NONRESIDENT
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COURSE

Aviation Structural Mechanic E

NAVEDTRA 14327

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PREFACE

About this course:

This is a self-study course. By studying this course, you can improve your professional/military knowledge, as well as prepare for the Navywide advancement-in-rate examination. It contains subject matter about day-to-day occupational knowledge and skill requirements and includes text, tables, and illustrations to help you understand the information. An additional important feature of this course is its reference to useful information in other publications. The well-prepared Sailor will take the time to look up the additional information.

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CHAPTER 1

MARTIN-BAKER MK-GRUEA-7 EJECTION SEAT

The EA-6B aircraft is equipped with the Martin-Baker MK-GRUEA-7 rocket-assisted ejection seat. The MK-GRUEA-7 seat provides crewmembers with completely automatic escape at ground level (zero altitude, 80-knot minimum) and throughout the entire speed and altitude range of the aircraft.

This chapter discusses the system description, operating principles, and components of the MK-GRUEA-7 seat.

SAFETY PRECAUTIONS

LEARNING OBJECTIVE: Identify the safety hazards and general safety precautions when working on ejection seats.

The MK-GRUEA-7 emergency escape system has several explosive cartridges and rockets with propellant charges. Accidental firing of any of these may cause serious or fatal injury to personnel on or near, the aircraft.

> **WARNING**
>
> Ejection control handle safety pins and safe/armed handles are provided to render the ejection seats safe when the aircraft is parked on the ground. The ejection control handle safety pins are removed by the aircrew before flight and installed by the plane captain after flight. Movement of the safe/armed handle is the responsibility of the aircrew.
>
> Before entering the cockpit, personnel should ensure that the correct safety precautions have been applied.

Safety precautions must be strictly observed when working around aircraft with an ejection seat. Each ejection seat has several ground safety pins on red-flagged lanyards at every point of possible danger. They must be installed whenever the aircraft is on the ground or deck, and they must never be removed until the aircraft is ready for flight.

The following general precautions should always be kept in mind:

- Ejection seats must be treated with the same respect as a loaded gun - always consider an ejection seat system as loaded and armed.
- Before you enter a cockpit, know where the ejection seat safety pins are located and make certain of their installation.
- Only authorized personnel may work on, remove, or install ejection seats and components, and only in authorized areas.

Supervisors take note: It has been said that nothing is foolproof because fools are so ingenious. Personal safety for those who work around ejection seats cannot be guaranteed; however, a high level of safety can be achieved if personnel have the proper attitude, understanding, training, and supervision. Unless proper maintenance procedures are followed exactly, even routine ejection seat maintenance tasks can bring about an accident or injury. Education of the workers is the best assurance for personnel safety. The workers should be made aware of potential hazards and the proper means of protecting themselves.

SYSTEM DESCRIPTION

LEARNING OBJECTIVES: Describe the function and capabilities of the Martin-Baker MK-GRUEA-7 ejection seat. Identify the sequence and time delay intervals between seat ejections.

This section will describe system operation involving the following components: lower ejection handle, emergency restraint release, rocket motor, drogue parachute assembly, guillotine breech, seawater activated release system (SEAWARS), survival kit, and automatic sequencing system.

The aircraft has four Martin-Baker MK-GRUEA-7 rocket-assisted ejection seats (fig. 1-1) installed for the pilot and three electronic countermeasures officer (ECMO) crewmembers.

All seats are identical in operation and differ only in time delay firing mechanism assemblies and in the rocket motor inboard nozzle diameter, located on opposite sides, so that during ejection, each seat takes a different path. Because of this, certain components of the seat assemblies are designed to ensure that each seat can be fitted only to its correct position. The seat gives the occupants a maximum degree of comfort on long flights by including ventilated seat-position actuators. Each seat has height adjustment while only the pilot's seat has both height and tilt (FWD/AFT) adjustment.

The primary means of ejection is through the canopy. If time permits, the canopy may be jettisoned (only below 250 knots indicated airspeed [KIAS]) prior to ejection. There is no interlock mechanism in this aircraft between the ejection seat and the canopy jettison system. The canopies must be jettisoned as a separate function.

Once ejection is initiated by command-sequenced ejection or by individual activation of the face curtain (primary firing control), the seat functions as a completely automatic system. Each seat is fitted with a gas-operated harness retraction unit, which ensures that the seat occupant's upper body is correctly positioned and retained to enable the occupant to withstand the forces of ejection. The occupant's upper restraint harness is pulled in and locked, and on leaving the aircraft, the occupant's legs are withdrawn, the emergency oxygen supply is started, the timing devices of both the drogue gun and the time-release mechanism assemblies are started, and the rocket motor initiator fires the rocket motor. When clear of the aircraft and approximately at the rocket motor burnout, the drogue gun fires to deploy the stabilizing drogue parachutes. With the proper altitude and time conditions satisfied, the time-release mechanism will activate the restraint release system and deploy the personnel parachute, separating the occupant from the seat as the personnel parachute inflates.

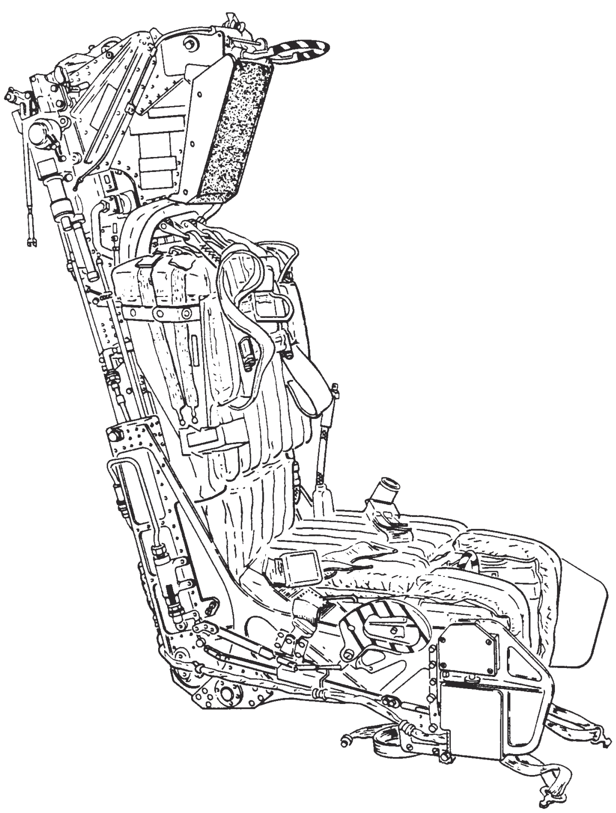


Figure 1-1.—Martin-Baker MK-GRUEA-7 rocket-assisted ejection seat.

LOWER EJECTION HANDLE

The lower ejection handle is on the forward face of the seat bucket in case injury or high-g conditions prevent the occupant from reaching overhead to use the face curtain.

EMERGENCY RESTRAINT RELEASE

An emergency restraint release control fires the guillotine, severing the personnel parachute withdrawal line from the drogue parachutes and also allowing the occupant to release all restraints as well as the personnel survival equipment. This gives the occupant manual escape from the seat in the event of failure of the automatic release system or during crash and ditching conditions.

ROCKET MOTOR

The thrust produced by the ejection gun is added to by the rocket motor, which enables the ejection seat to reach at least an 80-knot speed, zero-altitude.

DROGUE PARACHUTE ASSEMBLY

After ejection, the ejection seat and occupant are stabilized and decelerated by a duplex drogue parachute assembly, which is rapidly developed by a cartridge-operated drogue gun. A time-release mechanism assembly mounted on each seat automatically releases the personnel parachute container, the survival kit, the leg restraint lines, upper harness restraint, and the drogue parachute restraint. This causes withdrawal of the personnel parachute assembly from the seat at a preset interval after ejection, provided an altitude sensing barostat has freed the mechanism. Sticker clips on either side of the lower restraint harness cause the seat to rotate away from the occupant so that when the personnel parachute opens, the seat will not strike them.

GUILLOTINE BREECH

A guillotine breech and emergency restraint release is mounted on the right side of the seat bucket, the breech connected by a pipe run to a guillotine unit on the left upper side of the seat structure. Operation of the emergency restraint release will release the personnel parachute container, survival kit, leg-restraint lines, and the upper and lower restraint harness. Also, a cartridge in the guillotine unit will fire, which will sever the personnel parachute withdrawal line and move the wedges in the sticker clip blocks to lessen the sticker clip pullout load from 70 to 35 lb and prevent operation of the upper and lower ejection handles.

SEAWATER ACTIVATED RELEASE SYSTEM (SEAWARS)

The SEAWARS provides a backup automatic mode of separating the parachute from the crewmember. Automatic release is for disabled crewmembers or when there is not enough time to manually open the canopy release. The parachute harness sensing release units are designed to release the crewmember from the parachute within two seconds after seawater entry.

SURVIVAL KIT

Each ejection seat has an emergency oxygen supply in the survival kit, which is activated on ejection to supply gaseous oxygen during descent to ground contact. It also can be manually operated in the event of an aircraft oxygen system failure. A survival kit is in the seat bucket and is secured to the occupant's lower restraint harness.

AUTOMATIC SEQUENCING

Ejection seats not production-installed with the ECMO #1 command ejection capability, or not incorporating ACC #496, provide for automatically sequenced ejection of all crewmembers when the pilot initiates ejection and also provides for individually actuated ejections. Automatic sequencing cannot be initiated by any crewmember other than the pilot.

The sequence of ejection and the time delay interval (table 1-1) between individual seat ejections is as follows:

NOTE: Automatic timing devices are preset, and the preset delay will be encountered whenever an individual crewmember initiates ejection; for example, the right front seat would fire 0.8 second after initiated ejection. If all crewmembers eject individually and then the pilot ejects, his time delay is still 1.2 seconds.

Q1-1. Prior to entering a cockpit with an ejection seat, what precaution should you take?

Q1-2. State the purpose of varying the rocket motor inboard nozzle diameters.

Q1-3. The primary means of ejection is through the canopy, but if time permits, the canopy may be jettisoned at what maximum airspeed?

Q1-4. ECMO #1 ejects how many seconds after ECMO #2?

Q1-5. In what time frame does the pilot eject after ejection is initiated?

PRINCIPLES OF OPERATION

LEARNING OBJECTIVE: Identify the different types of ejections.

Table 1-1.—Sequence of Ejection

Left rear seat (ECMO #3)	0.0 second after ejection is initiated
Right rear seat (ECMO #2)	0.4 second after ejection is initiated (0.4 second after ECMO #3)
Right front seat (ECMO #1)	0.8 second after ejection is initiated (0.4 second after ECMO #2)
Left front seat (Pilot)	1.2 seconds after ejection is initiated (0.4 second after ECMO #1)

The pilot is the primary person to initiate command ejection, though modifications to the system have allowed ECMO #1 to have the ability to select command ejection. The following paragraphs will discuss command sequenced ejection, normal command position, ECMO command position, ejection sequence below and above 13,000 ± 1,500 feet, ejection sequence for manual separation, and separation of parachute from crewmembers.

COMMAND SEQUENCED EJECTION

Upon activation of either the pilot's face curtain or lower ejection handle, the following series of events will occur on ejection seats not having the ECMO #1 command ejection capability:

1. The pilot's harness retraction unit firing mechanism sear, the ejection gun time delay firing mechanism sear, and the sequence gas generator sear are extracted by rotation of the cross shaft assembly and movement of the linkage assembly, levers, and operating rods.
2. The cartridge within the harness retraction unit breech is fired and the unit automatically pulls back and restrains the seat occupant in the correct ejection position.
3. The time delay firing mechanism on top of the ejection gun is activated and the cartridge within the sequence gas generator breech is fired.
4. Through a series of flexible and rigid gas lines, pressurized gas from the fired pilot's sequence gas generator cartridge actuates the gas-actuated piston assembly on each of the three ECMO ejection seats.
5. Upward movement of the piston assembly rotates the cross shaft assembly, levers, and operating rod, and withdraws the sears from the harness retraction unit firing mechanism and the ejection gun time delay firing mechanism.

The pilot's ejection seat has been modified to be identical with the ECMO #1 ejection seat with the addition of the gas-actuated piston assembly and the modified cross shaft assembly. The ECMO #1 sequence gas generator and the pilot's gas-actuated piston assembly are connected to gas sequencing lines that connect the command eject control to both ejection seats. The command eject control, on the right side of the center console extension next to the ECMO #1 ejection seat, is accessible to the pilot and ECMO #1 during flight and allows either of the two crewmembers to select who shall initiate command ejection. The command eject control is the command eject control handle assembly (marked CMD EJECT SELECT) and an ejection mode selector valve operated by the handle assembly.

NORMAL COMMAND POSITION

With the CMD EJECT SELECT handle in the NORM (pilot's) command position, command-sequenced ejections and individual initiated ejections are similar to unmodified ejection seats, except that in each case the ECMO #1 sequence gas generator sear is extracted and the cartridge is fired. Pressurized gas from the fired ECMO #1 sequence gas generator cartridge enters the INLET port of the selector valve and exits through the DUMP port and into the cockpit area.

ECMO COMMAND POSITION

With the CMD EJECT SELECT handle in the ECMO command position, ECMO #1 is able to initiate command-sequenced ejection. Upon activation of either the ECMO #1 ejection seat face curtain or lower ejection handle, the following will occur:

1. The ECMO #1 harness retraction unit, ejection gun time delay mechanisms sear, and the sequence gas generator sear are extracted by the rotation of the cross shaft assembly and movement of the linkage assembly, levers, and operating rods.
2. The cartridge within the harness retraction unit breech is fired and the unit automatically pulls back and restrains the seat occupant in the correct ejection position.
3. The time delay firing mechanism on top of the ejection gun is activated and the cartridge within the sequence gas generator breech is fired.
4. Pressurized gas from the fired sequence gas generator cartridge enters the INLET port of the selector valve and exits through the OUTLET port to actuate the pilot's ejection seat gas-actuated piston assembly.

5. Upward movement of the piston assembly rotates the cross shaft assembly and movement of the linkage assembly, levers, and operating rods, withdraws the sears from the harness retraction unit, ejection gun time delay firing mechanism, and sequence gas generator.
6. The pilot's ejection seat is actuated and the ECMO #2 and ECMO #3 ejection seats are then actuated in the same manner as if the pilot had initiated the command sequenced ejection. Ejection order and 0.4-second interval between ejections is unchanged.
7. ECMO #3 ejects immediately, followed in succession by ECMO #2, ECMO #1, and the pilot.

With the CMD EJECT SELECT handle in the ECMO command position, only ECMO #2 and ECMO #3 can eject individually. The pilot can initiate command-sequenced ejection regardless of what position the CMD EJECT SELECT handle is in.

EJECTION SEQUENCE BELOW 13,000 ± 1,500 FEET

Time permitting, and below 250 KIAS, the canopies will be jettisoned by the pilot (or forward crewmember) prior to ejection, otherwise the primary means of ejection is through the canopy. Ejection can be initiated by the command-sequenced ejection or individual pulling of the face curtain handle, which fires the harness retraction unit cartridge and ejection gun primary cartridge. If the face curtain handle cannot initiate ejection, the occupant can pull the lower ejection handle on the forward edge of the seat bucket. As the ejection gun begins to propel the seat upwards, the following occurs:

1. The initial upward movement of the seat pulls in and retains the occupant's legs against the forward face of the seat bucket with the leg restraint mechanism.
2. The drogue gun assembly and time-release mechanism assembly trip rods (secured to the fixed ejection gun bracket) are extracted, arming the escapements of both mechanisms.
3. The emergency oxygen supply is activated.
4. The IFF/CHAFF switch on the ejection gun fixed bracket is released, activating the emergency channel of IFF (identification friend or foe) and dispensing all chaff if power is available and selected.
5. The emergency beacon radio in the survival kit is activated.
6. Immediately before the ejection gun inner piston separates from the intermediate piston, the rocket motor initiator static line becomes taut and the initiator fires the rocket motor.
7. At approximately 0.5 second after ejection, the drogue gun assembly will fire. The drogue gun piston withdraws the controller drogue parachute from its container on top of the seat. The pull of the deployed controller drogue in the slipstream withdraws the stabilizer drogue from the container. The stabilizer drogue, when fully deployed, decelerates and stabilizes the seat. Approximately two seconds after the escapement mechanism starts, the time-release mechanism assembly performs the following actions:
    a. Removes restraint from the scissor shackle retaining plunger, allowing the scissor shackle to open and free the drogue shackle. The pull of the drogue parachutes through the link line then releases the occupant's face curtain, withdraws the parachute withdrawal line from the guillotine unit, and pulls the personnel parachute from its container.
    b. Extension of the time-release mechanism harness release plunger rotates the harness release lever, releasing the upper and lower harness locks, the personnel parachute retaining locks, the survival kit retaining locks, and the leg restraint locks.

The resistance produced by the fully developed personnel parachute pulls the occupant and survival kit free of the sticker clips, ensuring clean separation between the seat and occupant.

EJECTION SEQUENCE ABOVE 13,000 ± 1,500 FEET

The seat-ejection sequence for ejections above 14,500 feet (fig. 1-2) is similar to that for low-level ejection except for the operation of the time-release mechanism barostat assembly. The barostat assembly prevents operation of the time-release mechanism escapement until the seat and occupant have descended, stabilized by the drogue parachutes, to an altitude between 14,500 and 11,500 feet. During the stabilizer descent from the time of ejection to the time

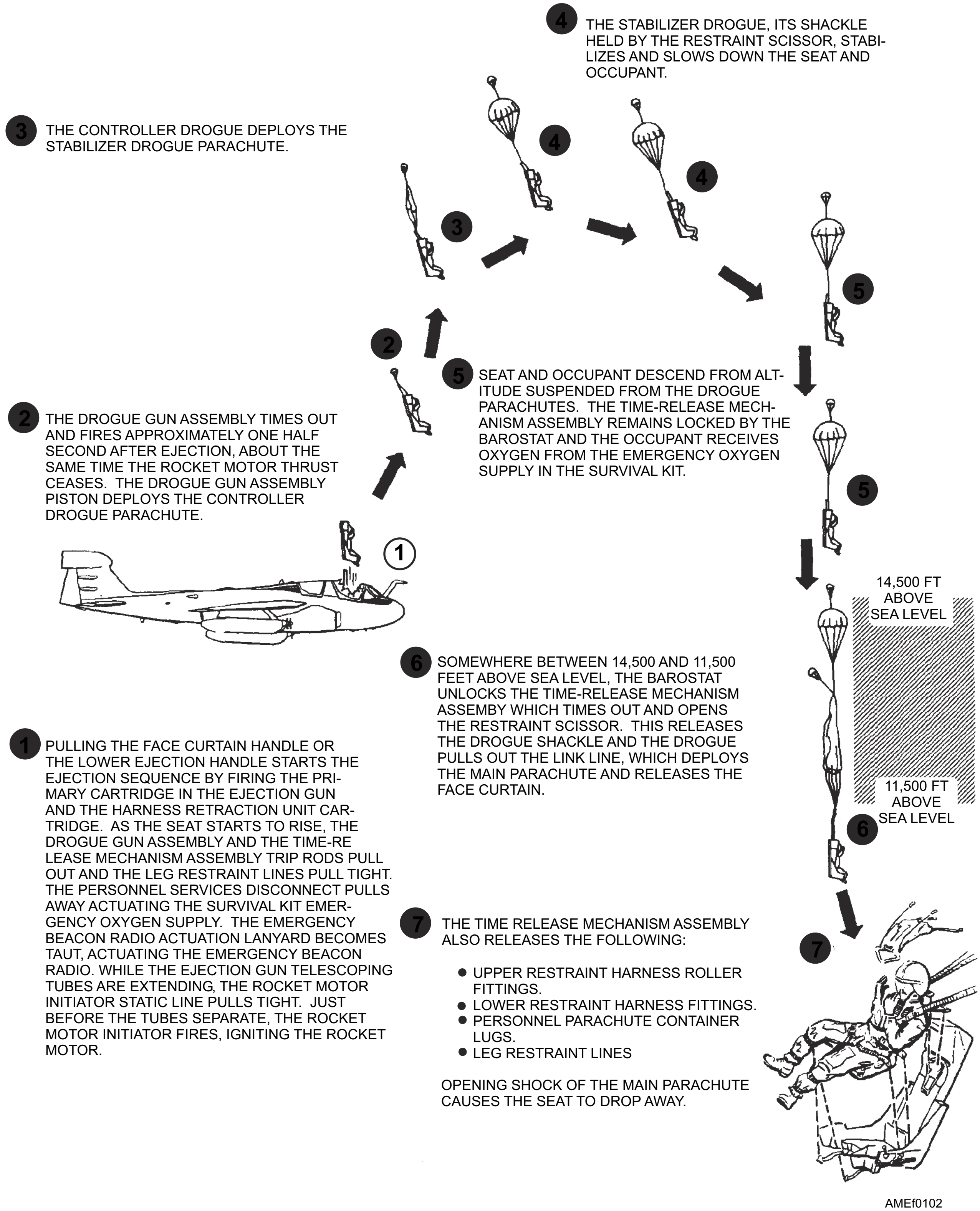


Figure 1-2.—Ejection sequence above 13,000 ± 1,500 feet.

of surface contact, the occupant has oxygen from a system in the survival kit. At an altitude between 14,500 and 11,500 feet, the barostat assembly releases the time-release mechanism escapement, initiating its timed operation. Upon actuation of the time-release mechanism, occupant release and separation occurs the same way as ejection sequence below 13,000 ± 1,500 feet.

EJECTION SEQUENCE FOR MANUAL SEPARATION

If the time-release mechanism fails, or if the terrain altitude is above the setting of the barostat, the occupant must initiate manual separation from the seat and deployment of the personnel parachute. The following will occur:

1. The occupant puts the emergency restraint release in its full up unlock position, releasing the upper harness locks, personnel parachute restraint locks, survival kit to seat lock, and leg-restraint line locks. This action reduces sticker clip tension and fires the guillotine cartridge.
2. The gas from the cartridge operates the guillotine unit to sever the personnel parachute withdrawal line.
3. The occupant must now rotate forward and push the seat bucket with his hands to separate from the seat.
4. When free of the seat, the occupant must pull the personnel parachute manual release (parachute ripcord handle) to deploy the personnel parachute.

SEPARATION OF PARACHUTE FROM CREWMEMBERS

Manually opening the canopy release assembly is the primary means of separating the parachute from the crewmember. The SEAWARS (a backup mode) automatically releases the parachute from the crewmember within two seconds after seawater entry. When the parachute harness sensing release units are immersed in seawater, cartridges fire to separate the parachute risers from the canopy release assembly. Immersion in fresh water will not activate the parachute harness sensing release units.

Q1-6. During command sequenced ejection, the sequence gas generator sear is extracted by rotation of what assembly?

Q1-7. With the CMD EJECT SELECT handle in the ECMO command position, what crewmember is able to initiate command-sequenced ejection?

Q1-8. During ejections below 13,000 ± 1,500 feet, what assembly will actuate at approximately 0.5 second after ejection?

Q1-9. What procedure must be initiated if the time-release mechanism fails?

COMPONENTS

LEARNING OBJECTIVE: Identify the major ejection seat components.

The components discussed below include the rocket motor (DODIC M938, M939, and M940), rocket motor initiator, color-coded brackets, main beam assembly, top latch mechanism, time-release mechanism, personnel parachute, upper restraint harness, and parachute harness sensing-release units.

ROCKET MOTOR (DODIC M938, M939, AND M940)

Each Martin-Baker MK GRUA-7 ejection seat has a rocket motor attached to the underside of the seat bucket (fig. 1-3). The rocket motor is connected by a

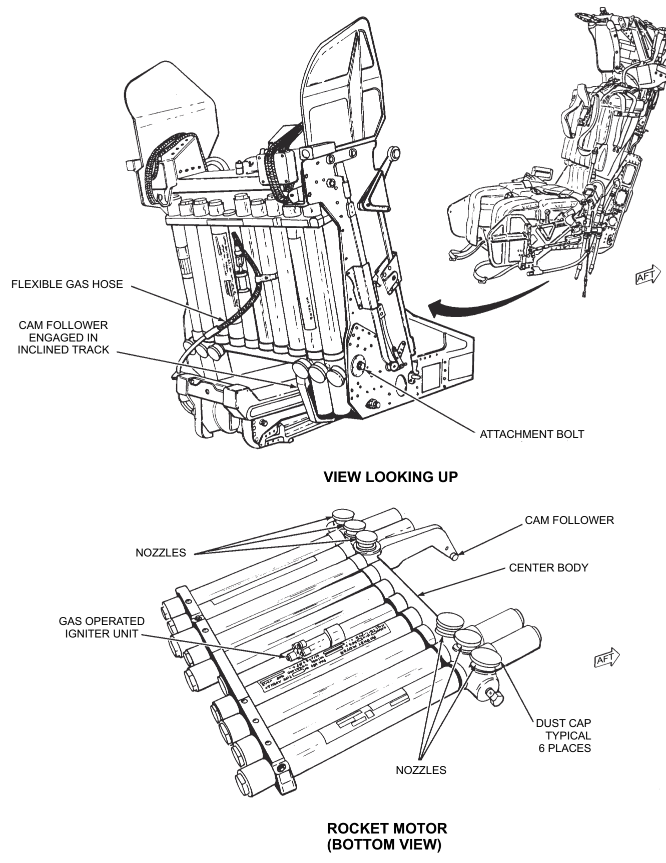


Figure 1-3.—Rocket motor (DODIC M938, M939, and M940).

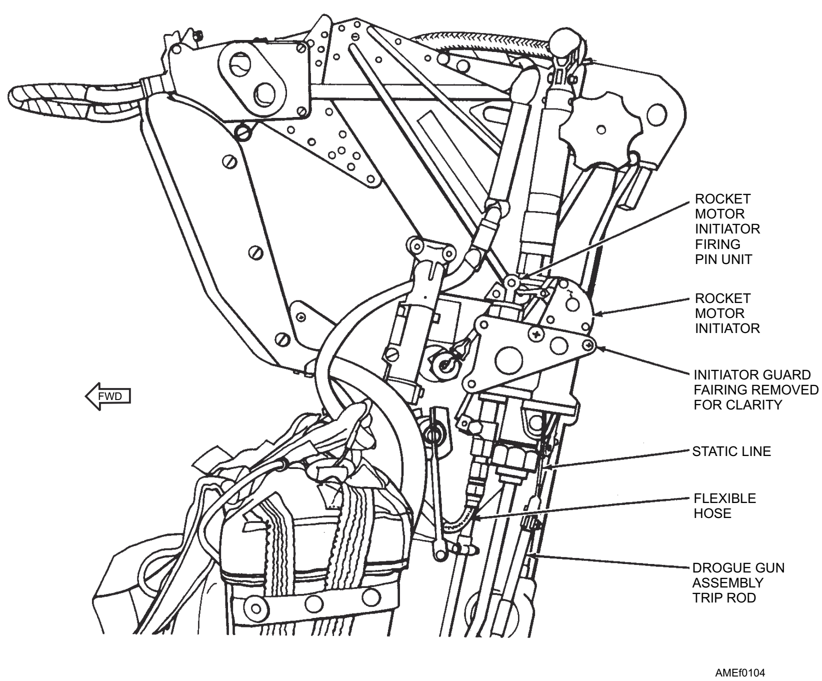


Figure 1-4.—Rocket motor initiator mounting.

flexible hose to a rocket motor initiator attached to the left upper side of the seat structure (fig. 1-4).

> **WARNING**
>
> The rocket motor unit is a sealed unit; therefore, do not attempt to remove the rocket motor igniter cartridge.

Each rocket motor consists of a center body to which is attached 14 tubes, 10 facing forward and 4 facing aft. One of the forward facing tubes contains a primer-fired igniter cartridge and is initiated by the gas generated by the impulse cartridge (DODIC M783). The remaining 13 tubes contain rocket propellant. Six rocket efflux nozzles are attached, three at either end of the center body, each nozzle being sealed by a blowout disk. Projecting aft from the center body is an arm that contains a cam follower; the cam follower engages the inclined track attached to the left main beam of the ejection seat structure. This provides a pivoting action to the rocket motor, which adjusts the nozzle angle to compensate for the change in the seat-occupant center of gravity due to raising or lowering of the seat bucket. At either outboard end of the center body is a threaded hole to which the attaching bolts fit.

The rocket motor (DODIC M938) of the pilot and ECMO #3 seats are identical. The inboard (right side) nozzle of the rocket motor is larger to ensure the seats eject to the left. ECMO #1 rocket motor (DODIC M939) is a mirror image of the pilot seat rocket motor and the inboard (left side) rocket nozzle is larger to ensure the seats eject to the right. The attachment bolts for each rocket motor vary in size to ensure the installation of the correct rocket motor to its related seat and proper divergent trajectories.

The rocket nozzles of the ECMO #2 rocket motor (DODIC M940) are symmetrical and the divergent effect is zero. The divergent angle is predetermined to ensure adequate distance between crewmembers during sequenced ejections.

For rocket motor handling, identification and service life, refer to NAVAIR 11-100-1.1, General Use Cartridge and Cartridge Actuated Devices for Aircraft.

ROCKET MOTOR INITIATOR

The rocket motor initiator is mounted on a plate, which is secured to the drogue gun assembly mounting bolts (fig. 1-5). The unit is divided into two

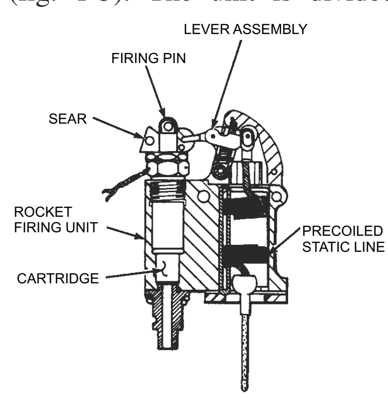


Figure 1-5.—Rocket motor initiator.

compartments. The forward compartment contains an impulse cartridge (DODIC M783) and a firing pin unit. Secured to the lower end of the forward compartment is an end plug that attaches to the gas-operated igniter unit in the igniter tube of the rocket motor. The rear compartment of the rocket motor initiator contains a precoiled static line, the lower end of which is attached to the upper end of the drogue gun trip barrel, which is connected to a fixed bracket on the ejection gun. The upper end of the cable is attached to a lever assembly by a link to the firing pin unit sear.

COLOR-CODED BRACKETS

Each seat is provided with a different color-coded time delay firing mechanism and a color-coded murphy-proof bracket to prevent changing seats. The corresponding color code and crewmember position is seen in figure 1-6.

Pressure sensitive decals (table 1-2) are installed on the ejection seats, which provide seat identification, warnings, and maintenance instructions.

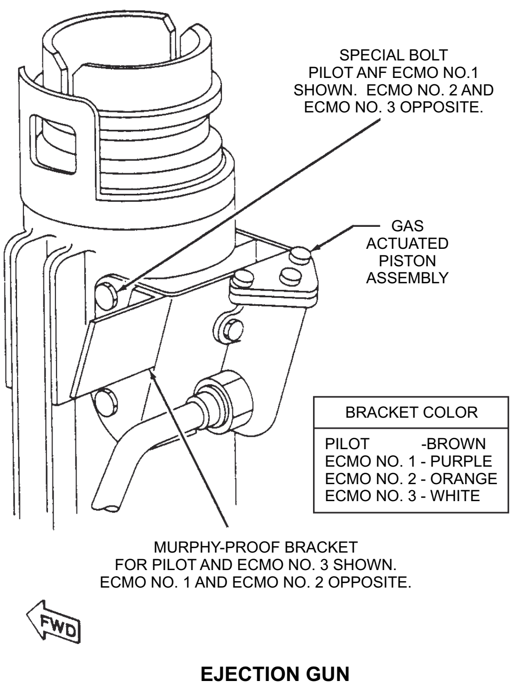


Figure 1-6.—Color-coded murphy-proof bracket.

Table 1-2.—Decal Color Code

SEAT	COLOR CODE
Left front (pilot)	Brown
Right front (ECMO #1)	Purple
Right rear (ECMO #2)	Orange
Left rear (ECMO #3)	White

MAIN BEAM ASSEMBLY

The main beam assembly consists of two vertical main beams, bridged and fixed in position by three horizontal cross-beams, forming a strong, light-weight structure able to withstand high-g loads. This assembly is the structural frame of the seat assembly to which major components such as the drogue container, drogue gun, time-release mechanism, harness retraction unit, and seat bucket are secured. The main beams are designed to prevent ejection seat interchangeability.

The top cross-beam positions the seat on the ejection gun and receives the thrust of the ejection gun during ejection. Passing through the left main beam and top cross-beam is the top latch plunger, which locks the ejection gun inner piston and ejection seat to the ejection gun cylinder. Bolted to the top cross-beam is a scissor shackle assembly, which holds the drogue assembly to the main beam assembly before operation of the time-release mechanism assembly.

The center cross-beam forms the upper attachment point for the seat positioning actuator (seat bucket height positioning actuator) and the bottom cross-beam is the bottom support of the main beams.

Located on the inner face of each main beam are three slippers, positioned in the guide rails of the ejection gun cylinder. Two guide tracks are attached to the outer face of each main beam, providing the mounting for the seat bucket. Located at the lower outer face of the left -main beam is an inclined track, which adjusts the angle of thrust of the rocket motor according to the position of the seat bucket on the main beam assembly.

TOP LATCH MECHANISM

The top latch mechanism (fig. 1-7), on the upper left side of the top cross-member and main beam assembly, locks the three ejection tubes and main beam assembly together, securing the seat in the aircraft. Locking is done by a spring-loaded plunger that protrudes through the left main beam, the ejection gun outer cylinder barrel safety latch, and the housing, its wedge-shaped end protruding into the inner piston tube breech locking groove. Before removing the seat from the aircraft, the plunger must be mechanically withdrawn by screwing a handwheel onto the plunger. On ejection, the top latch plunger is withdrawn by forces from the initial movement of the inner piston tube acting between the breech groove and the wedge-shaped end of the plunger.

A spring-loaded dowel indicator in the top latch plunger extends beyond the wedge-shaped end of the plunger to ensure that the plunger is completely bottomed in the inner piston tube breech groove. The dowel indicator is the same length as the top latch plunger. When the plunger is completely bottomed in the inner piston tube breech groove, the indicator is forced back against the spring and its outboard end is flush with the end of the plunger. If the latch is not completely bottomed in the breech groove, the plunger extends beyond the plunger housing and the dowel indicator is recessed within the plunger.

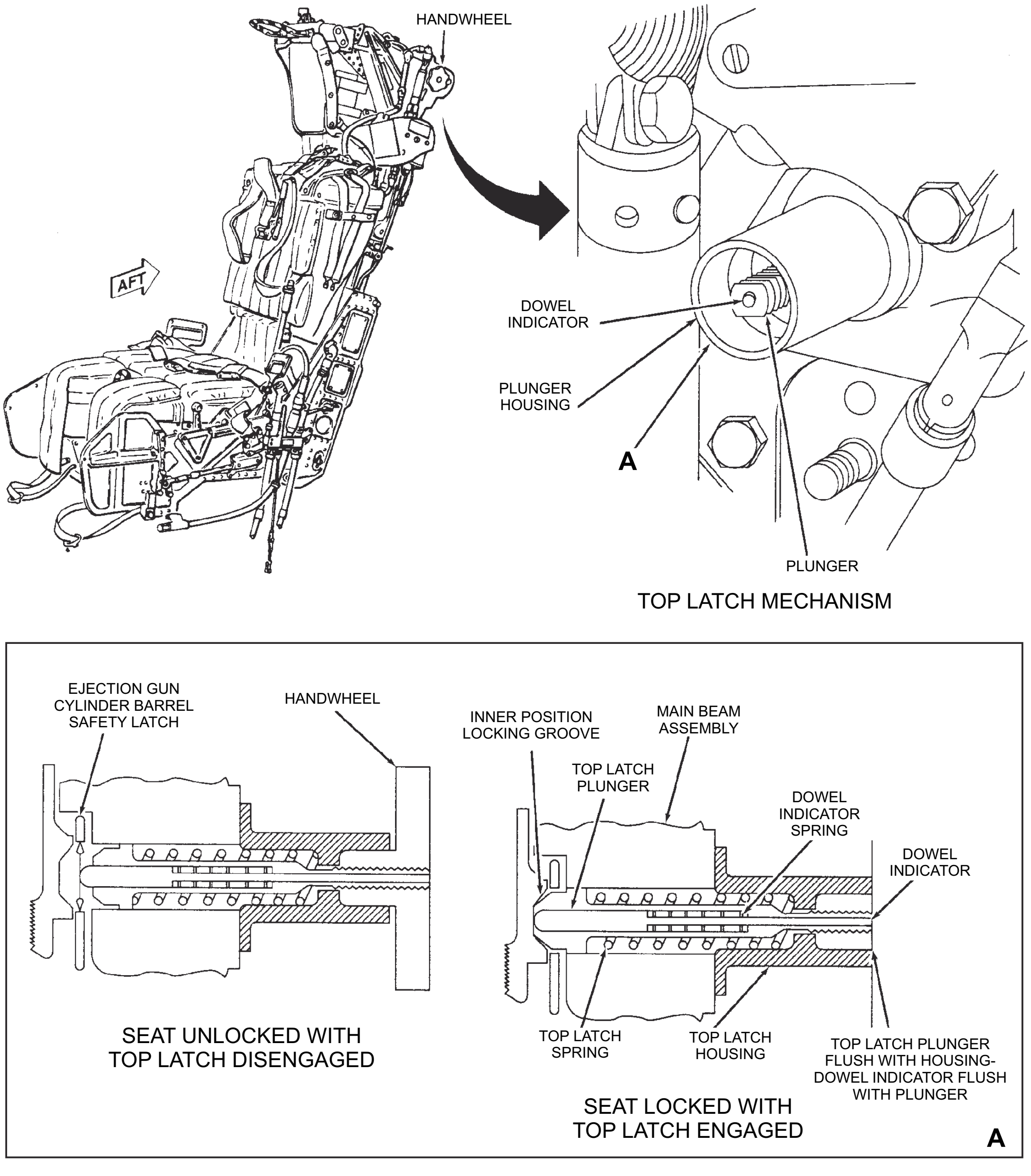


Figure 1-7.—Top latch mechanism.

TIME-RELEASE MECHANISM

The time-release mechanism assembly is on the upper right portion of the main beam assembly (fig. 1-8). This assembly provides automatic actuation of the harness release mechanism, releasing the drogue parachute and deploying the personnel parachute, which releases all occupant restraints between 1.9 and 2.1 seconds after initiation of the escapement mechanism. The barostat assembly governs initiation of the escapement mechanism until both the seat and occupant have descended to an altitude between 14,500 and 11,500 feet. The time-release mechanism assembly is a spring-loaded harness release plunger controlled by a spring-loaded rack plunger. The spring-loaded rack plunger is meshed with a gear train controlled by an escapement mechanism. The gear train consists of a primary wheel and pinion, secondary wheel and pinion, and escapement wheel and rocker. A barostat assembly consisting of an aneroid capsule in a housing is screwed into the case in a position that allows a peg attached to the capsule to engage the teeth of the escapement wheel and prevent the release mechanism from operating.

The time-release mechanism assembly trip rod also is used to check that the ejection seat is properly installed in the aircraft. When the seat is properly installed, the insignia red portion of the inner rod of the trip rod is not visible. If the seat is improperly installed and the trip rod is connected, the trip rod extends and causes the insignia red portion of the inner rod to extend beyond the yellow-orange trip rod barrel.

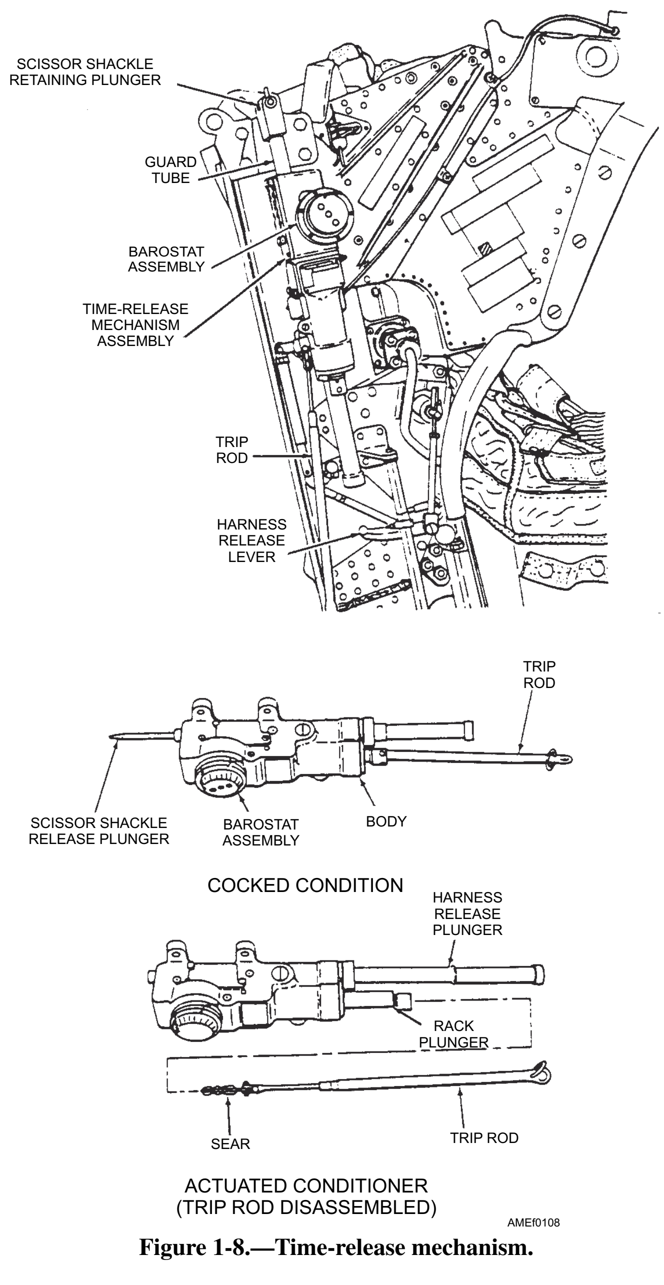


Figure 1-8.—Time-release mechanism.

