

WARNING

Do not eject unless the canopy is either closed or jettisoned clear of the aircraft.

GROUND EMERGENCY EGRESS PROCEDURE

▲1. **CANOPY OPEN OR JETTISON.**

Open or jettison the canopies first unless fire danger exists. Retain the canopies until all preparations for evacuation are completed if there is danger of fire engulfing the cockpit area.

The recommended order for canopy jettison is pilot, then RSO, so that the pilot's canopy cannot fall upon an open RSO cockpit and strike the RSO.

▲2. **SCRAMBLE HANDLE.**

Pull the scramble handle after the aircraft has stopped. This releases:

(1) Lap belt. (The belt remains attached to the parachute.)
(2) Inertia reel shoulder harness.
(3) Foot retention cables.
(4) Parachute arming lanyard and housing.
(5) Cable on ejection D-ring.

NOTE

When pulling the scramble handle, expect a loud report from the initiator firing.

WARNING

If the scramble handle does not function normally, the ejection seat safety pin should be installed to prevent inadvertent ejection. Then the harness, spurs, and lap belt must be released manually as required.

▲3. **KIT HANDLE.**

Pull the survival kit handle. This releases the kit from the torso harness, disconnects personal leads to the normal and emergency oxygen supplies, and releases the parachute from the survival kit lid. It also detaches the kit lanyard from the torso harness if the kit is seated firmly.

The kit can also be released manually by pressing the quick release latches below each hip. The right latch also releases the kit lanyard.

WARNING

- The crewmember must remain seated until the survival kit handle is pulled.
- The crewmember is still attached to the survival kit by the oxygen hose when using the quick release latches instead of the kit handle to disconnect from the kit.

▲4. **CHUTE RELEASE.**

Open the parachute quick disconnects at the shoulder and lap, and lift the shoulder straps from the suit velcro patches.

Egress with the chute is possible if it cannot be released.

WARNING

Mobility with the chute is limited.

Standing up separates the helmet electrical connections and the suit vent hose.

ENGINE FIRE

If a fire is evident during start, or on notification:

1. **THROTTLES OFF.**

2. **FUEL OFF.**

   Set both guarded EMER FUEL SHUTOFF switches to the fuel off position (up). Ac and dc power are required. During engine start, the ground crew should continue turning the engine if the fire is contained in the tailpipe. If the starter unit has disengaged, it cannot be re-engaged until the engine has come to a complete stop.

3. Battery - OFF.

▲4. Abandon the aircraft.

CAUTION

Without ground power, simultaneous shutdown of both engines may result in generator cut-out and loss of AC power before the emergency fuel shutoff valves can completely shut off the engine fuel supply. Similarly, actuating the battery switch within 5 seconds of closing the emergency fuel shutoff switches may result in incomplete valve operation.

CAUTION

If ground power is not connected, as during taxiing or after landing, and if crew safety is not an immediate factor, shut down the affected engine first followed by the affected engine fuel shutoff switch. To assure complete fuel shut-off to that side, allow 5 seconds before shutting down the second engine and actuating the battery switch.

BRAKE OR STEERING FAILURE

Illumination of the ANTI-SKID OUT caution light may indicate brake failure.

BRAKE OR STEERING FAILURE PROCEDURE

If normal brakes and/or nosewheel steering are not effective, or if L hydraulic pressure is not available:

1. **ALT STEER & BRAKE**

   The green nosewheel steering engaged (STEER ON) light extinguishes if steering disengages due to loss of hydraulic pressure. Release brake pedal pressure, then move the brake switch to ALT STEER & BRAKE.

   In ALT STEER & BRAKE, the power source for braking is the R hydraulic system; nosewheel steering is powered by the L system until L system pressure decreases below 2200 psi, then steering shifts to the R hydraulic system automatically.

NOTE

If both engines are shutdown while the aircraft is moving, the brake switch should be set to OFF and steady pressure applied in one application until completely stopped; otherwise, antiskid cycling or pumping the brakes depletes the hydraulic system accumulator and results in loss of brakes. The L hydraulic system accumulator may provide up to 3 brake applications; however, the brake accumulator is not required to hold a charge.

If the antiskid system relieves brake pressure and wheel rpm does not increase within 2.7 seconds: the antiskid fail-safe circuit should deactivate antiskid and illuminate the ANTI SKID OUT annunciator caution light; and braking without antiskid protection should become available.

(T) a. Brake switch - OFF.

Selection of OFF electrically disengages the aft cockpit switch from the brake system. Selection of ANTI SKID ON or ALT STEER & BRAKE overrides the forward cockpit brake switch setting.

If alternate brakes are ineffective:

2. **ANTISKID OFF.**

If the brake switch is placed to OFF: the L hydraulic system powers braking and steering, antiskid is disabled, and the ANTI-SKID OUT annunciator caution light illuminates.

After S/B R-2695, holding the trigger switch depressed will disable antiskid and illuminate the ANTI-SKID OUT annunciator caution light. The hydraulic power source for brakes remains as selected by the brake switch. If R hydraulic pressure is not available, move the brake switch out of ALT STEER & BRAKE.

ANTISKID OUT

The ANTI-SKID OUT caution light illuminates while on the ground if: the brake switch is in OFF; the antiskid system is disabled or fails; or, after S/B R-2695, the trigger switch is held depressed.

With the ANTI-SKID OUT light on unaccountably:

1. Antiskid - Recycle.

Attempt to recycle the antiskid brake system by repositioning the brake switch if the situation permits and if there is no apparent reason for the system being disabled. After S/B R-2695 check that the trigger switch is not stuck in the depressed position.

If the ANTI-SKID OUT light persists:

2. Brake switch - OFF.

Without antiskid operating, extreme caution must be used while braking to prevent wheel skid. Skidding is hard to detect due to aircraft size and weight. Tires may fail before a skid can be recognized and corrected. A main landing gear tire blowout may be sensed as a thump or muffled explosive sound.

TIRE FAILURE

At takeoff weights, to decrease the probability of further tire failures, taxi distance should be minimized if one or two tires per main gear are flat. Taxiing is permitted to clear a runway with all tires failed on a main gear, as the massive tire bead protects the wheels for some distance. At normal landing weight, the aircraft can be taxied if one tire per main gear remains inflated.

SINGLE-ENGINE MINIMUM AERODYNAMIC CONTROL SPEED

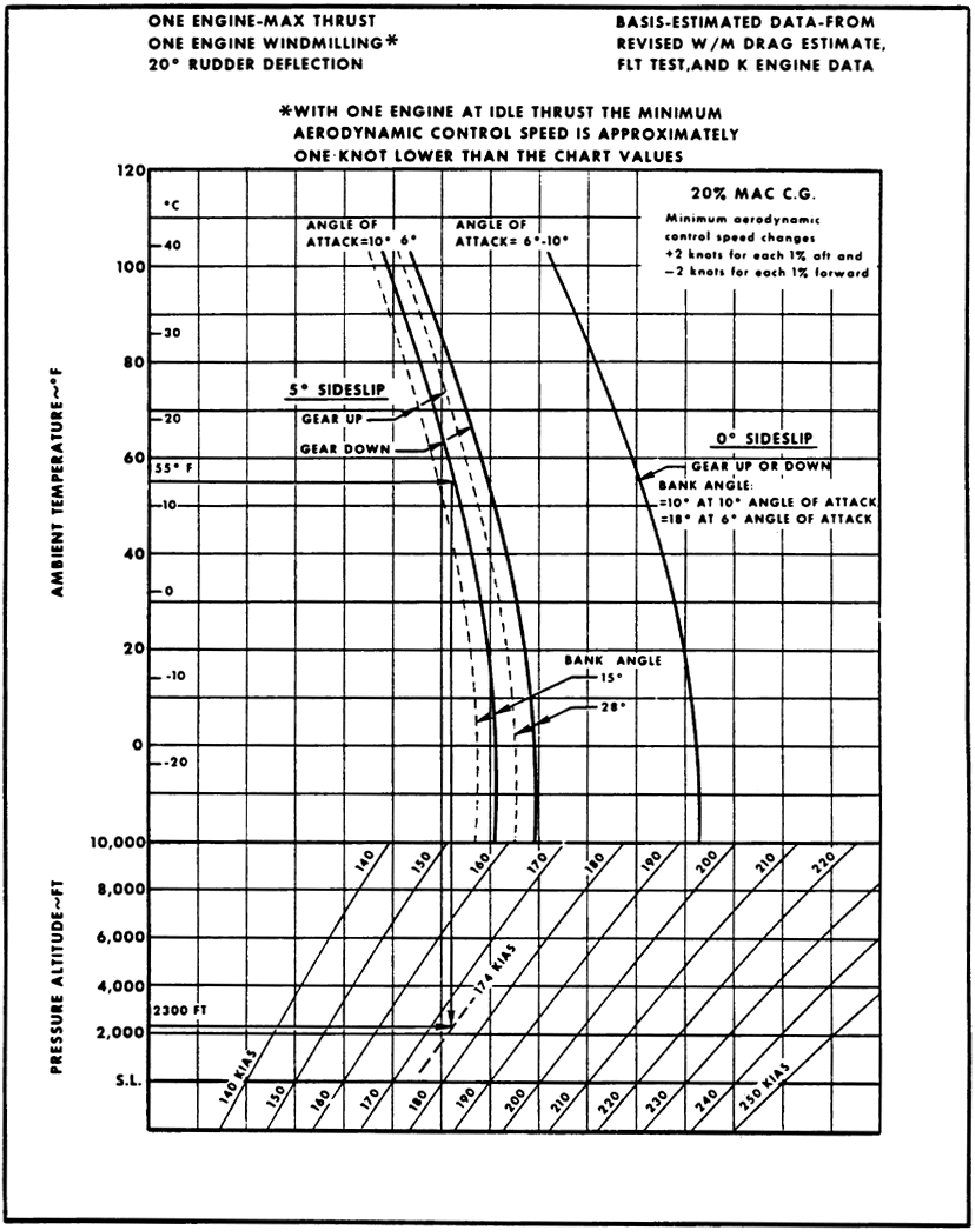


Figure 3-2

TAKEOFF EMERGENCIES

These procedures apply from the start of takeoff until the initial climb schedule is established.

PROPULSION SYSTEM

The propulsion system includes the main engines, afterburners, inlets, nozzles, tailpipes, fuel controls, and fuel-hydraulic, lubrication, and ignition systems. If abnormal operation of any of these components is indicated prior to reaching the acceleration check distance, the takeoff should be aborted. Refer to Abort procedure, this section.

ENGINE FAILURE

If conditions permit and gear retraction has not been initiated:

1. **ABORT.**

   Abort if abnormal operation of any of the propulsion system components is indicated before reaching the acceleration check distance.

   Abort if the acceleration check is unsatisfactory, or if a fire warning occurs before refusal speed.

   Abort if the thrust of either engine decays to the point that minimum single-engine flight speed cannot be attained, provided that conditions permit and landing gear retraction has not been initiated.

   WARNING

   Under most conditions below single-engine minimum aerodynamic control speed, directional control on the ground cannot be maintained with maximum thrust on one engine and the other engine decaying or failed.

   If both engines fail immediately after takeoff, decay of engine rpm results in rapid loss of A and B hydraulic system pressure and subsequent loss of aircraft control. Land straight ahead if the gear is down and sufficient runway is available.

After takeoff, if unable to hold altitude and accelerate:

▲1. **EJECT.**

   If gear retraction has been initiated, eject rather than attempt to land with the gear partially retracted or up.

If able to maintain altitude or accelerate:

1. **THROTTLES MAX.**

   If an engine fails immediately after takeoff and the decision is made to continue, maintain Maximum thrust on the operating engine. Lateral and directional control can be maintained when airspeed remains above the minimum single engine control speeds shown on Figure 3-2; however, ability to maintain altitude and accelerate or climb depends on weight, drag, altitude, airspeed, and temperature. Refer to performance data, Appendix I.

2. **GEAR UP.**

   Initiate gear retraction if not already accomplished.

3. Dump fuel as required.

   Fuel dumping in addition to consumption by the operating engine lightens the aircraft at an appreciable rate. When at heavy weight for the existing air temperature, dumping fuel may reduce weight sufficiently to remain airborne. If turning at a sufficient speed, the inoperative engine will also discharge fuel from its afterburner.

Monitor c.g. carefully if dumping with crossfeed open.

4. PUMP REL switch - Press to release Tank 4.

   Dumping fuel with Tank 4 selected manually will cause premature termination of normal fuel dumping when Tank 4 quantity reaches 3700 lbs.

5. Rudder trim - As necessary.

   Bank and sideslip toward the operating engine as necessary to maintain directional control and minimize drag. 7 to 9 degrees of rudder trim, with bank and sideslip to maintain course, yields minimum drag in the critical speed range from 220 to 250 KIAS.

Failed engine:

6. Complete Engine Shutdown or Airstart procedure, as appropriate.

WARNING

Positively identify the failed engine before retarding the throttle.

AFTERBURNER FAILURE DURING TAKEOFF

Abort if an afterburner fails prior to reaching the acceleration check speed. Refer to the Abort Procedure, this section.

If an afterburner fails after reaching the acceleration check speed, confirm that both throttles are at the maximum afterburner position and continue the takeoff. Check EGT and for derichment. When safely airborne, positively identify the affected engine and then retard that throttle below the afterburner range. Pause at Military if the nozzle position indication is near closed, then check nozzle operation by retarding the throttle until the nozzle starts to open. A relight may be attempted if engine instrument indications and observation of the nacelle with the periscope disclose normal conditions; however, a malfunction should be assumed. Land when practical.

AFTERBURNER NOZZLE FAILURE

Nozzle failure is indicated when nozzle position and engine rpm response to throttle positioning are not normal. Engine shutdown may be necessary.

If a nozzle fails open and takeoff is continued, keep the throttle in maximum afterburner until a reduction in thrust is possible. Anticipate engine overspeed when the throttle is retarded and be prepared to reduce throttle position below Military.

If a nozzle fails toward closed, expect EGT rise, rpm suppression, compressor stall, and possible engine flameout.

Use the Afterburner Nozzle Failure procedures under In-Flight Emergency Procedures, this section, and land as soon as possible.

FIRE

Abort if either fire warning light illuminates before refusal speed. Above refusal speed, use the Engine Fire/Engine Shutdown procedure, this section, and land as soon as possible.

ABORT

The abort procedure assumes that a decision to abort is made before rotation speed. Aborts from above rotation speed are not prohibited, but the risks associated with aborting from such a high initial speed at takeoff weight must be balanced against the risks of continuing a takeoff. In general, after rotation speed, the best course of action is to continue rather than abort, unless the aircraft cannot fly.

Engine Management

Both throttles should be retarded to IDLE and the brakes applied with the nose down as soon as the decision to abort is made. The planned rotation speed may be exceeded; however, the nosewheel should be kept on the runway to take advantage of nosewheel steering.

NOTE

For chute failure, shutdown the right engine after both are idling, or complete the shutdown of a failed or flamed out engine. This reduction in thrust decreases stopping distance. and reduces the possibility of tire failure.

WARNING

Wait until rpm and EGT show that both engines are idling (or that one engine is failing) before selecting the engine to shutdown. Loss of both engines will result in loss of hydraulic pressure for steering, and braking may not be possible.

Aircraft Attitude, With Decision to Abort

Lower the nose and start braking at nosewheel contact. When rotation is well advanced, the aircraft may accelerate beyond takeoff speed and lift off before rotation can be checked. In this case, hold the aircraft off sufficiently to regain control and then touchdown without sideslip, near the center of the runway if possible.

Chute Deployment

The drag chute requires 4 to 5 seconds for deployment after drag chute control actuation. If above 210 KIAS, it is permissible to actuate the DRAG CHUTE T-handle while decelerating in anticipation of reaching the limit airspeed for chute deployment; however, deployment above 210 KIAS can destroy the chute. Actuation of the chute system to reach 210 KIAS simultaneously with loading of the chute is not recommended unless the risk is justified by very marginal stopping distance. Retain the drag chute.

Drag Chute Failure

If the drag chute does not deploy, shut down the failed engine (or shut down the right engine if there has been no engine failure) to reduce thrust and decrease stopping distance. Use moderate up elevon to provide as much drag as possible without lifting the nosewheel. The increased gear load may cause tire failure at heavy weight; however, tire failure may be acceptable since the tires will not necessarily disintegrate. Braking deceleration available is nearly the same for braked tire rolling and blown tire locked conditions with a smooth, wet surface. Locked wheel skids of 7000 feet on an ungrooved wet runway have left the wheels undamaged.

Braking On Wet Runways

Unless hydroplaning, good nosewheel and rudder steering characteristics can be expected. Well controlled stops have been demonstrated on wet runways with and without the drag chute, with all main gear tires blown and wheels locked, and with one engine shut down.

Hydroplaning is a limiting factor with wet runway conditions and, although nosewheel and rudder steering remain effective, wheel braking force is nil until the tires can make contact with the runway. The aircraft tends to follow a trajectory and drifts with a crosswind.

Except for the extended stopping distances, skids across or into dry runway areas are the chief hazard of wet runway stops. The wheels tend to lock-up and cause blown tires while sliding on a wet surface. Dry areas can destroy the tires due to increased friction or wheel spin-up. This allows the wheels to make runway contact and may ultimately destroy the wheels and brake assemblies.

Even so, the aircraft can probably survive on the landing gear struts if it remains on the runway or on a hard surface overrun (assuming a smooth transition from runway to overrun).

ABORT PROCEDURE

WARNING

- Do not release lap belt or shoulder harness, or pull scramble handle until the aircraft stops.
- The landing gear should be left extended.

1. **THROTTLES IDLE.**

Retard both throttles to IDLE. Do not shut down either engine immediately unless failure to do so would vitally endanger the aircraft, such as engine fire.

2. **BRAKES.**

Lower nose and -
For dry runway: Use moderate to heavy brake pressure until stop is assured. Do not use up elevon because risk of tire failure is increased.

For wet runway: Use light to moderate brake pressure. Up elevon for additional drag may be used if braking is marginal or if the drag chute fails.

NOTE

- Rated brake energy capacities and maximum braking speeds may be disregarded during an abort. It is better to use the brakes at high speed, as tire failure may occur if the roll is extended by delayed braking.
- On wet runways without grooves, deceleration is nearly the same with blown tires locked as with braked tires rolling.

CAUTION

Hard braking may result in brake seizure after stopping, increasing time to clear the runway. If possible, keep the aircraft moving at slow speed until clear of the runway. Taxiing at low speed to clear a runway is permitted with all tires failed on a main gear. The massive tire bead protects the wheels for a short distance at heavy weight.

3. **CHUTE DEPLOY.**

The maximum airspeed for drag chute deployment is 210 KIAS. Retain the drag chute.

If normal chute deployment does not occur in five seconds, rotate the DRAG CHUTE control handle 90 degrees counterclockwise and pull out 8 inches. A pull force of approximately 65 pounds is required.

If tire failure occurs and braking is abnormal:

4. **ANTISKID OFF.**

Set the brake switch OFF or, after S/B R-2695, depress and hold the trigger switch. Brake with steady pressure.

If tire failure occurs with either wet or dry conditions, increased brake pressure will be required on that side to maintain braking force on the remaining tires. Maintain moderate to heavy brake pressure to prevent spin-up of wheels with failed tires and wheel and/or tire disintegration at high rotational speeds.

For L hydraulic or left engine failure:

5. Brake switch - ALT STEER & BRAKE.

Set the brake switch to ALT STEER & BRAKE when the L hydraulic pressure is below normal, or with left engine failure. Extinguishing of the STEER ON light may indicate L hydraulic system failure.

CAUTION

Selecting ALT STEER & BRAKE changes the source of brake pressure from the L to the R hydraulic system. Decrease brake pressure momentarily to avoid skidding the tires.

For fire, drag chute failure, or if stopping distance is critical:

6. Throttle - OFF.

   a. Shutdown the engine that is failed or on fire.

   WARNING

   Positively identify the failed engine before retarding the throttle.

   b. Shutdown the right engine if both engines and L hydraulic pressure are normal at idle.

7. Fuel - OFF.

   The periscope may assist in determining if a major fire exists. For engine fire (if crew safety is not an immediate factor) shut down the affected engine and allow 5 seconds for operation of the engine fuel shutoff valve before shutting down the other engine.

   WARNING

   If the aircraft is on fire, shut down both engines after stop and abandon the aircraft.

Prepare to engage the barrier if a suitable barrier is available and it appears that a reasonably safe stop can be made. If a safe stop is obviously impossible, ejection prior to reaching an unprepared surface is recommended.

If ejecting, eject early enough to avoid descent into a fire area.

WARNING

- If the aircraft has a major fire, ejection prior to barrier engagement is recommended. Burning fuel can engulf and spread ahead of the aircraft as it stops in the restraining cable.
- If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

If possible, turn into the wind when stopping.

CAUTION

Brakes must be cooled to approximately ambient temperature before attempting another takeoff.

BARRIER ENGAGEMENT

The following applies only to BAK-11 cable engaging systems installed with modified dual BAK-12 arresting engines.

Barrier Operation

The barrier is controlled from the control tower, and is armed prior to all takeoffs and landings. The pilot may call for disarming of the barrier if it is apparent that a safe stop can be made without it.

When armed, the barrier is operated by the aircraft nosewheel and main gear as they roll over pressure-sensitive switchmats located in the runway ahead of the main cable. A row of switchmats located a short distance beyond the arresting cable prevents barrier actuation before the nosewheel has passed over the cable. The switches energize a timing computer which causes the arresting cable to be thrown up to engage the main gear struts. On engagement, the arresting cable is pulled out with a relatively constant restraining force to stop the aircraft within 2000 feet.

Operating Restrictions

The maximum recommended groundspeed for barrier engagement is 180 knots at all gross weights. The minimum groundspeed is 30 knots with the model 8200/BAK-11/12 installation (Beale AFB) and 15 knots with the model 8200-2/BAK-11/12 installation (Kadena AB). The barrier cable will not eject below these speeds.

Optimum barrier engagement is perpendicular between the runway side stripe markings. A successful engagement can be expected, however, if the aircraft centerline is no closer than approximately 40 feet from the edge of the runway at the barrier. The probability of a successful engagement when closer than 40 feet to the edge of the runway is marginal, especially at high speeds.

The nosewheel must be on the runway when crossing the switchmats. Steer to maintain runway heading and contact the barrier squarely.

BARRIER ENGAGEMENT PROCEDURE

1. **NOSE DOWN.**

   Barrier switchmats must be crossed in a three-point attitude.

2. **BRAKES RELEASE.**

   To prevent exceeding strut structural limits, release brakes before barrier engagement. Steer to approach the barrier squarely, and if possible, in the center. Do not jettison the drag chute.

   CAUTION

   Steer to engage perpendicular to the barrier and discontinue braking before engagement.

3. Fuel - Off.

   Allow 5 seconds for the fuel shutoff valves to close.

4. Throttles - OFF.

WARNING

- If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.
- Do not release lap belt or shoulder harness, or pull the scramble handle until the aircraft stops.

TIRE FAILURE

Long runs during taxi or takeoff at heavy weight can result in blown tires. Critical temperature in the tire bead is approximately 455°F. Failure of a main gear tire during takeoff overloads the remaining tires on that side when takeoff weight exceeds 92,500 pounds; however, the remaining tires should sustain a 50% overload for the remaining period required to takeoff at maximum weight or stop if required cooling procedures are completed before takeoff. (See Figures 5-7 and 5-8.) Because each main gear tire loss decreases the available brake energy capability by one-sixth, ability to stop from high speed is largely dependent on the drag chute.

Nosewheel Tire Failure

Failure of a nosewheel tire should not fail the other tire. It may not be possible to determine immediately whether a nose or main gear tire has failed. In either case, engine or structural damage may be sustained from tire fragments.

Tire Failure Procedure

Depending on airspeed and whether or not engine damage is indicated, takeoff may be preferable to aborting. The speed at which takeoff becomes preferable is close to acceleration check speed. Before refusal speed, attempt to determine if engine damage has been sustained.

If tire failure occurs before acceleration check speed:

1. **ABORT.**

If takeoff is continued:

1. **DON'T RETRACT GEAR.**

   Leave the gear extended to minimize damage to the wheel well.

2. **ANTISKID OFF.**

   Braking is disabled while the gear is down without weight on the gear if antiskid is enabled. The brake switch must be OFF or, after S/B R-2695, the trigger switch must be held depressed to stop the wheels rapidly after takeoff. The ANTI-SKID out annunciator caution light will not illuminate when antiskid is disabled while airborne.

3. **BRAKE WHEELS.**

   The blown tire(s) must be stopped to minimize damage to the aircraft.

4. Confirm tire and aircraft condition.

   The gear should not be retracted until visually checked from another aircraft or the ground.

EMERGENCY GEAR RETRACTION

If the gear lever cannot be moved UP after takeoff:

1. Gear override button - Press and hold.

   This overrides the solenoid which is normally actuated by the landing gear switch.

2. Landing gear lever - UP.

IN-FLIGHT EMERGENCIES

BAILOUT

Eject if loss of control is imminent, or if a safe landing or stop cannot be accomplished. Ejection expectations are:

a. At sea level, wind blast exerts minor forces on the body up to 525 KIAS; appreciable forces from 525 to 600 KIAS; and excessive forces above 600 KIAS. The aircraft limit airspeed is below the speeds for excessive forces; however, when flying without a pressure suit, delay ejection until below Mach 1.0 and 420 KEAS (slower when conditions permit.)

b. Successful chute deployment should result after ejection from zero speed and altitude.

c. Free fall from high altitude down to 15,000 feet with drogue chute stabilization is the quickest descent.

During any low altitude ejection, the chance for success is greatly increased by zooming the aircraft to exchange excess airspeed for altitude. Ejection should be accomplished while the aircraft is level or climbing. A climbing or level attitude results in a more nearly vertical trajectory for the seat and crew member, thus providing more altitude and time for seat separation and parachute deployment. The zero altitude capability of the ejection system should not be used as a basis for delaying ejection. Accident statistics emphatically show a progressive decrease in successful ejections as ejection altitude decreases below 2000 feet. Whenever possible, eject above 2000 feet.

Before Ejection

If time and conditions permit:

1. Alert RSO

   Advise the RSO by interphone and the ALERT position of the RSO BAILOUT switch. See Figure 3-3.

2. Altitude - Reduce so that the pressure suit is not essential to survival.

3. Airspeed - Reduce to subsonic and as slow as conditions permit.

4. Head aircraft toward unpopulated area.

5. Transmit location and intentions to nearest radio facility.

(T6.) IFF - EMER.

▲7. Lower helmet visor.

▲8. Green apple - Pull.

To Bailout

Accomplish as many of the following steps as are necessary to clear the aircraft. Refer to Figure 3-3.

1. **ALERT RSO.**

   Call "bailout, bailout, bailout" or otherwise positively advise RSO on the interphone, and set the RSO BAILOUT switch to GO.

▲2. **EJECTION D-RING.**

   Sit erect with head against headrest and feet back firmly against the seat. To pull ejection D-ring, cross arms (if possible) to assist in keeping arms close to the body.

   The RSO should eject first. The pilot should wait for the RSO EJECTED light to illuminate before ejecting, if conditions permit.

If the seat fails to eject:

▲3. **CANOPY JETTISON**

Pull the canopy jettison handle. If the canopy still does not jettison, pull the canopy latching handle aft and push the canopy into the air stream.

▲4. **EJECTION T-HANDLE.**

WARNING

- Do not pull the secondary ejection T-handle with the canopy still in place.
- Keep elbows close to sides and feet firmly against seat while pulling the secondary ejection T-handle, since the foot retractors and shoulder harness powered retraction may not have actuated.

If an ejection seat is inoperative:

The following procedure should be used to separate from the aircraft if sufficient control remains. If the RSO's seat fails, the pilot should remain with the aircraft, assist the RSO to leave the aircraft, and then eject.

5. Airspeed - 250 to 300 KEAS.

▲6. Green apple - Pull.

▲7. Scramble handle - Pull.

WARNING

Do not pull the survival kit release (inboard) handle while in the seat, as this disconnects the emergency oxygen supply and releases the kit and kit lanyard.

▲8. Suit vent hose - Disconnect.

9. Trim full nose down.

▲10. Lean forward, push stick forward, and push against seat to separate.

After manual bailout, when clear of the aircraft and below 20,000 feet:

▲11. Pull parachute manual deploy ring.

WARNING

- The crewmember must deploy the main chute manually, using the chute D-ring, after separating from the seat manually.
- After manual bailout, the crewmember is not stabilized by the drogue chute and may spin or tumble until the main chute is deployed.
- A free fall to a reasonably safe altitude avoids serious chute damage due to high speed deployment.
- Visor heat will not be available.

After Ejection

After ejection, descent is normally made to approximately 15,000 feet while in the seat with drogue chute stabilization. (Refer to Figure 3-3.)

NOTE

The seat may spin and rotate while descending with the drogue chute deployed. It may be possible to arrest such motions by using the arms and hands in the air stream.

If the automatic man-seat separation sequence fails, or if the crewmember elects to separate from the seat before automatic separation at approximately 15,000 feet, the crewmember initiates separation manually by pulling the scramble handle.

WARNING

- o Do not pull the survival kit release (inboard) handle while in the seat, as this disconnects the emergency oxygen supply and releases the kit and kit lanyard.
- o The crewmember must deploy the main chute manually, using the chute D-ring, after separating from the seat manually.
- o After manual seat separation, the crewmember is not stabilized by the drogue chute and may spin or tumble until the main chute is deployed.
- o A free fall to a reasonably safe altitude avoids serious chute damage due to high speed deployment.
- o Visor heat will not be available.

A lanyard with a 7-inch loop is provided on each rear riser, tacked to the strap with breakaway thread. If the parachute is not damaged, pull each loop downward approximately 1-1/2 feet with a sharp tug. This releases three pairs of suspension lines on each side -- 24 remain -- and imparts a three to four ft/sec forward speed to the chute for steering.

WARNING

Do not pull either loop if the chute has sustained damage.

NOTE

Pull both loops. The chute will revolve continuously if only one set of lines is released.

Before Landing

Unless a tree landing is anticipated, pull the yellow survival kit release handle after the main parachute has opened and when approximately 2000 feet above the landing point. The release handle should be pulled rapidly through its complete arc of travel for a clean release. Refer to Figure 3-3.

NOTE

Do not pull the kit release handle if a tree landing is anticipated. This avoids entanglement of the kit, lanyard, and gear.

Prior to water landing:

(a) Close the visor to prevent the helmet from filling with water.

(b) Inflate the flotation gear by pulling down firmly on a CO_2 inflation tab. If flotation gear fails to inflate, pull the other CO_2 inflation tab.

NOTE

The flotation gear cannot be inflated orally without actuating the CO_2 lanyards first.

(c) Remove spurs if possible.

CAUTION

If retained, the spurs or severed foot retraction cables may puncture the dinghy.

(d) Release both Koch parachute riser releases when in the water.

(e) Open visor after returning to the surface of the water.

NOTE

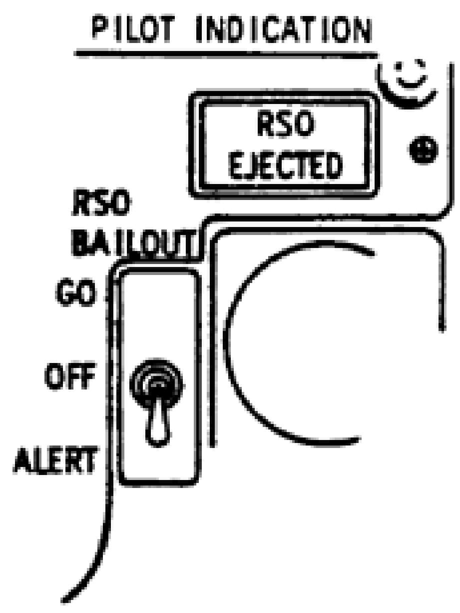
If latches fail to keep visor open, bend the microphone boom out to prevent the visor from closing.

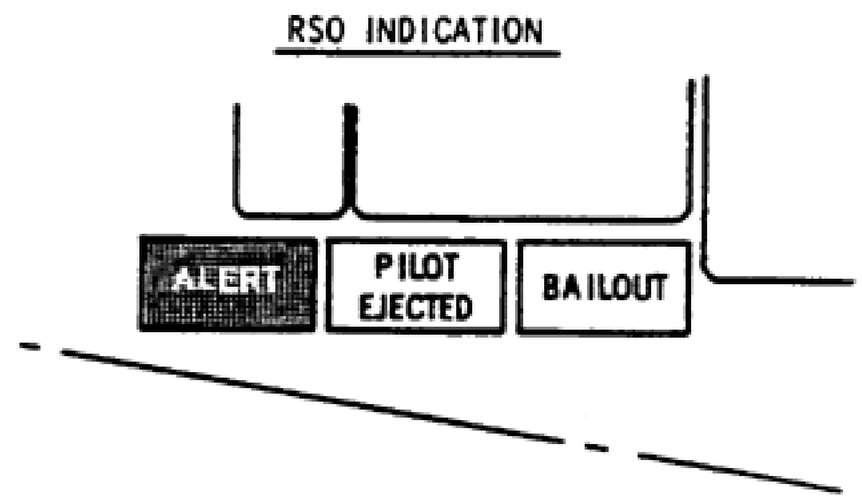
(f) Release the chute bag by opening the lap belt Koch fastener if desired. Attempt to salvage the radio beacon.

EJECTION

1 ALERT RSO

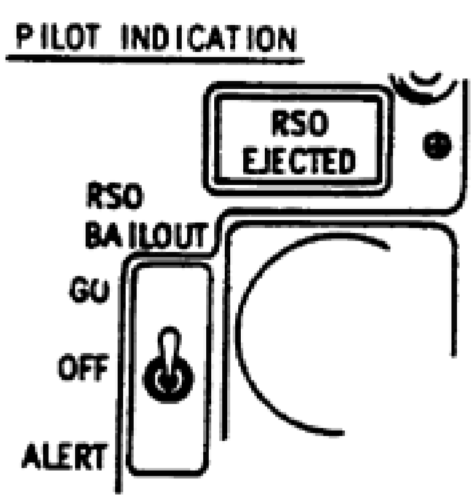
Pilot moves RSO BAILOUT switch to ALERT (down) position

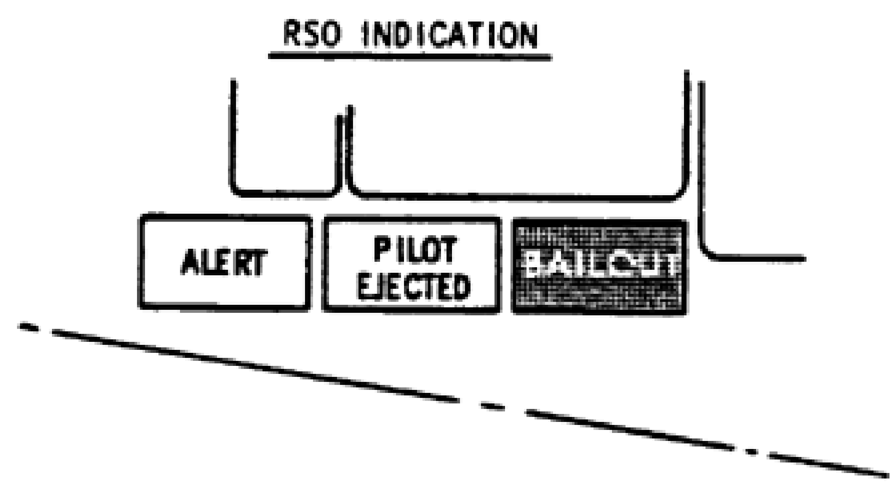




2 BAILOUT SIGNAL TO RSO

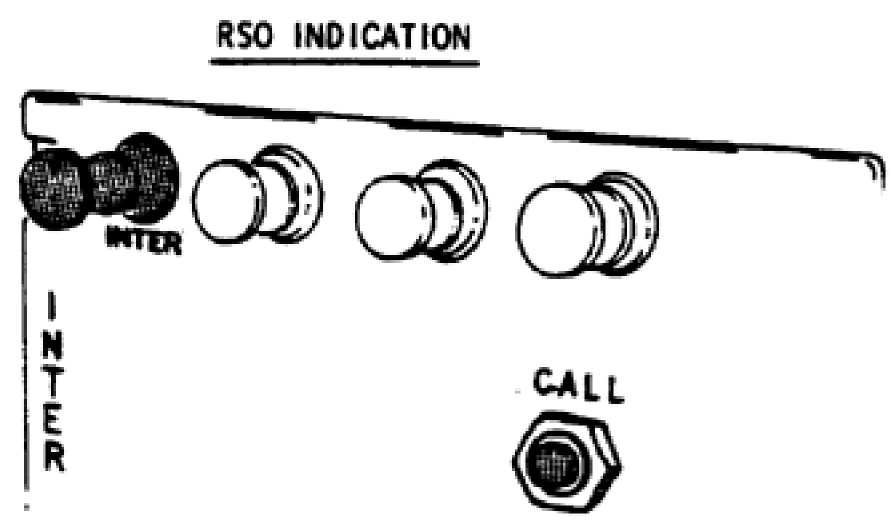
Pilot moves RSO BAILOUT switch to GO (up) position





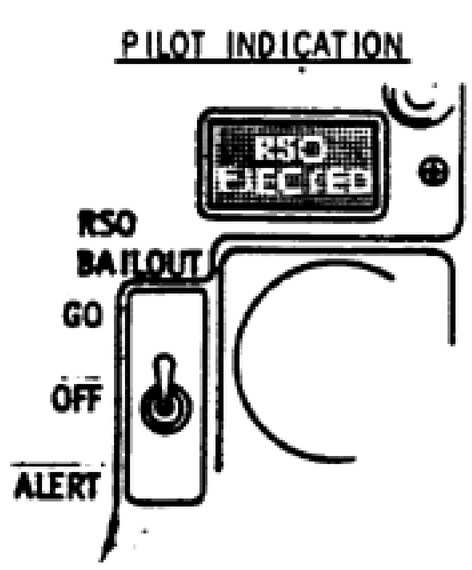
3 RSO INTERPHONE SETTING FOR BAILOUT

An emergency announcement accomplished by pressing the CALL button will always be heard.



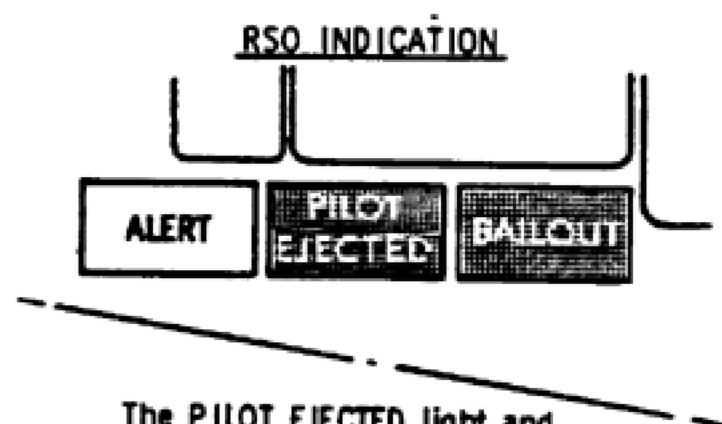
4 PILOT INDICATION THAT RSO HAS EJECTED

The RSO seat ejection activates the RSO EJECTED light on the pilots instrument panel



5 RSO INDICATION SHOULD THE PILOT EJECT FIRST

The pilot seat ejection activates the PILOT EJECTED light on the RSO instrument panel



The PILOT EJECTED light and the BAILOUT light will be on

Figure 3-3 (Sheet 1 of 8)

F203-96(1)(c)

EJECTION

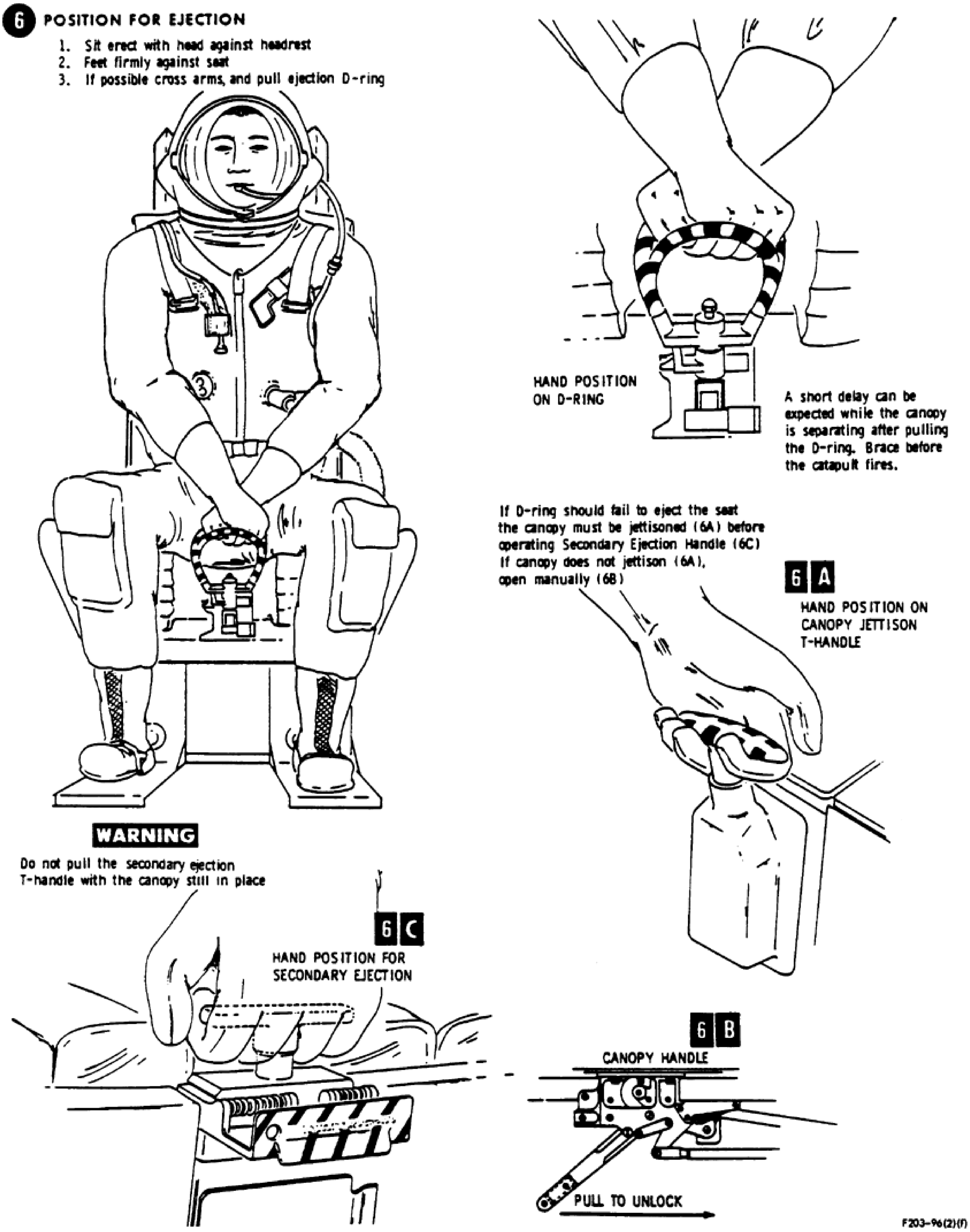
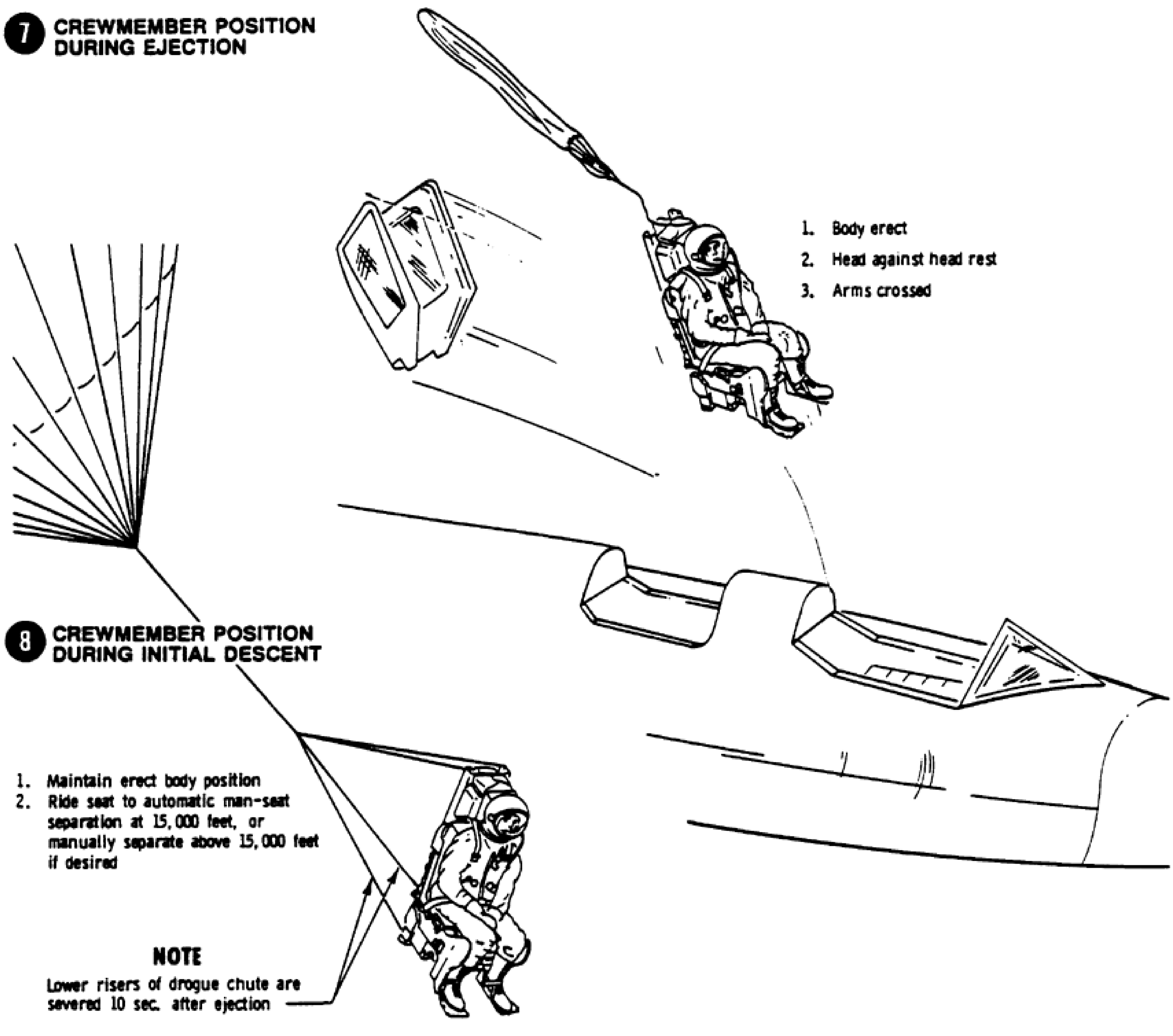
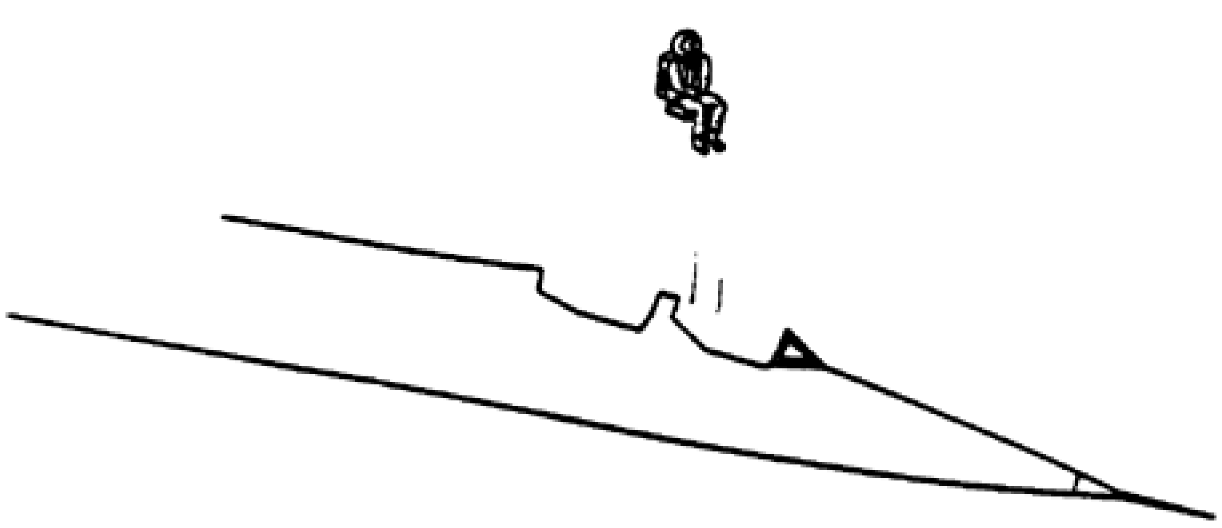


Figure 3-3 (Sheet 2 of 8)

EJECTION



BAILOUT WITH EJECTION SEAT INOPERATIVE



1. Airspeed - 250 to 300 KEAS
2. Canopy - Jettison or manually release
3. Green Apple - Pull
4. Scramble Handle - Pull
5. Trim full nose down.
6. Lean forward, push stick forward, and push sharply against seat to separate.
7. When clear of aircraft and below 20,000 feet pull parachute manual deploy ring.

Sequence continues at step 10

F203 96(3)(d)

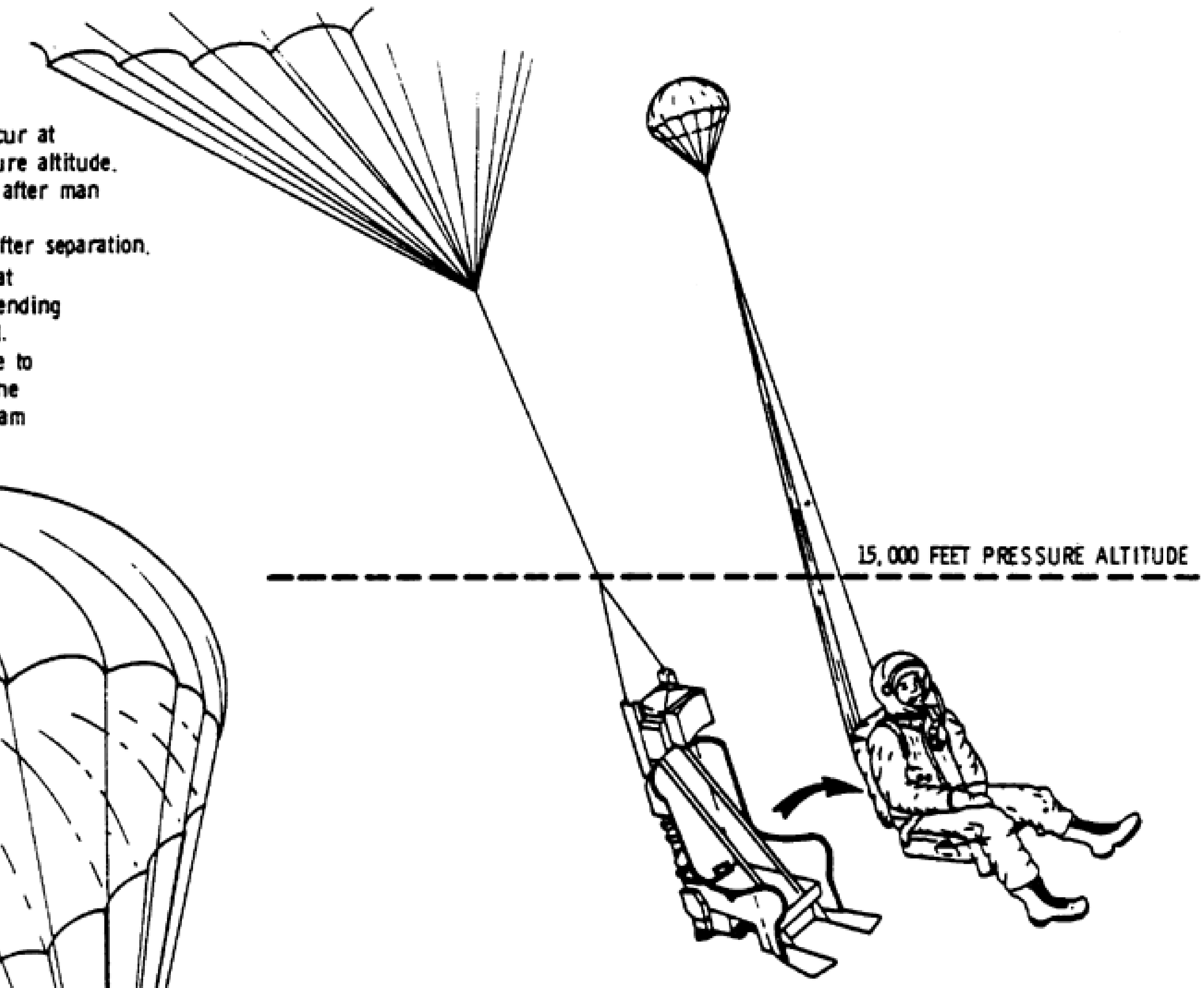
Figure 3-3 (Sheet 3 of 8)

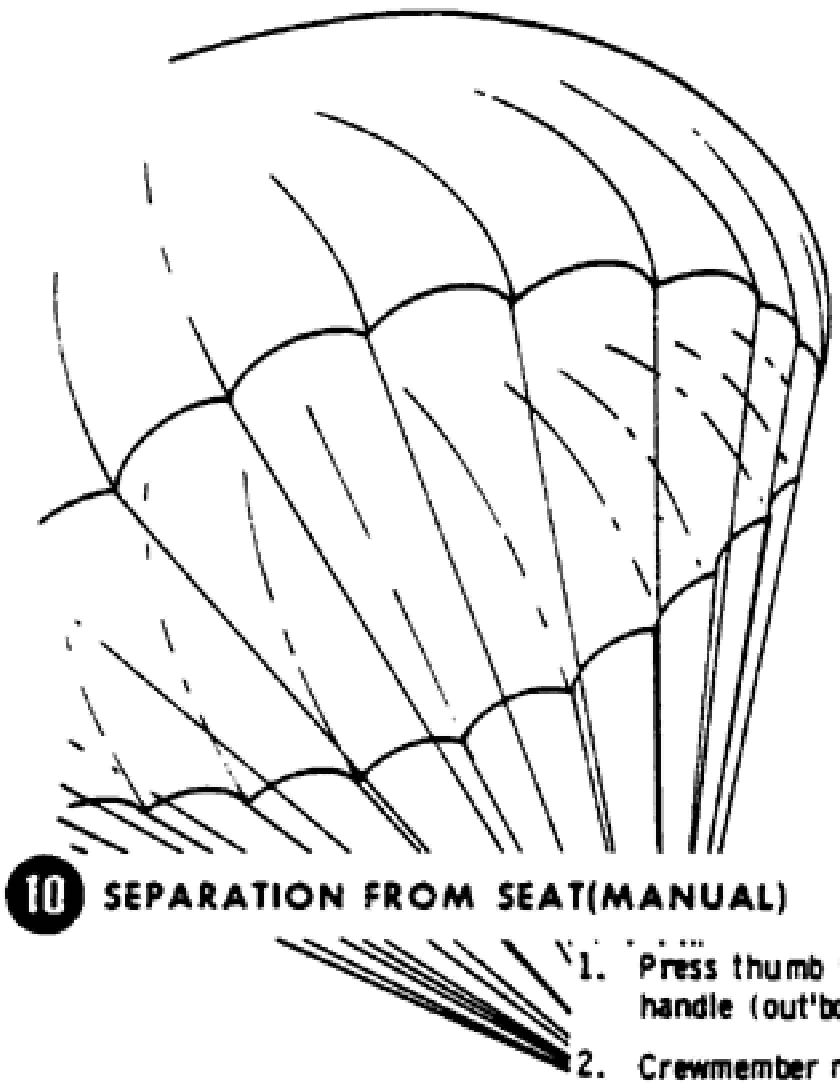
EJECTION

9 SEPARATION FROM SEAT(AUTOMATIC)

NOTE

Man-seat separation should occur at approximately 15,000 feet pressure altitude. Upper risers are cut 0.3 sec. after man separates from seat.
Main chute deploys 0.2 sec. after separation.
Rotation or spinning of the seat may be experienced while descending with the drogue chute deployed.
If it occurs, it may be possible to arrest such motion by using the arms and hands in the airstream





WARNING

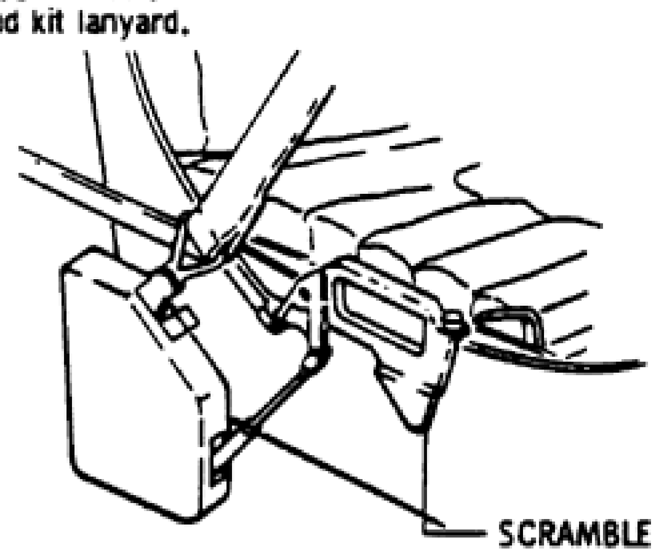
The crewmember must deploy the main chute manually, using the chute D-ring, after separating from the seat manually.

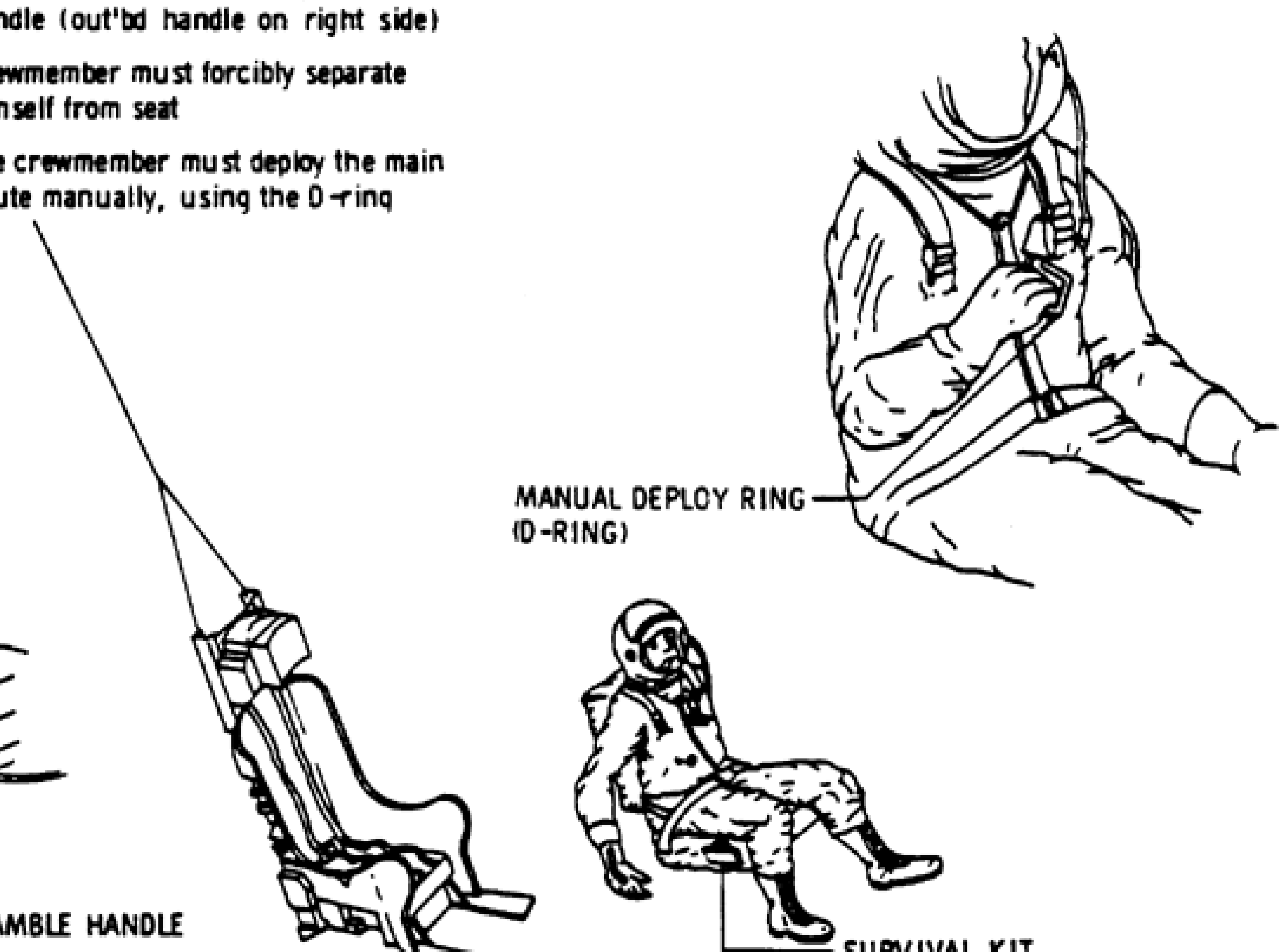
10 SEPARATION FROM SEAT(MANUAL)

1. Press thumb button then pull scramble handle (out'bd handle on right side)
2. Crewmember must forcibly separate himself from seat
3. The crewmember must deploy the main chute manually, using the D-ring

WARNING

Do not pull the survival kit release (inboard) handle while in the seat as this disconnects the emergency oxygen supply and releases the kit and kit lanyard.





F203-96(4)(a)

Figure 3-3 (Sheet 4 of 8)

EJECTION

11 PREPARATION FOR LANDING

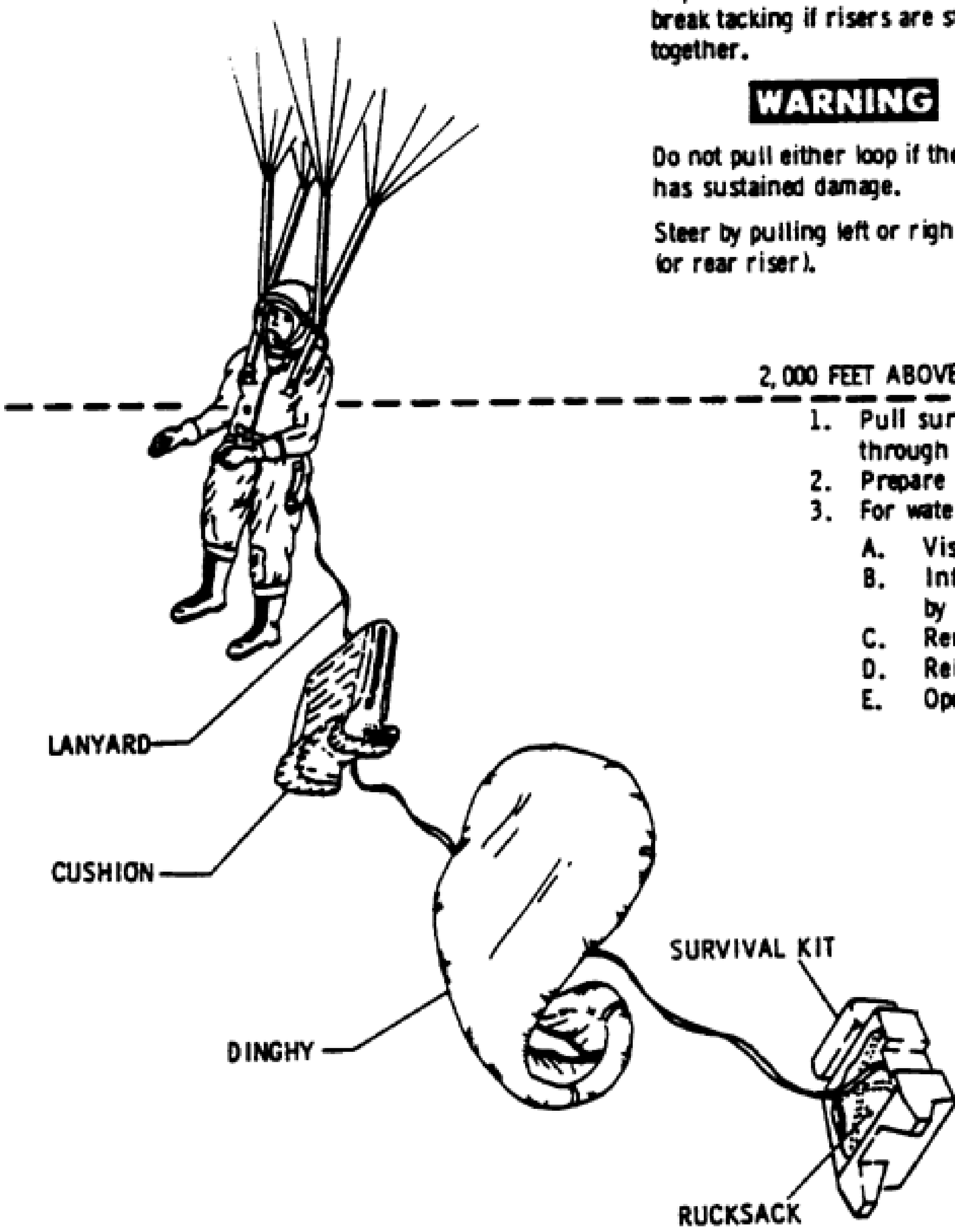
AFTER CHUTE DEPLOYMENT

Pull loops to release slip-knots of suspension lines from rear straps. Slip hand between riser straps and break tacking if risers are stuck together.

WARNING

Do not pull either loop if the chute has sustained damage.

Steer by pulling left or right loop (or rear riser).



2,000 FEET ABOVE LANDING SURFACE

1. Pull survival kit release handle rapidly through its complete arc of travel
2. Prepare for landing
3. For water landing:
   - A. Visor down
   - B. Inflate flotation vest before water entry by actuating lanyard.
   - C. Remove spurs.
   - D. Release chute when in water.
   - E. Open visor.

NOTE

If latches fail to keep visor open, bend the microphone boom out to prevent the visor from closing.

CAUTION

If retained, the foot spurs or severed foot retraction cables may puncture the dinghy.

NOTE

Kit touchdown relief can be felt prior to crewmember landing

Retain helmet liner if possible, it can be used as a cap

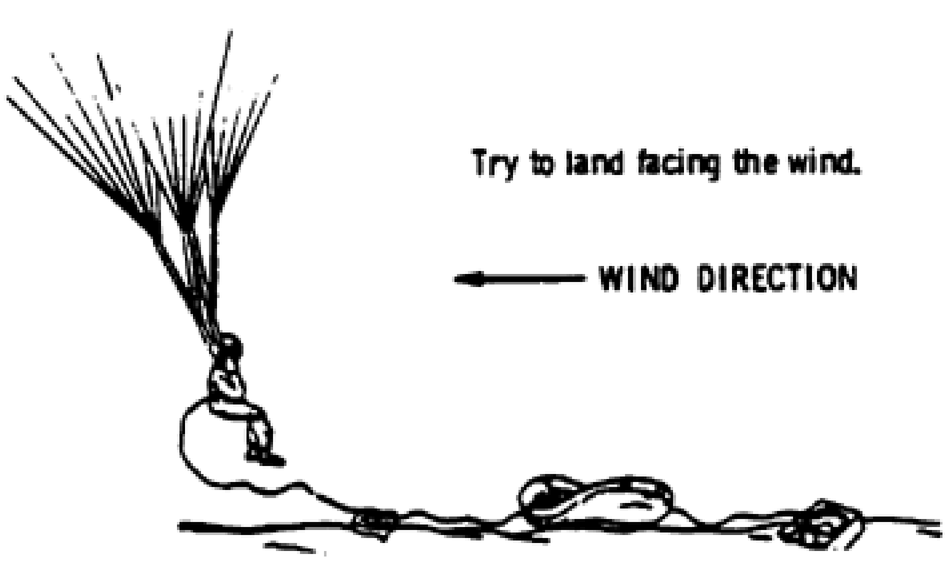
If signal fire built, stand away from fire area to simplify helicopter rescue

Turn radio beacon off, after rescue is assured, to avoid interference with voice communications on the rescue frequency

12 SURFACE CONTACT POSITIONS

Try to land facing the wind.

← WIND DIRECTION



F203-96(5)(I)

Figure 3-3 (Sheet 5 of 8)

EJECTION

13 RETRIEVAL OF SURVIVAL GEAR (WATER LANDING)

14 SUMMARY OF SEQUENCE OF EVENTS

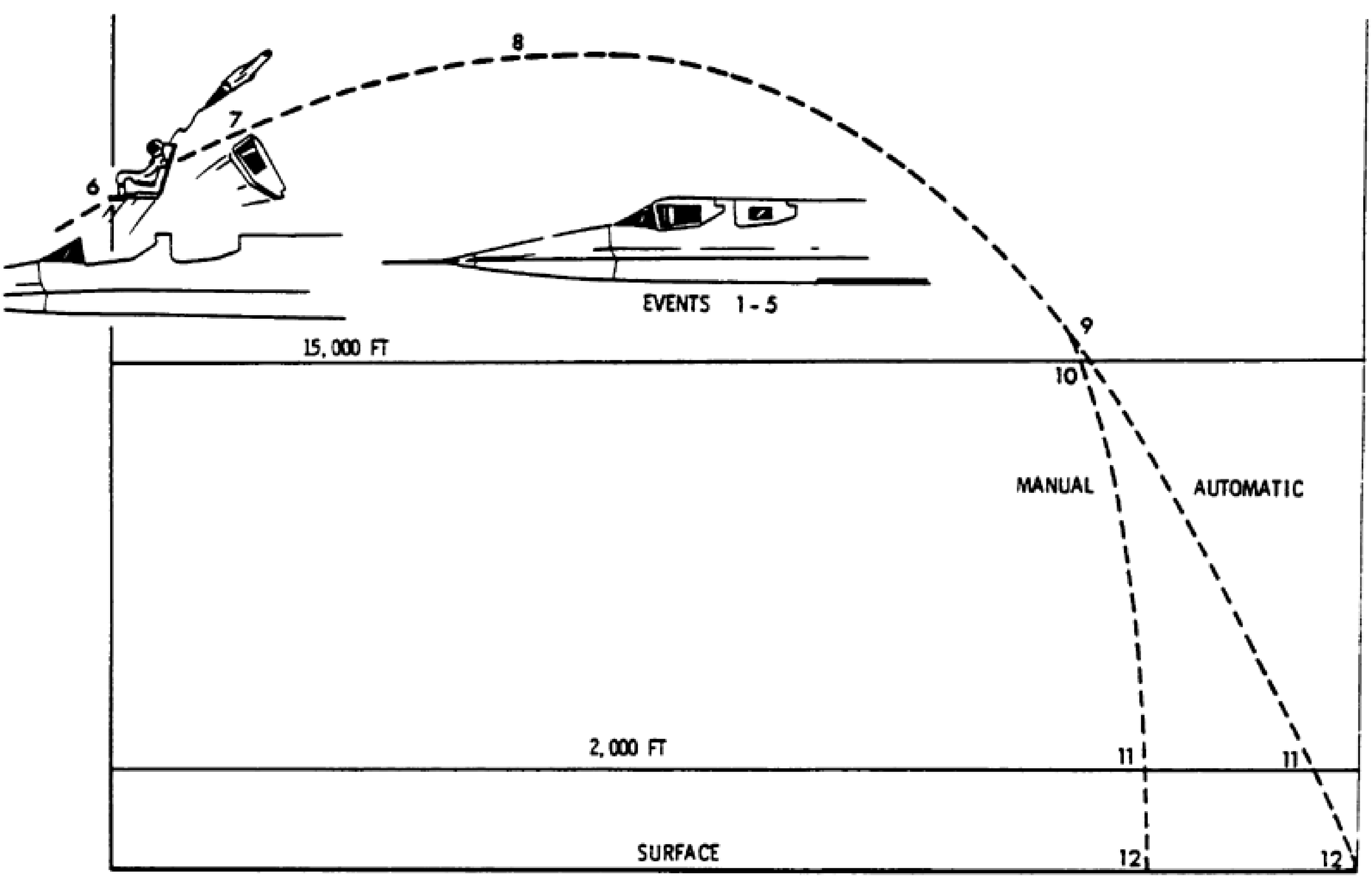


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Figure 3-3 (Sheet 6 of 8)

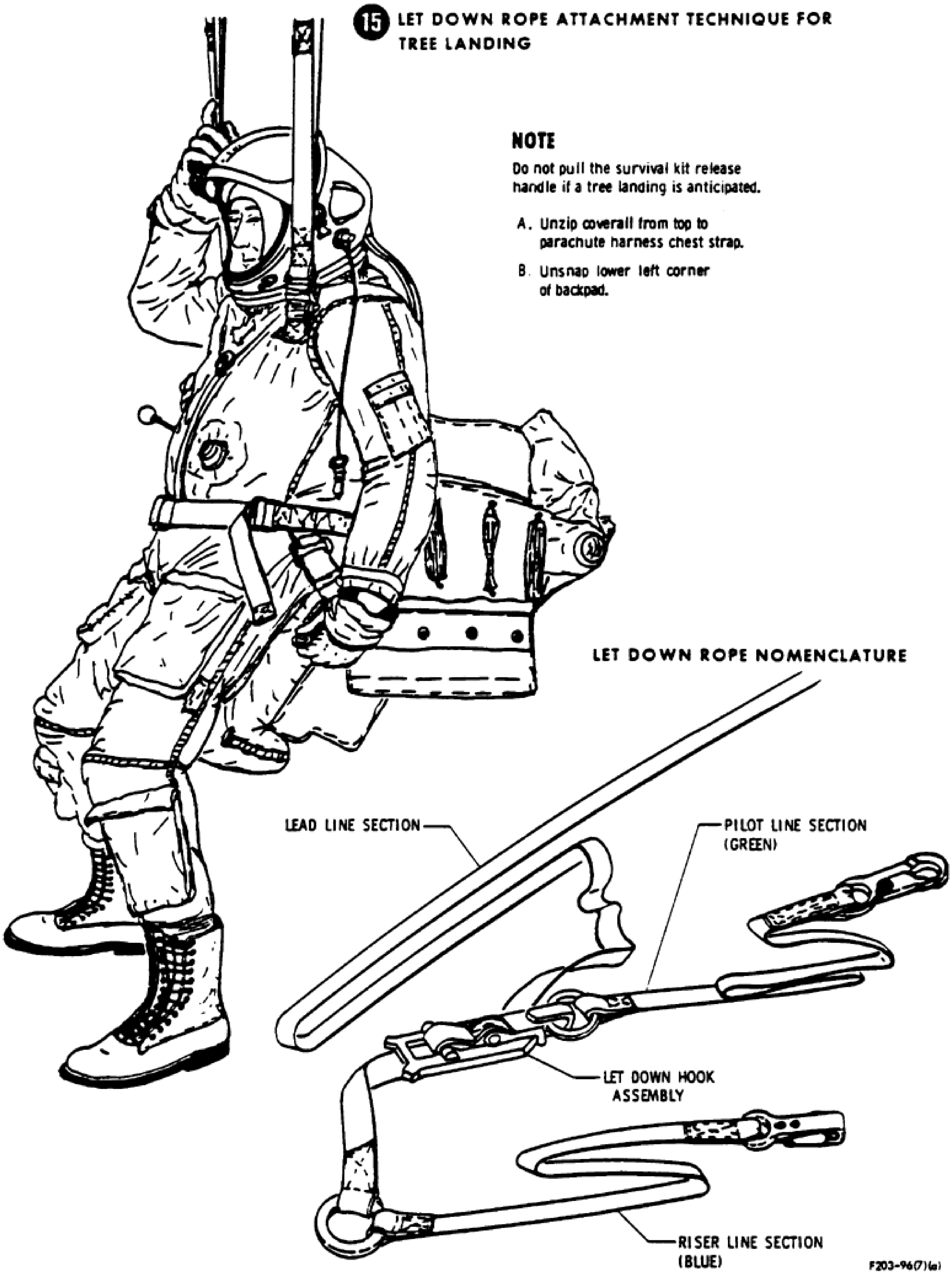

Figure 3-3 (Sheet 7 of 8)

EJECTION

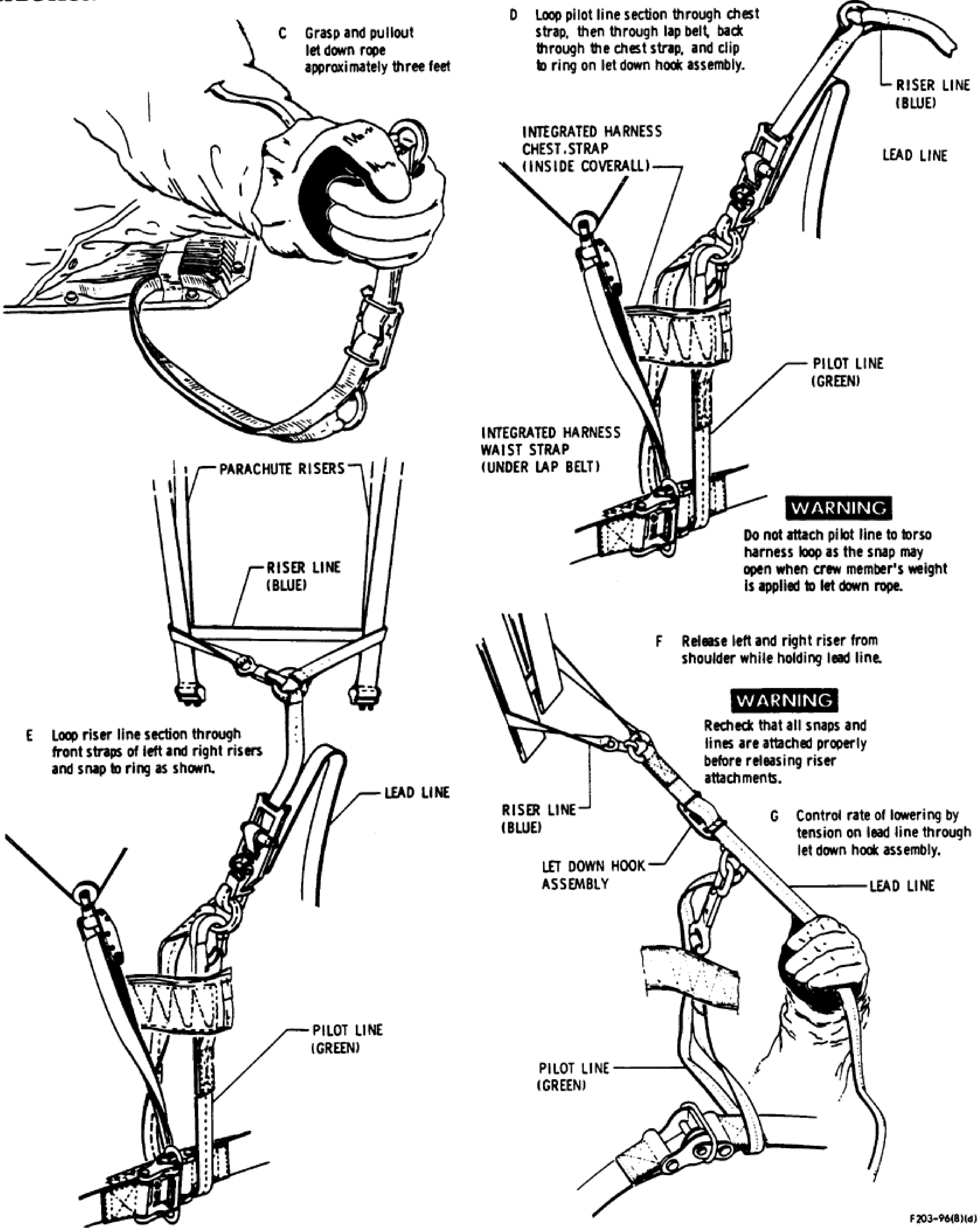

Figure 3-3 (Sheet 8 of 8)

FORCED LANDING OR DITCHING

Ditching, landing with both engines inoperative, or other forced landing should not be attempted. Ejection is the best course of action. If an ejection seat fails to fire, manual bailout is preferable to ditching or forced landing, since the aircraft will probably break up on touchdown.

SMOKE OR FUMES

The crew cannot detect cockpit fumes when wearing pressure suits. Each helmet oxygen system is independent of the cockpit and suit air supply. Smoke can be eliminated promptly by dumping cabin pressure unless smoke is entering the cockpit from the air conditioning system.

WARNING

> When cabin pressure is dumped, cockpit depressurization occurs very rapidly.

The pressure suits inflate if altitude is above 35,000 feet.

AIR-CONDITIONING SYSTEM SMOKE

If smoke is entering the cockpit from the air conditioning system:

1. L and R refrigeration switches - Cycle individually.

   Attempt to isolate the source of smoke by operating either L or R refrigeration switch to OFF for a few seconds. If the smoke does not begin to clear, operate the switch back to ON and then set the other refrigeration switch to OFF.

With source isolated to one system:

2. Complete L or R Air System Out procedure.

With smoke from both systems:

3. L and R refrigeration switches - OFF.

   If smoke is entering from both systems, shutdown both systems. This shuts off all vehicle air.

WARNING

> - Shutting off both systems will depressurize the cockpits rapidly.
> - Continuing at supersonic speeds with both systems off will rapidly overheat the cockpit and equipment areas.

4. Begin emergency descent (if supersonic).

ELECTRICAL FIRE

The pilot and RSO depend on visual detection of electrical fire when wearing pressure suits since they cannot smell cockpit air.

▲1. Isolate the malfunction.

   Turn off electrical systems to isolate the malfunction(s). If necessary, deactivate suspected systems by pulling circuit breakers. The battery and one generator may be turned off without adverse effect on essential systems; however, both generators should not be off simultaneously unless absolutely necessary as this shuts down all fuel boost pumps.

▲2. Leave failed system off.

If required:

3. Cockpit pressure dump switch - ON.

4. Land as soon as possible.

EMERGENCY DESCENT

This procedure may be used when extreme circumstances exist or are expected to develop (such as crew emergency, impending loss of all fuel or control system hydrualic power, etc.) and minimum descent time is absolutely required.

Aircraft Control and Attitudes

A minimum use of flight controls is recommended for rapid descents during which aircraft control has become or may become critical (e.g., crew emergency, aft c.g. location with boost pumps inoperative). This may include nonturning flight until lower speeds are attained. If aircraft control is not critical (e.g., low oxygen quantity) a spiral descent is very effective in providing a rapid loss of altitude.

The nose will be between 10 and 30 degrees below the horizon while descending through the transonic speed region.

Power Setting and Inlet Configuration

The configuration of restarts on, idle power, and aft bypass closed provides high drag for rapid descent, the least probability of yaw asymmetry due to unstart, and the best means of avoiding compressor stall and flameout. Inlet unstarts may be encountered near Mach 2.0 if engine rpm is below nominal idle rpm. (See unstart boundary with spike forward and forward bypass open, Figure 3-4.)

CAUTION

Some damage to the engines can occur during an emergency descent if initial CIT is high and rate of deceleration exceeds 1.0 Mach number in three minutes while above Mach 1.8; however, continued subsonic operation is permissible if engine operation appears normal.

Use Of Landing Gear For Drag

The landing gear may be extended at 400 KEAS when subsonic to maintain maximum rate of descent; however, the gear doors may be damaged if the gear is extended while above 300 KEAS or Mach 0.7. Gear extension at supersonic speeds is forbidden. Extending the landing gear above Mach 2.3 may cause heat damage to the tires and result in a hazardous landing condition. With gear extended, a large nose-up pitching moment occurs between Mach 1.6 and 0.9. Full nose-down elevon is insufficient to maintain 1-g flight at high KEAS and/or aft c.g. in this area.

EMERGENCY DESCENT PROCEDURE

If extreme conditions require a rapid descent:

1. **RESTARTS ON.**

   Move the throttle restart switch to its aft position, or position both inlet restart switches to ON simultaneously. Expect large yawing moments if the inlets do not respond together.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected all normal restart capability for the respective inlet is lost.

2. **THROTTLES IDLE.**
3. Aft bypass switches - CLOSE.
4. KEAS - 350 to 400

   The autopilot KEAS hold mode may be engaged.

WARNING

- Do not exceed 400 KEAS or 1.5 g load factor.
- Increase rpm of one engine if high suit inflow temperatures are experienced. Engine stall might result, especially if IGV shift occurs.

5. Monitor fuel tank pressure.

WARNING

If necessary, reduce rate of descent to maintain fuel tank pressure above -.5 psi.

6. IGV switches - LOCKOUT checked.

▲7. Cockpit pressure selector switch - Set 10,000 FT.

NOTE

Select Bay Air OFF while descending if the pressure suit tends to inflate. This provides maximum airflow to the cockpits and closes the nose air shut-off valve. Return the Bay Air switch to ON when subsonic.

8. C.G. - Forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits.

Below Mach 1.7:

9. Pitot heat - ON.

10. Exterior lights - On.

When subsonic:

11. Inlets - Normal.

Move the throttle restart switch to the normal (forward) position, or select the off (up) position of the inlet restart switches.

12. IGV switches - NORMAL.

NOTE

Continued subsonic operation is permissible if engine appears normal.

For continued descent:

13. Landing gear lever - DOWN.

WARNING

Gear extension at supersonic speeds is forbidden.

CAUTION

Gear door strength limits the airspeed with gear down to 300 KEAS or Mach 0.7, whichever is less, with a maximum permissible sideslip angle of 10°. Maximum permissible speeds are 300 KEAS or Mach 0.9, whichever is less, with gear down when sideslip angle does not exceed 5°.

PROPULSION SYSTEM EMERGENCIES

Propulsion system components are: inlet, engine, afterburner, nozzle, fuel control, lubrication, fuel-hydraulic, and ignition systems.

INLET UNSTART

Inlet unstarts can only occur when supersonic after an inlet has been "started"; that is, supersonic flow is established inside part of the inlet. Unstart (shock expulsion) may be caused by inlet pressure behind the shock wave becoming too great or spike position too far aft. Improper spike or door positions can result from inlet control error, loss of hydraulic power, or electrical or mechanical failure. Unstarts are usually associated with climb or cruise operations above Mach 2 when at normal engine speeds; however, they may be encountered during reduced rpm descents at speeds above Mach 1.3.

Between Mach 1.3 and 2.2, when near Military rpm, recovery procedures using restart ON may result in compressor stall.

Inlet unstart characteristics may be similar to compressor stall characteristics and, in fact, stalls and unstarts may be intermingled. The term "aerodynamic disturbance" or "A/D", as used in the Inlet Unstart procedure, refers to either condition - - regardless of whether it has or has not been identified as an unstart or compressor stall.

Flight Characteristics During Unstarts

Unstarts are generally recognizable by airframe roughness, loud "banging" noises, aircraft yawing and rolling, and decrease of compressor inlet pressure (CIP) toward 4 psi. Fuel flow decreases quickly and the afterburner may blow out. EGT usually rises, with the rate of increase being faster when operating near limit Mach number and ceiling. A distinct increase in drag and loss of thrust occurs because of increased air spillage around the inlet and reduced airflow through the engine.

The aircraft yaws toward an unstarted inlet. This yaw causes a roll in the same direction. A pitch-up tendency may occur due to yaw and roll rates developed during the inlet unstart. Pitch control problems can also occur during associated maneuvering and will be accentuated by low KEAS and/or high angles of attack, maximum altitude operation, aft c.g., high Mach, and any pitch rate which existed prior to inlet unstart. During the unstart, primary emphasis must be placed on maintaining pitch control to prevent nose-up pitch rates and angles of attack in excess of eight degrees. Reduce thrust asymmetry as soon as possible.

Above Mach 2.8, inlet unstart may require yaw axis stability augmentation to avoid excessive sideslip and bank angles which could cause the other inlet to unstart.

Aileron effectiveness is reduced at high altitudes and high angles of attack. Roll control may become critical if the unstart occurs on the down-wing inlet during a bank. At altitudes above 75,000 feet, aileron control may be ineffective in controlling roll during an unstart unless the angle of attack is immediately reduced. Aileron effectiveness increases rapidly as the angle of attack is reduced and only moderate aileron inputs will be required to control the roll. An excessive nose-down attitude may result in an overspeed (KEAS and Mach) if the inlets are restarted during a recovery maneuver. Therefore, maintain the restart configuration until speed and attitude are fully under control.

The roughness usually clears after the forward bypass doors open and the spikes are started forward (manually or automatically) however, five to eight seconds may be required to clear the roughness. Roughness may persist until the spikes are fully forward during manual restarts at design Mach when aft bypass open has been required.

Inlet pressure should be checked during recovery. Moderate CIP increases occur as the inlet "clears" (inlet in restart configuration with no roughness). If the inlet has restarted (captured the shock), moderate CIP increases occur when the spike retracts to restrict the inlet throat, and CIP then increases to normal pressure when the forward bypass door closes to the normal schedule.

Unstarts caused by improper automatic spike scheduling will recur if the aircraft accelerates again to the unstart Mach. Manual spike and forward bypass door scheduling is necessary to accelerate further.

If unstarts occur because automatic scheduling is closing the forward doors too much, check the aft bypass position and manually schedule the forward bypass door. In general, more bypass is required than for automatic operation and required bypass area decreases as Mach increases.

Each time the shock expulsion sensor (SES) detects an unstart, the DPR schedule for the forward bypass door of the inlet that unstarted, is reduced 10 mpr (milli-pressure ratios). The DPR schedule for the other inlet is not changed. The lower DPR schedule commands the forward bypass door slightly more open when the inlet returns to automatic control after autorestart. A 10 mpr change in DPR schedule is so small it may not be noticeable to the pilot. If unstart occurred because the DPR schedule was set too high, unstart should not recur after one autorestart. If unstart was caused by a mechanical malfunction (such as a leak in the PSD8 lines that measure inlet pressure), the reduction in DPR is unlikely to prevent repeated unstarts and the forward door must be manually scheduled. The total reduction in DPR schedule on each inlet will not exceed 40 mpr regardless of how many unstarts occur.

Unstart Boundary Charts

Figure 3-4 shows unstart boundaries (a function of Mach, engine speed, and spike and bypass door positions). With spike full forward, the smallest roughness area below the idle rpm range occurs with the forward and aft bypass doors open. A more extensive area occurs with the bypass doors open, but with the spike moving automatically. In both cases, the onset of inlet airflow instability occurs earlier (i.e., at higher engine speeds) with the bypass doors closed. At windmilling rpm, heavy roughness will occur above Mach 1.3 unless the spike is positioned fully aft.

INLET UNSTART PROCEDURE

Accomplish only those steps which are necessary to clear the inlet and return to normal operation.

For inlet A/D:

1. **α WITHIN LIMIT.**

   Apply pure pitch correction (stick forward) first to eliminate the nose-up pitch rate and to maintain angle of attack within the limit. Alpha and pitch rate must be kept, or reestablished, within the APW stick shaker boundary. Rudders may be used to assist in roll correction, if necessary. Delay roll correction (with the stick) until pitch angle is controlled.
   Disconnect autopilot (or press the CSC button) if it is necessary to hold the control stick forward; otherwise, the autopilot will trim the elevons up, thus reducing nose-down control authority.

WARNING

- Start pitch correction first. High angles of attack can develop if pitch rate is not controlled, and this can result in pitch-up. Maintain angle of attack and pitch rate below the APW stick shaker boundary. Decreasing angle of attack first assists roll control and makes recovery of attitude more positive.
- Nose-up pitch trim above zero indication reduces down-elevon authority. If full forward stick is not sufficient to control angle of attack and pitch rate, trim nose down.

Except for spike(s) and forward bypass door(s) in manual control, the automatic inlet restart system will automatically position the spike and forward bypass to clear the A/D. Above Mach 2.3, both inlets respond due to the inlet cross-tie feature.

Observe CIP changes, and spike and forward bypass position indications to confirm normal action of the autorestart system (forward doors open, spikes move 15 inches forward then back to normal, CIP recovers to normal as forward doors close to normal). At high Mach, autorestart may not recapture the shock. If CIP does not recover after autorestart, manual restart is necessary to move the spike full forward and capture the shock.

With only one forward bypass door in manual control, an unstart on either inlet results in automatic actuation of both spikes and the door in automatic control. If the manually controlled door remains in its position, an unstart and possible engine stall can be expected on

INLET UNSTART BOUNDARIES AFT BYPASS CLOSED*

STANDARD DAY

Based On Mach And FAT For Std. Day At 400 KEAS

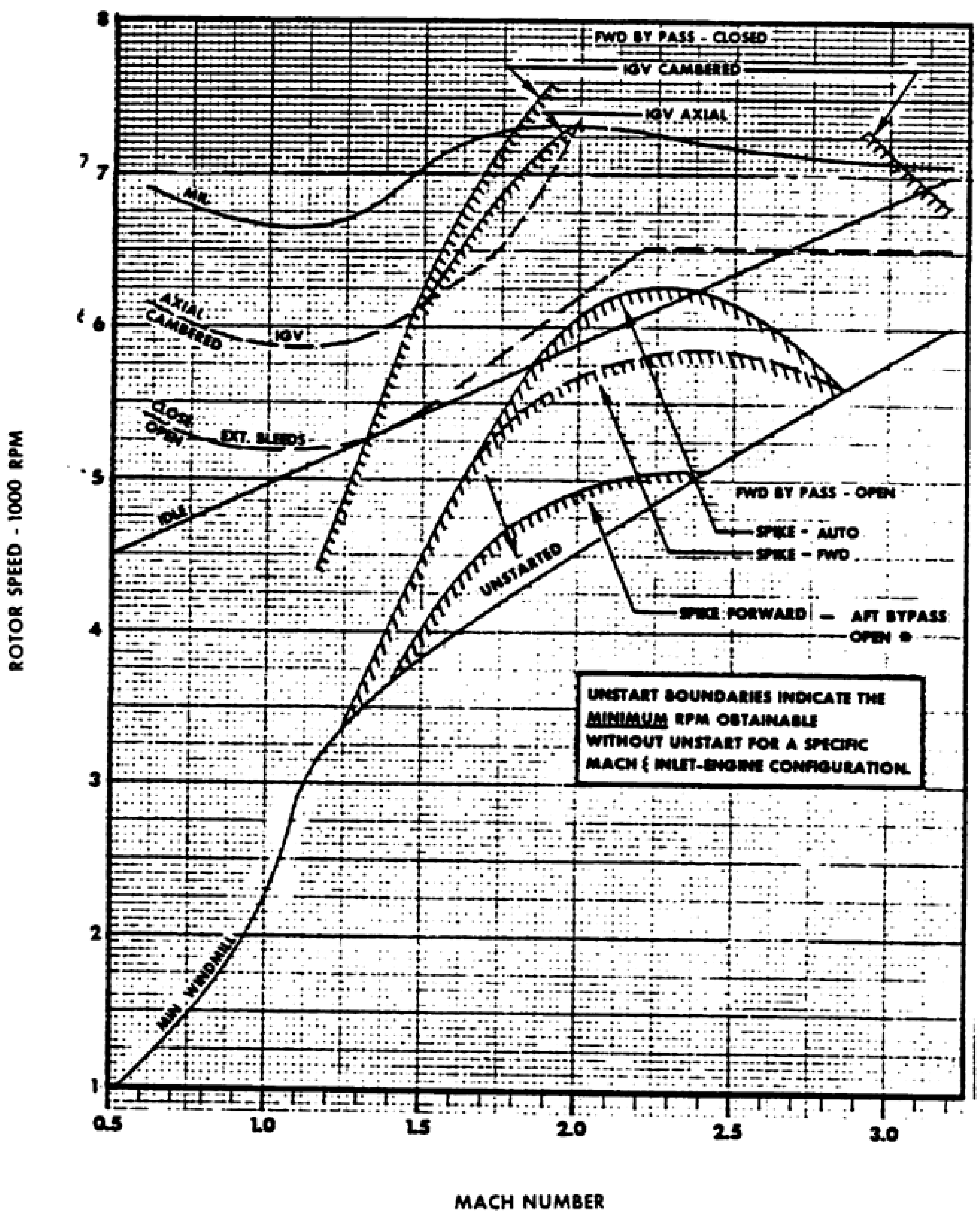

Figure 3-4

that inlet, even if unstart of the opposite inlet initiated automatic restart. The forward bypass must be set 100% open by the respective restart switch or forward bypass control knob. The intermediate position of the throttle restart switch may be used to control forward bypass positioning of both inlets during the autorestart cycle; otherwise, proceed as follows.

If either inlet is in manual control prior to the A/D, or if autorestart is not effective (unstart recurs, inlet does not clear, or CIP does not recover):

2. **RESTARTS ON.**

   The inlet autorestart and cross-tie features do not override a manually positioned forward bypass, or spike and forward bypass combination, on either inlet. If using a manual inlet schedule or if autorestart is not effective in one cycle of the spike and bypass positioning, either use the throttle restart switch or set both inlet restart switches ON (down) to establish the restart configuration. In the restart position, the forward bypass is 100% open and the spike is full forward.

   WARNING

   - Initially put both inlets in the restart configuration to avoid confusing which inlet unstarted and to reduce control problems.
   - If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

3. **AFT BYPASS.**

   If roughness does not clear with the inlets in restart, cycle the aft bypass switches OPEN, then to CLOSE. Aft bypass cycling is not normally required below Mach 3.0, and definitely should not be used if roughness is associated with compressor stall.

   CAUTION

   - If roughness cannot be cleared, retard the throttles to minimum afterburner or Military, depending on the severity of the unstart.
   - Check for engine failure or inlet system malfunction.

   If deceleration is required with the inlets in restart, close the aft bypass of each inlet and set the affected engine throttle to 6500 rpm upon reaching Mach 2.5. Refer to the Inlet Malfunction procedure and to the manual inlet schedule, this section.

4. **CHECK EGT.**

   Be prepared to shutdown the affected engine(s).

   WARNING

   Shutdown the affected engine for EGT:

   - Above emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT) and below 900°C for 2 minutes.
   - Between 900°C and 950°C for 15 seconds.
   - Over 950°C for 3 seconds.

   EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

Since the main fuel control cannot reduce fuel flow below the minimum fixed schedule, manual or automatic EGT trimming and throttle reduction to IDLE have no effect during a severe overtemperature condition with the inlet(s) unstarted. See Abnormal EGT Indications, Engine Fire/Shutdown, Engine Flameout, Glide Distance, and Airstart, this section.

At high Mach and high altitude, inlet unstart can cause severe engine overtemperature if the derich system is not effective, or if the Fuel Derich switch is positioned to REARM or OFF before inlet restart (CIP recovery) is obtained.

CAUTION

Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

5. **350 KEAS.**

   Adjust airspeed toward 350 KEAS.

WARNING

If in a nose-down attitide, leave the inlets in the restart configuration until speed and attitude are under control.

Below Mach 3.0, continued heavy roughness with the inlets in the restart configuration indicates compressor stall, regardless of the cause of the initial disturbance. Maintain airspeed above 350 KEAS and employ the compressor stall recovery procedure immediately to preclude flameout.

For compressor stall below Mach 3, affected inlet:

6. Aft bypass switch - CLOSE.

   If the aft bypass doors are not closed, this is a high risk stall area with the inlet in restart. (See Figure 3-7.)

If the compressor stall does not clear, affected engine(s):

7. Throttle - Reduce rpm.

   Retard the throttle toward IDLE until the compressor stall clears.

   Remain in the restart configuration while retarding the throttle, regardless of Mach. Refer to Figures 3-4 and 3-7. Note that there is a chance of clearing the stall while still near military rpm by returning the spike to automatic scheduling. However, with substantial rpm reduction toward idle, there is a definite probability of encountering the idle rpm unstart region between Mach 1.8 and 2.4, unless the spike is kept forward.

When the unstart or compressor stall clears:

8. Inlets - Reset individually.

   If the throttle restart switch has been used, setting both restart switches ON before moving the throttle switch off (forward) will allow inlets to be reset individually. Then, unless in manual inlet control before the A/D, resume automatic operation by setting the restart switches off individually.

   If using the manual inlet schedule prior to the A/D, do not set the restart switches off before selecting 100% OPEN on the affected inlet forward bypass control. Return to the manual bypass schedule after the spike has been returned to automatic scheduling or to the desired manual position.

   Alternatively, <u>if</u> automatic spike operation appears normal, position the throttle restart switch in the middle position, allow the spikes to recover to the automatic schedule, and set the affected inlet forward bypass to 100% OPEN before moving the throttle restart switch off.

<u>After CIP recovers:</u>

9. Derich switch - Recycle to ARM as necessary.

If a fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

CAUTION

Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

After derichment (derich light on), rearm the fuel derich system only after CIP has recovered and before lighting the afterburner. Relighting the A/B while deriched can result in engine speed suppression of up to 750 rpm.

Afterburner blowout due to low EGT and suppressed rpm, may occur during inlet recovery. The afterburner may relight automatically when EGT returns to normal (after the derich system is cycled) through operation of the catalytic igniters.

Without derichment, the catalytic igniters may sustain the afterburners or cause relights as soon as the inlet recovers.

10. Throttles - Reset and check afterburners as desired.

After CIP has recovered, reset the throttles, if necessary. Check that the nozzles are not abnornally closed if throttles are in afterburning range. Check that nozzle position responds to throttle position (by retarding throttle below Military) if afterburner blowout occurs. Relight the afterburner, if desired.

If an inlet unstarts after its restart switch is off, set the affected inlet restart switch ON and use the Manual Inlet Schedule or complete the Inlet Malfunction procedure, this section.

INLET MALFUNCTION

When at supersonic speeds, inlet system malfunction is indicated by successive unstarts, abnormally high or low CIP, or engine stalls. Malfunction of an inlet may be due to failure of the spike and/or forward bypass automatic controls, aft bypass control, actuators, or electrical or hydraulic control power. The engine and hydraulic instruments and inlet control circuit breakers should be checked before employing the inlet malfunction procedure, to determine that an inlet malfunction is not associated with some other abnormal condition. The respective inlet restart switch, or spike and door position controls, individually control the left or right inlet. The throttle restart switch affects both inlets simultaneously.

NOTE

- Since nozzle failure will affect engine rpm, and rpm, in turn, affects automatic forward bypass door operation (supersonic), abnormal forward bypass door indications can result from nozzle failure.
- Use spike and forward bypass position, turn-and-slip ball, CIP, ENP, fuel flow, and rpm indications for malfunction analysis.
- In some cases when unstarts have occurred due to automatic spike control malfunction, automatic operation can be continued below the Mach at which the unstart occured. Continuing at lower Mach may be preferable to using the manual spike schedule.

Failure To Schedule Normally

A combination of asymmetric thrust and fuel flow, and low CIP on one side during acceleration indicates that a spike and/or forward bypass has failed to schedule properly. This may be caused by failure of the automatic control(s) or of the spike forward lock to disengage when above 30,000 feet, or by circuit breaker opening. Normal spike and forward bypass positions and CIPs are provided by Figure 1-22.

Inlet Spike Unstable

Spike instability is reflected by fluctuations of the respective L or R hydraulic (SPIKE) pressure gage and by the spike position indication. If large-amplitude spike oscillations occur, the gage fluctuations are several hundred psi and a "hammering" may be felt. If spike instability persists, attempt to restore normal operation by cycling the manual spike control to match flight Mach number, then return to automatic control. If the condition persists, use the schedule for manual inlet operation until a different Mach number is reached, then return to automatic control. If the condition still continues, use the manual schedule.

Aft Bypass Control Failure

Malfunction of an aft bypass control is indicated by failure of the corresponding position indication light to extinguish after the aft bypass control position setting is changed. It may be possible to correct a malfunction by cycling the control setting. Control failure can result in reduced performance, inlet roughness or unstart, or engine stall, depending on the existing or subsequent flight conditions. Refer to Stall and Unstart Boundary charts, this section, for conditions to expect with the aft bypass, spike, and forward bypass in various positions.

INLET MALFUNCTION PROCEDURE

This procedure should be followed when the pilot has identified a specific inlet that will not operate automatically, but has not identified the reason for the unstart(s). The procedure allows an orderly transition from a cleared inlet, in the restart configuration, to the appropriate manual inlet schedule.

CAUTION

Observe altitude, speed, and bank angle restrictions during manual inlet operation.

Affected inlet:

1. Restart switch - ON.
2. Forward bypass control - 100% OPEN.
3. Restart switch - Off.

If unstart does not repeat:

4. Forward bypass control - Manual schedule.

   Assume that spike operation is normal and if aft bypass operation is normal, that there is a malfunction in the automatic forward bypass control.

If unstart repeats:

5. Restart switch - ON.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

6. Spike control - Manual schedule.
7. Restart switch - Off.

   Unstart should not repeat if malfunction is in the automatic spike control.

8. Forward and aft bypass controls - Manual schedule.

   The normal aft bypass and manual forward bypass schedules must be used when operating with manual spike control to obtain near-normal inlet performance.

After CIP recovers:

9. Derich switch - Recycle to ARM as necessary.

   If a fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

   CAUTION

   Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

   After derichment (derich light on), rearm the fuel derich system only after CIP has recovered and before lighting the afterburner. Relighting the A/B while deriched can result in engine speed suppression of up to 750 rpm.

   Afterburner blowout due to low EGT and suppressed rpm, may occur during inlet recovery. The afterburner may relight automatically when EGT returns to normal (after the derich system is cycled) through operation of the catalytic igniters.

   Without derichment, the catalytic igniters may sustain the afterburners or cause relights as soon as the inlet recovers.

10. Throttles - Reset and check afterburners as desired.

   After CIP has recovered, reset the throttles, if necessary. Check that the nozzles are not abnormally closed if throttles are in afterburning range. Check that nozzle position responds to throttle position (by retarding throttle below Military) if afterburner blowout occurs. Relight the afterburner, if desired.

MANUAL INLET OPERATION

The inlet spike and forward bypass may be positioned manually if an automatic inlet control malfunctions. Manual control is also desirable if engine shutdown is necessary while at high speed, as the spike aft position results in minimum inlet roughness during descent to subsonic speeds. Refer to Engine Shutdown procedure, this section.

CAUTION

Observe altitude, speed, and bank angle restrictions during manual inlet operation.

Manual Control of Forward Bypass

Manual operation of the forward bypass is permissible with AUTO spike selected, or in combination with manual spike scheduling. The normal aft bypass schedule should be used with the manual inlet schedule, (Figure 3-5). Figure 3-6 illustrates the forward bypass positioning for manual scheduling and for standard-day automatic operation.

NOTE

During cruise, if one inlet is controlled manually, set the forward bypass control to 1.0 psi less than the CIP of the normally operating inlet. If both inlets are controlled manually, set the forward bypass controls to 2.0 psi below the CIP "barber pole".

Manual Control of Spike

Manual operation of a spike is permissible; however, the effect on forward bypass positioning must be recognized. When an inlet forward bypass control is in AUTO and the spike control is in the manual range, the manual spike control overrides automatic bypass operation and causes the forward bypass

SCHEDULE FOR MANUAL INLET CONTROL FOR SPIKE AND/OR FORWARD BYPASS AUTOMATIC CONTROL MALFUNCTION

CLIMB & CRUISE SPEED	SPIKE SETTINGS: SPIKE **WITH** ① IND	SPIKE SETTINGS: SPIKE W/O ② IND	**FWD DOOR** SETTINGS: auto/man spike, DOOR **WITH** IND ①	**FWD DOOR** SETTINGS: auto spike, DOOR W/O IND ②	**FWD DOOR** SETTINGS: man spike, DOOR W/O IND
Below M 1.7	FWD	FWD	0%	0%	0%
Before IGV Shift	1" fwd of auto side	Lag TDI 0.1 Mach	Match auto side + 25%	40%	20%
After IGV Shift			Auto + 10%	30% ③	10%
Cruise		Match Mach	CIP - 1 psi low ④		

Use normal aft bypass schedule.
Adjust fwd door 20% more open before shifting aft door toward closed, or A/B light or cutoff.
Adjust spike 0.1 Mach no. forward before turns.

① Set indicator relative to opposite inlet auto indicator.
② Set marked knob setting if indicator inop, or if opposite inlet indicator is manual or inop.
③ If IGV shifts below Mach 2.1, set aft bypass to B before closing fwd bypass.
④ With dual manual inlet: 2 psi below barber pole.

MANUAL INLET RESTRICTIONS:
Max speed: Above FL 700; Mach 3.0, 400 KEAS.
Max altitude: FL 800.
Max bank: 20° above FL 750, 35° between FL 700 & FL 750.
Min airspeed: Above FL 700, KEAS for 6° α.

SUPERSONIC DESCENT	
SPEED	All manual inlet conditions
All	RESTART - ON
Above M2.5	720° EGT to Military
Below M2.5	Set 6500 rpm. Let rpm decrease. Retard throttle if compressor stalls.
With IGV Lockout Failure: At M2.0	Set idle
At M1.3	Spike forward, forward bypass closed, then restart OFF.