PERSONNEL PARACHUTE AND UPPER RESTRAINT HARNESS

The personnel parachute and upper restraint harness (fig. 1-9) consists of a 28-foot diameter personnel parachute, parachute container, and shoulder harness roller and canopy releases. The personnel parachute is packed per NAVAIR 13-1-6.2, within a specially shaped rigid container, which rests on the parachute support plate. The container is secured to the seat by inserting two taper plugs into the parachute container locks attached to the main beams and forming part of the harness-release mechanism.

The personnel parachute withdrawal line is routed up the left side of the headbox and through the guillotine unit, and attaches by a screwed coupling to the drogue parachute assembly link line. The withdrawal line is held to the seat by a lug attached partway along the line, inserted into the left upper harness lock together with, and outboard of, the left webbing strap of the harness retraction unit. Attached to the left parachute riser is the personnel parachute manual release cable, used to deploy the parachute for either over-the-side bailout or after manual separation from the seat during ejection.

The upper restraint harness consists of roller assemblies attached to the parachute risers. The harness retraction unit webbing straps pass through the rollers and the lugs are inserted in the upper harness locks. The parachute risers are attached to the occupant harness by canopy releases. A ventilated back pad is provided forward of the personnel parachute and secured by a touch-and-close fastener to the personnel parachute container.

PARACHUTE HARNESS SENSING-RELEASE UNITS

The SEAWARS consists of two parachute harness sensing-release units, one fitted to each parachute riser. The units are designed to release the crewmember from the parachute within two seconds after seawater entry. Each unit is composed of a canopy release assembly (Koch fitting), electronics package assembly (EPA), battery, cartridge assembly (DODIC MW19), electrically activated explosive device (EED), and mechanical parts.

Q1-10. What is the purpose of the different color-coded brackets?

Q1-11. What component is the structural frame of the seat assembly?

Q1-12. What component provides automatic actuation of the harness release mechanism?

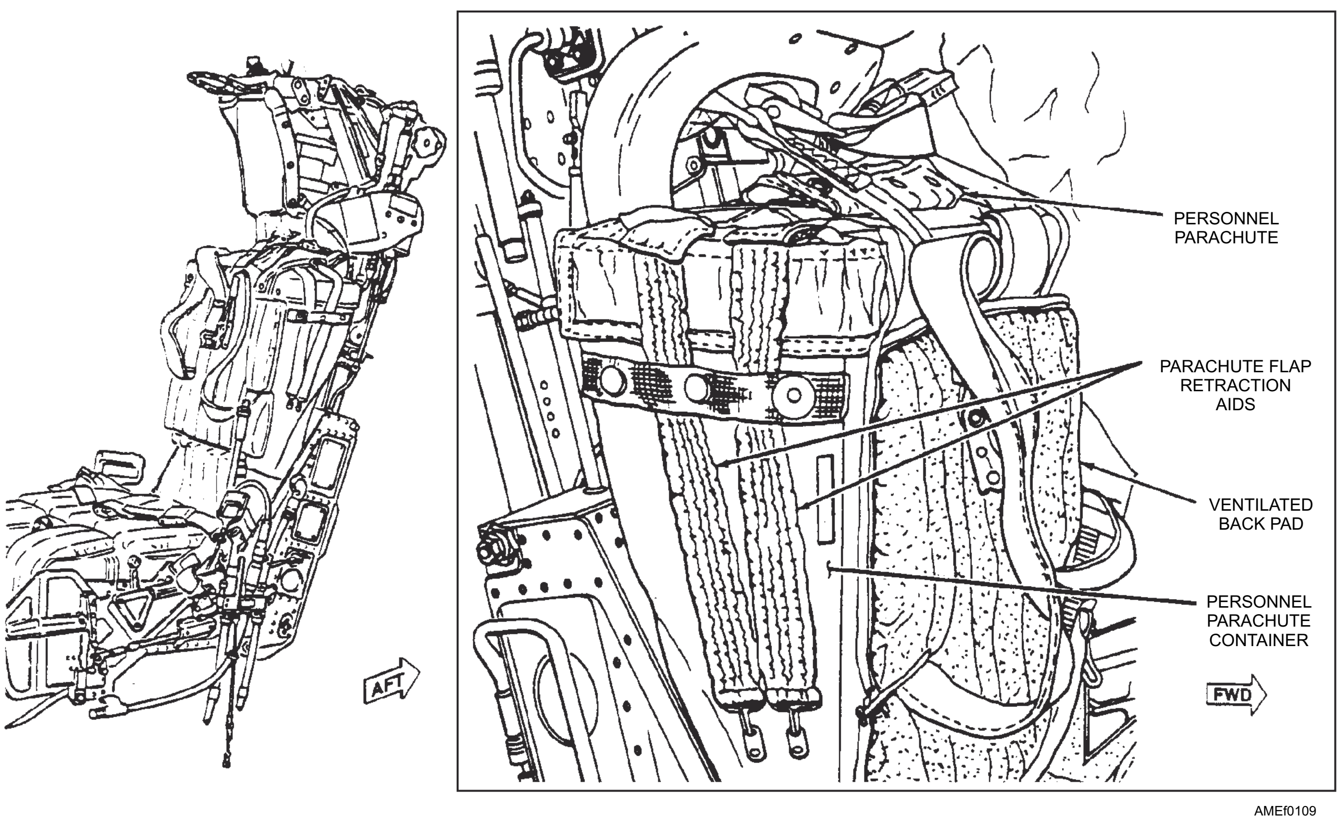


Figure 1-9.—Personnel parachute and upper restraint harness.

CHAPTER 1

ANSWERS TO REVIEW QUESTIONS

A1-1. Ensure the ejection handle safety pins and safe/armed handles are in the safe position

A1-2. Allows each seat to take a divergent path during ejection

A1-3. 250 KIAS

A1-4. 0.4 second

A1-5. 1.2 seconds

A1-6. Cross shaft

A1-7. ECMO #1

A1-8. Drogue gun

A1-9. Occupant must initiate manual separation from the seat and deployment of the personnel parachute

A1-10. To prevent interchangeability of seats

A1-11. Main beam assembly

A1-12. Time-release mechanism

CHAPTER 2

NAVY AIRCREW COMMON EJECTION SEAT (NACES)

The NACES seat (figs. 2-1 and 2-2) is a cartridge-operated and rocket-assisted ejection seat with an automatic electronic sequencing system. Safe escape is provided for most combinations of aircraft altitude, speed, altitude and flight path within the envelope of zero speed, zero altitude in a substantially level altitude to a maximum speed of 600 knots equivalent airspeed (keas) between zero altitude and 50,000 feet.

Ejection is initiated by pulling a seat-firing handle on the front of the seat bucket between the occupant's thighs. The parachute container is fitted with the canopy breakers to enable the seat to eject through the

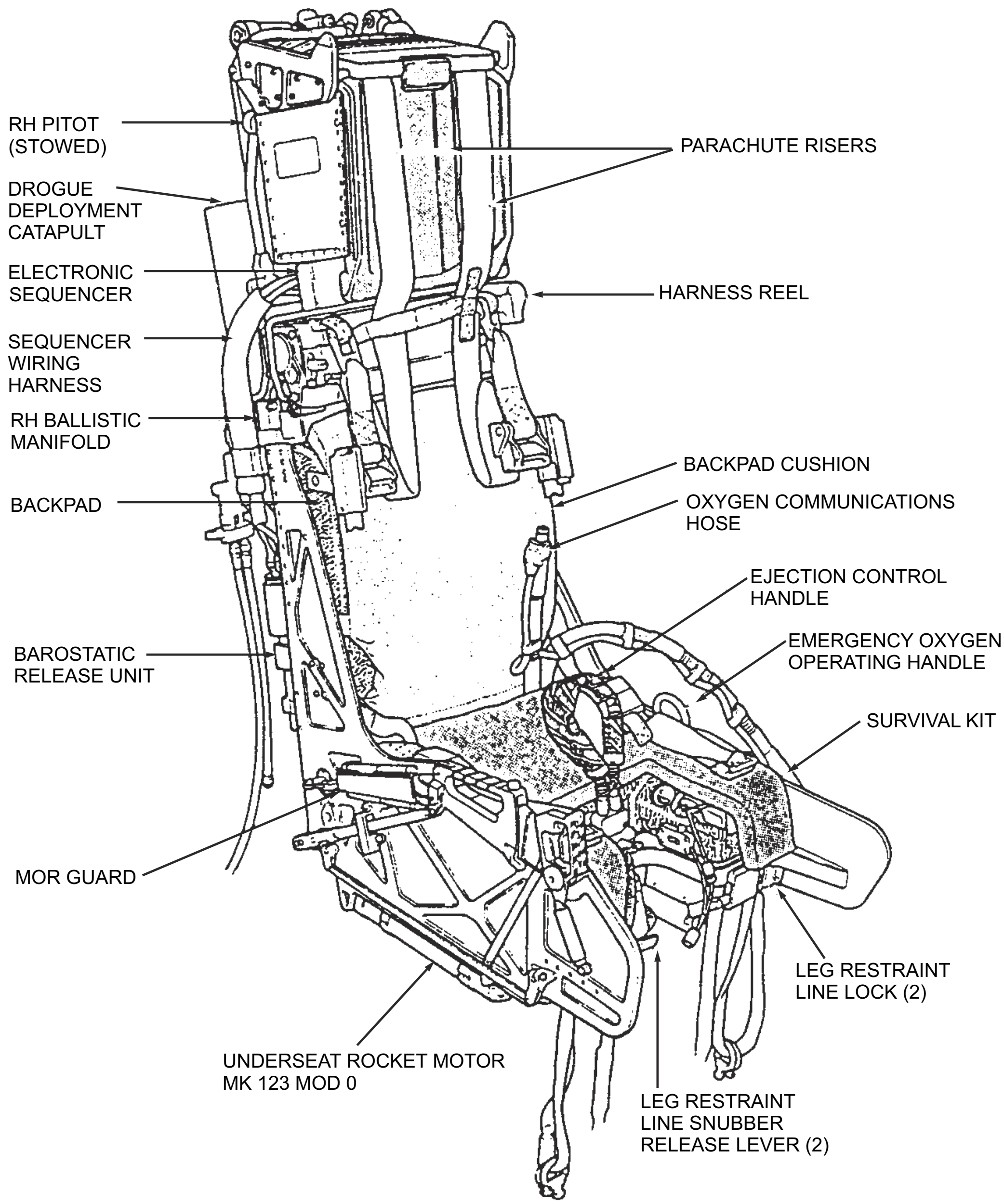


Figure 2-1.—Forward ejection seat, RH view (SJU-17(V)2/A).

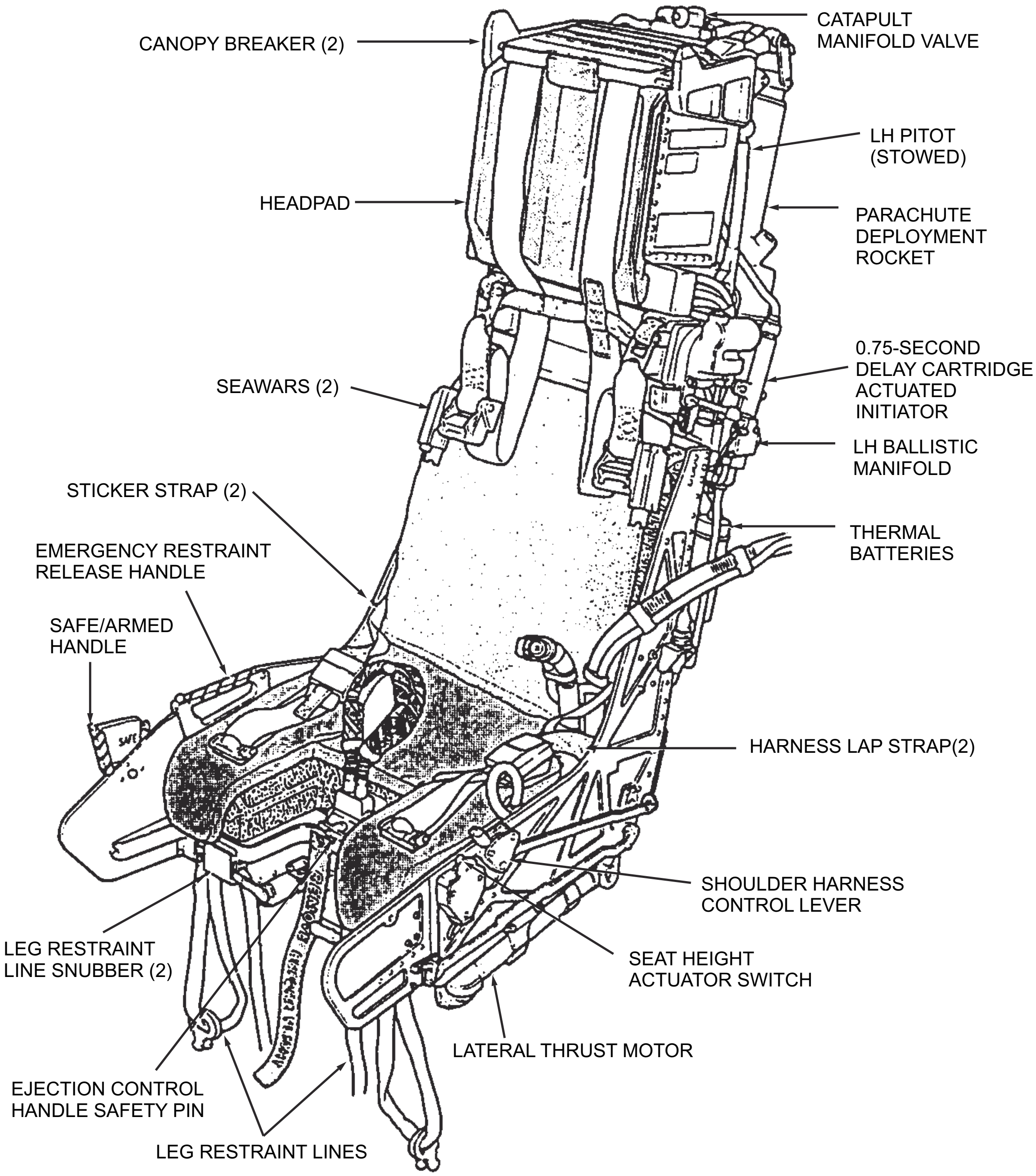


Figure 2-2.—Forward ejection seat, LH view (SJU-17(V)2/A).

cockpit canopy should the canopy jettison/fracturing system fail. After ejection, an on-board multi-mode electronic sequencer automatically controls drogue deployment, man/seat separation and parachute deployment. A barostatic release unit provides for partial or total failure of the electronic sequencer and an emergency restraint release (manual override) system provides a further backup in the event of failure of the barostatic release.

The seat is ejected by the gas pressure developed within a telescopic catapult when the cartridges are ignited. An underseat rocket motor is fired as the catapult reaches the end of its stroke and sustains the thrust of the catapult to carry the seat to a height sufficient to deploy the parachute. The seat is stabilized and the forward speed retarded by a drogue and bridle system, followed by automatic deployment of the personnel parachute and separation of the occupant from the seat. Timing of all events after rocket motor initiation is controlled by the electronic sequencer, which utilizes altitude and airspeed information to select the correct mode of operation.

This chapter provides descriptive and operation information for the SJU-17/A series ejection seats. The seats are installed in F/A-18C, F/A-18D, F-14D and T-45A aircraft as detailed below:

AIRCRAFT	SEAT
F/A-18C	SJU-17(V)1/A
F/A-18D forward	SJU-17(V)2/A
F/A18D aft	SJU-17(V)9/A
F-14D forward	SJU-17(V)3/A
F-14D aft	SJU-17(V)4/A
T-45A forward	SJU-17(V)5/A
T-45A aft	SJU-17(V)6/A

The seven seat variants are essentially similar but incorporate differences to accommodate the seven aircraft installations. For convenience, the description that follows applies to all variants except where noted. Where reference is made to the single seat configuration, the F/A-18C (SJU-17(V)1/A applies, the description applies equally to the aft seat F/A-18D (SJU-17(V)9/A) aircraft installation, except where noted.

GENERAL DESCRIPTION

LEARNING OBJECTIVE: Identify the components of the NACES seat and their function.

Each ejection seat, as installed in the aircraft, comprises five main assemblies (fig. 2-3), which are briefly described in the following paragraphs:

- The catapult assembly secures the ejection seat to the aircraft.
- The main beam assembly includes the left hand (LH) and right hand (RH) main beams, upper and lower cross-beams, shoulder harness retraction unit, parachute deployment rocket motor, electronic sequencer system, barostatic release unit, drogue deployment catapult, two

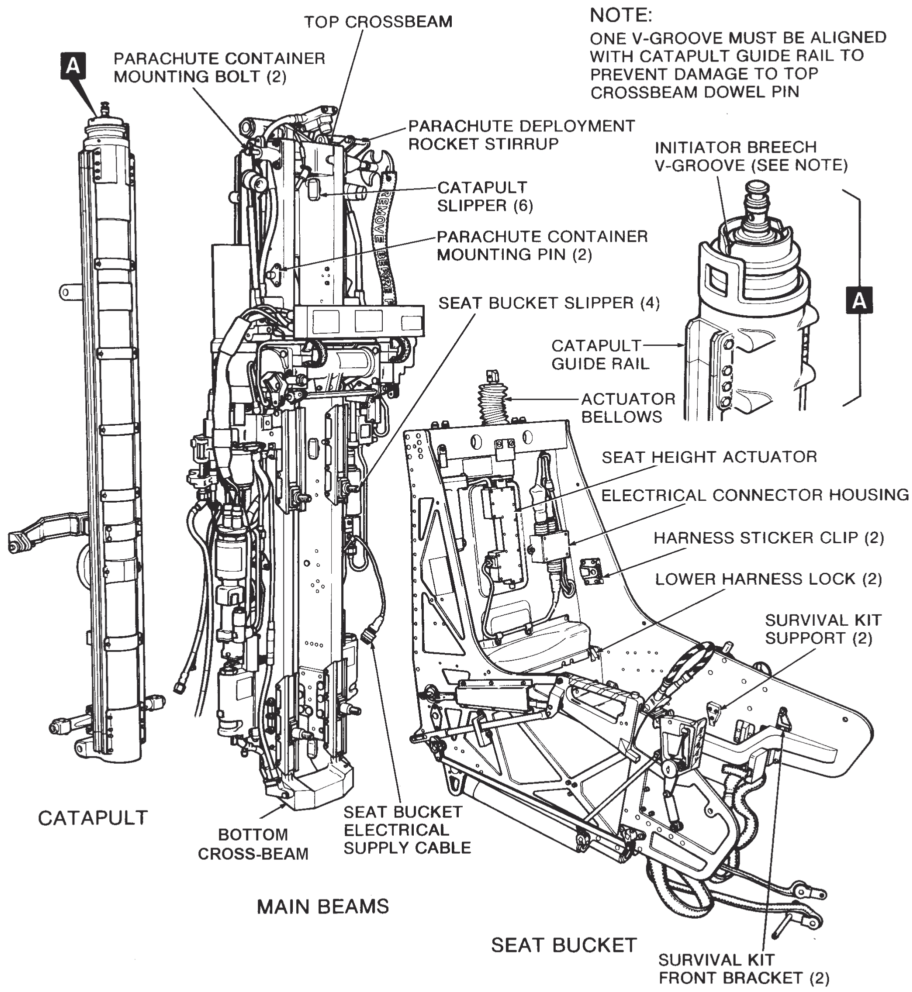


Figure 2-3.—Forward ejection seat, main assemblies (SJU-17(V)2/A).

multipurpose initiators, and two ballistic manifolds.

- The seat bucket assembly includes the underseat rocket motor, leg restraint system, ejection control handle, safe/armed handle, emergency restraint release system, and shoulder harness release fittings.
- The parachute assembly consists of the parachute container and parachute canopy.
- The seat survival kit includes the emergency oxygen system, liferaft, survival aids, lap belts, and release fittings.

CATAPULT ASSEMBLY

The catapult (fig. 2-4) secures the ejection seat to the aircraft structure and provides the initial power for the ejection of the seat. The catapult consists of an outer barrel, an inner telescopic piston, and a catapult manifold valve. The barrel is attached to the aircraft structure and the piston and barrel are engaged at the top end by the top latch plunger installed in the main beam assembly.

Explosive charges are contained in an ejection gun initiator JAU-56A and a secondary cartridge. Gas pressure from the seat firing system or the aircraft

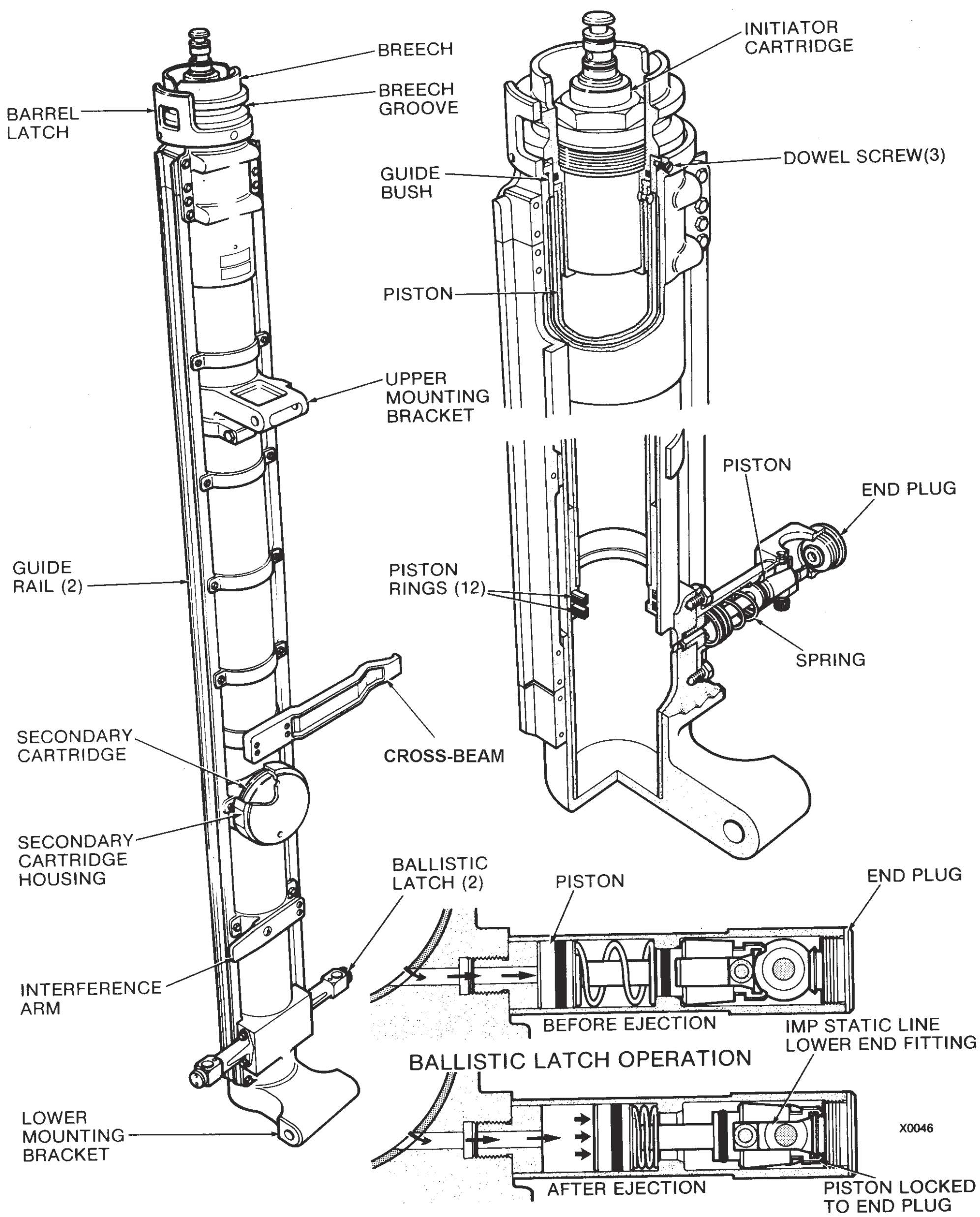


Figure 2-4.—Catapult assembly, forward seat (SJU-17(V)2/A).

command sequencing system operates twin firing pins in the ejection gun initiator to fire the explosive charge. The resultant gas pressure and the heat operate the ballistic latches in the barrel and fire the secondary cartridge as the piston extends. The catapult is water sealed, having seals fitted to the initiator, the secondary cartridge, the breech, and the guide bush.

Barrel

The barrel is a built-up structure consisting of a light alloy tube with an accurately lapped bore that has permanently attached top and bottom end fittings; a housing towards the bottom end contains the secondary cartridge. Five brackets support two guide rails bolted on diametrically opposite sides of the tube. The bottom end fitting incorporates the lower mounting bracket for attaching the catapult to the aircraft and studs for attachment of the ballistic latches. The upper mounting consists of a bracket clamped on the barrel towards the upper end. It has an interference shoulder on one side to ensure location of the catapult in the correct cockpit (fig. 2-5). An interference arm mounted on one of the guide rail brackets ensures that the correct main beam assembly is installed. A cross-beam secured to the barrel provides an anchorage point for the RH ballistic manifold quick-disconnect lanyard.

The top end fitting of the barrel has a square aperture, the barrel latch, through which the plunger of the top latch mechanism fitted on the seat main beam protrudes when the seat is installed on the catapult. A guide bush, fitted in the internal diameter of the top end fitting, is secured by three dowels that are sheared by the head of the piston striking the guide bush. The piston then separates from the barrel and the guide bush remains on the piston.

Two ballistic latches are attached to the bottom end fitting by studs and nuts. Each latch comprises a body, internally drilled to form a cylinder and containing a

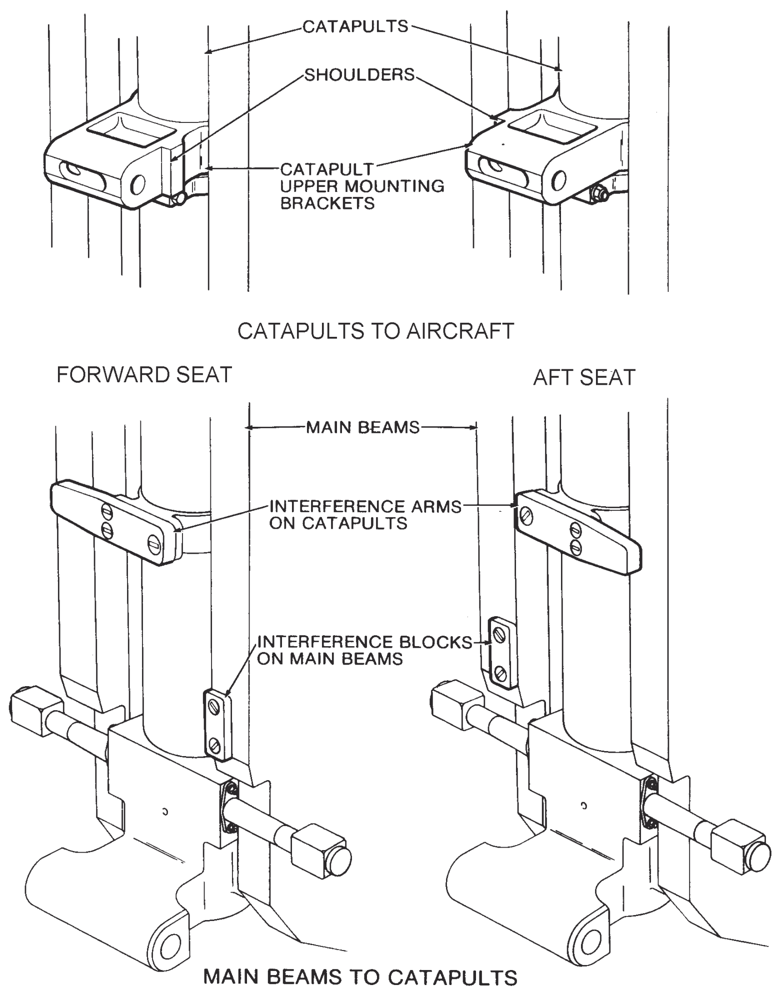


Figure 2-5.—Interference devices, forward and aft seats (SJU-17(V)2/A).

spring-loaded piston. When operated during the ejection sequence, gas pressure from within the catapult acts on the latch pistons, overcoming the springs and retaining the multipurpose initiator static lanyard lower end fittings.

Piston

The piston consists of a light alloy tube, attached to the lower end of a necked end fitted with piston rings to provide a gas seal between the piston and the barrel. At the upper end of the piston is a breech into which is inserted the ejection gun initiator. The breech has a groove machined around its outer diameter into which the plunger of the top latch mechanism on the seat main beams engages when the seat is installed on the catapult. A V-groove in the top of the breech engages a dowel on the seat top cross-beam when the seat is installed in the aircraft.

Catapult Manifold Valve

The catapult manifold valve (fig. 2-6) is a body with two gas inlet ports, each with a check valve, connected by drillings to a vertical bore. The top of the bore is sealed by a screwed cap and incorporates a spring-loaded sleeve. The end of a key operated spring-loaded plunger protrudes into the bore below the sleeve and a transverse drilling in the valve body breaks through the vertical bore opposite and level with the spring-loaded plunger. The bore of the valve fits over the ejection gun initiator inlet connector, depressing the sleeve against the spring. The valve is held to the inlet connector by the spring-loaded plunger and a key operated quick-release pin that passes through the transverse drilling and engages in a circular groove in the inlet connector. O-ring seals maintain gas integrity between the components.

MAIN BEAM ASSEMBLY

The main beam assembly is manufactured almost entirely from light alloy and is comprised of two parallel main beams bridged by top and bottom cross-beams and a top latch assembly. A shoulder harness reel is mounted across the front face of the main beams and provides extra rigidity. An electronic sequencer is mounted above the shoulder harness reel. Bolted to the inside face of each main beam are three slippers, which engage in the guide rails on the catapult. Two seat bucket runner guides are attached to the front face of the each main beam and accommodate the top

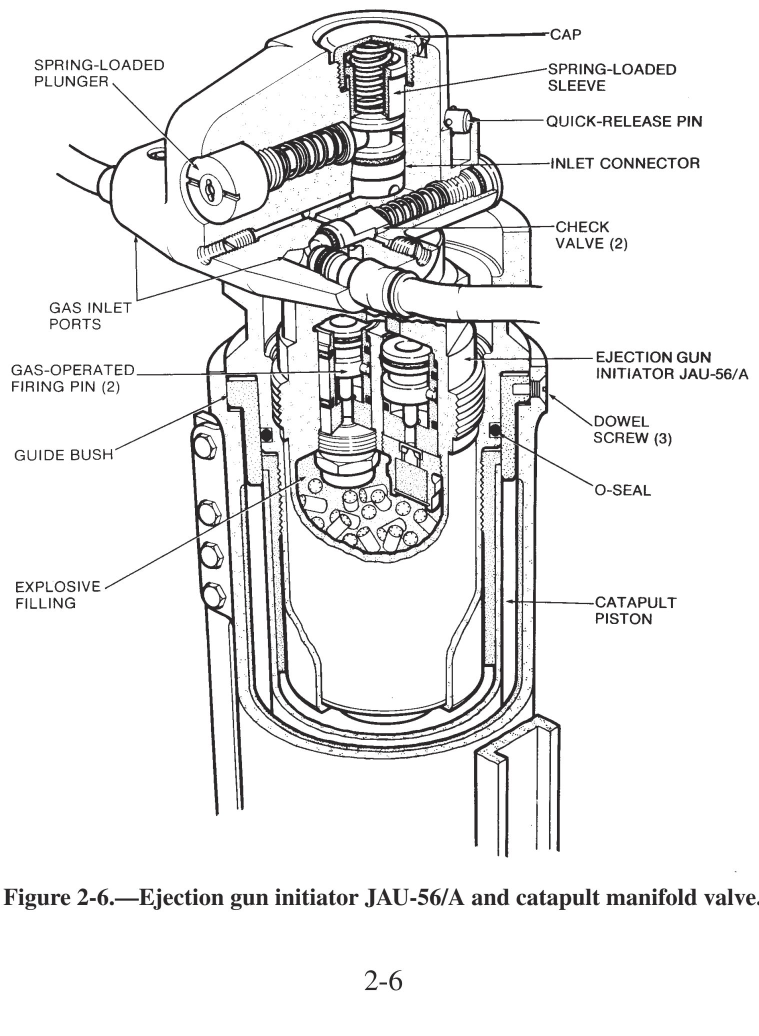


Figure 2-6.—Ejection gun initiator JAU-56/A and catapult manifold valve.

and bottom seat bucket slippers. The slippers provide smooth movement of the seat bucket and have threaded studs to attach the seat bucket to the main beam. Friction pads in the studs restrict lateral movement of the seat bucket. Drogue bridle retaining channels are secured to the rear of both main beams. Locating pins for the parachute container hooked brackets are bolted to the upper outside face of each main beam. Interference blocks on the RH beam (forward seat) or LH beam (aft seat) correspond with interference devices on the catapult and the seat bucket to ensure that only the correct assemblies are installed in forward and aft cockpits (fig. 2-5).

Top Cross-Beam

The top cross-beam receives and positions the top of the catapult and takes the full thrust of the catapult during ejection. Incorporated into the cross-beam is the upper drogue bridle release unit, which attaches the upper leg of the drogue bridle to the seat. The studs securing the RH main beam to the top cross-beam also retain the RH parachute container mounting bracket. Two of the studs securing the LH main beam to the top cross-beam also retain the top latch assembly. A dowel in the top cross-beam is positioned in one of the catapult breech V-grooves when the seat is installed in the aircraft.

Bottom Cross-Beam

The bottom cross-beam is machined from solid light alloy and retains the main beams at the bottom end. Incorporated into the cross-beam is a gas passage that forms part of the drogue bridle release system.

Top Latch Assembly

The top latch assembly fitted to the LH main beam secures the seat structure to the catapult. The assembly consists of a housing with a spring-loaded latch plunger, one end of which is shaped to engage the catapult piston. The plunger may be withdrawn using the top latch withdrawal tool (handwheel). Passing through the center of the latch plunger is a spring-loaded indicator plunger. When the ejection seat is fitted to the catapult and the handwheel is removed, the latch plunger passes through the top cross-beam and engages with the barrel latch. The shaped end of the plunger protrudes still further to engage the groove of the catapult piston. Operation of the top latch is shown in figure 2-7.

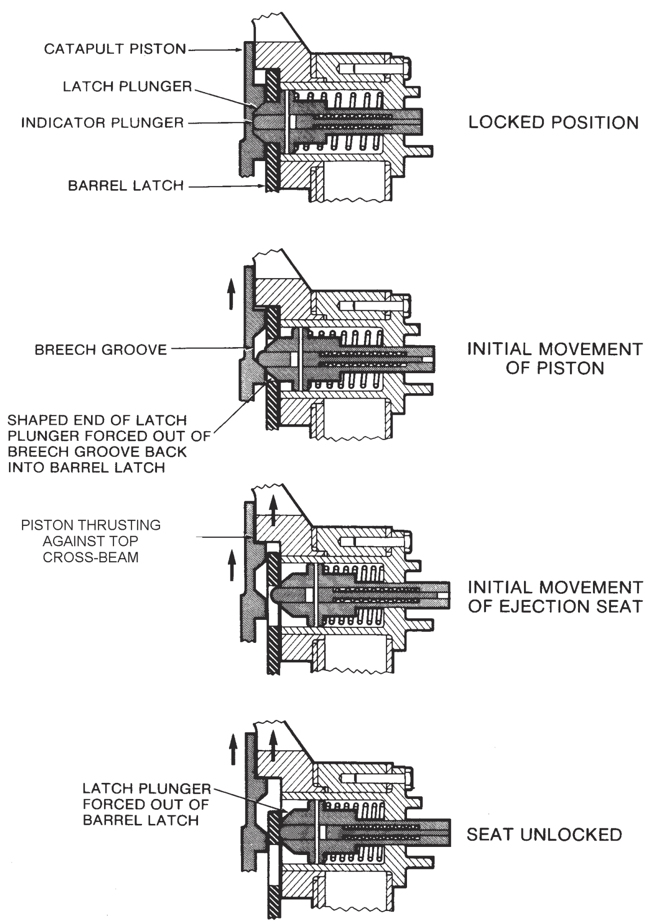


Figure 2-7.—Operation of the top latch assembly.

Drogue Deployment Catapult

The drogue deployment catapult (fig. 2-8) is mounted outboard of the RH main beam of the ejection seat. Its function is to deploy the stabilization drogue and bridle assembly rapidly without becoming entangled with the seat. The firing of the drogue deployment catapult is controlled by the electronic sequencer to ensure that the seat has cleared the aircraft before the drogue is deployed. The drogue deployment catapult is a cylindrical body with an electrically operated impulse cartridge CCU0101/A, a two-piece telescopic piston assembly, and an enlarged upper end into which is fitted a drogue and canister assembly.

DROGUE AND CANISTER ASSEMBLY.— The drogue and canister assembly is comprised of a 57-inch diameter ribbon drogue, pressure-packed into an 8.25-inch-long light alloy cylinder, closed at the

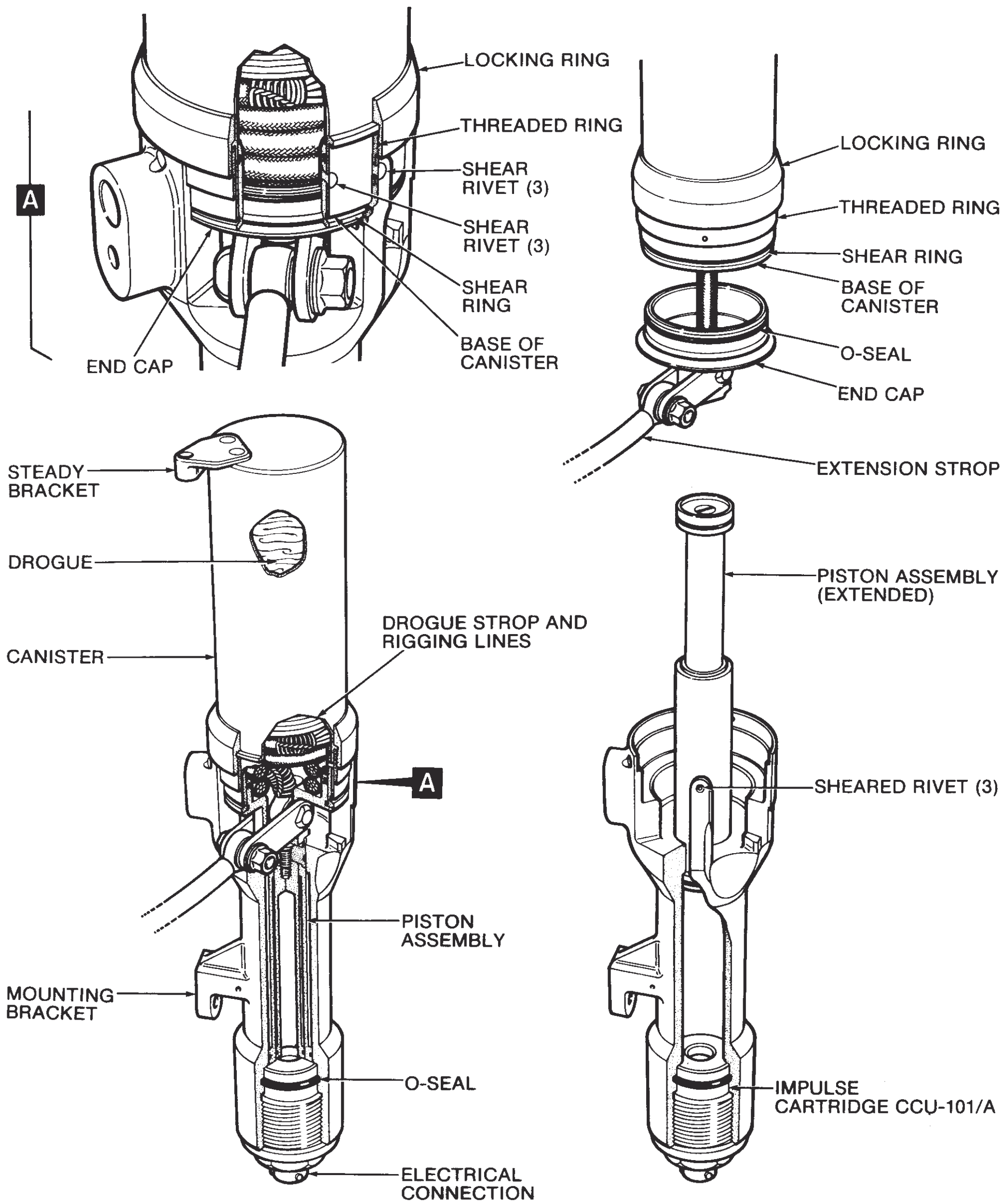


Figure 2-8.—Drogue deployment catapult.

upper end. Riveted within the lower end of the canister is a shear ring, incorporating a shouldered portion axially separated from the base of the canister by 0.1 inch. At the lower end of the end cap, the same bolt that secures the drogue strop attaches a link assembly. When installed on the ejection seat, the link assembly attaches to the drogue bridle and the canister assembly is retained in the body by a threaded locking ring. At the upper end of the catapult body is riveted a threaded ring onto which the locking ring is screwed when installing the drogue canister.