Figure 3-5

FORWARD BYPASS POSITIONING - AUTOMATIC & MANUAL SCHEDULING

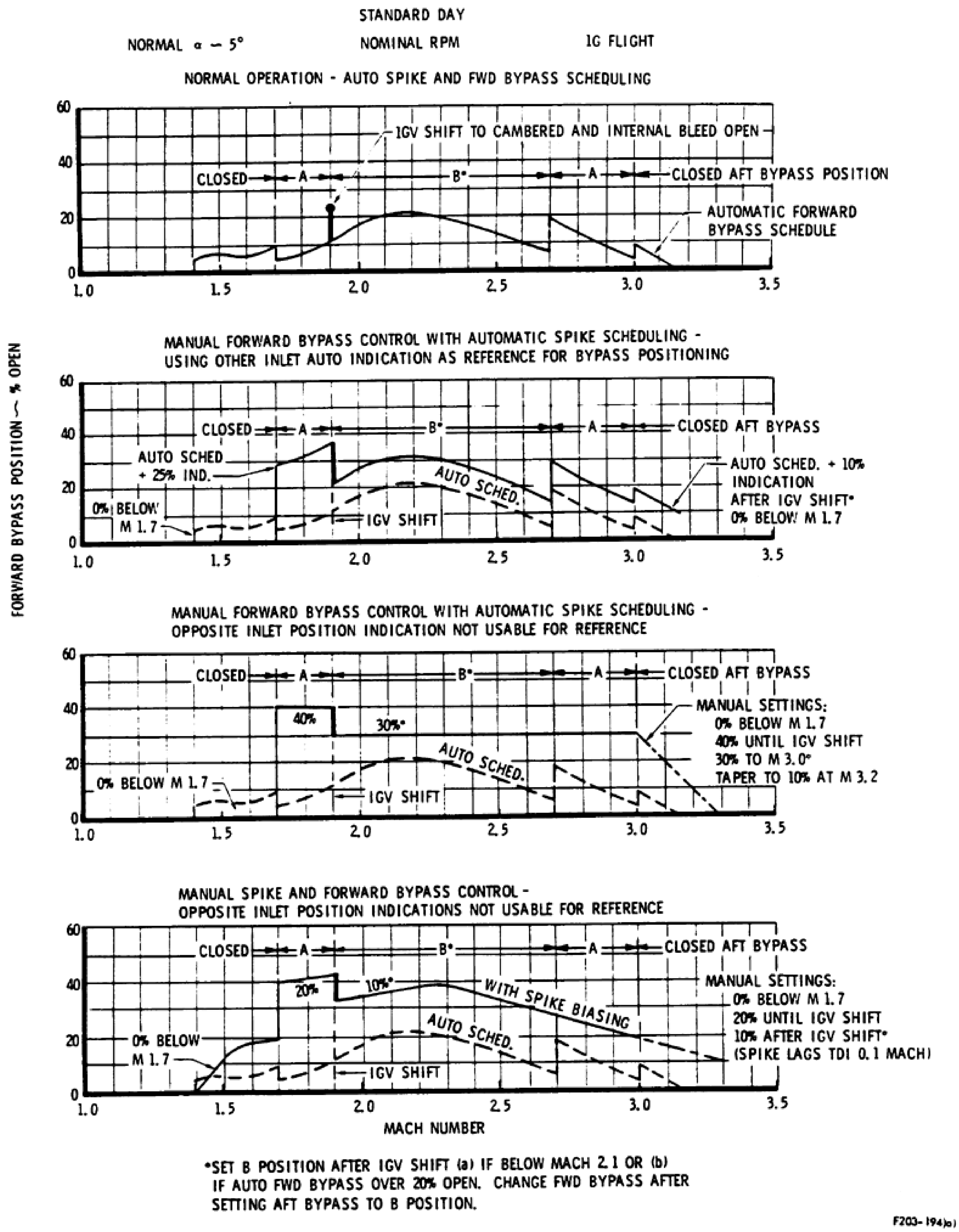

Figure 3-6

to open 100%. The forward bypass must be controlled manually to obtain positions less than 100% open during manual spike operation. When both are set in the manual control range, spike settings above Mach 1.4 bias the actual forward bypass position more open than the bypass control position settings. The maximum bias is approximately 25% when the spike setting is Mach 2.3, and at least 10% bias when spike control settings are between Mach 1.5 and Mach 2.8. Refer to Figures 1-30 and 3-6.

CAUTION

During supersonic climbs above Mach 1.7 but before IGV shift to cambered, expect the manual spike setting to bias the forward door about 20% more open (see Figure 1-30). Forward door indications of more than 40% open may cause stalls in this region of the climb. These stalls usually can be cleared by closing the forward door to the setting specified in Figure 3-5.

NOTE

Set spike position first when manual spike and forward bypass setting changes are scheduled. Allow the spike to reach its new position, then reset the forward bypass.

Manual Inlet Schedule

Use the schedule from Figure 3-5 if manual inlet operation is necessary or desired. (Checklist emergency procedures include an abbreviated form of this table.) During manual inlet descent below Mach 2.5, a combination of restart on and high rpm results in compressor stall. Set 6500 rpm at Mach 2.5 and let rpm drop under the stall boundary condition. If an IGV lockout failure is suspected on the affected manual inlet, set Idle at Mach 2.0. Unless rpm is reduced below the IGV/internal bleed shift line in Figure 3-7, stall may be encountered when the internal bleed and IGV shift with the forward door near 100% open.

WARNING

Risk of engine stall and flameout exists if the internal bleed and IGV shifts (to axial) during deceleration with an inlet forward bypass full open. Engine stalls have also been encountered during acceleration with the forward bypass failed open.

COMPRESSOR STALL

Compressor stall is usually indicated by thumping pulsations. Other characteristic indications are a loss of thrust, fluctuating CIP, RPM, ENP, or EGT at fixed throttle position, or failure of rpm to increase during throttle advance. Afterburner flameout with/without catalytic reignition can occur. At low airspeeds, compressor stall frequently results in engine flameout. Some of these stall characteristics are also descriptive of inlet unstarts, so accurate differentiation between stall and unstart is difficult. In addition, stalls and unstarts may be intermingled, making identification more difficult. A supersonic stall clearing procedure is incorporated in the Inlet Unstart procedure.

Compressor Stall Regions - Supersonic

Stall regions are shown in Figure 3-7. Maximum stall risk is at military rpm with IGV axial, aft bypass full open, and in restart. Minimum stall risk is near idle rpm with IGV cambered, engine internal bleeds open, with aft bypass closed. Stalls may be caused by transient airflow conditions resulting from compressor bleed or IGV shift, or by unstable or manual inlet operations. Other causes may be abrupt or erratic throttle movement, failure to momentarily delay throttle advancement during afterburner light, or improper scheduling of IGV or engine bleeds. Recovery from stall accompanying inlet unstart at high altitude is aided by reducing altitude. Below Mach 2.5, recovery is more consistently obtained by retarding the throttle.

ENGINE STALL REGIONS - SUPERSONIC

STANDARD DAY

Based On Mach And FAT
For Std. Day At 400 KEAS

	STALL REGION / ENGINE CONFIG	STALL RISK ① IGV AXIAL	STALL RISK ② INT. BL. OPEN	STALL RISK ③ EXT. BL. OPEN
INLET CONFIG	AUTO - AFT CLSD	MODERATE	SLIGHT	SLIGHT
	AUTO - AFT OPEN	MODERATE	SLIGHT	MODERATE
	RESTART - AFT CLSD	EXTREME	MODERATE	SLIGHT
	RESTART - AFT OPEN	EXTREME	HIGH	HIGH

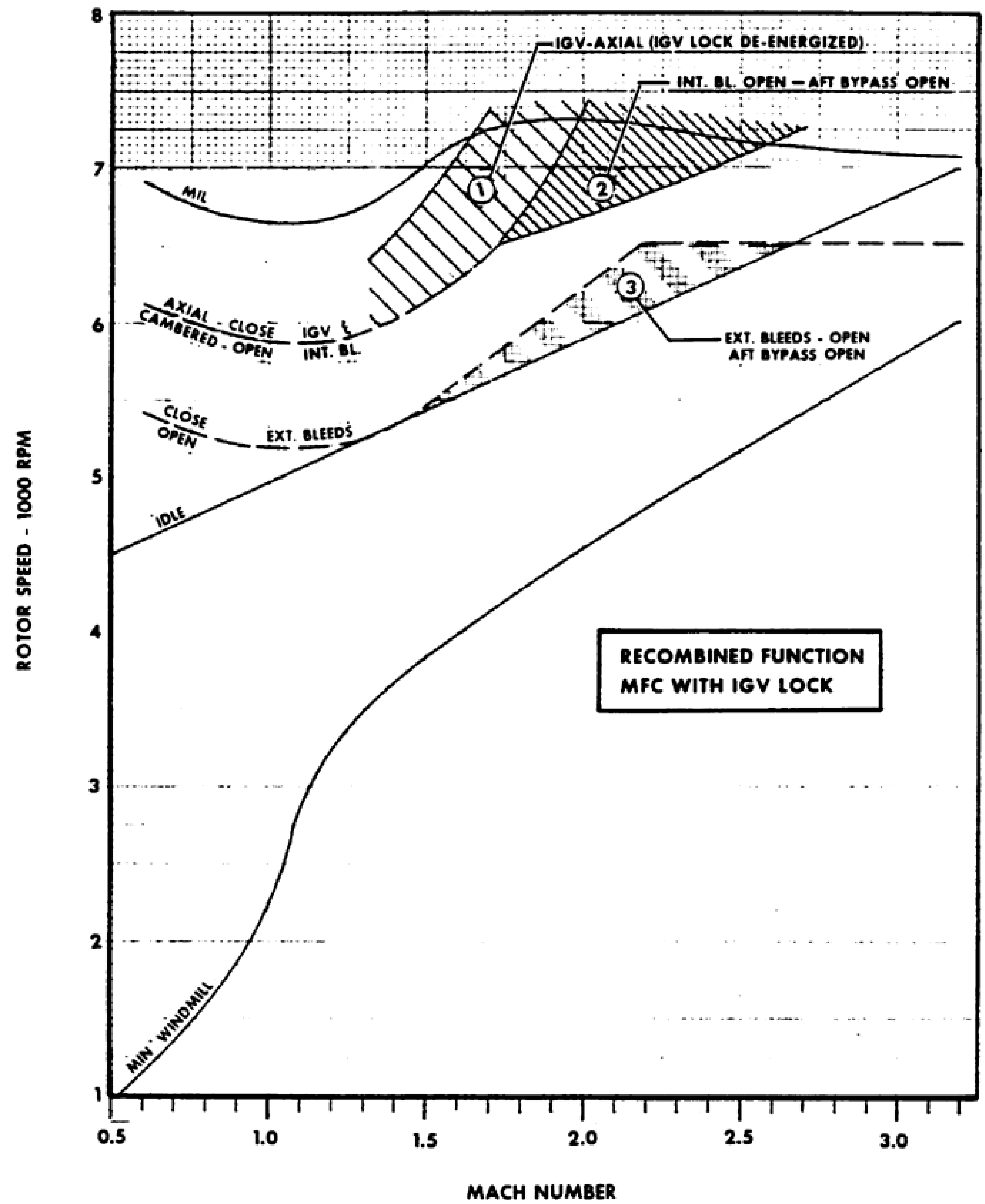

Figure 3-7

Effect of Open Aft Bypass on Stall - Supersonic

Unless the shock trap bleed flow is restricted by secondary airflow back pressure, open aft bypass positioning generally has slight effect on engine stall at supersonic speeds as long as the forward bypass continues scheduling. Stall risk, particularly below Mach 3.0, is significantly increased when excessive aft bypass opening results in a closed, non-scheduling forward bypass. While below Mach 2.5 with an inlet restart switch ON, appreciable stall risk exists while near Military rpm and in Idle with engine start (external) bleeds open. During airstart, the aft bypass should be closed as rpm increases.

Effect of Manual Inlet Operation - Supersonic

During manual inlet operation, stall risk is increased due to greater inlet distortion and reduced inlet efficiency. Full open forward bypass or restart results in extreme stall risk when the IGV light is on (indicating axial position), and should be avoided.

SUBSONIC COMPRESSOR STALLS

In addition to the more readily recognized abnormal rpm, EGT, nozzle position, and fuel flow conditions (for which emergency procedures are described in this section), engine stall parameters include angle of attack (α), compressor inlet pressure (CIP), turbulence, wind shear, and rapidly changing ambient air temperatures.

Engine stalls that occur during throttle advance are usually the result of excessive EGT uptrim. Engine stalls may also be caused by excessive EGT while at constant throttle settings, or malfunctioning nozzles, fuel controls, guide vanes, or engine bleeds. Engine stalls that occur when engine operating conditions are otherwise normal and when control parameters are not being changed may indicate an approach to dangerous flight situations. A low airspeed or high angle of attack condition, or both, may exist. Then, the stalls can be a result of low CIP (which is associated with low airspeed when at moderate to high subsonic operating altitudes) or result from high distortion in the inlet (which occurs at high angles of attack). Either can be dangerous when associated with operation beyond established flight limits.

When subsonic at angles of attack above 10°, engine compressor stalls may occur; however, stall-free operation has been obtained at angles of attack as high as 15° (Aircraft limit is 14°. See Figure 5-3).

Engine stalls are more probable when at Military rpm with CIT's below +10°C than at higher CIT's. This condition is in the rapidly changing portion of the EGT trim band. The probability of stall is increased at low CIP (high altitude, low airspeed), if there is a sudden decrease in air temperature, or if there is clear air turbulence, aircraft maneuvering, or open bypass door conditions. The effects can be additive.

High angles of attack do not affect CIP directly; rather, they cause nonuniform pressure distribution (inlet distortion) and disturbed airflow at the engine face. An engine can operate normally with large amounts of distortion if at relatively high CIP (low altitude or high KEAS). If there is very little distortion, operation may continue at CIP's as low as 2.5 psi. If at moderate to high altitudes and at low KEAS or CIP, a small amount of distortion can result in compressor stall.

Figure 6-2, which presents lift coefficient vs angle of attack, shows a generally linear slope for subsonic conditions away from ground effect. At angles of attack for normal subsonic flight (Mach 0.75 to 0.90), increasing load factor (or lift coefficient) results in an almost linear (equal factor) increase in angle of attack. Thus, if a gust changes load factor from one-g to two-g's, angle of attack will also double.

Sudden increases in angle of attack, such as from gusts, do not change CIP significantly; however, such sudden increases do increase inlet distortion. Therefore, gusts can contribute to engine stall probability.

SUBSONIC COMPRESSOR STALL PROCEDURE

1. α WITHIN LIMIT.

   Reduce angle of attack and then maintain angle of attack and airspeed within limits.

   WARNING

   When subsonic, if an APW system or high angle of attack warning occurs, or if angle of attack and airspeed are not within limits, make angle of attack and speed corrections before adjusting the throttles. These actions alone may clear engine stall conditions, and are mandatory to avoid pitch-up, if at high angle of attack and/or low airspeed.

After angle of attack and KEAS within limits:

2. Throttle - Retard toward 6100 rpm.

   Retard both throttles as necessary to clear the compressor stall, but do not reduce engine speed below 6100 rpm until nozzle response can be checked. Continuing stalls with EGT below the military schedule may indicate engine fuel-hydraulic system failure. In this event, maintain engine speed above 6100 rpm at whatever speed can be maintained without stalling. The engine will not operate at idle rpm with internal and external bleed valves closed or exhaust nozzles failed closed. Refer to Fuel-Hydraulic System Failure and Afterburner Nozzle Failure, this section.

If the compressor stall does not clear and nozzle response is normal, continue throttle reduction toward idle. Check IGV shift to cambered (IGV light off) as an indication of normal fuel-hydraulic system operation.

3. KEAS - Adjust toward 350 KEAS.

   Apply sufficient pitch correction to compensate for thrust loss. Airspeeds near 350 KEAS are favorable to normal engine operation.

When the engine stall clears:

4. EGT - Downtrim manually if necessary.

   Downtrim EGT if the compressor stalls occurred at military power or with the afterburner operating.

   Downtrim both EGT trim switches for at least three seconds if engine stalls are due to high EGT. With the throttles retarded, the response to trim will not be apparent in EGT indication as trim only affects EGT at or above Military power.

5. Derich switch - Recycle to ARM as necessary.

   If the fuel derich light is on and EGT is not high, move the fuel derich switch to REARM, then back to ARM.

6. EGT - Monitor.

   Retrim EGT manually to the normal operating range if necessary. If AUTO EGT trimming is resumed, monitor EGT and HOT/COLD flag indications to assure that no malfunction persists.

If stalls persist, affected engine:

7. Throttle - OFF.

8. Aft Bypass - Open.

9. Nozzle position - Verify full open.

10. IGV position - Check IGV light off (cambered position).

NOTE

If IGV and/or nozzle position indications are abnormal, set the throttle to Military when starting if an airstart attempt is necessary. An airstart attempt may result in further engine damage. Engine stalls are likely following light-off, but it may be possible to accelerate and obtain stall-free operation at military power. Observe EGT limits, and follow nozzle failed closed procedures for the remainder of the flight.

11. Check for abnormally high fuel flow.

12. Check visually for streaming fuel.

    Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

13. Emergency fuel shutoff - Fuel off.

If IGV, nozzle, and fuel flow normal:

14. Accomplish Airstart procedure, if desired.

If airstart not desired:

15. Complete the Engine Shutdown & Descent procedure.

COMPRESSOR STALL IN DESCENT

Compressor stalls may occur during descent at internal bleed and IGV shifts, especially if rpm droops below the military schedule. Often these stalls are self-clearing through reopening bleeds or recambering IGV. After a few of these cycles of shift followed by stall, the bleed or IGV shift is completed and stalls then do not recur. IGV Lockout prevents IGV shift but does not prevent internal bleed shift. With forward bypass open or inlet in restart, compressor stalls are likely at any rpm while above Mach 1.4 when the internal bleeds shift to closed and if the IGV shifts to axial. Stall and unstart characteristics are very similar and accurate identification of which condition exists is difficult. Use of the wrong corrective procedure can result in continued stall or unstart with eventual flameout. The following procedure is designed to clear severe or protracted stalls, or similar inlet roughness conditions which cannot be positively identified.

For severe or protracted compressor stall in descent:

Affected engine:

1. Restart - ON.

   Do not use the throttle restart switch as both inlets would be affected.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. Throttle - IDLE immediately.

   Retard the throttle to idle immediately after setting the inlet restart switch ON.

NOTE

When near the internal bleed shift point (about Mach 1.8), setting the restart switch ON without throttle reduction can induce engine stall and flameout.

If stall persists:

3. Increase KEAS.

When subsonic:

4. Restart - OFF.

5. Throttles - As desired.

CAUTION

If an engine stall cannot be cleared, shut down that engine and accomplish airstart.

IGV Lockout Failure

The IGV light illuminates when the guide vanes leave the fully cambered position if the IGV lockout fails. The IGV and bypass bleed shift occurs at approximately 65°C CIT or Mach 1.7 while decelerating with reduced rpm, and at approximately 85°C CIT or Mach 1.8 when using the 720° EGT descent procedure. Mild self-clearing compressor stalls may occur during the shift. If protracted or non-self-clearing stalls are encountered, accomplish the Compressor Stall in Descent procedure.

With a known IGV lockout failure prior to descent, set the throttle of the affected engine to Military above Mach 2.5 and 720° EGT at Mach 2.5, rather than 6900 RPM. Maintain at least 700°C EGT on that engine while above Mach 1.3. If the affected inlet was in manual operation, use the manual inlet descent procedure, but set Idle at Mach 2.0.

NOTE

> Monitor EGT, rpm, and nozzle position. 700°C EGT minimum should hold rpm at the military schedule and maintain nozzle governing. ENP greater than 70% open will result in less than military rpm; in this event, advance the throttle as necessary to maintain military rpm. Maximum rpm occurs near 100°C CIT, as during acceleration. Mild self-clearing stalls may occur near 85°C CIT (at Military rpm) when the IGV/internal bleeds shift if EGT has dropped excessively.

ENGINE FLAMEOUT

Engine flameout characteristics are a loss of thrust, and a drop in EGT and rpm. If flameout occurs during supersonic descent, recognition will be especially difficult because of the similarity between normal engine instrument indications and those of an engine which has flamed out. The only positive indications of a failure in this regime may be low EGT and a lack of response to a change in throttle position. Fuel flow may or may not decrease, depending on the operating condition prior to flameout. Engine flameout can result from interruption of fuel supply, component malfunctions, or unstable inlet conditions with the compressor stalled.

If flameout occurs with afterburners on, the operating engine's throttle should be retarded to minimum afterburning to reduce thrust asymmetry.

For engine flameout, as confirmed by cross-checking EGT, fuel flow, rpm, and ENP, either accomplish the Engine Shutdown and Descent, or the Airstart procedure.

DOUBLE ENGINE FLAMEOUT

With both engines out, the hydraulic pumps provide sufficient flow for satisfactory control surface rates at engine windmilling speeds above 3000 rpm. Control capability is progressively reduced as speed decreases, becoming marginal at approximately 1500 rpm.

Generator(s) in NORM continue to supply ac electrical power at engine windmilling speeds down to 3500 rpm, below which the frequency will begin to drop and then the generator(s) trip off. If both generators drop off, the battery and inverter provide power for DAFICS and other equipment on the emergency ac and essential dc busses. Without generator power, the boost pumps are inoperative and the probability of engine start is reduced, particularly if one or more fuel tanks are empty.

Below 3500 rpm engine windmilling speed, when generator(s) in the EMER mode power the boost pumps, boost pump output decreases as engine windmilling speed decreases. See Figure 3-7 for a comparison of engine rpm with Mach. The essential ac bus is not powered by generator(s) operating in EMER mode.

DOUBLE ENGINE FLAMEOUT PROCEDURE

With both L and R GEN OUT lights:

Perform the Double Generator Failure boldface procedure to regain boost pump pressure. Refer to Double Generator Failure Procedures, this section.

▲1. **ATTITUDE REFERENCE INS**

Select the INS to maintain a primary attitude reference.

2. **BOTH GENS EMER**

With both generators inoperative, placing both generator switches in EMER should restore power to the boost pumps and the ac hot bus.

3. **PRESS TANK 4 ON**

If at least one generator operates in EMER, manually selecting Tank 4 should restore some fuel manifold pressure to both engines.

Engine(s):

4. **AIRSTART**

When altitude is critical or flight control is marginal:

▲5. Eject

WINDMILLING GLIDE DISTANCE

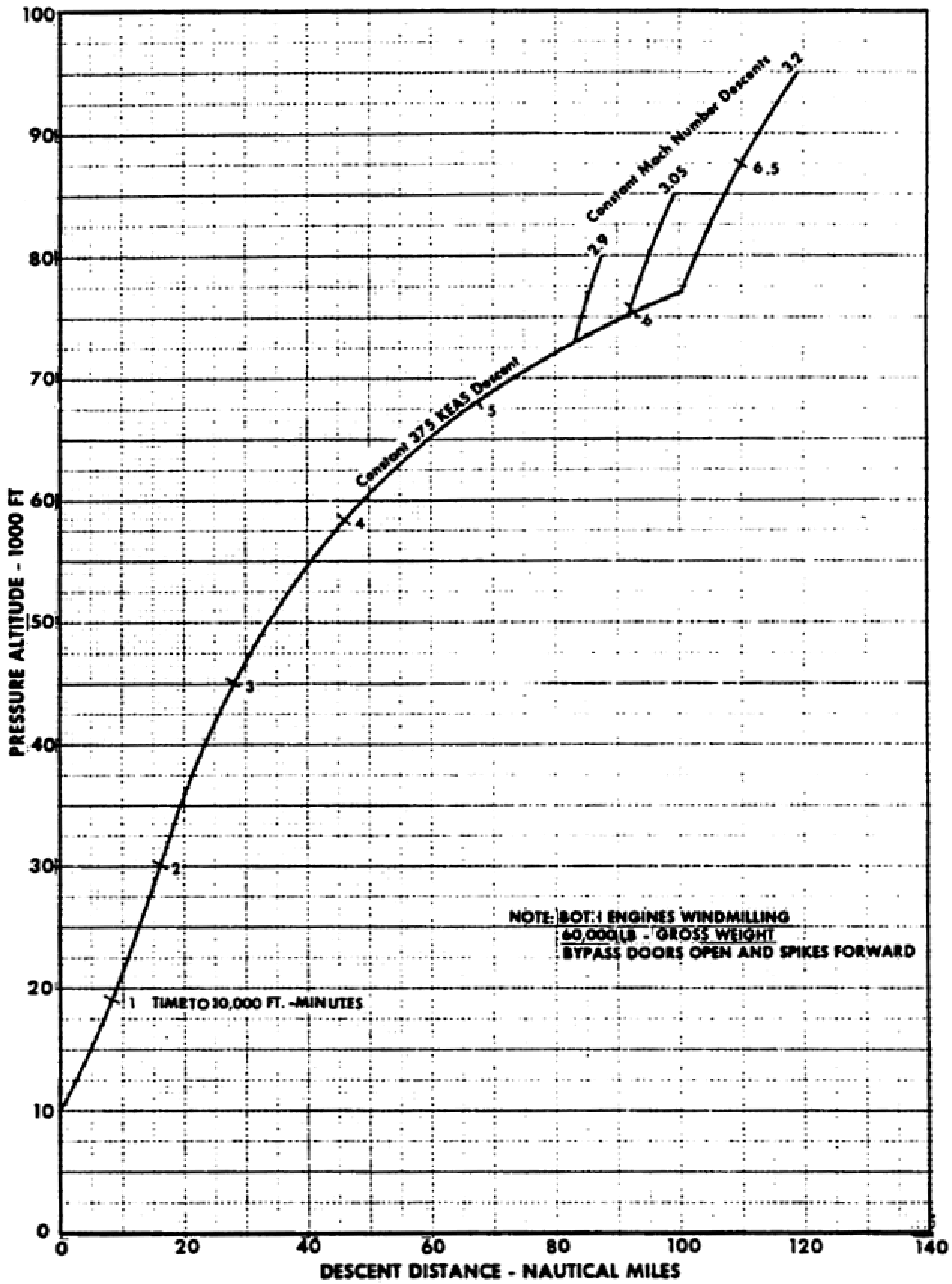

Figure 3-8

Glide Distance – Both Engines Inoperative

The glide distance chart, Figure 3-8, shows zero-wind glide distances with both engines windmilling. 375 KEAS glide speed is recommended for airstarts. Somewhat slower airspeeds provide greater range but reduced airstart capability. There is sufficient engine rpm for adequate hydraulic pressure to approximately 10,000 feet.

WARNING

Landing with both engines inoperative should not be attempted.

AIRSTART

If flameout is caused by temporary flow interruption, the throttle should be moved OFF immediately. Airstart procedures should be initiated after flameout; however, the reason for the flameout or shutdown must be considered before initiating restart.

Use of Crossfeed

If crossfeed is left open after an airstart is obtained, c.g. will move aft. Turn on an additional tank to the side where flow interruption is suspected before crossfeed is discontinued.

Airstart With Cold Oil

There are no special restrictions on airstarting and subsequent operation of the engines as long as oil pressure indications respond normally to rpm changes during the start. Operation above IDLE should be minimized after starting if oil pressure is not normal.

AIRSTART PROCEDURE

The best airstart conditions are 375 to 400 KEAS and at least 7 psi CIP.

NOTE

If subsonic, accomplish only * items.

On the affected side:

1. RESTART ON.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. AFT BYPASS OPEN

Set the restart switch ON and open the aft bypass to avoid unstart and/or to attempt smoothing the inlet. (Figure 3-4 shows that unstart is probable below Mach 2.8 if the aft bypass is not open.) This procedure may not smooth the inlet, and roughness may become severe below Mach 2.8. Although airstarts have been obtained while in roughness (inlet unstarted), there is a higher probability of restarting the engine when smooth operation has been restored.

If the restart switch on the opposite inlet is also placed ON, reduce rpm on that side to avoid compressor stall and/or flameout. (See Figure 3-7).

* 3. DERICH.

Cycle the derich switch to REARM, then to ARM, if the fuel derichment system has been actuated by high EGT.

* 4. X-FEED OPEN

Selecting crossfeed OPEN is the fastest method of assuring a positive supply of fuel to the engine before attempting an airstart.

* 5. **THROTTLE OFF, THEN 1/3 TO 1/2 MIL.**

Cycle the throttle to OFF, pause several seconds to assure cycling of the TEB chemical ignition system, then set the throttle at the position for 1/3 to 1/2 of the non-A/B range.

While supersonic, allow 15 seconds for rpm to increase (indicating that an airstart is being accomplished), observing the cessation of streaming fuel by use of the periscope. Repeat procedure as necessary. Do not expend all TEB during airstart attempts while supersonic.

While subsonic, an airstart can usually be obtained in 15 to 30 seconds at almost any allowable flight condition; however, 375-400 KEAS and at least 7 psi CIP are recommended. Over 30 seconds may be required for starting. Repeated rapid airstart attempts are not as effective as leaving the throttle in OFF several seconds to assure complete cycling of the TEB system and then leaving the throttle in the 1/3 to 1/2 Military position several minutes until positive that no start was obtained.

CAUTION

If rotor speed is below 1200 rpm, airstart is unlikely. Severe roughness and EGT overtemperature should be anticipated if airstart is attempted.

After engine starts:

6. **AFT BYPASS SET.**

Set the inlet aft bypass closed as rpm increases. Between approximately Mach 1.3 and Mach 2.3, compressor stall may be encountered if the IGV shifts as engine speed increases. If compressor stall in this speed range results in flameout, repeat the procedure, and maintain rpm below 6000 rpm after start. After starting and with the aft bypass closed, set the throttles as required and reset the crossfeed switch and inlet controls.

If continued airstart attempts in the descent are desired:

7. Check operative inlet and engine conditions and complete steps 9 through 15 of the Engine Shutdown & Descent procedure.

If the engine will not start:

* 8. Complete the Engine Shutdown & Descent procedure.

ENGINE FIRE & ENGINE SHUTDOWN

Illumination of a FIRE warning light indicates a nacelle compartment temperature above 565°C.

Engine shutdown must be accomplished after complete engine failure, such as seizure, explosion, or fire. Shutdown should also be accomplished for mechanical failure within the engine or its accessories to avoid or delay complete engine failure. Mechanical failure situations include uncontrollable rpm or EGT, and unaccountably abnormal oil pressure, fuel flow, or vibration. Refer to emergency procedures related to the engine oil, EGT, fuel, and nozzle systems, and to information in this section relating to operation with one or both engines inoperative.

Windmill speeds below 3500 rpm result in generator lowspeed cutout and a 50% loss of fuel tank boost pump capability to the good engine if the bus tie splits. If below Mach 2.0 or decelerating through Mach 2.0, turn off the affected generator as soon as possible after engine failure to prevent bus tie split and assure full boost pump capability.

Complete engine failure probably will not permit normal windmilling operation, but if the engine continues to rotate, cooling fuel circulates through the engine and aircraft cooling loops even with the throttle off. If the engine is not windmilling, an airstart should not be attempted since doing so could result in fire or explosion. Normal windmilling speeds can be expected after shutdown for some mechanical failures. Fuel cooling will continue unless the emergency fuel shutoff switch is shutoff or drive shaft power to the fuel circulating pumps is lost.

Descent distance can be extended by decelerating with maximum afterburning on the good engine. Overall economy can be improved by decelerating with minimum afterburning or Military power on the operating side. Base the choice of A/B (on or off) on the power condition to be used for single-engine cruise. When no airstart is to be attempted, descend at 350 KEAS until subsonic cruise altitude is reached.

WARNING

With the spike forward, roughness intensity increases during deceleration between Mach 2.5 and Mach 1.3. Very severe roughness should be anticipated in this speed range if the spike is not positioned aft. Maximum structural loads imposed are severe, but are well below design limits.

ENGINE FIRE/ENGINE SHUTDOWN & DESCENT PROCEDURE

NOTE

If subsonic, accomplish only * items.

If a FIRE warning light illuminates, affected engine:

* 1. **THROTTLE MIL/IDLE.**

Positively identify the affected engine. Then retard its throttle to Military when operating at a higher power setting. Retard the throttle toward IDLE if the warning light remains on or if operating with afterburner off when the warning occurs. If supersonic, retarding the throttle of the affected engine to Military (or less) will result in deceleration to subsonic speeds.

The thrust required for level flight may govern the power reduction possible on the affected engine if at low airspeed and heavy weight, as for fire warning immediately after takeoff. During landing approach, minimum control speed considerations may govern the amount of power advancement which can be used on the unaffected engine.

Check for abnormal EGT, trailing smoke, or any other indicaton of fire. Use the rear view periscope and RSO mirrors. Request confirmation of fire from other personnel if available. In case of doubt, assume that a fire does exist.

If the FIRE light extinguishes while at reduced power, and if there is no confirmation of fire, the flight may be continued with power reduced on the affected engine until a landing can be made at the nearest suitable facility. Land as soon as possible.

If the FIRE light remains on with the throttle at IDLE, or if a fire is confirmed, shutdown that engine.

WARNING

If the fire warning light extinguishes while shutting down the engine, do not attempt a restart. Fire or explosion could result.

If engine shutdown is necessary:

2. **RESTART ON.**

The spike-forward and forward-bypass-open configuration delays onset of roughness or unstart if the engine is shutdown near Mach 3. Use of the throttle restart switch affects both inlets and may not be desirable.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

* 3. **THROTTLE OFF.**

* 4. **AFT BYPASS OPEN.**

Initial onset of roughness can be expected near Mach 2.5 with the aft bypass open, inlet in restart.

* 5. **FUEL OFF FOR FIRE.**

Positively identify the emergency fuel shutoff switch for the affected engine and set it to the fuel off (up) position if shutdown is a result of fire.

WARNING

Shutting off fuel to a windmilling engine while at high Mach may cause additional emergencies due to loss of cooling fuel for the engine and aircraft systems. However, it is imperative to shut off fuel to the nacelle in the event of fire.

Fuel shutoff stops flow through one fuel cooling loop system. If speed is above approximately Mach 2.2, shutting off the fuel may cause engine oil to overheat and result in engine seizure. Shutting off the fuel may also cause additional emergencies due to loss of the associated aircraft cooling systems. Reduced Mach decreases cooling requirements.

6. Spike control - Mach 3.2 (full clockwise).

7. Airspeed - 350 KEAS (recommended).

Adjust speed toward 375 KEAS if airstart attempt is intended.

When roughness is encountered:

8. Restart switch - OFF.

Turn the restart switch OFF at onset of roughness (approximately Mach 2.5).

The full clockwise position of the spike control provides full aft spike and forward bypass open positioning (with the forward bypass control in the AUTO position) after the restart switch is off. Expect mild buffet as the spike moves aft and restricts inlet airflow.

CAUTION

Do not attempt airstart with the spike positioned aft.

At Mach 2.0:

* 9. Affected engine generator switch - OFF.

Check that the affected engine GEN OUT caution light illuminates.

Tripping the generator of the affected engine provides the most rapid load transfer to the unaffected engine generator. This minimizes switching delays which might otherwise occur when the windmilling engine generator automatically trips due to the underspeed cut-out. The remaining generator has sufficient capacity for all normal electrical loads.

CAUTION

Windmill speeds below 3500 rpm result in generator lowspeed cutout and a 50% loss of fuel tank boost pump capability to the good engine if the bus tie splits. If below Mach 2.0 or decelerating through Mach 2.0, shut off the affected generator as soon as possible after engine failure to prevent bus tie split and assure full boost pump capability.

NOTE

All flight control trim systems will be inoperative if the remaining generator fails, unless power is available from the EMER function of the generator(s) to power pitch and yaw trim through the ac hot bus.

Operative Inlet & Engine Conditions

1. Inlet controls - AUTO and CLOSE

   Position the spike and forward bypass controls to AUTO and set the aft bypass controls at CLOSE unless manual inlet control procedures are required.

2. IGV switch - LOCKOUT.

3. Throttle - Min A/B above Mach 2.0.

4. Throttle - Mil or Min A/B below Mach 2.0.

   A/B on is required while above Mach 2.0 to keep deceleration rates within limits. Minimum afterburner or Military power is recommended below Mach 2.0 until subsonic. Maximum afterburner results in greatest descent distance extension; however, maximum power should not be selected while above Mach 3.0 (to avoid unstarting the good inlet due to sideslip) and it is relatively uneconomical while below Mach 2.0.

* 10. Bay air switch - OFF.

This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

Turn the affected side refrigeration switch OFF if necessary (such as for smoke entering the cockpit).

* (11) Chine bay equipment (except MRS) -Off.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

* 12. C.G. - Forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits. Monitor tank 1 quantity while transferring fuel.

* 13. Cockpit temperature control rheostat - COLD, if necessary.

Approximately 75% of the normal flow of cooling air to the cockpits remains available.

Below Mach 1.7:

14. Pitot heat switch - ON.

15. Exterior lights - On.

Below Mach 1.3:

* 16. Restart switch - ON.

Set the restart switch ON and reposition the aft bypass (when necessary) to minimize roughness.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

17. IGV switches - NORMAL.

    Deenergizing the IGV Lockout System restores the engine to maximum thrust capability. The IGV should shift to axial and IGV lights illuminate if RPM is above 5500-6000 rpm.

When subsonic:

*18. C.G. - Monitor and control.

    Press crossfeed OPEN when tanks 5 and 6 are empty.

*19. SAS - Appropriate channels off.

    Review SAS and hydraulic systems available. Refer to procedures for SAS and hydraulic system emergencies.

*20. Land as soon as possible.

*21. Complete the Single-Engine Penetration and Landing procedure.

SINGLE-ENGINE FLIGHT CHARACTERISTICS

The loss of one engine will not result in loss of all hydraulic or electrical systems. If an engine fails just after takeoff, the large amount of asymmetric thrust will require bank toward the good engine and may require full rudder for directional control. Refer to Figure 3-2 for minimum single-engine control speeds. After regaining directional control, 7° to 9° rudder trim with bank and sideslip toward the good engine provide minimum drag during acceleration to climb speed. Charts showing single-engine climb capabilities are included in the performance data appendix. Acceleration to climb speed and climb to landing pattern altitude must be accomplished with Maximum thrust on the operating engine. During single-engine cruise, or after climb, reduction to zero rudder trim and use of bank and sideslip to maintain course provides minimum drag. A bank of up to 10 degrees is recommended, using no more than enough rudder trim to maintain course.

NOTE

During single-engine operation at low speed, a large rudder input may be required to maintain directional control under high asymmetric thrust conditions. A yaw toward the failed engine will cause a SAS correction proportional to the yaw rate up to 8 degrees maximum. Once the sum of the rudder and SAS inputs reaches 20 degrees maximum rudder displacement, any additional Yaw SAS input feeds back through the servo's internal linkage moving the rudder pedal suddenly back toward neutral an amount up to approximately one-half of the full pedal authority. In this case, the sum of the rudder and yaw SAS inputs remains 20 degrees, and no actual change in rudder position occurs even though the rudder pedal position has moved. As the yaw SAS input washes out (approximately 12 seconds), the pilot must continue to apply rudder pressure to compensate for the loss in SAS authority, or rudder deflection will decrease.

Trim Changes

Pitch trim changes can be expected while dumping fuel, due to shifting center of gravity. Directional trim is quite sensitive to changes in airspeed and power during landing

SINGLE-ENGINE AIR REFUELING

ACTUAL	SIMULATED
Receiver weight and altitude variations may result in conditions where military power is inadequate and afterburning power is excessive. Single engine rendezvous and refueling can be accomplished satisfactorily with approximately 10,000 pounds of fuel and 27,000 feet aircraft altitude. Approximately the same control trim and forces as for single engine cruise may be used with bank angles up to 10 degrees. After completing rendezvous:	Practice of single-engine refueling techniques can be accomplished at normal refueling altitudes with a fuel load of 25,000 - 30,000 pounds, one engine in IDLE, and one engine in afterburner:
1. Adjust throttles (and EGT trim if necessary) to stabilize behind tanker in mid-afterburner.	1. Same as "ACTUAL".
2. Turn both roll SAS channels off.	2. Same as "ACTUAL".
3. Trim roll and yaw axes to reduce effects of asymmetric thrust on stick pressures.	3. Same as "ACTUAL".
4. Turn forward transfer on if left engine is being used. Select crossfeed OPEN if right engine is being used.	4. Same as "ACTUAL".
5. Set brake switch to operate refueling system with appropriate L or R hydraulic system, then establish tanker contact.	5. Brake switch - ANTI-SKID ON.
6. If EGT is manually downtrimmed, uptrim EGT to nominal AUTO band or return EGT trim to AUTO as fuel is being transferred. Trimming beyond nominal band exposes the engine to stall.	6. Same as "ACTUAL".
7. Initiate a toboggan maneuver prior to reaching maximum afterburner.	7. Same as "ACTUAL" or: Initiate disconnect when power is limited at maximum afterburner. Do not intentionally exercise an outer limit disconnect.
	8. Reestablish normal 2-engine refuel operations if desired.

Figure 3-9

pattern operation. At high speed, engine failure or engine flameout could cause yaw angle to become critical if an effective damper were not operating. Temporary thrust reduction on the good engine helps to counteract the asymmetric thrust. Follow-up rudder action is necessary. If large yaw angles develop, inlet duct airflow disturbances may cause the other engine to stall or flame out.

<u>Fuel System Management</u>

Fuel system management during protracted engine-out operation should consider maintaining center of gravity, making all of the fuel available to the operating engine and, when possible, continuing the fuel cooling of necessary systems. Refer to Fuel System Management with Engine Shutdown, this section.

<u>Single-Engine Air Refueling</u>

Single-engine air refueling procedures for actual and simulated operation are provided by Figure 3-9.

WARNING

> Do not air refuel or land with only one roll SAS servo engaged.

<u>Single-Engine Cruise</u>

Conservative single-engine cruise performance data for Military, Minimum A/B, and Maximum A/B thrust are in Figure 3-10.

The cruise altitudes in Figure 3-10 are also the aircraft constant throttle single-engine ceiling capability. An altitude capability lower than shown on the charts must be expected on a hot day.

Minimum A/B thrust and Military thrust provide the best single-engine cruise options. Military provides the best range performance, but penalizes altitude capability especially at heavy gross weights. Minimum A/B provides good range performance with an ample altitude capability.

Maximum A/B single-engine cruise has poor range performance and should only be used when the required cruise altitude is higher than the minimum A/B cruise altitude capability. At least two fuel tank boost pumps are required for maximum afterburning fuel flow. If bus tie split occurs, manual selection of an additional fuel tank may be required. Simultaneous forward transfer and fuel dump should be avoided.

AFTERBURNER FLAMEOUT

Afterburner flameout can result from engine stall, abnormal inlet operation, or insufficient airspeed at altitude. Afterburner flameout may be detected by a loss of thrust and by comparison of nozzle position indicators. The flamed-out afterburner nozzle will be noticeably more closed. Fuel continues to flow from the spray bars until the throttle is retarded to Military. A fuel vapor trail may be observed through the periscope. Correct the inlet, engine, or airspeed and altitude condition before attempting afterburner relight. At high Mach, the minimum airspeed necessary for afterburner operation is lower with spike scheduling than with spike forward.

Affected engine:

1. Throttle - Military.
2. Nozzle - Check proper operation.

   Retard the throttle below Military momentarily and observe ENP moves toward open.
3. Throttle - A/B midrange.

   Note fuel flow increase.
4. Nozzle position - Checked.

   Check for more-open nozzle position when A/B relights.

SINGLE-ENGINE CRUISE PERFORMANCE

DATA BASIS: FLIGHT TEST

1 - ENGINE CRUISE

Fuel Remain Lb	TDI Alt.	TDI KEAS	TDI MACH	Fuel Flow Lb/Hr	NMI K Lb	TAS Knots	Time to 5K Lb HR:MIN	Range to 5K Lb N. MI
MAX A/B THRUST								
80 K	19.2M	362	0.80	56.9K	9.0	490	1:55	953
70	21.1	358	0.82	51.8	9.8	501	1:44	859
60	23.2	347	0.83	47.5	10.6	504	1:32	757
50	25.3	332		43.4	11.5	499	1:19	647
45	26.4	324		41.4	12.0	497	1:12	588
40	27.6	316		39.5	12.5	494	1:05	527
35	28.7	308		37.6	13.1	492	:57	463
30	29.9	300		35.7	13.7	490	:49	396
25	31.0		0.85	34.7	14.4	501	:36	311
20	31.9		0.87	33.9	15 0	510	:28	238
15	32.8		0.89	33.2	15.6	518	:18	162
10	33.5		0.90	32.3	16.2	524	:09	82
5	34.2		0.92	31.9	16.6	530	0	0
MIN A/B THRUST								
80 K	11.5M	380	0.71	38.3K	11.8	453	2:50	1316
70	14.1	364	0.72	34.9	12.9	452	2:33	1192
60	16.9	351	0.74	32.2	14.2	457	2:15	1057
50	19.5	350	0.77	30.4	15.7	476	1:56	907
45	20.7	344	0.78	29.0	16.5	478	1:46	827
40	21.8	337		27.4	17.4	476	1:35	743
35	22.9	329		26.0	18.2	474	1:24	654
30	24.0	320		24.5	19.2	472	1:12	560
25	25.2	312		23.0	20.4	469	1:00	461
20	26.5	303		21.6	21.6	467	:46	356
15	27.7	300	0.79	20.6	22.8	471	:30	240
10	28.8		0.81	20.0	24.0	480	:15	123
5	29.8		0.83	19.5	25.0	488	0	0
MILITARY THRUST								
60K	7.8M	359	0.62	22.3K	18.0	402	3:19	1379
50	10.9	348	0.64	20.5	20.0	410	2:51	1189
40	14.5	335	0.67	18.6	22.4	418	2:21	978
30	17.5	321	0.68	16.8	25.2	422	1:47	740
25	18.8	313		15.7	26.7	420	1:28	611
20	20.2	304		14.7	28.3	418	1:09	473
15	21.5	300	0.69	14.0	30.3	423	:45	323
10	22.9		0.71	13.4	32.3	432	:23	167
5	24.1		0.73	12.9	34.4	442	0	0

Set zero rudder trim.
Use bank & sideslip to hold course.
Restart ON. Set aft bypass for smoothness.

Figure 3-10

If relight not successful:

5. EGT - Increase trim.

   For CIT above 40°C, trim toward 845°C EGT (emergency limit).

   For CIT below 40°C, trim toward 865°C EGT (emergency limit). Switch the FUEL DERICH to OFF when approaching 860°C EGT.

   CAUTION

   Uptrim toward 865°C EGT carefully due to possibility of engine surge (compressor stall).

If relight not successful:

6. Throttle - Military.

AFTERBURNER CUTOFF FAILURE

If the afterburner does not cut off when the throttle is retarded to Military, attempt to vary the thrust by retarding the throttle below Military. The engine should be shut down if thrust cannot be modulated satisfactorily. After shutdown, the respective emergency fuel shutoff switch should be activated if the fuel flow and/or periscope observation indicates that the afterburner is dumping fuel.

AFTERBURNER NOZZLE FAILURE

Nozzle malfunctions are indicated by the exhaust nozzle position (ENP) indicator and either excessive rpm fluctuations or rpm deviation from the scheduled speed. This may be accompanied by compressor stall and exhaust gas overtemperature. Precautionary engine shut down may be necessary.

NOTE

Since nozzle failure will affect engine rpm, and rpm, in turn, affects automatic forward bypass door operation (supersonic), abnormal forward bypass door indications can result from nozzle failure.

Afterburner nozzle malfunctions may result from an exhaust nozzle control (ENC) failure, nozzle actuator failure, fuel-hydraulic pump failure, or a ruptured fuel-hydraulic line. A ruptured fuel-hydraulic line can be identified by excessively high fuel flow. It may not be possible to identify which one of the other causes of nozzle failure is responsible by using cockpit instruments. Therefore, the procedures address the nozzle position indication rather than the cause of the malfunction.

Nozzle Failed Open

A nozzle full open failure can be verified by failure of the nozzle to respond to throttle changes, and by abnormally high rpm at high power settings. If accompanied by excessively high fuel flow indications, the condition could indicate rupture of a nozzle actuator line in the engine fuel-hydraulic system. With nozzle failure, the main fuel control limits engine overspeed to approximately 350 rpm above the normal schedule; however, the actual overspeed rpm varies significantly with power setting. For example, at high altitude and maximum afterburner, the normal nozzle position is 80% to 100% open. A nozzle failure to full open results in a slight to moderate overspeed. As the throttle is retarded while in afterburner, the nozzle will normally close to approximately 60% open at minimum afterburner. A full open nozzle failure in this case would result in an overspeed approaching 350 rpm over the normal schedule. At military power, the nozzle would normally be almost closed to maintain the scheduled rpm and a full open failure would result in maximum overspeed. The accompanying EGT would be abnormally low and unresponsive to EGT trim inputs, as the fuel control will schedule fuel flow to restrict the overspeed. It is unlikely that the afterburner could be lighted while at such a high rpm and low EGT condition. At idle power, engine operation would be normal, as the nozzle would ordinarily be full open at that power setting.

Engine overspeed can be reduced while in afterburner by setting maximum thrust and downtrimming EGT. Overspeed while in non-afterburning conditions can be eliminated by throttle reduction below military.

NOTE

> If the thrust required is critical with the nozzle failed open, as during takeoff, it may be practical to retain maximum thrust - -even with engine overspeed - - until safe airspeed and altitude are attained.

NOZZLE FAILED OPEN PROCEDURE

NOTE

> If subsonic, accomplish only * items.

For high altitude cruise, affected engine:

1. Throttle - Set maximum afterburner position.
2. EGT - Downtrim to keep engine below 7250 rpm at cruise speed.

   Downtrim EGT to maintain engine speed within 200 rpm of the normal schedule. Refer to Figure 5-2.

   The main fuel control fuel flow schedule limits engine overspeed to approximately 350 rpm above the normal schedule at all power settings. Engine overspeed may be much less while at maximum afterburner and high Mach, since normal nozzle scheduling positions the nozzle nearly full open at these conditions.

   Some rpm control can be achieved at maximum afterburner by downtrimming EGT.

If rpm at cruise cannot be kept below 7300 with CIT above 300° or below 7450 with CIT below 300°:

3. Begin normal descent immediately.

   An immediate descent is <u>not</u> required if rpm can be controlled.

*4. Check for abnormally high fuel flow.

*5. Check visually for streaming fuel.

   Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

*6. Proceed with Fuel-Hydraulic Line Leak procedure at step 3.

For descent:

7. Throttle, affected side - Match opposite engine rpm.

   EGT will be much lower than the opposite engine.

At Mach 2.5:

8. Throttles - Set 6900 rpm.
9. Throttle, affected side - Maintain at least 6100 rpm.

   Maintain engine speed above 6100 rpm, particularly while at low subsonic speeds and low altitudes, until operation of the fuel-hydraulic system is confirmed to be normal.

   Continued engine operation is permissible with a failed afterburner nozzle if maximum limits for engine rpm are observed.

   Land as soon as possible.

Below Mach 1.3, or subsonic:

*10. IGV - Check operation, if desired.

If decelerating from supersonic speeds with the IGV cambered, select IGV NORM. Check IGV light on. Slowly reduce engine speed toward 5500 rpm to extinguish the IGV light. If engine operation becomes unstable, or the IGV light remains on at 5500 rpm, increase engine speed above 6100 rpm. With IGV light off, increase engine speed toward Military to illuminate the IGV light. If the IGV fails to cycle properly, or engine instability prevented completion of the IGV operational check, fuel hydraulic pump failure is indicated.

If the IGV is inoperative or not checked:

*11. Complete the Fuel-Hydraulic System Pump Failure procedure.

For confirmed nozzle failure:

*12. Land as soon as possible.

*13. Throttle, affected side - Match opposite engine rpm.

Match opposite engine rpm for subsonic cruise, penetration, approach and landing, but keep rpm within limits.

NOTE

With a nozzle failed open and a normally operating fuel-hydraulic system, operation at any rpm within rpm limits (including idle) is permissible.

*14. Use single-engine airspeeds for approach and landing, holding 200 KIAS minimum on final approach.

Nozzle Failed Closed or Toward Closed

A nozzle failed closed or toward closed condition can be verified by failure of the nozzle to respond to throttle setting changes, and by high EGT and engine stalls if in afterburner, or near idle power. Engine operation will be normal only near military power. If the nozzle failure occurs while in afterburner, immediate rpm suppression and engine stall will result – with a very high probability of engine flameout. If engine speed is allowed to decrease below 6100 rpm, the engine will normally experience a compressor stall and may flame out. If compressor stall is encountered, immediately advance throttle to increase engine speed above 6100 rpm. If subsonic, it may be possible to clear the stall by increasing airspeed above 400 KEAS and slowly advancing the throttle. If the stall cannot be cleared, the engine should be shut down. After engine shutdown or flameout, the restart possibilities with a closed nozzle are poor.

NOZZLE FAILED CLOSED OR TOWARD CLOSED PROCEDURE

NOTE

If subsonic, accomplish only * items.

Affected engine:

*1. Throttle - Military.

Engine stall and afterburner blow-out are probable at the onset of nozzle failure if supersonic with the afterburner on. Retard the throttle to Military. RPM suppression due to a closed nozzle is minimized at Military power.

Do not attempt to light the afterburner, as an unrecoverable engine stall and flameout may result.

* 2. Derich switch - Recycle to ARM as necessary.

If the fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

* 3. EGT - Maintain within limits.

Adjust the throttle to maintain EGT within limits; however, avoid power settings below 6100 rpm as the engine may experience compressor stall or flame out.

For nozzle failure while supersonic:

4. Begin normal descent.

At Mach 2.5:

5. Throttles - set 6900 rpm.

* 6. Throttle, affected side - Maintain at least 6100 rpm.

Land as soon as possible.

* 7. Check for abnormally high fuel flow.

* 8. Check visually for streaming fuel.

Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

* 9. Proceed with Fuel-Hydraulic Line Leak procedure at step 7.

If neither high fuel flow nor streaming fuel:

*10. Complete Fuel-Hydraulic System Pump Failure procedure.

NOTE

Engine considerations for a nozzle failed closed with functioning fuel-hydraulic pump are the same as for a failed fuel-hydraulic pump.

FUEL-HYDRAULIC SYSTEM MALFUNCTION

Fuel-hydraulic system malfunction usually results from engine fuel-hydraulic system pump failure or leakage from a broken fuel-hydraulic system line, connector, or actuator. If a rupture occurs, pressure at the actuators may remain high enough for near-normal operation of the nozzle, bleed, and IGV systems. Complete system failure renders the engine nozzle, compressor bleeds, and variable inlet guide vane system inoperative. The nozzle may remain stationary or it may drift full open or closed, depending on internal nozzle pressure and external air loads; however, if the fuel hydraulic pump shaft shears, the engine nozzle will move to the 60% open position via the pressure fuel servo in the exhaust nozzle control unit.