DROGUE AND BRIDLE SYSTEM.—The drogue and bridle assembly (fig. 2-9) is fitted to decelerate and stabilize the ejection seat prior to deployment of the personnel parachute.

The drogue bridle is manufactured from 2000-pound Kevlar cord environmentally protected by heat-shrink sleeving and consists of:

- two lower bridle legs, 42 inches long,
- an upper bridle leg, 43 inches long, and
- an extension strop, 37 inches long.

The four lengths of drogue bridle are joined at one point by stitching to a 2.5-inch diameter light alloy ring.

When installed on the ejection seat, the lower drogue bridle spools are secured in two lower drogue bridle release units built into the multipurpose initiators on the lower main beams. The upper drogue bridle spool is secured in an upper drogue bridle release unit in the top cross-beam and the extension strop spool is attached to the lower end of the link assembly in the drogue deployment catapult. The drogue bridle is retained in channels on the rear face of the seat main beams and folded into a frangible container mounted at the top rear of the main beams. The three bridle release units are activated at the correct time in the ejection sequence by gas pressure from an electrically operated impulse cartridge CCU-100/A installed in a breech in the RH ballistic manifold.

The drogue is an Irvin T108-2, 57-inch diameter, 20-degree conical ribbon drogue, attached at the confluence of the rigging lines to a drogue strap. The opposite end of the strap ends in a spool and is attached by a nut and bolt to the link in the drogue deployment catapult.

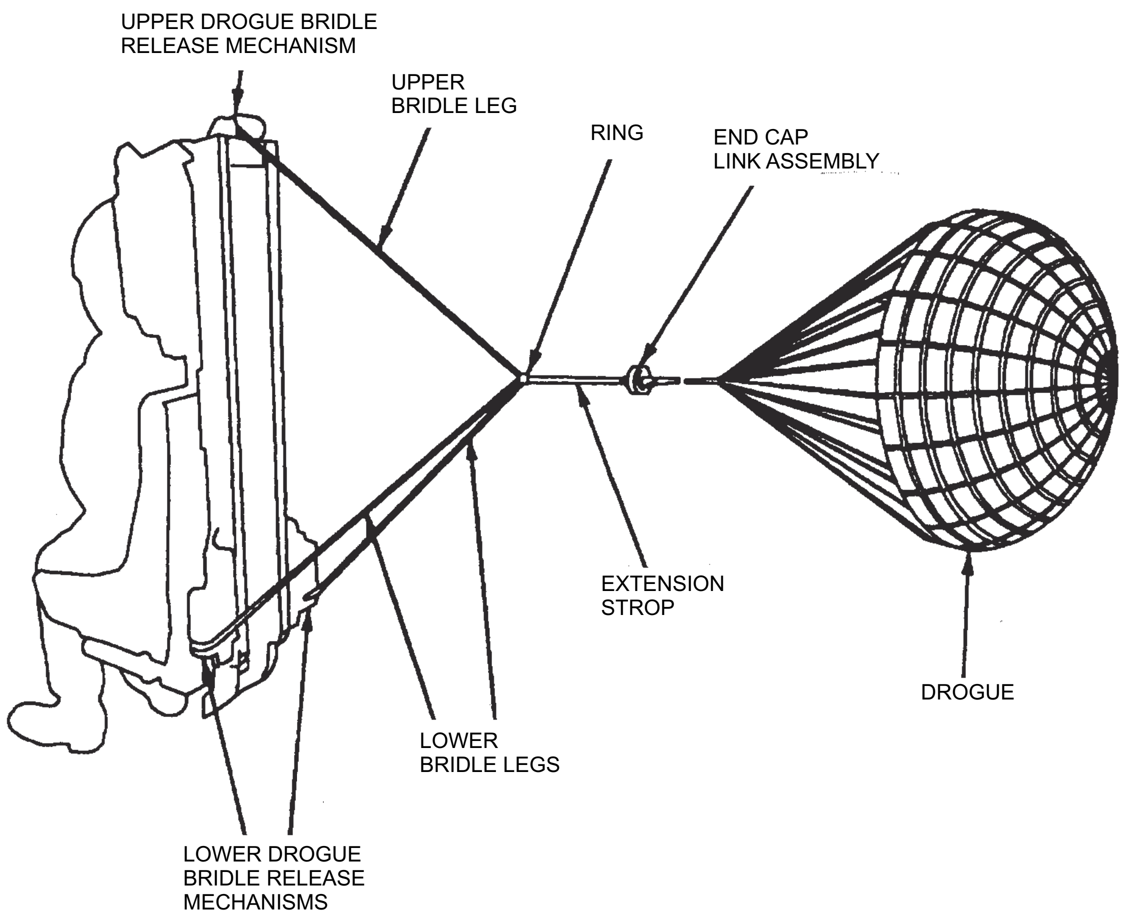


Figure 2-9.—Drogue deployed.

Parachute Deployment Rocket Motor MK 122 MOD 0

The parachute deployment rocket motor (PDRM) (fig. 2-10) is mounted on the LH main beam of the seat. It extracts the personnel parachute from the parachute container and enables the parachute to deploy and develop rapidly without becoming entangled in the seat.

The PDRM is a sealed unit and consists of a cylindrical body containing a gas-operated secondary cartridge in a breech at the lower end of a rocket, with an integral gas-operated igniter cartridge in a barrel at the upper end. In a parallel-connected chamber is an electrically initiated primary cartridge. A gas inlet is connected by gas pipe to the harness release system.

The rocket incorporates a top cap with four integral rocket nozzles equally spaced around the perimeter. Fitted around the rocket is a sliding stirrup connected to the parachute withdrawal line that is free to slide down the rocket as it leaves the barrel.

A retaining screw mounted at an angle in the body bears down on the flanged base of the rocket igniter

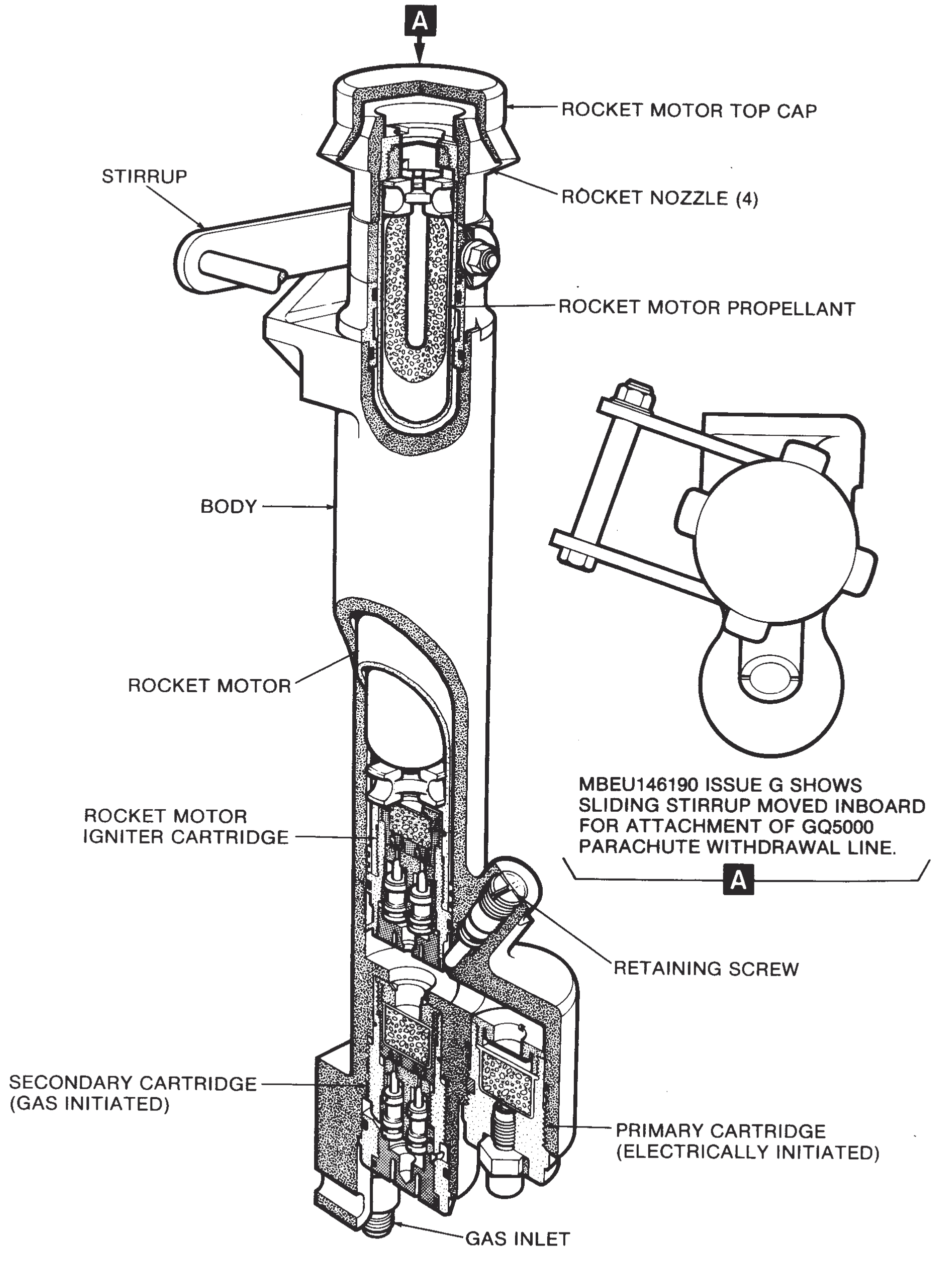


Figure 2-10.—Parachute deployment rocket motor MK 122 MOD 0.

cartridge to retain the rocket in the barrel. The cartridge flange will shear to permit ejection of the rocket during operation.

Electronic Sequencing System

The electronic sequencing system consists of an electronic sequencer, two thermal batteries, two pitot assemblies, two sequencer start switch assemblies, and the associated electrical wiring.

SEQUENCER.—The sequencer (fig. 2-11) is attached across the front of the seat main beams below the parachute assembly. It is connected by pipes to the pitot assemblies and by electrical wiring to the thermal batteries, the sequencer start switches, and the electrically operated cartridges. The sequencer controls drogue deployment and release, personnel parachute deployment, and the man/seat separation. Timings vary with altitude and airspeed. An external test receptacle is provided for periodic testing of the sequencer.

THERMAL BATTERIES.—Two thermal batteries supplying power for sequencer operation are mounted together in a manifold on the LH main beam.

To provide system redundancy, each battery is initiated independently by a manifold-mounted gas-operated firing mechanism. Both firing mechanisms are initiated by gas pressure from the seat initiator cartridges or the aircraft command sequencing system.

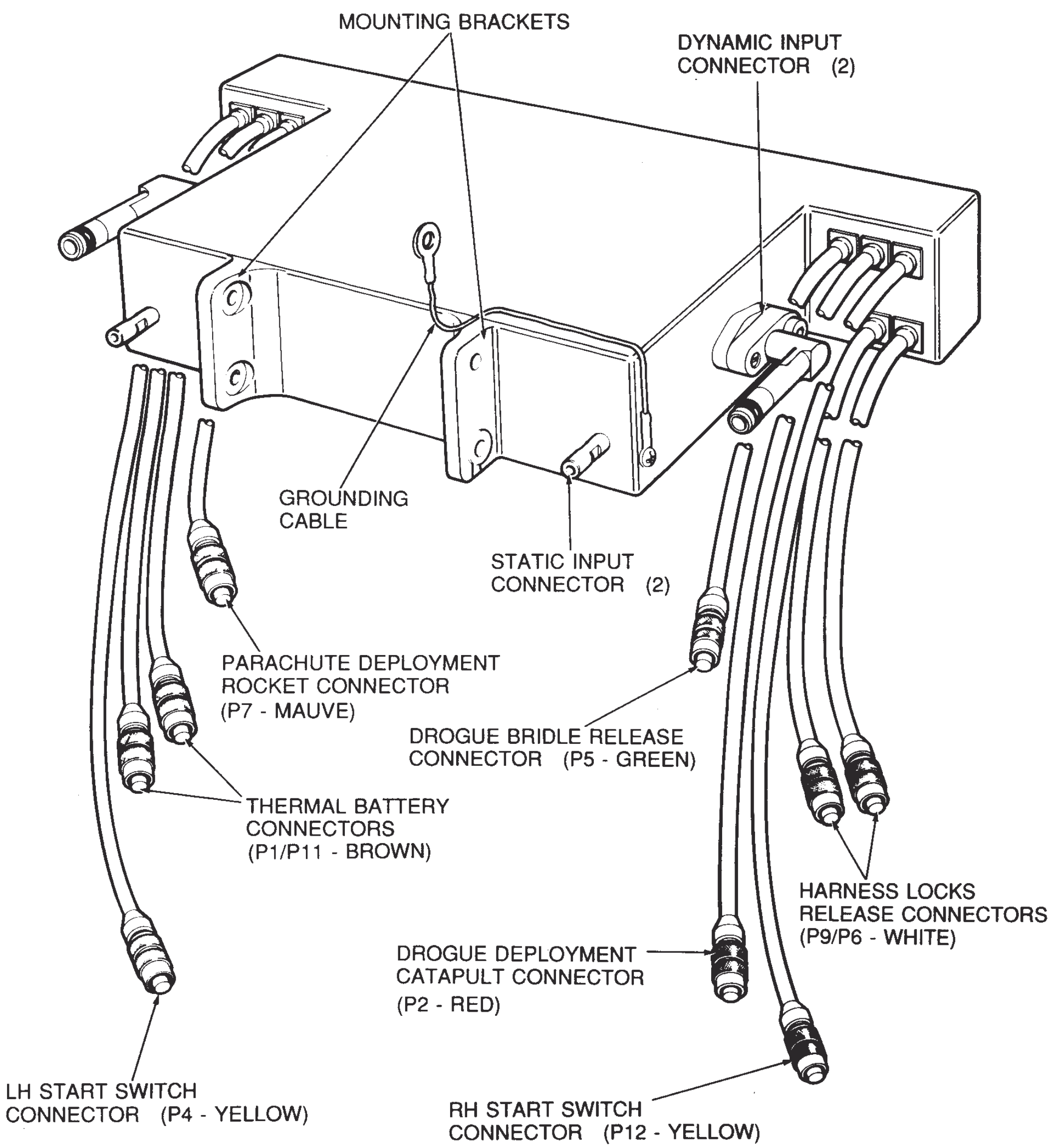


Figure 2-11.—Electronic sequencer.

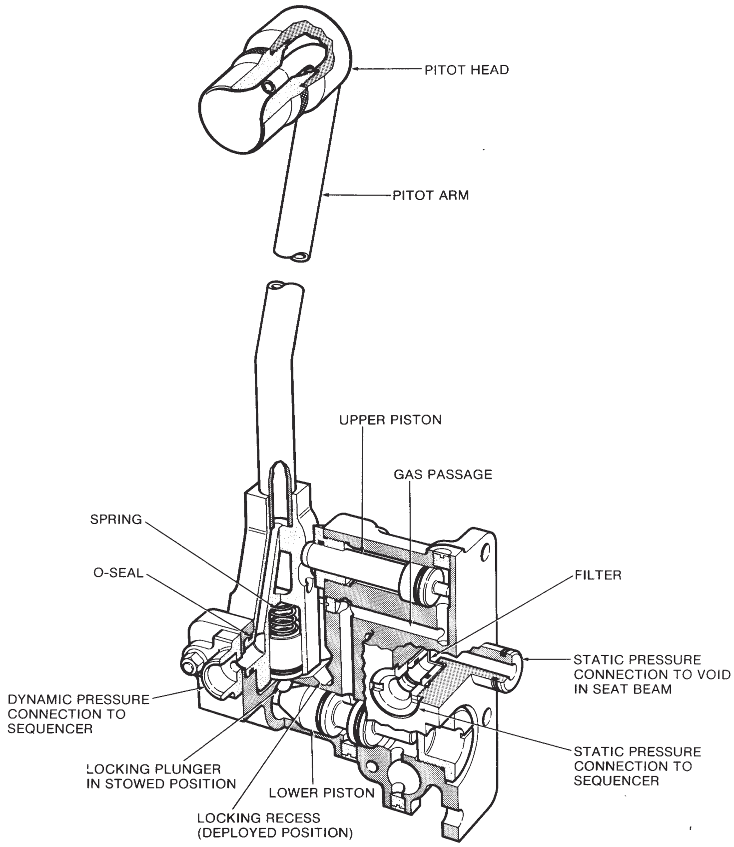


Figure 2-12.—Pitot assembly, right hand.

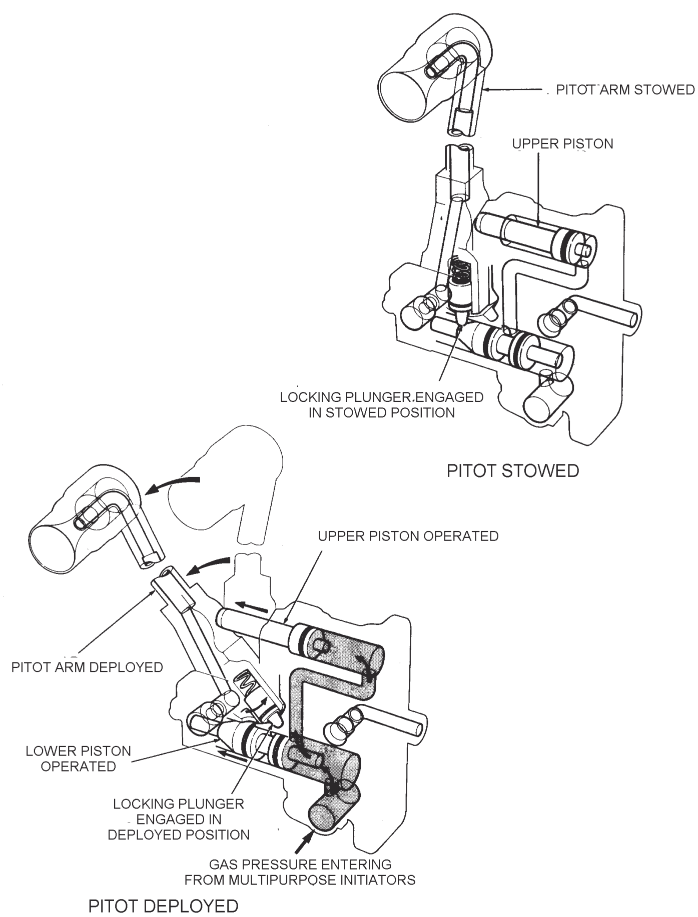


Figure 2-13.—Pitot assembly, right hand, operation.

PITOT ASSEMBLIES.—Two pitot assemblies incorporating deployable pitot heads (fig. 2-12) are mounted on the main beams behind the parachute container. Removable covers prevent entrance of foreign objects during maintenance.

The pitot heads are maintained in the stowed position by locking mechanisms that are released during seat ejection, as the seat separates from the catapult by gas pressure from the multipurpose initiator cartridges (fig. 2-13). When deployed, the pitot head assemblies supply dynamic pressure inputs to the electronic sequencer.

When the pitot assembly is installed on the seat beam, the inboard static pressure connector connects to a void in the seat beam. The sequencer is installed on the forward face of both pitot assemblies and connects to the dynamic and forward static pressure connectors.

START SWITCH ASSEMBLIES.—Two start switch assemblies are incorporated into the multi-purpose initiators. During ejection, the start switches supply a start signal to the sequencer at the correct time in the sequence.

Multipurpose Initiators

Two initiators multipurpose (IMP) (fig. 2-14) are attached to the lower outer faces of the seat main beams. During the ejection sequence, the IMPs supply gas pressure to operate the barostatic release unit delay mechanism, the underseat rocket motor, the pitot deployment mechanisms, and the internally mounted start switch assemblies.

Each IMP comprises a body, machined and drilled to accept a start switch, a static lanyard assembly, a spring-loaded firing pin, and an impulse cartridge. A

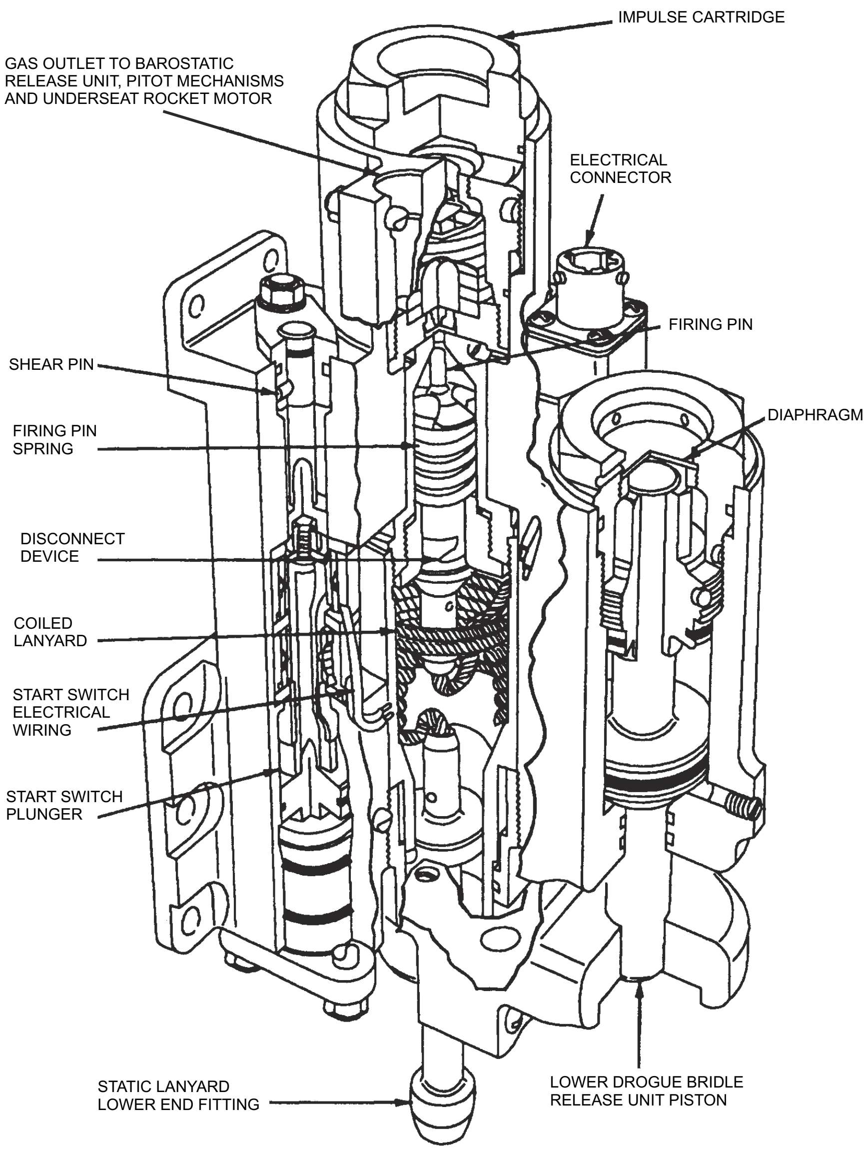


Figure 2-14.—Multipurpose initiator, left hand.

gas passage through the unit body connects the cartridge breech to the lower end of the start switch plunger.

The static lanyard assembly comprises a lanyard precoiled into a cylindrical container with special fittings swaged onto each end. The upper end fitting has a wedge-shaped disconnect device, which engages with the lower end of a spring-loaded firing pin positioned below the cartridge. The lower end fitting protrudes through the lower end of the body and is retained by a shear pin. When the seat is installed on a catapult, the protruding lower end fitting fits in one of the catapult-mounted ballistic latches.

The start switch is a series of metal sleeves and insulated sections, installed vertically to form an electrical switch assembly. An internal plunger has a short gold-plated section with piston head at its lower end, and is partially sleeved with insulation. A shear pin prevents movement of the plunger before operation.

The impulse cartridge is percussion-operated by the firing pin and is screwed into a breech at the upper end of the body. A gas tube machined in the upper part of the cartridge ensures even distribution of gas pressure when the cartridge fires.

Barostatic Release Unit

The barostatic release unit (BRU) is located on the RH main beam of the seat and contains an impulse cartridge CCU-102/A. The CCU-102/A normally is initiated by the sequencer to supply gas pressure to release the upper and lower harness locks and fire the secondary cartridge in the parachute deployment rocket motor. If the sequencer fails, the BRU cartridge will be fired by mechanical operation of the BRU.

The BRU (fig. 2-15) consists of a body containing the impulse cartridge, a barostat assembly, and a 4-second time delay mechanism.

BAROSTAT.—The barostat consists of an aneroid capsule housed in the release unit so that a peg attached to the capsule may engage a starwheel in the delay mechanism. At altitudes in excess of the barostat rating (14,000-16,000 feet), the peg engages the starwheel

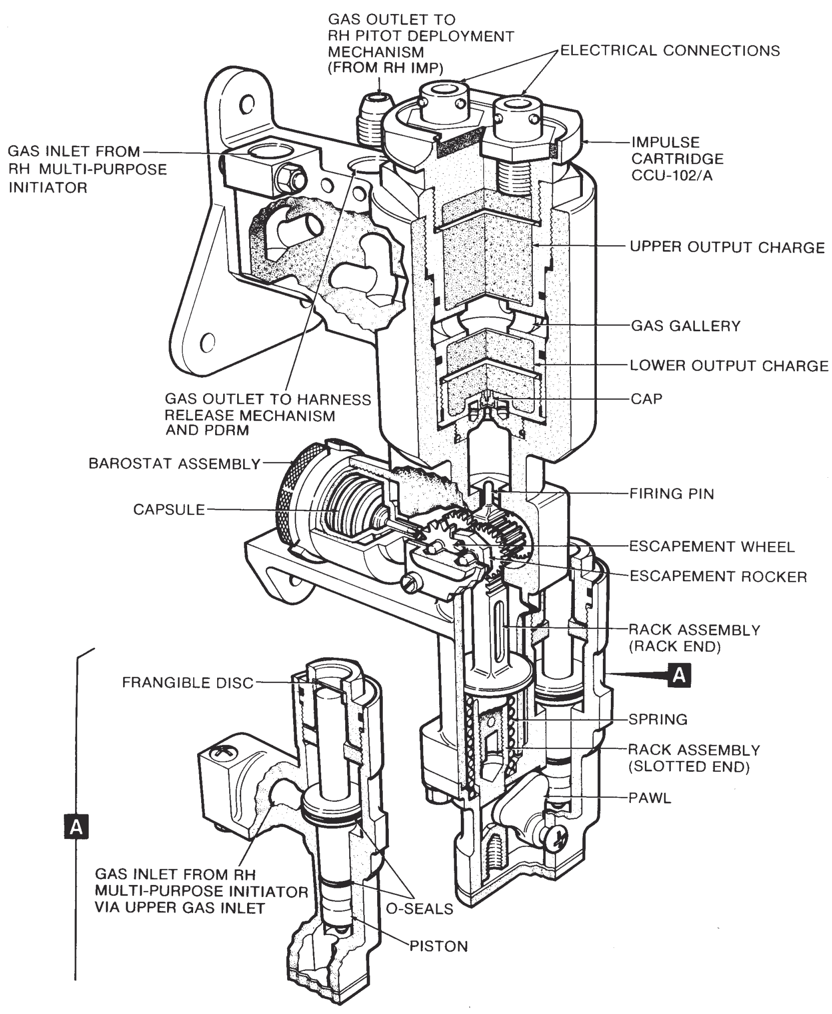


Figure 2-15.—Barostatic release unit.

and prevents the delay mechanisms from operating. As altitude decreases, the capsule peg retracts and allows the mechanism to function.

IMPULSE CARTRIDGE.—The impulse cartridge CCU-102/A consists of a cylindrical brass body containing two output charge chambers separated by a central connecting gas gallery. The upper end of the cartridge has two electrical igniters and is electrically initiated by signals from the electronic sequencer—a primary signal to initiate the cartridge and a backup signal through the second connector to provide system redundancy. The lower end is initiated by the delay mechanism firing pin striking the percussion cap. Output charge initiated at either end will crossfire, via the gas gallery, to ignite the output charge in the other chamber. The resultant gas pressure is discharged from the center of the cartridge into an annular groove via gas ports spaced evenly around the central gas gallery.

TIME-DELAY MECHANISM.—The time-delay mechanism consists of a spring-loaded rack assembly in mesh with a gear train controlled by an escapement. The gear train consists of a primary spur and gear, a secondary spur and gear, an idler wheel, a release wheel, and a release rocker.

The rack assembly consists of a rack end screwed into a slotted end. The two components are secured together with a locking screw. The upper end of the rack end is shaped to form a firing pin.

To retain the rack in the cocked position, one face of a ratchet in the bottom housing engages in the slotted end of the rack assembly. Another face of the ratchet engages in a groove in a gas-operated piston installed in a housing attached to the lower part of the unit body. The piston is held in position by a frangible disc.

When the RH multipurpose initiator cartridge fires during ejection, gas pressure from the cartridge enters the piston housing and moves the piston upwards, rupturing the frangible disc and allowing the ratchet to pivot clear of the rack assembly's slotted end. When the altitude is low enough that the barostat is not restraining the mechanism, the rack assembly will rise under the action of its spring, governed by the delay mechanism. After the delay has elapsed, the rack disengages from the gear train and the firing pin rises rapidly to strike the cartridge. If the cartridge has not previously been fired electrically by the sequencer, the gas produced by the cartridge passes out of the BRU to operate the upper and lower harness locks along with the secondary cartridge in the parachute deployment rocket motor.

Shoulder Harness Reel

The shoulder harness reel (fig. 2-16) is fitted horizontally across the front faces of the main beams and serves as a center cross-beam for the main beams assembly as well as a means of securing the upper harness. It ensures the occupant will be correctly positioned and locked in for ejection. It permits the seat occupant to lean forward and twist around in the seat for maximum visibility, but restrains forward movement in the event of excessive forward deceleration. For normal flight operations the shoulder harness is free to extend and retract as the occupant moves in the ejection seat. The shoulder harness control

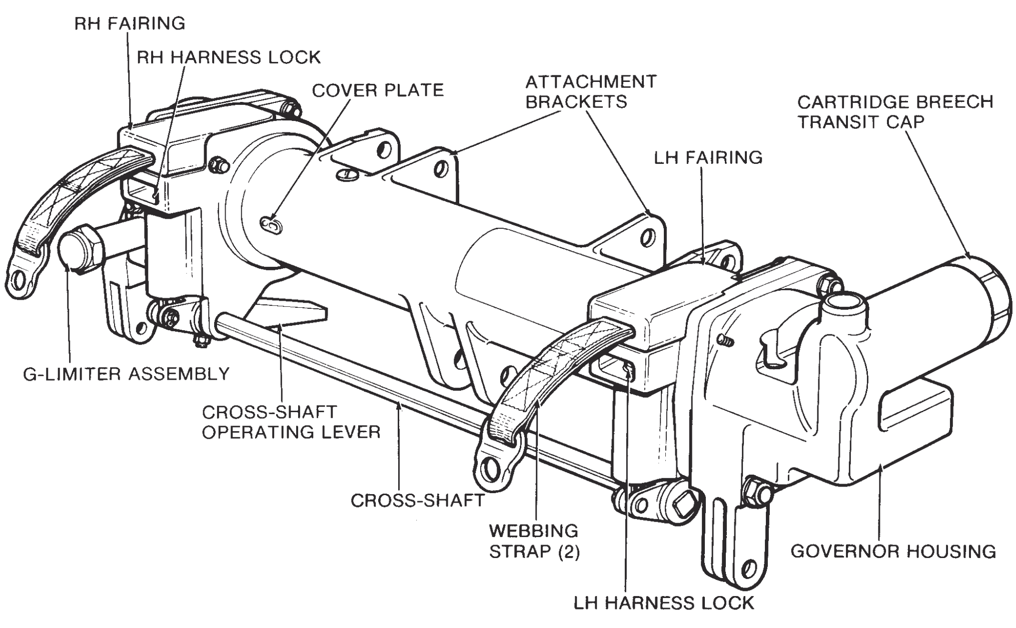


Figure 2-16.—Shoulder harness reel.

lever on the LH side of the seat bucket can be moved to the forward (locked) position, which will permit the harness straps to retract, but prevent them extending.

When in the normal unlocked state, the occupant is protected against rapid forward movement under high g-loading by automatic locks, which respond to an excessive rate of strap extraction or aircraft deceleration. On rapid strap extraction or aircraft deceleration the unit mechanism will lock, and when the extraction or deceleration load is released the unit will revert to its normal free state.

A g-limiter assembly is installed within the RH end cap. If the seat is subjected to a horizontal deceleration in excess of 0.7g, a weighted ratchet wheel attached to the RH end of the drive screw will prevent strap extraction. Reduction of deceleration below 0.7g and easing of any tension on the straps allows the ratchet spring to reset itself and disengage the ratchet from

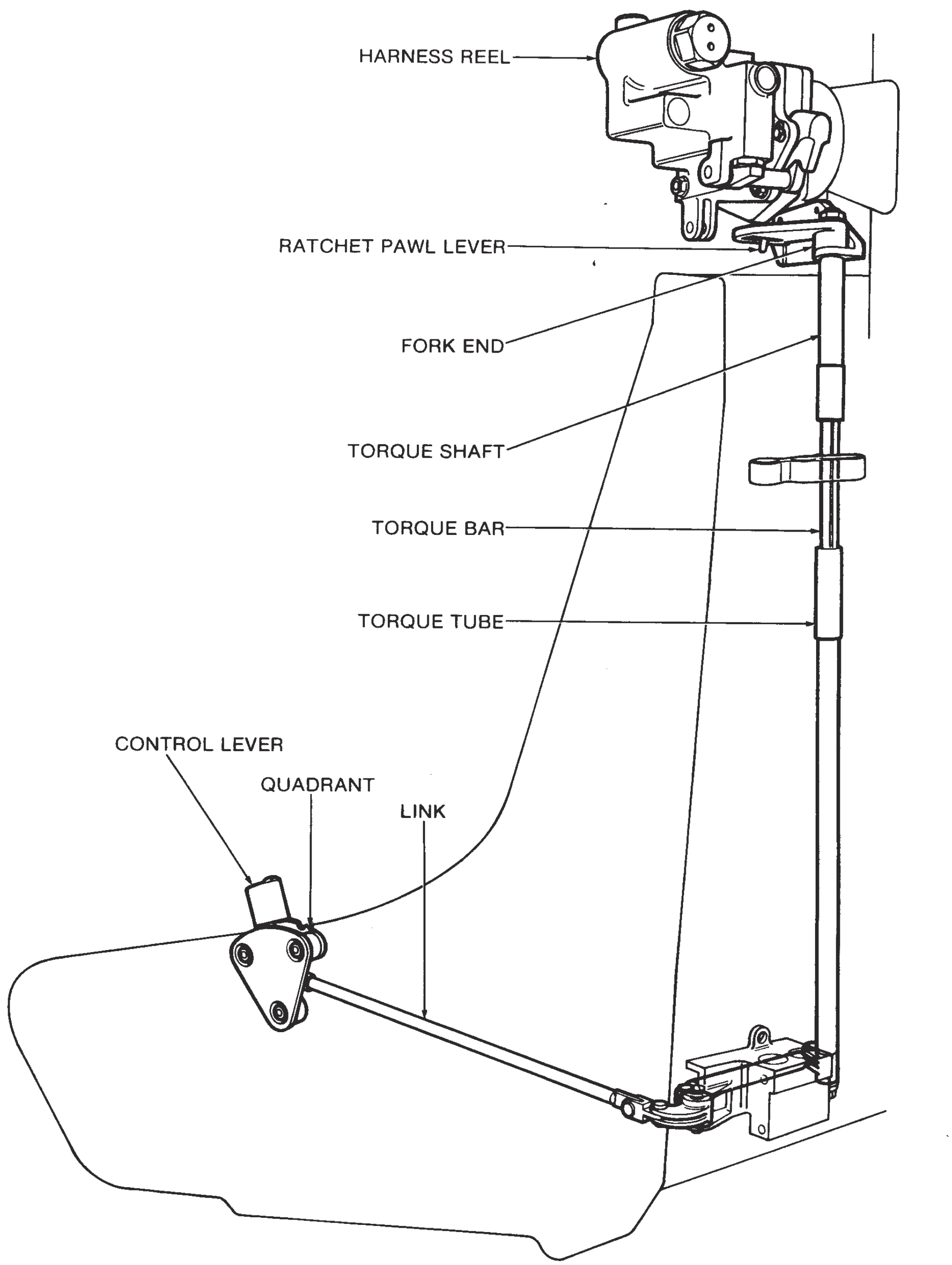


Figure 2-17.—Shoulder harness control system (SJU-17(V)1/A, 2/A and 9/A).

the ratchet wheel, permitting free withdrawal of the straps.

SHOULDER HARNESS CONTROL SYSTEM.—The shoulder harness control lever (fig. 2-17), on the LH side of the bucket, engages in either one of two positions in a quadrant. The lever is connected by links and levers to a torque tube secured to the rear of the seat bucket. A torque bar engaged within the tube allows for vertical adjustment of the seat bucket. The torque bar is secured to the main beam assembly, together with the LH trombone tubes, by a quick-release pin, its upper end engaging in a torque shaft. The shaft is secured to the harness reel and has a fork-end that engages the ratchet wheel.

SEAT BUCKET ASSEMBLY

The seat bucket is constructed to form a square pan and houses the seat operating controls. The extended back, the bottom and front are made from sheet aluminum alloy. The sides are solid aluminum alloy plates and extend forward to provide thigh protection and support. The bucket is secured to studs incorporated into sliding runners on the seat main beams by four nuts. Interference devices on the rear of the seat bucket and on the main beam assemblies ensure that only the correct seat bucket is installed in forward and aft cockpits (fig. 2-18).

Because of aircraft installation requirements, SJU-17(V)1/A, 2/A and 9/A seat bucket assemblies are one inch wider than SJU-17(V)3/A thru 6A assemblies. Detail assemblies are essentially similar between aft seat buckets.

The back of the seat bucket contains a rigid molded pad that forms the backrest. It is contoured so at ejection the seat occupant is automatically pulled back by the shoulder harness reel into the correct ejection posture. The backrest is secured by a screw through each side of the seat bucket. A cushion attached to the backrest provides additional comfort.

Underseat Rocket Motor MK 123 MOD 0

An underseat rocket motor MK123 MOD 0 (forward seat) or MK 124 MOD 0 (aft seat) installed under the seat bucket is secured to the side plates by nuts and bolts. Differences in mounting bolt sizes

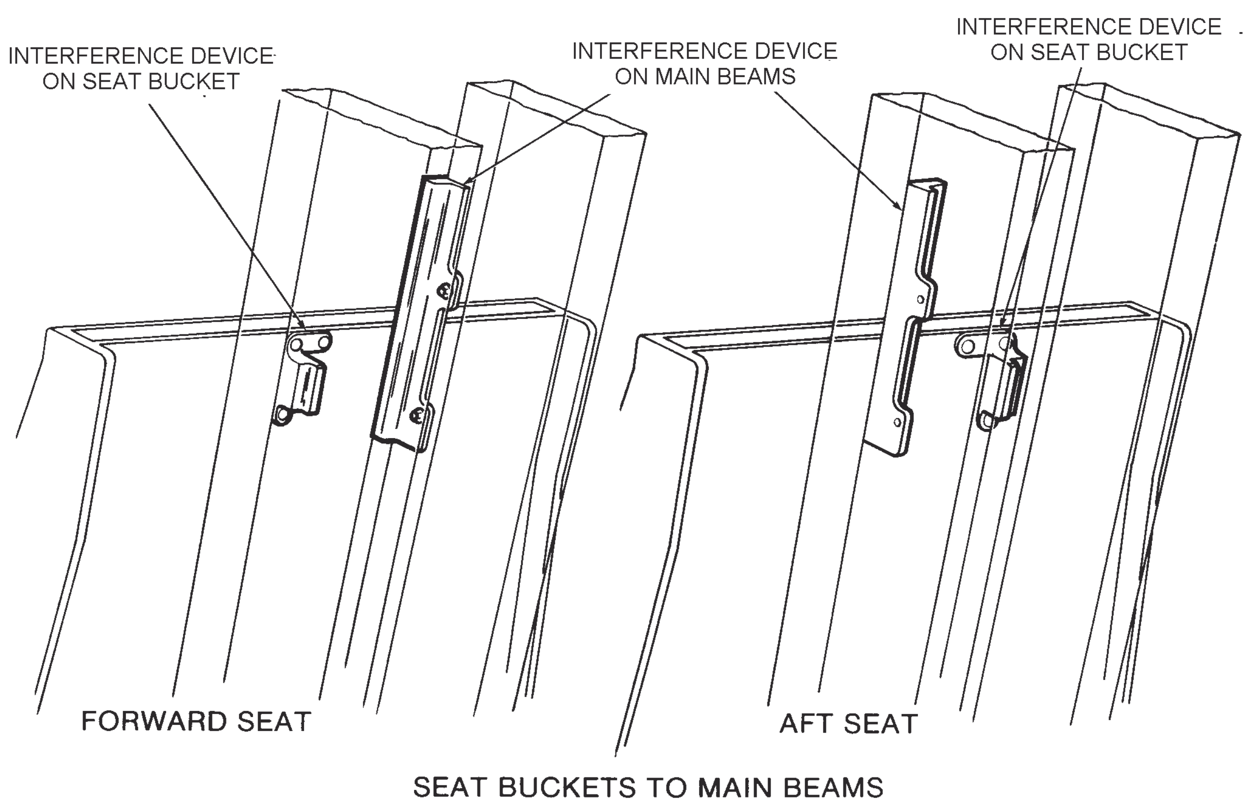


Figure 2-18.—Interference devices, seat bucket to main beams for the forward and aft seats (SJU-17(V)2/A).

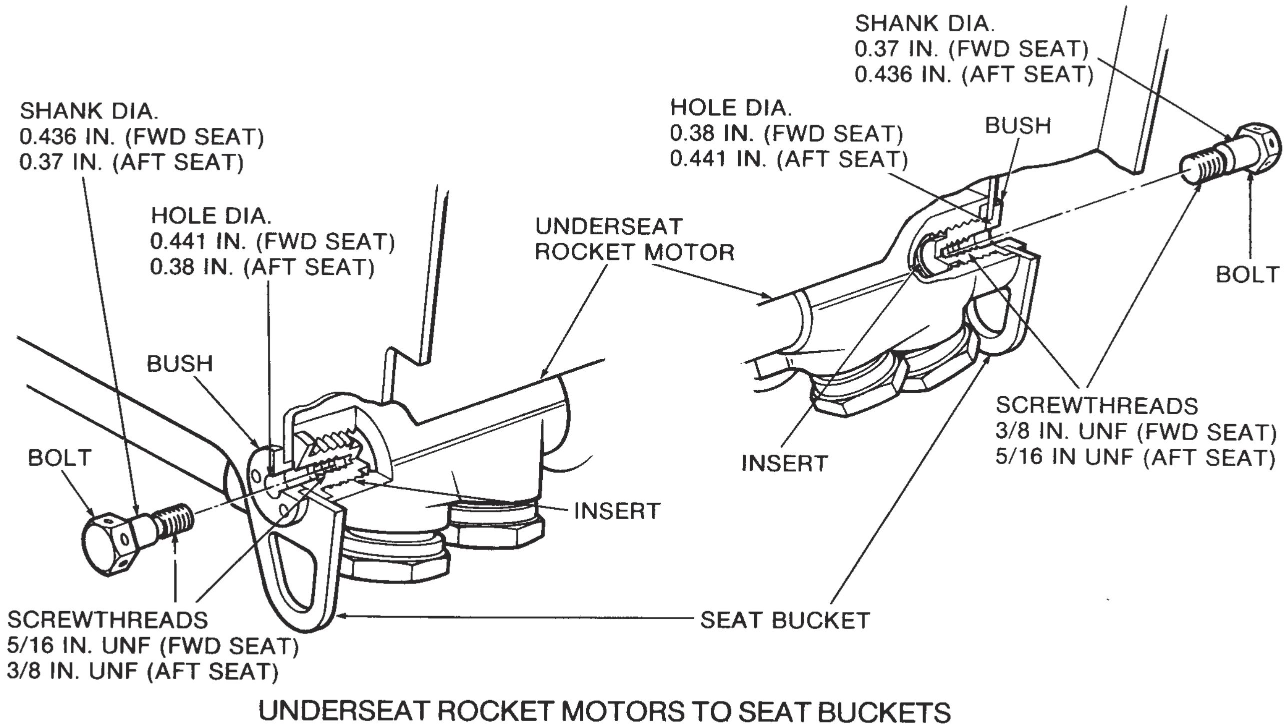


Figure 2-19.—Underseat rocket motor mounting bolt sizes (SJU-17(V)2/A).

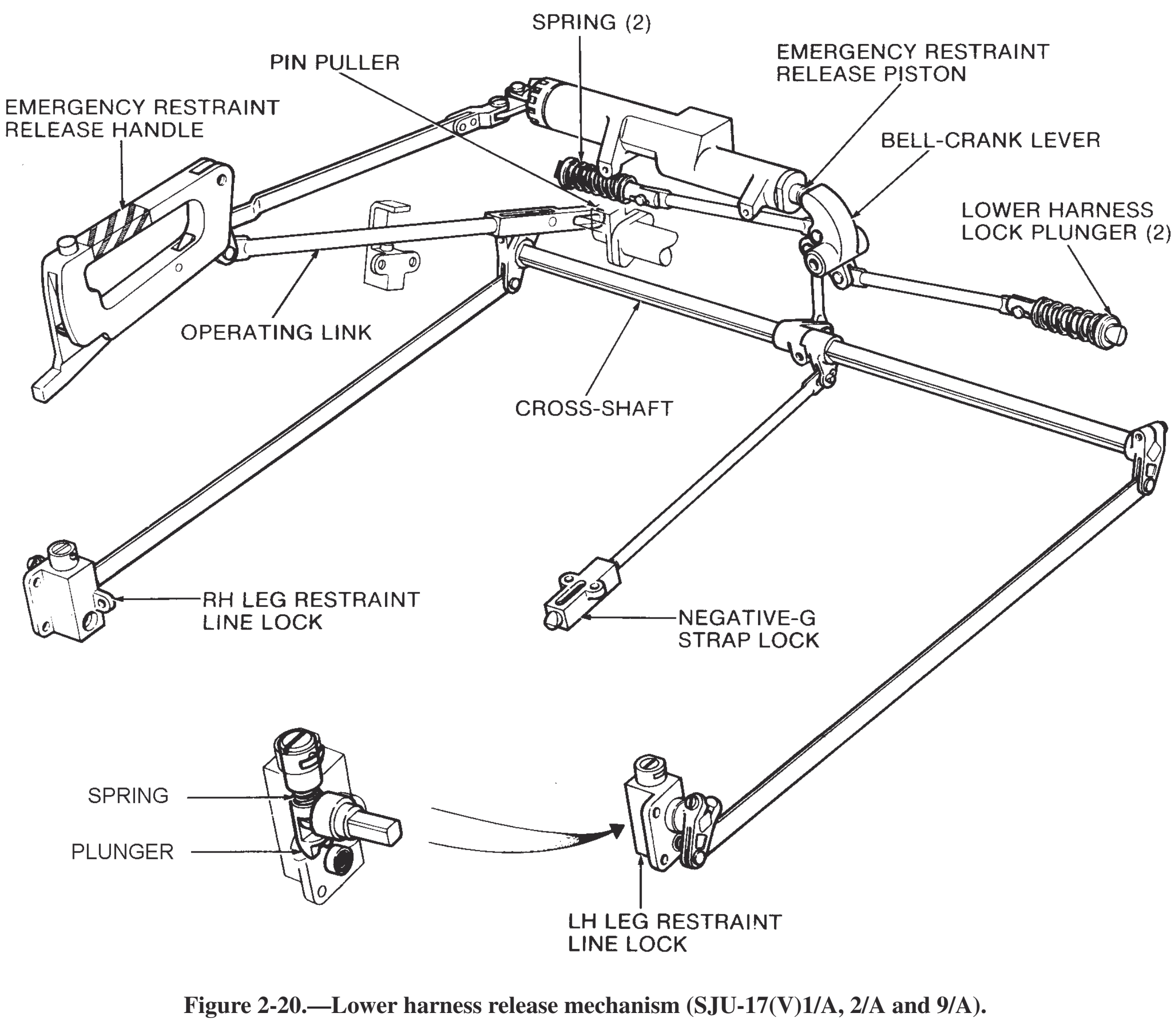


Figure 2-20.—Lower harness release mechanism (SJU-17(V)1/A, 2/A and 9/A).

(fig. 2-19) ensure that the correct rocket motor is installed. A gas pipe to the rocket motor firing mechanism is connected to a trombone tube on the LH rear of the seat bucket. The trombone tubes on the rear of the seat bucket connect to ballistic manifolds mounted on the main beams. Connections are a push fit secured by key operated quick-release pins, gas integrity being maintained by O-ring seals.

Leg Restraint System

The lower harness locks and release mechanism are within the lower rear corners of the seat bucket (fig. 2-20). Halfway up the inner face of the seat bucket sides are sticker clips. The pin puller is mounted at the rear of the seat bucket on the lower right hand side.

Two leg restraint line snubbers, each with a leg restraint line, are attached to the front face of the seat bucket. Pulling inboard on the fabric loops attached to the release plungers on the inboard side of each snubber will release them to adjust the leg lines. The leg restraint lines taper plugs are secured in locks positioned on the seat bucket side plates.

Seat Height Actuator

The seat height actuator (fig. 2-21) adjusts the seat bucket vertically in relation to the seat beams. The assembly consists of a vertical electric motor and housing assembly connected by a transverse gearbox assembly to the upper end of a screwjack housing.

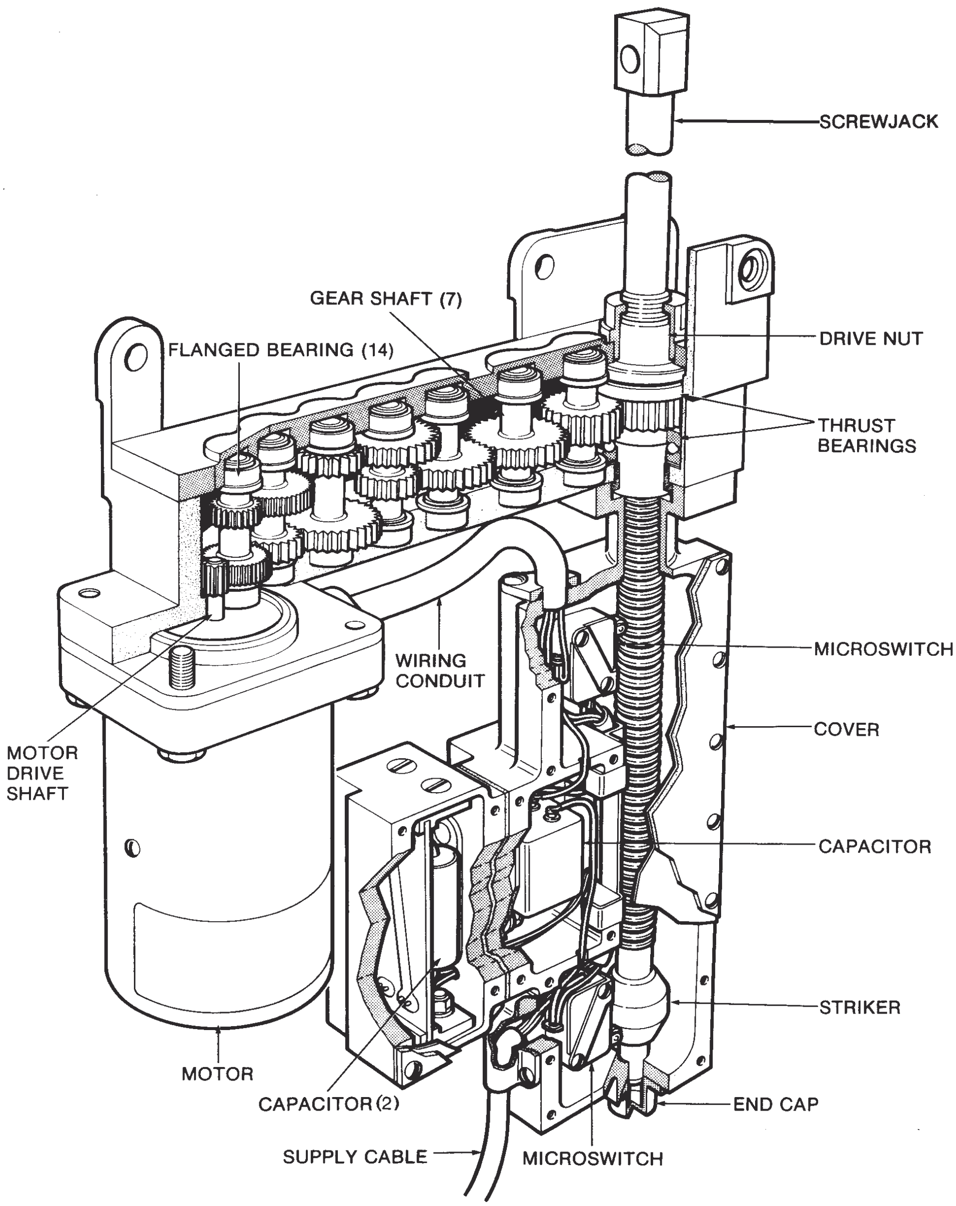


Figure 2-21.—Seat height actuator (SJU-17(V)3/A and 4/A).

Operating Controls

The ejection control handle (figs. 22 and 23) is on the front of the seat bucket, connected by a link and crossbar to the twin sears of the seat initiator located under the seat bucket. The seat initiator is connected by two fixed pipes attached to two trombone tube assemblies, one on either side at the rear of the seat bucket. An upward pull on the ejection handle withdraws the two sears of the seat initiator to simultaneously fire the two-seat initiator impulse cartridges CCU-105/A.

SAFE/ARMED Handle

The SAFE/ARMED handle is on the RH side of the seat bucket immediately forward of the emergency restraint release handle. A catch in the handle locks it in either the ARMED or SAFE position. The handle is connected to a linkage terminating in a safety plunger, which passes through the link of the ejection control handle when the handle is in the SAFE position and prevents operation of the ejection control handle. In the ARMED position, the visible portion of the handle is colored with yellow and black stripes and engraved ARMED; in the SAFE position the visible portion is colored white and engraved SAFE. An electrical visual SAFE/ARMED indicator is in the cockpit central warning panel and is operated by a micro-switch actuated by the safety plunger.

Emergency Restraint Release System

The emergency restraint release handle is connected by two link assemblies to the lower harness lock release mechanism and a firing mechanism housed

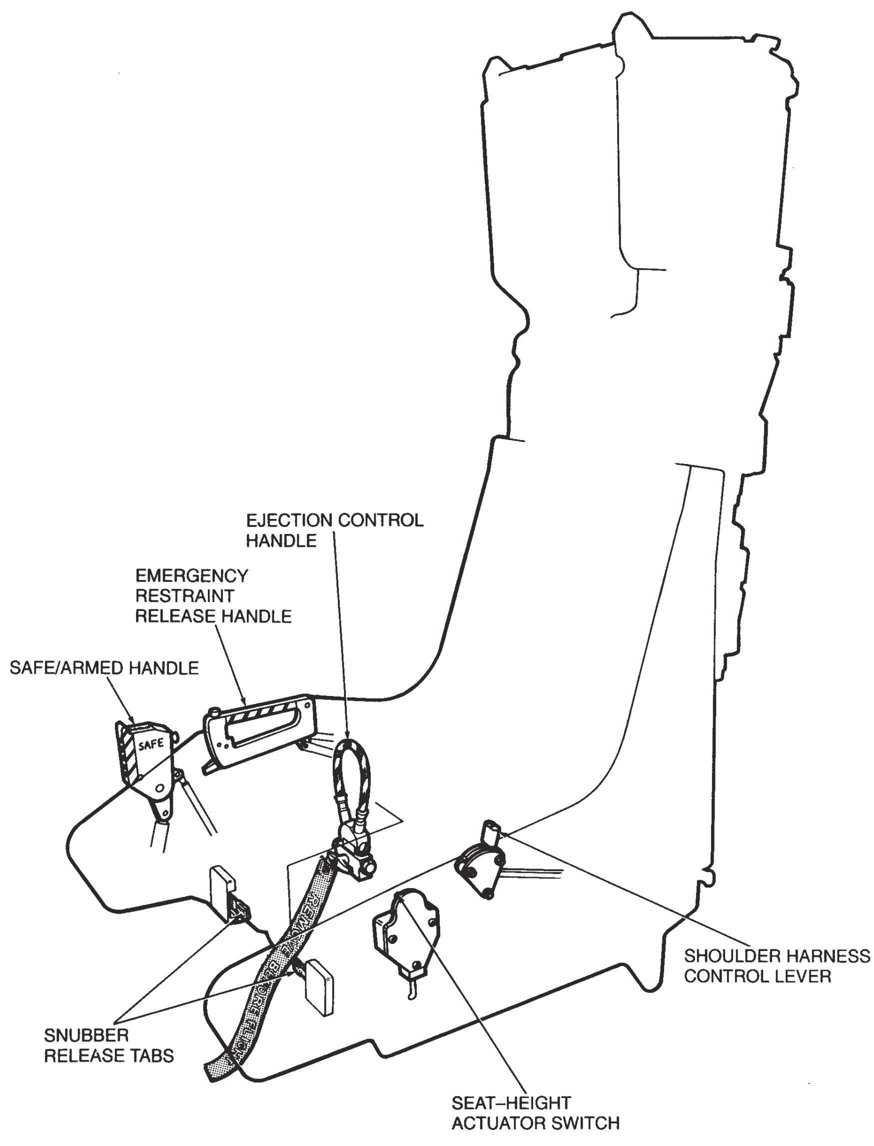


Figure 2-22.—Operating controls (SJU-17(V)1/A, 2/A, and 9/A).

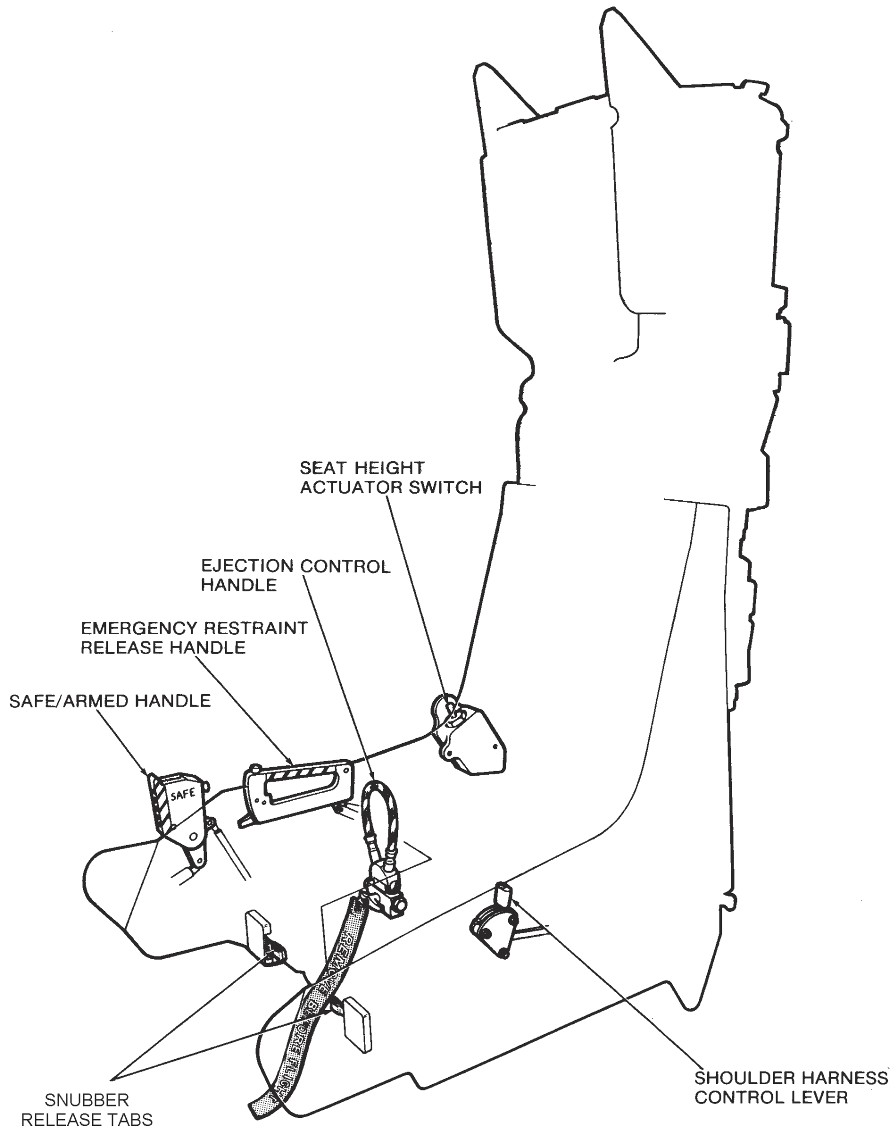


Figure 2-23.—Operating controls (SJU-17(V)3/A and 4/A).

in the rear lower RH side of the seat bucket. The handle is locked in the down position by a catch operated by a thumb button at the forward end of the handle; depression of the thumb button allows the handle to be rotated rearward. Handle operation when the seat is installed is restricted by the pin puller so it releases only the lower torso restraint and leg restraint lines to permit emergency ground egress. On ejection, the pin puller is automatically disengaged from the handle-operating link. Operation of the emergency restraint release handle simultaneously operates the SAFE/ARMED handle to the SAFE position. In the unlikely event of automatic sequence failure, operation of the emergency restraint release handle subsequent to ejection will fire a cartridge to operate the upper and lower harness locks and the parachute deployment rocket motor.

Shoulder Harness Control System

The shoulder harness control lever is attached to the LH side of the seat bucket and is connected by a linkage, torque tube, and rod to the shoulder harness reel. When the lever is in the forward position the shoulder harness reel is locked, preventing all forward movement of the seat occupant. When moved to the rear position, the seat occupant is free to move forward and aft at will; should the seat occupant move forward rapidly, however, the shoulder harness reel will lock until the load on the webbing straps is eased. To operate the control, the lever is moved along a quadrant until a spring-loaded plunger engages in either one of two positions in the quadrant backplate. The lever will automatically engage where selected.

On SJU-17(V) seats 1/A, 2/A, 5/A, 6/A, and 9/A the seat height actuator switch is situated immediately forward of the shoulder harness control lever on the LH side of the seat bucket. On SJU-17(V) 3/A and 4/A the switch is situated immediately aft of the emergency restraint release handle on the RH side of the seat bucket. Forward movement of the toggle switch lowers the seat bucket, and aft movement raises the seat bucket. When released, the toggle assumes the center OFF position.

PARACHUTE ASSEMBLY

The parachute assembly (fig. 2-24) is a 21-foot-diameter GQ Type 5000 personnel parachute packed into a rigid container and connected to the parachute risers. The parachute risers incorporate seawater-activated release switches (SEAWARS) for attachment to the upper torso harness. These switches will automatically release the ejectee from the parachute following descent into seawater. The parachute assembly is attached to the upper forward face of the ejection seat main beams.

Parachute Container

The parachute container is made of light alloy, with canopy penetrators fitted to each upper outboard side. The penetrators on the forward seat are longer than those on the aft seat. The SJU-17(V)9/A parachute, installed in the aft cockpit of the TF-18/A, also has a single penetrator installed centrally aft on the container lid. Brackets, integral with the rear of the canopy penetrators, are bolted to brackets on the main beams. A shaped headpad is attached to the front face of the container for head placement during ejection. Hook and pile fasteners are fitted to the front face of the headpad to position the parachute risers. A rigid top cover closes

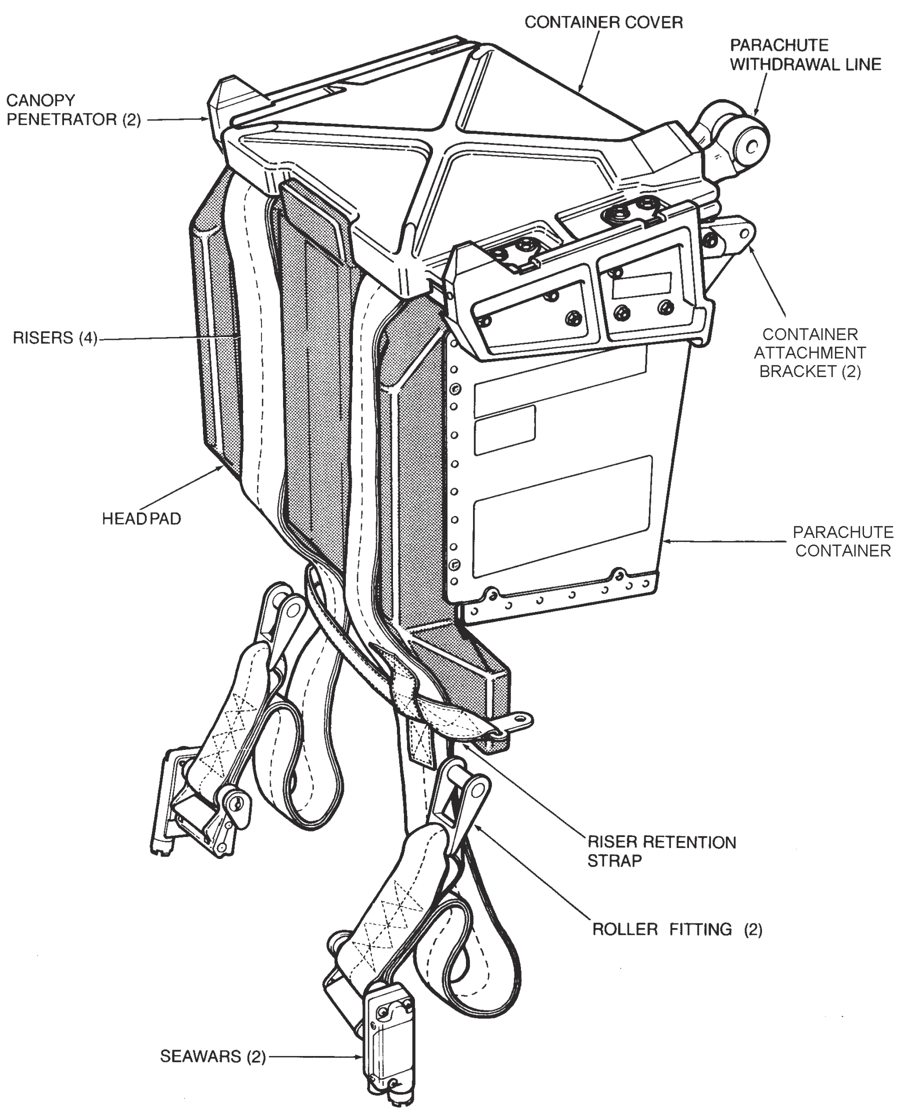


Figure 2-24.—Parachute assembly (SJU-17(V)2/A and 5/A).

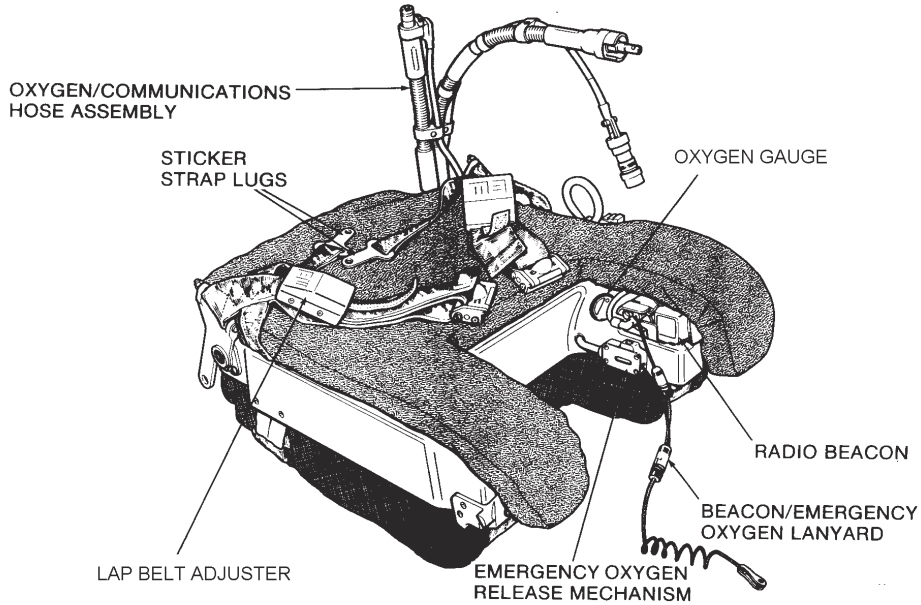


Figure 2-25.—Seat survival kit, top view.

the container, with a single lug on the RH side and two lugs on the LH side. The RH lug is positioned in a slot in the RH canopy mechanism incorporated into the LH canopy penetrator. The LH lugs deform during parachute extraction, releasing the cover to permit rapid parachute deployment. A fairing on the LH rear corner of the cover protects the parachute withdrawal line where it exits the container. The lid and withdrawal are fitted with seals to prevent the entry of moisture.

Parachute Canopy

The parachute canopy is comprised of 20 gore and shroud lines, and incorporates water pockets and steering facilities. The canopy is packed peak first into a deployment bag, the closed end of which is attached via a withdrawal line to the stirrup on the parachute deployment rocket. During the ejection sequence the parachute deployment rocket motor fires, extending the withdrawal line that withdraws the parachute in its bag. The parachute canopy emerges from the bag, perimeter first, followed progressively by the remainder of the canopy. The extractor rocket and bag clear the area. At high airspeeds the crown section inflates and surplus air is vented through a circumferential netted slot and the peak vent. The lower section remains closed until airspeed is reduced to safe opening speed, when the lower portion inflates normally.

SEAT SURVIVAL KIT

The survival kit (figs. 2-25 and 2-26) fits into the seat bucket and consists of a rigid contoured platform to which is attached an emergency oxygen system and a

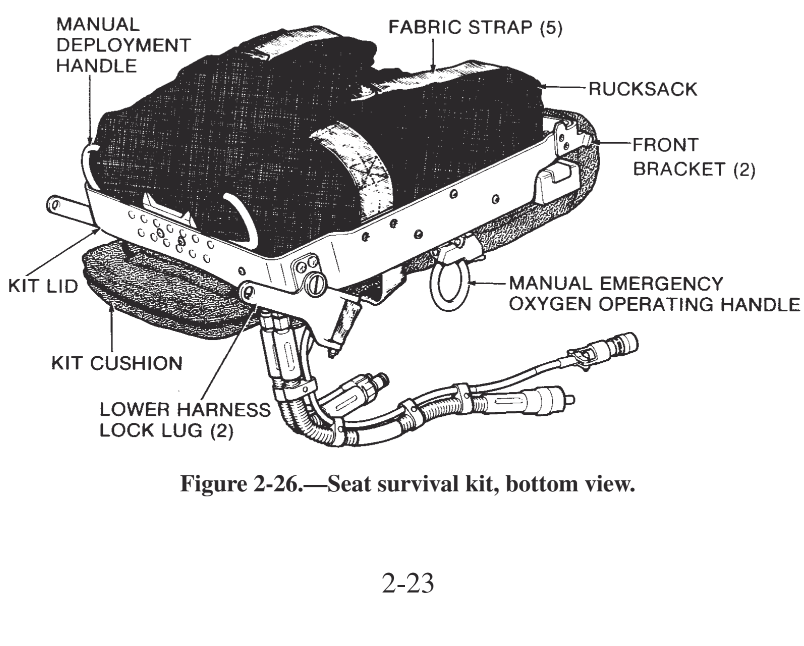


Figure 2-26.—Seat survival kit, bottom view.

fabric survival package. A cushion on top of the platform provides a firm and comfortable seat for the occupant.

There are three different survival kit configurations for the various NACES platforms:

KIT	AIRCRAFT	CONFIGURATION
SKU-7/A	F-14D	SJU-17(V)3/A and 4/A
SKU-10/A	F/A-18C/D	SJU-17(V)1/A, 2/A and 9/A
SKU-11/A	T-45A	SJU-17(V)5/A and 6/A

Basic differences between survival kits are as follows:

KIT	CHARACTERISTICS
SKU-7/A	Narrow kit 50-cubic-inch oxygen cylinder (100 liters) Used in conjunction with Personnel Services Disconnect installed on the LH
SKU-10/A	Wide kit 100 cubic inch oxygen cylinder (200 liters)
SKU-11/A	Narrow kit 100 cubic inch oxygen cylinder (200 liters)

Rigid Platform

The rigid platform forms a hard protective cover to the survival package and oxygen system and is retained in position in the seat bucket by brackets at the front and lugs at the rear to secure the lower harness locks. Attached to the lugs are two adjustable lap belts with integral quick-release fittings.

Emergency Oxygen System

An emergency oxygen cylinder, a pressure reducer, and associated plumbing are mounted on the underside of the platform. A green manual operating handle is mounted on the LH side of the platform and a cylinder quantity gauge is on the inside of the face of the left-hand thigh support. The emergency oxygen is automatically activated during ejection by a lanyard connected to the cockpit floor. An oxygen/communications hose is connected to unions on the LH rear top of the rigid platform and provides connections between the seat occupant, aircraft, and survival kit systems.

URT-33/A Radio Locator Beacon

The URT-33/A radio locator beacon is located in a cut-out in the left thigh support. The beacon is actuated during ejection by a lanyard connected to a common anchorage point with the emergency oxygen lanyard.

Survival Package

The survival package is held on the underside of the rigid platform by five fabric straps and a double cone and pin release system. The package accommodates a liferaft and the survival aids. Yellow manual deployment handles mounted on the kit enable the occupant to deploy the package onto a lowering line after man/seat separation. The liferaft inflates automatically on survival package deployment.

SAFE/ARMED Indicator Switch

The SAFE/ARMED indicator switch is located on the front of the seat bucket, left of the ejection control handle linkage. The SAFE/ARMED indicator switch is made up of a switch, plunger, and a wiring harness that mate to the electrical connector housing in the seat bucket. The ejection control handle mechanical safety lock actuates the plunger on the SAFE/ARMED indicator switch when the SAFE/ARMED handle is up in the SAFE position.

The SAFE/ARMED handle is set to the ARMED position (seat armed) when the aircraft is ready for flight. When in the ARMED position, the visible portion of the handle is colored with yellow and black markings and placarded as ARMED. When in the SAFE position, the visible portion is colored white and placarded as SAFE.

Q2-1. List the five main assemblies of the NACES.

Q2-2. What is the purpose of the drogue and bridle system?

Q2-3. What component supplies dynamic pressure inputs to the electronic sequencer?

Q2-4. The SAFE/ARMED handle displays what color when in the ARMED position?

Q2-5. An F/A-18C aircraft uses what type of seat survival kit?

EJECTION

LEARNING OBJECTIVE: Identify the ejection sequence and the different modes of operation.

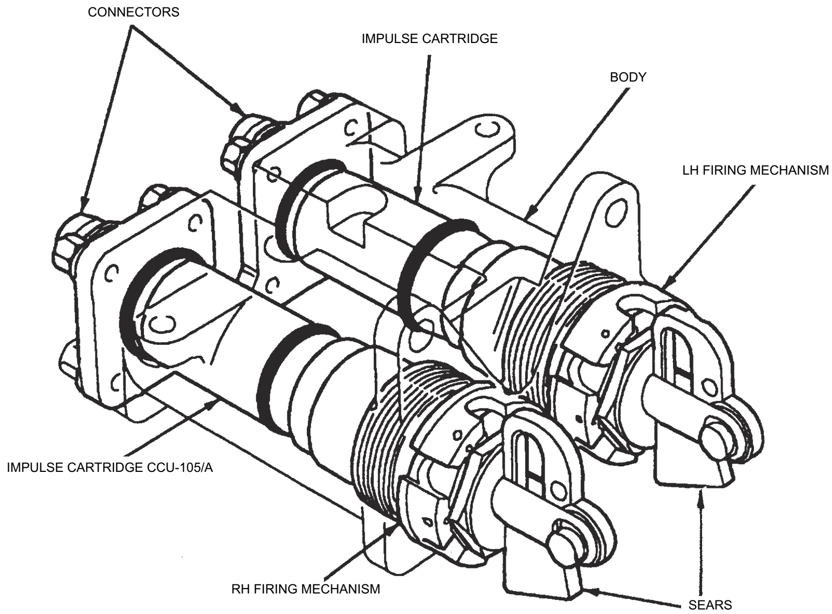


Figure 2-27.—Seat initiator.

When the ejection control handle is pulled, the sears are withdrawn from the seat initiator firing mechanisms (fig. 2-27) and the two impulse cartridges are fired, catapulting the seat free of the aircraft and starting the sequencer modes for seat/occupant separation and parachute deployment.

EJECTION SEQUENCE

On firing of the impulse cartridges, gas from the RH and LH cartridges is routed as described.

RH Initiator Cartridge

Gas from the RH cartridge is piped as follows:

1. To the pin puller (fig. 2-28), which withdraws a piston from engagement in the lower operating

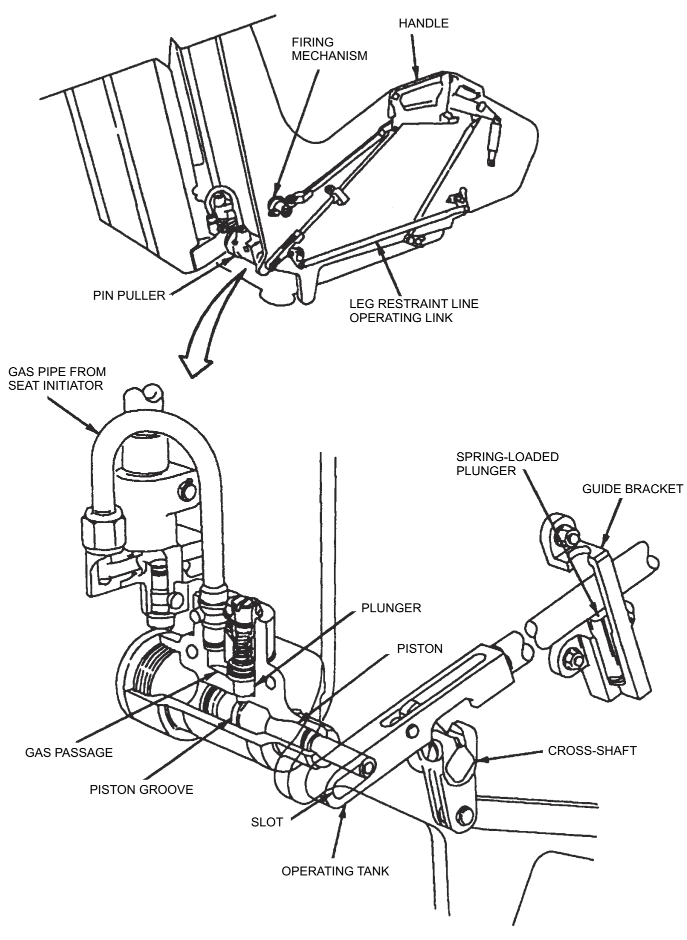


Figure 2-28.—Emergency restraint release system (SJU-17(V)1/A, 2/A, and 9/A).

link of the emergency restraint release mechanism.

2. To the inboard connector of the command sequencing system quick-disconnect on the RH ballistic manifold (fig. 2-29) to operate the command sequencing system.

3. SJU-17(V)1/A, 6/A and 9/A only. To the cartridge actuated initiator on the RH ballistic manifold. Gas from the initiator passes to the RH inlet of the catapult manifold to initiate the catapult.

4. To the breech of the shoulder harness reel where it fires the impulse cartridge to pull the seat occupant into the correct position for ejection.

5. To the thermal batteries.

6. SJU-17(V)2/A thru 5/A only. To the cartridge actuated initiator on the LH ballistic manifold (fig. 2-30). Gas from the initiator passes to the LH inlet of the catapult manifold valve to initiate the catapult.

7. All configurations. If the seat is command ejected (i.e., the ejection control handle on the other seat has been pulled) gas from the command sequencing system enters the RH seat initiating system through the inboard connector of the command sequencing quick-disconnect on the RH ballistic manifold. On SJU-17(V)2/A thru 5/A, gas pressure also enters the outboard connector on the command sequencing quick-disconnect and is passed to the catapult manifold valve to initiate the catapult. This gas pressure is also piped, via a check valve, to the shoulder harness reel and thermal batteries.