The initial indications of fuel-hydraulic system failure are similar to those for afterburner nozzle failure, i.e. a lack of nozzle response to changes in throttle position <u>and</u> either excessive rpm fluctuations or rpm deviation from the scheduled speed.

A fuel-hydraulic system leak is indicated by a sudden step increase in total fuel flow indication as much as 25,000 pph and fuel streaming from the engine (or an engine fire). Engine rpm response and nozzle function may appear normal with persistent high fuel flow indications.

For fuel-hydraulic system pump failure, fuel flow response to throttle, airspeed, and altitude will be near normal. In afterburner cruise, the nozzle will eventually move to full open. However, during subsonic cruise with the throttle below the afterburner range, the nozzle will normally remain in the failed position.

The main fuel control fuel flow schedule limits engine overspeed at all power settings to approximately 350 rpm above the normal military schedule. Engine overspeed may not be nearly this great while at maximum afterburning and high Mach, since normal nozzle scheduling is nearly full open at these conditions. Some rpm control can be achieved by downtrimming EGT while in maximum afterburner.

Inlet guide vane position does not drift with engine fuel-hydraulic system failure. The vanes maintain their settings, either axial or cambered, regardless of the existing IGV Lockout switch position, CIT, or engine rpm. If cambered, the guide vanes are held in this position by the latching feature of the IGV Lockout system. Fuel-hydraulic system pressure is required to overpower this latch,

DIAGNOSTIC FLOW CHART EXHAUST NOZZLE/FUEL HYDRAULIC FAILURES

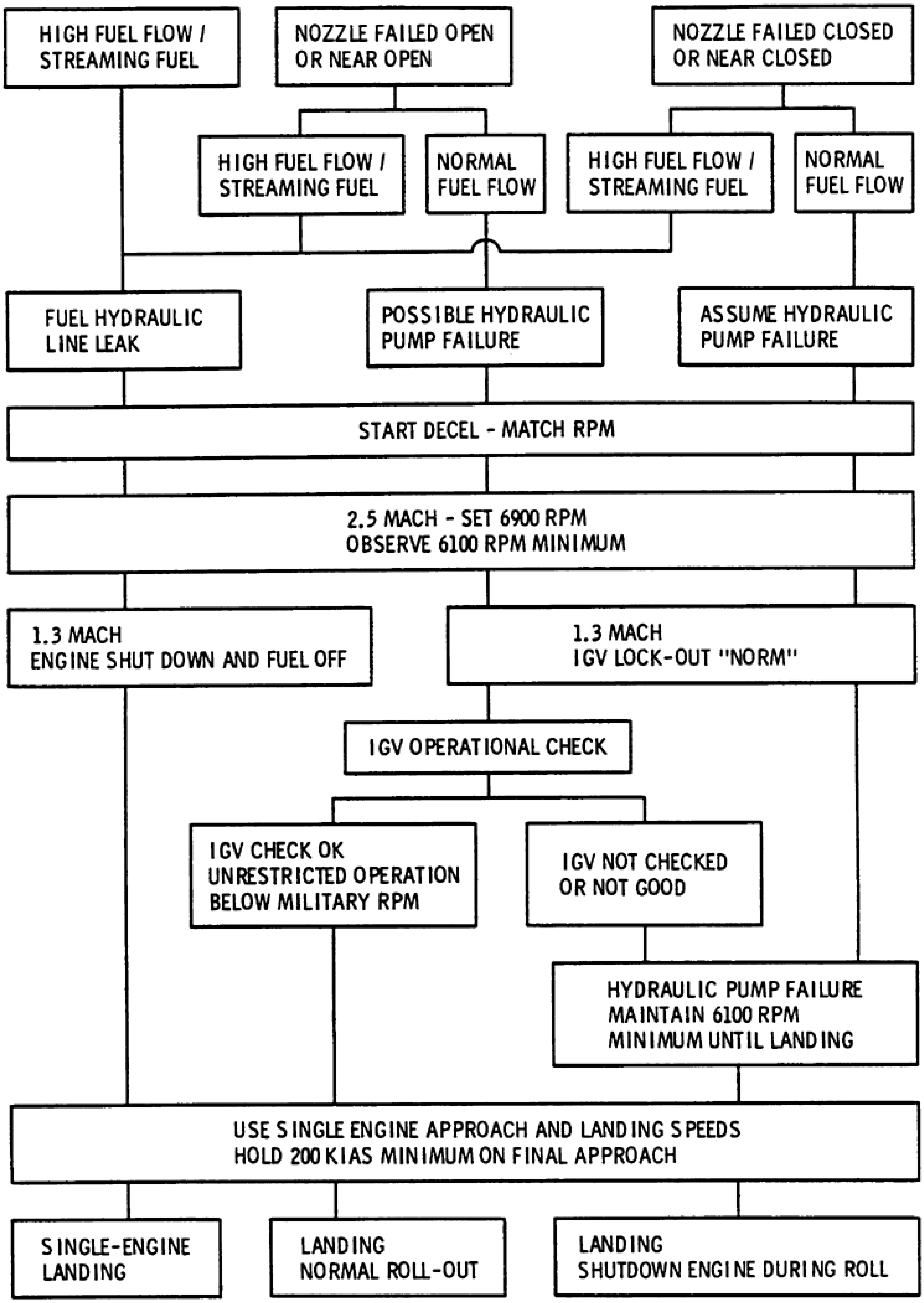

Figure 3-11

but the latch is ineffective if the IGV actuator line ruptures. If in the axial position, the IGV position light will remain on, and CIT must be maintained below CIT limits listed in Section V to avoid engine stalls and/or IGV blade flutter.

The engine internal (bypass) bleeds tend to open or remain open if engine fuel-hydraulic system failure occurs.

The external (start) bleeds are normally closed for all flight conditions (except when windmilling and, possibly, when idling at low airspeed). See Figure 1-11. They can be expected to remain closed with the fuel-hydraulic system failed. The closed condition may result in engine stall and flameout when at idle or at low rpm and airspeed, and airstart attempts after flameout for this condition would probably be unsuccessful. If the start bleeds remain closed during landing, rpm may "collapse" during the roll-out, and a damaging overtemperature will occur if the engine is not shutdown immediately.

Continued engine operation is permissible with a failed hydraulic pump if engine speed is maintained above 6100 rpm and if maximum limits for rpm and EGT and the existing IGV positions are observed; however, land as soon as possible.

FUEL-HYDRAULIC LINE LEAK

NOTE

If subsonic, accomplish only * items.

For a ruptured or leaking fuel-hydraulic line:

* 1. Check for abnormally high fuel flow.

   Expect fuel flow to be 8,000 to 25,000 pounds per hour above normal with a fuel-hydraulic line rupture.

   If abnormally high fuel flow indications are accompanied by open nozzle and rpm overspeed indications, a fuel-hydraulic system line rupture or leakage is confirmed. However, engine nozzle functioning can be near normal. If below Mach 1.3, shutdown the engine and activate the emergency fuel shutoff switch to isolate the fuel system of the affected engine. If at higher supersonic speeds, delay shutdown and fuel shut-off until below Mach 1.3, if practicable, to avoid engine damage.

* 2. Check visually for streaming fuel.

   Check through the periscope for a fuel trail.

If a ruptured fuel-hydraulic line is confirmed:

3. Begin a normal descent.

4. Throttle, affected side - Match opposite engine rpm.

At Mach 2.5:

5. Throttles - Set 6900 rpm.

6. Throttle, affected side - Maintain at least 6100 rpm.

Below Mach 1.3:

* 7. Throttle, affected side - OFF.

* 8. Emergency fuel shutoff - Fuel off.

   This switch operates the emergency fuel shutoff valve and closes the fuel heatsink crossfeed valve for that engine, isolating the nacelle from the ship's fuel supply system.

* 9. Complete Engine Shutdown and Descent procedure.

FUEL-HYDRAULIC SYSTEM PUMP FAILURE

For fuel-hydraulic system pump failure (nozzle failed, IGV inoperative, <u>no</u> excessive fuel flow or streaming fuel):

* 1. Throttle, affected side - Maintain at least 6100 rpm until landing.

   Continued engine operation is permissible with a failed hydraulic pump if engine speed is maintained above 6100 rpm and if maximum limits for rpm, EGT, and CIT (for the existing IGV position) are observed.

Maintain at least 6100 rpm and minimize throttle movement. This eliminates the need for IGV and bleed shift. The engine may experience compressor stall and flameout if rpm decreases below 6100.

* 2. Land as soon as possible.

* 3. Plan for an extended enroute descent, or lower the landing gear for penetration.

* 4. Brakes & Anti-skid - Set.

a. For left engine pump failed - ALT STEER & BRAKES.

b. For right engine pump failed -ANTI-SKID ON.

(T) c. Brake switch - OFF.

* 5. Use single-engine airspeeds for approach and landing, holding 200 KIAS minimum on final approach.

The external (start) bleeds are normally closed for all flight conditions (except when windmilling and, possibly, when idling at low airspeed). See Figure 1-11. They can be expected to remain closed with the fuel-hydraulic system failed. The closed condition may result in engine stall and flameout when at idle or at low rpm and airspeed. Airstart attempts after flameout for this condition would probably be unsuccessful.

NOTE

If IGV and/or nozzle position indications are abnormal, set the throttle to military when starting if an airstart attempt is necessary. An airstart attempt may result in further engine damage. Engine stalls are likely following light-off, but it may be possible to accelerate and obtain stall-free operation at military power.

* 6. Affected engine condition - Monitor.

CAUTION

Shutdown the engine if overtemperature or flameout occurs due to engine compressor stall or rpm rollback. The EGT limit at idle rpm is 565°C.

During the landing roll:

* 7. Throttle - OFF.

Shutdown the engine as a precaution to avoid EGT overtemperature. The affected engine will probably flameout when the throttles are retarded for touchdown. If rpm "collapse" occurs without flameout during the landing roll, a damaging overtemperature will occur if the engine is not shutdown immediately. The engine EGT limit at or below idle rpm is 565°C.

Anticipate loss of the affected engine and its associated hydraulic, generator, and refrigeration systems.

* 8. Retain drag chute after landing, if practical.

After engine stops windmilling:

* 9. Emergency fuel shutoff (affected engine) - Fuel off.

Shutoff fuel to isolate the nacelle from the ship's fuel supply system. Delay fuel shutoff until after windmilling stops to avoid unnecessarily cavitating fuel lines.

ABNORMAL EGT INDICATIONS

EGT Overtemperature

EGT overtemperature may be caused by intentional or inadvertent uptrimming, failure of the main fuel control to regulate EGT, malfunction of the automatic EGT trim system, nozzle failure, or airflow transients during engine stall or inlet unstart. EGT indication over 860°C illuminates the EGT gage red warning light. If the fuel derich system is armed, the Fuel Derich light also illuminates when EGT indication exceeds 860°C. The fuel derich light remains on until the derich switch is cycled to REARM (or OFF) even if EGT returns below 860°C. A relatively small rpm and/or fuel flow increase may be observed when the fuel derich is rearmed.

Downtrimming EGT or throttle repositioning below Military will usually correct overtemperature unless the condition is caused by inlet airflow disturbances. In this case, use the appropriate compressor stall or inlet unstart procedures.

The Derich system reduces EGT by decreasing fuel flow to the affected engine(s) if 860°C is exceeded while the system is armed. The Fuel Derich system should be rearmed only <u>after</u> normal inlet or engine operation has been restored and EGT is within normal limits.

Overtemperature is usually more extreme at high altitude and/or low KEAS. EGT may become uncontrollable when near maximum altitude and Mach if the overtemperature is associated with compressor stall or unstart and if the Derich system is not sufficiently effective.

Inlet airflow is severly reduced during unstarts or compressor stalls, causing the main fuel control to operate on its minimum fixed fuel flow schedule. Consequently, manual or automatic trimming and throttle reduction to IDLE have no effect. The fuel flow reduction accomplished by the Derich System may not be sufficient to reduce EGT while at extreme altitudes. It may be necessary to shut down the engine to control EGT if there is insufficient time to clear the compressor stall or inlet unstart by increasing airflow (increasing KEAS/decreasing altitude). Refer to Engine Operating Limits, In-Flight Shutdown, Section V.

WARNING

Shutdown the affected engine for EGT:

- Above emergency EGT limit (845° C above 40°C CIT; 865°C below 40°C CIT) and below 900°C for 2 minutes.
- Between 900°C and 950°C for 15 seconds.
- Over 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

The airstart procedure can be initiated as soon as flight conditions are suitable.

<u>Auto EGT System - Malfunctioning Permission Circuit</u>

The Auto EGT Trim System is operative if the EXHAUST GAS TEMP switch is in AUTO and the permission circuit is off (throttle at or above the military position and Derich not actuated). The Auto EGT Trim System is disabled by a solenoid-operated interlock switch which is powered when the permission circuit is on (throttle position below military or Derich System actuated). If the permission circuit malfunctions on (energized), only manual EGT downtrim is available.

<u>EGT Gage Malfunction</u>

If an EGT gage malfunctions, the indication may stick, fluctuate, operate erratically, or slew to zero or to the maximum indication of 1198°C. If the indication exceeds 860°C, the gage warning light illuminates and derichment occurs if the Derich system is armed. If EGT gage malfunction is confirmed, pull the respective L or R FUEL DERICH circuit breaker to return the deriched engine to normal.

If the EGT gage temperature display malfunctions, the HOT and COLD condition flags should continue to operate normally.

The flags should not be displayed persistently. Their operation is controlled by the Auto EGT Vernier Temperature Control rather than by the gage temperature display. Occasional temporary appearance of a flag while at or above Military indicates normal automatic trim system operation. EGT may be downtrimmed manually to test that the COLD flag will appear on return to automatic trimming while at or above Military.

If only the EGT gage digital indication malfunctions, the Auto EGT system should be left on. Attempt to match nozzle positions and to minimize sideslip if using less than military power. If the afterburners are on, attempt to match fuel flow indications and minimize sideslip. The EGT condition flags (HOT and COLD flags) will operate normally.

EGT Harness Malfunction

The automatic EGT system (vernier control of HOT and COLD flags) and the EGT gage digital indication provide separate cockpit indications of EGT. The EGT is sensed by nine temperature probes arranged concentrically about the engine, aft of the second stage turbine. The nine probes are linked together by the EGT harness. The harness combines the individual signals from the probes into a single, averaged value which is sent to the automatic EGT control system and the EGT gage digital indication.

A malfunction which causes varying resistance within the harness appears as an erratic and/or wandering EGT gage digital indication with associated HOT and COLD flag activity.

Degraded power or loss of signal from a temperature probe causes erroneously low temperature indication from that probe. This lowers the average signal to both the EGT gage digital indication and the automatic EGT system. If the automatic EGT system is operating, initial cockpit indications are low EGT gage digital reading with the COLD flag in view. As the engine uptrims, EGT and fuel flow will increase, the nozzle will move toward closed, and the turn-and-slip ball will move toward the uptrimming engine. This type of harness malfunction could be insidious and is potentially dangerous. Severe engine damage caused by EGT overtemperature is possible.

The automatic EGT system will continue to respond to an erroneous signal from the harness and will uptrim/downtrim the engine as long as the respective EGT switch is in AUTO. Discontinue automatic EGT operation, downtrim to assure that actual EGT is within operating limits, and control EGT by reference to fuel flow, nozzle position, and turn-and-slip ball position.

ABNORMAL EGT PROCEDURE

Initiate this procedure if the EGT system has malfunctioned while operating in afterburner with Auto EGT on.

Accomplish those steps necessary to assure that EGT is controllable within the normal limit (805°C above 40°C CIT) and to identify the cause of the EGT malfunction. Then, either continue the Abnormal EGT Procedure or complete the appropriate procedure for that specific malfunction (EGT Gage Malfunction, EGT Harness Malfunction, or Permission Switch Stuck On procedure).

If an abnormal EGT condition occurs while the throttle is in Military, retard the throttle and downtrim EGT. With the EGT switch in manual, cautiously readvance throttle to Military (if continued operation with the throttle at or above Military is desired) and then initiate the Abnormal EGT Procedure.

The Abnormal EGT Procedure is complete when a decision is made concerning further flight operations: continue with no in-flight restrictions, land when practical, or land as soon as possible. If EGT remained below the emergency limit (845°C above 40°C CIT; 865°C below 40°C CIT) and manual EGT trim is operative, continue unrestricted. If EGT trimmed above the emergency limit but remained below 900°C, or if the EGT harness is inoperative, land when practical. If EGT was above 900°C, land as soon as possible.

In all circumstances, if EGT exceeded the normal limits (805°C above 40°C CIT; 830°C below 40°C CIT), record peak EGT and write up the magnitude and duration of the overtemperature.

WARNING

Shutdown the affected engine for EGT:

- Above the emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT), and below 900°C for 2 minutes.
- Between 900°C and 950°C for 15 seconds.
- Above 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

NOTE

Where the phrase "throttles matched" appears in the Abnormal EGT Procedure, it means: move the throttles to a position which provided equal thrust (turn-and-slip ball centered with matched fuel flow indications) before the abnormal EGT condition occurred. Refer to Cruise, Optimizing Trim, Section II.

Affected engine:

1. Downtrim EGT.

   If a HOT or COLD flag was present, it should dissappear when the EGT trim switch is out of AUTO.

   Hold the EGT trim switch in DECR for at least 3 seconds and until EGT is below the normal limit (805°C above 40°C CIT). EGT indication should decrease 8°C per second when downtrimming.

   Confirm effective downtrimming by observing EGT digital indication decreasing, fuel flow decreasing, ENP moving toward open, and the turn-and-slip ball moving away from the downtrimming engine.

   CAUTION

   Downtrim EGT immediately for at least 10 seconds if the affected engine is deriched or appears to have higher EGT than the normal engine.

   This should reduce EGT approximately 80°C, about half the trim range available. The trim motor may have reached full uptrim while in Auto EGT.

   CAUTION

   Stop downtrimming if rpm decreases, as some rpm suppression can be expected if EGT is actually approaching the bottom of the trim band and the nozzle is full open.

2. If downtrim has no effect - Check EGT TRIM ac circuit breaker.

   If a HOT or COLD condition flag was present when the EGT trim switch was in AUTO, the EGT vernier was receiving power through the EGT TRIM ac circuit breaker.

   If there is no response to downtrim with the EGT TRIM ac circuit breaker in, the trim motor may be at the bottom of its trim range.

3. With throttles matched, can downtrim achieve normal or low thrust?

   To confirm low thrust, check for turn-and-slip ball away from the affected engine, lower EGT digital indication, lower fuel flow, and ENP more open. The fuel flow check may not be conclusive if the normal fuel flow was below 15,000 pounds per hour. Compare readings with the other engine. This analysis of the engines' instruments, and the cross-check of engine parameters and aircraft performance will assist in determining which system(s) and/or indicator(s) are abnormal.

   Yes: (Continue step 4)

   No: Retard throttle below Military. (Go to step 8)

   If manual EGT downtrim does not reduce thrust to normal, the EGT gage digital indication is probably accurate and runaway EGT uptrim may exist. Retard the throttle below Military until EGT is within the normal range; throttle movement in the afterburner range has no effect on EGT control.

4. Cautiously check EGT uptrim from a low-thrust condition.

WARNING

Do not attempt uptrim or return to Auto EGT unless, with throttles matched, a low thrust condition is readily apparent on the suspected engine.

With throttles matched, cautiously uptrim toward equal thrust (turn-and-slip ball toward center, but do not go beyond center). It may be necessary to tap the turn-and-slip indicator to prevent the ball sticking. Cross-check EGT gage digitial indication, fuel flow, and ENP with the other engine. Manual EGT uptrim rate is 8°C per second.

5. Is EGT uptrim effective?

Yes: Recheck EGT downtrim to a low-thrust condition. (Continue step 6)

If the trim motor was at the bottom of its trim range when downtrim was previously attempted, downtrim effectiveness can be evaluated after uptrim.

No: Complete Permission Switch Stuck On procedure.

6. Is manual EGT trim effective?

Yes: Check EGT dc circuit breaker. (Continue step 7)

Without EGT dc circuit breaker power to the Auto EGT power interlock, Auto EGT is disabled and the HOT and COLD flags will not appear (see Figure 1-8). Since dc power for the EGT permission circuit goes through the EGT circuit breaker, the permission circuit is off when the circuit breaker is open; therefore, manual EGT downtrim <u>and</u> uptrim are available (regardless of throttle position).

No: Monitor EGT and land when practical; if EGT exceeded 900°C, land as soon as possible. (Checklist complete)

If EGT does not follow trim switch operation, the trim circuit, vernier temperature control, or trim motor may have failed. Also, trim motor switching may fail in a manner which prevents travel in one direction only. In these cases, the EGT gage digital indication should still be accurate. With throttles matched, monitor EGT digital indication, fuel flow, ENP, and the turn-and-slip ball to ensure EGT remains within normal limits.

7. Does EGT digital indication appear accurate?

Yes: Use manual EGT trim and continue unrestricted. (Auto EGT trim malfunction)

If manual EGT trim is effective and the EGT gage digital indication is accurate, it is probable that the Auto EGT trim system malfunctioned and that manual control will be satisfactory. Continue unrestricted operations, using manual EGT trim, if engine response and EGT indications appear normal and if the EGT emergency limit was not exceeded.

a. If EGT trimmed above the emergency limit (845°C above 40°C CIT) but remained below 900°C, land when practical.

b. If EGT exceeded 900°C, land as soon as possible. (Checklist complete)

No: Complete EGT Gage Malfunction procedure.

If throttle is retarded below Military (from step 3):

8. Is EGT controllable below the emergency limit (845°C above 40°C CIT; 865°C below 40°C CIT)?

Yes: Downtrim EGT for at least 10 seconds. (Continue step 9)

Auto EGT trim and manual uptrim are disabled by the permission switch when the throttle is below Military (or when deriched). Manual downtrim should always be available if ac power is supplied.

No: Shut down the affected engine. Complete the Engine Fire/ Shutdown & Descent procedure.

WARNING

Shutdown the affected engine for EGT:

- o Above the emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT), and below 900°C for 2 minutes.
- o Between 900°C and 950°C for 15 seconds.
- o Above 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

Lack of EGT response to throttle movement below Military indicates a fuel control failure. If throttle control cannot keep EGT within normal parameters, engine shutdown is necessary.

9. Pull appropriate EGT TRIM ac circuit breaker.

10. Cautiously check EGT in Military, if desired.

The effectiveness of downtrimming cannot be determined while the throttle is below Military. Actual EGT downtrim can be confirmed by readvancing the throttle to Military and cross-checking performance and engine parameters.

a. Afterburner operation is not recommended but is permitted.

b. If downtrimming is required, the throttle must be retarded below Military and the EGT TRIM ac circuit breaker reset.

c. Ensure the EGT TRIM ac circuit breaker is pulled before readvancing the throttle to Military.

With runaway EGT uptrim, the EGT gage digital indication is probably accurate, but check thrust with throttles matched to be sure.

11. Land when practical; if EGT exceeded 900°C, land as soon as possible.

EGT Gage Malfunction Procedure

With low thrust confirmed, if the EGT digital indication is not accurate:

1. Pull and reset appropriate EGT IND ac circuit breaker.

Pulling and resetting the EGT IND ac circuit breaker may free a sticking digital indicator.

If EGT gage is still not accurate:

2. Pull appropriate FUEL DERICH dc circuit breaker.

Maximum altitude: 75,000 feet.

Pull the FUEL DERICH dc circuit breaker for the affected engine so that false EGT digital indications above 860°C will not derich the engine. Maximum altitude with derich inoperative is 75,000 feet.

NOTE

Pulling one FUEL DERICH dc circuit breaker does not disable the Fuel Derich System for the other engine.

3. Check COLD flag response.

ABNORMAL EGT
Logic Diagram

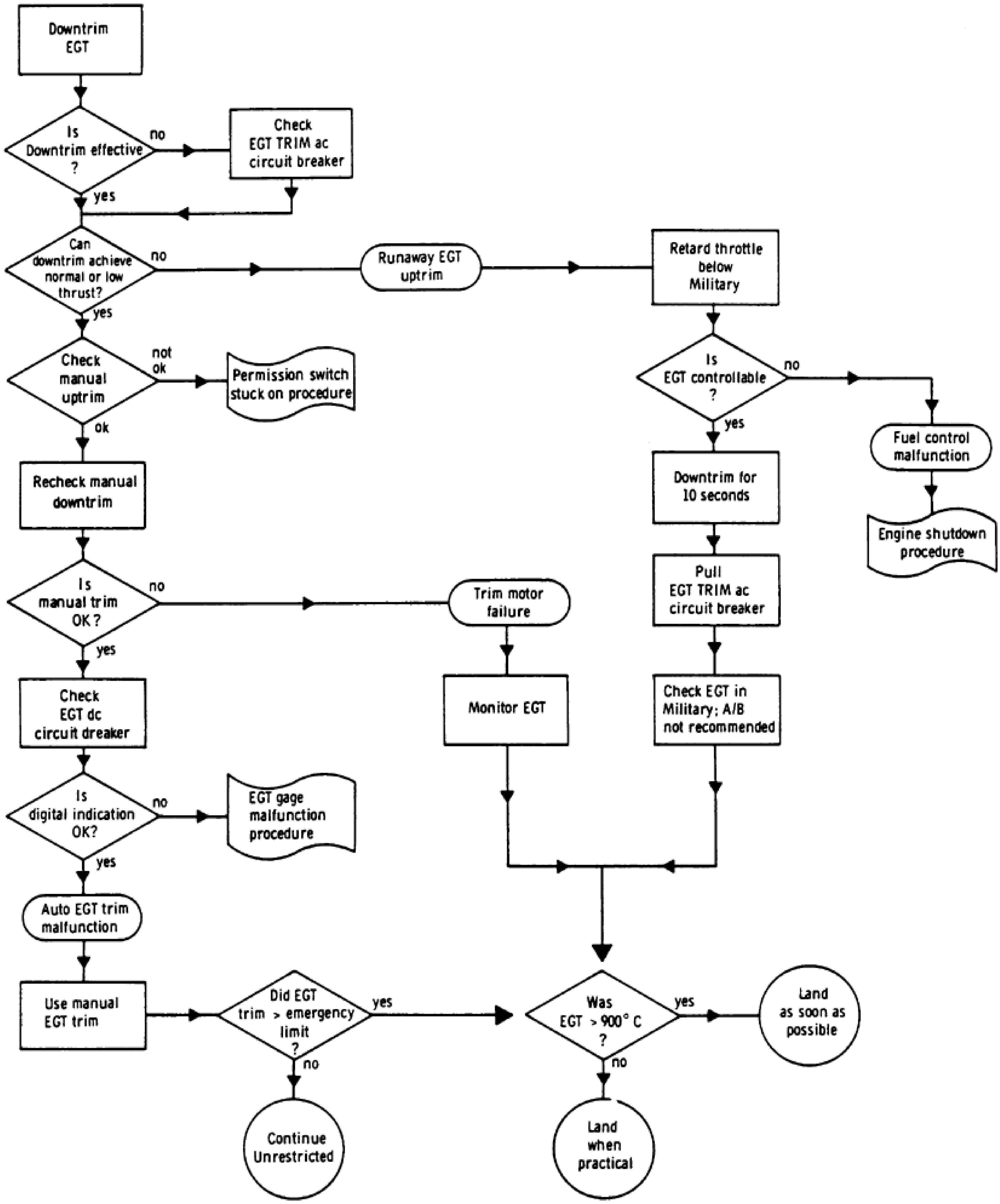

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Figure 3-12 (Sheet 1 of 3)

EGT GAGE/HARNESS MALFUNCTION
Logic Diagram

With low thrust confirmed:

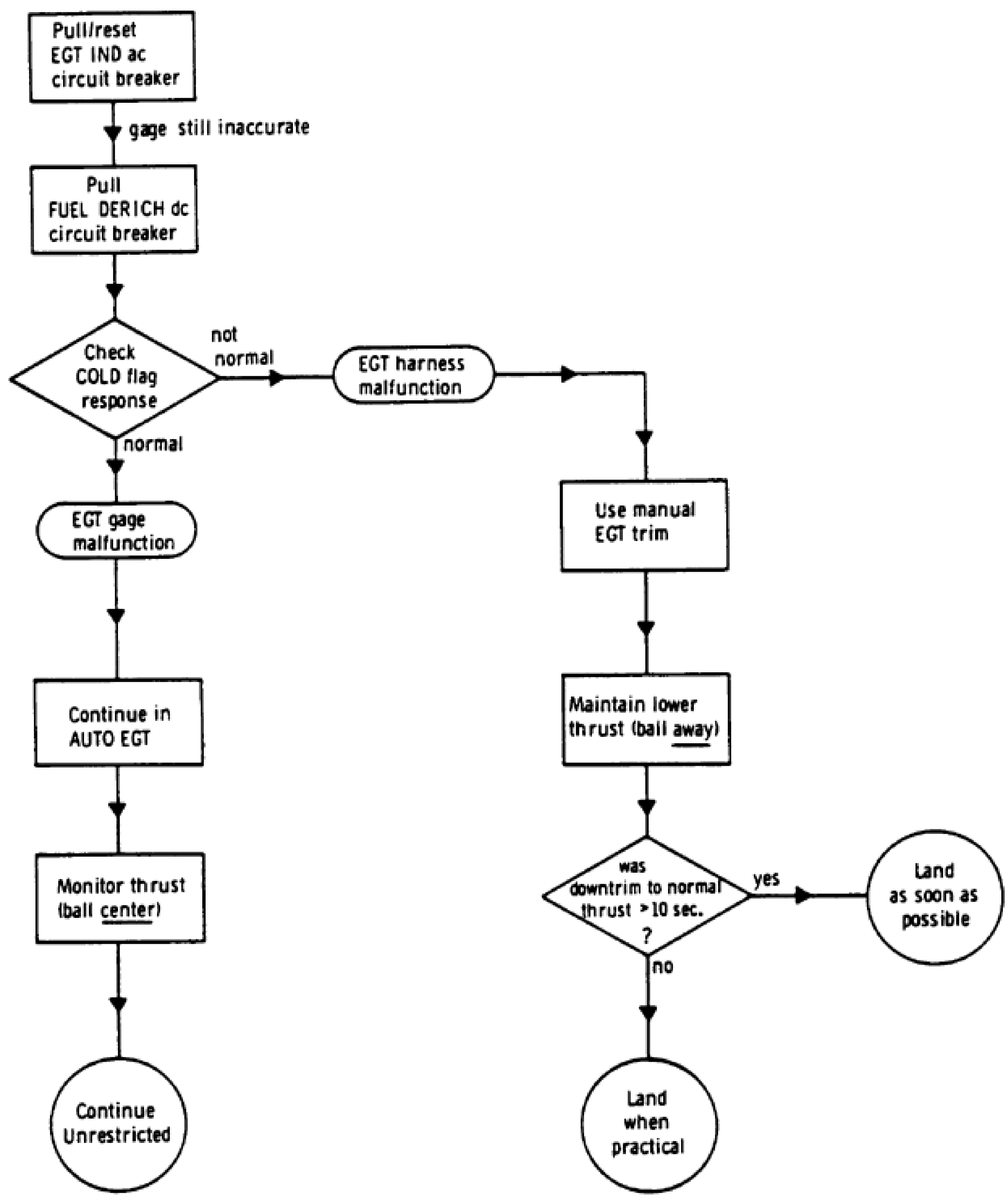
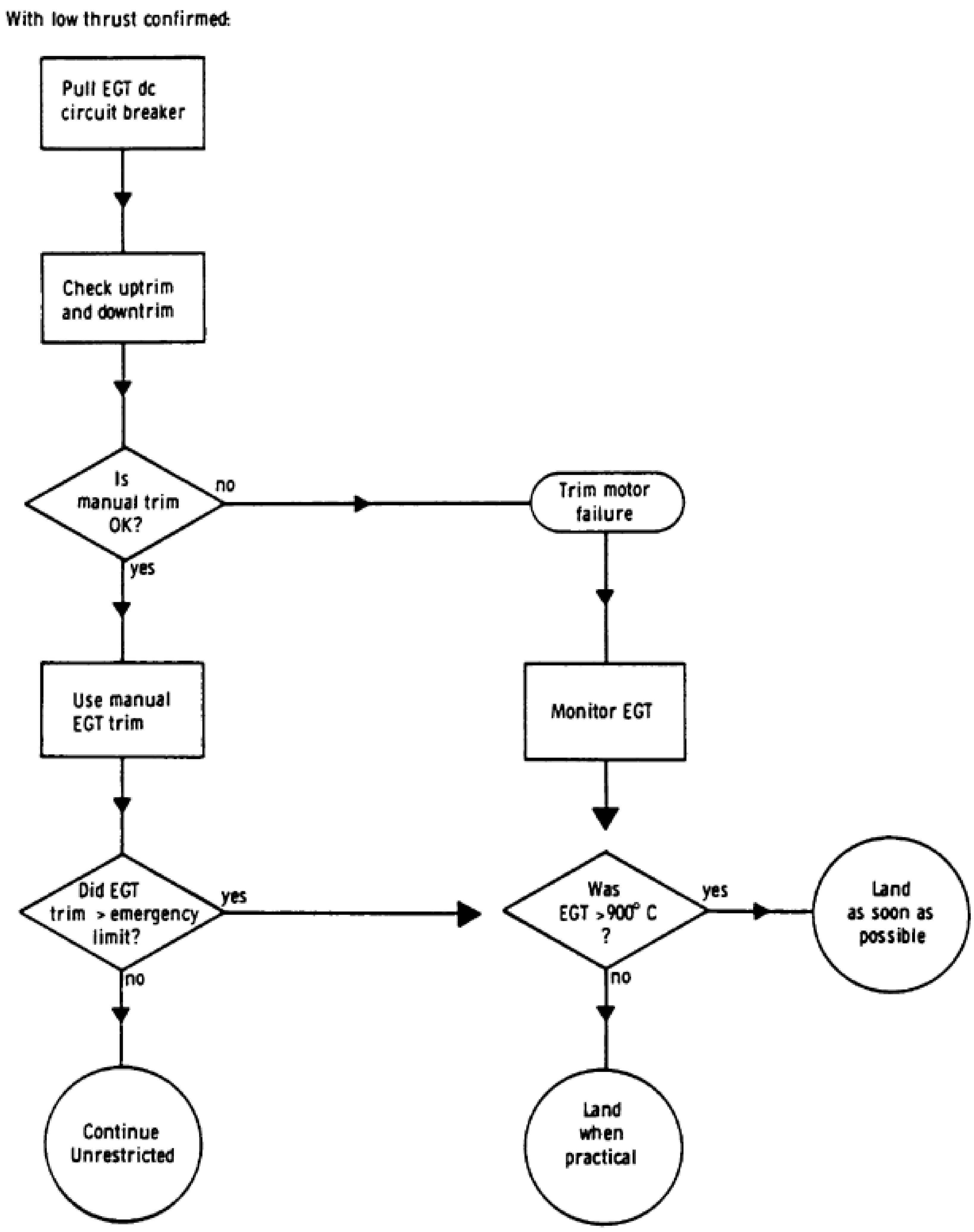


Figure 3-12 (Sheet 2 of 3)

PERMISSION SWITCH STUCK ON
Logic Diagram



F203-321

Figure 3-12 (Sheet 3 of 3)

ABNORMAL EGT INDICATIONS - Auto EGT on Initially

Indication EGT	Indication Flag	First Actions	Typical Response	Possible Cause	Follow-up actions
Low	COLD	Trim EGT Down	Ball remains toward eng.	False EGT indication (harness malfunction)	Downtrim at least 10 sec. Land when practical or ASAP.
		Check Thrust	Ball in center No trim	Trim motor failure	Monitor EGT, land when practical.
			Ball away from engine	Auto trim malfunction	Cross-check thrust, & uptrim. If EGT appears accurate, continue in manual EGT trim.
Low or High	HOT or COLD	Trim EGT Down Check Thrust	EGT follows manual trim	Auto trim malfunction	Trim EGT in manual. Continue if engine parameters are normal.
High	HOT	Trim EGT Down	EGT follows manual trim	Auto trim malfunction	Trim EGT in manual. Continue if engine parameters are normal.
		Check Thrust	None	Runaway EGT uptrim	Set throttle below Military. Downtrim EGT & pull EGT TRIM c/b. Check in Military. A/B not recommended. Land when practical or ASAP.
				Fuel control	If EGT does not respond to throttle, shut down affected engine.
High or Low	None	Trim EGT Down	EGT follows manual trim down & up	Auto trim failed	Check EGT TRIM and EGT c/b's. Trim EGT in manual.
			EGT only follows man. downtrim	Permission switch stuck on	Pull EGT dc c/b and use manual EGT trim.
		Check EGT TRIM c/b	COLD Flag appears in AUTO but EGT doesn't follow	EGT gage digital indication has failed	Pull FUEL DERICH c/b. Use Auto EGT & monitor flags. Max altitude 75,000 ft.
		Check Thrust	No flag in AUTO, or no EGT change	Trim ckt, trim motor fuel control	Check EGT TRIM & EGT c/b's. Set throttle below Mil to control high EGT. If EGT does not respond to throttle, shut down affected engine.
With throttle below MIL: Low	Cold	Trim EGT Down	No flag in man EGT, man trim usable.	Auto EGT Permission circuit inoperative	Use manual EGT trim when increasing pwr to Mil. Do not use AUTO EGT while below Mil.

Figu[redacted]

[redacted]

a. With throttles matched, confirm low-thrust condition.

b. EGT trim switch — AUTO.

c. Monitor engine parameters for normal uptrim.

With throttles matched, check for COLD flag appearance and Auto EGT uptrim. Cross-check performance and engine parameters with the other engine: the fuel flow should increase, the ENP should move toward closed, and the turn-and-slip ball should move toward the affected engine (do not go beyond center). The initial uptrim rate is 1°C per second if EGT is more than 10°C below the EGT trim deadband. The COLD flag should retract and uptrim continue at 1/3°C per second when EGT is within 10°C of the nominal deadband.

If COLD flag response is normal (fuel flow, ENP, and turn-and-slip ball indicate normal Auto EGT operation), an EGT gage digital indication malfunction is confirmed.

Discontinue check and manually downtrim EGT if fuel flow, ENP, and/or turn-and-slip ball indicate Auto EGT uptrim above normal limits.

Nonappearance of the COLD flag confirms either an Auto EGT system malfunction (harness malfunction if the EGT digital indication is also inaccurate) or an electrical supply malfunction. The COLD flag will not appear if either the EGT TRIM ac <u>or</u> the EGT dc circuit breaker is out.

NOTE

Auto EGT trimming (including the HOT and COLD condition flags) and the EGT digital indicator operate independently; however, they receive a common electrical signal from the EGT harness.

If COLD flag response is <u>not</u> normal:

4. Complete EGT Harness Malfunction Procedure.

If COLD flag response <u>is</u> normal:

5. Continue in Auto EGT trim.

6. Monitor engine for normal thrust by reference to fuel flow, ENP, turn-and-slip ball, and EGT condition flags.

   Monitor HOT and COLD flags (periodic appearance is normal) and with throttles matched, correlate fuel flow and ENP with the other engine; the turn-and-slip ball should remain in the center.

7. Continue unrestricted.

   With only an EGT gage digital indication malfunction, EGT should never have exceeded the normal automatic trim band.

If downtrim is required to achieve <u>normal</u> thrust:

8. Complete the EGT Harness Malfunction procedure.

<u>EGT Harness Malfunction Procedure</u>

With low thrust confirmed, if EGT digital indication is not accurate <u>and</u> Auto EGT trim is not normal:

1. Use manual EGT trim.

   WARNING

   If the EGT harness has malfunctioned, operating EGT in AUTO could result in severe engine overtemperature.

2. With throttles matched, maintain lower fuel flow, ENP more-open, turn-and-slip ball <u>away</u> from affected engine.

If both the EGT digital indicator <u>and</u> the Auto EGT system are not operating normally, the EGT harness has malfunctioned and attempting to control EGT near normal thrust is not recommended; therefore, with throttles matched, use manual EGT trim to maintain the affected engine's thrust below the thrust of the other engine (turn-and-slip ball <u>away</u> from the affected engine).

3. Pull appropriate FUEL DERICH dc circuit breaker.

   Maximum altitude: 75,000 feet.

   Pull the FUEL DERICH dc circuit breaker for the affected engine so that false EGT digital indications above 860^oC will not derich the engine. Maximum altitude with derich inoperative is 75,000 feet.

NOTE

Pulling one FUEL DERICH dc circuit breaker does not disable the Fuel Derich System for the other engine.

4. Land when practical.

If total downtrim time to normal thrust was greater than 10 seconds:

5. Land as soon as possible.

   With a lower-than-actual EGT indication (low digital reading <u>and</u> the COLD flag in view), severe engine damage may have been sustained due to actual high EGT from automatic uptrim. The rate of manual downtrim is 8^o per second. If harness failure was detected by a continuous COLD flag (continuous uptrim) and normal thrust was achieved within 10 seconds of downtrim, severe turbine damage is unlikely. If downtrim to normal thrust exceeded 10 seconds <u>or</u> the pilot is unsure of the duration of excessive EGT, land as soon as possible since severe engine damage may have been sustained.

<u>Permission Switch Stuck On Procedure</u>

With low thrust confirmed, if uptrim is <u>not</u> effective:

1. Pull appropriate EGT dc circuit breaker.

   If the permission switch is stuck on, the COLD flag would have been disabled when the EGT trim switch was in AUTO and <u>uptrim</u> (manual and Auto) is inhibited. Pulling the EGT dc circuit breaker disables the permission circuit, and manual uptrim (and downtrim) should be possible regardless of throttle position; Auto EGT is disabled since power is removed from the Auto EGT power interlock (see Figure 1-8). Manual EGT trim must be used for the remainder of the flight.

2. Check EGT uptrim and downtrim.

If manual EGT trim <u>is</u> effective:

3. Use manual EGT trim and continue unrestricted.

   a. If EGT trimmed above the emergency limit (845^oC above 40^oC CIT) but remained below 900^oC, land when practical.

   b. If EGT exceeded 900^oC, land as soon as possible.

If manual EGT trim is <u>not</u> effective:

4. Monitor EGT and land when practical; if EGT exceeded 900^oC, land as soon as possible.

   If EGT does not follow trim switch operation, the trim circuit, vernier temperature control, or trim motor may have failed. Also, trim motor switching may fail in a manner which prevents travel in one direction only. In these cases, the EGT gage digital indication should still be accurate. With throttles matched, monitor EGT digital indication, fuel flow, ENP, and the turn-and-slip ball to ensure EGT remains within normal limits.

EGT GAGE COLD FLAG VISIBLE WHILE THROTTLE BELOW MILITARY POSITION (PERMISSION SWITCH OFF)

Appearance of an EGT gage COLD flag while the corresponding engine throttle is below Military indicates that its Auto EGT permission circuit is stuck off or inoperative. EGT will automatically uptrim while the throttle is below Military with this condition. EGT overtemperature is possible when the throttle is advanced to Military if the uptrim condition is not corrected.

For COLD flag indication with throttle below Military (permission switch off):

1. Downtrim EGT.

   The COLD flag should disappear.

   Downtrim for the same length of time that the COLD flag was in view. If in doubt as to the time, downtrim for at least ten seconds.

   The effectiveness of downtrimming cannot be determined while the throttle is below Military. Actual EGT downtrim can only be confirmed by advancing the throttle to Military.

2. Cautiously check EGT at Military.

   Downtrim as necessary to keep EGT within limits while advancing the throttle.

With the throttle at or above Military:

3. EGT manual downtrim and uptrim - Check.

If manual EGT trim and EGT indications are normal:

4. Use manual EGT trim.

   Unless manual trim is used, Auto EGT will uptrim the engine while operating below Military.

   When the throttle is at or above Military, Auto EGT remains usable with the permission circuit failed, although its use is not recommended. If Auto EGT is used, Auto EGT should be disengaged before operating below Military. Check EGT while advancing power from below Military.

ACCESSORY DRIVE SYSTEM (ADS) FAILURE

An accessory drive system (ADS) failure is indicated by progressive loss of the associated generator and the corresponding A and L or B and R hydraulic systems. The rpm, oil pressure, fuel flow, and nozzle position indications should also be monitored in case ADS failure is a symptom of or is followed by engine failure. The roll SAS servos will probably disengage.

Hydraulic, electrical, and environmental control system emergency procedures are incorporated in the ADS failure procedure. Steps for an immediate descent to subsonic speed are also incorporated. Do not reset the remaining roll SAS servo immediately after identifying an ADS failure. Shut down the affected engine if there is an indication of fire or for excessive vibration; otherwise, operate the affected engine as required.

With ADS failure at high speed, loss of the associated flight control and utility hydraulic system on that side can lead to difficulty in maintaining control of aircraft attitude. The affected inlet will unstart if hydraulic pressure is lost before corrective action is taken, as its forward bypass will not open when aerodynamic pressure moves the spike forward. The unstart cannot be cleared in this case until low supersonic speeds are reached. Actuation of the throttle restart switch immediately after recognizing ADS failure is of particular importance, especially if turning and if the failed ADS is on the down-wing side, even though the restart switch for the affected inlet may have been operated previously as part of the utility hydraulic system emergency procedure. Use of the throttle restart switch while reducing to minimum afterburning or military power produces a symmetrical thrust and drag configuration in the least time. This minimizes control problems and starts a deceleration. When adequate control has been established, the operative inlet may be returned to normal operation and up to maximum power may be set on both engines if it is necessary to delay further descent; however, land as soon as possible.

If both roll SAS servos are engaged initially, both will disengage immediately after loss of one primary hydraulic system if the aircraft has any appreciable rolling motion. This is due to servo logic which operates automatically when a difference in roll servo positions is detected. If there is any appreciable motion in the pitch and/or yaw axis, the corresponding SAS servo(s) for the affected side also disengages when the A or B system hydraulic pressure decreases below 1500 to 1300 psi. Refer to the SAS descriptions in Section I.

The usable roll SAS servo should not be reengaged while banking, as roll coupling will disturb control in the pitch axis. Refer to Roll Axis Failure, this section.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

The circulating fuel pump which is driven by the malfunctioning ADS will also be inoperative. This affects items in the fuel heat sink system which are listed on Figure 1-34. Fuel flow through the primary and secondary air conditioning heat exchangers is lost. If the left ADS has failed, fuel cooling flow to the pitch and yaw SAS gyros (supplied from the left heat sink system only) is reduced. (Since gyro cooling fuel is discharged into tank 2 from the gyro cans, boost pump pressure can maintain some cooling flow.) Also refer to the Environmental Control System schematic diagram, Figure 1-80.

ACCESSORY DRIVE SYSTEM FAILURE PROCEDURE

For a combined left or right GEN OUT caution plus the corresponding A HYD and L HYD or B HYD and R HYD annunciator panel warnings or decreasing hydraulic pressure indications.

NOTE

If subsonic, accomplish only * items.

* 1. THROTTLE RESTART ON.

Immediately select the full aft position of the throttle restart switch. Opening the forward bypass in each inlet while hydraulic pressure remains on the affected side and starting both spikes forward in the least possible time is necessary to maintain a symmetrical inlet configuration. A symmetrical inlet configuration minimizes attitude control difficulties at high speed.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

NOTE

If the forward bypass does not open and the spike moves to its forward position while supersonic, expect unstarts, compressor stalls, and/or flameout on the affected side. Engine restart is unlikely above Mach 1.3.

Normally, the spikes are automatically locked forward while below 30,000 feet. If the affected spike is not locked and its forward bypass is closed, the inlet will become "choked" if the spike is sucked aft by engine airflow requirements. If this should happen at low altitude, a combination of high rpm and low airspeed might collapse the duct due to a critical differential between ambient air pressure and pressure within the duct. If the spike is aft and the forward door is closed while subsonic, use minimum required power when above 5000 feet, and IDLE below 5000 feet.

2. Airspeed - 350 KEAS.

* a. If subsonic, under 350 KEAS.

Reduce power immediately and until wings-level.

Subsonic operation and a landing as soon as possible are recommended. Operational restrictions are 350 KEAS and Mach 2.8. Use the manual inlet descent schedule while in restart.

In restart:

> Set the throttle at 720°C to Military above Mach 2.5. Set 6500 rpm at Mach 2.5, and let rpm decrease. Throttle setting is optional below Mach 1.3.

NOTE

Expect roll SAS disengagement. Leaving the roll SAS OFF for turns will avoid coupling into the pitch axis.

The available roll SAS servo may be reengaged after attitude is stabilized, wings level.

3. Aft bypass - CLOSE.

Set both aft bypass controls to CLOSE. The control switch on the affected side may be ineffective unless sufficient residual hydraulic pressure remains; if so, note the bypass position. If the bypass is not closed, anticipate compressor stalls on the affected side while decelerating near Mach 2.

4. IGV switches - LOCKOUT checked.

Operation may be continued at intermediate supersonic speeds, if necessary, if an aft-bypass-closed and forward-bypass-open configuration can be obtained and the engine inlet guide vanes are maintained cambered. Sustained operation at airspeeds which result in engine internal bleed shifting should be avoided.

5. LN_2 quantity - Check.

On the affected side (steps 6, 7):

* 6. Engine instruments - Check.

Check rpm, oil pressure, fuel flow, and nozzle indications for evidence of engine failure.

Shut down the affected engine for fire or excessive vibration.

* 7. Restart switch - ON.

* 8. Throttle restart switch - OFF.

On the unaffected side, resume normal rpm and inlet schedules.

For normal side with restart off:

> Set 720°C EGT to Military above Mach 2.5. Set 6900 rpm at Mach 2.5, and as required below Mach 1.3.

AUTO spike and forward bypass

Afterburner is permissible to reduce rate of descent for tactical considerations. It should be possible to maintain Mach 2.4 to 2.6 with one inlet in restart and one inlet in automatic operation with full power on both engines.

* 9. Affected SAS servos - Off.

Set the affected pitch, roll, and yaw SAS servo engage switches off.

* 10. Operational roll servo - Cycle off, then ON.

Recycle the operating roll SAS servo to regain roll damping.

* 11. Affected generator switch - OFF.

12. C.G. - forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits.

* 13. Bay Air switch - OFF.

This closes the bay and nose air valves to make the maximum amount of cooling air available to the cockpits.

* 14. Chine Bay equipment (except MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

* 15. Cockpit temperature control rheostat-COLD, if necessary.

Approximately 75% of the normal flow of cooling air to the cockpits remains available.

At Mach 2.5:

16. Throttles - Set.

Set the affected engine at 6500 rpm to conform with the manual inlet schedule. Let rpm decrease and retard the throttle if compressor stall occurs. Set 6900 rpm on the unaffected side.

At FL 600:

T17. IFF Mode C - Set.

18. DEF Systems - As required.

Below Mach 1.7:

19. Pitot heat switch - ON.

20. Exterior lights - ON.

Below Mach 1.3:

* 21. Inlets - Check.

a. Both spikes forward.

b. Affected side, forward bypass open.

c. Normal side, forward bypass closed.

22. IGV switches - NORMAL.

* 23. Throttles - As required.

Reduce rate of descent, if necessary, to avoid low fuel tank pressure below FL 400.

When c.g. is forward of 20%:

* 24. Fuel forward transfer switch -OFF.

* 25. C.G. - Maintain forward of 20%.

* 26. Crossfeed - Set.

* 27. Land as soon as possible.

350 KEAS is the maximum airspeed.

CAUTION

- Monitor spike and forward bypass positions.
- If the forward bypass remains closed and the spike is not locked forward, fly approach at single-engine approach speed with idle power on the affected inlet.

* 28. Accomplish Single-Engine Penetration and Landing Procedure, except use normal approach speed.

Loss of Liquid Nitrogen Supply

Loss of LN_2 supply to the ADS does not affect ADS operation during flight, as contamination of the ADS by oxygen does not occur until the ADS is completely cooled. However, loss of LN_2 must be reported following flight.

OIL PRESSURE ABNORMAL

Refer to Oil Pressure limits, Section V. Although not desirable, operation may be continued with oil pressure above the normal pressure range. Operation may also be continued with oil pressure in the 35 to 40 psi range; however, engine operation should be monitored for indications of failure, which include engine roughness or rapidly increasing vibration. Oil pressure below 35 psi is unsafe and requires that a landing be made as soon as possible using the minimum thrust required to sustain flight. The engine may have to be shut down.

OIL QUANTITY LOW

Cross-check oil pressure indication when low oil quantity is indicated by illumination of either L or R OIL QTY warning light.

Disregard intermittent illumination of the L or R OIL QTY warning light if accompanied by normal oil pressure. Flickering of the light may occur, particularly during climb, if foaming or out-gassing of the engine oil reduces relative bouyancy of the tank float, resulting in a false indication of fluid surface.

If a L or R OIL QTY warning light illuminates continuously, or if intermittent illumination is accompanied by low or fluctuating oil pressure indication for the corresponding engine:

1. Begin normal descent.
2. Oil pressure - Monitor.
3. Land as soon as possible.

NOTE

Monitor engine operation for oil pressure fluctuations, high temperature, vibration, or other indications of imminent engine failure. Be prepared to shutdown the engine.

Oil Temperature Abnormal

The L and R OIL TEMP annunciator lights are not functional. The OIL TEMP light only illuminates when the IND & LT TEST button is depressed.

FUEL CONTROL FAILURE

If a fuel control malfunction is suspected:

1. Minimize throttle movements.
2. Monitor RPM and EGT.

If unable to keep RPM and EGT within limits:

3. Complete Engine Shutdown and Descent procedure.

ENGINE INSTABILITY DURING SUPERSONIC DESCENT

Hot fuel (greater than 300°F) may cause engine instability during the first few minutes of the descent when using the normal descent procedure. RPM, ENP, and EGT fluctuations may occur shortly after A/B cutoff. These fluctuations can result in an inlet unstart, derichment, and possibly flameout on the affected engine. With derichment, the nozzle will fully open and the RPM and EGT fluctuations will be reduced or eliminated. Recycling the derich switch will restore nozzle scheduling and another unstart, derichment, and flameout may result.

To reduce engine instability, retard the throttle on the affected engine until the nozzle is fully open, when RPM, ENP, and EGT fluctuations are recognized. Some intermittent engine roughness may be encountered which requires no corrective action. With automatic inlet scheduling, maintain RPM above 6500 to avoid inlet unstart. Normal descent procedures can be reestablished at Mach 2.5.

If RPM, ENP, and EGT fluctuations occur after A/B cutoff:

1. Crossfeed - OPEN.

2. Throttle, affected engine - Retard toward 6500 rpm. Maintain 6500 rpm minimum.

   Retard throttle until the nozzle is fully open but not below 6500 rpm.