LH Initiator Cartridge

Gas from the LH cartridge is piped as follows:

1. To the thermal batteries.

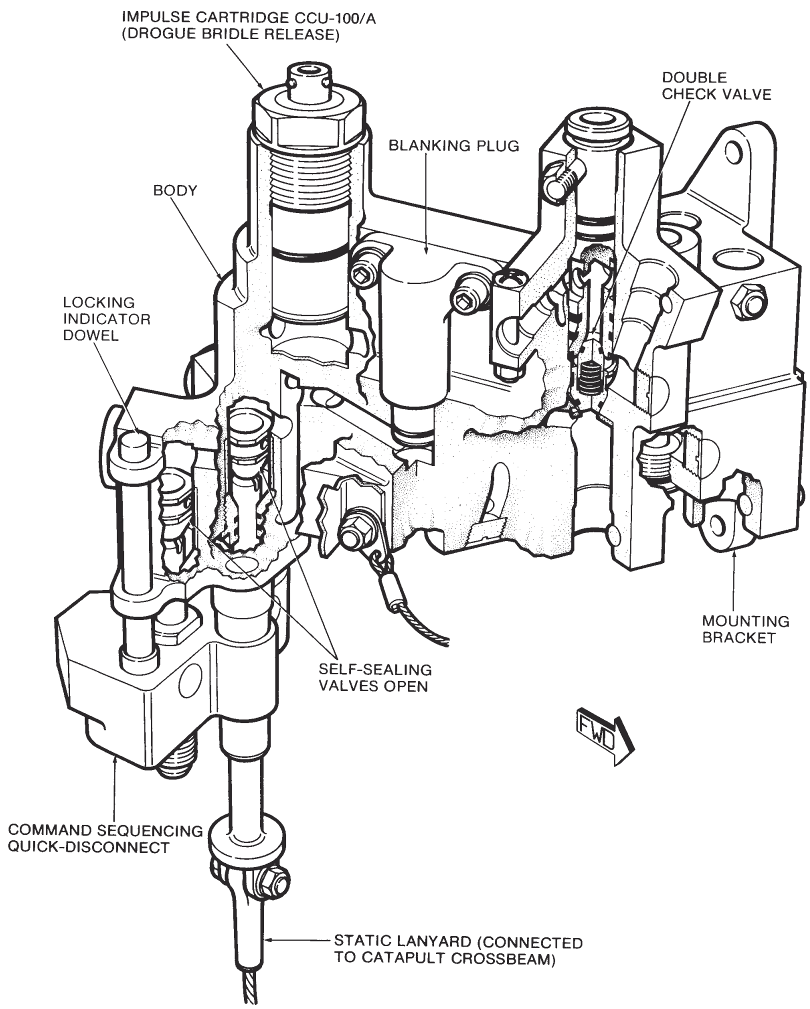


Figure 2-29. RH ballistic manifold (SJU-17(V)2/A thru 5/A).

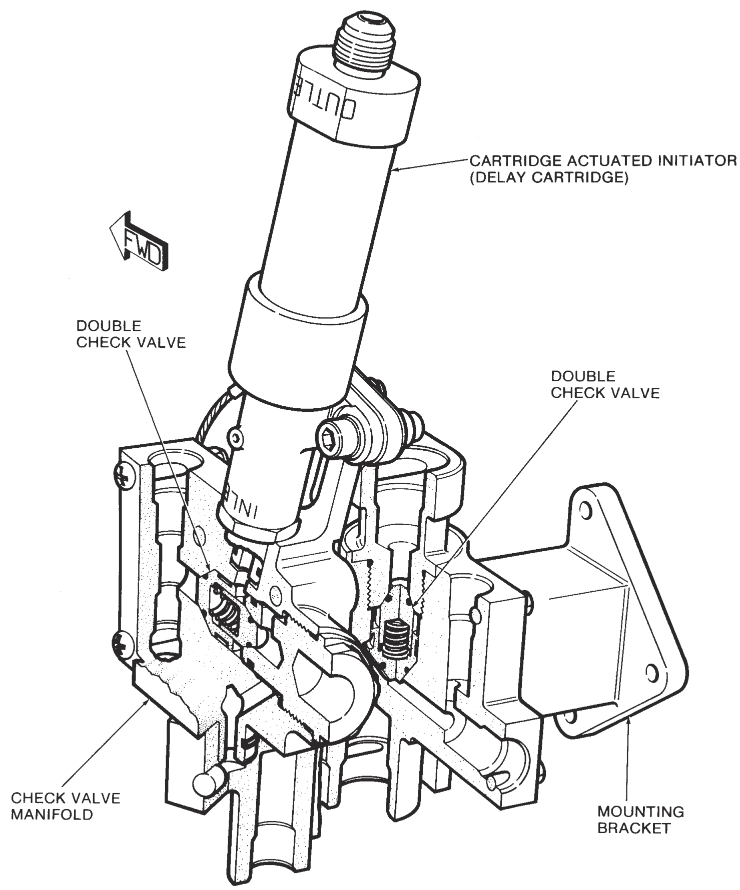


Figure 2-30. LH ballistic manifold (SJU-17(V)2/A thru 5/A).

2. SJU-17(V)1/A thru 5/A and 9/A only. To the cartridge actuated initiator on the LH ballistic manifold. Gas from the initiator passes to the LH inlet of the catapult manifold valve to initiate the catapult.
3. SJU-17(V)6/A only. To the LH inlet of the catapult manifold valve to initiate the catapult.

Gas from the cartridge actuated initiator(s) or the command sequencing system is piped to the ejection gun initiator via the manifold valve. Gas pressure developed by the ejection gun initiator passes down the catapult to operate the ballistic latches, retaining the IMP lanyard end fittings. As the pressure increases within the catapult, the catapult piston rises, releases the top latch, and begins to move the seat upwards. Further movement of the piston uncovers the catapult secondary cartridge, which is fired by the heat and pressure of the ejection gun initiator gas. Staggered firing of the catapult cartridges provides a relatively even increase in gas pressure during catapult stroke to eliminate excessive g-forces during ejection.

As the seat ascends the guide rails:

1. The IMP lanyards begin to withdraw.
2. Personnel services between the seat and aircraft are disconnected.
3. The command sequencing system quick-disconnect is disconnected.
4. The emergency oxygen supply is initiated.
5. The URT-33/A beacon is activated.
6. The leg restraint lines are drawn through the snubbers and restrain the occupant’s legs to the front of the seat bucket. When the leg restraint lines become taut, the special break rings in the leg lines fail and the lines are freed from the aircraft. The lines being restrained by the snubbers prevent forward movement of the legs.

Near the end of the catapult stroke, the IMP lanyards become taut and operate the firing mechanisms. Gas pressure from the IMP cartridges passes:

1. To the start switch plungers. Closure of the start switches commences sequencer timing.
2. To the barostatic release unit release piston (from the RH IMP only).

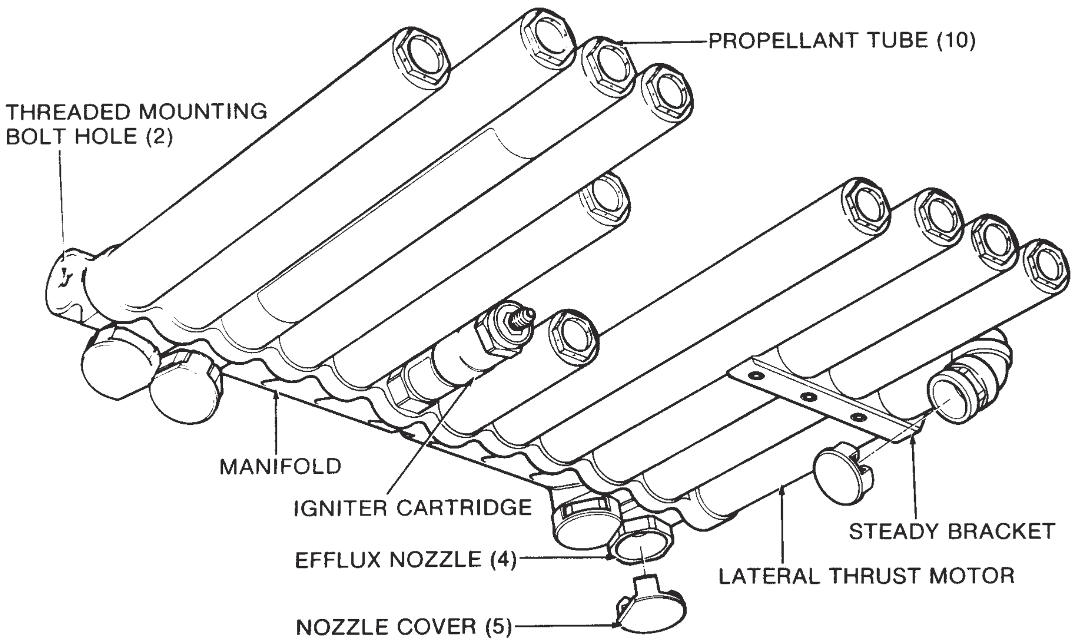


Figure 2-31.—Underseat rocket motor MK 123 MOD 0 (SJU-17(V)2/A, 3/A, and 5/A).

3. To the pitot mechanisms to deploy the pitot heads.
4. Via the LH ballistic manifold and trombone tube to the underseat rocket motor (fig. 2-31). The rocket motor ignites, sustaining the thrust of the catapult to carry the seat clear of the aircraft.

Sequencer Modes

Figures 2-32 and 2-33 identify the various modes. Electronic sequencer timing (table 2-1) commences

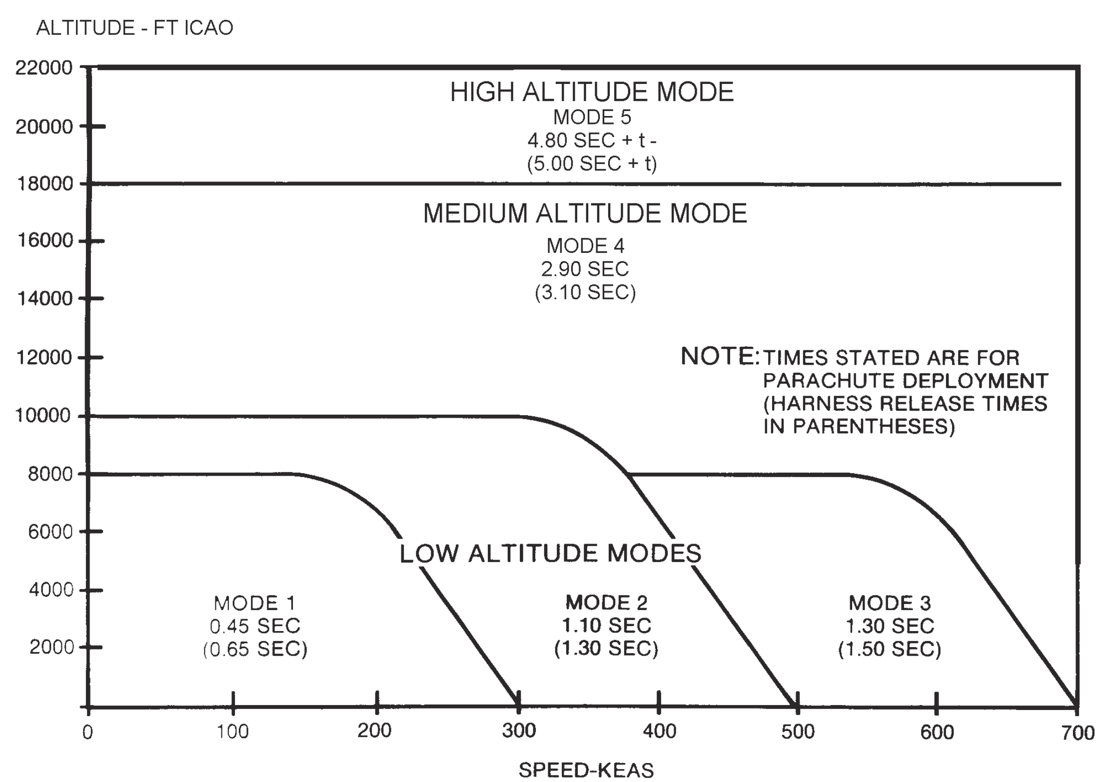


Figure 2-32.—Ejection modes.

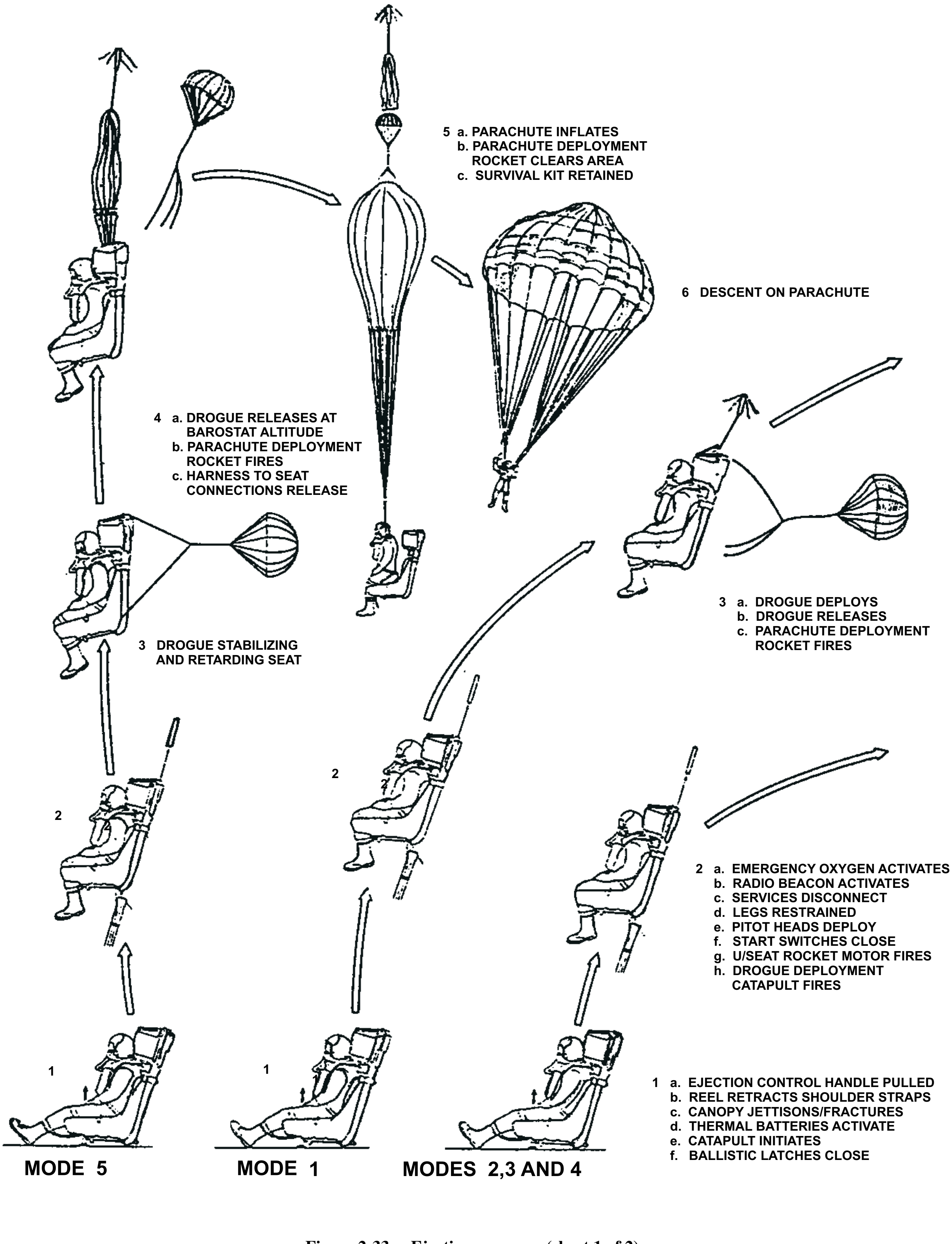


Figure 2-33.—Ejection sequence (sheet 1 of 2).

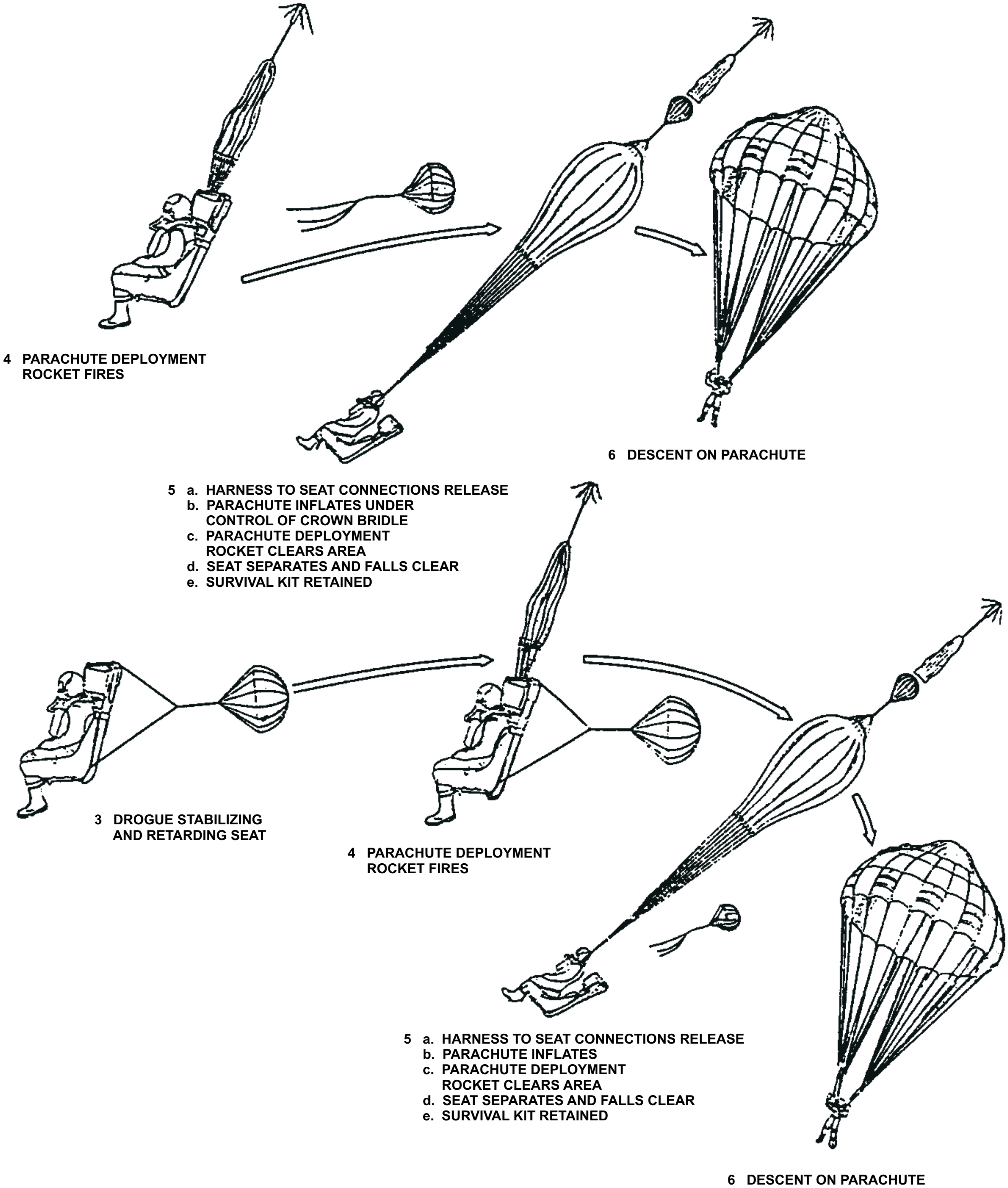


Figure 2-33.—Ejection sequence (sheet 2 of 2).

Table 2-1.—Sequencer Timings

	Altitude (ft):	0-8K			8K-18K	18+
	KEAS:	0-300	300-500	500-600	ALL	ALL
	MODE:	1	2	3	4	5
1.	Gas pressure from seat initiator cartridges, delay cartridge, or command sequencing system initiates catapult and thermal batteries.	0.00	0.00	0.00	0.00	0.00
2.	Start switches close after 32 inches of seat travel.	0.18	0.18	0.18	0.18	0.18
3.	Sequencer supplies dual pulse to fire drogue deployment catapult.	0.22	0.22	0.22	0.22	0.22
4.	Sequencer supplies dual pulse to fire drogue bridle release cartridge and release drogue bridle.	0.32	—	—	—	—
5.	Sequencer supplies dual pulse to fire parachute deployment rocket.	0.45	1.10	1.30	2.90	4.80 +t
6.	Sequencer supplies dual pulse to fire drogue bridle release cartridge and release drogue bridle.	—	.125	1.45	3.05	4.95 +t
7.	Sequencer supplies dual pulse to fire barostatic release unit cartridge and release harness locks.	0.65	1.30	1.50	3.10	5.00 +t
8.	Sequencer supplies dual pulse to fire barostatic release unit cartridge (backup).	0.66	1.31	1.51	3.11	5.01 +t

NOTES TO TABLE 2-1

1. All times are referenced to seat catapult initiation. To obtain times referenced to sequencer start switches, subtract 0.18 second.
2. Mode selection environmental sensing takes place between 0.245 second and 0.305 second (8 microprocessor cycles).
3. In mode 5 operation, altitude sensing recommences at 4.80 seconds, continuing until the seat falls to 18,000 ft. (t)=time interval between 4.80 seconds and falling to 18,000 ft.

when the start switches close. Mode selection is dependent on altitude and airspeed parameters.

SEQUENCER MODES

When the ejection seat is fired, two onboard thermal batteries are immediately energized, supplying usable electrical power to the sequencer after just 100 milliseconds, with the seat having traveled about 5 inches up the ejection catapult. The sequencer microprocessors then run through an initialization routine and by 120 milliseconds the sequencer is ready and waiting to perform.

As the seat rises from the cockpit, two steel cables (approximately 42 inches) are pulled from the multipurpose initiators, actuating two pyrotechnic cartridges. The gas generated by these two cartridges is piped around the seat to perform the following functions:

- Initiate the underseat rocket motor
- Deploy the pitot tubes from the sides of the seat headbox
- Close two electrical switches (sequencer start switches)

The sequencer responds to the closure of either start switch by changing to the *ejection* mode. The switch starts an electronic clock and all subsequent events are timed from this point. In the absence of a start switch signal, the sequencer will simply continue in the *wait* mode. This mode is a safety feature designed to ensure that the drogue and parachute can only be deployed after the seat has physically separated from the aircraft.

The ignition of the underseat rocket motor is timed to occur just as the seat separates from the ejection catapult, at about 200 milliseconds, so as to maintain a uniform vertical acceleration profile on the seat and occupant. The motor has a burn time of 250 milliseconds. Once the sequencer is switched into the *ejection* mode, its first action is to electrically fire the drogue deployment canister, which occurs at precisely 40 milliseconds after the start switch (approximately 220 milliseconds from seat initiation), while the seat rocket motor is burning. This happens regardless of the speed and altitude conditions.

The sequencer then enters its most crucial period, when it will sense the seat airspeed and altitude and choose the appropriate timings from a set of five available sequences. This occurs during a 60 millisecond *environmental sensing time window* that starts just after the drogue canister is fired, and is completed before the drogue is fully deployed and pulling on the back of the seat. The sequencer measures the speed and altitude from the information it receives from three types of sensor: pitot pressure, base pressure, and accelerometer.

Several samples of each parameter are taken during the environmental window. These are used to determine the ejection conditions. The sequencer then selects the appropriate times for the remaining events, known as *mode* selection, and completes the sequence accordingly.

ALL MODES.—The start switches close after approximately 32 inches of the seat travel, and after 0.04 seconds the drogue deploys onto the bridle to stabilize and decelerate the seat.

MODE 1: LOW SPEED – LOW ALTITUDE.—The drogue bridle is released, the parachute deployment motor fires to deploy the personnel parachute and the harness release system operates to free the occupant from the seat. The occupant is momentarily held in the seat bucket by the sticker straps.

MODES 2, 3 and 4: MEDIUM and HIGH SPEEDS/LOW ALTITUDE and ALL SPEEDS/MEDIUM ALTITUDE.—The drogue bridle is released, the parachute deployment rocket fires to deploy the parachute, the drogue bridle is released, and the harness release system operates to free the occupant from the seat. The occupant is momentarily held in the seat bucket by the sticker straps.

MODE 5: ALL SPEEDS/HIGH ALTITUDE.—The drogue bridle remains connected until the seat has descended to 18,000 feet. This arrangement prevents prolonged exposure to low temperature and unsubstantial air. This enables the occupant to ride down in the seat supplied with emergency oxygen to a more tolerable altitude. When the seat has descended to 18,000 feet, the parachute deployment rocket motor fires to deploy the personnel parachute, the drogue bridle is released and the harness release system operates to free the occupant from the seat. The occupant is momentarily held in the seat bucket by the sticker straps.

ALL MODES.—The personnel parachute, when developed, lifts the occupant and survival kit from the seat, pulling the sticker straps from their clips. This arrangement ensures that there is no possibility of collision between the seat and occupant after separation.

Q2-6. For all configurations, if the seat is command ejected, gas from the command sequencing system enters through what initiating system?

Q2-7. During ejection, what distance does the seat have to travel before the drogue chute deploys?

Q2-8. MODE 1 occurs at what speed and altitude?

CHAPTER 2

ANSWERS TO REVIEW QUESTIONS

A2-1. The catapult, main beam assembly, seat bucket assembly, parachute assembly, and seat survival kit

A2-2. Used to decelerate and stabilize the ejection seat prior to deployment of the personnel parachute

A2-3. Pitot assemblies

A2-4. Yellow and black stripes

A2-5. SKU-10/A

A2-6. RH seat initiating system

A2-7. 32 inches

A2-8. Low speed—low altitude

CHAPTER 3

CANOPY SYSTEMS

The canopy on modern high-performance aircraft serves several purposes. It protects the crew, provides enhanced visibility, and serves as an avenue of escape in case of emergency.

The canopy system includes the canopy itself, plus all the components used in opening and closing the canopy for normal entrance and exit, as well as those used in jettisoning the canopy during an emergency. Inspection and maintenance of canopy actuating systems are important responsibilities of the AME.

Aircraft manufacturers have designed various methods of actuating the canopy. Normal opening and closing may be done pneumatically (compressed air), electrically, manually, or hydraulically. Emergency opening (jettisoning) is done pneumatically or explosively.

In most instances, more than one method is provided for normal opening and closing of the canopy; thus, if one system fails, the other may be used. The same holds true for jettisoning the canopy. This chapter will discuss the pneumatic canopy system on the F-14 and the frangible escape canopy system on the S-3 aircraft.

DESCRIPTION

LEARNING OBJECTIVE: Describe the F-14 pneumatic canopy system.

The pneumatic canopy system provides normal opening and closing of the canopy in the F-14 aircraft. The system is controlled with the canopy control handle at each crew station or with the external canopy control handle on the fuselage left side. Pneumatic pressure from externally serviced reservoirs supplies the power for the different modes of canopy operation. The canopy also can be manually opened and closed. A reference mark is painted on the fuselage and canopy. When the canopy is closed and locked, the marks are aligned.

Q3-1. What provides the power for the different modes of canopy operation?

Q3-2. What is painted on the canopy to provide a visual display of being closed and locked?

COMPONENTS

LEARNING OBJECTIVE: Identify components of the pneumatic canopy system and their function.

This section will cover the canopy and following components: canopy hydraulic actuator, canopy-lock pneumatic actuator, lock actuator restrictor, canopy pneumatic timer, canopy pneumatic control module, canopy pneumatic reservoir, pneumatic servicing charging module, canopy switch, auxiliary pneumatic reservoir, unlock shuttle valve, and the lock actuator check valve.

CANOPY

The canopy is a transparent enclosure for the cockpit; it consists of two acrylic panels in a metal frame. During normal operation, a pneumatically controlled canopy hydraulic actuator opens and closes the canopy. A canopy-lock pneumatic actuator moves it to the locked or unlocked position. It is locked in the closed position by 14 locking hooks that engage latches on the cockpit sill. An inflatable rubber seal in the canopy is closed and locked. Three rearview mirrors are mounted on the pilot forward canopy frame; one, on the naval flight officer (NFO) forward canopy frame. The canopy can be jettisoned in an emergency on the ground and during the ejection sequence. Figure 3-1 displays the canopy pneumatic systems component locations.

CANOPY HYDRAULIC ACTUATOR

The canopy hydraulic actuator (fig. 3-1, Item D) opens and closes the canopy. It consists of a double-acting hydraulic cylinder, two transfer cylinders, and two hydraulic control modules. The transfer cylinders transfer pneumatic pressure from the canopy pneumatic control module to hydraulic power. The hydraulic control modules contain pneumatically actuated shutoff valves that hydraulically lock the canopy actuator in any position. When the canopy pneumatic control module is in the neutral position, flow regulators control actuator speed by permitting free flow of hydraulic fluid to the actuator and restricted flow from the actuator, and thermal relief valves relieve pressure from the double-acting cylinder to the transfer

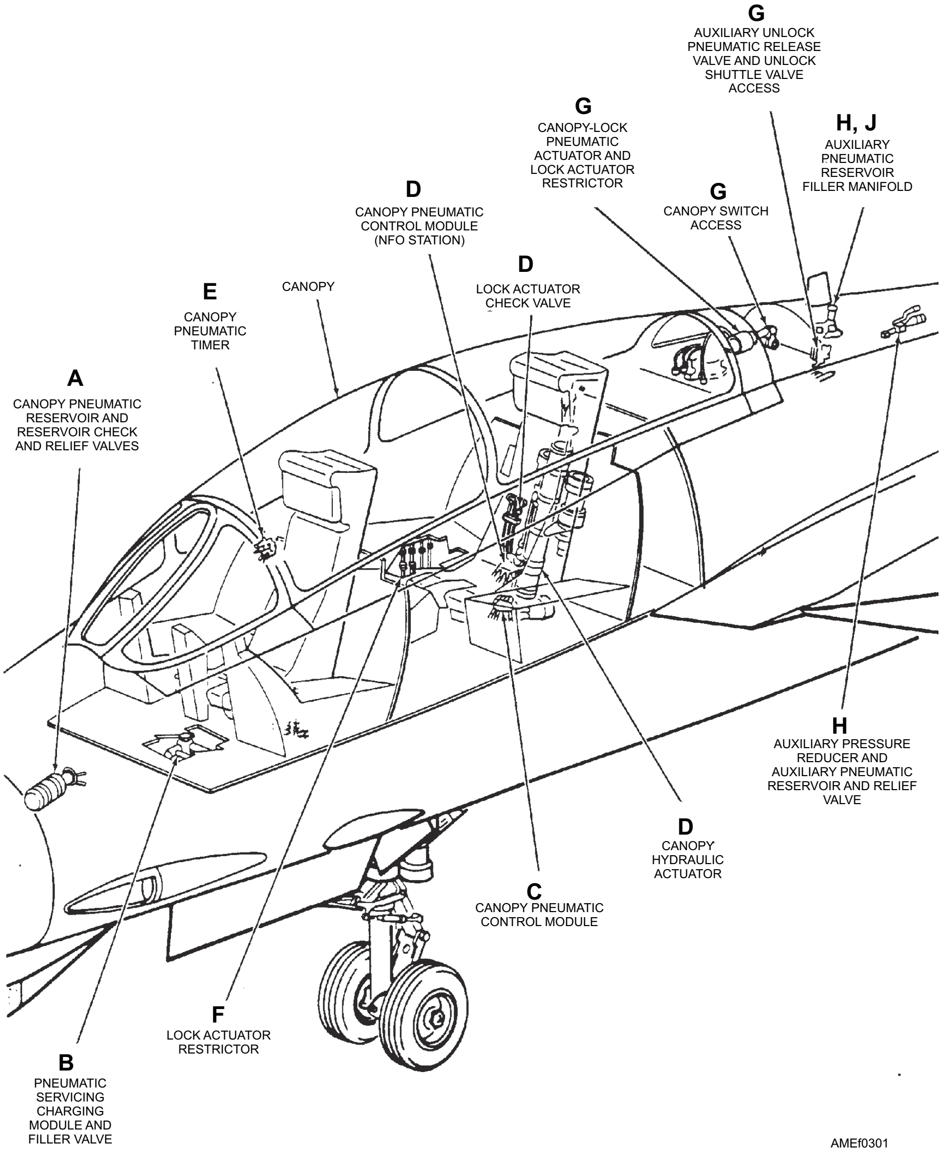


Figure 3-1.—Canopy pneumatic system components.

cylinders. The canopy hydraulic actuator is accessible from the NFO station when the canopy is opened and the NFO ejection seat is removed.

CANOPY-LOCK PNUEMATIC ACTUATOR

The canopy-lock pneumatic actuator (fig. 3-1, Item G) locks and unlocks the canopy. It operates with nitrogen pressure from the canopy pneumatic control module and the canopy pneumatic timer. The actuator moves the canopy forward or aft the RETR (locked) or EXT (unlocked) position, respectively. When the actuator piston reaches its full EXT (unlock) travel limit, the timer check valve permits pneumatic-pressure flow from the canopy hydraulic actuator. While the canopy closes, the timer check valve vents pneumatic pressure from the canopy hydraulic actuator through the canopy pneumatic control module. When the canopy-lock pneumatic actuator piston moves toward the RETR (locked) position, the timer check valve reseats.

LOCK ACTUATOR RESTRICTOR

The lock actuator restrictors (fig. 3-1, Item G) regulate the speed of the canopy-lock pneumatic actuator during locking and unlocking of the canopy.

CANOPY PNEUMATIC TIMER

The canopy pneumatic timer (fig. 3-1, Item E) permits pneumatic pressure flow from the canopy pneumatic control module to the lock side of the canopy-lock pneumatic actuator and vents or pressurizes the canopy hydraulic actuator shutoff valves. The last closing motion of the canopy actuates the timer.

CANOPY PNEUMATIC CONTROL MODULE

The canopy pneumatic control module (fig. 3-1, Item C) regulates pressure from the canopy pneumatic reservoir and directs it to the canopy pneumatic timer, the timer check valve, canopy hydraulic actuator, and the canopy-lock pneumatic actuator. The module contains a filter, a restrictor, two pressure reducers, two relief valves, a low-pressure sensor, and control valves. If canopy pneumatic reservoir pressure drops below 225 pounds per square inch (psi), the low-pressure sensor causes the module valves to lock the remaining pressure in the canopy hydraulic actuator to counterbalance the weight of the canopy. Canopy unlocking is done by the auxiliary unlock mode.

CANOPY PNEUMATIC RESERVOIR

The canopy pneumatic reservoir (fig. 3-1, Item A) stores high-pressure dry nitrogen for operation of the canopy pneumatic system. The reservoir is serviced to 3,000 psi; it has a 225-cubic inch capacity. Servicing is done through the pneumatic servicing charging module, which is remote from the reservoir.

The reservoir relief valve (fig. 3-1, Item A), on the canopy pneumatic reservoir, prevents overpressurization of the reservoir. The valve opens at 4,500 psi and reseats at 4,100 psi.

PNEUMATIC SERVICING CHARGING MODULE

The pneumatic servicing charging module contains a filler valve, a filter, two check valves, and two pressure gauges. The filler valve enables filling both the canopy pneumatic reservoir and the emergency landing gear reservoir from a single point. The check valve prevents reverse flow when one reservoir has a lower pressure than the other.

CANOPY SWITCH

The canopy switch (fig. 3-1, Item G) is actuated by the canopy locking mechanism lock pin. The switch closes when the canopy unlocks. This completes a circuit to the canopy caution indicator lights on the pilot and NFO caution advisory indicators. When the canopy locks, the switch opens.

AUXILIARY PNEUMATIC RESERVOIR

The auxiliary pneumatic reservoir (fig. 3-1, Item H) has a 14.6-cubic-inch capacity. It stores high-pressure dry nitrogen for unlocking the canopy in the auxiliary mode. The reservoir is serviced, through the filler manifold, to 3,000 psi.

Auxiliary Pneumatic Reservoir Filler Manifold

The auxiliary pneumatic reservoir filler manifold (fig. 3-1, Item J) is connected to the auxiliary pneumatic reservoir. It consists of a nitrogen filler valve and pressure gauge.

Auxiliary Pneumatic Reservoir Relief Valve

The auxiliary pneumatic reservoir relief valve (fig. 3-1, Item H), adjacent to the auxiliary pneumatic reservoir, is connected to the reserve outlet port. It is a spring-loaded poppet valve that prevents over-pressurization of the auxiliary pneumatic reservoir. Valve cracking pressure is 4,500 pounds per square inch gauge (psig); full flow occurs at 5,100 psig. The valve reseats when the auxiliary pneumatic pressure drops to 4,100 psig.

Auxiliary Pressure Reducer

The auxiliary pressure reducer (fig. 3-1, Item H) is downstream of the auxiliary pneumatic reservoir. It reduces pneumatic pressure to 760 ± 30 psi applied to the auxiliary unlock pneumatic release valve.

Auxiliary Unlock Pneumatic Release Valve

The auxiliary unlock pneumatic release valve (fig. 3-1, Item G) is a lever-operated shutoff valve that is connected by a cable and pulley assembly to the canopy control handle in the pilot and NFO stations. It is a two-position valve operated by a cam mechanism, which maintains it in the open position. An internal vent releases pneumatic pressure when the auxiliary mode is not selected. When the auxiliary mode is selected to unlock the canopy, the vent port is blocked to permit pneumatic pressure application to unlock shuttle valve. After each auxiliary mode operation, the cam must be reset manually to return the system to normal.

UNLOCK SHUTTLE VALVE

The unlock shuttle valve (fig. 3-1, Item G) is a three-port, pressure-operated valve. An internal spool is shuttled by pneumatic pressure at either end of the valve housing to block one of the two end inlet ports. When the canopy control handle is moved to the OPEN position, pneumatic pressure flows from the canopy pneumatic control module, through the shuttle valve and the unlock actuator restrictor, to the unlock side of the canopy-lock pneumatic actuator. In the auxiliary mode (AUX OPEN), auxiliary pneumatic pressure shuttles the valve spool in the opposite direction to route auxiliary pneumatic flow from the auxiliary unlock release valve to the unlock end of the canopy-unlock release valve to the unlock end of the canopy-lock pneumatic actuator.

LOCK ACTUATOR CHECK VALVE

The lock actuator check valve (fig. 3-1, Item G) prevents nitrogen from venting overboard during the canopy normal closing and holding modes.

Q3-3. The canopy is made of what type of material?

Q3-4. How is the canopy actuator locked?

Q3-5. Describe the function of the lock actuator restrictor.

Q3-6. At what pressure does the low-pressure sensor cause the module valves to lock the remaining pressure in the canopy hydraulic actuator?

Q3-7. The canopy pneumatic reservoir is (a) what cubic capacity and (b) serviced to what psi?

Q3-8. What item prevents overpressurization of the reservoir?

Q3-9. Where is the auxiliary pressure reducer?

Q3-10. What type of valve is the unlock shuttle valve?

OPERATION

LEARNING OBJECTIVE: Describe the modes of operation of the pneumatic canopy system.

The canopy pneumatic system is operated by setting any one of the three canopy control handles, which positions valves within the pneumatic control module to route pneumatic pressure to or from the system. The modes of operation that can be selected are: normal opening mode, holding mode, normal closing mode, boost closing mode, and auxiliary opening mode. The function of all three control handles is the same; the following modes describe the operation using the pilot handle.

NORMAL OPENING MODE

Setting the pilot canopy control handle to OPEN pulls the lock pin and positions valves no. 1, 2, and 6 within the control module. This directs nitrogen (325 psi), through the C1 and C3 ports of the module, to the timer check valve and unlock port of the canopy lock pneumatic actuator. Simultaneously, the shutoff valves in the open and close modules of the canopy hydraulic actuator are vented to atmosphere through the C5 port of the actuator, through the canopy pneumatic timer, and through valve no. 3 in the control module. The lock port of the canopy lock pneumatic actuator is vented overboard through the pneumatic timer; the piston of the actuator extends and, by means of torque tube, cranks, and links, moves the canopy aft to unlock it from the still locks. When the extending piston reaches the end of its stroke, ball locks engage to hold it in that position. The extended piston also actuates the timer check valve, which directs the 325-psi nitrogen to the C1 port of the canopy hydraulic actuator. The nitrogen that enters the hydraulic actuator acts against the piston of the open transfer cylinder. This pressure, acting against the piston, causes the hydraulic fluid on the opposite side of the piston to extend the actuator. The extending actuator rotates the canopy on the aft hinge to open the canopy. As the actuator extends, fluid displaced from the close side of the actuator acts against the piston of the close transfer cylinder. The nitrogen on the opposite side of this piston is vented overboard through the C2 port of the hydraulic actuator and through valve no. 4 of the control module. Pulling the lock pin at the beginning of the opening cycle closes the canopy switch, which provides 28 volts from the essential dc no. 2 bus, through the CAN/LAD CAUTION/EJECT CMD IND circuit breaker, to the canopy caution indicator light on the pilot and NFO CAUTION ADVISORY indicators.