3. ENP, affected engine - Checked 100% open.

At Mach 2.5:

4. Resume normal Descent procedure.

If compressor stalls develop:

5. Complete Compressor Stall in Descent procedure.

AIRCRAFT SYSTEM EMERGENCIES

FUEL SYSTEM

Automatic operation of the fuel system provides center of gravity and trim drag control in addition to furnishing fuel to the engines. Fuel is also used to cool cockpit air, engine and accessory drive system oil, hydraulic fluid, and the SAS gyros. Abnormal operating conditions or emergencies affecting fuel system operation (such as generator failure) may affect c.g. control and operation of the fuel-cooled systems in addition to engine operation.

Fuel System Manual Operation

Manual control of the fuel system is accomplished through: the fuel panel crossfeed, tank pump and, pump release switches; the forward and aft transfer switches; and the essential dc bus circuit breakers for the automatic aft transfer and ullage systems. Manual control, manual pump selection, crossfeed, and/or fuel transfer is necessary for low fuel pressure, abnormal c.g. condition or c.g. trend, incorrect boost pump sequencing, single engine operation, or if using the emergency mode of the generators.

NOTE

> Manual operation supplements, but does not terminate, automatic fuel sequencing.

Crossfeed During Forward Transfer

Forward transfer is less efficient with XFEED OPEN when fuel remains in tanks 5 or 6. During cruise, most of the fuel transferred would come from the operating tank(s) of group 2, 3 or 4 because of the aircraft nose-up attitude and the lower fuel pressure head that these forward tank pumps would have to overcome. Only a small forward c.g. shift would result.

FUEL QUANTITY LOW CAUTION

Illumination of the FUEL QTY LOW caution light indicates that fuel is below the low-level float switches in both tanks 1 and 4. At 6.2 degrees pitch angle, the caution light indicates less than 5400 pounds in tank 1 and less than 4050 pounds in tank 4. As the caution may indicate premature depletion of tanks 1 and 4 with ample fuel remaining in other tanks, confirm remaining total fuel from individual tank quantity indications. (TOTAL and individual tank quantity indications are affected to some degree by pitch attitude and accelerations.) If the quantity in either tank 1 or 4 is above the low-level float switch, the caution light can be extinguished by cycling the air refuel switch to AIR REFUEL and OFF. Proceed as described under Fuel Sequencing Incorrect if tanks 1 and 4 deplete prematurely.

Fuel Quantity Low Condition

Confirm crossfeed open. Monitor total fuel quantity and land with at least 5000 pounds if possible. If immediate landing is not possible and a tanker aircraft is available, accomplish air refueling with any JP-type fuel. Subsequent operation, should be restricted below Mach 1.5 if refueled with other than standard JP-7 fuel. Flight operations may be continued with a FUEL QTY LOW caution light if the total fuel remaining will allow air refueling or landing with an adequate fuel reserve.

FUEL PRESSURE LOW WARNING

If one or both FUEL PRESS warning lights illuminate:

1. **X-FEED OPEN.**

   Press the crossfeed control switch to illuminate XFEED. The OPEN portion of the switch illuminates when the crossfeed valve is fully open.

2. **PRESS TANK 4 ON.**

   Fuel pressure should be restored with crossfeed and tank 4 on. Analyze the difficulty and attempt to resume sequencing. The warning could be caused by dumping fuel or selecting forward or aft manual fuel transfer at high power without selecting an extra boost pump.

3. Check tank quantities, proper sequencing, FWD TRANSFER OFF and no streaming fuel.

   The L or R FUEL PRESS warning light may illuminate due to: a weak or inoperative fuel boost pump in a tank supplying fuel to an engine; a fuel manifold or fuel-hydraulic system leak; the use of afterburner at low altitude without additional boost pumps selected; the use of forward transfer when in afterburner without additional boost pumps selected; or fuel dumping when engine fuel demands are high. If appropriate, complete the Fuel Sequencing Incorrect procedure or the Fuel-Hydraulic Line Leak procedure.

To restore automatic sequencing:

4. Pump release - Press.

5. Crossfeed - Press closed.

If pressure cannot be restored:

6. Land as soon as possible.

FUEL TANK PRESSURIZATION FAILURE

Fuel tank pressurization failure is indicated by the tank pressure gage and illumination of the TANK PRESS annunciator panel warning light. Liquid nitrogen quantity gages should indicate empty if the TANK PRESS warning light illuminates. Impending tank pressurization failure may be indicated by illumination of both the SYS 1 and SYS 2 N QTY LOW caution lights.

NOTE

Do not continue flight above Mach 2.6 without nitrogen inerting of the fuel system.

No corrective action is possible after all liquid nitrogen systems deplete, except to limit maximum speed to Mach 2.6 and to reduce rates of descent to minimize the difference between fuel tank and ambient pressures. In descent, the fuel tank suction relief valve in the nosewheel well opens when slightly negative tank pressures occur. Limit rate of descent so that tank pressure does not become less than -0.5 psi to maintain normal maneuvering capability and structural safety factor.

Air refueling and normal climb may be accomplished without nitrogen inerting of the fuel system. In climbs, the fuel tank vent relieves internal pressure when the tank-to-ambient differential pressure reaches 3.0 to 3.5 psi. Mach 2.6 must not be exceeded.

WARNING

Limit tank pressures are -0.5 and +5.0 psi. The limits are based on structural capabilities of the fuselage tanks with design limit load factors.

1. Cruise at or below Mach 2.6.

To descend with fuel tank pressurization failure:

2. Descend within tank pressure limit (-0.5 psi).

   Adjust rate of descent as required.

After cruise over Mach 2.6 (steps 3 - 9):

3. Adjust descent to allow subsonic cruise between FL 400 and FL 350 for 10 minutes, if possible.

   An early on-course descent to allow a 100 mile subsonic cruise between FL 400 and FL 350 uses about 1400 pounds more fuel than supersonic cruise, descent, and no subsonic cruise.

At Mach 1.3:

4. Inlet controls - Checked.

5. IGV switches - NORMAL.

6. Maintain c.g. forward of 22% for subsonic loiter.

7. Below FL 400, maintain altitude and slow to 275 KEAS (250 KEAS Min).

   Do not slow to subsonic flight until c.g. is forward of 22%.

   During descent from flight above Mach 2.6 with fuel tank pressurization failure, 250 KEAS minimum airspeed is permissible below FL 400.

8. Throttles - Military.

9. Loiter subsonic at 275 KEAS between FL 400 to FL 350 for 10 minutes, if possible. Descend from FL 400 to FL 350 as slowly as practical.

WARNING

After flight above Mach 2.6 with fuel tank pressurization failure, remain subsonic above FL 350 for 10 minutes to cool tank structure and prevent autogenous ignition of fuel vapor and vent air.

For supersonic flight after refueling:

10. Do not exceed Mach 2.6.

For penetration (steps 11 & 12):

11. Maintain tank pressure above -0.5 psi. Plan slowest descent at low altitude where pressure gradient is highest. Descend at about 1500 fpm at low altitude.

    Figure A1-9 shows that the atmospheric pressure gradient is about .05 psi/1000 ft at FL 600, .25 psi/1000 ft at FL 240 and .50 psi/1000 ft near sea level.

12. Landing gear - Down, if desired.

NOTE

- o Cooling will be accelerated and pressure may be relieved faster when subsonic if the nose gear is extended.
- o If the suction relief valve has stuck and a tanker is available, it may be possible to relieve negative pressure by insertion of the tanker IFR probe into the air refueling receptacle.

FUEL SYSTEM MANAGEMENT WITH ENGINE SHUTDOWN

Although automatic fuel sequencing continues during single-engine operation, manual control of the fuel system is necessary. With the right engine operating, the crossfeed valve should be opened as soon as tanks 5 and 6 are empty. Forward transfer as necessary to obtain a c.g. for subsonic operation. If the right engine has failed, tanks 5 and 6 may be emptied by successive forward transfer, leaving the crossfeed valve closed. This maintains c.g. properly and makes the maximum quantity of fuel available to the operating engine in case of subsequent loss of ac power.

NOTE

When operating on battery power, fuel transfer capability is lost and the crossfeed valve position cannot be changed. An aft c.g. condition can be expected as forward fuel is consumed unless tanks 5 and 6 are empty.

Fuel cooling will continue automatically and there will be an indication of fuel flow to the inoperative engine, if it is windmilling, unless its emergency fuel shutoff switch is actuated. This heat sink system fuel is either supplied automatically to the opposite engine's mixing valve, if the crossfeed and fuel shut off valves are open, or returned to tank 4.

FUEL SEQUENCING INCORRECT

Incorrect automatic fuel sequencing is indicated primarily by the fuel boost pump lights. (A light may illuminate out of normal sequence, or fail to illuminate on schedule.) In this event, control the boost pumps manually until correct automatic sequencing resumes. Faulty fuel sequencing may cause a fuel EMPTY light to illuminate prematurely, or cause an abnormal pitch trim requirement (due to c.g. change by faulty fuel distribution). Forward c.g. requires increased power to maintain speed and altitude due to trim drag. If normal sequencing does not resume and manual sequencing is not practical, press XFEED OPEN (and transfer fuel as necessary) so that any available fuel feeds the engines.

CAUTION

Do not permit a manually selected fuel boost pump to continue running in an empty fuel tank. The boost pump will be damaged.

NOTE

Crossfeed OPEN may be required to provide fuel to both engines during fuel sequence malfunctions.

PARTIAL LOSS OF BOOST PUMPS

Partial loss of boost pumps may result from individual pump failure, sequencing failure, or loss of ac power at the generator bus. Partial boost pump failure may not be indicated by the fuel pressure low (L or R FUEL PRESS) warning lights unless the condition is associated with some other system emergency (such as generator failure with bus tie split).

NOTE

- o Loss of pump 5-1 and either pump in tank 6 may trap fuel in tank 6A when fuel dump and/or forward transfer are on.
- o Loss of pump 1-3 will temporarily trap approximately 2500 lbs of fuel in tank 1 while supersonic. When tank 4 has 3600 lb remaining, pump 1-4 is started. Manual selection of tank 1 pumps to obtain feed from pump 1-4 is not recommended since forward pumps 1-1 and 1-2 would be operating dry. Continuation of cruise with automatic sequencing could result in c.g. of 22% at end of cruise. Early selection of tank 2 plus use of manual aft transfer results in near-normal c.g. position in supersonic cruise.

Incorrect fuel sequencing and center of gravity shift may be the first indication. Proceed as directed for Fuel Sequencing Incorrect.

COMPLETE LOSS OF BOOST PUMPS

Use this procedure if both generators will not operate in NORM or EMER.

Loss of all boost pumps can only result from multiple failures such as loss of both generators. The condition is indicated by illumination of the L and R FUEL PRESS warning lights, probably in conjunction with the L and R GEN OUT caution lights. If this occurs during takeoff, ground test shows that fuel tank pressurization will supply sufficient fuel to the engine-driven pumps to maintain engine and afterburner operation if all tanks are nearly full. Abort the takeoff if speed and runway length permit; otherwise, continue takeoff and land as soon as possible.

WARNING

Fuel cannot be dumped with complete boost pump failure. Observe operating limits of Section V if a heavy weight landing is required.

Maintain a higher power setting on the right engine than the left engine to minimize aft c.g. shift as fuel is used.

Fuel Management Prior to Complete Pump Failure

When there is a possibility of complete pump failure; e.g., after loss of one generator, make successive forward transfers to obtain and maintain a c.g. of at least 22% (17% is preferable) until tanks 5 and 6 are empty. Crossfeed should remain closed until tanks 5 and 6 are empty, then press XFEED OPEN to minimize tank 4 usage.

Subsonic Cruise Capability Without Boost Pumps

The cruise capability remaining with boost pumps inoperative depends on fuel quantity remaining in tanks 1, 2, 4, and 5 prior to complete failure. Tanks 3 and 6 should not be expected to feed. Fuel can flow from tanks 1, 2, 4, and 5 as long as individual quantities remain above the minimums described below.

The engines can draw fuel from tanks 2 and 4 with all other tanks empty if low power settings are used and a level or nose-up attitude is maintained. Since multiple failures are involved in loss of all boost pumps, it should be possible to transfer fuel prior to loss of all pumps and to continue operation of both engines for a "reasonable" time without pumps, using subsonic loiter power, speed and altitude schedules. The time available depends on location and quantity of usable fuel and the c.g. developed as the fuel is used. Full scale mock-up simulations indicate the following unusable quantities when operating at loiter speeds without boost pumps. (Values are approximate.)

Tank 1	2300 lb.
Tank 2	3400 lb.
Tank 4	1200 lb.
Tank 5	1900 lb.

Tank 4 quantity is critical. Both engines will probably be lost when the unusable quantity is reached in this tank, regardless of crossfeed position or quantities remaining in other tanks. The minimum value may be higher with XFEED OPEN. With crossfeed closed, the left engine will probably flameout when tank 2 reaches 3400 to 2800 pounds unless tank 4 reaches 1200 pounds remaining first.

NOTE

- Fuel quantity indications are inoperative without ac power. Quantities remaining must be estimated.
- Except where specifically noted otherwise, fuel system operating characteristics with boost pumps off are based on ground tests with a full scale mock-up of the fuel system. The tests simulated engine flow requirements, expected tank environments, pitch attitudes, and stable flight conditions. Fuel sloshing due to aircraft motion was not simulated.

A gradual aft c.g. shift toward 22% can be expected, using symmetrical power settings, if tank 6 is emptied and a c.g. of approximately 17% attained prior to loss of pumps. If near 25% c.g. it will be necessary to advance right engine power to Military to maintain that c.g.; with symmetrical power settings, the c.g. will travel aft rapidly and the aircraft may become uncontrollable.

Without generator or battery power, the inlet spikes remain locked forward.

WARNING

If the boost pumps are inoperative, there is no assurance of continued engine operation if one or more fuel tanks are empty. If one of the tanks serving an engine is empty, engine flameout can occur at any time if flight attitude, engine flow requirements, and/or fuel level in the associated tank(s) is such that the remaining head of fuel in the supply tank(s) cannot keep that manifold clear of fuel vapor or nitrogen gas.

Supersonic Descent

Use normal descent speed and Military power to minimize the rate of descent and maintain a positive deck angle. If the inlets are in restart, use the manual inlet descent procedure. At some point, probably below 60,000 feet, the engines will be receiving insufficient fuel flow to maintain full power. The engines may surge. If this occurs, reduce the throttle setting to eliminate "chugging".

Subsonic Cruise

Loiter speed and altitude schedules are recommended to minimize engine fuel flow requirements. The optimum loiter altitude is approximately 7000 feet below the altitude for long range cruise; Mach 0.75 to 0.80 is suggested.

Landing Approach

A straight-in landing approach without abrupt nose-over should be started approximately 20 minutes prior to intended landing, using approximately 250 KIAS to maintain a level or nose-up deck angle. The probability of engine failure during approach is increased if rpm is advanced during approach.

WARNING

Bailout if a complete flameout occurs. Do not attempt a dead-stick landing.

ELECTRICAL SYSTEM

Either generator is capable of supplying all electrical system power requirements.

SINGLE GENERATOR FAILURE

Illumination of an L or R GEN OUT caution light indicates that the respective generator has been disconnected. The GEN BUS TIE OPEN light may illuminate also. This procedure allows for either situation. A combined generator out and bus-tie open condition is confirmed by illumination of the corresponding XFMR RECT OUT caution light.

NOTE

> If a split-bus condition is not indicated, do not press the BUS TIE switch; this would split the left and right generator buses for the remainder of the flight.

With an L or R GEN OUT caution light illuminated (alone or with the GEN BUS TIE OPEN light on):

1. Affected generator switch - OFF, then NORM.

   If the fault was momentary, the generator will be reconnected to the system, and the caution light will extinguish.

NOTE

> Monitor hydraulic system warning lights and pressure instruments for indication of ADS failure.

A generator reset is required after an engine is windmilled at subsonic speed and restarted if the generator disconnected automatically.

WARNING

> Do not recycle the generator switch more than twice during an attempt to reset an automatically disengaged generator. If a fault in the generator feeder system exists, multiple cycling of its generator switch could cause repeated momentary short circuits each time while the protective system is operating to disconnect the generator.

NOTE

> It may be possible to accomplish generator reset after attaining subsonic temperatures.

If the L or R GEN OUT light remains on after 1 minute (steps 2 and 3):

2. If the GEN BUS TIE OPEN light is also illuminated - Depress BUS TIE switch momentarily.

   The bus tie will close if the fault is not in a generator ac bus and the generator switch of the affected generator is in NORM.

   The GEN BUS TIE OPEN and L or R XFMR RECT OUT caution lights may extinguish. With the GEN BUS TIE OPEN caution light extinguished, all ac and dc systems are powered by the operating generator.

   If the GEN BUS TIE OPEN light remains illuminated with L or R GEN OUT light on, the essential ac bus is powered by the operating generator regardless of whether the inoperative generator can then be reset or not. Refer to GEN BUS TIE OPEN Light On, this section.

   If the inoperative generator is reset later and either generator subsequently fails, the essential ac bus will be powered automatically by the operating generator.

3. Affected generator switch - OFF.

With one generator inoperative:

4. Speed - Subsonic recommended. Operational restrictions are Mach 2.8 and 350 KEAS while supersonic.

NOTE

All flight control trim systems will be inoperative if the remaining generator fails unless power is available from the EMER function of a generator to power pitch and yaw trim through the ac hot bus.

5. C.G. - forward of 22%.

   Transfer fuel to maintain c.g. within subsonic limit.

When subsonic:

6. Affected generator - Attempt to reset.

If the L or R GEN OUT Light remains on after 1 minute:

7. C.G. - Maintain forward of 20%.

8. Land as soon as possible.

   If both generators reset in NORM, land when practical.

DOUBLE GENERATOR FAILURE

If both generators disengage automatically (L and R GEN OUT and L and R XFMR RECT OUT caution lights illuminated), the essential dc busses and the emergency ac bus are powered by the battery. Attempt to provide ac power to the boost pumps and the ac hot bus by placing both generator switches in EMER. If a generator in EMER is turning at sufficient speed and its windings are intact, the ac hot bus and half the fuel boost pumps are energized with power of unregulated frequency and voltage and the corresponding L or R GEN OUT light extinguishes. If both generators are operating in EMER, all fuel boost pumps are energized with unregulated power. The GEN BUS TIE OPEN light illuminates if either generator switch is in EMER.

If a generator is operating in EMER (corresponding L or R GEN OUT caution light extinguished) and there is sufficient voltage, the transformer-rectifier on that generator bus will power the essential dc buses (corresponding L or R XFMR RECT OUT caution light extinguished and EMER BAT ON caution light extinguished); otherwise, dc buses will be powered by the batteries (L and R XFMR RECT OUT caution lights both illuminated and EMER BAT ON caution light illuminated). The dc monitored bus is locked-out in either case, by loss of transformer-rectifier power or by placing a generator switch in EMER.

When regulated ac power cannot be obtained from the generators, the emergency ac bus is powered from the No. 1 essential dc bus through the instrument inverter (whether the No. 1 essential bus is powered by the No. 1 battery or an operating transformer-rectifier). The emergency ac bus never receives power directly from a generator in EMER (see Figure 1-45). The instrument inverter should automatically start if either generator is not operating in NORM and should automatically power the emergency ac bus (INSTR INVERTER ON caution light illuminated) if neither generator is operating in NORM. If the emergency ac bus does not receive power, place the emergency ac bus switch to EMER AC BUS (up) and check that the INSTR INVERTER ON caution light illuminates.

The batteries will last approximately 40 minutes with reduced usage. Battery power is in use when the EMER BAT ON and the L and R XFMR RECT OUT caution lights illuminate. Systems not essential for flight or not usable on battery power alone should be turned off to minimize battery drain (see Figure 1-43).

The essential ac bus is never powered with double generator failure, even with generator(s) operating in EMER.

Fuel System Remaining Capability

Boost pumps are powered by the left and right generator busses. If neither generator will operate in NORM or EMER, the fuel boost pumps will be inoperative. The ac hot bus, including the fuel quantity indicators and c.g. indicators, will also be inoperative. Refer to Complete Loss of Boost Pumps, this section.

If only one generator is operating in EMER (corresponding L or R GEN OUT caution light extinguished) half the fuel boost pumps are energized.

When the generators are operating in EMER, the boost pumps must be manually selected.

WARNING

With double engine flameout, if both generators trip off, perform the Double Generator Failure boldface procedures to regain boost pump pressure before attempting airstart.

Flight Control System Capability Remaining

With at least one generator operating in EMER (corresponding L or R GEN OUT caution light extinguished), ac hot bus power is available to the pitch and yaw trim motors. The pitch trim indicator, powered by the emergency ac bus, should be operative. The yaw trim indicator, powered by the essential ac bus, is inoperative.

DOUBLE GENERATOR FAILURE PROCEDURE

Failure or disengagement of both generators is indicated by illumination of both L and R GEN OUT caution lights. In addition, some or all of the following lights may be expected to form a massive display on the annunciator panel:

L/R FUEL PRESS	INSTR INVERTER ON
L/R XFMR RECT OUT	AUTO PILOT OFF
GEN BUS TIE OPEN	ANS REF
EMER BAT ON	

The A and L, or B and R HYD lights will also illuminate if a generator disengagement is due to ADS failure.

With both L and R GEN OUT lights on:

▲1. **ATTITUDE REFERENCE INS.**

Select the INS to maintain a primary attitude reference.

The ANS reference platform is inoperative without both essential ac and dc power. The pilot's ANS REF and the RSO's ANS FAIL caution lights illuminate. The pilot's INS REF caution light should remain off.

NOTE

The INS will continue to operate normally as long as emergency ac bus power is available.

PVD operation should resume when the ATT REF SELECT switch is in INS.

The standby attitude indicator remains operative. If power to the standby attitude indicator is lost (emergency ac power for the 2 inch standby attitude indicator; essential dc power for the 3 inch standby attitude indicator), the standby attitude indicator will continue to display usable pitch and roll information for at least nine minutes.

2. **BOTH GENS EMER.**

   Set both generator switches to EMER and check the annunciator panel lights.

   With double generator failure, placing both generator switches in EMER offers the best chance of restoring power to boost pumps and to the ac hot bus.

   Check both L and R GEN OUT caution lights. If at least one generator resets, fuel manifold pressure can be restored to both engines by manually selecting Tank 4. The pilot's and RSO's fuel quantity and c.g. instruments and manual pitch and yaw trim will be available with ac hot bus power.

   Check the L and R XFMR RECT OUT and EMER BAT ON caution lights. A generator operating in EMER may provide sufficient voltage to operate its transformer-rectifier and supply the essential dc bus. The corresponding L or R XFMR RECT OUT light and the EMER BAT ON light will extinguish in this case. Monitor the dc loads as necessary.

3. **PRESS TANK 4 ON**

   Manually selecting Tank 4 should restore fuel manifold pressure to both engines.

   Check both L and R FUEL PRESS lights extinguish. Manually select fuel boost pumps and/or XFEED OPEN as required to maintain fuel pressure in both manifolds.

The emergency ac bus should remain on, powered by the instrument inverter.

If the emergency ac bus is not powered, the A, B, and M CMPTR OUT lights illuminate immediately and the INS REF light illuminates 10 seconds later. (Without emergency ac bus power, the INS remains operational for 10 seconds, powered by its self-contained battery.)

The INSTR INVERTER ON light should remain on, as the emergency ac bus never receives ac power directly from a generator(s) in EMER.

4. If the INSTR INVERTER ON light is not illuminated, emergency ac bus switch - EMER AC BUS (up).

   If the instrument inverter did not energize automatically, positioning the emergency ac bus switch to EMER AC BUS (up), energizes the inverter and mechanically latches the emergency ac bus to the instrument inverter.

5. DAFICS Computers and SAS - Check.

   If emergency ac power is interrupted, DAFICS computers and SAS should automatically reset when power is restored to the emergency ac bus. If necessary, reset DAFICS computers and SAS sensors/servos. If all SAS is lost near maximum Mach, pitch axis stability may be marginal and there is little damping of yaw oscillations. Refer to DAFICS Computer Failures and Stability Augmentation System, this section.

If either generator resets with EMER selected:

6. Boost pumps, and crossfeed - Control manually.

   Do not deplete tank 4 prematurely.

   The automatic fuel sequencing system is inoperative. Use manual control to schedule the boost pumps, and forward and aft transfer to adjust c.g.

   Only one tank of tank group 1, 2, 3 and one tank of tank group 4, 5, 6 can be manually selected at the same time. XFEED OPEN may assist maintaining fuel pressure in both manifolds.

7. C.G. - forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

T 8. Display mode select switch - Other than ANS.

   HSI compass card will be frozen if the display mode select switch remains in ANS with the ANS not powered.

9. Airspeed - Subsonic recommended.

   Operational restrictions are 350 KEAS while supersonic and Mach 2.8 with one generator functioning.

When appropriate:

10. Generator switches - Attempt to reset NORM.

   Attempt to reset the generators individually. If only one generator will operate in EMER, that generator is more likely to reset in NORM.

   Select an appropriate time considering speed, altitude, and location. An attempt to restore normal power will result in temporary loss of the only operating generator if the opposite generator is inoperative both in NORM and EMER. This may result in complete loss of generator power if NORM reset attempts are not successful and service in EMER cannot be regained.

WARNING

Do not recycle the generator switch more than twice during an attempt to reset an automatically disengaged generator. If a fault in the generator feeder system exists, multiple cycling of its generator switch could cause repeated momentary short circuits each time while the protective system is operating to disconnect the generator.

NOTE

It may be possible to accomplish generator reset after attaining subsonic temperatures.

If one generator resets in NORM:

11. Failed generator - Off.

CAUTION

Inflight, do not operate either generator in EMER unless both generators have failed.

NOTE

One generator switch in EMER will cause loss of power to the monitored dc bus even if the other generator is operating in NORM.

(12.) MRS - Recycle to ON.

   Cycle the MRS power switch to restore normal operation.

13. Emergency ac bus switch -NORM.

   A, B, and M CMPTR OUT lights may blink on then off during power transfer. INSTR INVERTER ON light will extinguish.

14. C.G. - Maintain forward of 20% (subsonic).

15. Land as soon as possible.

   If both generators reset in NORM, land when practical.

If both generators remain inoperative:

16. Control c.g.

WARNING

The c.g. will tend to shift aft as fuel is used. If possible, use a higher power setting on the right engine to maintain c.g. position.

▲17. Conserve battery.

One pitch and yaw SAS servo and both roll SAS servos may be disengaged while supersonic. Turn off the UHF, VHF, IFF, TACAN, and other nonessential systems where possible.

When subsonic, select spikes forward and forward bypass doors open, aft bypass doors closed, and then pull the following inlet circuit breakers: L & R SPIKE, L & R SOL, and AFT BYPASS circuit breakers on the pilot's left console; and the L & R SPIKE AND DOOR circuit breakers on the pilot's right console.

Battery loads may be reduced further when subsonic by disengaging all SAS and pulling circuit breakers for nonessential systems and by turning the battery OFF if flying VFR. The EMER BAT ON light may extinguish if dc load is reduced below 10 amperes.

CAUTION

Computer circuit breakers in the aft cockpit should not be pulled. The gyros should remain operating in case SAS reengagement is desired. Single channel pitch SAS reengagement may be required if a subsonic c.g. has not been attained.

The maximum duration of the dual-battery power system is approximately 40 minutes if unnecessary equipment is turned off. Figure 1-43 lists power requirements of equipment energized from the essential dc buses.

WARNING

If the boost pumps are inoperative, there is no assurance of continued engine operation if one or more fuel tanks are empty. If one of the tanks serving an engine is empty, engine flameout can occur at any time if flight attitude, engine flow requirements, and/or fuel level in the associated tank(s) is such that the remaining head of fuel in the supply tank(s) cannot keep that manifold clear of fuel vapor or nitrogen gas.

By airspeed control, attempt to maintain level to nose-up fuselage attitude during descent.

Just before landing:

18. Pitch SAS - Attempt servo engagement.

Equipment available with at least one generator operating in EMER:
Boost pumps, ac hot bus (crossfeed, fuel quantity and c.g. indicators, pitch & yaw trim, forward cockpit instrument lights). Emergency ac bus & essential dc bus available from battery (or from transformer-rectifier(s) if generator(s) in EMER has sufficient voltage).

Equipment available with only battery power:	
Attitude indicators	*Pitch trim ind
* ADI	*Fire warning
* RSO attitude ind	Fuel dump & transfer valves
* 2 inch standby	Hydro sys crossover
3 inch standby	IFF (Except Mode 4)
Cockpit lighting	Igniter purge
*DAFICS	ILS
* Air data (& PTAs)	*Inlet controls & ind
* α indicator	Inph & (T) Emer ICS
* APW	*INS
* High- α warning	Landing gear, brakes & steering
* Auto inlets	Manual air-cond control
* Roll Autopilot	Rain remvr & deice
* SAS	Rudder limiter
* Both TDIs	Seat adjust
* Unstart lights	*Turn and slip
Drag chute	VHF radio
Face Heat	
*HSI	
*PVD	

*Equipment on emergency ac bus powered by the inverter.

Rain removal is deleted after S/B R-2674.

GENERATOR BUS TIE OPEN LIGHT ON

All electrical busses are still powered if the bus tie splits (GEN BUS TIE OPEN caution light illuminates); however, be prepared for the possibility of a generator or constant speed drive system malfunction. If either generator subsequently trips, the essential ac, emergency ac, and ac hot bus will automatically be powered by the remaining generator. DAFICS computers should automatically reset if power is momentarily interrupted during transfer to battery power; however, reset the affected DAFICS computer(s) and/or SAS sensors and servos if they do not automatically reset.

Do not take action if the GEN BUS TIE OPEN caution light illuminates unless the condition is followed by erratic ac power system indications (such as abnormally fluctuating lights and/or ac instrument indications). In this case, an abnormality in the right generator or its control or drive system is indicated. Cycle the right generator control switch to OFF momentarily, then back to NORM. This transfers the essential and emergency bus loads to the left generator. If either generator should subsequently fail, all loads (except its boost pumps and transformer rectifier) will transfer to the remaining generator in the least required time. Otherwise, a transfer time of up to seven seconds could be required if the right generator should fail with the buses split. The appearances of electrical failure during this transfer delay are similar to simultaneous double generator failure indications.

TRANSFORMER-RECTIFIER FAILURE

One transformer-rectifier can supply the normal electrical demands. If a single transformer-rectifier fails, no action is required.

A double failure of the transformer-rectifiers is indicated by illumination of both L and R XFMR RECT OUT caution lights. Generator power is removed from all of the dc buses, but the batteries automatically supply power to the essential dc buses (indicated when EMER BAT ON caution light illuminates). DAFICS computers should automatically reset if power is momentarily interrupted during transfer to battery power; however, the affected DAFICS computer(s) and/or SAS sensors/servos should be reset if they do not automatically reset.

With both L and R XFMR RECT OUT caution lights on:

1. EMER BAT ON caution light - Check on.
2. Complete Double Generator Failure Procedure, steps 13 through 18.

EMERGENCY AC BUS POWER LOSS

Loss of emergency ac bus power is indicated by loss of the A, B and M computers and, after ten seconds, the INS. The following power OFF warning flags should appear: INS, TDI, ADI, Angle of Attack Indicator and the 2 inch Standby Attitude Indicator. (The 3 inch Standby Attitude Indicator is powered by dc power and is not affected.)

WARNING

With emergency ac bus failure, second condition SAS failure limits apply.

Power may be restored by moving the emergency ac bus switch to the EMER AC BUS (up) position. Actuation of the emergency ac bus switch may be accompanied by heading and attitude indication transients. The DAFICS computers reset automatically within one second.

Expect loss of all DAFICS computers and INS until EMER AC BUS is selected. All DAFICS computers should automatically reset when emergency ac power is restored; however, any disengaged computers or SAS sensors/servos should be reset if they do not automatically reset.

If emergency ac power is not restored to the INS within 10 seconds, the INS platform may be lost. In this case, use the Standby Attitude Indicator and complete an INS inflight alignment.

HYDRAULIC SYSTEM

With both engines out, the hydraulic pumps provide sufficient flow for satisfactory flight control system operation at windmilling speeds above 3000 rpm. Reduced control system capability is available down to a windmilling speed of approximately 1500 rpm. With one engine windmilling, all flight control and most utility services are supplied by the operating engine hydraulic systems. The windmilling engine utility system pressure and flow may be sufficient to supply service until the engine is almost stopped.

ABNORMAL HYDRAULIC PRESSURE

Steady hydraulic system pressures between 2200 and 3000 psi, and above 3500 psi, are considered abnormal. An abnormal pressure should be corrected before flight. Although not desirable, unrestricted operation may be continued if abnormal pressure is observed during flight; however, system operation should be monitored for indications of low quantity or degraded performance and the condition must be reported after landing. Transient pressure fluctuations are not considered abnormal when they can be associated with system demand.

L & R (UTILITY) HYDRAULIC SYSTEMS

Illumination of an L or R HYD warning light indicates low fluid quantity for that system (not low quantity and/or low pressure as the A and B HYD warning lights). Low pressure is indicated by the corresponding hand of the L and R hydraulic system (SPIKE) pressure gage. If L system pressure becomes less than 2200 psi during gear retraction, an automatic crossover to the R system continues until retraction is completed. If L system has failed, the Emergency Gear Extension procedure must be used to lower the landing gear.

L AND/OR R HYDRAULIC SYSTEM FAILED

Assume that an L or R hydraulic system has failed when its pressure indication remains below 2200 psi or its L or R HYD annunciator warning light remains illuminated. If at high Mach, a descent should be started in either case. Subsonic operating speeds are recommended; however, operation may be continued at intermediate supersonic speeds, when necessary, if an aft-bypass-closed and restart configuration is achieved and the engine inlet guide vanes maintained in the cambered position (IGV LOCKOUT). Sustained operation at speeds which result in engine internal bleed shifting should be avoided. Refer to Figures 3-4 and 3-7 for Unstart and Compressor Stall Boundary conditions for various inlet configurations.

NOTE

If subsonic, accomplish only * items.

With a low quantity warning or if pressure remains below 2200 psi, affected inlet:

* 1. **RESTART ON.**

Check the spike indicates full forward and the forward bypass indicates 100% open.

If supersonic, the spike will move forward because of air pressure in the inlet, regardless of hydraulic pressure available. However, some hydraulic pressure must be available to open the forward bypass.

NOTE

Without residual hydraulic pressure, the affected aft bypass will remain in the last selected position.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

NOTE

If the forward bypass does not open and the spike moves to its forward position while supersonic, expect unstarts, compressor stalls, and/or flameout on the affected side. Engine restart is unlikely above Mach 1.3.

2. Aft Bypass - CLOSE.

3. Begin normal descent.

On the affected side:

4. Throttle - Set.

   - o 720° EGT to Military above Mach 2.5.
   - o 6500 rpm at Mach 2.5, let rpm decrease.
   - o Retard throttle if compressor stalls.

NOTE

Use the normal Descent procedure for the good inlet. If desired, afterburner can be used on the unaffected side to reduce the rate of deceleration while above Mach 2.0.

CAUTION

Monitor spike and forward bypass positions.

If the forward bypass is closed <u>and</u> the spike free to move, the inlet will become "choked" if the spike is sucked aft by engine airflow requirements. If this should happen at low altitude, a combination of high rpm and low airspeed might collapse the duct due to a critical differential between ambient air pressure and pressure within the duct. If the spike is aft and the forward door is closed while subsonic, use minimum required power when above 5000 feet and IDLE below 5000 feet.

CAUTION

If the forward bypass remains closed and the spike is not locked forward, fly approach at single-engine approach speed with idle power on the affected inlet.

If the forward bypass is open and the spike is aft (or free to move), duct collapse is not likely; however, to minimize the possiblity of compressor stalls, avoid using afterburner and avoid full military power. With IGVs cambered (locked out), compressor stalls are unlikely up to full military power.

* 5. Land when practical.

Refueling is not recommended if the L hydraulic system has failed; however, R system pressure may be used for refueling by moving the brake switch to ALT STEER & BRAKE. Do not leave the brake switch in ALT STEER & BRAKE after refueling.

WARNING

With both the L and R systems failed, wheel brakes may not be available and steering will not be available. Ejection may be necessary if a suitable landing area cannot be reached.

With the L system failed:

* 6. Brakes and antiskid - DRY/WET, ALT STEER & BRAKE.

CAUTION

R hydraulic pressure may be lost also if L system fluid loss is due to a malfunction of the steering or refueling system.

* 7. If L HYD Pressure is insufficient to lower the gear, complete Gear Emergency Extension procedure.

Allow additional time to lower the gear. At least 90 seconds must be allowed if Gear Emergency Extension, is required.

* 8. Retain drag chute after landing, if practical.

Jettison the drag chute for directional control, if required.

A AND B HYDRAULIC SYSTEMS

The loss of either A or B hydraulic system fluid quantity or pressure illuminates the corresponding A or B HYD annunciator warning light. The A and B hydraulic pressure gage will indicate complete failure of a system. If the A or B hydraulic system fails, the control forces will not change. Either system will operate the control surfaces, but at a slower rate and with some reduction in available control at higher KEAS and Mach. Airspeed reduction with a single hydraulic system is a precaution which allows for the reduction in available hinge moment capability. The APW system stick pusher is inoperative if the A system fails. Monitor system operation closely and attempt to determine if complete failure is imminent. Prepare for ejection prior to complete failure.

Effect of System Loss on SAS

Manual disengagement of the failed A or B hydraulic system SAS servos is necessary to regain normal SAS damping capability in all channels, as a hydraulic system failure is not sensed directly by DAFICS. The signal gain of the operating yaw servo is doubled automatically by disengagement of the servo for the failed hydraulic system.

It is necessary to recycle the operating roll SAS servo to regain damping in roll. The useable roll SAS servo should not be reengaged while banking, as roll coupling will disturb control in the pitch axis. Refer to Roll Axis Failures, this section.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

A OR B HYD LIGHT ON

NOTE

If subsonic, accomplish only * items.

If an A or B HYD warning light illuminates:

*1. A and B hydraulic systems -Check for normal pressure indication.

2. Begin normal descent.

*3. Land as soon as possible.

A OR B HYDRAULIC SYSTEM FAILED

If an A or B hydraulic system fails, as indicated by illumination of the A or B HYD warning light and confirmed by indication of the hydraulic pressure gage:

NOTE

If subsonic, accomplish only * items.

*1. Airspeed - 350 KEAS or less.

CAUTION

Do not exceed 350 KEAS (subsonic or supersonic) with only one A or B hydraulic system operative. If either system fails above this speed, reduce airspeed immediately. Set Idle power if transonic with higher KEAS.

*2. SAS - Affected servos off.

*3. Roll SAS - Cycle operating servo off, then ON, if roll SAS desired.

The roll SAS may be left off, if desired, to avoid pitch coupling.

4. Make normal descent at 350 KEAS to subsonic speed.

*5. Land as soon as possible.

A AND B HYDRAULIC SYSTEMS FAILED

If both the A and B hydraulic systems fail as indicated by illumination of the A HYD and B HYD warning lights and confirmed by loss of A and B hydraulic pressure and deteriorating control effectiveness:

▲1. Eject.

WARNING

All control will be lost if both the A and B hydraulic systems fail.

FLIGHT CONTROL SYSTEM

AIRCRAFT CONTROL ABNORMAL

If unusual aircraft control is encountered:

1. A and B hydraulic systems - Check for normal pressure indications.

2. Autopilot - Disengage and check control.

▲3. Electrical system - Check warning lights off and circuit breakers normal.

NOTE

Do not pull and reset DAFICS computer ac circuit breakers not already out; otherwise, DAFICS will detect multiple computer/sensor power supply failures.

4. DAFICS Computers/SAS - Check caution lights.

If failure has occurred, refer to DAFICS Computer Failures and/or SAS Emergency Operation, this section.

If unable to determine cause of malfunction:

5. Proceed at subsonic speeds (recommended) and land when practical.

TRIM FAILURES

Pitch, yaw or roll trim may fail inoperative or may runaway. Runaway trim failures in pitch may occur at the slow rate (0.113°/sec) if due to a runaway automatic trim motor, or at fast rate (1.13°/sec) if due to a runaway manual trim motor. A slow rate runaway malfunction will be manifest by the need for constant manual pitch trimming. A fast rate runaway pitch trim will result in a moderately rapid change in pitch attitude or stick forces. If the cause is a sticky manual pitch trim switch, a rapid oscillation may develop if the pilot applies corrective pitch trim inputs. The possibility of manual trim runaway can be minimized by manually centering the trim switch following each trim application. The runaway yaw trim rate is 0.90°/sec. The roll trim rate is .96°/sec. Runaway yaw trim will be accompanied by rudder pedal deflections as the surfaces move. Runaway pitch or roll trim will <u>not</u> be accompanied by stick movement with surface movement.

If runaway trim is suspected:

1. **TRIGGER HOLD.**

   Depress the control stick trigger switch to disengage the autopilot, pitch and yaw trim, and to disable the APW stick pusher. Keep the trigger depressed until trim power switch is OFF.

2. Trim power switch - OFF.

   All manual and automatic trim are inoperative with the Trim Power switch OFF.

When circumstances permit:

3. Reduce supersonic speed below 350 KEAS and Mach 2.5.

With runaway nose-up trim:

4. Transfer fuel forward to reduce forward stick requirement.

With runaway nose-down trim:

5. Do not transfer fuel aft of normal c.g. limits in an attempt to reduce aft stick requirements.

6. Affected trim circuit breaker(s) - Pull.

NOTE

The manual pitch and yaw trim motors are powered from the same circuit breaker.

Trim Malfunctions:

a. If runaway slow rate pitch trim - Pull the AUTO PITCH trim circuit breaker.

b. If runaway high rate pitch trim -Pull the PITCH AND YAW trim circuit breaker.

c. If runaway roll or yaw trim - Pull the ROLL trim or PITCH AND YAW trim circuit breaker.

7. Trim power switch - ON.

With manual pitch trim inoperative and autotrim available, engagement of the pitch autopilot will gradually correct an out-of-pitch-trim condition. This will relieve the pilot from maintaining stick deflection to maintain attitude. The pitch autopilot will not remain engaged when the auto trim motor is inoperative because DAFICS will disengage the autopilot when autotrim does not follow autopilot inputs.

If the trim malfunction is a runaway in the roll axis, right or left stick deflection will be required for the rest of the flight, but stick force will not be more than normally required for the same amount of deflection. If the malfunction was a runaway in the yaw axis, rudder pedal force will be required to maintain neutral rudder pedal position.

STABILITY AUGMENTATION SYSTEM (SAS)

SAS disengagements may result from failures of: servo(s), multiple sensors, multiple DAFICS computer failures, or electrical power fluctuations and failures. Disengagement or loss of effectiveness may also occur as a result of complete or partial loss of A or B system hydraulic power. Failure of SAS sensors and servos is indicated by illumination of the master caution light, the SAS OUT annunciator caution light, and one or more of the indicator lights on the SAS control panel.

A steady YAW SENSOR light indicates a yaw rate gyro failure. A flashing YAW SENSOR light indicates failure of a lateral accelerometer. If both the yaw rate gyro and lateral accelerometer in the same yaw sensor fail, that YAW SENSOR light will illuminate steady. DAFICS provides analytical redundancy for yaw rate, but not for lateral acceleration.

No SAS capability is lost as a result of a single DAFICS computer failure. SAS sensor redundancy is reduced in pitch and yaw by any dual computer failure. Also, SAS channel A is lost in pitch and yaw due to servo disengagements if the A and M computers fail. SAS channel B is lost in pitch and yaw due to servo disengagements if the B and M computers fail. All roll SAS is lost if A and B computers fail. Refer to DAFICS Computer Failures, this section.

All SAS is disengaged if all three DAFICS computers fail. SAS is functionally inoperative while DAFICS is in the ground test mode (DAFICS preflight BIT TEST or FAIL light illuminated steady).

WARNING

Only the master caution and the A, B, and M CMPTR OUT lights illuminate if all three DAFICS computers fail.

NOTE

Computer failures are indicated by illumination of the A, B, and/or M CMPTR OUT annunciator caution lights. SAS disengagement due to multiple computer failures is not indicated by lights on the SAS control panel.

SAS EMERGENCY OPERATION

When any SAS SERVO or SENSOR light illuminates:

1. A and B hydraulic systems - Check for normal pressure indications.

   If hydraulic pressure failure is indicated, follow A or B Hydraulic System Failed procedure, this section.

▲2. Electrical system - Check warning lights off and circuit breakers normal.

NOTE

Do not pull and reset DAFICS computer ac circuit breakers not already popped; otherwise, DAFICS might detect multiple computer/sensor power supply failures.

3. Recycle appropriate SENSOR/SERVO lights.

   a. Single sensor or servo failure:

      For pitch or yaw SAS, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. For roll SAS, cycle either A or B ROLL channel engage switch off, then ON. If the malfunction was a transient condition, the sensor/servo monitor will reset.

   b. Multiple sensor failures in one axis:

      Multiple lateral accelerometer failures (flashing A, B, and M YAW SENSOR lights) cannot be reset.

      If more than one SAS rate-gyro fails in the pitch or yaw axis, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. Pressing a recycle light resets only one sensor. The DAFICS computers determine which sensor resets regardless of which recycle light is pressed. If the malfunction was a transient condition, a sensor will reset. If no SENSOR light extinguishes, press a recycle light again to attempt reset of another sensor. After one sensor resets (one SENSOR light extinguishes), DAFICS will not allow reset of another sensor in the same axis until the pilot pulses the aircraft in both directions in that axis to assure that the sensor is tracking.

      If both roll SAS sensors fail, cycle either A or B ROLL channel engage switch off, then ON. Cycling an engage switch resets only one sensor. The DAFICS computers determine which sensor resets regardless of which switch is cycled. If the malfunction was a transient condition, a sensor will reset. Since one sensor is still failed, the ROLL SENSOR light remains illuminated. The pilot must pulse the airplane in roll to determine if a sensor has reset. If a sensor resets, DAFICS will not allow reset of the other roll sensor until the pilot rolls the aircraft both left and right to assure that the sensor is tracking.

If more than one rate-gyro SAS sensor fails in an axis, DAFICS compares the first sensor reset in that axis to analytical redundancy (ANR). Therefore, recycling of multiple sensor failures in an axis is only possible when the attitude source (ANS or INS) selected by the pilot's ATT REF SELECT switch is reliable.

c. Dual servo failure in one axis:

For dual SAS servo failures in the pitch or yaw axis, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. Pressing a recycle light once resets servos in only one channel. The DAFICS computers determine which servos reset regardless of which recycle light is pressed. Press a recycle light again to reset the servos in the other channel. If the malfunction was a transient condition, both servo monitors will reset.

For dual roll SAS servo failure, cycling either A or B ROLL channel engage switch off, then ON reengages servos in both channels.

4. Pulse the aircraft in the appropriate axis.

Pulsing the aircraft checks for a dead or sticking sensor. Although this check is desirable, it is not conclusive. If the SENSOR/SERVO light remains extinguished, assume no failure. If the light reilluminates during movement (active trip) or will not recycle (passive trip), assume a failure.

Pulse the aircraft both directions in the appropriate axis, i.e. generate up and down movement after resets in pitch, left and right movement (with rudder) after resets in yaw, and left and right roll rates after resets in roll.

NOTE

Consider that no failure exists if all pitch, yaw, and roll recycle lights extinguish. Normal operation of the recycle lights is verified by depressing the SAS LITE TEST button.

5. For multiple sensor failures in the same axis, repeat steps 3 and 4 as required.

With multiple rate-gyro failures, after one sensor resets, DAFICS will not allow reset of another sensor in the same axis until the pilot pulses the aircraft in both directions in that axis to assure that the sensor is tracking.

If the A, B, and/or M CMPTR OUT, the 2 PTA CHAN OUT or the ANR (flashing DAFICS PREFLIGHT BIT FAIL light) caution lights illuminate, refer to the appropriate procedure.

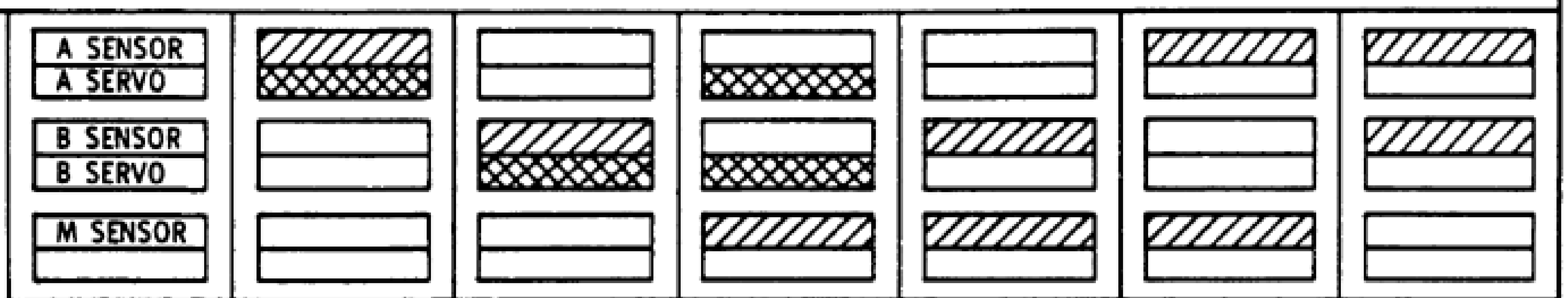
The SAS Warning Lights charts, Figure 3-14, illustrate the probable causes of failure, indications, remaining capabilities, procedures and limits which apply after channel disengagement.

SAS WARNING LIGHTS CHART

PITCH SENSOR/SERVO FAILURES

FUNCTION SELECTOR

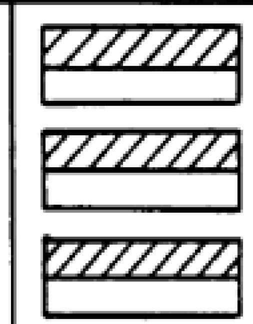
Recycle Lights Illuminated Steady



Operable Channels – SENSOR FAILURES		A & B	A & B	A & B	A & B	A & B	A & B
Operable Channels – SERVO FAILURES		B	A	NONE			

ACTION: Check Hydro Press Electrical Sys Then try to press lights off.

Then: If servo light remains on, turn failed servo off. If pitch axis failed while supersonic move c. g. forward.



NONE

NOTE 1 Without analytical redundancy:

a. Treat the loss of one sensor as a "first" condition SAS failure.

b. Two sensor failures will result in "second" condition SAS failure.

c. A sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

2 Servo failure coupled with dual computer failure can result in "second" condition SAS failure.

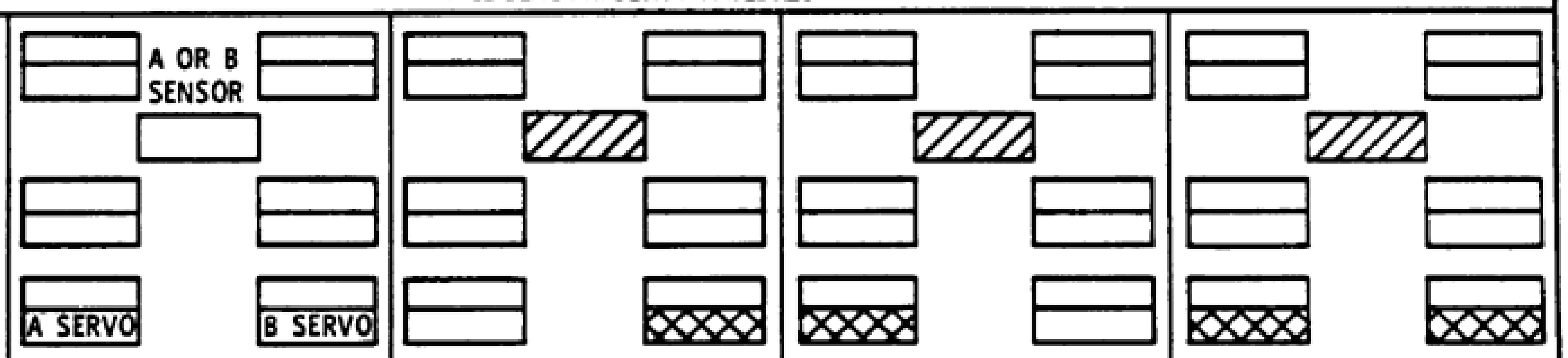
3 Dual sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

LIMITS: For Single Servo, Single Sensor w/o ANR, or Dual Sensor Failure	Max Supersonic speed:	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical. Land when practical.
LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic speed:	Mach 2.0, 350 KEAS Subsonic c.g. limits required Subsonic Operation recommended Land when practical

ROLL SENSOR/SERVO FAILURES

FUNCTION SELECTOR

Recycle Lights Illuminated Steady



Operable Channels – SENSOR FAILURES		A AND B OR NONE	A AND B OR NONE	A AND B OR NONE
Operable Channels – SERVO FAILURES		A OR NONE *	B OR NONE *	NONE **

ACTION: Check Hydro Press Electrical Sys Then try to reset (Either Roll Engage Switch off and ON)

Then: If servo light(s) stay on:

Turn off failed servo switch and recycle good servo switch.

If second failure is detected by loss of damping, disengage remaining servo switch.

LIMITS: Single or Dual Channel Out	Single servo not to be used during refueling or landings. No restriction on operation without roll SAS	* Servo light indication does not change for a second servo failure, both roll servos disengage with first servo failure. A subsequent failure in the re-engaged good channel will neither disengage the servo nor illuminate the servo light in that channel. ** Illumination of both servo lights results from intentional disengagement of both channels, or in infrequent occasions when system comparison of servos against model does not yield a positive identification of the servo which has failed.

F203-219(h)

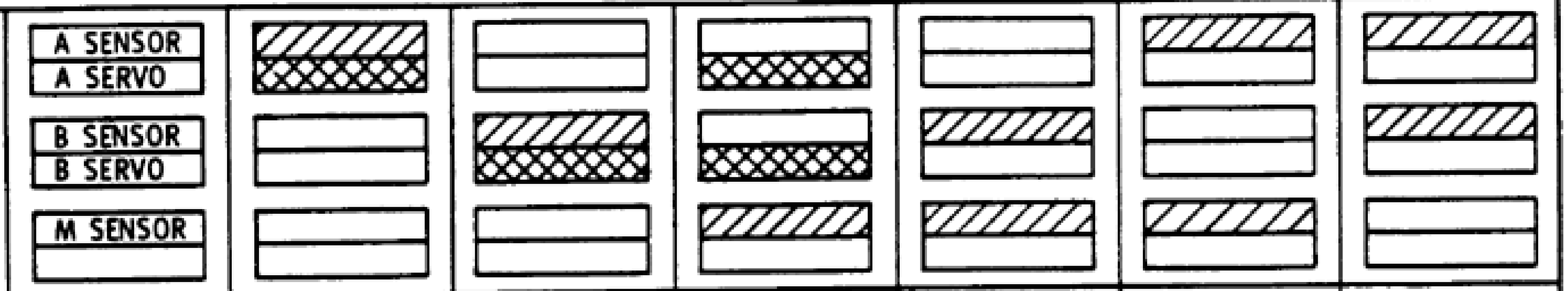
Figure 3-14 (Sheet 1 of 2)

SAS WARNING LIGHTS CHART

YAW AXIS RATE-GYRO/SERVO FAILURES

FUNCTION SELECTOR

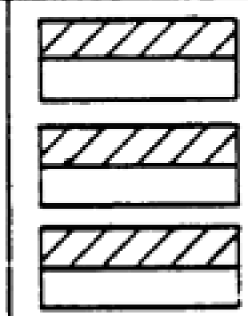
Recycle Lights Illuminated Steady



Operable Channels } SENSOR FAILURES		A & B	A & B	A & B	A & B	A & B	A & B
Operable Channels } SERVO FAILURES		B	A	NONE			

ACTION: Check Hydro Press, Electrical Sys. Then try to press lights OFF

Then: If servo light remains on, turn failed servo OFF. If both yaw servos failed while at cruise, decel by symmetric use of RESTART switches.



NONE

NOTE

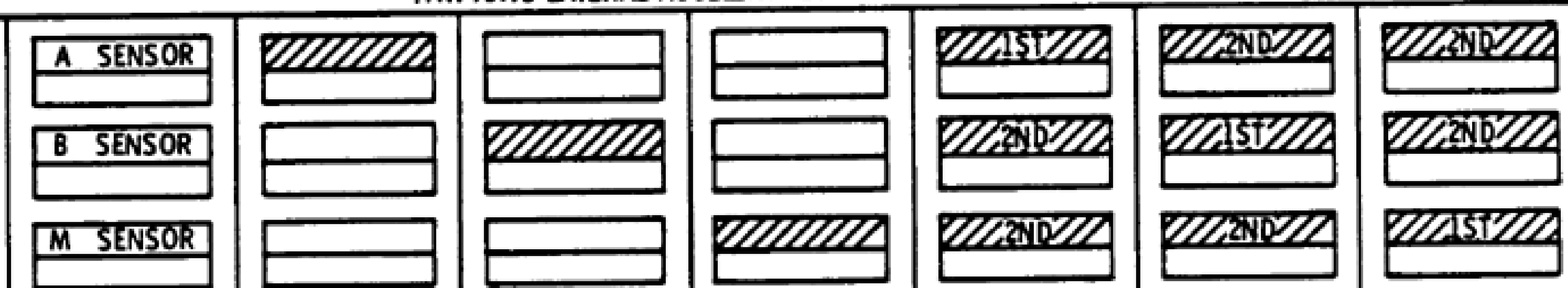
1. Without analytical redundancy:
   a. Treat the loss of one sensor as a "first" condition SAS failure.
   b. Two sensor failures will result in "second" condition SAS failure.
   c. A sensor failure coupled with dual computer failure can result in "second" condition SAS failure.
2. Servo failure coupled with dual computer failure can result in "second" condition SAS failure.
3. Dual sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

LIMITS: For Single Servo, Single Sensor w/o ANR, or Dual Sensor Failure	Max Supersonic speed:	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical. Land when practical.
LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic speed:	Mach 2.0, 350 KEAS. Subsonic c.g. limits required. Subsonic Operation recommended. Land when practical

YAW AXIS LATERAL ACCELEROMETER FAILURES

FUNCTION SELECTOR

Recycle Lights Illuminated Flashing



Operable Channels } SENSOR FAILURES		A & B	A & B	A & B	NONE	NONE	NONE

ACTION: Check Hydro Press, Electrical Sys. Then try to press lights off.

Then: If light(s) stay ON: Land when practical. For complete yaw axis failure while at cruise, decel by symmetric use of RESTART switches.

NOTE

1. If a lateral accelerometer and YAW rate gyro fail in the same sensor, the YAW sensor light will illuminate steady.
2. Sensor failure coupled with dual computer failures can result in "second" condition SAS failure.

LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic Speed:	Mach 2.0, 350 KEAS. Subsonic c.g limits required. Subsonic Operation recommended. Land when practical

F200-220(h)

Figure 3-14 (Sheet 2 of 2)

PITCH OR YAW AXIS "FIRST" CONDITION FAILURE

A "first" condition failure exists after the SAS Emergency Operation procedure has been accomplished and either an A or B SAS servo is inoperative in the pitch and/or yaw axis. "First" condition failure limitations are also observed for: dual pitch sensor or dual yaw rate gyro failures; and single pitch sensor or single yaw rate gyro failure with ANR failure (DAFICS Preflight BIT red FAIL light flashing).

Sensors

There is no combination of pitch or yaw sensor failures that can fail only one channel in either axis. Both SAS channels operate if one sensor is available in that axis. No SAS channel is lost in pitch or yaw as a result of a single sensor failure; however, "first" condition failure limitations should be observed for single pitch sensor or yaw-rate gyro failure with ANR failure. If analytical redundancy is operative, no pitch or yaw SAS channel is lost if two pitch sensors or two yaw rate gyros are lost; however, "first" condition failure limitations should be observed for dual pitch sensor or dual yaw rate gyro failures.

Servos

A "first" condition failure exists after the SAS Emergency Operation procedure has been accomplished and one servo light remains on (A PITCH SERVO, B PITCH SERVO, A YAW SERVO, or B YAW SERVO) or one servo light remains on in each axis (any combination of one PITCH SERVO and one YAW SERVO light). Aircraft flight characteristics do not change as a result of a failure or combination of failures which leaves one A or B servo operating in each axis.

Computers

No SAS capability is lost as a result of a single computer failure. SAS channel A is lost in pitch and yaw due to servo disengagement if the A and M computers fail. SAS channel B is lost in pitch and yaw due to servo disengagement if the B and M computers fail.

NOTE

> Computer failures are indicated by illumination of the A, B, and/or M CMPTR OUT annunciator caution lights. SAS disengagement due to multiple computer failures is not indicated by lights on the SAS control panel.

Appropriate SAS emergency procedures are incorporated in multiple computer failure procedures. Refer to DAFICS Computer Failures, this section.

PITCH OR YAW AXIS "FIRST" CONDITION FAILURE PROCEDURE

This procedure is only initiated after the SAS Emergency Operation procedure is complete.

NOTE

> If subsonic, accomplish only * items.

Sensor

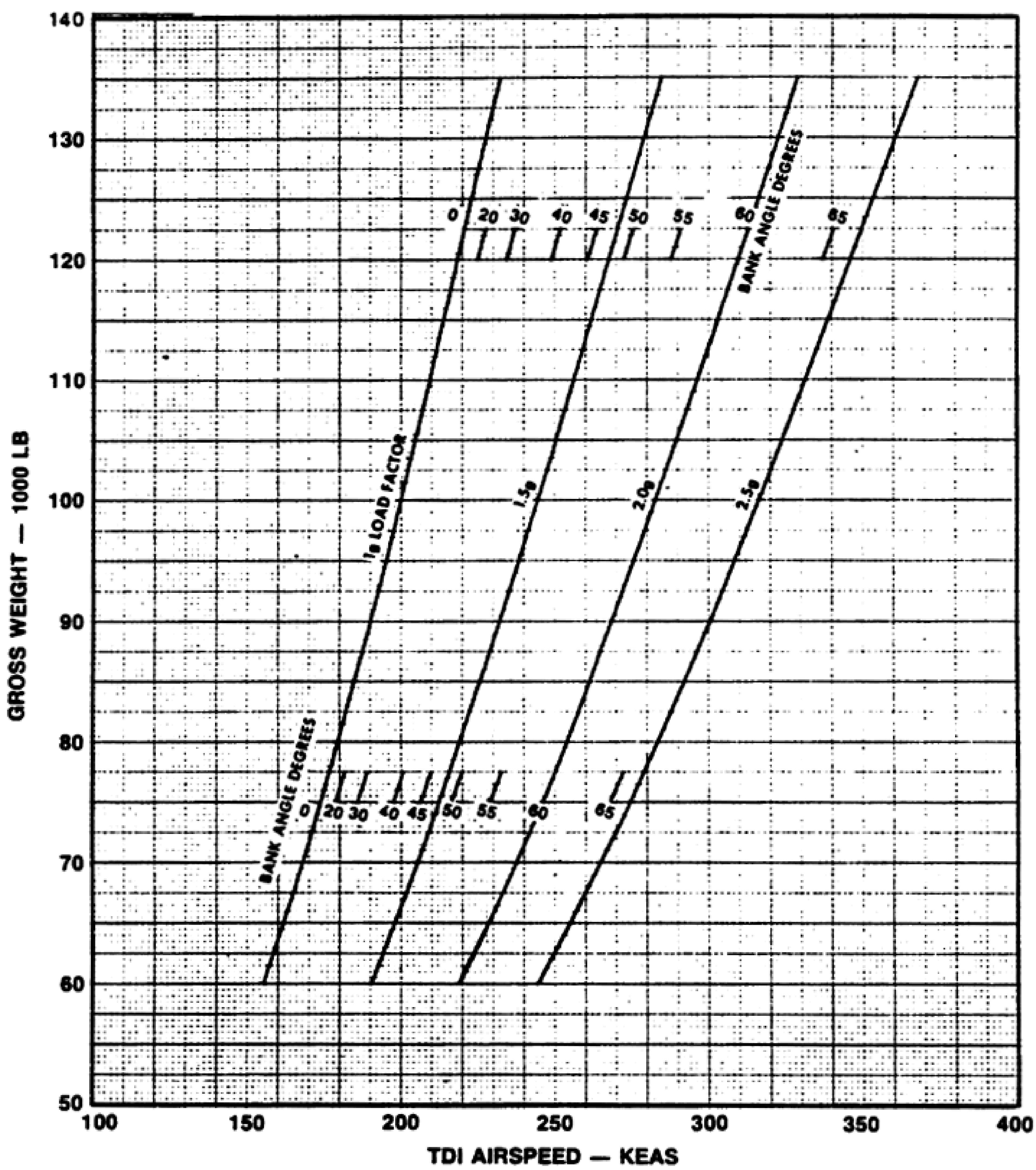
No action is required for a single sensor failure in the pitch and/or yaw axis (A PITCH SENSOR, B PITCH SENSOR, M PITCH SENSOR, A YAW SENSOR, B YAW SENSOR, or M YAW SENSOR light or any combination of one PITCH SENSOR light and one YAW SENSOR light) unless ANR failure is also indicated. No action is required for two sensor lights in the yaw axis if one light is a yaw rate gyro (steady) and the other is a lateral accelerometer (flashing) unless ANR failure is also indicated.

Servo, Dual Pitch Sensor or Dual Yaw Rate Gyro, Single Pitch Sensor With ANR Failure, or Single Yaw Rate Gyro With ANR Failure

When A PITCH, B PITCH, A YAW or B YAW SERVO light is on; one PITCH SERVO and one YAW SERVO light is on; dual PITCH SENSOR lights or steady dual YAW SENSOR lights are on; a single PITCH SENSOR light is

MINIMUM RECOMMENDED SUBSONIC AIRSPEED WITH PITCH SAS INOPERATIVE

$C_L = 0.46$
(10° ANGLE OF ATTACK — SUBSONIC
AWAY FROM GROUND EFFECT)



Refer to Section V for listing of airspeed restrictions.

Figure 3-15

on with ANR failure; or a single steady YAW SENSOR light is on with ANR failure:

1. Maximum supersonic speed - Mach 3.0, 400 KEAS.

   Intermediate Altitude profile is recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.

* 2. For servo failure, failed servo switch - Off.

* 3. For first condition pitch failure, C.G. - Forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

* 4. Land when practical.

NOTE

With dual PITCH SENSOR lights or dual steady YAW SENSOR lights, changing the position of the pilot's attitude reference switch will not illuminate an ANR light or SENSOR light but will momentarily disengage <u>all</u> SAS in that axis until analytical redundancy is restored.

PITCH OR YAW AXIS "SECOND" CONDITION FAILURE

A "second" condition failure exists when both SAS servos disengage in the same axis.

<u>Pitch SAS Disengaged Characteristics</u>

Normally, pitch SAS opposes pitch rates that result from control stick inputs. Without pitch SAS, the aircraft pitch rate and load factor response to a pilot input is greater than the response to the same stick movement or stick force when pitch SAS is operating. With pitch SAS off, longitudinal overcontrol is likely, particularly at high Mach (where static margin is low and normal pitch SAS gain is high). Observance of "second" failure limits is required, and descent to subsonic speed is recommended when practical. Air refueling and landing may present difficulties in maintaining precise attitude control. With SAS off, divergent speed and attitude tendencies occur slowly enough to be controllable. Stability improves when the c.g. is moved forward (see Stability Characteristics, Sec. VI). Minimum airspeed at or above normal pattern speeds (i.e. angle of attack at or below 10°) is recommended until landing. See Figure 3-15.

<u>Pitch Sensors</u>

Due to analytical redundancy models in the DAFICS computers, neither pitch SAS channel is lost until all three pitch sensors fail, or two pitch sensors and analytical redundancy fail. These triple failures will cause the A, B, and M PITCH SENSOR lights to illuminate and both pitch SAS channels to disengage. In this case, the pitch servo lights on the SAS control panel will not illuminate.

<u>Pitch Servos</u>

A failure of both pitch servos (A PITCH SERVO and B PITCH SERVO lights on) will cause both pitch SAS channels to disengage.

<u>Yaw SAS Disengaged Characteristics</u>

At high Mach, neutral to slightly positive stability exists and there is little damping of yaw oscillations after they commence. Above Mach 2.8, automatic scheduling of the inlets may induce neutrally damped directional oscillations. Directional and roll control could become difficult (as a result of large bank angles generated by yawing motion) if an unstart or flameout occurs above Mach 2.9. Pilot rudder inputs usually aggravate this condition. These conditions could also result in excessive rudder surface loads above 400 KEAS. Use of both restart switches is recommended while decelerating to avoid asymmetric nacelle drag or unstarts.

<u>Yaw Sensors</u>

Due to yaw rate analytical redundancy models in the DAFICS computers, neither yaw SAS channel is lost until all three yaw rate gyros fail or two yaw rate gyros and analytical redundancy fail. These triple failures will cause the A, B, and M YAW

SENSOR lights to illuminate steady and both yaw SAS channels to disengage. Because analytical redundancy is not provided for lateral accelerometers, the failure of any two lateral accelerometers will cause the A, B, and M YAW SENSOR lights to illuminate flashing and both yaw channels to disengage. In either case, the YAW SERVO lights on the SAS control panel will not illuminate.

Yaw Servos

Failure of both yaw servos (A YAW SERVO and B YAW SERVO lights on) will cause both yaw SAS channels to disengage.

Computers

If all three DAFICS computers fail, all SAS channels will disengage. In this case, all SAS capability is lost and the A CMPTR OUT, B CMPTR OUT and M CMPTR OUT annunciator lights illuminate. SAS disengagement will not be indicated by lights on the SAS control panel. Refer to the A, B, and M Computers Out procedure, this section, which incorporates appropriate SAS emergency actions.

If two DAFICS computers are inoperative, SAS redundancy is degraded. The loss of a servo or sensor in combination with a dual computer failure may result in a "second" condition SAS failure. Appropriate SAS emergency procedures are incorporated in computer-out procedures. Refer to A and B, (A and M) or (B and M) Computers Out procedure as appropriate.

PITCH OR YAW AXIS "SECOND" CONDITION FAILURE PROCEDURE

When triple PITCH SENSOR, triple YAW SENSOR (steady or flashing), both PITCH SERVO, or both YAW SERVO lights are on:

NOTE

If subsonic, accomplish only * items.

The maximum supersonic speed restrictions are 350 KEAS and Mach 2.0. Subsonic operation is recommended.

1. Restarts ON simultaneously.

   The throttle restart switch will expeditiously put both inlets in restart.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. Maintain 350 KEAS.
3. Aft bypass - CLOSE.

Above Mach 2.5:

4. Throttles - 720°C EGT to Military.
5. IGV switches - LOCKOUT.
6. C. G. - Forward of 22%.

At Mach 2.5:

7. Throttles - Set 6500 rpm.

To cruise at Mach 2.0:

8. Restart switches - Off.
9. Aft bypass controls - Normal schedule.
10. Throttles - As required.

At Mach 2.0, to continue deceleration:

* 11. C.G. - Forward of 20%.

12. Resume normal checklist procedures.

* 13. Land when practical.

ROLL AXIS FAILURES

With one ROLL SERVO failed, some undesirable cross-coupling may occur during single roll SAS channel operation, particularly during turns. This appears as small amplitude oscillations in the pitch and yaw axes. Roll coupling occurs because the A and B roll SAS servos only operate through their left and right side elevons. With the "A" roll servo off, for example, the "B" servo only supplies stability augmentation through the right side elevons. However, the pitch axis SAS channel which remains will continue to operate through the elevons on both sides of the aircraft. A disturbance in the roll axis which is resisted by the B roll SAS servo results in a nose-up or nose-down pitch signal to the right side elevons. There is no balancing roll signal to the left side elevons if the A roll SAS servo is off, and a pitch transient is introduced. When this happens, the pitch SAS will immediately resist any disturbance in the longitudinal axis which is introduced by the right side elevons. It reacts against the roll SAS command, and deflects the elevons on both sides toward the opposite direction. The result is a pitch transient in the opposite direction to that of the original roll SAS input. The magnitude of the transient and the number of resultant transients depends largely on the strength of the original disturbance.

Roll coupling can occur in wings-level or turning flight. The effect is not unduly hazardous unless compounded by other abnormal or emergency situations - - such as an unstart. Therefore, the usable roll SAS servo can be reengaged when level, if desired, and autopilot AUTO NAV can be engaged. As a precaution, the roll SAS can be disengaged before turns.

Scheduled activity may be continued for the remainder of the flight with a single roll SAS channel operating. The roll autopilot may be engaged and AUTO NAV used as desired.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

NOTE

- Operation with both roll channels disengaged is permitted without limitation.
- With an engine failure at low speed or while reducing airspeed, loss of hydraulic power from the windmilling engine may cause failure of that roll SAS channel and simultaneous automatic disengagement of the other roll channel.

Use of Roll SAS for Single-Engine Landing

To avoid changes in pitch control characteristics at a critical time during single-engine landings, make the approach and landing with all roll SAS off. With both roll channels off, roll response is increased and the airplane feels lighter in roll. Therefore, the roll channels should be turned off early enough to allow the pilot to become accustomed to the new feel prior to landing.

Roll SAS Failure at High Speed

A second roll SAS failure while at high speed will probably be indicated by loss of roll damping or possibly illumination of both roll servo lights.

Loss of ANR (DAFICS Preflight BIT light flashing red) with a single roll sensor failure causes loss of all roll SAS.

Operation with Roll SAS Disengaged

Failure or intentional disengagement of both roll SAS channels is expected to increase pilot fatigue, reduce mission effectiveness, and will disable the roll autopilot and AUTO NAV; however, no hazard to safety should result and there are no flight restrictions for continued operation.

ROLL SAS FAILURE PROCEDURE

This procedure is only initiated after the SAS Emergency Operation procedure is complete.

NOTE

> With A and B CMPTR OUT lights illuminated, roll A & B SENSOR and SERVO lights and roll A & B channels are inoperative.

With A or B ROLL SERVO light illuminated:

1. A and B roll servo switches - Off.
2. Operative roll servo switch - ON.

   A SERVO failed, engage channel B,
   or
   B SERVO failed, engage channel A.

With both ROLL SERVO lights illuminated:

3. A and B roll servo switches - Off.
4. A roll servo switch - ON.

If a hard-over obtained or if no improvement:

5. A roll servo switch - Off.
6. B roll servo switch - ON.

If a hard-over obtained or if no improvement:

7. A and B roll servo switches - Off.

For ROLL SENSOR light illuminated:

8. Check for normal roll damping.

   If normal, a single ROLL SENSOR has failed. Single sensor failure will not disengage or degrade roll SAS.

If abnormal:

9. A and B roll SAS servo switches - Off.

   Both ROLL SENSORS have failed and both roll SAS servos have disengaged.

With ROLL SENSOR light illuminated and ANR failure (DAFICS Preflight BIT light flashing):

10. A and B roll SAS servo switches - Off.

    Roll SAS cannot operate on one sensor unless ANR is available.

ANALYTICAL REDUNDANCY FAILURE

If the BIT FAIL light illuminates flashing, analytical redundancy for pitch, roll, and/or yaw SAS sensors has failed. DAFICS fails ANR if pitch, yaw, or roll rates derived from movement of the inertial platform selected by the pilot (ANS or INS) do not compare with SAS rate gyros in an axis when two SAS rate gyros are operating in that axis. In effect, the two rate gyros are voting out the inertial platform. Because a platform error may be present, the PVD is inhibited when ANR failure is indicated.

Without analytical redundancy, two sensor failures in the pitch and the yaw axis and a single sensor failure in the roll axis will result in loss of all SAS in that axis ("second" condition SAS failure).

A transient failure of analytical redundancy may be cleared by cycling the ATT REF SELECT switch. If the BIT FAIL light continues to flash after cycling the ATT REF SELECT switch, the selected attitude reference may be marginally degraded or unreliable. Analytical redundancy for SAS may be regained by setting the ATT REF SELECT switch to the opposite source, if desired.

ANALYTICAL REDUNDANCY FAILURE PROCEDURE

If the BIT FAIL light illuminates flashing:

▲1. Attitude indicators and annunciator lights - Check.

   Check attitude indicators and the annunciator panel caution lights (ANS REF/INS REF).

2. ATT REF SELECT switch - Cycle.

   Cycling the switch to the other attitude source and back will recycle a transient failure.

If the BIT FAIL light continues to flash:

3. ATT REF SELECT switch - Select other attitude source, if desired.

AUTOPILOT FAILURE

If the pitch axis and/or the roll axis of the autopilot will not engage, the ATT REF SELECT switch must be cycled to reset the DAFICS software; otherwise, the autopilot cannot be reengaged.

If the autopilot will not engage:

▲1. Attitude indicators and annunciator lights - Check.

   Check attitude indicators and the annunciator panel caution lights (ANS REF/INS REF).

2. ATT REF SELECT switch - Cycle.

   Cycling the switch to the other attitude source and back will reset the DAFICS software and permit reengagement.

3. Autopilot - Engage.

DAFICS COMPUTER FAILURES

The A CMPTR OUT, B CMPTR OUT, and M CMPTR OUT caution lights on the pilot's annunciator panel indicate DAFICS computer failures. To reset a computer, momentarily position the corresponding CMPTR RESET switch up and release it. The up position interrupts power to the computer. Releasing the switch restores power and reinitiates computer self-test; the computer will not reset if a fault is detected.

Report all computer failures even if reset was successful.

SINGLE COMPUTER OUT

If the A or B CMPTR OUT annunciator caution light illuminates, computer system redundancy is lost; however, no DAFICS systems are degraded.

With A, B, or M DAFICS computer failed, the forward bypass door duct pressure ratio (DPR) schedule for automatic inlet operation is biased slightly lower on both inlets. The lower DPR schedule causes the forward bypass doors to open slightly and provides increased margin from unstart. The DPR schedule returns to normal if the computer resets.

If the M CMPTR OUT annunciator caution light illuminates, M PTA inputs are lost and the beta (sideslip) value will go to zero. Auto inlet scheduling will not be biased for sideslip and unstarts are likely if the aircraft is yawed. Also, the computer input to the CIP barber pole is disabled and the reference needle displays zero. Altitude change is disabled and IFF MODE C will continue to report the altitude at the time of failure. TAS to the Pilot's & RSO's map projector automatic map rate at the time of failure will continue to be used. DAFICS related signals to the DMRS are disabled. The altitude and TAS values at the time of failure will continue to be sent to the ANS and affects the following:

1) DEAD RECKON MODE (TAS to ANS computer).

2) NAV V/H source (altitude from ANS to V/H).

3) RADAR ALTITUDE (altitude from ANS to CAPRE SLR).

Single Computer Out Procedure

If the A or B or M CMPTR OUT caution light illuminates:

1. Appropriate CMPTR RESET switch - Reset.

If an A or B CMPTR OUT light remains illuminated, no further action is required.

If M CMPTR OUT caution light remains illuminated:

▲2. Use manual map rate.

(3.) V/H SOURCE selector switch - VWSGT or MAN.

(T4.) IFF MODE C switch - OUT.

A AND B COMPUTERS OUT, M COMPUTER OPERATIVE

If only the A and B CMPTR OUT lights illuminate, only the M computer is operating. If the A or B computer cannot be reset, revert to use of pitot-static instruments. If A and B CMPTR OUT caution lights illuminate, both inlets revert to restart unless in manual control. Use the Schedule For Manual Inlet Control, Figure 3-5, for supersonic cruise & descent, and subsonic operation. Refer to Figure 3-16 for the list of operative equipment.

NOTE

The following are inoperative if only the M computer remains.

- TDI (front and rear)
- Auto Inlet
- PITCH & YAW A SENSOR caution lights
- ROLL A & B SENSOR & SERVO caution lights
- ROLL A & B engage switches
- A/P panel controls and indicators
- APW & High Alpha Warning System
- AOA Indicator
- KEAS Warning System
- SURFACE LIMITER annunciator light

NOTE

Since each PTA only sends information to its respective computer, only one PTA remains when two computers are out.

A and B Computers Out Procedure

NOTE

If subsonic, accomplish only * items.

If the A and B CMPTR OUT lights illuminate (M CMPTR OUT not illuminated):

* 1. A CMPTR RESET switch - Reset.

* 2. B CMPTR RESET switch - Reset.

If at least one computer resets, no further action is required.

If both the A and B CMPTR OUT lights remain illuminated:

* 3. Use pitot-static instruments.

4. Use the Schedule For Manual Inlet Control, Figure 3-5.

* 5. A and B ROLL servo switches - Off.

* 6. APW switch - OFF.

If aircraft control difficulties are encountered:

* 7. Complete the SAS Emergency Operation procedure.

If aircraft control does not improve:

* 8. Complete the Pitch or Yaw Axis "Second" Failure procedure.

With A and B computers failed, Pitch A and Yaw A sensors are not available; however, the respective sensor indicator lights on the SAS control panel do not illuminate. Failure of Pitch B and M sensor, or failure of analytical redundancy plus Pitch B or M sensor results in loss of all pitch SAS. Failure of Yaw B and M rate-gyro, failure of analytical redundancy plus Yaw B or M rate-gyro, or failure of Yaw B or M lateral-accelerometer results in loss of all yaw SAS.

(A AND M) OR (B AND M) COMPUTERS OUT

If only the (A and M) or (B and M) CMPTR OUT annunciator panel lights illuminate, most DAFICS functions will remain operating. Aircraft control and performance will not be degraded under this condition; however, either A or B Pitch and Yaw SAS will be inoperative. Although the single operative computer is capable of driving the DAFICS system, there is no longer protection for erroneous outputs from the system. The APW stick pusher is disabled.

The forward bypass door duct pressure ratio (DPR) schedule for automatic inlet operation is biased slightly lower on both inlets. The lower DPR schedule causes the forward bypass doors to open slightly and provides increased margin from unstart. The DPR schedule returns to normal if both computers reset.

NOTE

> Since each PTA only sends information to its respective computer, only one PTA remains when two computers are out.

The TDI's may be inaccurate and inlet unstarts could occur above Mach 1.6, if the operating computer/PTA is supplying unreliable information. See Single Computer Out, this section, for additional equipment disabled due to M computer out.

(A and M) or (B and M) Computers Out Procedure

NOTE

> If subsonic, accomplish only * items.

If only the (A and M) or (B and M) CMPTR OUT lights illuminate:

* 1. A or B CMPTR RESET switch - Reset.

Attempt to reset the failed computer.

* 2. M CMPTR RESET switch - Reset.

If the M computer resets and only the A or B computer cannot be reset, no further action is required. If only the M computer cannot be reset, complete Single Computer Out procedure, this section.

If both the (A and M) or (B and M) CMPTR OUT lights remain illuminated:

3. Maximum supersonic speed - Mach 3.0, 400 KEAS.

   Intermediate Altitude profile is recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.

* 4. Failed pitch and yaw servo switches - Off.

   a. If the A and M computers fail, pitch A and yaw A servos are inoperative.

      Also, the following SENSOR/SERVO lights are inoperative:
      - M PITCH SENSOR light
      - M YAW SENSOR light
      - A PITCH SERVO light
      - A YAW SERVO light

   b. If the B and M computers fail, pitch B and yaw B servos are inoperative.

      Also, the following SENSOR/SERVO lights are inoperative:
      - B PITCH SENSOR light
      - B YAW SENSOR light
      - B PITCH SERVO light
      - B YAW SERVO light

NOTE

> Roll SAS is not degraded with either (A and M) or (B and M) computer failures.

*▲5. Use manual map rate.

*(6.) V/H SOURCE selector switch VWSGT or MAN

*(T7.) IFF MODE C switch - OUT.

* 8. Land when practical.

* 9. C.G. - Forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

* 10. Check TDI against airspeed and altimeter.

If TDI inaccurate (steps 11, 12, and 13):

*11. Use pitot-static instruments.

*12. Autopilot - Off.

*13. AUTO PITCH TRIM ac c/b - Pull.

If inlets unstart repeatedly or schedule abnormally:

14. Use the schedule for Manual Inlet Control.

If aircraft control difficulties are encountered:

*15. Complete the SAS Emergency Operation procedure.

If aircraft control does not improve:

*16. Complete the Pitch or Yaw Axis "Second" Condition Failure procedure.

With A and M computers failed, Pitch M and Yaw M sensors are not available and Pitch A and Yaw A servos are inoperative; however, the respective sensor and servo indicator lights on the SAS control panel do not illuminate. Failure of Pitch A and B sensors, failure of analytical redundancy plus Pitch A or B sensor, or failure of Pitch B servo results in loss of all pitch SAS. Failure of Yaw A and B rate-gyros, failure of analytical redundancy plus Yaw A or B rate-gyro, failure of Yaw A or B lateral-accelerometer or failure of Yaw B servo results in loss of all yaw SAS.

With B and M computers failed, Pitch B and Yaw B sensors are not available and Pitch B and Yaw B servos are inoperative; however, the respective sensor and servo indicator lights on the SAS control panel do not illuminate. Failure of Pitch A and M sensors, failure of analytical redundancy plus Pitch A or M sensor, or failure of Pitch A servo results in loss of all pitch SAS. Failure of Yaw A and M rate-gyros, failure of analytical redundancy plus Yaw A or M rate-gyro, failure of Yaw A or M lateral-accelerometer, or failure of Yaw A servo results in loss of all yaw SAS.

A, B AND M COMPUTERS OUT

If the A, B, and M CMPTR OUT caution lights illuminate, both inlets revert to restart unless in manual control. Use pitot-static instruments.

NOTE

The following systems or items are inoperative if all three DAFICS computers fail.

- TDI (front and rear)
- Auto Inlet
- Manual Inlet (If M computer loses A and C or B and C phase power)
- SAS
- Autopilot
- Mach Trim
- APW & High Alpha Warning
- AOA Indicator
- KEAS Warning
- CIP Barber Pole
- IFF Mode C
- Automatic Map Rate
- Altitude from ANS to V/H and RADAR
- TAS to ANS
- MRS (DAFICS related portions)
- All warning, caution, and condition lights on the main annunciator panel and system panels, associated with the above systems, will not illuminate.
- SURFACE LIMITER annunciator panel light will not illuminate.

WARNING

Only A, B, and M CMPTR OUT lights illuminate if all three DAFICS computers fail.

EQUIPMENT AVAILABLE WITH DAFICS COMPUTER(S) OUT

COMPUTER(S) OUT					
None or A or B	M	A and M	B and M	A and B	A, B and M
Auto Inlets	X	X	X		
Manual Inlets (See NOTE)	X	X	X	X	X
A Pitch Servo	X		X	X	
B Pitch Servo	X	X		X	
A Yaw Servo	X		X	X	
B Yaw Servo	X	X		X	
A Roll Servo	X	X	X		
B Roll Servo	X	X	X		
Mach Trim	X	X	X	X	
Autopilot	X	X	X		
APW & High Alpha Warning	X	X	X		
KEAS Warning	X	X	X		
AOA Indicator	X	X	X		
TDI (Pilot's & RSO's)	X	X	X		
Surface Limiter Caution Light	X	X	X		
DMRS (DAFICS Portions)				X	
CIP Barber Pole				X	
Altitude Reporting				X	
Altitude & TAS to ANS				X	
TAS to Auto Map Rate				X	
X Indicates Equipment Available					

NOTE: Manual Inlet control is disabled if the M computer loses A and C phase or B and C phase power.

Figure 3-16

A, B and M Computers Out Procedure

NOTE

If subsonic, accomplish only * items.

* 1. A CMPTR RESET switch - Reset.
* 2. B CMPTR RESET switch - Reset.
* 3. M CMPTR RESET switch - Reset.

If any of the computers reset, refer to the appropriate procedure for the computers which remain out.

If none of the computers reset:

4. Emergency ac bus switch -EMER AC BUS (up).

If any of the computers reset, refer to the appropriate procedure for the computers which remain out.

If none of the computers reset:

5. Restarts ON simultaneously.

 The throttle restart switch will expeditiously put both inlets in restart.

6. Maintain 350 KEAS.
7. Aft bypass - CLOSE.

Above Mach 2.5:

8. Throttles - 720° to Military.
9. IGV switches - LOCKOUT.
10. C. G. - Forward of 22%.

At Mach 2.5:

11. Throttles - Set 6500 rpm.

At Mach 2.0:

*12. C.G. - Forward of 20%.

*▲13. Use manual map rate.

*14. V/H SOURCE selector switch - VWSGT or MAN.

*T15. IFF MODE C switch - Out.

*16. Resume normal checklist procedures.

*17. Land when practical.

APW and HIGH ALPHA WARNING SYSTEMS

NOTE

- o With A and B CMPTR OUT lights illuminated, both the APW and High Alpha Warning systems are inoperative, but the APW annunciator light will not illuminate.
- o The APW stick shaker and pusher are disabled while the APW annunciator light is on.
- o The APW stick pusher is disabled when any two DAFICS computers are inoperative.

If DAFICS detects a 2 PTA failure, both the 2 PTA CHAN OUT and the APW annunciator caution lights illuminate. Refer to the 2 PTA Channels Out procedure, this section.

If the APW switch is OFF, the High Angle of Attack Warning system stick shaker will continue to operate. The High Alpha Warning system shaker limits are 14° when below Mach 1.55, and 8° when above Mach 1.55. The High Alpha Warning system may be unreliable if the 2 PTA CHAN OUT annunciator light illuminates.

The ADI pitch boundary indication continues to operate with the APW switch OFF. However, it should be considered unreliable if the APW light was illuminated before the APW switch was OFF or any of the following caution light combinations exist:

- 2 PTA CHAN OUT
- A and B CMPTR OUT
- PITCH SENSOR A, B and M

NOTE

Hydraulic power for APW stick pusher is lost if the A Hydraulic system fails.

The stick pusher assembly is a hydraulically powered piston. A solenoid valve on the assembly allows A hydro pressure to extend the piston when it receives an electrical signal from DAFICS. It is possible, through a series of failures in DAFICS, to have the stick pusher assembly extend. With an additional failure to retract, it would require 30 to 35 pounds pull force on the control stick to overpower the stick pusher spring; the control stick trigger and APW control switch would be ineffective. Inadvertent pusher activation could be particularly hazardous when supersonic or near the ground.

If the APW pusher extends, the elevons deflect 1.7° down from the trimmed position and the control stick moves 2.5° (1.5 inches) forward of neutral. A pull force on the stick of 30 to 35 pounds will be required to overpower the forward stick displacement. Pitch trim capability remains and can be used to retrim the elevons and relieve the stick force; however, the stick will remain approximately 2.5° (1.5 inches) forward of the original neutral position unless the pilot pulls aft with 30 to 35 pounds in addition to the normal stick force gradient. No abnormal force is required to move the stick <u>forward</u> of the new neutral position.

With trim indication at zero, the maximum manual up-elevon deflection is 10° (11.7° up from the new neutral position) with the APW pusher extended. This is due to mechanical limits in the mixer assembly. When the pusher is extended, the manual down-elevon deflection available, with trim indication at zero, remains 10° (8.3° down from the new neutral position).

WARNING

Immediately depress and hold the control stick trigger switch to deactivate the APW stick pusher if a false stick pusher activation occurs while close to the ground. If the stick pusher is not deactivated by the trigger, use a pull force of 30 to 35 pounds, in addition to normal stick forces, to overcome the stick pusher. Use pitch trim to relieve stick force.

For false stick pusher:

1. **TRIGGER HOLD.**

   Depress and hold the control stick trigger switch until the APW switch is turned off.

For continuous stick shaker operation, or false pusher warnings:

2. Pitch attitude - Keep within limits.
3. APW switch - OFF.

   Trim as required. Trim position affects up-elevon authority.

NOTE

If the stick trigger or APW switch do not deactivate the stick pusher, use a pull force of 30 to 35 pounds, in addition to normal stick forces, to overcome the stick pusher spring. Use control stick pitch trim to relieve stick force.

If shaker continues:

4. STALL WARN dc circuit breaker - Pull.

If false pusher continues:

5. Speed - A maximum speed of Mach 3.0 is recommended.

If higher speed must be maintained, the maximum recommended bank angle is 35°.

WARNING

Keep at least one hand on the control stick and monitor the ADI and stick position for any tendency of the aircraft to increase nose-up attitude in response to release of the stick pusher actuator.

NOTE

- Unless absolutely necessary, air refueling is not recommended because of the reduced elevon deflection available with the APW pusher extended.
- A c.g. aft of 19% is recommended for landing, to reduce elevon requirements.
- Trim position effects up-elevon authority. Use nose-up trim if increased elevon deflection is required for refueling or landing.

With an unreliable alpha indication:

6. Land when practical.

TWO PTA CHANNELS OUT

If the 2 PTA CHAN OUT annunciator caution light illuminates, air data functions may be unreliable although they will continue to operate.

If DAFICS detects a 2 PTA failure, both the 2 PTA CHAN OUT and the APW annunciator caution lights illuminate. The APW stick shaker and pusher are inoperative while the APW annunciator light is illuminated. The APW light may subsequently extinguish, but the 2 PTA CHAN OUT light will remain on until reset by maintenance personnel.

TDI and alpha indications should be cross-checked against the pitot-static operated airspeed and altitude instruments. If the cross-check shows the TDI to be inaccurate, revert to pitot-static operated airspeed and altitude instruments for aircraft control. Inlet unstarts can be expected above Mach 1.6 if TDI and alpha information is unreliable; the AUTO PITCH TRIM essential ac circuit breaker should be pulled and the autopilot should be turned off. SAS gain schedules may be in error and could result in poor aircraft damping in all three aircraft axes. Caution should be exercised about magnitude of rudder motion and angle of attack excursions induced. If inlets unstart, use manual control, referring to the pitot-static Mach and altitude instruments. If inlets do not clear, use the Inlet Unstart procedure, this section.

If all PTA self-check signals to the DAFICS computers fail, OFF flags appear in both TDIs. Air data functions are unreliable, although they may continue to operate.

2 PTA CHANNELS OUT PROCEDURE

If the 2 PTA CHAN OUT light illuminates, it will remain on until reset by maintenance personnel.

1. Check TDI against airspeed and altimeter.

If TDI inaccurate:

2. Use pitot-static operated instruments.
3. Autopilot - OFF.
4. AUTO PITCH TRIM ac c/b - Pull.

If inlets unstart repeatedly or schedule abnormally:

5. Complete the Inlet Unstart procedure.
6. AOA - Check Accuracy.

AIR DATA MALFUNCTION

Each PTA (A, B, M) is powered by its respective (A, B, M) computer. When the M CMPTR OUT annunciator caution light illuminates, the M PTA is not powered and the beta (sideslip) value goes to zero. Appropriate procedures are included in DAFICS Computer Failure procedures, this section.

Sideslip angle data is only provided by the M PTA. If sideslip data is erroneous, spike and door scheduling on <u>both</u> inlets will be biased excessively and may cause an unacceptable degradation in performance. If required, refer to Inlet Malfunction, this section.

If DAFICS is not receiving sideslip angle data from the M PTA (as determined by PTA self test), or the sideslip angle from the M PTA is unreasonably high (as determined by comparison with the yaw SAS lateral accelerometers), the angle of sideslip used for automatic inlet operation computations is zero and the DPR schedules for both inlets are biased slightly lower. Auto inlet scheduling will not be biased for sideslips, and unstarts are likely if the aircraft is yawed significantly. If unstarts occur, refer to Inlet Unstart and Inlet Malfunction, this section.

If air data malfunctions are not associated with DAFICS computer failures, refer to Two PTA Channels Out procedure, this section.

If accuracy of air data is suspect:

1. Cross-check TDI against pitot-static airspeed, Mach and altimeter.

If cross-check shows both TDI <u>and</u> pitot-static indications to be suspect:

2. Complete the Pitot-Static System Malfunction procedure.

If cross-check shows only TDI to be inaccurate:

3. Complete the 2 PTA Channels Out procedure.

PITOT-STATIC SYSTEM MALFUNCTION

The pitot and static pressure sources for the TDI are separate from the pitot and static sources for the pilot's airspeed, altimeter and inertial-lead vertical speed indicator; however, both pitot and static pressures are sensed in the nose boom. Both of the pitot-static sources may become inaccurate or inoperative from a common malfunction. In icing conditions, failure of the pitot heater may affect both systems (and angle of attack indication). The pitot probe also could be plugged by a foreign body.

If both TDI <u>and</u> pilot's direct pitot-static instruments are unreliable:

1. Maintain aircraft control by use of attitude and power.

2. Check pitot heat switch and circuit breaker.

3. Request chase aircraft for letdown and landing.

NAVIGATION SYSTEMS

Refer to Section IV for ANS and INS warning indications.

ANS MALFUNCTION

If the ANS REF annunciator caution light illuminates in either cockpit:

▲1. ATT REF SELECT switch - INS.

T 2. DISPLAY MODE SEL switch - Other than ANS.

(3) BDHI HDG SELECT switch - INS.

(T4) ANS circuit breakers - Check.

(T5) Follow MAL light procedures.

INS MALFUNCTION

▲1. ATT REF SELECT switch - ANS.

T 2. DISPLAY MODE SEL switch - ANS.

(3) BDHI HDG SELECT switch - ANS.

(T4) If the INS attitude appears reasonable, set the INS FUNCTION switch to ATT, BDHI HDG SELECT to INS, and set heading with HEADING SLEW knob.

▲5. ATT REF SELECT switch - As desired.

6. DISPLAY MODE SEL switch - As desired.

(T7) Cross-check and reset INS heading as required.

(T8) If the INS attitude is in error, perform the INS Airborne Attitude Alignment procedure.

ENVIRONMENTAL CONTROL SYSTEM

L OR R AIR SYSTEM OUT

If one air conditioning system fails or if the L or R AIR SYS OUT annunciator caution light illuminates:

1. Bay Air switch - OFF.

   This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

(2.) Chine bay equipment (except MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

If supersonic:

3. Cockpit temperature control rheostat - COLD, if necessary.

   Approximately 75% of the normal flow of cooling air to the cockpits remains available.

4. Descend when practical.

   Supersonic cruise can be maintained indefinitely at reduced cooling if the power to the mission equipment is turned off.

5. Monitor E and R bay temperatures for indication of overheat.

COCKPIT OVERTEMPERATURE

High cockpit temperatures can result from failure of the cockpit air mixing valve, manifold temperature control valve, or hot air bypass valve. They can also result from malfunction of the cold air manifold, or cockpit air automatic or manual temperature controls, or if operation of an air cycle machine cooling turbine is marginal. High temperatures can also result from high fuel temperatures in the heat sink system, or if high back-pressure at the cooling turbines prevents effective operation.

With abnormally high cockpit air temperatures, check E and R Bay temperature. Suspect the cockpit temperature control system if E and R Bay and suit vent temperatures are normal.

1. Defog switch - Check CLOSED.

▲2. Cabin pressure select switch - 26,000 FT.

If automatic temperature control is not effective and cockpit temperature remains too high:

3. Cockpit temperature override switch - Hold in COLD.

NOTE

The motor driven valve takes from 7 to 13 seconds to travel from full hot to full cold.

4. Check E and R Bay temperature.

If there is no decrease in cockpit temperature in 30 seconds, or if the E and R Bay are also hot:

5. Manifold temperature switch - FULL COLD.

If there is no decrease in cockpit temperature in 30 seconds:

6. MANF TEMP dc circuit breaker - Pull.

   This deenergizes the hot air bypass solenoids, closes the hot air bypass valves (if open), and results in maximum available air-to-air and air-to-fuel cooling.

7. Bay Air switch - OFF.

   This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

(8.) Chine bay equipment (except MRS) -Off.

CAUTION

+ The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

If supersonic:

9. Descend as soon as possible.

If below 25,000 feet MSL and temperature remains too hot:

(T10.) Cockpit air shutoff control - OFF (forward).

COCKPIT TOO COLD

Cockpit air and suit vent air temperatures may become unbearably low, even when cruising at high Mach, with some types of air conditioning system malfunctions or if the FULL COLD position of the manifold temperature control switch is selected inadvertently. Temperatures may be substantially below -30°F. A landing may be necessary if the condition cannot be corrected. In general, the aft cockpit will be colder. If the automatic and manual temperature controls are ineffective with AUTO manifold temperature selected, attempt to minimize suit vent air flow and increase suit air temperature. The pilot can use defog air to heat the forward cockpit. If these actions are not sufficient, shut off an air conditioning unit. Positioning the cockpit air handle OFF shuts off the cockpit air supply but does not shut off suit vent air flow.

1. Manifold temperature switch - Check in AUTO.

If in AUTO or no response:

2. Cockpit temperature override switch - Hold in HOT.

▲3. Suit Air Vent - As required.

4. Suit heat - Increase.

If cockpit temperature remains uncomfortably cold:

T 5. Defog switch - OPEN

   Defog air will only heat the pilot's cockpit.

If temperature remains uncomfortably cold:

6. One refrigeration switch - OFF.

▲7. Cabin pressure select switch - 10,000 FT.

If below 25,000 feet MSL and temperature remains too cold:

(T8.) Cockpit air shutoff control - OFF (forward).

COCKPIT DEPRESSURIZATION

If the cockpit pressure is above 35,000 feet, the pressure suits will inflate.

1. Cockpit altitude - Check.

▲2. Canopy seal levers - Check ON.

3. Cockpit pressure dump switch - Check OFF.

   If all cockpit pressure has been lost (cockpit pressure equals ambient pressure), cycle the cockpit pressure dump switch, if desired.

(T4.) Cockpit air shutoff control - Check on (aft).

WARNING

During this time, the crew members will be depending on the pressure suit for altitude protection.

If cockpit does not repressurize:

5. Descend as soon as possible.

CAUTION

Loss of cockpit pressurization, or cockpit air off at supersonic cruise will cause overheat and subsequent failure of the PTAs if a descent is not begun within 15 minutes.

SUIT OVERTEMPERATURE

1. Suit heat rheostat - OFF (full counterclockwise).

If tank 3 is near empty:

2. Press tank 2 on.

   At high Mach, as tank 3 nears empty, the temperature of tank fuel supplied to the fuel manifold and the fuel-air heat exchangers increases due to high skin temperature.

3. SUIT HTR ac c/b - Pull.

▲4. Suit vent flow - Restrict.

5. L and R AIR SYS OUT lights - Check.

6. Cockpit temperature - Check.

   If cockpit temperature is excessive, complete the Cockpit Overtemperature procedure, this section.

If overtemperature persists:

7. Descend as soon as possible.

E OR R BAY OVERHEAT

If E or R BAY OVERHEAT caution light illuminates:

1. Bay air temperature - Check.

   An indication in excess of 150°F confirms the overheat warning.

2. Manifold temperature switch - FULL COLD.

NOTE

An ANS undertemperature condition (ANS steady TOLR light indication) may eventually result from selecting FULL COLD.

▲3. Nonessential bay equipment (except MRS) - Off.

If overtemperature continues:

4. Descend when practical.

When overtemperature corrected:

5. Manifold temperature switch - AUTO.

LIFE SUPPORT SYSTEMS

NOTE

Steps with a # apply to the crewmember with a life support system malfunction.

BREATHING OR SUIT PRESSURIZATION DIFFICULTY PROCEDURE

\# 1. Advise other crewmember.

WARNING

If a breathing difficulty is experienced, immediately notify the other crewmember and check personal equipment and oxygen system controls, lights, and quantity and pressure indications.

For a suit or helmet leak, or if No. 1 <u>and</u> No. 2 oxygen systems are lost:

2. Begin normal descent.

For oxygen system or breathing difficulty, if using the emergency oxygen system, or for a helmet leak, descend below 10,000 feet cabin altitude (10,000 feet aircraft altitude, terrain and range permitting). Monitor oxygen system pressure and quantity.

With loss of Number 1 and 2 systems, the integrity of the standby system is suspect, as failures within Number 1 and 2 systems could result in loss of the standby system when it is selected. Be prepared to use the emergency oxygen supply.

For a leak in the pressure suit, descend below FL 350.

If either crewmember experiences continued difficulty in breathing or maintaining oxygen flow:

3. Make emergency descent.

\# 4. Emergency oxygen - Pull GREEN APPLE.

The dual emergency oxygen system provides sufficient duration for a normal descent if the helmet and emergency systems are intact.

▲5. Cockpit pressure select switch - 10,000 FT.

As the aircraft descends (with 10,000 FT selected), cockpit altitude will decrease toward the 5.0 psi differential pressure schedule shown by Figure 1-81. At 45,000 feet, for example, the cockpit altitude will be less than 19,000 feet.

For suit inflation:

6. Bay Air switch - OFF.

With partial suit inflation, cockpit pressure may be restored by turning bay air off. This also reduces cockpit out-flow by closing the nose air shutoff valve. With the bay air and nose air valves closed, there is sufficient engine bleed air pressure to maintain cockpit pressurization until engine speeds approach windmilling rpm.

▲7. Non-essential bay equipment (except MRS) - Off.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

8. Land when practical.

If either crewmember experiences abnormal psysiological symptoms or decompression sickness, land as soon as possible.

USE OF STANDBY OXYGEN SYSTEM

If one or both normal oxygen systems fail:

1. Standby oxygen system - ON, to failed system.

▲2. Standby system quantity and pressure - Monitor.

Switch liquid oxygen system quantity switch as necessary to monitor both systems.

If standby system quantity or pressure is depleting rapidly:

3. Standby oxygen system - ON, to other ship system.

4. Standby oxygen system - OFF, to failed system.

▲5. Monitor quantity and pressure of the remaining oxygen supply.

Be prepared to activate emergency oxygen (GREEN APPLE).

USE OF EMERGENCY OXYGEN

With loss of all three aircraft oxygen systems due to failures other than separation at the seat connection point, the individual crewmember's emergency oxygen should be available. Emergency oxygen duration is approximately 15 minutes.

#1. Pull GREEN APPLE.

CONTAMINATED OXYGEN

▲1. Pull GREEN APPLE.

▲2. No. 1 and/or No. 2 Oxygen supply levers - OFF.

Because emergency oxygen system regulated pressure is lower than the aircraft system pressure, turn the normal oxygen system supply lever(s) to OFF after actuating emergency oxygen if contamination of the aircraft system is suspected. Emergency oxygen duration is approximately 15 minutes.

USE OF PRESSURE SUIT AIR WITH ALL OXYGEN LOST

Aircraft ventilation air is capable of increasing suit pressure approximately 2.35 psi above cabin pressure. If all oxygen supplies are lost, it may be possible to establish ventilation airflow into the oral nasal cavity of the helmet by inflating the suit and loosening the face seal.

#1. Suit controller valve - Close.

NOTE

Tighten the helmet tie-down strap.

#2. Suit vent air valve - Open.

#3. Face seal - Loosen.

Loosen the face seal with the barrier control knob to aid airflow from the suit into the face area of the helmet.

4. Bay Air switch - OFF.

Shut off the bay air supply to make the most air pressure available to the cockpit and suit while descending. Make emergency descent.

(5) Chine bay equipment (except (MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

▲6. Cockpit pressure select switch - 10,000 FT.

7. Autopilot - KEAS HOLD and AUTO NAV, as desired.

   Consider using the autopilot with KEAS HOLD and AUTO NAV engaged to assist a safe descent.

(8.) RSO be prepared to eject.

   If the pilot has lost oxygen, the RSO must closely monitor attitude and speed, and evaluate the pilot's capability of making a successful recovery. If the pilot does not respond, and if aircraft control is obviously lost, the RSO should eject.

LOSS OF VISOR HEAT

Without visor heat, moisture could condense in the helmet and cause the oxygen controller to freeze during bailout.

#1. Check FACE HTR dc circuit breaker and communication cord.

2. Cockpit temperature - Increase near 100°F.

   Increase cockpit air temperature by use of automatic or manual air temperature controls. Defog air may also be used.

   Loss of visor heat can be a minor discrepancy if visor fogging and moisture condensation are controlled by increasing cockpit temperature and use of defog air.

If visor fogging begins to block vision:

#3. Insert feeding/drinking probe into helmet feeding port.

   This will help clear the visor by allowing a continuous flow of oxygen.

4. Descend below 10,000 foot cabin altitude, terrain and range permitting.

5. Autopilot - KEAS HOLD and AUTO NAV, as desired.

   Consider using the autopilot with KEAS HOLD and AUTO NAV engaged to assist a safe descent.

#6. Raise visor.

LOSS OF SUIT VENT AIR

#1. Check vent hose connection.

If affected crewmember perspires excessively:

2. Adjust cockpit temperature.

DRAG CHUTE SYSTEM

DRAG CHUTE UNSAFE WARNING

If the DRAG CHUTE UNSAFE annunciator caution light illuminates because of power loss to both actuator motors, the chute could still be in a safe condition and would not have to be deployed. However, to verify that loss of power to the actuator motors has occurred and that the chute mechanism is safe (will not deploy inadvertently):

While subsonic:

1. Airspeed - Establish 275-295 KEAS

   Speeds between 275 and 295 KEAS assure failure of the chute canopy, panel and/or shroud lines. Deploying the chute at lower speeds (255 KEAS or less) may result in a successful (unwanted) deployment. Maximum power would be insufficient to overcome the drag and break away the chute.

   WARNING

   Do not deploy the chute while supersonic.

2. Drag chute handle - Pull to deploy position then push to jettison position.

   Break away is accompanied by a slight nose-up pitching motion and a momentary shock. The pilot may hear a loud noise as chute separation or failure occurs. Depending on the nature of the break away, shroud lines may remain attached and stream behind the aircraft.

If the chute does not deploy and break away, assume that the chute mechanism is safe. Use emergency (mechanical) deployment after landing.