HOLDING MODE

The HOLD position stops canopy motion at any desired opening. Valve no. 3 in the control module directs 325-psi nitrogen through the C5 port of the module, through the pneumatic timer to the C5 port of the hydraulic actuator. The nitrogen that enters the C5 port closes the shutoff valves in the open and close modules. The closed shutoff valves trap hydraulic fluid on the open and close side of the actuator piston, stopping piston travel.

NORMAL CLOSING MODE

Setting the control handle to CLOSE positions valves no. 1, 2, 4, and 5 in the control module to vent both transfer cylinders and the unlock port of the canopy-lock pneumatic actuator overboard. The weight of the canopy closes it; pneumatic power is not required. The closing time, approximately 10 seconds from the fully open position, is controlled by the flow regulators in the open and close control modules of the hydraulic actuator, unlatching the ball locks. The actuator piston retracts and, by means of a torque tube, cranks, and links, moves the canopy forward to engage the canopy hooks in the sill locks. With the canopy in its fully forward position, the lock pin engages and prevents aft transition of the canopy. The final motion of the lock pin opens the canopy switch, breaking the circuit to the canopy caution indicator light on the CAUTION ADVISORY indicators; the lights go off.

BOOST CLOSING MODE

To close the canopy under high-headwind conditions, the canopy control handle must be moved to BOOST. Valve no. 4, in the control module, is positioned to direct 790 psi nitrogen through the C2 port of the canopy hydraulic actuator to the close transfer cylinder, and through the lock actuator check valve to the P5 port of the pneumatic timer. This nitrogen, acting against the transfer cylinder piston, causes the hydraulic fluid on the opposite side of the piston to retract the actuator, closing the canopy. The final closing motion of the canopy actuates the pneumatic timer, directing 790 psi nitrogen to the lock port of the canopy lock pneumatic actuator; this unlatches the ball locks. The system functions in the same manner to complete the locking action as in the normal closing mode. The other valves in the control module are positioned as when CLOSE is selected. The flow regulators in the open and close control modules of the hydraulic actuator also control the closing time for this mode of operation. After completion of boost mode operation, the canopy control handle shall be positioned to NORMAL close position; otherwise, depletion of nitrogen pressure from the canopy pneumatic reservoir will occur as shown in table 3-1.

Table 3-1.—Nitrogen Pressure Depletion

N2 Pressure (psi)	Time
Charged at 3,000	Initial time 0
1,000	After 1 minute
800	After 2 minutes
600	After 3 minutes
500	After 4 minutes

AUXILIARY OPENING MODE

The auxiliary opening mode is used to unlock the canopy when normal pneumatic system reservoir pressure drops below 225 psi. To prevent further depletion of nitrogen pressure in the normal system, a low-pressure sensor repositions valves no. 5 and 6 in the control module. The canopy must be unlocked by activating the auxiliary opening mode. When the control handle is set to AUX OPEN, the auxiliary unlock pneumatic release valve releases pressurized nitrogen from the auxiliary pneumatic reservoir. Nitrogen pressure from the reservoir flows through a 760 ± 30 psi pressure reducer through the release valve and pneumatic unlock shuttle valve, to shift position of the unlock shuttle internal spool. This directs nitrogen pressure to the unlock port of the canopy-lock pneumatic actuator, unlocking the canopy. Valve no. 1 in the control module directs reservoir pressure to open the transfer cylinder of the hydraulic actuator. This low-pressure nitrogen, acting against the transfer cylinder piston, counterbalances the weight of the canopy. The canopy can then be opened and closed manually with nominal effort; the canopy cannot be locked closed under these conditions. To return the system to normal operation, the control handle must be set to OPEN. The release valve eccentric cam must be manually reset to block auxiliary nitrogen pressure flow to the shuttle valve and to vent the pressure in the canopy-lock pneumatic actuator.

Q3-11. How many modes of operation are there for the F-14 canopy system?

Q3-12. In what mode can the canopy stop at a desired opening?

Q3-13. On a fully opened canopy, what is the approximate closing time?

Q3-14. When reservoir pressure drops below 225 psi, what mode is used to unlock the canopy?

CANOPY INFLATABLE SEAL SYSTEM

LEARNING OBJECTIVE: Describe the canopy inflatable seal system and its components.

The canopy inflatable seal system (fig. 3-2) provides an airtight seal between the canopy assembly and the aircraft structure to maintain cockpit pressurization. This section will cover the description, components, and operation of the canopy inflatable seal system.

The system, using cooled engine bleed air from the service air heat exchanger core, inflates the canopy seal in response to movement of the canopy locking linkage. The system deflates the seal when the canopy is

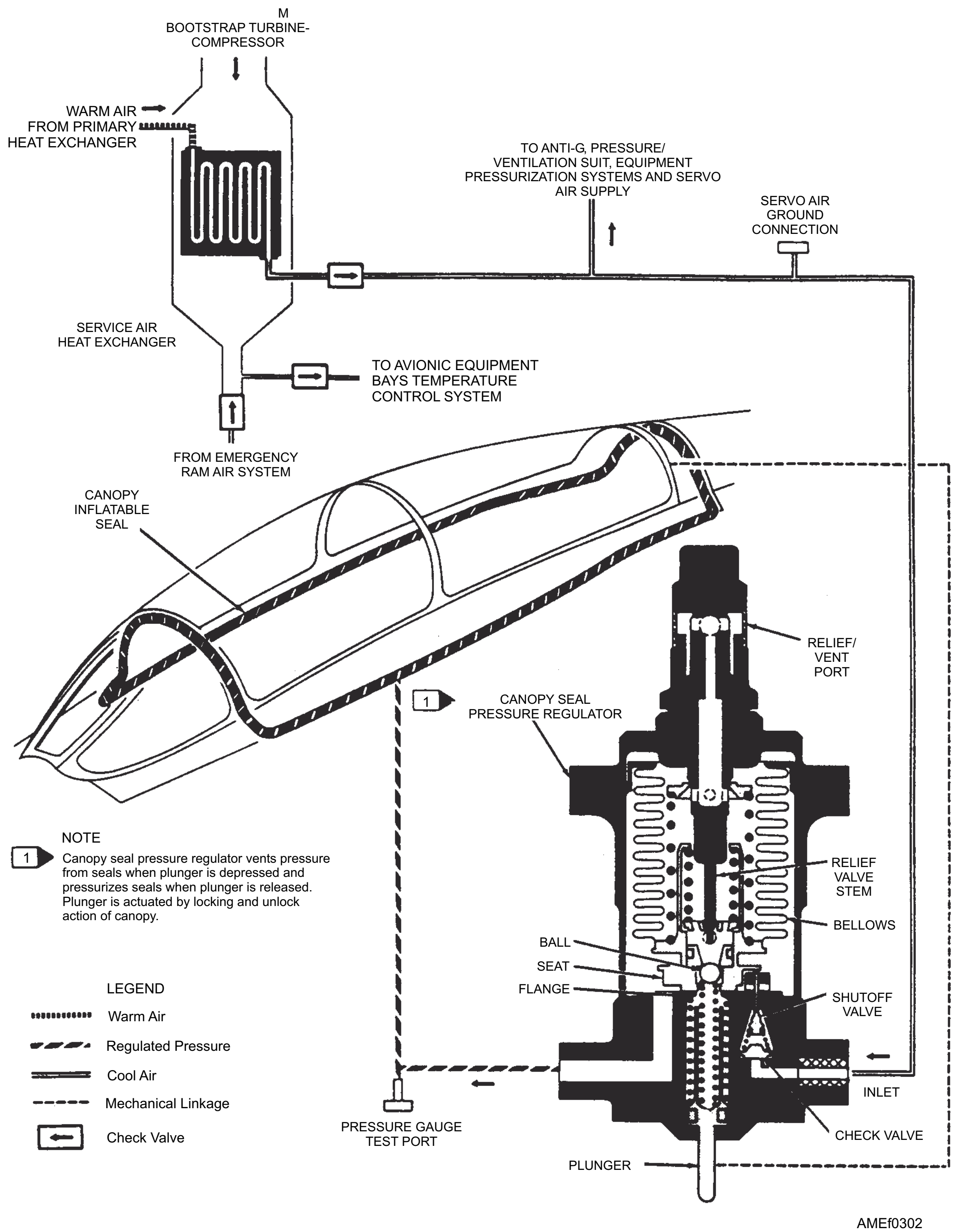


Figure 3-2.—Canopy inflatable seal system.

unlocked. On aircraft modified by AFC 581, the canopy structure also contains a flat rain seal to prevent water intrusion into the cockpit when the aircraft is in static conditions.

COMPONENTS

Components of the canopy inflatable seal system are the canopy inflatable seal and the canopy seal pressure regulator.

Canopy Inflatable Seal

The canopy inflatable seal (fig. 3-3) is retained in a channel around the circumference of the canopy assembly frame. When inflated, the seal fills the gap between the frame and aircraft structure.

Canopy Seal Pressure Regulator

The canopy seal pressure regulator (fig. 3-4) is on the turtle deck. It consists mainly of a check valve, shutoff valve, bellows, spring-loaded ball, and plunger. The regulator regulates its 80-psi bleed air input to the 25 ± 5 psi required by the canopy seal system, and controls inflation and deflation of the canopy inflatable seal. The regulator also receives pressures in excess of 6 to 8 psi above regulated value.

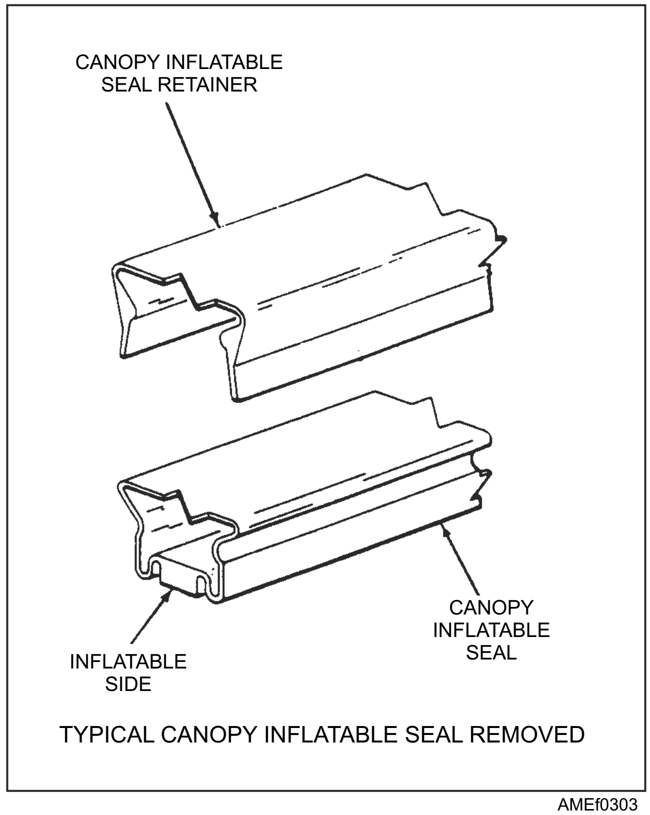


Figure 3-3.—Canopy inflatable seal (removed).

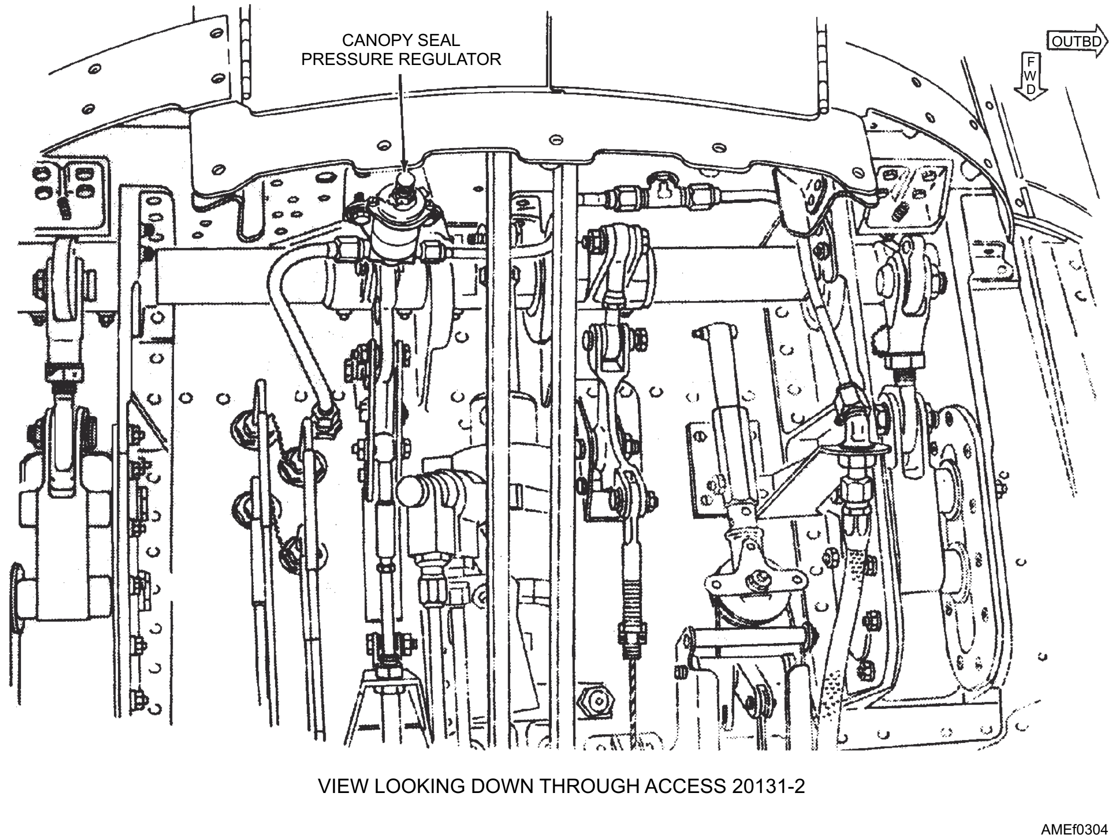


Figure 3-4.—Canopy seal pressure regulator location.

OPERATION

The canopy seal pressure receives cooled engine bleed air, at approximately 80 psi, from the service air heat exchanger. When the canopy is closed and locked, the regulator plunger is released; this opens the shutoff valve. Air from the regulator inlet then flows past the check valve and shutoff valve, through the outlet port to the canopy inflatable seal. As air pressure in the seal increases, pressure buildup in the regulator chamber moves the bellows seat away from the flange. The interior of the bellows is vented to ambient. When pressure in the seal reaches 25 ± 5 psi above ambient, the bellows has moved sufficiently to seat the shutoff seal, which fills the gap between the canopy frame and the mating aircraft structure, preventing loss of cockpit pressure. If pressure downstream of the regulator increases to 6 to 8 psi above the regulated pressure, additional bellows movement causes the relief valve stem to unseat the ball in the seat to vent the excess pressure through the relief/vent port. The check valve prevents loss of pressure from the inflatable seal should the air supply to the system fail.

When the canopy is unlocked, the regulator plunger is depressed. The plunger moves the bellows seat toward the relief valve stem to close the shutoff valve and unseat the ball, venting downstream pressure through the relief/vent port.

Q3-15. What is the purpose of the canopy inflatable seal system?

Q3-16. The canopy seal pressure regulator regulates 80-psi bleed air input down to what pressure?

Q3-17. Where does the canopy seal system receive its pressure?

Q3-18. What prevents loss of pressure should the air supply to the system fail?

CANOPY EMERGENCY JETTISON SYSTEM

LEARNING OBJECTIVE: Describe the components and operation of the canopy emergency jettison system.

The canopy emergency jettison system jettisons the canopy clear of the cockpit during emergency conditions that necessitate seat ejection and/or ditching. The canopy is jettisoned clear of the cockpit for normal ejection mode. Through the use of pyrotechnics, the canopy is automatically unlocked and jettisoned when ejection is initiated. It also may be jettisoned without initiating ejection by the aircrew (with canopy jettison initiator handles in the aircraft) or by a groundcrew (with an external canopy jettison initiator handle at each side of the aircraft). Figure 3-5

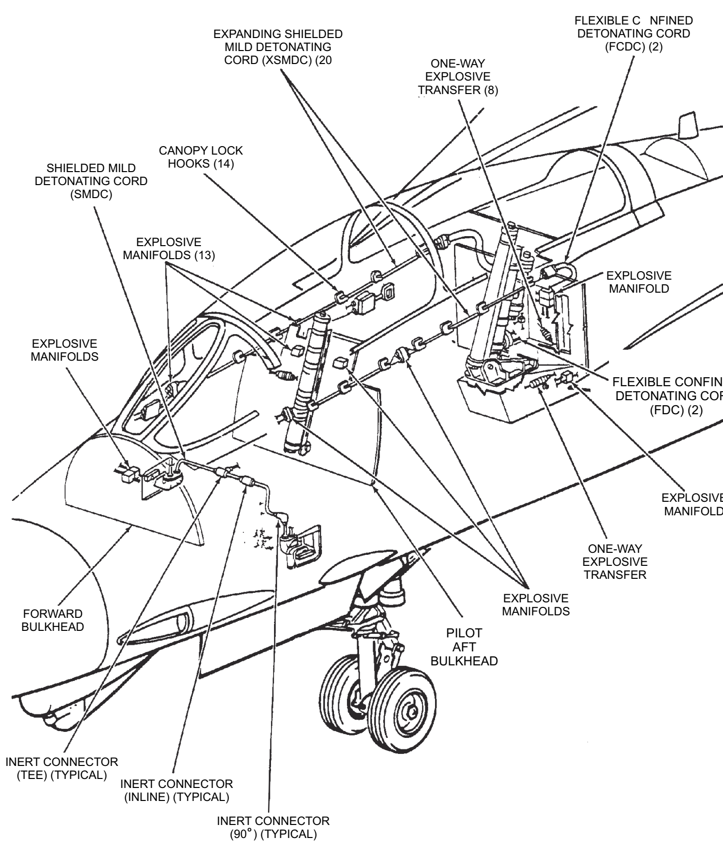


Figure 3-5.—Canopy emergency jettison system components.

displays the canopy emergency jettison system components. The following paragraphs will discuss the components and operation of the canopy emergency jettison system.

COMPONENTS

Components of the emergency jettison system include pyrotechnic cords, internal and external canopy jettison initiators, shielded mild detonating cord (SMDC)/gas initiators, gas generators, inert connectors and manifolds, explosive manifolds, and one-way explosive transfers.

Pyrotechnic Cords

Three types of pyrotechnic cords are used in the F-14 escape systems: expanding shielded mild detonating cord (XSMDC), flexible confined detonating cord (FCDC), and SMDC. Two XSMDC cords are routed parallel through each side of the canopy sills. When charged, the cords expand diametrically and sever hardware in all 14 canopy lock hooks, freeing the canopy. The firing of the canopy gas generator then jettisons the canopy. The FCDC, which is used in areas requiring mechanical movement, connects the canopy jettison gas generator to the SMDC, and starboard XSMDC to port XSMDC. The SMDCs are rigid tubes located throughout the cockpit fuselage and bulkheads.

Internal Canopy Jettison Initiators

Two internal canopy jettison initiators enable the aircrewman to jettison the canopy during emergency conditions without initiating seat ejection. One initiator is actuated with the CANOPY JETTISON handle on the pilot right instrument panel; the other initiator, with the CANOPY JETTISON handle on the NFO right instrument panel.

External Canopy Jettison Initiator

An external jettison initiator (fig. 3-6) enables the groundcrew to jettison the canopy during ground emergency conditions. Each initiator is manually actuated with its external canopy jettison handle.

Initiators (SMDC to Gas/Gas to SMDC)

The system has four SMDC to gas (two pilot and two NFO) and four gas SMDC initiators (two pilot and two NFO). The initiators are behind each ejection seat, mounted on an initiator manifold and connected to each seat with a pyrotechnic quick-disconnect. The gas to SMDC initiators are activated by pyrotechnic gas signals which result from pulling the ejection control handle. They provide the initial explosive signal for canopy jettison and seat ejection. The SMDC to gas initiators are activated by the aircraft sequencing system, sending a gas signal to the seat to eject the crewmember.

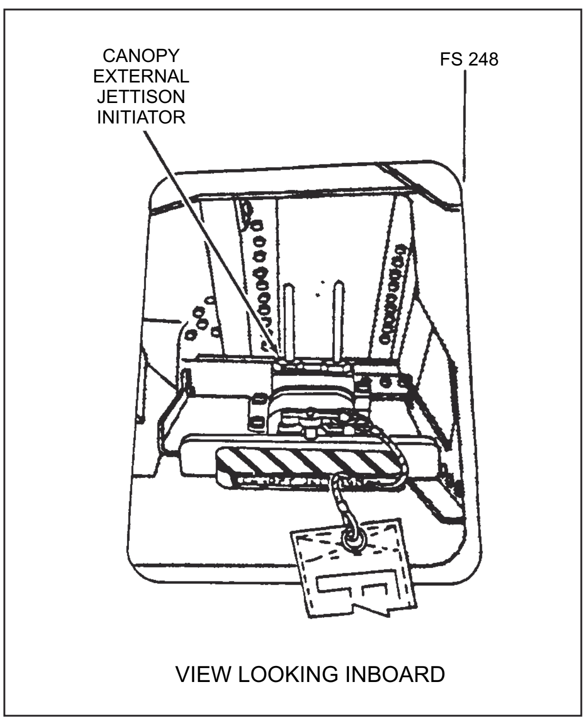


Figure 3-6.—External canopy jettison initiator.

Canopy Jettison Gas Generator

The canopy jettison gas generator (fig. 3-7) is attached to the lower end of the canopy actuator. The canopy jettison gas generator provides high-pressure gas to the canopy actuator to jettison the canopy from the aircraft.

Inert Connectors and Manifolds

Inert connectors and manifolds (fig. 3-5) throughout SMDC lines allow the interconnection of SMDC lines.

Explosive Manifolds

Explosive manifolds within SMDC line routing incorporate an internal explosive crossover that permits SMDC to fire both output SMDC lines. The manifolds also provide structural support for mounting the SMDC lines to the aircraft structure.

One-Way Explosive Transfers

One-way explosive transfers (fig. 3-5), within SMDC line routing, provide unrestricted explosive transfer in one direction only. If an explosive signal is introduced in the opposite direction, it is blocked.

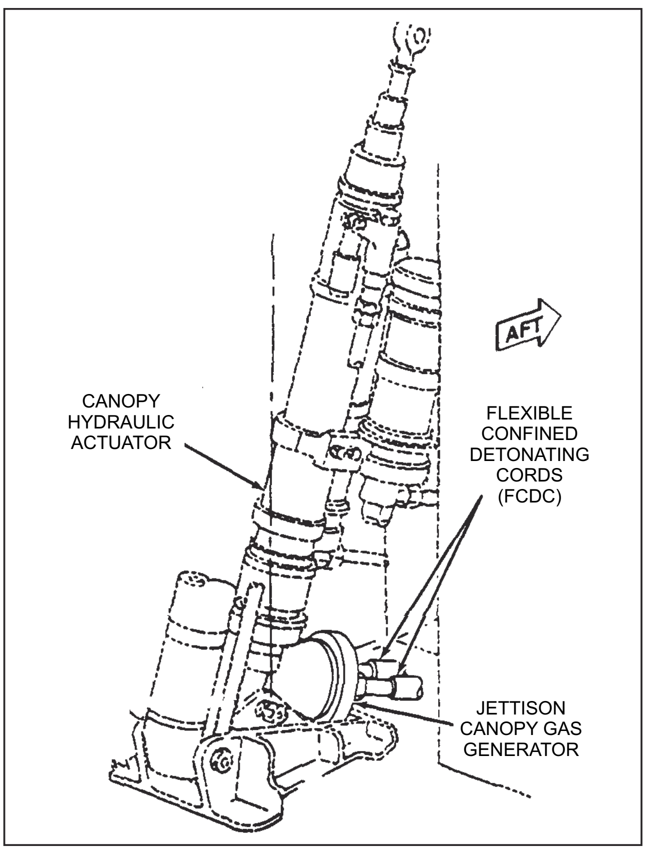


Figure 3-7.—Canopy jettison gas generator.

OPERATION

Pulling the pilot or NFO ejection control handle initiates ejection. When the seat firing handle is pulled, a sear is pulled from dual redundant cartridges, sending a gas signal through the seat disconnect to the gas SMDC initiators mounted on the initiator manifold. This sends an explosive signal through SMDC lines to safe-and-arm firing pins, canopy-separation charge (XSMDC), and canopy jettison gas generator. XSMDC lines, routed through the latch hooks, break the canopy latch frangible bolts. This allows the hooks to rotate upward, releasing the canopy.

The canopy jettison gas generator produces high-pressure gas that forces the canopy actuator shaft upward, ballistically jettisoning the canopy. As the canopy leaves the aircraft, the lanyard becomes taut and removes the sear. This fires an explosive charge within the safe-and-arm seat ejection module. This signal is routed to the ejection seat via the sequencing system SMDC lines to fire the SMDC to gas initiators. The SMDC to gas initiators send a gas signal through the pyrotechnic quick-disconnect, ejecting the crew-member by firing the primary cartridge.

During ground emergency conditions, the canopy may be jettisoned clear of the cockpit by actuating the external canopy jettison initiator handle at either side of the aircraft. The pilot or NFO also may jettison it without initiating ejection with the internal canopy jettison handle.

The explosive signal provided by the canopy jettison initiator is blocked from entering the SMDC lines of the seat ejection system by the one-way explosive transfers. Inert connectors joining the SMDC lines transfer the explosive stimuli through the bulkheads, straight runs, tee connections, and 90° bends. The canopy lock separates SMDC explosive manifolds within SMDC lines, which allows output SMDC lines to be initiated from one SMDC input. This assures system redundancy by providing dual-line initiation for the canopy-separation charge.

Q3-19. What types of pyrotechnic cords are used in the F-14 escape system?

Q3-20. What component enables the aircrewman to jettison the canopy during emergency conditions without initiating seat ejection?

Q3-21. What provides high-pressure gas to the canopy actuator to jettison the canopy?

Q3-22. What component provides interconnection of SMDC lines?

Q3-23. Explosive manifolds provide support for mounting the __ lines to the aircraft structure.

Q3-24. What component prevents explosive transfer in one direction only?

Q3-25. The external canopy jettison handles are used for what purpose?

FRANGIBLE ESCAPE CANOPY SYSTEMS

LEARNING OBJECTIVE: Describe the frangible escape system and its components.

The S-3 aircraft frangible escape system (fig. 3-8) provides a means of escape from the aircraft for crewmembers after ditching or after a wheels-up landing by initiation of explosive charges to blow out windows and hatches. The emergency egress system uses SMDC instead of hot gas, as well as explosive charges instead of actuators found in hot gas systems. The S-3 emergency egress system is less susceptible to inadvertent actuation than hot gas systems, and more convenient and safer for maintenance personnel.

This section will describe the components and operation of the frangible escape canopy system.

COMPONENT DESCRIPTION

The emergency egress system consists of two window/hatch external jettison handle/initiators, three window/hatch internal jettison handles/initiators, window and hatch explosive charges, fillet-severance and fillet-support severance explosive-shaped charges, SMDC, FCDC, and SMDC one-way transfers.

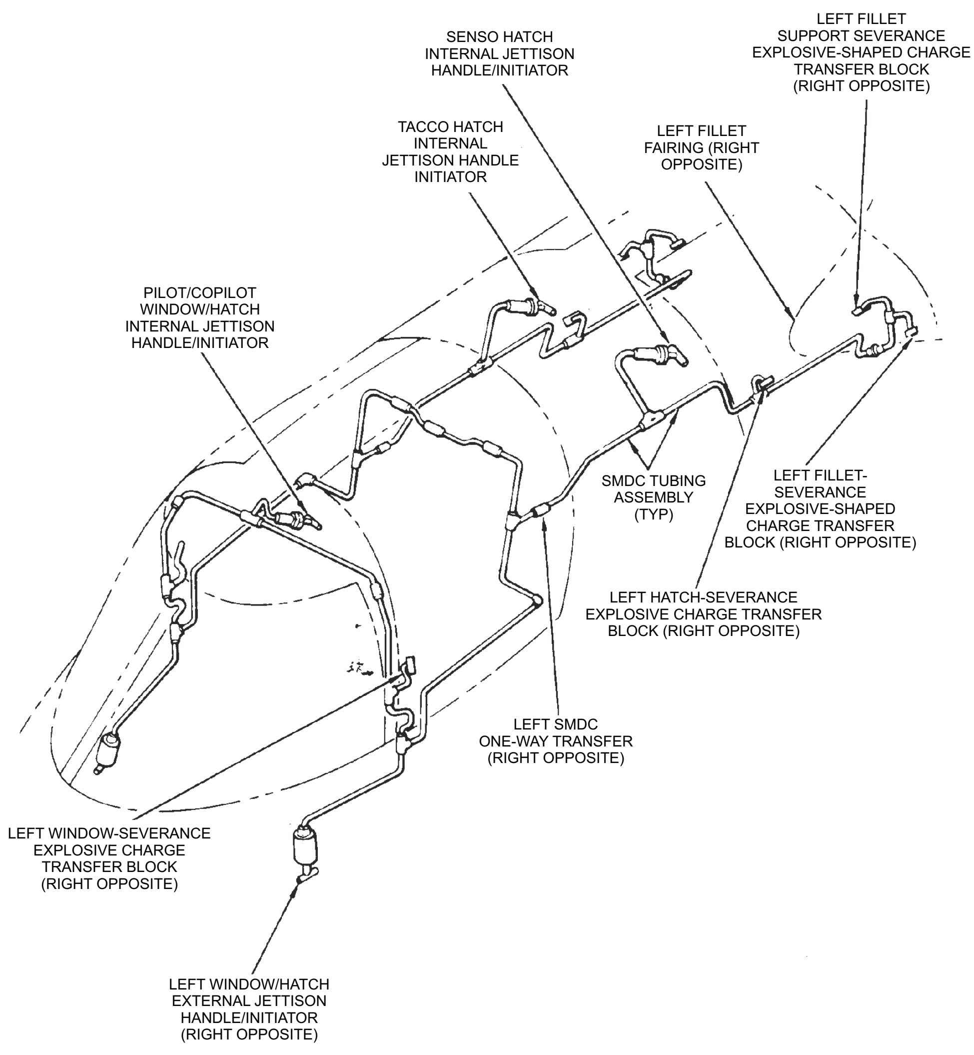


Figure 3-8.—Emergency egress system components and plumbing.

Window/Hatch External Jettison Handle/Initiator

Two external jettison initiators (fig. 3-9) are installed inside access doors on each exterior side of the aircraft just below and forward of the windshield aft posts. The external jettison initiator is a mechanically fired device, with the firing pin relaxed (not precocked) before handle actuation. The sear mechanism is a conventional ball-and-node type, which disengages completely after 3/4 inch of travel. During travel, the firing pin withdraws, but the handle does not disengage. The primer fires into a lead charge, which fires the output charge. The external jettison initiators have no safety pins, but use a 10-foot lanyard to protect against inadvertent initiation. Any partial withdrawal of the handle from the external jettison initiator is cause for rejection and replacement. Either external initiator will cause all windows, hatches, fillets, and fillet supports to blow away from the aircraft.

Window/Hatch Internal Jettison Handle/Initiator

Three internal jettison initiators (fig. 3-10) are located in the crew compartment: one at the eyebrow panel and one each at the tactical coordinator (TACCO) and sensor operator (SENSO) instrument panels. The internal jettison initiators are the squeeze-to-pull type, which have a quick-release safety pin in the squeeze segment of the operation for safetying. The pilot/copilot handle will blow all windows and hatches, whereas the TACCO and SENSO handles will blow only the hatch above the crewmember. The basic internal jettison initiators are similar to the external jettison initiators except for the handle and the absence of the lanyard feature.

Window-Severance Explosive Charge

An explosive charge is attached to the inside periphery of the pilot and copilot windows. An SMDC or FCDC connects to a transfer block at the lower front corner of the explosive charge. The window explosive charge is actuated by the pilot/copilot internal jettison initiator or by either external jettison initiator through the SMDC and FCDC segments. The explosive charge acts as the cutting device for the window glass.

Hatch-Severance Explosive Charge

The hatch explosive charge is similar to the window explosive charge. The explosive charges of the

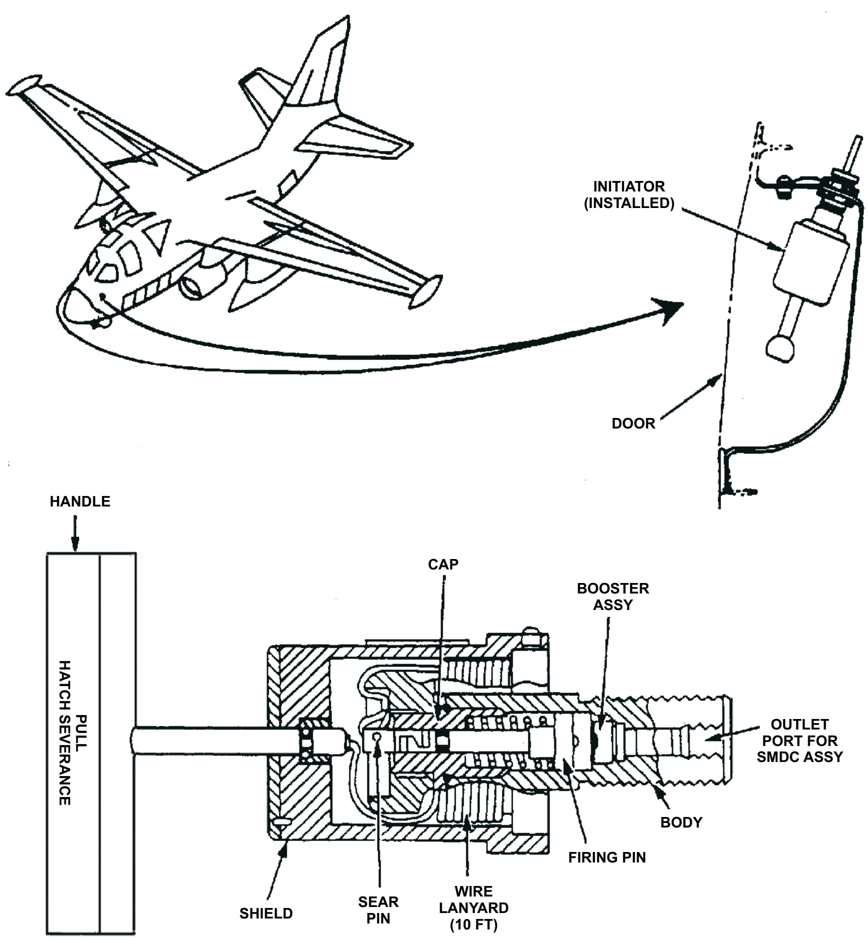


Figure 3-9.—External canopy and hatch jettison initiator.

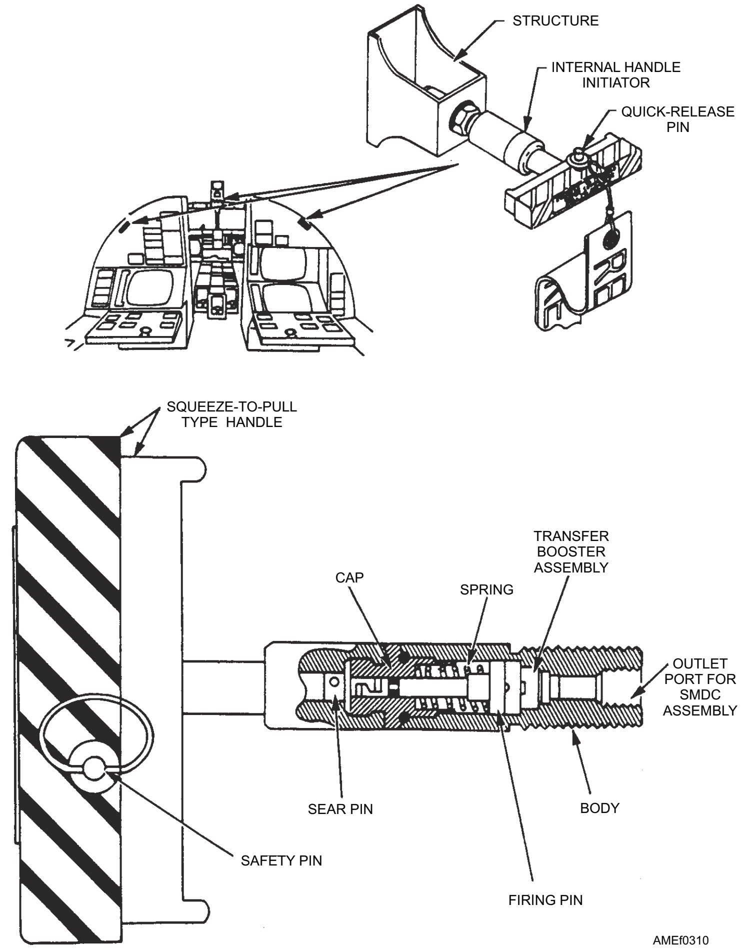


Figure 3-10.—Internal canopy and hatch jettison initiator.

hatches can be actuated by the external jettison initiators or by the pilot/copilot internal jettison initiator.

The TACCO or SENSO hatch explosive charges can be actuated individually by the respective TACCO or SENSO handle/initiator.

Fillet-Severance Explosive-Shaped Charge

Each right and left upper wing-to-fuselage fillet has an explosive-shaped charge attached near the outer and rear fillet attachments (fig. 3-11). The explosive-shaped charge cuts the attached fillet from the aircraft to allow complete egress of the respective hatch. A fillet support is cut by a second explosive-shaped charge attached at the bottom.

The fillet-support severance explosive-shaped charge is attached at the bottom of the internal fillet support to cut the support, allowing the fillet to separate from the aircraft during the emergency egress system operation.

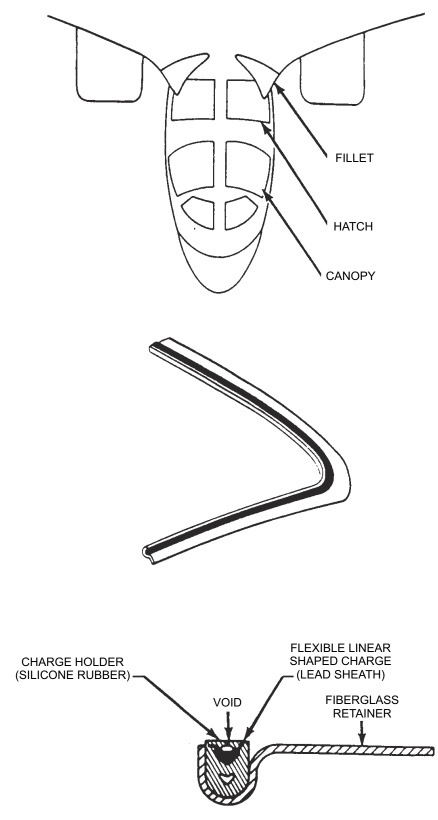


Figure 3-11.—Fillet FLSC assembly.

Shielded Mild-Detonating Cord and Flexible Confined Detonating Cord

The SMDC and FCDC segments act as the plumbing for the emergency egress system. The SMDC and FCDC connect all external and internal jettison initiators; all connectors, tees, and manifolds or one-way transfers; all explosive charges; and all explosive-shaped charges. When initiated, the extremely high velocity and pressure of the cord is focused onto the end of the next adjacent SMDC segment, which acts as acceptor charge.

Shielded Mild-Detonating Cord One-Way Transfer

Two SMDC one-way transfers are located on the pilot and copilot bulkhead. The SMDC one-way transfer acts as a check valve or one-way detonating transfer device. The SMDC one-way transfer is a self-contained unit housing a sealed receptacle for dual-shaped charges. Any detonating entering the in ports will transfer to the out port. Any detonation originating from the aft port (TACCO or SENSO) segment of the SMDC one-way transfer will not transfer forward. This would occur when either the TACCO or SENSO elects to cut the respective hatch; the remaining two windows and the opposite hatch would not be affected.

OPERATION

The emergency egress system is initiated from any one of the five positions: two on the outside of the flight station, and three located in the crew compartment at the eyebrow panel and at the TACCO and SENSO instrument panels. All windows and hatches are cut and blown outward by the actuation of either external jettison initiator and by the pilot/copilot internal jettison initiator. The TACCO and SENSO internal jettison initiators cut only the respective panel next to the crewmember. The emergency egress system is used primarily for ground and water rescues. The handle/initiators have a trigger action. Once the emergency egress system is actuated, the emergency egress system will respond to completion without further action by crewmembers. The functional sequence is from the handle/initiator (anyone), to the SMDC, to the explosive charge, which is the actual cutting tool for the window or hatch glass. If either or both the TACCO and SENSO hatches are to be blown, the respective fillet and fillet support will be cut to allow complete egress of the hatch. When either the TACCO or SENSO crewmember actuates the handle/initiators, the opposite hatch and the two flight stations windows will not be cut, since the SMDC one-way transfer (check valve) restricts transfer of pyrotechnic energy flow in one direction.