NOTE

The DRAG CHUTE circuit breakers on the pilot's essential dc circuit breaker panel may be pulled, if desired.

3. Land when practical.

After landing, if drag chute did not deploy and breakaway:

4. Drag chute - Deploy mechanically.

   Emergency chute deployment will be necessary after landing. A suitable base with a dry or grooved runway is preferred.

NOTE

If the light illuminates when committed to a landing, land and be prepared to deploy the chute mechanically.

LANDING EMERGENCIES

SINGLE-ENGINE PENETRATION & LANDING

This procedure may be used in lieu of the normal Before Penetration, Penetration, Before Landing and After Touchdown procedures when one engine is inoperative and the Engine Shutdown & Descent procedure has been completed. In addition, refer to All Weather Operation procedures, Section VII, when applicable.

1. Display mode selector switch - Set.

T 2. Defog switch - Set.

T 3. Altimeter - Set.

(4.) DEF systems power - OFF.

(5.) Sensor operate switches - STP.

(6.) Sensor power switches - Off.

(7.) V/H power switch - OFF.

(8.) Exposure power switch - OFF.

NOTE

Do not shut down the MRS.

(9.) G-Band Beacon switch - OFF.

(T10.) INS altitude - Update.

Update the INS altitude to field elevation.

11. Gross Weight & c.g. - Dump & transfer fuel as required.

When time and conditions permit, dump fuel to obtain normal landing weight. Monitor c.g. Transfer fuel as necessary to maintain subsonic c.g. limits (17-22%). If c.g. is between 14.5% and 17% no more than half the remaining fuel may be transferred to tank 1; otherwise, the reduced load factor limits shown by sheet 3 of Figure 5-5 are not valid.

12. Crossfeed switch - Pressed OPEN.

CAUTION

Leave crossfeed open to assure fuel supply to the engine(s) during landing and possible use of afterburner.

13. SAS channels - Set.

 a. Operative engine pitch and yaw SAS - ON.

 b. Inoperative engine SAS servos - Off.

 b. Both roll SAS servos - Off.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

Below Mach 0.5:

14. Brakes & antiskid - Set.

 a. For left engine failed - ALT STEER & BRAKES.

 b. For right engine failed - ANTI-SKID ON.

 (T) c. Brake switch - OFF.

 d. Set antiskid - DRY/WET.

Use the DRY antiskid position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume that a wet runway condition exists if moisture is visible on the runway, particularly as evidenced by glare or reflections.

15. Surface limiter control handle - Pulled, light off.

Pull and rotate the surface limiter handle 90 degrees to disengage the surface limiters, lock the handle, and extinguish the SURFACE LIMITER caution light.

▲16. UHF power selector - Set.

Set power 4 or lower if making ILS approach.

T 17. Defog switch - Set.

18. Landing light switch - Set.

▲19. Approach and landing speeds - Compute.

The minimum approach speed is 200 KIAS. If it is necessary to land with more than 35,000 pounds of fuel remaining, add 1 knot for each additional 1000 pounds.

A single-engine landing is basically the same as normal landing. Expand the pattern to avoid steep turns. Establish a steeper than normal final approach. A rate of descent of 1500 fpm is recommended.

Attempt to dump fuel and avoid a heavy weight landing if an instrument approach is required. When landing at heavy weight, the single-engine performance available with maximum power may not be sufficient to maintain a 2.5° glide path with the gear down.

At heavy weights, increase airspeed as necessary to maintain angle of attack less than 8 degrees for turns to base leg and 9 degrees for turns to final approach.

The APW stick pusher is inoperative if the A hydraulic system has failed.

20. Landing gear lever - DOWN and checked.

Check gear warning lights.

a. For left engine failed, put landing gear handle DOWN. If L HYD pressure is insufficient to lower the gear, use Gear Emergency Extension procedure, this section.

Allow additional time to lower the gear if the left engine is windmilling and normal gear extension is attempted.

At least 90 seconds must be allowed for gear emergency extension if the L hydraulic system is inoperative.

b. For right engine failed (if the left hydraulic system is operating), the landing gear may be lowered on final approach. Normal gear extension time is 12 to 16 seconds.

21. Hydraulic pressure - Checked.

With both engines operating (simulated single-engine, ADS failure, etc):

22. Right refrigeration switch - OFF.

(T23.) Cockpit air handle - OFF.

Place the cockpit air handle in the forward (valve closed) position to preclude cockpit fogging. The pilot's CKPT AIR OFF caution light should illuminate.

24. Annunciator panel - Checked.

NOTE

Lowering the vision splitter during night landings will reduce the glare caused by reflections off the inside of the windshield.

25. Rudder trim - Neutral.

During single-engine approach, the required rudder and bank compensation changes as thrust is varied. Set the rudder trim indication to neutral before landing so that, after power is reduced to idle in the flare, rudder position will be normal for landing.

When landing is assured, retard throttle smoothly and make a normal landing.

After touchdown:

26. Drag chute - Deploy

27. Nosewheel steering - Engage

28. Brakes - Checked

29. Retain drag chute, if practical.

    Jettison the drag chute for directional control, if required.

    Retain the drag chute, if practical, to reduce demand on the operative brake system.

    If the antiskid system relieves brake pressure and wheel rpm does not increase within 2.7 seconds: the antiskid fail-safe circuit should deactivate antiskid and illuminate the ANTI SKID OUT annunciator caution light; and braking without antiskid protection should become available.

    The L hydraulic system accumulator may provide up to 3 brake applications; however, the brake accumulator is not required to hold a charge after L hydraulic system failure.

With loss of L hydraulic pressure:

30. Stop straight ahead, have downlocks installed before clearing runway.

After landing, continue to monitor the ANS temperature lights.

CAUTION

Shut down the ANS after landing if the TEMP TOLR light flashes. This minimizes the possibility of ANS damage due to high internal temperatures.

SIMULATED SINGLE-ENGINE LANDING

Directional trim changes are more pronounced during an actual single-engine approach with one engine windmilling.

1. Retard one throttle to IDLE.
2. Follow Single-Engine Penetration & Landing procedure.

SINGLE-ENGINE GO-AROUND

Make decision to go-around as soon as possible and definitely prior to flare.

1. Throttle - As required.
2. Leave gear down until go-around is assured.
3. Landing gear lever - UP, as appropriate.

   Delay gear retraction until there is no possibility of contacting the runway.

4. Accelerate to 275 KIAS.

LANDING GEAR SYSTEM EMERGENCIES

GEAR UNSAFE INDICATION

An unsafe indication could be caused by low L hydraulic system pressure or malfunction within the landing gear extension or indicating system. With unsafe gear indication:

1. Landing gear CONT dc and landing gear IND dc circuit breakers - Check.
2. (T) Landing gear switch - DOWN.
3. L hydraulic pressure - Check.
4. IND & LT TEST Push-button - Press.

   If a landing gear indicator light does not illuminate, either the indicator light circuit is faulty or the light bulb is burned out. Switching light bulbs with one known to be operative may restore a gear safe indication.

5. Recycle landing gear lever to down position, repeat as required.

If landing gear still indicates unsafe:

6. Accomplish Gear Emergency Extension procedure.

GEAR EMERGENCY EXTENSION

The landing gear emergency extension system unlocks the landing gear uplocks and allows the landing gear to free-fall to the down-and-locked position. The landing gear handle should be placed in the DOWN position and the landing gear control circuit breaker should be pulled to permit emergency gear extension. If the landing gear handle cannot be placed DOWN and the landing gear CONT circuit breaker is not pulled, the landing gear will retract if there is pressure in the R hydraulic system. The time required for emergency gear extension is 60 to 90 seconds. The emergency landing gear release handle must be pulled approximately 9 inches for full actuation. If it is not fully actuated, one or more gear may fail to extend. Up to 65 pounds of force is required.

If inability to extend the gear is due to a failure in the plastic knob on the landing gear control handle, slide the pin forward 1/4 inch to release a catch within the control handle mechanism, then push the gear handle down. Refer to Figure 3-17.

If normal gear extension is unsuccessful:

1. Landing gear handle - DOWN.

(T) 2. Landing gear switch - DOWN.

3. Landing gear CONT dc circuit breaker - Pull. (For SR-71B, also pull landing gear WARN dc circuit breaker).

4. Emergency landing gear release handle - Pull.

   Pull the GEAR RELEASE handle approximately 9-1/3 inch. Up to 65 pounds of force is required.

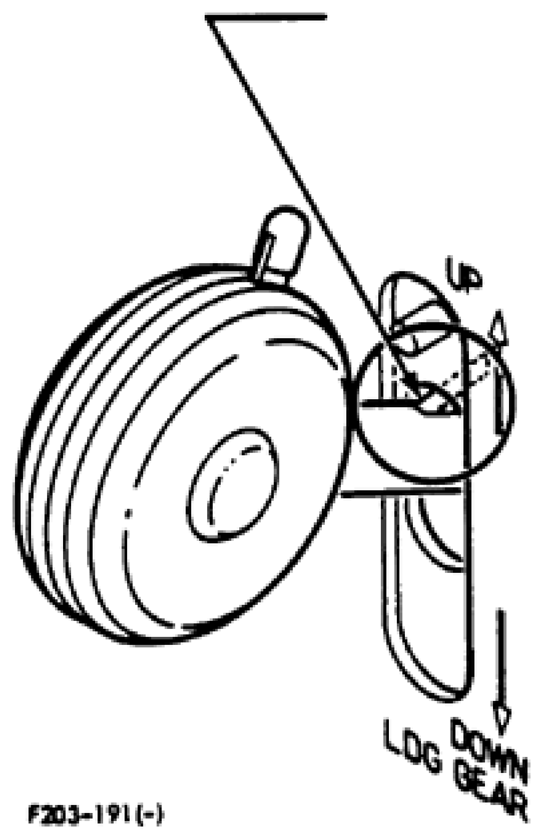


Figure 3-17

CAUTION

The landing gear must not be retracted while the emergency gear release handle is pulled as damage to the system can result. The GEAR RELEASE handle must be stowed before attempting to retract the gear.

If gear is down and locked and R hydraulic pressure is normal:

5. Brake switch - ALT STEER & BRAKE.

   With the landing gear CONT dc circuit breaker open, selecting ALT STEER & BRAKE restores nosewheel steering. Hydraulic power for nosewheel steering is automatically supplied by the L system if its pressure remains above 2200 psi; otherwise, the R system will provide hydraulic power. Power for the brake system will be supplied by the R hydraulic system and the antiskid system will be operative.

   The landing gear strut dampers will be inoperative unless L system hydraulic pressure remains available. The normal brake system accumulator pressure is isolated so that its pressure is not dumped when ALT STEER & BRAKE is selected; however, the brake accumulator is not required to hold a charge after L hydraulic system failure.

6. Retain the drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

7. Stop straight ahead, have downlocks installed before taxiing.

If gear still indicates unsafe:

8. Increasing airspeed and pitch pulses may lock a partially extended nose gear.

9. Yawing aircraft may lock a partially extended main landing gear.

If gear appears down, but still indicates unsafe:

10. Igniter purge switch - Dump during approach.

    Holding the spring-loaded switch up for 40 seconds will dump a full load of TEB.

11. Battery switch - OFF.

▲12. Shoulder harness - Manually LOCK.

13. Make normal landing on side of runway away from unsafe gear.

14. Hold weight off unsafe gear, lower nose at 130 KIAS.

15. Retain the drag chute after landing, if practical.

    Jettison the drag chute for directional control, if required.

16. Stop straight ahead, have downlocks installed before taxiing.

If gear is definitely not down and locked:

17. Accomplish Partial Gear Landing procedure.

PARTIAL GEAR LANDING

A landing with the nose gear retracted or with all gear up should not be attempted. Under ideal circumstances, a landing with the nose gear extended and both main wheels retracted may be possible. If this configuration can be accomplished, base a decision to land or eject on whether or not other factors are favorable.

If a decision is made to land, conventional final approach and landing speeds and attitudes are recommended. This will result in the tail touching while the nose height is less than normal. An attempt to hold the aircraft off by using a higher pitch angle is not recommended because of the greater possibility of high impact loads as the nose gear slaps down. Tank 1 should be empty, if possible.

1. Acccomplish nose-gear-only configuration, as follows:

   a. Landing gear CONT dc circuit breaker - Push in.

   b. Landing gear lever - Up.

   c. Landing gear CONT dc circuit breaker - Pull.

   d. Emergency gear release handle -Pull to release nose gear only (first lock releases nose gear). Check nose gear down light - ON.

2. Do not transfer fuel forward.

3. Fuel dump switch - DUMP, if necessary.

4. Igniter purge switch - Dump during approach.

   Holding the spring-loaded switch up for 40 seconds will dump a full tank of TEB.

5. Battery switch - OFF.

▲6. Shoulder harness - Manually LOCK.

▲7. Canopy jettison handle - Pull, if desired.

NOTE

If the canopy is not jettisoned prior to landing, it should not be unlocked until the aircraft has stopped.

8. Make normal approach and landing.

9. Drag chute - Deploy.

(T) a. Drag chute switch - OFF.

10. Use rudders for directional control.

11. Retain the drag chute after landing, if practical.

Jettison the drag chute for directional control, if required.

12. Throttles - OFF, when directional control is no longer possible.

NOTE

Interphone will not be powered.

▲13. Abandon aircraft.

MAIN GEAR FLAT TIRE LANDING

For a landing with one or more flat tires, turn the antiskid system off to obtain effective braking. With antiskid on, the brake system prevents spin-down of the inboard and outboard wheels of each truck. If either or both of these tires has failed, normal runway contact is not made and they tend to lock-up when braking is attempted. The antiskid system defeats the braking attempt by releasing brake pressure as soon as the wheel starts to spin down.

Plan the landing for minimum gross weight, and touchdown on the good truck first on the side of the runway away from the flat tire(s). Little danger exists when landing at light weight if only one tire on a truck has failed, as the remaining tires have sufficient strength to support the aircraft. If two tires on a truck have failed, the third may fail during the roll-out because of the overload.

When all tires on a truck are known to have failed, apply enough brake pressure to lock all three wheels on that side. Maintain the pressure to prevent spin-up and the tire/wheel fragmentation that might result with rolling wheels. Use asymmetric braking (modulating the opposite side), nosewheel steering, and rudder and elevon roll inputs for directional control and stopping.

Engine shutdown is not recommended unless critical for stopping. Do not shut down the engine on the downwind side if an appreciable crosswind exists. Left engine shutdown would require selection of the alternate brake system. Therefore, if a choice exists, landing into the wind or at least with the right engine into the crosswind is preferable. After S/B R-2695, if the left engine must be shut down, select the alternate brake system then depress and hold the trigger switch to disable antiskid.

With all tires failed on both trucks, lock the wheels and skid to a stop rather than risk wheel fragmentation. Use the nosewheel and aerodynamic steering for directional control.

1. Gross weight - Dump fuel to obtain minimum gross weight.

2. Antiskid - OFF.

3. Make normal landing on side of runway away from flat tire(s).

4. Touch down on good tires.

5. Hold weight off bad side as long as possible using full aileron.

6. Drag chute - Deploy, as soon as possible.

(T) a. Drag chute switch - OFF.

7. Nosewheel - Lower.

8. Nosewheel steering - Engage.

9. Brakes - Apply cautiously.

   Refer to Abort procedure, this section.

10. Use nosewheel steering and differential braking for directional control.

11. Retain drag chute after landing, if practical.

    Jettison the drag chute for directional control, if required.

WARNING

If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

BLOWN MAIN GEAR TIRE AFTER LANDING

If main gear tire failure is suspected or occurs after touchdown and braking is abnormal:

1. **ANTISKID OFF.**

   Set the brake switch to OFF or, after S/B R-2695, depress and hold the trigger switch.

   Tire failure may be heard or felt by the crew; however, the primary indication of failure is ineffective braking on one side with antiskid braking selected. Refer to the Main Gear Flat Tire Landing procedure.

CAUTION

- If antiskid OFF is selected, R system hydraulic power is not available for braking or steering.
- The antiskid brakes are disabled if the landing gear BRK & SKD dc circuit breaker is opened. The alternate brake and the alternate nosewheel steering systems are also disabled.

2. Brakes - Apply cautiously.

   If tire failure occurs, increased brake pressure will be required to maintain braking force on the remaining tires. Moderate to heavy brake pressure may be required to prevent spin-up of wheels with failed tires and wheel and/or tire disintegration at high rotational speeds. Refer to Abort and Main Gear Flat Tire Landing, this section.

3. Nosewheel steering - Check engaged.

   Check for illumination of the STEER ON light.

4. Use nosewheel steering and differential braking for directional control.

5. Retain drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

WARNING

If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

NOSE GEAR FLAT TIRE LANDING

If it is necessary to land with a flat nosewheel tire(s), avoid c.g. forward of 20% if possible.

1. C.G. - 20% to 22%.

After normal touchdown:

2. Drag chute - Deploy.

   (T) a. Drag chute switch - OFF.

3. Nose gear - Hold off to 130 knots, then lower gently.

4. Use nosewheel steering and differential braking for directional control.

5. Retain the drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

After stop, before shutdown:

6. C.G. - Forward of 17%.

LANDING WITHOUT NOSEWHEEL STEERING

It should be possible to stop safely without nosewheel steering when landing on a dry or grooved runway with crosswind components within recommended values. However, crosswinds combined with a slippery runway or damaged tire can be hazardous.

NOTE

> Do not overcontrol the aircraft on a slippery runway and start a lateral skid. The reduced side reaction force capability of the main gear tires may result in a "break out" and slide.

Distinguish between aircraft heading and ground track. A lateral skid can develop if the main gear loses traction because of a slippery runway and/or damaged main gear tires. The ground track will probably diverge downwind. First, attempt to regain traction by steering into the skid. If this is successful, bring the heading back parallel to the runway centerline, then steer to the upwind side of the runway. Steer by applying roll control first. After full elevon deflection is reached, use rudder as necessary. Lateral stick deflection toward the desired direction of heading change should start a turn, but without the side force in the opposite direction which the rudders produce. Upwind rudder deflection produces a turn, but also results in a downwind rudder force which compounds the downwind skid problem.

Jettison the drag chute if roll control and use of the rudders fails to correct the ground track and it appears that the aircraft may slide off the runway. Otherwise, retain the drag chute.

If traction cannot be regained by turning into the skid, and if the ground track continues to diverge, try bringing the aircraft heading around so that it is well upwind of the ground track direction. This moves the relative wind to the other side of the nose, and puts the upwind weathercock force in the direction of the ground track. The thrust component of the idling engines tends to correct the track. If the aircraft continues to slide, the weathercock force will tend to rotate the heading back into the relative wind. Use roll control first, then the rudders, to keep the heading upwind and maintain a track on the runway. Use differential braking whenever main gear traction can be regained.

NOTE

> Assymmetric thrust is not recommended for directional control because of the difficulty expected in obtaining a controlled and timely response. Lateral stick and rudder steering should be adequate to control aircraft heading. However, if an otherwise irretrievable drift has developed, short bursts of equal thrust on both engines may correct the ground track to stay on the runway for barrier engagement. Thrust is in the proper direction to help regain runway position.

The effects of the weathercock force and aerodynamic steering with the elevons and rudders is shown by Figure 3-18 for a heavy crosswind combined with a slippery runway and ineffective nosewheel steering.

FLAT STRUT LANDING

The initial indication of a flat strut on landing is a 5^{o} - 10^{o} wing low condition after touchdown, and a directional control characteristic similar to that for crosswinds. Directional control may be difficult. The wings-not-level attitude is similar to that for all tires blown on one side and causes uneven loading of the inboard and outboard tires on each truck. This may result in wheel spin-down for the more lightly loaded tires during braking. Protracted cycling of the antiskid

EFFECTS OF WEATHERCOCK FORCE AND AERODYNAMIC STEERING ON CROSSWIND LANDING WITHOUT NOSEWHEEL STEERING

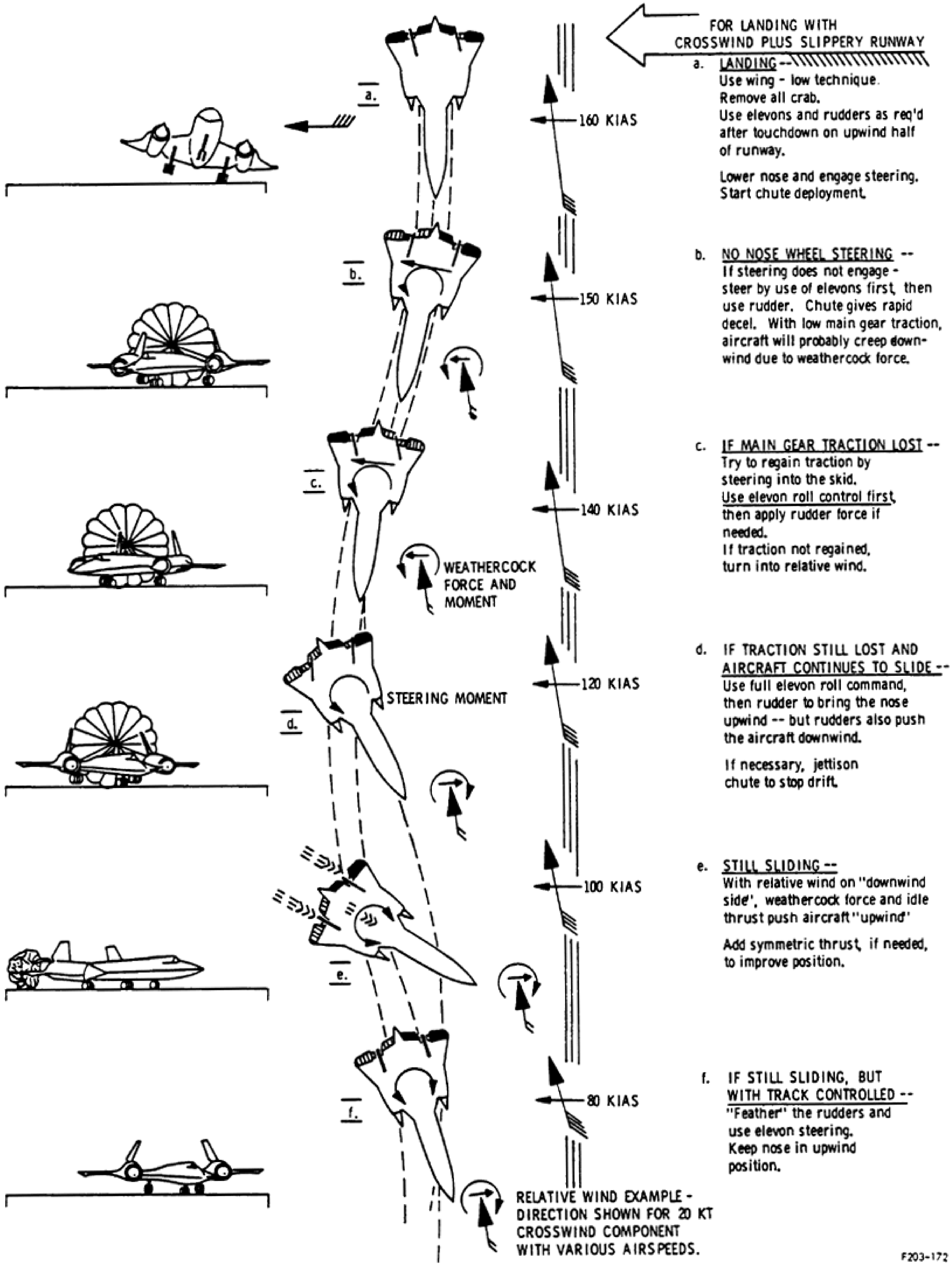


Figure 3-18

[redacted]

system can occur and result in reduced braking effectiveness if the antiskid system is not turned off. When brakes are applied, the lightly loaded tires may blow out.

After stop, clear the runway and wait for assistance. If inflation of the strut is not possible, the other strut should be deflated to 1" clearance to reduce side loads during aircraft movement. Slow taxiing is permitted; however, towing is recommended.

FLAT STRUT LANDING PROCEDURE

1. Antiskid - OFF.

After landing:

2. Drag chute - Deploy.

   (T) a. Drag chute switch - Off.

3. Lower nose immediately.

4. Nosewheel steering - Engage.

5. Brakes - Apply cautiously.

6. Use nosewheel steering and differential braking for directional control.

7. Retain the drag chute, if practical.

   Jettison the drag chute for directional control, if required.

WARNING

If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

GEAR DOWN AIR REFUELING

During air refueling rendezvous, airspeed must be monitored to prevent exceeding landing gear limits. Engine response is very rapid; therefore, throttle movements just prior to and during contact should be less than those used at normal refueling altitudes.

COCKPIT FOG

COCKPIT DEFOGGING

The possibility of cockpit fogging exists when ambient humidity is high. When the ambient air is cooled below its dew point temperature, moisture condenses into fog. Fogging will be most noticeable near sea level when near Military rpm. Under these conditions, the rate of airflow into the cockpit is greatest and the air may be cooled to as low as 37°F.

Cockpit Temperature Control

To eliminate cockpit fog, raise the temperature of the cockpit air to evaporate the moisture. This can be accomplished by either manual or automatic control of cockpit temperature.

AUTO TEMP Control Positioning

If cockpit fog is anticipated due to high ambient humidity, attempt to set the automatic temperature control to maintain cockpit temperature at or slightly above ambient temperature while the engines are at a high rpm. A little experimenting should establish a position on the AUTO TEMP selector that prevents excessive fogging. After takeoff, readjust the control for comfort. The same control position may be reestablished prior to landing to prevent fogging.

Water Separators

To minimize system pressure drop and to maintain maximum refrigeration capacity, the aircraft is not provided with a water separator in the cockpit air supply duct. A water separator in the cockpit system would cause considerable back-pressure at the cooling turbines. Water separators provided in the supply ducting to the ANS and mission equipment do not affect the overall refrigeration system performance. The equipment bays are not pressurized and additional pressure drop at these points does not raise the cooling turbine discharge pressure.

If fogging is encountered and increasing cockpit temperature is not practical:

(T1.) COCKPIT AIR OFF.

Position the cockpit air handle off (forward).

2. Right refrigeration switch - OFF.

Turn both refrigeration switches off if the cockpit air handle is inoperative; however, this will result in loss of cooling air to the ANS and requires ANS shutdown.

If cockpit fog persists:

3. Defog switch - OPEN, then HOLD.

Defog hot air is available to raise the cockpit air temperature and evaporate the moisture, unless both refrigerators are turned off.

4. Bay air switch - OFF.

5. Cockpit temperature override switch - COLD 10 sec, then HOLD.

This causes the cockpit temperature control valve to close and prevents excessive hot air from entering the cold air manifold.

DAMAGED AIR REFUELING RECEPTACLE

If the air refueling receptacle is damaged, or if streaming fuel is reported after landing, make a complete stop on the runway and attempt to obtain precautionary assistance from fire fighting personnel and equipment before taxiing. If immediate taxiing is necessary to clear the runway, accomplish the turn at slow speed to minimize fuel spillage. Fuel sloshing from a damaged receptacle can be ingested by an inlet if taxi speed is not minimized while turning.

WARNING LIGHTS SYSTEM

Illumination of any light(s) on the annunciator panels indicates an abnormal or emergency operating condition, or a situation deserving special attention. A summary of the lights and recommended actions is provided in Figure 3-19.

TACTICAL LIMITS

Normal Restrictions vs Tactical Limits

If the crew finds the normal operating restrictions unacceptable because of operations in a hostile area, the pilot is authorized to use the tactical limits listed in Figure 3-20 to exit the hostile area by the most expeditious means.

The margin of safety provided by the tactical limits is substantially reduced and exposure to such limits must be as brief as possible. They are to be used only when adherence to the normal/emergency restrictions would place the aircraft in a more hazardous situation because of probable hostile actions. Subsequent reentry into situations which rely on use of these limits is NOT authorized.

Figure 3-20 summarizes the existing operating restrictions and the tactical limits which are authorized with various malfunctioning systems. The term "tactical limits" is NOT synonymous with aircraft limits provided in Section V.

WARNING

The use of tactical limits is not authorized for training conditions, or for operational missions outside a hostile area.

EMERGENCY ENTRANCE

If qualified ground personnel are not available, use the procedures illustrated in Figure 3-21 for emergency access to the cockpits and crew.

ANNUNCIATOR PANEL LIGHTS ANALYSIS CHART

LIGHT	CONDITION	RECOMMEMDED ACTION
RED WARNINGS		
C.G.	c.g. aft 25.3% or fwd of 17%	Correct c.g. Transfer fuel or manually select tanks.
FUEL PRESS	Pressure to engine below 7 psi	Open crossfeed and press tank 4 on.
A or B HYD	Quan below 1-1/4 gal or press below 2200 psi	Descend if supersonic. If pressure low, stay below 350 KEAS, check SAS, & land.
L or R HYD	Quan below 1-1/4 gal	Restart on and begin descent to subsonic speed.
OIL QTY	Eng quan below 2-1/4 gal	Descend if supersonic. Monitor pressure.
OIL TEMP		Not functionally operating. Will only illuminate when the IND & TEST button is depressed.
TANK PRESS	Tank press below 0.25 psi	Check LN_2 quan. Decrease rate of descent.
AMBER CAUTIONS		
A CMPTR OUT	No degradation of DAFICS for single failure.	Reset A computer. Redundancy is lost if computer does not reset.
AIR SYS OUT	Air cond sys off or failed	Bay air off. Chine eqpt off (except MRS). Temp control to COLD. Monitor bay temps.
ANS FAIL ANS REF	ANS hdg & attitude ref lost. RSO's MAL or TEMP LIMIT warning on, or nav sys not ready.	Set attitude ref to INS. RSO check ANS for MAL or TEMP LIMIT. Shutdown ANS if req'd.
ANTI-SKID OUT	Anti skid braking inop	Recycle anti-skid or set anti-skid off. If L HYD light on, set alt steer & brake.
AUTO NAV OUT	Autopilot Auto Nav mode disengaged	RSO confirm that AutoNav off desired.
APW	Auto pitch warn sys off	Monitor α . Check ADI pitch boundary ind. High α system still operates stick shaker.
AUTO PILOT OFF	Autopilot disengaged or will not engage	Check attitude reference. Cycle ATT REF SE-LECT switch. Reengage autopilot if desired.
BAY AIR OFF	Bay Air switch off	Turn Bay Air switch on. If no result, mainten-ance action required before flight.
BAY OVERHEAT	Bay temp over 150° F	Set manifold temp FULL COLD. Turn non-essential bay equipment off.
B CMPTR OUT	No degradation of DAFICS for single failure	Reset B computer. Redundancy is lost if computer does not reset.
CANOPY UNSAFE	Canopy not locked, or seal not inflated	Check latches, handles fwd & locked, seal pressure on. Land if canopy unsafe.
CKPT AIR OFF	RSO's cockpit air handle off (fwd)	If landing: turn R refrig off. If temp high: use cockpit o'temp procedure.
DRAG CHUTE UNSAFE	Mechanism unsafe, or pwr lost to both chute motors	In flt, try norm deploy at safe alt & 275-295 KEAS subsonic. Use emer deploy after landing.
EMER BAT ON	Ess dc on battery pwr. Both gens or T/R's off	Attitude ref to INS, check instr inv & SAS. Try to reset gens if out. If no result, control c.g., conserve batteries, and land.

Figure 3-19 (Sheet 1 of 2)

ANNUNCIATOR PANEL LIGHTS ANALYSIS CHART

LIGHT	CONDITION	RECOMMENDED ACTION
FUEL QTY LOW	At $6^{\circ}\alpha$, tank 1 below 5400 lb. and tank 4 below 4050 lb.	Xfeed open. Check fuel sequencing. If total fuel qty is low, land or refuel. If low qty not confirmed in tank 1 or 4, cycle A/R switch.
GEN BUS TIE OPEN	ac buses are split	No action unless ac power erratic;,then cycle the right gen to OFF and NORM.
GEN OUT	Respective generator is disconnected.	Recycle gen, check bus tie light, land ASAP. 350 KEAS & Mach 2.8 are limits with one gen.
INS REF	INS hdg inaccurate, cmptr or platform failed.	Select ANS attitude reference. RSO check INS heading and attitude.
INSTR INVERTER ON	Both gens out. Emer ac on inverter pwr.	If gen power cannot be restored to dc bus, conserve batteries and land.
MANUAL INLET	Restart on, or spike/door controls not all in auto.	If manual op not desired, turn restart off or turn spike & fwd door controls to Auto.
M CMPTR OUT	Inop: CIP-barber pole, automatic map rate, RADAR ALTITUDE, TAS to the ANS, and IFF Mode C.	Reset M computer. If computer does not reset, refer to SINGLE COMPUTER OUT.
N QTY LOW	Respective LN_2 sys quan below 3 liters.	Monitor fuel tank pressure. Limit speed is Mach 2.6 if all LN_2 low.
OXY PRESS LOW	Respective oxy sys press below 50 psi.	Use standby oxygen system.
OXY QTY LOW	Respective oxy sys quan below 1 liter.	Use standby oxygen system.
PITOT HEAT	Pitot heat switch in wrong position.	Check altitude. Change pitot heat switch position.
SAS OUT	Flight Mode	Try to recycle failed sensor or servo. Refer to SAS Lights Chart.
	Ground Test Mode	If BIT TEST light is flashing, press one of the six recycle switches.
SENSOR FAIL	Sensor malfunction	RSO check PWR & Sensor panel for fail indication.
SURFACE LIMITER	Surface limiter position not correct	Engage or release limiter handle.
2 PTA CHAN OUT	Air data may be unreliable	Check pitot-static instruments. Turn Autopilot Off. Pull AUTO PITCH TRIM ac c/b. If inlets unstart use manual inlet control & schedule.
WINDSHIELD DEICE ON	Windshield hot air on.	Monitor need for hot air de-icing.
XFMR RECT OUT	Respective transformer-rectifier not supplying pwr	For both lights on, check battery & SAS on. Land as soon as possible.

Figure 3-19 (Sheet 2 of 2)

TACTICAL LIMITS

Condition	Present Limit or Restriction	Tactical Limit
Limit Mach, Speed and Altitude Schedule -- With automatic inlets	Mach 3.2, aft c.g. limit - 25% MAC. Min airspeed - 310 KEAS unless restricted by 8° α or APW boundary. 85,000 ft max altitude. 45° max bank angle.	Mach 3.3 permitted with aft c.g. limit - 24.3% MAC when authorized by the commander.
With manual inlet control	Mach 3.0, aft c.g. limit - 25% MAC. Min airspeed - 310 KEAS unless restricted by 6° α or APW boundary. 400 KEAS max above FL 700. 80,000 ft max altitude. 20° max bank above FL 750, 35° max bank above FL 700.	Mach 3.2 permitted with aft c.g. limit - 24% MAC.
With loss of LN_2	Mach 2.6 maximum. -0.5 psi min tank pressure.	If in climb or cruise, Mach 3.2 and 85,000 ft max. Decel to Mach 2.6 10 minutes before descent and deceleration to subsonic speed and altitude conditions. Loiter 10 minutes between FL 400 and 350 at 0.9 Mach (above 250 KEAS) before refueling or landing if LN_2 is lost above Mach 2.6 while descending.
Single generator failure	Mach 2.8, 350 KEAS maximum.	Mach 3.2, 400 KEAS maximum.
SAS pitch or yaw, first failure	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.	Mach 3.2 permitted with aft c.g. limit - 24% MAC. 400 KEAS maximum.
SAS pitch or yaw, second failure	Mach 2.0, 350 KEAS maximum Aft c.g. limit - 22% MAC.	Speed available with both restart switches on, maximum afterburner, aft c.g. limit - 22% MAC.
L or R hydro system failed, or L and R hydro systems failed	Mach 2.3 maximum.	Speed available with one or both restart switches on, maximum afterburner.
A or B hydro system failed	Subsonic Mach required, 350 KEAS maximum.	Mach 3.2 permitted, 350 KEAS maximum.
High compressor inlet temperature	427° C CIT maximum	450° C CIT permitted with rpm within normal limits and Mach number within tactical limit. Report maximum CIT and time above 427° C. One hour total accumulated time allowed per engine.
High engine rpm	7450 rpm below 300° C CIT and 7300 rpm above 300° C CIT. Report maximum rpm and time above limit rpm if overspeed occurs.	7500 rpm permitted below 300° C CIT and 7350 rpm above 300° C CIT. Report maximum rpm and time above normal rpm limit if overspeed occurs.

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Figure 3-20

CRASH RESCUE PROCEDURES

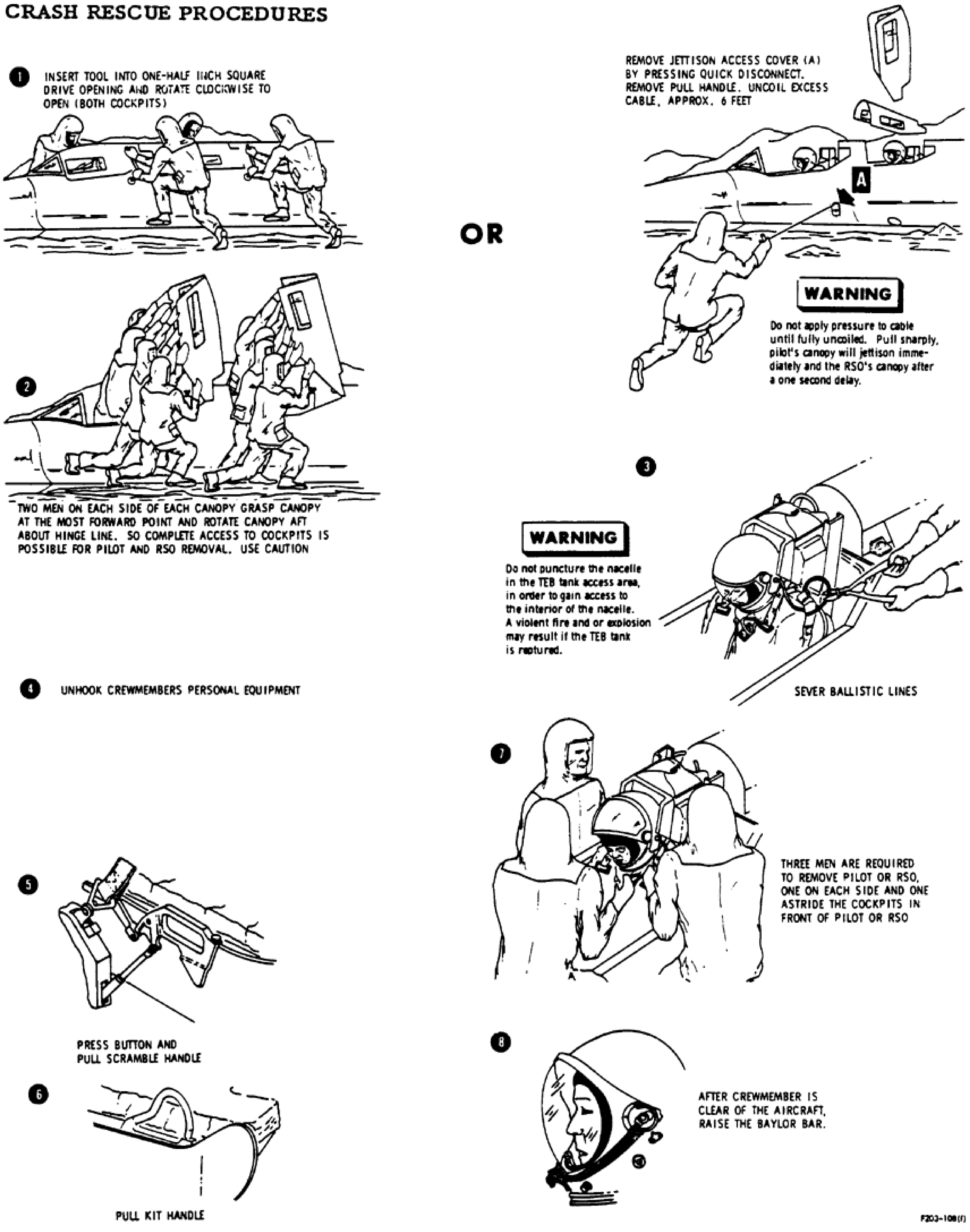

Figure 3-21

ASTROINERTIAL NAVIGATION SYSTEM (ANS) TAPE 12

The ANS is an inertial navigation system employing a star tracker to eliminate gyro drift and to limit position error. The system provides a steering signal to the autopilot for guiding the aircraft automatically along a predetermined flight path. It provides heading, attitude, and position information to cockpit displays. The ANS can control the CAPRE side-looking radar and technical objective cameras for imaging operations. The ANS supplies navigational data to the electromagnetic - reconnaissance sensor and mission data to the mission recorder system. See Figure 4-1 for an ANS functional diagram.

SYSTEM INTERFACES

The ANS provides signals for aircraft sytems as seen in Figure 4-1. The following equipment is either controlled by or receives inputs from the ANS:

1. DAFICS (for Autopilot and SAS analytical redundancy (ANR)).
2. Attitude Indicators (Pilot and RSO).
3. Flight Director Computer.
4. Horizontal Situation Indicator (Pilot).
5. Bearing, Distance, Heading Indicator (RSO).
6. Mission Recorder System.
7. EIP.
8. Technical Objective Cameras (in AUTO).
9. Optical Bar Camera
10. V/H System.
11. Viewsight.
12. Radar, including the RCD (controlled when in AUTO).
13. RSO Annunciator Panel.
14. Pilot Annunciator Panel.
15. Sensor time counter driver.
16. Peripheral Vision Display (PVD).

MODES OF OPERATION

The navigation system has four navigation modes: (1) astro inertial, (2) inertial only, (3) airstart (airspeed-damped astro inertial), and (4) dead reckoning. Figure 4-2 summarizes the navigational errors expected in each mode. The mode to be employed depends on the time for activation and alignment, and whether the aircraft is on the ground or airborne when the ANS is turned on. Astro inertial is the preferred mode.

ASTRO INERTIAL Mode

In this mode, navigation errors will be relatively small, depending on the alignment method, and do not increase with mission duration. As soon as the system begins navigating the star tracker automatically begins to search for stars. Stars are normally tracked at night and during the day provided good sky conditions exist. A 61 star catalog is stored in the ANS computer. Either normal or special coverage for the SR-71B trainer can be provided. The sun, moon and planets, are not used by the star-tracker. At least two different stars must be tracked for optimum performance. The star tracker measures the difference between the inertial platform orientation and celestial computed position. Data derived from stars is used to correct true heading, computed position, computed velocity, platform tilt, and gyro drift rates. Measured gyro drift rates are stored in the computer memory and are used to improve any subsequent inertial only navigation. This sequence eliminates the unbounded position error growth characteristic of pure inertial systems.

In a normal mission, either a rapid or gyro compassing alignment is performed prior to navigation. These alignments require 18 minutes and 36 minutes respectively, exclusive

NAVIGATION AND SENSOR CONTROL SYSTEM

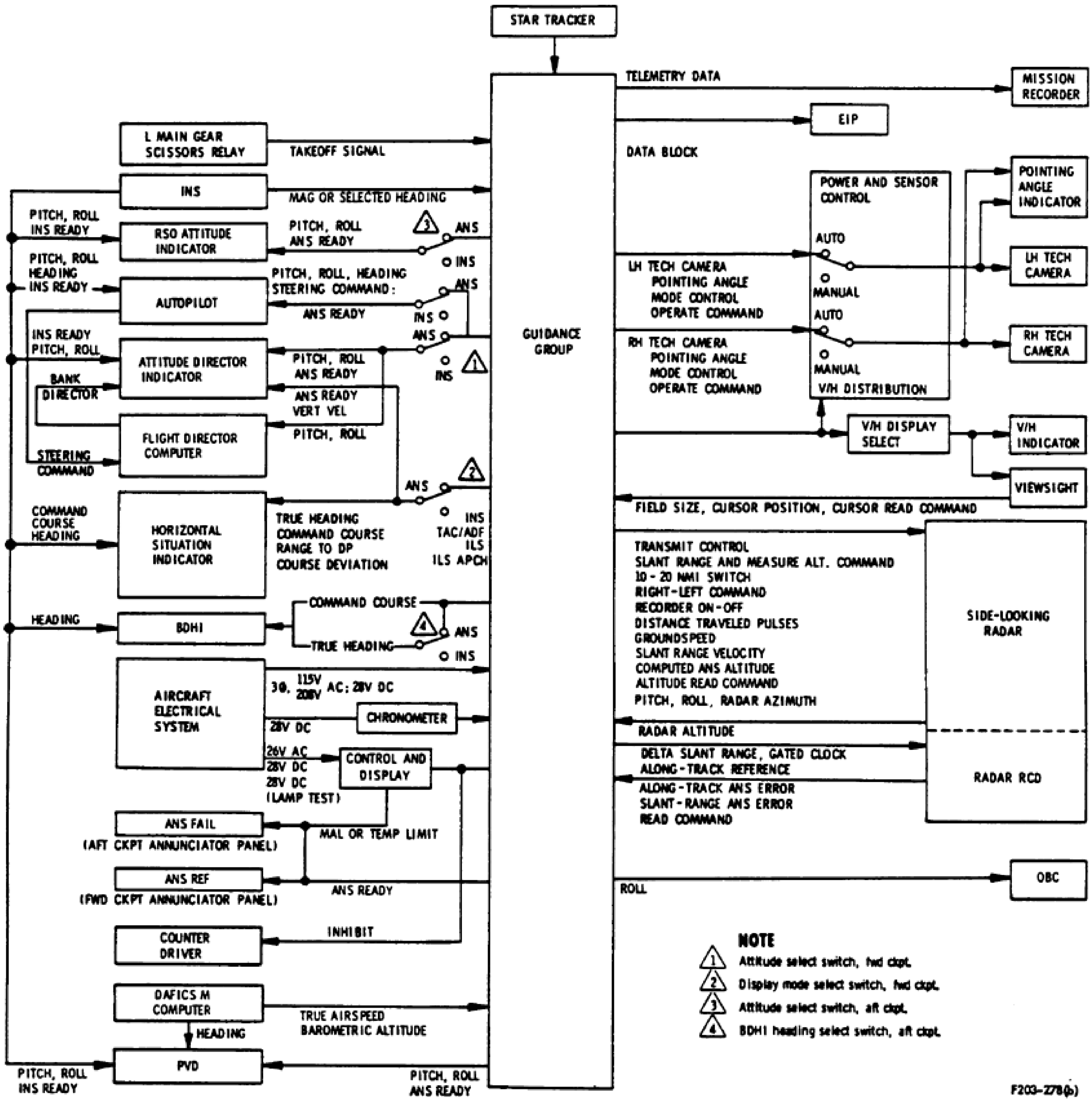

Figure 4-1

of warmup time. A ground hot start can be performed on a system previously aligned and shut down or on a system which has been shut down after operation in the astro inertial or inertial-only mode, provided the aircraft has not been moved. A runway heading alignment is recommended after a rapid alignment or a ground hot start. A heading update may or may not be required.

INERTIAL-ONLY Mode

INERTIAL-ONLY mode, in which only the inertial portion of the astroinertial system is employed, is recommended when the star-tracking capability of the navigation system is impaired. In this mode, navigation errors are unbounded.

AIRSTART Mode

The airspeed-damped, astro inertial (airstart) mode, which uses both the inertial platform and star tracker, is intended for: (1) scramble-initiated flights when the system is not prepared for a ground hot start, and (2) restart in flight. In this mode, errors can be large at first but should damp down with time to the values in Figure 4-2. Dead reckoning data are used for present position until three different stars have been acquired (steady illumination of the star ON light). Star acquisition is critical for accurate navigation.

Dead Reckon Mode (DR)

If the ANS inertial platform fails, navigation may continue using dead reckoning. In DEAD RECKON mode the ANS computer navigates using heading from the INS, true airspeed from the DAFICS (M computer) and inflight winds filled by the RSO. Position error increases proportional to errors in these inputs.

SYSTEM ERRORS

Error values in Figure 4-2 are based on the high altitude flight profiles. Abnormal flight profiles (low-altitude, race-track, touch-and-go, etc.,) may result in errors in excess of the listed values. The error values listed are probable radial errors (CEP's); therefore, under normal system operation, the listed errors will be exceeded about half the time. When star tracking is lost, a residual position error may develop that will not be totally eliminated when star tracking resumes. It might take as many as 3 navigation position updates (depending on Schuler cycle period) and a steady C star light to eliminate the total residual error.

SYSTEM COMPONENTS

The navigation system has three major assemblies: the control and display panel, the portable chronometer, and the guidance group. The control and display panel (Figure 4-3), located on the aft cockpit right console, is used to activate the system, select modes of operation, insert and monitor navigational data, modify the mission flight plan, and observe operating status.

A portable chronometer, in the aft cockpit supplies Greenwich Mean Time (GMT) (accurate to one-hundredth of a second) and the Julian date to establish the orientation of the Earth in inertial space for astro-inertial operations. The chronometer is set in the base shop, using a time standard set up to receive WWV time signals. Day can be set up to 511, thus allowing use of the computer star catalog into the next calendar year. A fully-charged, self-contained battery permits timekeeping for up to 24 hours without other power. Chronometer outputs are enabled only when aircraft power is applied. There is a GO, NO-GO indicator on the chronometer. GO indicates that either external or battery power is available and that the chronometer is operable, but does not indicate that the correct day and time is set. NO-GO indicates that chronometer outputs are unreliable.

The guidance group contains the electronic and optical-mechanical equipment for navigation and avionics subsystems control. The guidance group is mounted in the fuselage aft of the rear cockpit to provide an upward 78-degree cone of vision for the star-tracking telescope. The axis of the cone is vertical

NAVIGATION MODE PROBABLE RADIAL ERROR

NAVIGATION MODE	ALIGNMENT METHOD			
	GRD HOT START	RAPID	AIRSTART	GYROCOMPASS
ASTRO INERTIAL (4) (3)	1.0 nmi	0.3 nmi (up to 10 hrs) (5)	—	0.3 nmi (up to 10 hrs)
INERTIAL ONLY (1) (with fixpoints every hour)	5.0 nmi/hr	2 nmi/hr 1.28 nmi	—	2 nmi/hr 1.28 nmi
AIRSTART (without fixpoints)	—	—	after 2 hrs: 1.75 nmi	
(with 2 fixpoints in first hr 20±5 min apart) (1)	—	—	after 1 hr: 1.25 nmi	
DEAD RECKONING	(2) 55 nmi/hr (Depends on INS and DAFICS accuracy)			

(1) Using fixpoints ascertained to 1-nmi accuracy
(2) No alignment required - Accuracy only as good as inputs (W/V, Hdg, MV, TAS)
(3) Without continuous star tracking, errors approaching inertial operation can develop
(4) With current accelerometer null bias calibration
(5) With heading entry accurate to 0.1 degree

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Figure 4-2

when the aircraft pitch angle is 7-1/2 degrees. The guidance group includes an inertially stabilized platform and associated electronic and electromechanical components required to control (1) its attitude, (2) a star-tracking telescope, and (3) the electronic and electromechanical components for pointing, servo-controlling, and discrimination of telescope photo-detections. A digital computer computes auto-navigation, guidance and avionics control, and maintains a continuously updated account of navigational status and coordinate values. The computer also stores instrument and mathematical coefficients, predetermined data references that define stars, and the mission flight plan. The computer initiates and evaluates self-tests periodically throughout the operating interval. Software corrections to the star data are provided for: (1) the shock wave over the window that refracts the star light and (2) pressure and temperature gradients (differentials) acting on the window causing optical lens effects.

NAVIGATION CONTROL AND DISPLAY PANEL (NCD)

The NCD (Figure 4-3) on the aft cockpit right console controls the ANS.

NOTE

The positions of the ANS controls and the last pushbutton operations are recorded once each 0.832 seconds by the MRS. Events can be marked by using the ANS keyboard.

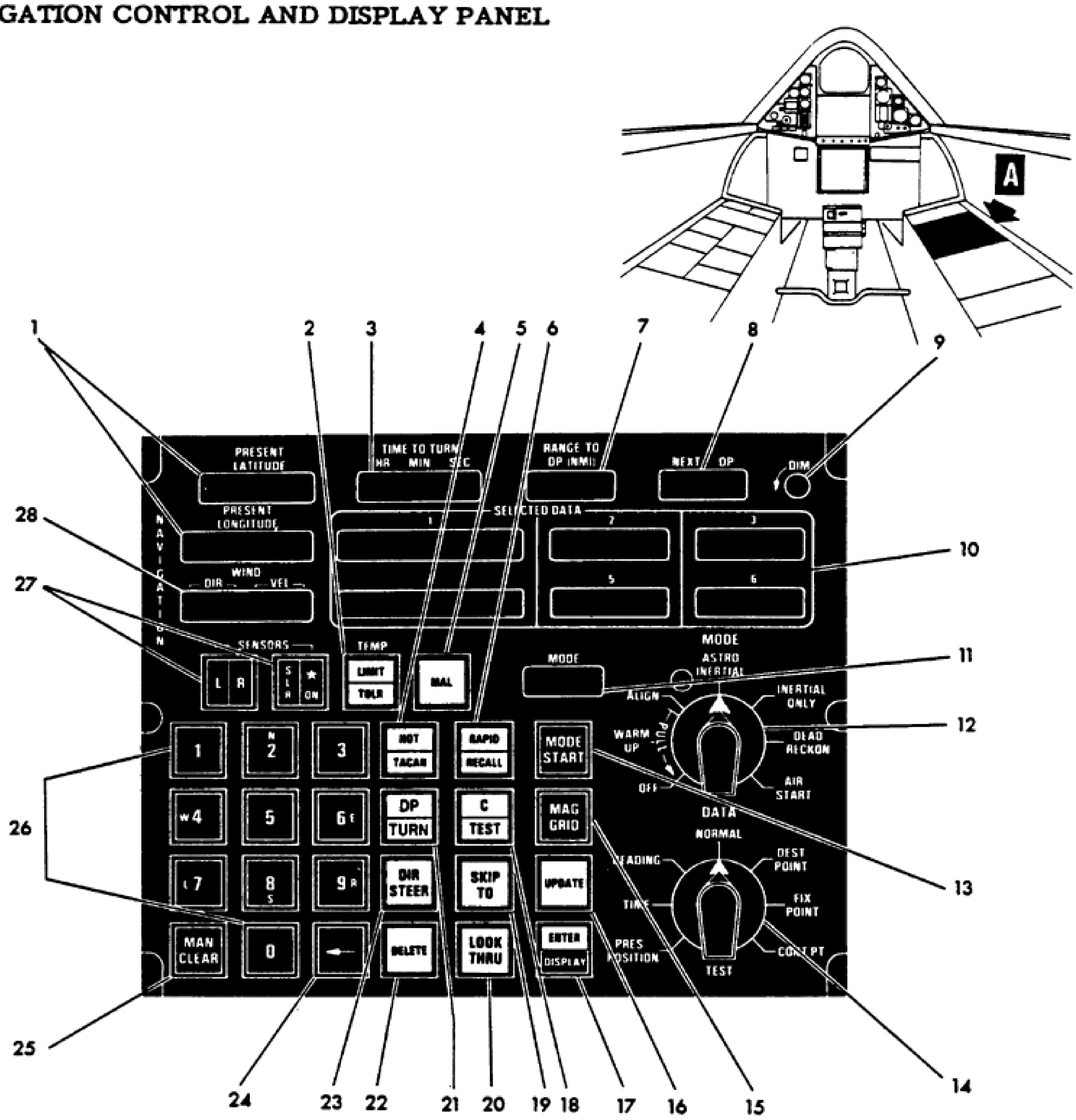
MODE Switch

The rotary MODE switch has seven positions:

OFF — Power is off except illumination power and chronometer power.