The emergency egress system is entirely self-sufficient and completely independent. The emergency egress system does not depend on any other aircraft system, nor does the emergency egress system air, assist, or sequence with another system. The SMDC is considered to be more reliable and much faster than a comparable hot gas system. The emergency egress system is safer from the standpoint of inadvertent actuation due to the extremely high initiating velocities and pressures. The high operating velocity is much too fast to permit emergency egress system initiation by ordinary sawing, filing, drilling, or hammering. With quick-release safety pins properly installed, the emergency egress system is virtually inert.

Q3-26. What is the purpose of the frangible escape system?

Q3-27. The S-3 emergency egress system is more susceptible to inadvertent actuation than hot gas systems. True or false?

Q3-28. Instead of safety pins, the external jettison initiators use what type of component to protect against inadvertent initiation?

Q3-29. How many internal jettison initiators are located in the crew compartment?

Q3-30. The __ and __ connect all external and internal jettison initiators.

Q3-31. What component restricts transfer of pyrotechnic flow in one direction?

Q3-32. The emergency egress system is virtually inert when what component is properly installed?

CHAPTER 3

ANSWERS TO REVIEW QUESTIONS

A3-1. Pneumatic pressure from externally serviced reservoirs

A3-2. Reference mark

A3-3. Acrylic

A3-4. Hydraulically

A3-5. It regulates the speed of the canopy-lock pneumatic actuator during locking and unlocking of the canopy.

A3-6. 225 psi

A3-7. (a) 225 cubic inch, (b) 3,000 psi

A3-8. Reservoir relief valve

A3-9. Downstream of the auxiliary pneumatic reservoir

A3-10. Three-port pressure operated

A3-11. Five

A3-12. Hold

A3-13. 10 seconds

A3-14. Auxiliary opening

A3-15. To provide an airtight seal between the canopy assembly and the aircraft structure to maintain cockpit pressurization

A3-16. 25 ± 5 psi

A3-17. Service air heat exchanger

A3-18. Check valve

A3-19. XSMDC, FCDC, and SMDC

A3-20. Internal canopy initiators

A3-21. Canopy jettison gas generator

A3-22. Inert connectors and manifolds

A3-23. SMDC

A3-24. One-way explosive transfers

A3-25. Ground emergency conditions

A3-26. Provides a means of escape from the aircraft for crewmembers after ditching or after a wheels-up landing by initiation of explosive charges to blow out windows and hatches

A3-27. False

A3-28. 10-foot lanyard

A3-29. Three

A3-30. SMDC, FCDC

A3-31. SMDC one-way transfer valve

A3-32. Safety pins

CHAPTER 4

EXPLOSIVES HANDLING PERSONNEL QUALIFICATION AND CERTIFICATION PROGRAM

Improper handling, loading, processing, disposal, demilitarization or testing of explosive devices has resulted in many mishaps with injuries, loss of life, damage amounting to millions of dollars, and reduced operational effectiveness. The purpose of this program is to eliminate these mishaps through proper qualification and certification of personnel.

ORDNANCE CERTIFICATION OVERVIEW

NOTE: The Explosives Handling Personnel Qualification and Certification (Qual/Cert) Program is governed by the OPNAVINST 8020 instruction, which directs type commanders (TYCOMs) to issue a Qual/Cert instruction for their cognizant commands. This chapter was referenced using the OPNAVINST 8020.14 joint instruction for COMNAVAIRPAC, COMNAVAIRLANT, COMNAVRESFOR, and CNATRA.

LEARNING OBJECTIVE: Identify the purpose and terminology of the Explosives Handling Personnel Qualification and Certification Program, OPNAVINST 8020.14.

The intent of the Qualification/Certification (Qual/Cert) Program is to ensure that before an individual performs any task involving explosives/explosive devices, they are qualified and formally certified by the command to which they are assigned. Each person must satisfactorily demonstrate the qualifications to properly and safely perform all required functions and tasks involving the explosives/explosive device. Accident-free explosive operations require command attention that includes certified workers, direct supervision, use of standard operating procedures (SOP), technical manuals and checklists for the task at hand, and a total quality assurance (QA) process where required. When properly managed and used, this program assures qualification of all personnel who work with explosives/explosive devices. This section will describe the background of the ordnance program and definitions of program terminology.

BACKGROUND

The Explosives Handling Personnel Qualification and Certification Program was established by the Chief of Naval Operations as a result of the catastrophic MK-24 parachute flare accident on the USS *ORISKANY* in 1966 that led to significant loss of life and major ship damage. The flag board of inquiry concluded the accident was attributed to a lack of training, direct supervision, and a method to determine personnel qualifications prior to being authorized to handle explosives. Qual/Cert, with proper oversight and management, can prevent similar accidents.

Although Qual/Cert has been in effect for over 30 years, improper handling, loading, processing, or testing of explosive devices continues to result in death, injury, and extensive high-dollar damage to equipment. Research has shown personnel error due to inadequate training, lack of adequate supervision, lack of or inadequate SOP, or just plain failure to follow the governing technical directives causes the majority of explosive mishaps. Qual/Cert is intended to be the cornerstone for a ZERO DEFECT SAFETY PROGRAM.

DEFINITIONS

NOTE: All explosives, ammunition, weapons, and devices using conventional ex- plosives, pyrotechnics, or incendiary material for their operation are included in the general term *explosive devices*.

Before you read about ordnance certification, you need to know the terminology that will be used in this discussion. The following definitions will help when working with the Qual/Cert program and completing the ordnance certification format (fig. 4-1).

Storage/Stowage. Physical act of stowing explosives/explosive devices in designated and approved magazines and ready service lockers. Demonstrated knowledge of afloat/ashore storage/stowage requirements per applicable instructions/directives.

ORDNANCE CERTIFICATION FORMAT (REVISED 01-00)	
CERTIFICATION LEVELS	**WORK TASK CODES**
TM - TEAM MEMBER I - INDIVIDUAL TL - TEAM LEADER QA - QUALITY ASSURANCE SO - SAFETY OBSERVER	1. STOWAGE /STORAGE 2. HANDLING 3. ASSEMBLY/DISSAMBLY 4. LOAD/DOWNLOAD 5. ARM/DE-ARM 6. INSTALL/REMOVE

EXPLOSIVE/ EXPLOSIVE DEVICE	CERT LEVEL /WORK TASK	INDIVIDUAL	BOARD MEMBER	BOARD CHAIRMAN	VALIDATION DATE
Aircraft Egress Systems	TL 1 2 3 6				
Cartridges	QA 1 2 3 6				

CERTIFICATIONS ABOVE HAVE BEEN REVIEWED AND RECERTIFIED PER SIGNATURES AND DATES INDICATED BELOW, EFFECTIVE FOR 1 YEAR.
NOTE: ITEMS NOT REQUIRED FOR RECERTIFICATION SHALL BE LINED OUT, INITIALED AND DATED BY THE BOARD CHAIRMAN.

INDIVIDUAL BEING RECERTIFIED SIGNATURE	BOARD MEMBER SIGNATURE	BOARD CHAIRMAN SIGNATURE	

NAME: SAILOR, JOHN COMMAND: USS UNDERWAY (CVN-99)	RANK/RATE: AME1

AMEf0401

Figure 4-1.—Ordnance certification format.

Handling. Physical act of transporting or moving explosives/explosive devices afloat or ashore, with powered equipment, with non-powered equipment, or manually.

Assembly/Disassembly. Physical act of mating/demating component to/from an all up round (AUR) configuration. This work task code is used when assembly/disassembly is authorized in applicable weapons assembly manuals (WAM).

Load/Download. Physical act of mating an AUR with the bomb rack/launcher from which delivery/initiation is authorized. Includes all operations incidental to aircraft loading/downloading included in those portions of the NAVAIR conventional weapons loading checklists, shipboard loading/downloading of close-in weapons system (CIWS), and NATO Sea Sparrow systems as listed in applicable maintenance requirement cards (MRC). Includes functions such as the installation of mechanical bomb fuses, arming wires, electrical/mechanical connections, installing bands on LUU-2 flares, MK-58 marine location markers (MLMs), and rack/launcher cartridges.

Arm/De-Arm. Applies to those procedures contained in the arm/de-arm section of the applicable NAVAIR loading manuals/checklist and NAVSEA MRCs, which place an explosives/explosive device or system in an armed or safe condition. This does not include the installation of cartridge-activated device/propellant-actuated device (CAD/PAD) in seats to place them in an armed condition. Arm/de-arm as it pertains to aircraft egress systems is covered in install/remove.

Install/Remove. Physical act of installing/removing all items listed in the family group aircraft egress systems and aircraft cable cutters, aircraft fire extinguisher cartridges and non-aircraft support cartridges/cartridge actuated devices.

Testing. Physical act of conducting a test on components. Built-in-test (BIT), programming, reprogramming, and presetting are included in this work task code.

Explosive Device. All combat and non-combat tools, instruments, implements, or mechanisms that use explosives for operation.

Explosive Driver. A driver of a motorized vehicle who has a valid USN license stamped "Explosive Driver." Possesses a valid explosive driver's physical certificate and is trained to operate and inspect for safety and security of both the motor vehicle and the explosives/explosive devices being transported.

Explosive or Explosives. Any chemical compound or mechanical mixture which, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressure in the surrounding medium. This term applies to all materials that either detonate or deflagrate.

CO/OIC (commanding officer/officer-in-charge) Signature. Indicates the signature of the person filling this billet. This billet will not be delegated.

Individual Signature. Signature of person being certified. Signing acknowledges certification level and work task code for the explosives/explosive device/family. Therefore, a signature is required for each line entry. Collective signatures are not authorized.

Certification Board Member Signature. Signature of the certification board member who either actually observed or verified that another board member observed the individual being certified performing the task under consideration. A signature is required for each line entry. Collective signatures are not authorized.

Board Chairman Signature. Signature of the CO/OIC, cognizant department head, ordnance handling officer (0110), carrier air group (CAG) gunner or Naval Airborne Weapons Maintenance Unit One (NAWMU-1) executive officer (designator 636X) designated to act as board chairman. Signature and date may be collective, if desired.

Validation date. Date certification is effective. Date may be collective. Date will be in day/month/year format.

Recertification. After review of on-the-job training (OJT), lectures, other documented training, and physical exams, recertification may be accomplished using the space provided. Once the individual, the board member, and the board chairman sign and date the form, recertification shall be valid for 1 year (365 days). Line items not requiring recertification shall be deleted by making a single line through the entire line entry. The board chairman shall initial and date the deletion on the right hand border.

Corrections. Corrections shall be made with a single line through the entire line entry. The board chairman shall initial the deletion line in the right hand border of each line deleted. At this point, initiate an entire new corrected line.

Decertification. The Qual/Cert form requires a diagonal line made in red ink, signed and dated by the individual and the board chairman, for revocation of certification for cause.

Delays. Newly assigned personnel should be certified within three months (90 days) of the demonstrated proficiency dates.

Family Groups. Family groups are explosives/explosive devices with similar characteristics.

Certification Levels. Only list the highest certification level applicable; i.e., QA entry automatically covers team leader (TL), individual (I), team member (TM); TL entry covers I, TM; I entry covers TM.

Descriptions of the different certification levels are given in table 4-1.

CERTIFICATION PROGRAM RESPONSIBILITY AND REQUIREMENTS

LEARNING OBJECTIVE: Identify the responsibility and requirements of the Explosives Handling Personnel Qualification and Certification Program, OPNAVINST 8020.14.

The Explosives Handling Personnel Qualification and Certification Program sets guidelines for weapons certification. **This program is independent from all other maintenance programs**. The Explosives Handling Personnel Qualification and Certification

Table 4-1.—Certification Levels

CERTIFICATION LEVELS	QUALIFICATION STANDARDS
TEAM MEMBER (TM)	1. BASIC QUALIFICATION. Aware of basic safety precautions relative to the task and explosives/explosive devices concerned, has received formal and/or on-the-job training and has been recommended by immediate supervisor. 2. Perform task(s) only under direct supervision of a team leader.
INDIVIDUAL (I)	1. Same as TM above. 2. Has sufficient knowledge and has demonstrated the proficiency to be entrusted with performing the work task alone in safe and reliable operations. 3. Capable of interpreting the requirements of applicable checklist, assembly/operating manuals, and SOP. 4. This certification level can be used in conjunction with explosives/explosive devices that normally require a team effort to load/download. This is to allow an individual to perform tasks contained in the loading procedure section of a checklist without the team leader at the immediate scene (i.e. issue and receipt, fusing, arming wires, installing/removing cartridges in bomb racks/stores). Applies to functions involving cartridge-actuated devices in aircrew escape propulsion system (AEPS) when a supervised crew concept is not appropriate. 5. QA/safety observer (SO) is still required.
TEAM LEADER (TL)	1. Same as I above. 2. Has sufficient knowledge and has demonstrated the proficiency to direct others in performing the work task safely and reliably.
QUALITY ASSURANCE (QA)	1. Same as TL. 2. Must have detailed knowledge of applicable explosives/explosive devices. 3. Must be able to determine that the necessary work task procedures have been completed using applicable directives. 4. Must not be confused with quality assurance representative per the OPNAV 4790.2 series and OPNAV 8600.2.
Note: ONLY TM, I, TL, and QA are interrelated, SO stands alone. Progressive certification from one level to the next is not mandatory.	
SAFETY OBSERVER (SO)	1. Must have sufficient knowledge and experience of applicable safety procedures, the functioning of safety devices, and working knowledge of work task procedures to determine subsequent reaction when safety procedures or devices are not properly used. 2. Not restricted to the most senior within a unit. A junior person who possesses the foregoing standards and demonstrates maturity may be certified.

Program is applicable to **all personnel** (both military and civilian, including contractors) in naval establishments where duties require evolutions or tasks involving explosive devices.

COs or OICs initiate, monitor, and maintain the Explosives Handling Personnel Qualification and Certification Program.

Personnel within the program should be sent to formal schools, if possible, and personnel qualification standards are required, where applicable. However, school attendance and personnel qualification standards do not necessarily qualify an individual for certification.

Certification must be documented by using the format shown in figure 4-1. The board chairman maintains the original. A copy is placed in the individual's training records. When the individual is transferred, the original (maintained by the board chairman) is placed on the left side of the individual's service record.

Certification of military personnel is transferable at the discretion of the receiving command. Receiving commands should validate the certification by placing the board chairman's signature in the recertification block. Certification, unless revoked, is valid for a period of 1 year.

This section will discuss requirements for individual and team certification, initial certification, and revocation of certification.

INDIVIDUAL CERTIFICATION

If a person's duties (including explosive ordnance disposal [EOD] personnel involved in non-EOD duties) require them to individually inspect (including the duty of safety observer), prepare, adjust, arm, or de-arm explosive devices, they must be qualified and certified for such tasks. Personnel who conduct magazine inspections, maintenance on aircraft safety and survival equipment, or perform any other function that involves explosive devices must be included in this program. The supervisor of explosive operations and members of the command-appointed certification board (except the chairman) must be individually certified for the evolution that they may supervise or observe.

TEAM CERTIFICATION

A person must be team certified and qualified or individually qualified to perform any of the following duties as a team member: packing, unpacking, assembling/disassembling, testing, fusing, loading/downloading, or arming/de-arming. When team operations are involved, the team leader must be designated and must be certified and qualified. Any change in team personnel must be kept to a minimum. Shipboard gun, missile crews, and air wing integrated arm/de-arm crews are considered teams for the purpose of qualification and certification. Requalification or recertification of a team after any personnel change is at the discretion of the commanding officer. At times, contractor personnel perform functions within the scope of the Explosives Handling Personnel Qualification and Certification Program at naval activities. The contractor must provide the CO or OIC with the documentation to prove that personnel are qualified and certified before performing any duties that come under the program.

INITIAL BOARD MEMBER CERTIFICATION

One major problem of the initial certification of personnel is to ensure that persons who perform qualification evaluations are themselves qualified. Occasionally, it is necessary to initially certify personnel to perform a particular explosive-related job if no certification board is currently established. Commanders should ensure the intent of this program when they select certification board qualifying observers.

The department head (or equivalent supervisor) reviews personnel for initial certification by screening school records, previous certification, demonstrated ability, and by conducting a personal interview. Then they make a recommendation to the CO or OIC as to whether a person should or should not be certified. Certification is made at the discretion of the CO or OIC. When sufficient personnel have been qualified, a minimum qualification, a certification board is established.

EXCEPTIONS

The following personnel are exempt from the provision of OPNAVINST 8020.14, but are not exempt from ensuring the required standards of explosive safety are in place and followed to the letter:

- Qual/Cert board chairman, provided the chairman does not handle explosives.
- Board advisors.
- Supervisors are not required to be qualified as power-operated handling equipment operators for those evolutions requiring the use of this

equipment, but must be thoroughly familiar with equipment operating characteristics and precautions.

- Operators of weapons elevators and conveyors who are qualified per NAVSHIPSTECHMAN S9086-ZN-STM-000.
- Ship's lookouts, underway watch standers, connected replenishments (CONREP) station operators, and shore station runway wheels watches required to handle, prepare, and launch marine markers or fire signaling devices.
- Working party personnel used to supplement qualified and certified personnel for the purpose of ammunition on-loads, off-loads, or replenishments. The OIC of the evolution shall provide all working party personnel with a thorough safety brief before and as necessary during the operation. Constant supervision from a qualified and certified team leader is mandatory.
- Personnel whose sole responsibility is to conduct tests or inspections of magazine sprinkler systems.
- Aircrew personnel during the performance of in-flight duties to include use of survival equipment. (Note: Ground handling of ordnance by aircrew personnel shall require certification per OPNAVINST 8020.14.)
- Personnel required to bear arms in the course of their duties, including security alert teams, back-up alert forces, reaction forces, or other security personnel who are trained and qualified through the current approved small arms training program.

DOCUMENTATION

Training record documentation is by specific explosive device and task. This training will be documented by using an ordnance certification training format (fig. 4-2). This documentation must support the level of certification listed on the individual's or team's certification form and must reflect all the individual's or team's training.

NOTE: Supplemental instruction of the Explosives Handling Personnel Qualification and Certification Program by subordinate commands is neither required nor desired.

OJT DOCUMENTATION TRANSFERS

Transfer of certification for military or civilian from one command to another is prohibited. However, the receiving command may use the OJT documentation from the transferring command as justification for immediate certification provided all the following conditions are met in their entirety:

- The individual's certification from the previous command abides by OPNAVINST 8020.14.
- The OJT documentation periodicity requirement is met for each explosive/explosive device certified (within the past 1 year).
- On previous command OJT forms, verification of assignment as a board member is not a requirement.
- Current command generates a new Qual/Cert form.
- The use of OJT documentation is limited to only those explosives/explosives devices, certification levels, and work task codes for which the individual was certified from the command.

If the individual was not certified for a particular item within a family group from the previous command, the complete qualification process for that particular item must be followed.

DECERTIFICATION

The CO/OIC is responsible for decertification of individuals. Decertification is mandatory if an explosive mishap is caused by negligence, carelessness, or procedural and/or safety infractions. Decertification allows for retraining and recertification and requires a new Qual/Cert form.

The procedures for decertification are:

- The Qual/Cert form requires a diagonal line made in red ink, signed and dated by the member being decertified and the board chairman.
- After retraining, the member may be submitted to the Qual/Cert board for certification as appropriate.
- If the member is considered not retrainable, assign the individual other tasks not involving explosive/explosive devices. Revocation of certification is then required.

ORDNANCE CERTIFICATION TRAINING FORMAT (NEW 01-00)	
CERTIFICATION LEVELS	WORK TASK CODES
TM - TEAM MEMBER I - INDIVIDUAL TL - TEAM LEADER QA - QUALITY ASSURANCE SO - SAFETY OBSERVER	1. STOWAGE /STORAGE 2. HANDLING 3. ASSEMBLY/DISSAMBLY 4. LOAD/DOWNLOAD 5. ARM/DE-ARM 6. INSTALL/REMOVE

Explosive/ Explosive Device	Cert Level	Work Task	Instructor/ Observer	Date	Remarks/ Lecture/ Inert
MF56/MK 109 MOD 0	TL	1 2 3 6	AME1 Jones	10 May 99	
	TL	1 2 3 6	AME1 Jones	22 Jun 99	
	QA/SO/IT	1 2 3 6	AME1 Jones	10 Jul 99	
			AME1 Jones	15 Jul 99	Lecture
MC50	TL	1 2 3 6	AME1 Jones	11 May 99	
	TL	1 2 3 6	AME1 Jones	22 Jun 99	
	QA/SO/IT	1 2 3 6	AME1 Jones	10 Jul 99	
			AME1 Jones	13 Jul 99	Lecture
MD68/MK 100 MOD 0	TL	1 2 3 6	AME1 Jones	10 May 99	
	TL	1 2 3 6	AME1 Jones	17 May 99	
			AME1 Jones	07 Jul 99	Lecture
	QA/SO	1 2 3 6	AME1 Jones	30 Jul 99	
MF72/JAU-27/A	TL	1 2 3 6	AME1 Jones	21 Jun 99	
	TL	1 2 3 6	AME1 Jones	28 Jun 99	
	QA/SO	1 2 3 6	AME1 Jones	30 Jul 99	
			AME1 Jones	01 Aug 99	Lecture

NAME: SAILOR, JOHN COMMAND: USS UNDERWAY (CVN-99)	RANK/RATE: AME1

AMEf0402

Figure 4-2.—Ordnance certification training format.

REVOCATION OF CERTIFICATION

The CO or OIC is responsible for revoking certification whenever such action is necessary in the interest of safety.

Revocation of certification is mandatory if an explosive mishap is caused by gross negligence, reckless operation of equipment used to handle explosive/explosive devices, or flagrant disregard of procedural and/or safety precautions.

Revocation of certification for cause of military personnel requires an entry in the appropriate portion of the service record, stating a specific reason for revocation.

For DoD civilian personnel, prepare a letter rescinding the previously issued certification letter/form and enter it in the civilian personnel jacket. Revoke the individual's certification letter/form.

For contractor civilian personnel, ensure actions taken are reported to the host activity and TYCOM.

CERTIFICATION BOARD

LEARNING OBJECTIVE: Identify the membership and responsibilities of the Explosives Handling Personnel Qualification and Certification Board.

The CO/OIC shall be the board chairman. At the discretion of the CO/OIC, the duties of the board chairman may be delegated in writing to the cognizant head of department assigned. The CO/OIC will assume the responsibility of board chairman for activities that do not have an active duty officer to fill this position.

BOARD CHAIRMAN RESPONSIBILITIES

The board chairman shall:

- Oversee the command Qual/Cert program and ensure that the provisions of OPNAVINST 8020.14 are carried out.
- Be aware of all explosive operations at the activity and ensure that involved personnel are in full compliance with OPNAVINST 8020.14.
- Ensure that sufficient quantities of qualified and certified board members are maintained on board at all times.
- Conduct a formal Qual/Cert board utilizing an oral and/or written examination.
- Maintain a board chairman's notebook with the following contents:
  - o A current copy of OPNAV 8020.14
  - o A current copy of the command's Qual/Cert training plan
  - o Board member designations until the last Qual/Cert signed by the transferred board member is no longer valid
  - o For a minimum of 1 year, all formal Qual/Cert board results to include date, board members present, personnel certified, and the individual's highest certification level awarded
  - o A copy of the approval for all waivers and initial certifications
  - o The original of all Qual/Cert forms, both current and past, awarded by the command for personnel presently assigned

BOARD MEMBERSHIP

Board members shall be:

- An E-6 or above and/or civilian supervisory equivalent.
- Designated by name, in writing, by the CO/OIC. Designation may be promulgated by individual letter or notice, provided the designation correspondent signature is not delegated below the CO/OIC.
- Qualified and certified as a QA and/or SO.
- Certified in the same explosive/explosive device and work task codes for which they are qualifying and certifying.

BOARD MEMBER RESPONSIBILITIES

The responsibilities of the certification board are as follows:

- Observe and evaluate the skill and proficiency of personnel being considered for certification/recertification.
- Ensure qualification-training requirements have been met prior to recommendation for certification.
- Inform the division officer or board chairman when personnel who are being considered for certification require additional training or experience before being certified.
- During the Qual/Cert board, review for accuracy all pertinent training documentation of personnel being nominated for certification and make recommendations to the board chairman.
- Monitor and submit changes, via the chain of command, to the command's training plan.

Q4-1. State the intent of the Explosives Handling Qualification and Certification Program.

Q4-2. For what period of time is recertification valid?

Q4-3. State what individuals are required to become ordnance certified.

Q4-4. State the responsibility of the department head (or equivalent supervisor) in regards to ordnance certification.

Q4-5. State the reason(s) an individual would receive a personnel record entry concerning an ordnance incident.

CHAPTER 4

ANSWERS TO REVIEW QUESTIONS

A4-1. To ensure that before an individual performs any task involving explosives/explosive devices they are qualified and formally certified by the command to which they are assigned.

A4-2. 1 year.

A4-3. Any person whose duties require them to individually inspect, prepare, adjust, arm, or de-arm explosive devices. Personnel who conduct magazine inspections, maintenance on aircraft safety and survival equipment, or perform any other function that involves explosive devices must be included in this program. The supervisor of explosive operations and members of the command-appointed certification board (except the chairman) must be individually certified for the evolution that they may supervise or observe.

A4-4. The department head (or equivalent supervisor) is responsible for initial certification by screening school records, previous certification, demonstrated ability, and for conducting a personal interview.

A4-5. If an individual causes an explosive mishap through gross negligence, reckless operation of equipment used to handle explosive/explosive devices, or flagrant disregard of procedural and/or safety precautions.

CHAPTER 5

UTILITY SYSTEMS

The utility systems of an aircraft provide an additional measure of flight safety, pilot comfort and convenience, and contribute to the overall mission capability of the aircraft. Many aircraft have utility systems that rely on a bleed air system to function.

AUXILIARY BLEED AIR SYSTEMS

LEARNING OBJECTIVE: Describe the auxiliary bleed air system.

An aircraft's auxiliary bleed air system furnishes supply air for air-conditioning and pressurization systems, as well as for electronic cooling, windshield washing, anti-icing, and anti-gravity (g) systems. These bleed air systems also pressurize fuel tanks, hydraulic reservoirs, and radar wave-guides on several types of aircraft.

The air for these systems is tapped off downstream of the air-conditioning turbine before any cooling takes place, or at various points within the air-conditioning system. Bleed air for these systems can range up to 400°F at pressures of up to 125 pounds per square inch (psi). Because each type of aircraft has a somewhat different approach in system design, temperatures, and pressures, the system and components in this manual will be representative of types found throughout the Navy. Under no circumstances should this manual be regarded as the final source of technical data to perform aircraft maintenance. For the most up-to-date information, refer to the maintenance instruction manual (MIM) for the system concerned.

Q5-1. Name four aircraft systems that use auxiliary bleed air.

Q5-2. An auxiliary bleed air system can reach up to what pressure?

BLEED AIR LEAK DETECTION SYSTEM

LEARNING OBJECTIVE: Recognize the operating principles and components for a bleed air leak detection system.

The S-3 aircraft bleed air leak detection system (fig. 5-1) consists of four loops of bleed air leak sensing elements located close to the auxiliary power unit (APU) duct, bleed air ducts, and an engine start port leak detector located near the engine ground start port. Sensing elements are mounted between ducts and the aircraft structure because bleed air temperature is sufficiently high to cause structural damage. Support clamps with quick-release fasteners are used to mount the sensing elements, which are protected by bushings. The bleed air leak detector control is located in the lower section of the left load center. This system is a fire-detection type of system that responds to heat. High temperature causes a chemical reaction in the sensing element, which provides a ground for the warning circuit that turns on an indicator light on the annunciator panel. A test circuit is activated by the BLEED AIR LEAK DETECT switch on the eject panel located on the eyebrow panel.

COMPONENTS

The bleed air leak detection system consists of a bleed air leak detector control, sensing elements, and an engine start port leak detector.

Bleed Air Leak Detector Control

The detector control is located in the lower section of the left load center. The detector control contains two modules with four electrical circuits. Each circuit has a test function and a control function. The test function verifies all sensing element loops, and the control function turns on a warning indicator light on the annunciator panel.

Bleed Air Leak Sensing Elements

The sensing elements are metal tubes with center conductors isolated from the tubes by a solid chemical. The sensing elements are mounted between the bleed air ducts and areas to be protected from very high temperatures that would develop if a duct were punctured or ruptured. The sensing elements are mounted within 2 to 5 inches of the duct.

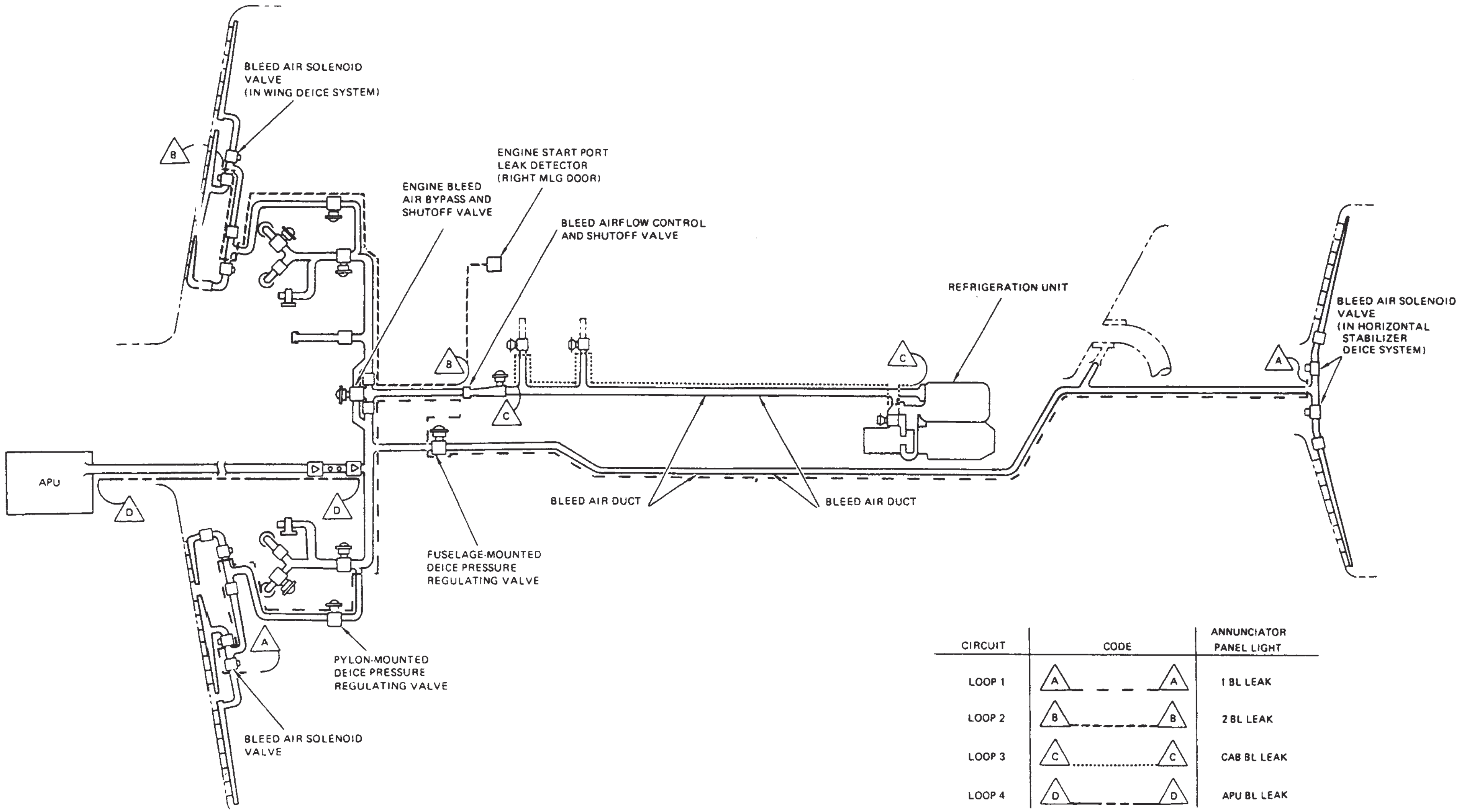


Figure 5-1.—Bleed air leak sensing element loop schematic diagram.

Engine Start Port Leak Detector

The leak detector is mounted inside the right main landing gear door. The leak detector is a heat-sensitive element that completes a ground circuit when subjected to temperatures in excess of 225°F. Its purpose is to detect leakage from the engine ground start port in the event of a check valve failure. The leak detector is wired in parallel with the loop 2 (2 BL LEAK) sensing elements.

OPERATION

The bleed air leak detection system is powered by a single-phase, 400-hertz (Hz), 115-volts alternating current (Vac) power from the essential ac bus. The test circuit uses 28 volts direct current (Vdc) power from the essential bus. When the bleed air leak detect switch on the elect panel is held in the TEST position, 28 Vdc is applied to the test relays. This completes the transformer circuit through the sensing elements to ground. The transformer conducts and applies a signal to a transistor circuit, which closes control relays. A ground circuit is completed through the control relay contacts to turn on the 1 BL LEAK, 2 BL LEAK, CAB BL LEAK, and APU BL LEAK indicator lights on the annunciator panel. When the momentary BLEED AIR LEAK DETECT switch is released to the OFF position, the annunciator panel indicator lights go off. In normal operation, when the temperature of a section or a short segment of the sensing element exceeds 255°F, the chemical in the tube conducts electric current, which completes a transformer circuit to ground similar to the test relay. The indicator light on the annunciator panel will come on to indicate the loop is overheating. This system will function even if there is an open (break) in the loop. During test position, the open element will prevent the indicator light from turning on. The individual loops will function separately or simultaneously if a leak is located in an area common to two loops. This will allow the pilot to take action to minimize damage due to bleed air leakage.

Q5-3. Describe an S-3 aircraft bleed air leak detection system.

Q5-4. During normal operation, describe what happens when the temperature in the sensing element exceeds 225°F.

Q5-5. What are the major components of a bleed air leak detection system?

Q5-6. How many modules make up the bleed air leak detector control?

ANTI-ICING SYSTEMS

LEARNING OBJECTIVE: Recognize the operating principles and components for an anti-icing system.

On days when there is visible moisture in the air, ice can form on aircraft leading edge surfaces at altitudes where freezing temperatures start. Water droplets in the air can be super-cooled to below freezing without actually turning into ice unless they are disturbed in some manner. This unusual occurrence is partly due to the surface tension of water droplet not allowing the droplet to expand and freeze. However, when aircraft surfaces disturb these droplets, they immediately turn to ice on the aircraft surfaces. The ice may have a glazed or rime appearance. Glazed ice is smooth and hard to detect visually. Rime ice is rough and easily noticed.

Frost is formed as a result of water vapor being turned directly into a solid. Frost can form on aircraft surfaces in two ways. First, it can accumulate on aircraft parked in the open and overnight when the temperature drops below freezing and proper humidity conditions exist. Second, it can form on aircraft surfaces, caused by flying at very cold altitudes and descending rapidly into warm, moist air. In this case, frost deposits will result before the structure warms up because of the marked cooling of air adjacent to the cold skin. Ice or frost forming on aircraft creates two basic hazards:

- The resulting malformation of airfoil, which could decrease the amount of life; and
- The additional weight and unequal formation of the ice, which could cause unbalancing of the aircraft, making it hard to control.

Enough ice to cause an unsafe flight condition can form in a very short period of time; thus some method of ice prevention or removal is necessary.

An anti-icing system is designed to prevent ice from forming on the aircraft. A deicing system is designed to remove ice after it has formed. An example of this is the deice boot system for the E-2 aircraft. An aircraft anti-ice system removes ice from propellers and the leading edges of wings and stabilizers. These systems may use electrical heaters, hot air, or a combination of both to remove the ice formation. As an AME, you are primarily concerned with hot air as a method to remove the formation of ice on wings and stabilizers. The P-3 wing anti-icing system is used as an example in this chapter to describe a hot-air system.

The P-3 aircraft uses an ice detector system to warn the pilot, visually, of an icing condition. A warning light is installed on the center instrument panel in the flight station.

COMPONENTS

The hot bleed air is directed and regulated to the leading edge ejector manifold through shutoff valves, modulating valves, thermostats, skin temperature sensors, and overheat warning sensors (fig. 5-2).

Shutoff Valves

The wing anti-ice system contains several shutoff valves. The fuselage bleed air shutoff valves, installed in the cross-ship manifold on the right and left wings, isolate the wings from the fuselage duct section. In addition, they may be used to isolate one wing duct from the other wing duct. Each valve is individually controlled by a guarded toggle switch mounted on the bleed air section of the ice control protection panel.

A bleed air shutoff valve is also installed in each engine nacelle. These shutoff valves are physically identical. They are of the butterfly-type and are actuated by an electric motor.

An indicator, located on top of the valve housing, shows the position of the valve—open or closed. This indicator enables you to visually check the operation of the valve while it is still installed in the anti-ice system.

Modulating Valves

The P-3 anti-icing system has three modulating valves installed in each wing. These valves are thermostatically controlled and pneumatically operated. They maintain the constant engine compressor bleed air temperature required for the wing leading edge. When anti-icing is not required, the valves operate as shutoff valves.

The modulating valves (fig. 5-3) have pilot solenoid valves that are electrically controlled by three switches on the bleed air section of the ice protection panel. When the solenoid is energized, it admits filtered, regulated, bleed air pressure to one side of a diaphragm chamber in the valve. The other side of the diaphragm chamber is spring-loaded to the closed position. Movement of the diaphragm operates a main line butterfly valve.

When the valve opens, hot air is admitted to the leading edge distribution system. The hot air goes

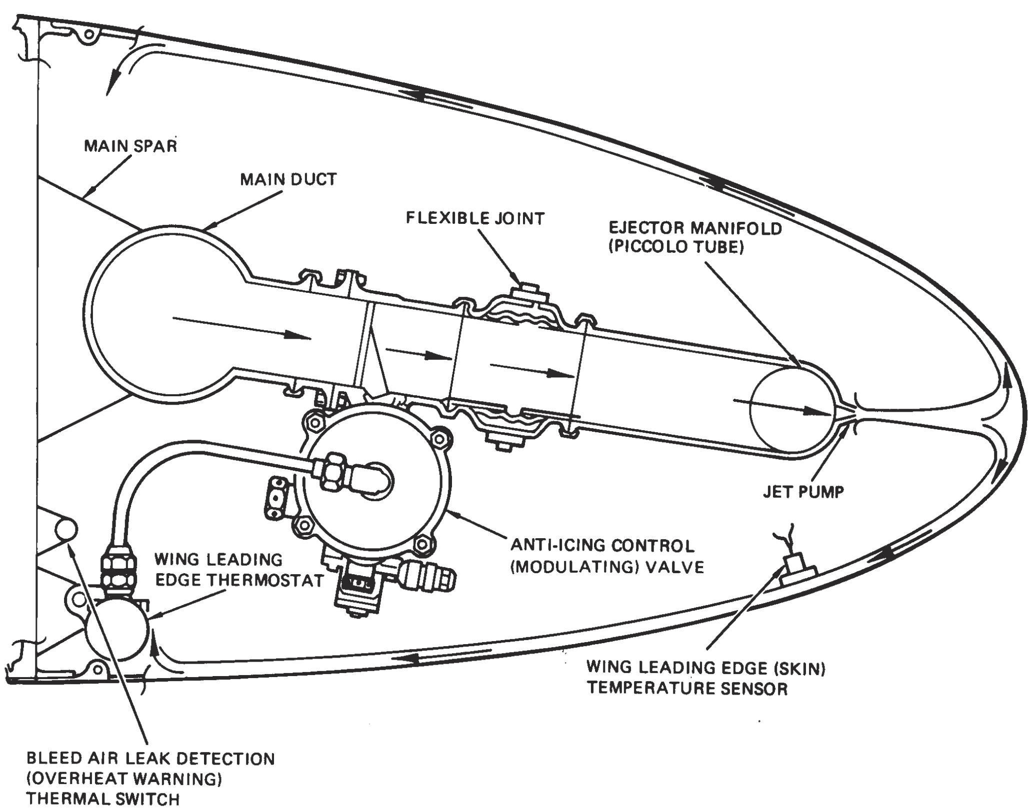


Figure 5-2.—Wing leading edge anti-icing cross section.