WARM UP — Power to temperature control circuitry and the computer.

NAVIGATION CONTROL AND DISPLAY PANEL



1 PRESENT POSITION WINDOWS
2 TEMPERATURE MONITOR LIGHTS
3 TIME-TO-TURN WINDOW
4 HOT/TACAN SWITCH
5 MALFUNCTION LIGHT
6 RAPID/RECALL SWITCH
7 RANGE TO DESTINATION POINT WINDOW
8 NEXT DESTINATION POINT WINDOW
9 DIM SWITCH
10 SELECTED DATA WINDOWS
11 MODE WINDOW
12 MODE SWITCH
13 MODE START SWITCH
14 DATA SWITCH
15 MAG/GRID SWITCH
16 UPDATE SWITCH
17 ENTER/DISPLAY SWITCH
18 C/TEST SWITCH
19 SKIP TO SWITCH
20 LOOK THRU SWITCH
21 DP/TURN SWITCH
22 DELETE SWITCH
23 DIRECT STEER SWITCH
24 BACK SPACE SWITCH
25 MANUAL CLEAR SWITCH
26 MANUAL KEYBOARD AND POSITION PREFIX REFERENCE SWITCHES
27 SENSOR OPERATION INDICATOR LIGHTS
28 WIND DIRECTION AND WIND VELOCITY WINDOWS

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Figure 4-3

The following five modes are called "operate" modes, since power is applied to the entire ANS. Operation begins only after the MODE START, RAPID, or HOT switch is pressed.

ALIGN	Used on the ground to remain in fine alignment or for ground alignment correct procedure.
ASTRO INERTIAL	Selects astro-inertial navigation.
INERTIAL ONLY	Selects inertial-only navigation.
DEAD RECKON	Selects dead-reckon navigation.
AIRSTART	Used to perform a cold airstart (in-flight alignment) which results in airspeed damped, astro inertial navigation.

The MODE switch has a detent that prevents switching to OFF or WARM UP from an "operate" mode without lifting the switch. A detent prevents moving the switch clockwise past AIRSTART.

MODE START Switch

After power on, pressing MODE START initiates a gyrocompass or cold airstart alignment. After alignment, pressing the self-illuminated switch enables the mode selected by the MODE and MAG/GRID switches.

MAG/GRID Switch

The MAG/Grid switch is an alternate-action switch. Either the MAG or GRID half of the switch is lighted at all times. The ANS computer interrogates this switch each time the MODE START switch is pressed.

Set the switch to MAG. There is no useable grid heading available to either cockpit with the SKN-2417 INS in normal operation. The ANS computer interprets the INS heading input as MAG heading and makes appropriate computations to provide a true heading value for the dead-reckoning reference frame.

DATA Switch

The rotary DATA switch is used to select a panel fill, update, display, or mission modification procedure. The position of the switch determines the first character (always alphabetical) of the SELECTED DATA (SD) window that expects data. The eight DATA switch positions are PRES POSITION, TIME, HEADING, NORMAL, DEST POINT, FIX POINT, CONT PT, and TEST.

Keyboard Switches

The ten numerical keyboard switches, labeled 0 through 9, are used to enter data into the ANS or to command display of ANS data.

MAN CLEAR Switch

Used to clear the SELECTED DATA windows if an error is made during a panel-initiated procedure, and to not use an ANS position, altitude, or runway-heading alignment update. It is also used in the ANS malfunction routines.

ARROW (Backspace) Switch

Used to erase filled data one digit at a time in reverse order prior to actuating an action switch such as ENTER.

LOOK THRU Switch

Used to display data pertaining to the destination point (DP) after the DP now approaching.

SKIP TO Switch

Used to command the ANS to skip to a selected DP from the current next DP.

RAPID/RECALL Switch

Used to select rapid ground alignment or to recall data for display of the previously panel-filled TACAN point.

DELETE Switch

Used to delete a particular panel-filled mission point from the 40-List of panel-filled points or the entire 40-List.

DIR STEER Switch

Used to make an immediate change in destination (direct steer) to a selected DP or to any panel-entered latitude and longitude.

HOT/TACAN Switch

Used to mark the time of reading current TACAN data and to freeze the ANS computed values of range and bearing or to select air or ground hot starts.

ENTER/DISPLAY Switch

Used to command the ANS computer to accept panel-filled data or to display selected data.

UPDATE Switch

Commands the ANS to correct computed position, heading, reinitialize the star tracker, or change the current track leg.

DP/TURN Switch

This push-button switch selects the source for the pilot's HSI range indicator. The DP/TURN switch is enabled when the ANS DATA switch is in TEST; pressing ENTER/DISPLAY will then illuminate the "DP" or "TURN" legend in the switch (corresponding to the mode presently selected); pressing the DP/TURN switch will change the mode and illuminate the other legend. When "DP" is illuminated, the pilot's HSI range indicator will read distance to the ANS destination point (DP); when "TURN" is illuminated, the pilot's HSI range indicator will read distance to the ANS-computed turn point. Refer to Horizontal Situation Indicator, Range Indicator, Section I.

C/TEST Switch

Used to perform a panel light test and to display ANS tape data and internal ANS conditions when used in conjunction with the TEST position of the DATA switch.

SELECTED DATA Indicators

The indicators or windows consist of six separate sets of digital displays. Various operating parameters are displayed in the indicators during the panel fill, mission modification, update, and alignment routines as shown in Figure 4-4.

Present Data Indicators

The PRESENT LATITUDE and PRESENT LONGITUDE windows show the present position coordinates in degrees and minutes. During ground alignment, the coordinates are blank until fine alignment is completed.

The WIND DIR and WIND VEL window displays the wind direction in degrees and the wind velocity in knots. The window displays zeros until airborne.

The TIME-TO-TURN window displays the time-to-turn in hours, minutes, and seconds. The window is blank until the aircraft is moving.

The RANGE TO DP window displays the range to the DP in nautical miles. The window is blank until present position coordinates are entered.

The NEXT DP window displays the next destination point number. The window is blank until the present position coordinates are entered.

Sensor Indicators

The TECH L and R, and SLR indicator lights illuminate during display of control points or fix points to indicate programmed sensor activity at the selected point. The SLR light is not illuminated during display of viewsight fixpoints. During NORMAL display, these lights illuminate during actual ANS on-time commands and are extinguished by standby control point commands. The lights do not illuminate during manual sensor operation.

These lights also illuminate to verify sensor selection when adding or replacing control points.

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES

SELECTED DATA WINDOW / PANEL ROUTINE	1	2	3	4	5	6
RUNWAY HEADING ALIGNMENT	Computed runway true heading, XXX°XX.X'			Filled runway true heading, XXX° XX.X'		
FILL PRESENT POSITION AND INITIAL ALTITUDE	Latitude, N/S XX XX.XX'		Altitude in hundreds of feet, XXX	Longitude E/W XXX° XX.XX'		
FILL WIND					Wind direction XXX°	Wind speed in Knots, XXX
FILL DAY AND TIME	GMT, XX hours XX minutes XX seconds					Julian day, XXX
FILL MAGNETIC VARIATION				Magnetic variation, E/W XXX° XX.X'		
FILL CHART CONVERGENCE FACTOR						Chart convergence factor X.XXX°
UPDATE HEADING				Heading XXX°XX.X'		
UPDATE PRESENT POSITION, USING REMOTE SOURCE DATA	North-South error, nautical miles, N/S OOXX.XX			East-West error, nautical miles, E/W OOO XX.XX		
UPDATE PRESENT POSITION USING RADAR	North-South error, nautical miles, N/S XX.XX			East-West error, nautical miles, E/W XX.XX		
UPDATE PRESENT POSITION, USING VIEWSIGHT	North-South error, nautical miles, N/S XX.XX			East-West error, in nautical miles, E/W XX.XX		
UPDATE PRESENT POSITION USING TACAN	North-South error, in nautical miles, N/S XX.XX			East-West error, in nautical miles, E/W XX.XX		
UPDATE TRACK LEG						All five digits of point - ID code, D XXXX

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Figure 4-4 (Sheet 1 of 2)

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES

PANEL ROUTINE / SELECTED DATA WINDOW	DIRECT STEER	SKIP TO DP	DELETE FP, CP, DP	ADD OR REPLACE FP, CP, DP	NORMAL DISPLAY	DISPLAY NEXT FP, CP, DP	DISPLAY SELECTED FP, CP, DP	DISPLAY HEADING	DISPLAY DAY OF YEAR/STAR DATA	DISPLAY PRESENT POSITION	DISPLAY LOOK THRU	DISPLAY TAPE NUMBERS/ TEST
1	Latitude if new point is filled, N/S XX° XX.XX'			Latitude, N/S XX° XX.XX'	GMT in XX hours, XX mins, XX seconds	Latitude, N/S XX° XX.XX'	Latitude N/S XX° XX.XX'	Velocity vector heading VXXX° XX.X'	GMT in XX hours, XX mins, XX seconds	Latitude of alternate present position frame, N/S XX° XX.XX'	Latitude of DP+1 N/SXX° XX.XX'	I TTMMCC T • Tape M • Mod C • Corr
2					True airspeed in knots TXXXX	Range to DP RXXX.X nmi slant range if TACAN FP SXXX.X nmi along track range to CP/ FP AXXX.X nmi	Great circle range for CP, DP, FP AXXX.X nmi slant range if TACAN FP SXXX.X nmi	Grid heading GXXX.X°	Star number SXX		Along track range to DP +1 R XXXX nmi	Mission tape No. OXXX O • * or A thru Z or a thru e
3				Terrain elevation in hundreds of feet for CP's or FP's XXX. Turn radius in nmi for DP's.	Next FP No. F/F1 XXXX	Turn radius to DP KXXX nmi terrain elev for CP, FP hundreds of feet XXX	Turn radius if DP KXXX nmi terrain elev if CP, FP, hundreds of feet EXXX	Chart convergence factor CX.XXX	Scan Rate Code R X	Nav altitude in hundreds of feet, AXXX	Turn radius of DP +1 K XXX nml	General instrument constants tape NO. GXXX
4	Longitude if new point is filled, E/W XXX XX.XX'			Longitude E/W XXX° XX.XX'	Aircraft cross track position, nautical miles L/R XXX.X	Longitude E/W XXX° XX.XX'	Longitude E/W XXX° XX.XX'	Aircraft true heading TXXX° XX.X'	Time in this star search T XX:XX min : sec	Longitude of alternate present position frame, E/W XXX° XX.XX'	Longitude of DP +1 E/W XXX° XX.XX'	
5				L/R XX.0 S1R code or L/R00.0 for CP, FP or E/W XX.X° mag var for TACAN FP's	Aircraft Ground Speed in Knots GXXXX	Relative bearing to DP, CP, FP L/R XXX.X° TACAN bearing to TACAN FP BXXX.X°	Relative bearing to point L/R XXX.X° Magnetic bearing if TACAN FP BXXX.X°	Magnetic variation E/W XXX.X°	Number of stars acquired AXXXX	Sun angle in degrees, (if positive) SXX.X°	Time to DP +1 TXXX.X min	TYY1 (Normal) TYY2 (Trainer) Where YY•year
6	All five digits of point - ID code if DP in memory is selected, D XXXX	All five digits of point - ID code, D XXXX	All five digits of point deleted D XXXX C/C1XXXX F/F1XXXX	Point ID Code D XXXX C/C1XXXX F/F1XXXX	Next CP No. C/C1XXXX	ID code of next point. D XXXX C/C1XXXX F/F1XXXX	Selected point ID code D XXXX C/C1XXXX F/F1XXXX	Magnetic heading MXXX°	Julian day of year DXXX (1-511)		DP + 1 ID No. D XXXX	Test 0 Indication T 0

Figure 4-4 (Sheet 2 of 2)

Star ON Indicator Light

The light indicates the status of star tracking as described in the Computer Program section. Steady illumination of the light indicates that a minimum of two different stars have been tracked within the last 5 minutes.

MODE Window

The MODE window displays a legend which shows the operating phase of the ANS. The MODE window also displays an error message in the event of an operator error and may indicate recommended action in case of system malfunction. The malfunction indications are described in the Malfunction Indicator and the ANS MALFUNCTION PROCEDURES paragraphs. The MODE window indications are:

Indication	Operating Phase	Definition
C/A	COARSE ALIGN	Initial phase of ground or air start alignment.
F/A	FINE ALIGN	Final phase ground alignment.
RES	RE-START	Second phase of air-start or ground hot start alignment.
A-I	ASTRO INERTIAL	Astro inertial navigation.
I/O	INERTIAL ONLY	Inertial-only navigation.
D/R	DEAD RECKON	Dead-reckon navigation.
ENT		Coarse align complete. Enter present position or heading.
ERR		An operator error in panel operation has been committed.
ENC		Encoding failure.
DP*		Mission tape program sequence in error.
BLANK	WARM UP	Mode switch is in WARM UP and 28 volts dc is present.

Temperature Limit/Tolerance Indicator

The temperature limit and tolerance indicator, labeled TEMP LIMIT/TOLR is a split-function indicator which displays monitored cooling air flow and system internal temperatures. The top half of the indicator is red with the LIMIT legend visible when lighted. The bottom half of the indicator is amber, with the TOLR legend (tolerance) visible when lighted. (Refer to ANS MALFUNCTION PROCEDURES.)

Malfunction Indicator

The ANS malfunction indicator, labeled MAL, is a red panel light that can be off, on-steady, or on-flashing. Generally, the MAL light is off during normal operation, on-steady when the ANS is in the WARM UP mode, and on-flashing when a system self test has failed. (Refer to ANS MALFUNCTION PROCEDURES for detailed description.)

COMPUTER PROGRAM

The basic instructions and constants for computer operation are contained in the main program tape which is loaded into the computer permanent memory. The computer program is loaded in two parts, a basic main program tape and a correction tape (if needed). In addition, a general instrument constant (GIC) tape, star catalog (SYY1, SYY2) tape, and mission tape are loaded. Each ASTRO INERTIAL (A-I) unit has its own GIC tape which defines gyro, accelerometer, resolver, etc. parameters unique to the respective A-I unit. Annual revisions are made to the star catalog tapes. The main program tape currently used is Tape 10639512 (Tape 12).

STAR DATA USAGE

STAR	DEFINITION	DATA USAGE
A	First star tracked after a hot or cold airstart, ground hot start, or after changing from A-I to I/O and back to the A-I mode.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
B	Second star tracked after an A star, or	Computational triad and platform are corrected and now in coincidence. Latitude, longitude and auto nav adjustments occur.
	First star tracked after a ground alignment.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
C	First and subsequent star tracked after B star.	Platform and computational triad are corrected. Auto-Nav transients are allowed on first star C but suppressed on subsequent ones until a bank angle exceeds 5^{o} or position fix inserted

Figure 4-5

__Astro Inertial Navigation__

The ANS operates in typical inertial navigation fashion. Outputs from two 2-axis gyros drive the platform gimbals to isolate three orthogonally mounted accelerometers from changes in aircraft attitude. The gyros and accelerometers are mounted on the platform's azimuth gimbal (stable element). The accelerometer outputs are components of aircraft velocity change. If the azimuth gimbal is not kept level, the accelerometers also measure a component of acceleration due to gravity and position errors are produced.

In INERTIAL ONLY, the computer uses the accelerometer outputs to calculate aircraft velocity and change in position, and gyro torquing rates. The gyro torquing rates (signals proportional to aircraft velocity plus earth's rate) are applied to the gyros to maintain the azimuth gimbal (and thus the accelerometers) level with respect to the earth. The success of inertial navigation is due to the fact that any system error eventually causes the accelerometers to go off level and measure a component of gravity which introduces an error that tends to cancel the original error. For example, if an accelerometer develops a null shift that appears to be an aircraft acceleration to the north, the platform will be torqued to keep up with the apparent aircraft motion over the earth's surface. Thus if the platform were level, it becomes tipped off level resulting in accelerometer measurement of gravity which looks like aircraft acceleration to the south. This characteristic of inertial systems is called Schuler tuning.

The star tracking function improves knowledge of accelerometer orientation in azimuth and eliminates the effects of gyro drift. Star search is initiated when astro-inertial mode is selected after completion of alignment. Selection of the star is made by the computer as a function of latitude, longitude, day of year, time of day, aircraft pitch and roll, and location of the sun. Aircraft pitch and roll determine the orientation of the star tracker window. For a given latitude, longitude, time of day and year, a particular star should be at a particular azimuth and elevation. If the star tracker measurements show that the star is not at the expected azimuth and elevation, there is an error in computed latitude and longitude and/or an error in platform orientation. Since the telescope is mounted on the platform, the star tracker measures the angular difference between the physical triad formed by the platform axes and the computational triad formed by the vertical through the computed position and the calculated orientation of the platform in azimuth. Thus the system cannot directly distinguish between a computed position error and a platform orientation error but, based on statistical probabilities determined by prestored error models and flight dynamics preceding the measurement, (as modeled by a Kalman filter, described later) it will attempt to optimally adjust the various navigational parameters.

To aid in describing star tracker logic, stars are given arbitrary labels depending on if they are the first, second, or third star tracked after the beginning of an operation. These are listed in Figure 4-5 with definitions and a summary of the usage of star tracker measured errors. In all cases, the end result of tracking two different stars is to align the computational triad with the platform triad or vice versa. A single star cannot be used to correct all errors since errors about the axis from the platform through that star are not measured. After the initial two stars are acquired, the normal interval between loss of track from one star to tracking the next star is about 30 seconds at altitude. Since the platform is almost continually brought into alignment with the computational triad, gyro errors have an almost negligible effect. The predominant ANS errors are those due to gyro drift that develop before stars are acquired and when star tracking is interrupted such as during aerial refueling. The star tracking data is used to update computed values of gyro drift to minimize error growth during any subsequent lapses in star tracking.

Star selection, tracker scan rate, and search patterns depend on many factors and are all under computer control. The computer selects a star by going through the star catalog which is arranged in order of decreasing star brightness until it finds a star that is within the window aperture, not within 10° of zenith (not within 5° of zenith for trainer aircraft), and not within $12\text{-}1/2^{\circ}$ of the sun. The tracker telescope is commanded to search for the selected star using a variable sized pattern which is symmetrical about the computed star position.

The star search pattern is an expanding rectangular spiral which starts at the side of the pattern and then passes across the computed star postion. See Figure 4-6. Maximum A star pattern size is a function of search rate so that all A star searches are completed within 23 minutes.

If the star is detected during this search, confirmation and reconfirmation patterns are made. If these are successful, the star is considered tracked, and elevation and azimuth errors are determined by the star actual position relative to its computed position. Search and track operations are discontinued if the star moves out of the window, the sky is too bright, or a position update is performed. The computer then goes to the next brightest star available, except that when a position update is performed, star search begins at the top of the star list (brightest star).

There are four scan rates which can be used in star search. Scan rate depends on star magnitude and sky brightness. The fastest is used on a bright star in a dim background while the slowest is used on a dim star in a bright background.

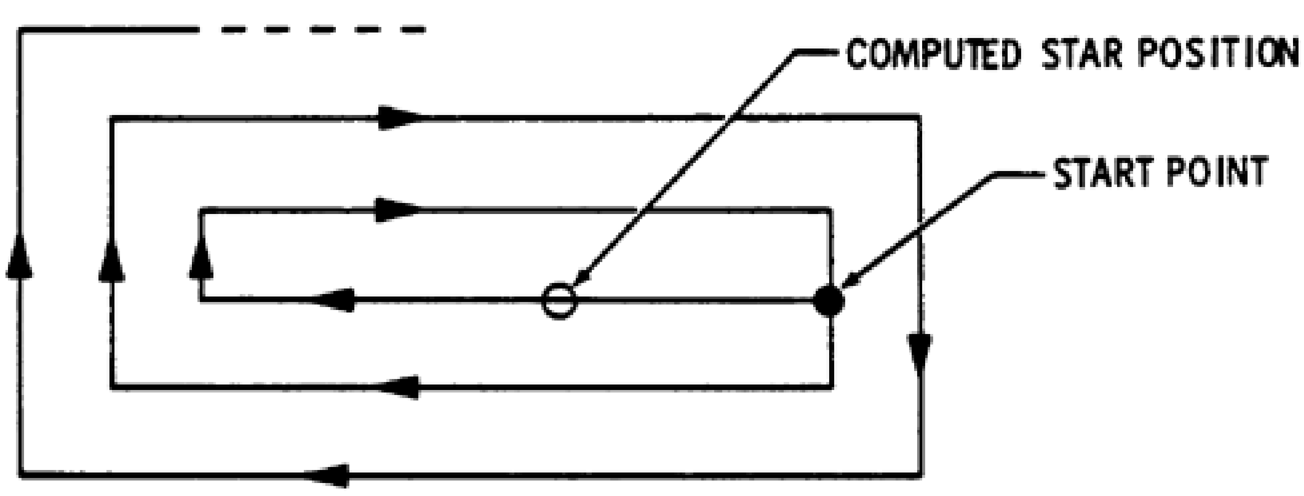
The search patterns are chosen as a function of the type of alignment and whether an A, B, or C star is being searched. See Figure 4-6. This table also lists the star ON light activity during star tracking operations.

Star Tracking Techniques

The star ON light provides the RSO with a guide for actions (listed in Figure 4-7) to optimize star tracking. Star tracking is automatic but the operator can assist the system in overcoming conditions such as overcasts, changes of sky background brightness, long

SEARCH PATTERNS AND STAR-ON LIGHT INDICATIONS

TYPES OF ALIGNMENT	STAR	SCAN RATE arc sec/sec	SEARCH AZIMUTH	SEARCH ELEVA-TION	MAXIMUM TIME REQUIRED TO COMPLETE SEARCH	AFTER TRACKING ★ LIGHT WILL
Hot or cold airstart or when search unsuccessfully completed for - A after ground hot start or INERTIAL ONLY navigation.	A	1250	3°	1°	17.3 min.	Flash at 1 second intervals.
	A	703	2.3°	.8°	18.1 min.	Flash at 1 second intervals.
	A	395.5	1.9°	.6°	20.8 min.	Flash at 1 second intervals.
	A	222.5	1.4°	.48°	22.7 min.	Flash at 1 second intervals.
	B	all	3°12'	6'	10.0 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Ground hot start or when changing mode from INERTIAL ONLY to ASTRO INERTIAL	A	all	36'	12'	3.9 min.	Flash at 1 second intervals.
	B	all	36'	12'	3.9 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
When INERTIAL ONLY was selected after ground alignment	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Rapid, gyro compass or runway heading alignment.	B	all	36'	12'	3.9 min.	Stay off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)



NOTE

1 All search patterns are expanding rectangular spirals with the first beginning at one side and passing horizontally across the computed star position.

2 Star B' (re-tracking of star B) is performed only if the azimuth error measured with star B is greater than 5.27 arc-minutes.

3 After tracking star C, the star light remains on until mode is changed to INERTIAL ONLY or five minutes have elapsed without tracking two different stars.

F203-253(b)

Figure 4-6

periods of ground time after system initialization to A-I mode, refueling, and periods when tracking is not being accomplished. The operator should attempt to commence tracking stars as soon as possible to prevent or eliminate position error growth.

Improving Star Tracker Scan Rates

The ANS uses different scan rates for the star tracker depending upon the lightness of the sky background around the computed star position. This sampling of background conditions is accomplished automatically prior to beginning each star search. The time it takes the ANS to acquire a star depends on the magnitude of ANS errors. In extreme cases approximately twenty minutes could be required to acquire an A star.

An active (optimum signal-to-noise) filter to the ANS increases the probability of star detection, improves the accuracy of angle measurement, reduces the time devoted to detection and tracking of each star, and increases position and heading accuracy.

By using position fixes or remote updates, the RSO can reinitialize star search at the top of the star list (brightest star). This provides a new sky background lightness measurement and a change in scan rate if sky background lightness has changed. The RSO should use this procedure when there is a noticeable improvement in background conditions and the star ON light is not illuminated.

The RSO should periodically note the star tracking performance as indicated by the star light and star data in the Time display. If star tracking performance is less than expected (intermittent or no star light) for the existing sky conditions, the RSO should display day of year and note star number and scan rate. He should perform a zero remote update or command A, B, C Star Search to select the brightest star available (indicated by a number equal to or less than that previously indicated in SELECTED DATA window 2). This action will match the scan rate to the current sky background condition. A slower scan rate than that previously observed indicates less than optimum sky background conditions. If a star is not acquired, a repeat of these routines when the sky background improves could increase the scan rate thus improving the probability of star acquisition. The scan rates are selected by the computer based on sky background measurements in the vicinity of the star. There are four scan rates available and the one in current use is indicated in SELECTED DATA window 3 as a code R1 (1250), R2 (703), R3 (395) or R4 (222) (arc sec/sec) when using the Time display routine. A dark sky background increases the likelihood of tracking stars and induces a fast scan rate. Conversely, a bright sky back ground decreases the likelihood of tracking stars and induces a slow scan rate.

CREW ACTIONS TO OPTIMIZE STAR TRACKING

CONDITION	ACTION
Search underway for A or B star.	Maintain straight and level flight.
Star ON light out.	Make maximum number of position checks.
Star ON light out after entering a good sky situation.	Restart star search by using zero remote update procedure.
Star ON light out more than 15 minutes after zero remote update procedure has been performed and good sky conditions prevail throughout.	Command star A tracking by changing mode to INERTIAL ONLY, then change back to ASTRO INERTIAL to increase search pattern size.
Preflight in hangar.	Select INERTIAL ONLY to terminate fine alignment. Select ASTRO INERTIAL after clearing hangar or cloud cover.

Figure 4-7

An example of when this procedure could assist star acquisition is: the system is put in A-I mode after completing ground alignment with haze or thin cirrus clouds; after takeoff and leveloff at 25,000 feet, the star ON indicator is not illuminated but the aircraft is now above all haze and cirrus. A zero remote update routine should cause the system to select a faster scan rate as a result of the darker sky background. In most cases, this will speed up star acquisition.

Commanding A and B Mode Stars

If a preflight alignment is performed while under cover, such as in a hangar, select the INERTIAL ONLY mode at the completion of fine alignment and remain in INERTIAL ONLY until clear of the covered area. This prevents false star acquisitions due to ceiling lights, etc. In this case the first star tracked after selecting ASTRO INERTIAL will be a B mode star.

The nominal error growth of the ANS in INERTIAL ONLY is based on pure inertial operation; that is, MODE in INERTIAL ONLY, disabling the tracker from star searching. The tracker slewing on top of the platform in search operation can induce further position error growth. Because of this, the operator should avoid leaving the ANS in the ASTRO INERTIAL mode when star tracking is not expected for 25 minutes or longer. Put the system in INERTIAL ONLY mode when star tracking is lost or is not expected for at least 25 minutes (e.g. during overcast conditions or operation behind a tanker.) Once INERTIAL ONLY has been selected, operation in this mode should be continued until suitable tracking conditions are encountered.

Above 60,000 feet, with nominal star availability and sun angle, the crew can expect A/B mode star acquisition in a few minutes after returning to the ASTRO INERTIAL mode.

NOTE

- Return the ANS to INERTIAL ONLY mode prior to entering a critical sensor "take" area if the star ON indicator has not indicated A/B star acquisition. This will inhibit A/B star updates which would cause auto nav roll transients.

- Although a star light generally indicates a bounded error of less than 1 nm, greater errors are possible. Computer and/or chronometer malflunctions have resulted in the star light being on when position error exceeded 10 miles.

Kalman Filter

The system employs a Kalman filter to optimally incorporate measurements from the star tracker, DAFICS M computer, and fixpoints to correct inertial system errors. The filter continually estimates the error state of 16 parameters:

1. Platform azimuth
2. Platform tilt axis 2
3. Platform tilt axis 3
4. Position error axis 2
5. Position error axis 3
6. Velocity error axis 2
7. Velocity error axis 3
8. Azimuth gyro drift rate
9. 2 axis gyro drift rate
10. 3 axis gyro drift rate
11. 2 axis accelerometer bias
12. 3 axis accelerometer bias
13. Telescope elevation bias
14. True airspeed scale factor
15. Axis 2 Wind
16. Axis 3 Wind

Each of these parameters has a calculated error probability which is initialized as a function of the type of alignment accomplished. During a ground alignment system position is monitored to detect deviations from the entered coordinates. These deviations are fed as measurements to the filter which utilizes them to refine the first ten listed parameters. When star measurements are obtained, the first thirteen parameters are refined, and when airborne, all sixteen elements are estimated and continually refined. Because of wind variability and the accuracy (±30 knots) of True Air Speed, the airspeed measurement has essentially zero influence on the first thirteen parameters except in the case of a cold and hot airstart. When fixpoint measurements are inserted by the operator, the filter adjusts the 16 parameters according to the ratio of their current estimated error state to the programmed accuracy of the fixpoint device (.25 n.m. for SLR, .5 n.m, for Viewsight, and 1.0 n.m. for TACAN). The system incorporates 100 percent of a fixpoint if the correction is more than 5.0 n.m..

Dead Reckoning

Dead reckoning is performed simultaneously and separately from inertial navigation. During normal operation in ASTRO INERTIAL or INERTIAL ONLY, the dead reckoning latitude and longitude do not appear to the RSO unless the display Present Position routine is performed. However, prior to continuous star tracking in a cold or hot air start, or when DEAD RECKON is selected, dead reckon data is used as the source of present position and heading for all displays, great circle navigation and guidance, and sensor control. DEAD RECKON is the only mode in which present position can be entered after navigation is started; this may be done as often as desired. When DEAD RECKON is selected, the ANS generates all its normal outputs and continues astroinertial or inertial only navigation so that the DEAD RECKON mode can be selected for training while permitting return to ASTRO INERTIAL or INERTIAL ONLY modes. In normal operation, when dead reckon data is not used for ANS outputs, the dead reckoned latitude, longitude, and difference between INS heading and ANS true heading (magnetic variation), if applicable, are updated every four minutes using inertial data.

Dead reckoning is the process of computing change in position using heading, speed, and elapsed time. True airspeed from DAFICS (M computer) is used with RSO entered values of wind speed and direction to approximate ground speed. Heading is provided from the INS and is magnetic heading except that ANS inertial heading is used following coarse alignment in a hot or cold air start.

When INS mag heading is being used, the RSO must periodically fill local magnetic variation so that computed true heading will have minimum error. When dead reckon data is not being used, magnetic variation need not be filled since the ANS itself computes a new magnetic variation every four minutes.

MISSION TAPE PROGRAM

The mission profile is defined in terms of destination points (DP), control points (CP), and fix points (FP), and the sensor operations associated with these points. Destination points delineate the prescribed mission track; they are intersections of the intended great-circle legs. Control points and fix points permit automatic activation of imaging sensors, and fix points define preferred navigational references. The mission plan is loaded into the computer memory on a mission tape prior to preflight operations. The mission tape can be programmed to hold up to 127 DP, 127 FP, and 127 CP (381 total). Additional temporary memory is provided for 40 point modification operations, known as the "40-List". The modifications may be performed using the Control and Display panel anytime power is supplied to the panel. Up to 40 add and/or replace operations and unlimited skip-to operations, are provided. In addition, there are special Anytime and Opportunity fix point procedures which do not use the 40-List. The mission tape may include a primary flight plan with one or more alternate routes that the crew may elect to follow by exercising the skip-to, direct steer, or track leg update options. The add and replace options of the 40-List permit additional alternate paths to be formulated, and allow last-minute changes to sensor activity on programmed legs.

The data loaded into specified cells of the computer memory are identified by function and order of use in the mission plan (D00003, C00007, F00021, etc.). Each point is further defined by its coordinates, its sensor-usage, applicable pointing parameters, and reference to the next consecutive point or points. The destination points reference the next point of all three classes. The information programmed for each type of point is listed in Figure 4-11.

Great-Circle Steering

The mission path is a sequence of great-circle legs computed on the basis of DP coordinates. The ANS supplies a steering (bank angle) command to the autopilot in all ANS navigation modes but it is usable only when all requirements for a "nav-ready" condition are present. In the autopilot AUTO-NAV mode, bank angle is commanded by the ANS to automatically guide the aircraft onto and along the preprogrammed flight path. The bank angle steering command is computed from aircraft cross-track position and velocity relative to the desired course. If the planner has scheduled a bank angle of 35° or less, the ANS will not command a bank greater than 35°, even if a higher bank is required to keep the aircraft on course. If the turn is planned above 35° (up to 42°) the ANS will command up to 45° to keep the aircraft on course.

If the AUTO NAV mode is engaged when the aircraft is considerably off track, the ANS will steer towards the desired track at a 30° intercept angle. Depending on current groundspeed, the ANS will compute where to initiate a turn to discontinue the intercept course and smoothly fair onto track. During supersonic cruise this point is approximately 20 nm off course.

Once on course, the aircraft should usually be within 300 feet of the commanded course, except in turns. Actual position of the track is dependent on ANS navigation accuracy.

ANS Steering Turn Modes

The mission planner can choose one of two different turn modes at each DP. These modes determine where the turn start to the next great circle leg will occur and the amount of bank angle commanded during the turn.

Auto-Range-To-Turn

The system computes the turn radius based on a 32° bank angle and the groundspeed at the start turn point. Once the turn is initiated, it is identical to the turn described in the Fixed-Range-To-Turn paragraphs.

Auto-Range-To-Turn should be used for subsonic turns to prevent high bank angles at heavy weights. Current groundspeed and the heading change from present course to next are used to compute and initiate an automatic turn (termed by the mission planners as Turn Start Automatic, or TSA). The TSA point varies since it depends on groundspeed. If actual groundspeed is different from planned groundspeed, the TSA will not occur where planned and the aircraft will not follow the turn line depicted on the strip map. However, if there are no other disturbances, the aircraft should make the turn at a 32° bank angle.

Fixed-Range-To-Turn

Fixed-Range-To-Turn is used by the mission planners for turns that indicate critical sensor legs and turns where strict adherence to the planned turn line is required. In this mode, the mission planner specifies a constant turn radius at a particular DP. The TSA point is a fixed distance plus a variable distance from the DP. The fixed distance is determined by the programmed turn radius and the change in course; it would be equal to turn radius on a 90° turn. The variable distance ranges from 0 to 4.5 nm, depending on groundspeed, and compensates for the distance required to roll into the turn. During the turn, commanded bank angle is the sum of two components. One component is the nominal bank required to achieve the programmed turn radius at the current

TYPICAL DESTINATION-POINT PLAN

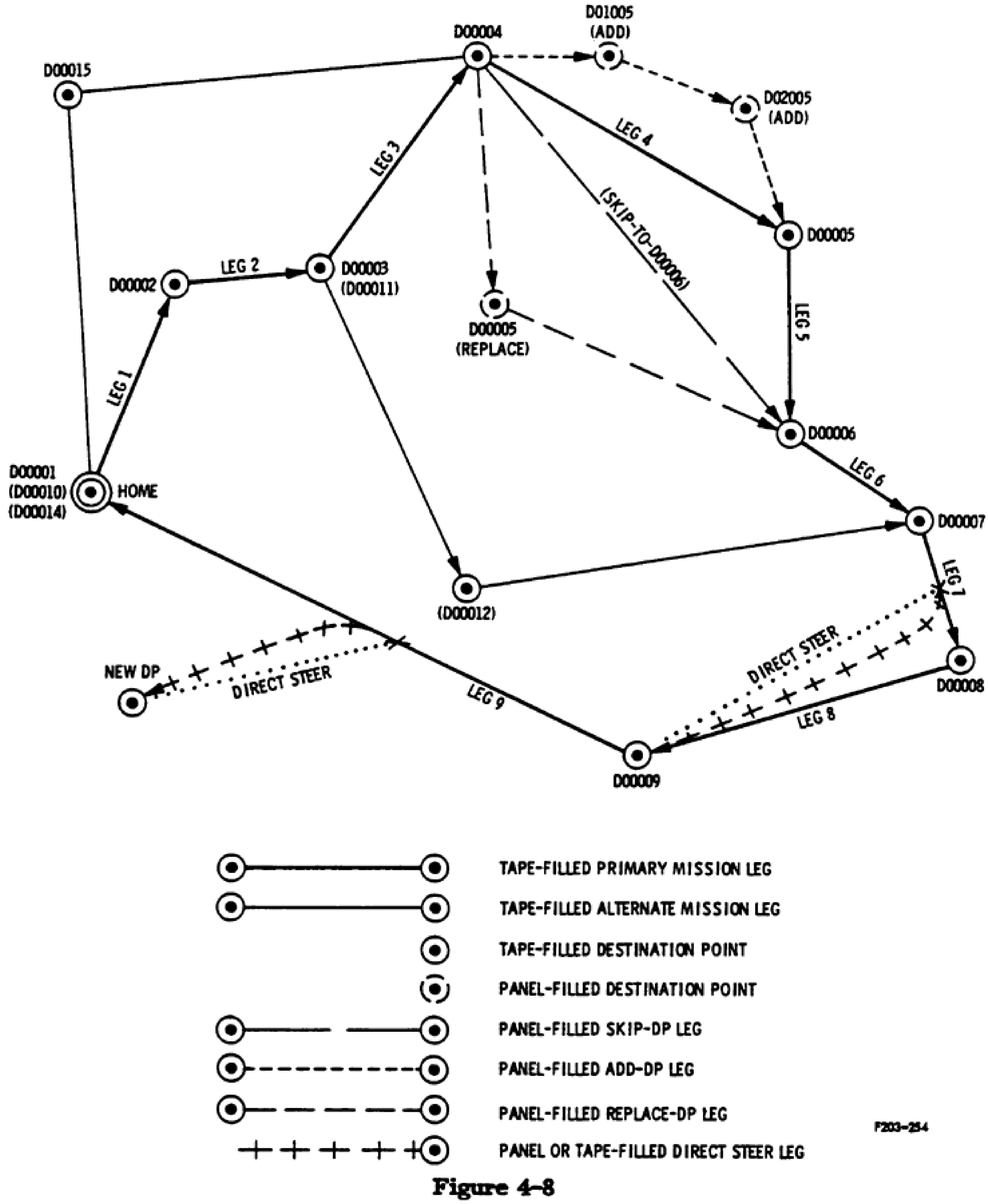


Figure 4-8

ground speed. The second component trims bank angle trim as a function of the radial speed and position relative to the programmed radius so that the aircraft follows the planned turn line throughout the turn. If a transient causes the aircraft to deviate from the turn line, bank angle trim varies within $\pm 10^{\circ}$ to return to the turn line.

Range to destination as displayed on the HSI and the NCD includes distance around a turn rather than the length of the great circle from present position to destination. This distance around the turn is also used in computing time to turn for the NORMAL display.

Turn steering automatically terminates when aircraft track is within 2° of the command course, the new track is crossed, or the theoretical tangency point is passed.

The sum of the nominal commanded bank angle and the bank angle trim is limited to the ANS maximum bank angle command of 45 degrees. Refer to Figures 4-14 and 4-15 for bank angle vs speed and turn radius information.

NOTE

> During preflight planning, do not schedule any turns above Mach 2.9 which have a radius smaller than can be maintained using a 42° bank angle.

Turns should be planned to require at least three degrees less than the planned bank angles limits. This provides a margin to accommodate aircraft trim requirements and/or greater ground speed than expected. However, when below Mach 2.9, bank angles of up to 44 degrees may be scheduled if justified by operational requirements. Crews should monitor ANS groundspeed prior to and during turns and prevent ground speed from exceeding the maximum value at which the planned track can be accomplished within bank angle limits.

When scheduling turns with greater than 35° bank angle, allow for expected altitude loss if maximum power will not maintain level flight. Refer to Parts V & VI of the Performance Data appendix and to the ceiling altitude data, Figure 6-8, in Section VI. When scheduling turns requiring 42° bank angle at speeds above Mach 3.0, consider the altitude at the turn (which is a function of weight) and the programmed Mach. For a given weight and bank angle it may be necessary to decrease altitude, which at a given Mach may increase the KEAS to the KEAS limit. Turns at maximum scheduled bank angles must not be programmed for such heavy weights that the maximum KEAS limit for normal operation would be exceeded. A descent of approximately 2500 to 3000 feet below the maximum range altitude may have to be made before entering a 42° bank turn.

In normal operation, the aircraft will follow the turn line and roll out onto the next leg within 0.2 nm. Overshoots and undershoots will degrade sensor performance if the maneuver to get onto track is outside sensor stabilization limits. For the TECH camera(s), roll and pitch rate should be less than 0.3° per second for good photography.

With the CAPRE radar, cross track velocity must be less than 35 fps in the programmed mode or 20 fps in the auto mode for good mapping. Figure 4-9 shows distances required to obtain cross track velocities within limits at standard cruise conditions. During most of the settle out distance, roll rates will be slight and suitable for good photography.

During a SKIP TO operation, the same fixed turn radius is used, but a different TSA and turn line will result if the next leg is different from the planned leg.

Manual Steering

The ANS provides navigation information so the pilot can manually steer the aircraft. The bank steering bar on the ADI indicates the error between aircraft roll angle and ANS bank angle command and centers when the two are equal. Centering the bar steers the aircraft on the same path as AUTONAV steering.

The pitch steering bar of the ADI indicates altitude rate (0 to $\pm$3484 fpm) and is used to maintain altitude.

The HSI displays true heading, command course, range to next DP, and cross track deviation (0 to $\pm$ 1 nm). These displays are relative to the turn line during turns or the great circle leg following turns; the range value represents the distance around the turn plus distance along the next leg.

Control Points (CPs)

The technical objective cameras (TECHs) are turned on or off and pointed as the aircraft's along-track range to the next destination

DISTANCE TO OBTAIN STABLE CROSS TRACK VELOCITIES

Peak Overshoot in NM	Additional Settle Out Distance in NM 20 fps	Additional Settle Out Distance in NM 35 fps	Additional Settle Out Time in Minutes and Seconds 20 fps	Additional Settle Out Time in Minutes and Seconds 35 fps
0.2	14	0	0:28	0:00
0.5	36	2	1:11	0:01
1.0	46	31	1:32	1:02
2.0	56	44	1:52	1:28
4.0	65	54	2:10	1:48
8.0	82	70	2:44	2:20

Figure 4-9

point coincides with the CP's along-track range to the next destination point. CPs bracket the target, with the turn-on control point at the same cross-track range as the target. The ANS computes the camera pointing angle required to cover the CP, and thus the target. (Actual target coordinates are not stored in the computer.) Camera CPs can be programmed along the turn line in Fixed-Range-To-Turn turns. Here the CP is located at the same radial distance from the turn line as the target.

The CAPRE side-looking radar (SLR) is controlled similarly to the cameras. In addition to the mode and range commands, the navigation system supplies altitude, groundspeed, cross track, vertical velocity, and aircraft attitude to the radar. These parameters permit compensation for aircraft motion while mapping. Programmed map swath, and a mapping progression marker transmitted every 2.5 n.m. are also supplied.

The mode commands to the TECH(s) and the SLR are updated at each CP and FP so that more than one sensor can be turned on or off at a single point. All CP's and FP's on a leg are processed on that leg, even if a mission planning error or a panel filled change puts a CP or FP past the start turn point at the end of a leg.

Fix Points (FPs)

FPs are accurately known and readily identifiable points along the mission path that are used in measuring ANS position error with the SLR and RCD (Radar Correlator Display), viewsight or TACAN. FPs are used to determine ANS error at the time of the fix. The ANS can be corrected by depressing the UPDATE button, or the routine can be terminated without updating the ANS by depressing the MAN CLEAR pushbutton.

The SLR is automatically turned on and pointed a prescribed distance in advance of the FP as determined by the mission planner. When the aircraft passes the FP, a MARK light appears at the bottom center of the RCD, the display stops moving, and the ANS transmits the computed fixpoint slant range to the radar. A right-angle "L" mark appears on the RCD 50 seconds later. The RSO measures ANS position error by first zeroing on the "L" mark and then moving the crosshairs to the actual fixpoint.

The MARK light extinguishes when the "L" mark moves into view. ANS errors appear as north-south and east-west values on the NCD after the radar READ ERR switch is pressed.

TYPICAL ADD/REPLACE PLAN FOR FIX AND CONTROL POINTS

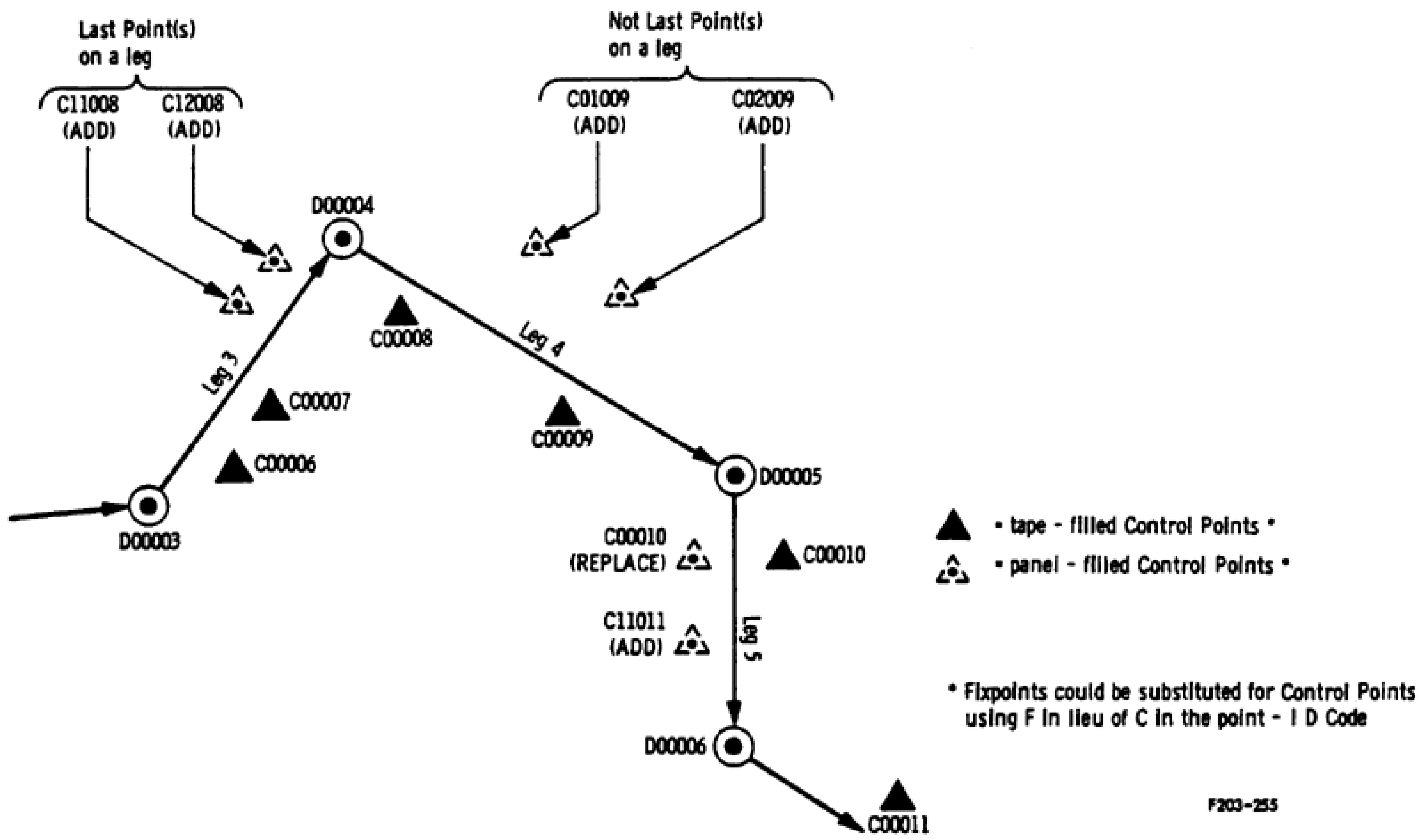


Figure 4-10

The radar remains on until a CP or FP commanding turn off occurs. RCD fixes are accurate to about 0.25 nm CEP.

For viewsight FPs, the RSO normally uses wide angle view to search for the FP as it approaches. After identifying the FP, select narrow view, if possible, for maximum accuracy. As the FP passes down the viewsight screen, move the cursor to intercept the FP as it passes under the nadir line. At that instant, press the viewsight READ switch. This provides the ANS with the location of the FP relative to the aircraft and allows measurement of ANS computed position error. Again, the errors appear in north-south, east-west values on the NCD after the READ switch is pressed. Viewsight fixes are accurate to about 0.5 nm CEP.

At TACAN FPs, ANS computed values of slant range and bearing to a TACAN station are displayed on the NCD for comparison with TACAN data observed on the BDHI. When a TACAN fix is desired, depress the TACAN switch, then enter the TACAN values of magnetic bearing (xxx°) and slant range (xxx nm) at the time the TACAN button was actuated. The ANS will then display the north-south and east-west errors.

MISSION POINT DATA

	Dest. Point		Control Point		Viewsight or SLR FP		TACAN FP (1)
	Tape Filled	40-List	Tape Filled	40-List	Tape Filled	40-List	Tape Filled
Latitude	x	x	x	x	x	x	x
Longitude	x	x	x	x	x	x	x
Turn radius	(2)	(2)					
Next DP No.	x	(3)					
Next FP No.	x				x	(3)	x
Next FP on Track (yes/no)	x				x		x
Next CP No.	x		x	(3)			
Next CP on Track (yes/no)	x		x	x			
Left TEOC Mode			x	(4)			
Right TEOC Mode			x	(4)			
Camera/Radar			x	(5)			
Left TEOC (on/off)			x	x	x		x
Right TEOC (on/off)			x	x	x		x
Radar (on/off)			x	x	x		x
Left/Right TEOC			x	(6)			
Terrain Altitude			x	x	x	x	x
Radar Range Code			x	(5)	x	(7)	
Radar (narrow/wide)			x	(8)	x	(8)	
Radar (left/right)			x	(6)	x	(7)	
Radar to Radar FP					x	(9)	x
Radar/Viewsight FP					x	(7)	
TACAN/Not-TACAN FP					x		x
Magnetic Variation							x

NOTE:

An "x" in a column indicates that the corresponding parameter is programmed for that type of point.

(1) There are no 40-list TACAN fix points. TACAN fix points are panel-filled as Anytime fix points which are not included on this chart.

(2) Tape filled points: Zero turn radius used for auto-range-to-turn.

40-list points: No turn radius filled for auto-range-to-turn.

(3) Point ID code is the 40-list equivalent to next point number. No point ID code entered for Anytime fixpoints or Opportunity Viewsight fix points.

(4) Mode 3 is automatically used for 40-list camera points.

(5) Camera/radar CP designation made by filling zero slant range code for camera points.

(6) 40-list marker designates left/right camera for camera CP's, radar left/right for radar CP's.

(7) Slant range code and left/right are not filled for viewsight FP's.

(8) Only narrow modes can be used for panel-filled points.

(9) 60 nm. is used automatically.

Figure 4-11

TACAN fixes are accurate to 2 to 3 nm at slant ranges from 20 to 200 nm. Accuracy is degraded at less than 20 nm and greater than 200 nm. The range data can generally be accepted, but TACAN bearing information may be somewhat inaccurate. When the INS is in the ATT mode, the TACAN mag bearing is correct, but the relative bearing may be in error.

If desired, the ANS computed position can be corrected by pressing the UPDATE switch; otherwise, press the MAN CLEAR switch to clear the measurement data. If FPs are used for updating, the ANS adjusts position, platform level, velocity, and heading based on the Kalman filter weighing matrices. The amounts applied to each of these parameters are optimized for the existing mode. Generally, corrections will not be necessary in the ASTRO INERTIAL mode although the measurement should be made to check the system.

Sensor operation may also be commanded at FPs. The point of execution will be at the along track position determined by the FP abeam point plus the range-to-turn-on value in the FP data of the mission tape. The TECH(s) may be turned on or off at any tape-filled FP. The camera(s) will be pointed and have the modes programmed at previous CPs. The SLR may be turned on or off at any tape-filled FP and may be repointed if the FP is not a TACAN FP.

MISSION MODIFICATION

The tape-filled mission program can be modified through the NCD panel. Up to 40 sets of data (40-List) may be entered to replace or add to previously stored mission points. In addition, the operator can skip any number of tape-filled or panel-filled destination points, or change destination. There are also special panel-filled fixpoints called Anytime or Opportunity fixpoints that are exclusive of the 40-List.

Add or Replace CP-FP-DP Routine

The mission tape is stored in the tape-filled memory of the computer. Panel-filled data for mission modification is stored in the panel-filled memory of the computer. Only Add or Replace modifications use the 40 panel-filled memory cells. Data required for each type of point, both panel-filled 40 List and tape-filled points, is listed in Figure 4-11. If necessary, the RSO can clear any or all of the mission modification data entered into the panel-filled memory and enter new data in the same 40 memory spaces. Detailed knowledge of the tape-filled mission is required to modify that mission, especially when control points or fixpoints are added or replaced.

Point-ID Code

Every tape-filled or 40-List mission point has an identification code. The code consists of a letter and five digits, referred to in the following text as digits 1, 2, 3, 4, and 5, counting from the left. This is the order in which the point-ID code is entered in the NCD panel. A letter C/C1, F/F1 or D designates the point as a control point, fixpoint, or destination point, respectively, and appears in the left-most display of the SELECTED DATA 6 window when a mission point is selected for display. When modifying a mission, this part of the ID code is entered by selecting FIXPOINT, CONT PT, or DEST POINT on the DATA switch.

Digits 3 thru 5 of the ID code denote the number assigned to each tape-filled CP, FP, and DP. Tape-filled points are numbered from 001 for the first CP, FP, and DP, to 127. In general, the points on the primary mission are numbered in sequence followed by the points on alternate legs. However, the sequence is not really important since the next point number of each type is listed with each tape-filled mission point; i.e., the data for DP 002 can define DP013 as the next DP, or vice versa. The same applies to CP's and FP's.

As shown on Figure 4-8, DP's which are the start points for alternate legs are doubly defined. This means that the same geographic point is contained in two different locations with different number and different next-point numbers (example: D00003 and