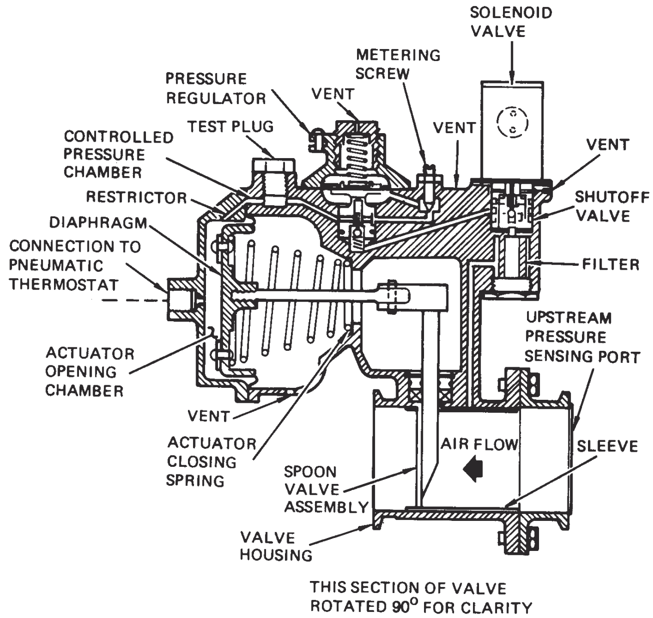


Figure 5-3.—Anti-icing modulating valve.

through the modulator valve to the ejector manifold, out the jet nozzles, and into the wing leading edge plenum area. The bleed air is then directed across a pneumatic thermostat. Increased temperature across the thermostat actuates the sensor and opens a bleed passage from the diaphragm chamber. This reduces the pressure on the diaphragm and allows a spring to close the main valve.

Thermostats

The wing leading edge pneumatic thermostat is installed adjacent to each modulating valve (fig. 5-2). The thermostat controls air pressure on the modulating valve diaphragm, and thereby controls the valve opening.

The unit is composed of a probe and a valve assembly (fig. 5-4). The probe is a core made of layers

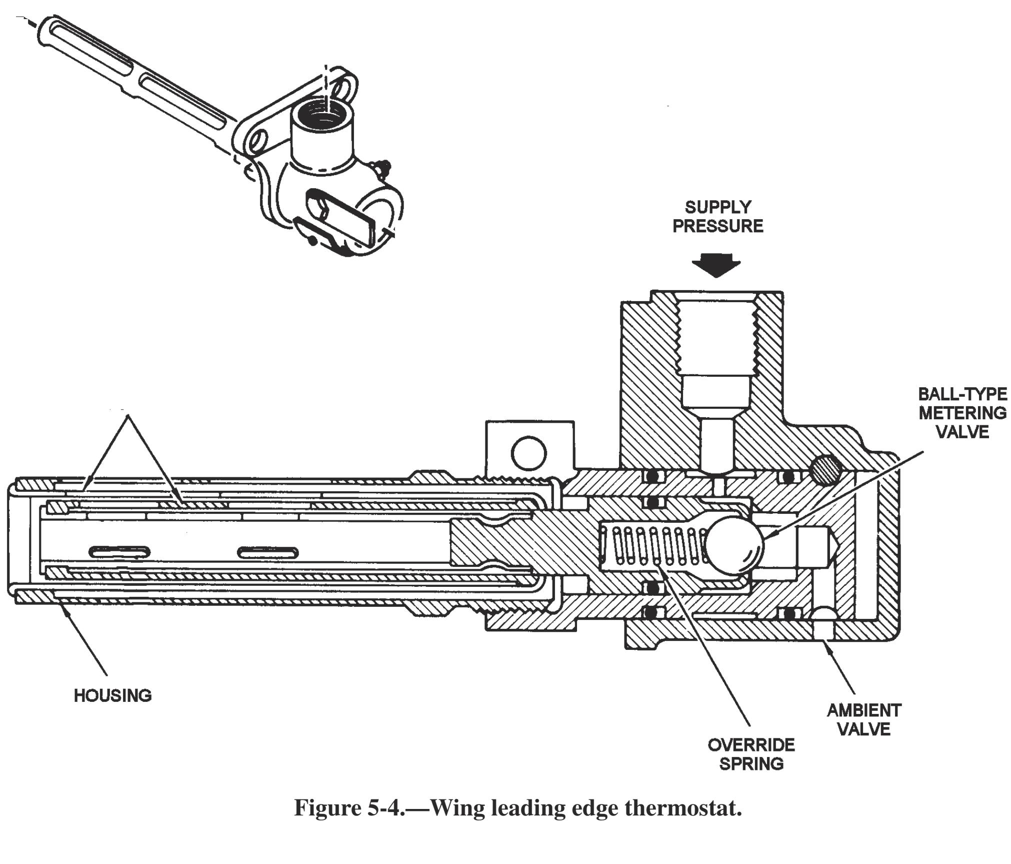


Figure 5-4.—Wing leading edge thermostat.

of high- and low-expansion material that is locked to a sliding piston. In addition, the piston contains an override spring and ball-type metering valve.

Airflow from the leading edge flows over the core and causes the materials to expand or contract. As temperature rises, the core pulls the piston and metering ball from the seated position. This allows pressure from the modulating valve diaphragm to vent. Increasing temperature causes more air to be bled from the diaphragm chamber. Because of spring action, the modulating valve moves toward the closed position. This restricts flow through the modulator valve and drops the skin temperature. The thermostats in the outboard leading edge plenum areas are set at 145°F. The wing inboard and center section thermostats are set at 120°F.

Leading Edge Skin Temperature Indicator and Overheat Circuit Caution Light Circuit

The temperatures of the wing leading edge sections are displayed on the LEAD EDGE TEMP indicator on the engine bleed air control panel. Six sensors are used in the system, one in each leading edge section. These sensors form part of the circuitry of the airfoil temperature sensors amplifier. When the temperature at one or more of the sensors exceeds 230°F, a relay energizes, providing a ground for the LE HOT caution light circuit, causing the light to come on. Whenever a leading edge skin overheat condition is detected, the location can be determined by setting WING LEADING EDGE SKIN TEMP BOMB BAY TEMP rotary switch to each position while observing the indicator. Since there is always a possibility of more than one section overheating, all six-wing leading edge sections should be checked. The airfoil temperature sensor amplifier is at the forward load center and is powered through the AIRFOIL IND & OVHT WARNING circuit breaker.

The circuit receives power from the AIRFOIL IND & OVHT WARNING circuit breaker. The caution light is energized through the indicator lights power system and the indicator light control. The indicator circuit does not disturb the caution function of the system.

High temperature within the leading edge is generally caused by bleed air leakage or malfunctioning modulator valves. You can detect the portion of the leading edge that has the over-temperature by placing the rotary selector switch, located on the ice control protection panel (fig. 5-5), to the different sensor positions: INBD (inboard), CTR (center), and OUTBD (outboard). The temperature at the selected sensor is then read at the indicator adjacent to the rotary switch. An excessive temperature reading on the indicator denotes a malfunction within the area being tested.

OPERATION

The P-3 aircraft wing anti-icing system prevents ice formation on wing leading edges during icing conditions. This is a hot wing type system utilizing hot compressed air from the engines. Engine bleed air, ducted from two ports at the 14th stage of each engine compressor, is orifice regulated. The supply is maintained at essentially a fixed percentage of engine airflow for all flights speeds and attitudes. The air from both ports, after passing through the two 14th stage duct check valves, is ducted through a single universal flexible joint to the bleed air shut-off valve aft of the 14th stage firewall (fig. 5-6).

The bleed air section of the ice protection panel in figure 5-5 shows a basic diagram of the wing anti-ice system. An engine number labels each engine. Directly below each engine block (in the diagram) is an OPEN light that illuminates when the bleed air valve is open 2 degrees or more. The cross-ship manifold from the bleed air valves goes to each modulating valve and the fuselage shutoff valves. The fuselage bleed air shutoff valves are normally in the CLOSE position during normal anti-icing operation. The bleed air pressure gauge reads cross-ship manifold pressure when one or both switches are opened.

A leak test switch is mounted on the upper right-hand side of the panel. This switch is used to determine if the leakage of the system is acceptable.

Three modulating valve control switches are located on the left side of the wing and empennage ice panel. The OUTBD switch controls the outboard modulating valve on the left and right wing, the CTR switch controls the two center modulating valves, and the INBD switch controls the two inboard modulating valves.

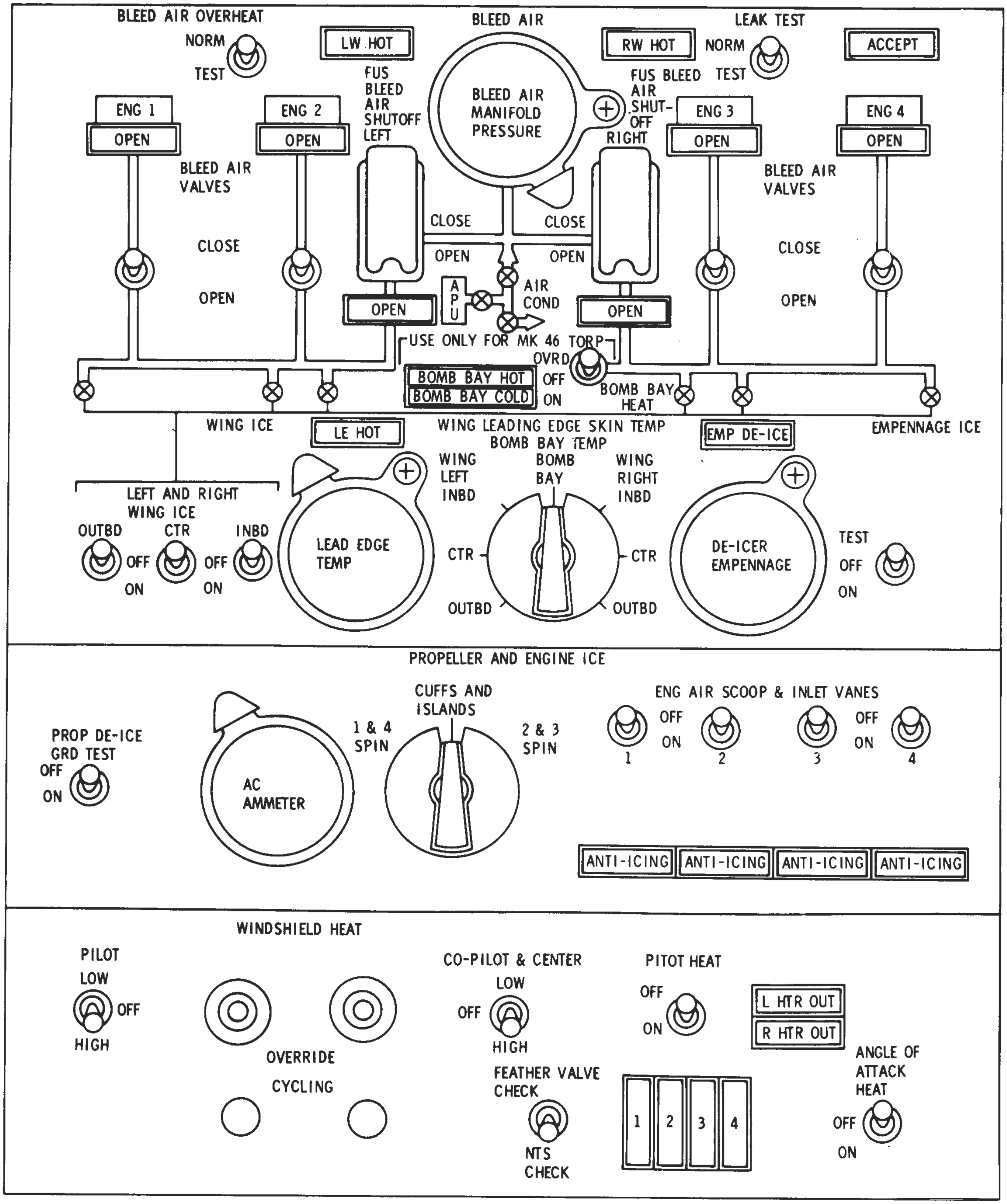
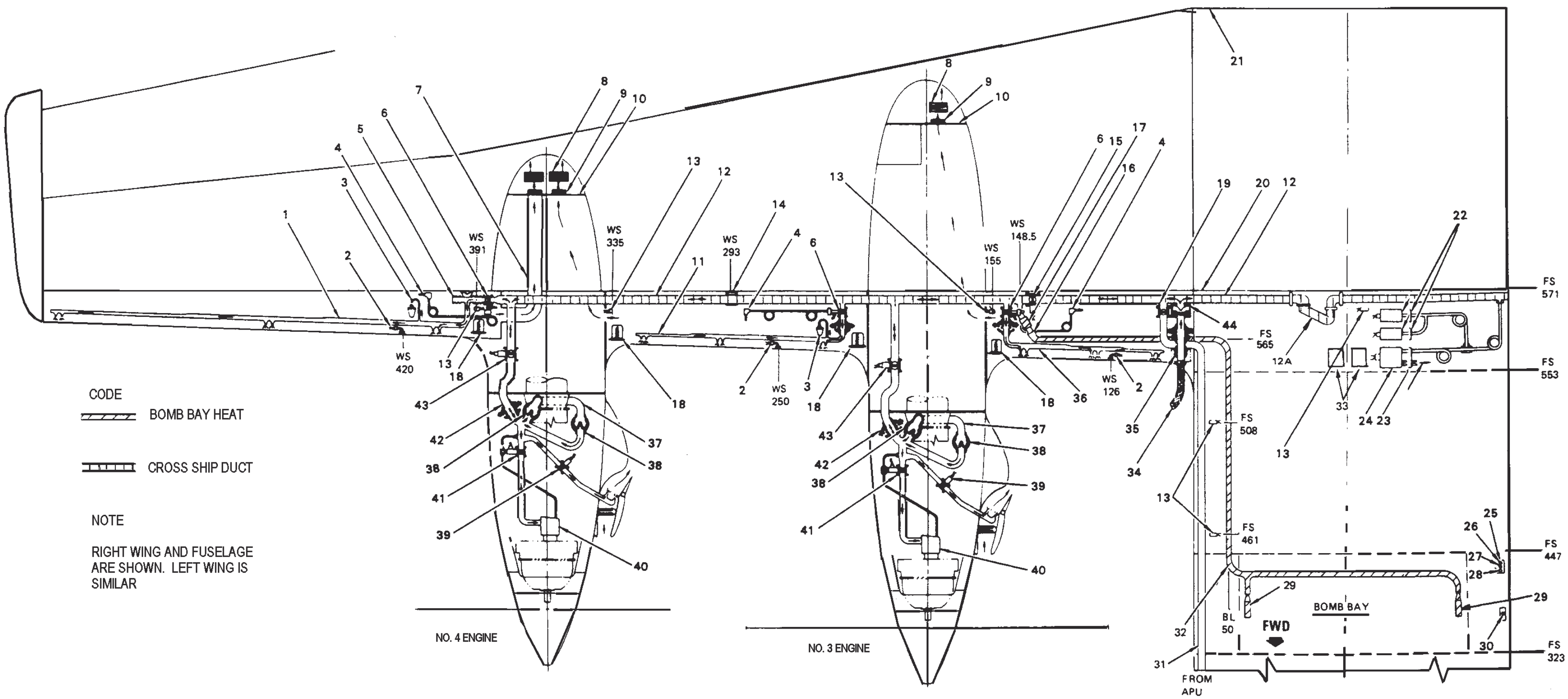


Figure 5-5.—Engine bleed air and anti-icing control panels.



1. EJECTOR MANIFOLD OUTBOARD WING LEADING EDGE
2. WING LEADING EDGE TEMPERATURE SENSORS (6 PLACES)
3. ANTI-ICING LINE FOR NACELLE COMPARTMENT COOLING DUCT AIR SCOOP (4 PLACES)
4. WING LEADING EDGE THERMOSTAT (6 PLACES)
5. TEE EXPANSION JOINT
6. ANTI-ICING (MODULATING) VALVE (6 PLACES)
7. PLENUM EXHAUST DUCT (TYPICAL OUTBOARD ENGINE)
8. OVERBOARD DUMP LOUVERS (4 PLACES)
9. FLAME ARRESTER (4 PLACES)
10. TERMINAL BULKHEAD (4 PLACES)
11. EJECTOR MANIFOLD (PICCOLO TUBE) CENTER SECTION WING LEADING EDGE
12. CROSS SHIP DUCT

12A. THERMAL EXPANSION LINK DUCT
13. BLEED AIR LEAK DETECTION THERMAL SWITCH (9 PLACES)
14. CROSS-SHIP DUCT ANCHOR
15. FUSELAGE BLEED AIR SHUTOFF VALVE (ISOLATION VALVE) (2 PLACES)
16. BOMB BAY BLEED AIR FLOW LIMITING VENTURE
17. BOMB BAY BLEED AIR SHUTOFF VALVE
18. BLOWOUT DOOR (8 PLACES)
19. INTEGRAL STARTING SYSTEM CHECK VALVE
20. WING FRONT BEAM
21. WING REAR BEAM
22. PRESSURE SWITCHES

23. TO AMBIENT AIR
24. PRESSURE TRANSMITTER
25. BOMB BAY TEMPERATURE THERMOSTAT
26. BOMB BAY TEMPERATURE READOUT SENSOR
27. COLD LIGHT THERMAL SWITCH
28. CYCLING THERMOSTAT
29. BOMB BAY BLEED AIR NOZZLE
30. HOT LIGHT THERMAL SWITCH
31. ENGINE START DUCT
32. BOMB BAY HEATING DUCT
33. BLOWOUT PANEL (2 PLACES)
34. GROUND START AIR HOSE (SHOWING CONNECTED)

35. GROUND AIR CONNECTION (NIPPLE)
36. EJECTOR MANIFOLD WING BUTT LEADING EDGE
37. POWERPLANT 14TH STAGE BLEED (4 PLACES)
38. ENGINE 14TH STAGE DUCT (BLEED) CHECK VALVE (8 PLACES)
39. ENGINE OIL AIR AUGMENTER VALVE (4 PLACES)
40. ENGINE STARTER (EXHAUST AIR DUMPS INTO NACELLES) (4 PLACES
41. STARTER CONTROL VALVE (4 PLACES)
42. FLEXIBLE UNIVERSAL JOINT (4 PLACES)
43. ENGINE NACELLE BLEED AIR SHUTOFF VALVE (4 PLACES)
44. START AIR PLUG-IN CHECK VALVE ASSEMBLY

Figure 5-6.—P-3 wing anti-icing system schematic.

During normal operation of the anti-icing system, all four-engine bleed air valves are open to supply bleed air to the cross-ship manifold, and both fuselage bleed air shutoff valves are closed. The modulating valves, which are controlled by pneumatic thermostats, maintain a controlled flow of bleed air to the leading edge distribution system. The complete system is monitored for hot spots by heat-sensing switches.

Before flight, the anti-icing manifold system may be tested for leakage. This leak test is performed by pressurizing the system: OPEN the No. 4 engine bleed air valve; the Nos. 1, 2, and 3 engine bleed air valves remain CLOSED, and both fuselage shutoff valves are in the OPEN position. When the bleed air pressure on the bleed air manifold reads 70 psi, the No. 4 engine bleed air valve is closed and the leak test switch is actuated. As the bleed air pressure drops, the time-delay relay will illuminate the ACCEPT light after an 8-second delay if the system is tight. The light will go out when the test switch is released.

Q5-7. Describe the difference between an anti-icing system and a deicing system.

Q5-8. In an anti-ice system, what method(s) are used to remove ice formation?

Q5-9. Identify the four major components of a P-3 anti-ice system.

Q5-10. The OPEN light on the ice protection panel will illuminate when what condition occurs?

WINDSHIELD ANTI-ICE/RAIN REMOVAL SYSTEM

LEARNING OBJECTIVE: Recognize the components and operating principles for a windshield anti-ice/rain removal system.

This system is designed to provide a means of maintaining visibility from the aircraft. The F-18 windshield anti-ice/rain removal system is typical of systems found in jet aircraft. This system supplies controlled temperature air from the air cycle air-conditioning system (ACS) to provide airflow over the external surface of the windshield for rain removal and windshield anti-icing.

COMPONENTS

Components of the windshield anti-ice/rain removal system include a warm air temperature control valve, temperature sensors, a flow/temperature limiting anti-ice modulating valve, an air control regulating valve, and an anti-ice/rain removal switch.

Warm Air Temperature Control Valve

The warm air temperature control valve operates to control temperature entering the windshield anti-ice and rain removal ducts. The valve is modulated by muscle pressure, which is controlled by the warm air temperature sensor.

Warm Air Temperature Sensor

The warm air temperature sensor (fig. 5-7, item A) is located downstream of the warm air temperature

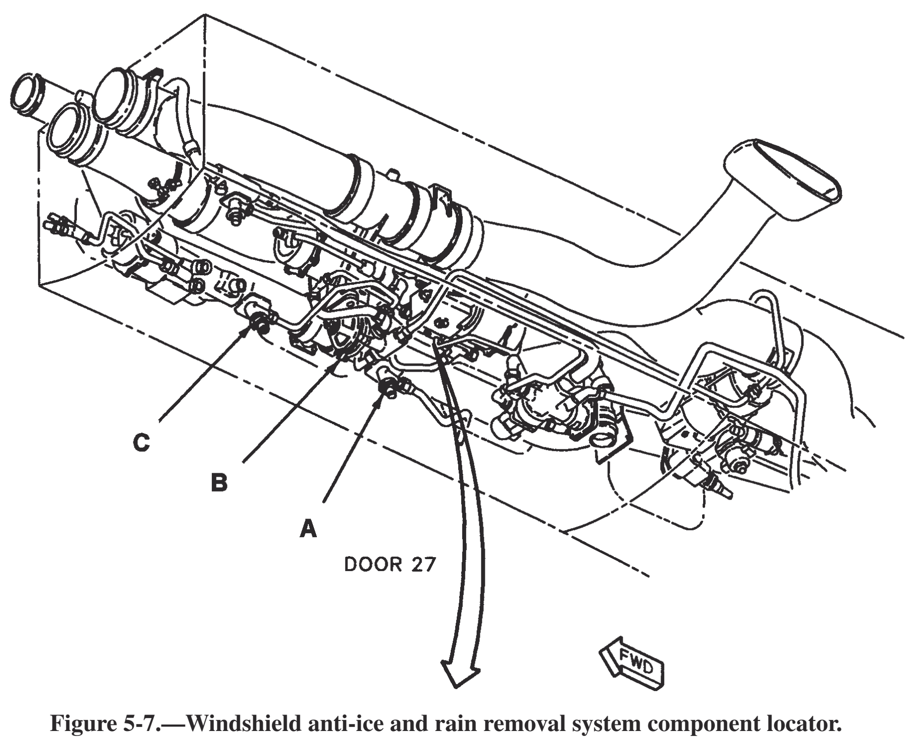


Figure 5-7.—Windshield anti-ice and rain removal system component locator.

control valve and opens to prevent muscle pressure to the warm air temperature control valve when duct temperature exceeds sensor settings.

Flow/Temperature Limiting Anti-Ice Modulating Valve

The flow/temperature limiting anti-ice modulating valve (fig. 5-7, item B), located downstream of the warm air temperature control valve, is a dual function valve. It is a pneumatically actuated flapper valve and a muscle pressure that is controlled by the warm air over-temperature sensor. The valve is normally open during system operation and modulates toward closed only if an over-temperature condition occurs. The muscle pressure regulator on this valve is the source of regulated muscle pressure used by the environmental control systems. It is a dual diaphragm regulator and uses source air pressure from either the windshield anti-ice and rain removal duct or the air cycle air-conditioning system, depending on which pressure is greater.

Warm Air Over-Temperature Sensor

The warm air over-temperature sensor (fig. 5-7, item C) is located downstream of the flow/temperature limiting anti-ice modulating valve. It opens if duct temperature reaches 375°F ±25°F to vent muscle pressure from the flow/temperature limiting anti-ice modulating valve. This causes the valve to modulate toward closed and restricts airflow to protect the windshield from overheat damage.

Anti-Ice/Rain Removal Air Control Regulating Valve

The anti-ice/rain removal air control-regulating valve (fig. 5-8) completes the final pressure regulation and flow control before airflow reaches the anti-ice/rain removal nozzle. The valve regulates pressure and flow rate relative to position of the WINDSHIELD ANTI-ICE/RAIN removal switch.

Windshield Overheat Temperature Sensor

The windshield overheat temperature sensor, located downstream of the anti-ice/rain removal air control regulating valve, is a temperature-activated switch, which opens if airflow temperature reaches 290° ±5°F. It closes when airflow temperature drops to 280° ±5°F. When the switch is open, a ground is lost to the signal data converter and the signal data computer, causing the digital display indicator to display a WDSHLD HOT caution message.

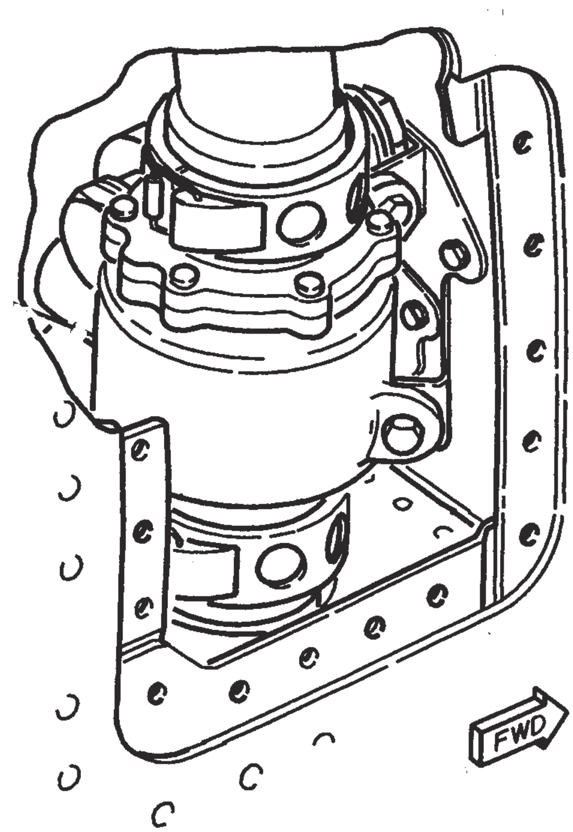


Figure 5-8.—Anti-ice/rain removal air control regulating valve.

Windshield Anti-Ice/Rain Removal Switch

This is a three-position control switch. The switch in OFF position removes power from the anti-ice/rain removal air control regulating valve to close the valve and shutoff airflow to the windshield. The switch in RAIN position allows low pressure (5.4 pounds per square inch gauge [psig]) and low volume (20 pounds per minute [lbs/min]) air at 250°F directed across the windshield through the anti-ice/rain removal nozzle. The switch in ANTI-ICE position allows high pressure (29.5 psig) and high volume (57 lbs/min) air at 250°F directed across the windshield through the anti-ice/rain removal nozzle.

OPERATION

The windshield anti-ice and rain removal system is used to supply controlled airflow to the anti-ice/rain removal nozzle to remove ice and/or rain from the windshield. The WINDSHIELD ANTI-ICE/RAIN removal switch controls the modes of operation.

Rain Removal

Positioning the WINDSHIELD ANTI-ICE/RAIN removal switch to RAIN controls the rain removal mode of operation. This will actuate the low pressure solenoid of the anti-ice rain removal air control regulating valve to supply low pressure (5.4 psig) and low flow (20 lbs/min) air at 250°F to the windshield.

Windshield Anti-Ice

Positioning the WINDSHIELD ANTI-ICE/RAIN removal switch to ANTI-ICE controls the anti-ice mode of operation. This will actuate the high pressure solenoid of the anti-ice rain removal air control regulating valve to supply high pressure (29.5 psig) and high flow (57 lbs/min) air at 250°F to the windshield.

Q5-11. What is the purpose of an F-18 windshield anti-ice/rain removal system?

Q5-12. Name the seven major components of an F-18 windshield anti-ice/rain removal system.

Q5-13. What component controls the temperature entering the windshield anti-ice and rain removal ducts?

Q5-14. The modes of operation for the anti-ice/rain removal system are controlled by what component?

WINDSHIELD-WASHING SYSTEM

LEARNING OBJECTIVE: Recognize the components and operating principles for a windshield-washing system.

The windshield-washer system on an EA-6B is typical of this system and provides cleaning for the pilot's windshield. The WINDSHIELD switch located on the DEFOG/ANTI-ICE & RAIN REMOVAL control panel controls the windshield-washing system. The system cleans the windshield by directing a stream of 50 percent water-methyl alcohol mixture over the outside surface of the glass. The water-methyl alcohol is dried by engine bleed air through the rain-removal nozzles. The system uses cooled bleed air supplied by the auxiliary heat exchanger of the forward refrigeration unit to pressurize the windshield-washing tank, which stores the washing fluid. The pressure forces the windshield-washing fluid through a series of five nozzles located at the base of the pilot's windshield. The windshield-washing shutoff valve controls the cool bleed airflow to the top of the windshield-washing tank.

COMPONENTS

Components of the windshield-washing system include a shutoff valve, tank, switch, and a nozzle assembly.

Windshield-Washing Shutoff Valve

The windshield-washing shutoff valve is mounted to a bracket on the right wing beam in the forward air-conditioning compartment (fig. 5-9). It is a solenoid-operated valve that controls air pressure to the windshield-washing tank. The WINDSHIELD switch on the DEFOG/ANTI-ICE & RAIN REMOVAL PANEL controls operation of the valve. The valve consists of a pressure-reducer valve, a check valve, a solenoid-operated combination shutoff and dump valve, and relief valve. When the solenoid is deenergized, the valve is closed and the outlet port is vented to the atmosphere. This shuts off the flow of cooled bleed air to the windshield-washing tank and reduces the pressure in the tank to zero. When the solenoid is energized, the valve opens and regulates the pressure of cooled bleed air to the windshield-washing tank at 10 ±1 psig. If the pressure in the tank goes above 13 ±0.5 psig, a relief valve inside the valve opens and pressure in the tank is reduced.

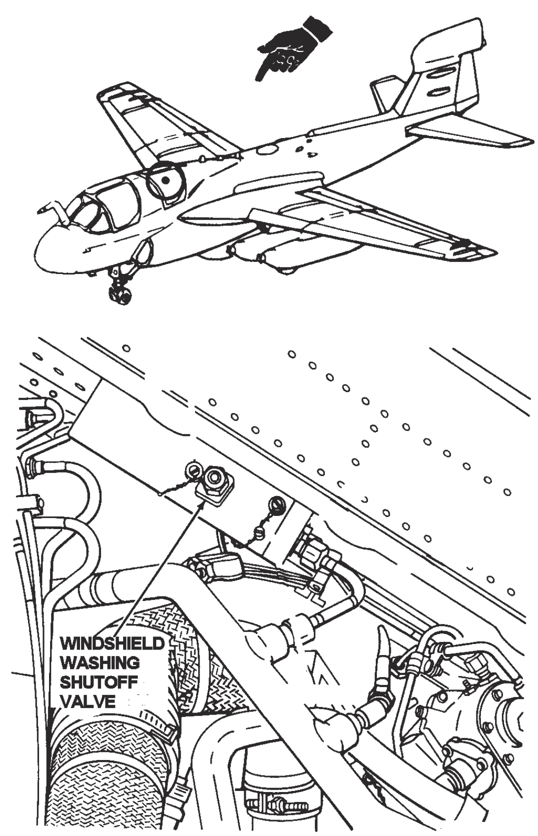


Figure 5-9.—Windshield-washing shutoff valve.

Windshield-Washing Tank

The windshield-washing tank is built into the outside structure of the right engine inlet duct. A windshield-washing tank cap is removed to fill the tank. The tank holds 1 1/2 gallons of washing fluid, which is a mixture of 50 percent methanol (methyl alcohol) and 50 percent water.

Windshield Switch

The WINDSHIELD switch is a single-pole, three-position switch mounted on the DEFOG/ANTI-ICE & RAIN REMOVAL PANEL (fig. 5-10). The three positions are OFF, AIR, and WASH. This switch controls the operation of the windshield-washing shutoff valve and rain-removal pressure-regulator shutoff valve. The WINDSHIELD switch is momentarily in either WASH or AIR position. When released, the switch returns to OFF. Placing the switch to WASH directs streams of washing fluid against the base of the pilot's windshield; placing the switch at AIR directs a wide stream of hot air across the glass.

Windshield-Washing Nozzle Assembly

The windshield-washing nozzle assembly consists of five nozzles connected to a common inlet tube (fig. 5-11). The nozzles protrude through the rain-removal nozzle assembly at the base of the pilot's windshield.

OPERATION

The WINDSHIELD switch controls the windshield-washing system. Holding the switch to WASH routes 28 Vdc to open the windshield-washing shutoff valve. With the valve open, regulated air pressure from the auxiliary heat exchanger of the forward refrigeration unit is routed to the top of the windshield-washing tank. The valve controls the pressure in the tank at 10 ±1 psi. If the pressure in the tank exceeds 13 ±0.5 psi, the relief portion of the shutoff valve opens, reducing tank pressure.

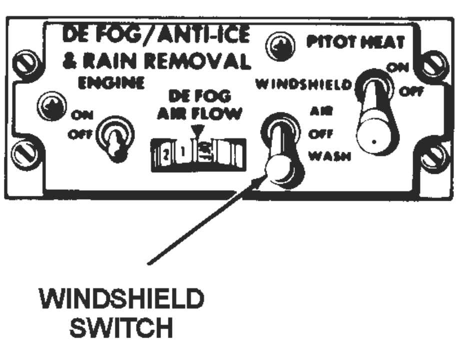


Figure 5-10.—Windshield switch.

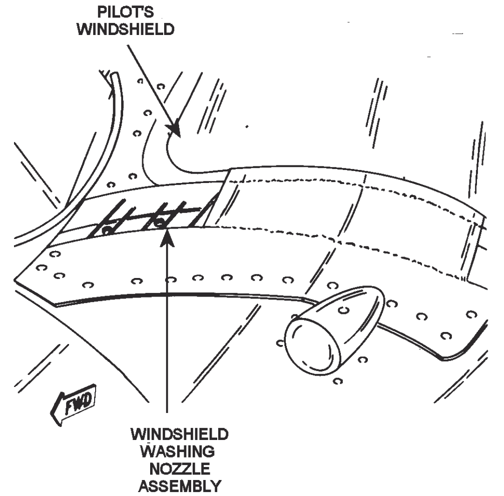


Figure 5-11.—Windshield-washing nozzle assembly.

The 10-psi air pressure in the windshield-washing tank forces the mixture of 50 percent methyl alcohol and 50 percent water through five nozzles of the windshield-washing assembly. Releasing the WINDSHIELD switch allows it to return to OFF. This closes the windshield-washing shutoff valve and the supply of air to the windshield-washing tank. Excess pressure in the tank is vented into the atmosphere.

Q5-15. Describe the mixture content on an EA-6B windshield-washer system.

Q5-16. What type of valve is the windshield-washing shutoff valve?

Q5-17. What event takes place if the pressure in the windshield-washing tank goes above 13 ±0.5 psig?

Q5-18. What is the capacity of the windshield-washing tank?

ANTI-G SYSTEM

LEARNING OBJECTIVE: Recognize the components and operating principles for an anti-g system.

The anti-g system automatically regulates air-pressure to the pilot anti-g suit. The anti-g suit reduces the fatiguing effect of repeated exposure to positive or negative g-forces that can cause grayout and/or blackout. The anti-g system also provides a method by which the pilot can relieve fatigue and physical tension during extended flight. Air pressure to the anti-g system is supplied from the air cycle air-conditioning system.

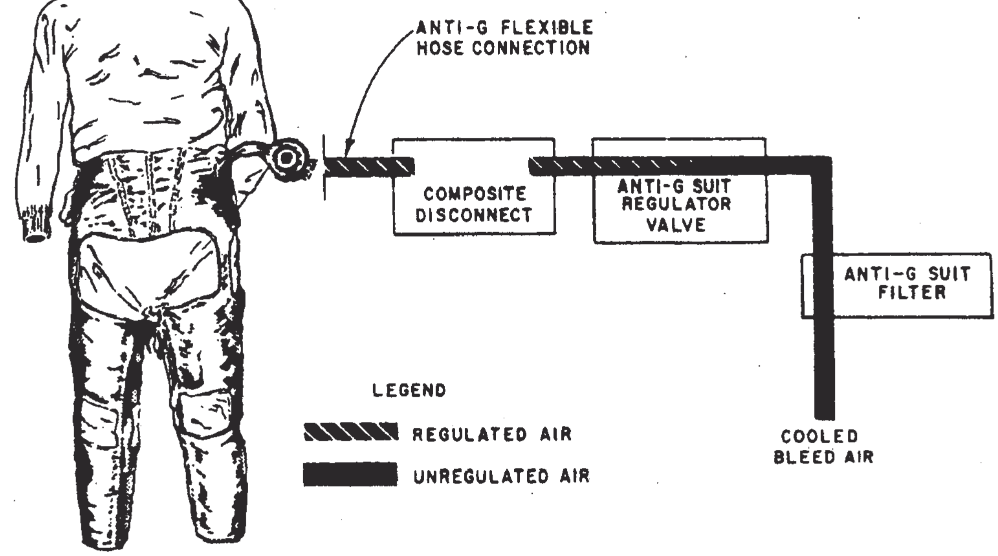


Figure 5-12.—Anti-g system.

Most anti-g systems are similar to the one illustrated in figure 5-12. This system consists of a supply line, an air filter, a pressure regulating valve, a connecting hose, and a suit attachment fitting (single quick-disconnect or composite quick-disconnect). The air pressure used in this system may be taken directly from the engine compressor bleed air ducting, but is usually taken off the air-conditioning ducting downstream from the heat exchanger.

COMPONENTS

Components of the anti-g system include a valve, a system filter, and quick-disconnects.

Anti-g Valve

The anti-g valve (fig. 5-13) is automatically controlled by any positive or negative g-force. The anti-g valve receives air from the high-pressure bleed system and regulates it to a maximum of 10 psi for delivery to the g-suit. The anti-g valve incorporates an internal demand, exhaust, and relief valve. The internal relief valve relieves excessive suit pressure and maintains pressure at a maximum of 11 psi.

When a force of approximately 1.5 g's is exerted on the aircraft, the activating weight overcomes the upper spring tension and closes the exhaust valve (fig. 5-14,

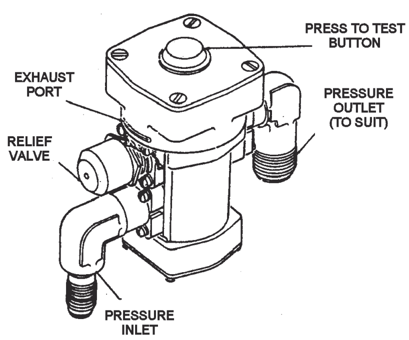


Figure 5-13.—Anti-g pressure regulating valve.

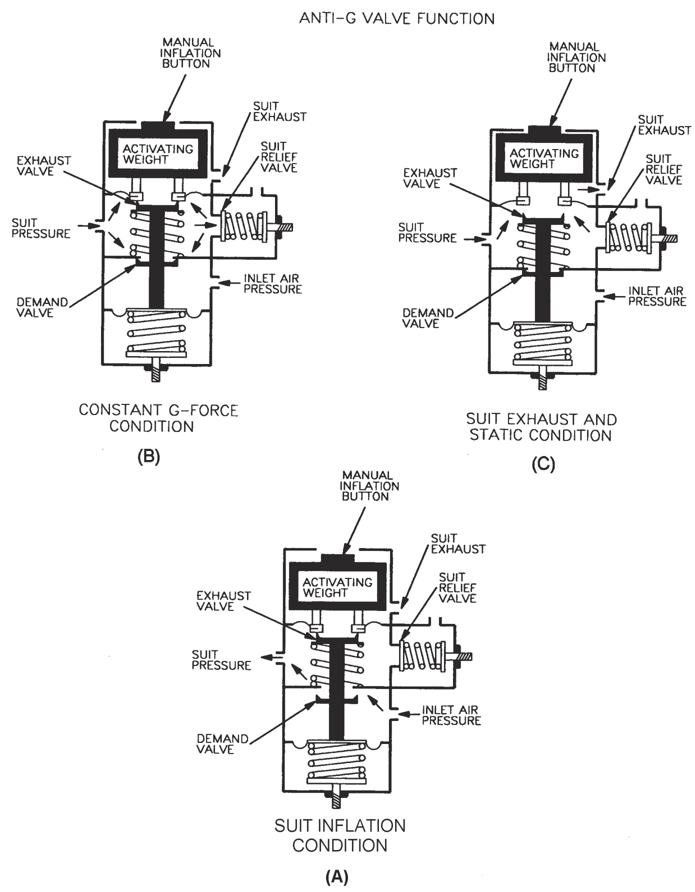


Figure 5-14.—Anti-g valve operation.

view A). As the weight travels downward, it further depresses the valve assembly, forcing the demand valve from its seat, thus overriding the pressure of the lower spring and opening the demand valve. Air pressure then flows past the open demand valve, through the valve outlet into the valve outlet line, through the suit quick-disconnect, and into the anti-g suit.

As the g-forces being applied to the aircraft are stabilized and become constant, the pressure under the activating weight diaphragm builds up sufficiently to lift the weight and to reduce the pressure on the valve assembly enough to close the demand valve (fig. 5-14, view B). The demand valve closes under pressure of the heaver lower spring, while the exhaust valve remains closed by the activating weight. The suit pressure is then trapped in the pressure outlet chamber of the anti-g valve and remains constant until the g-forces change.

As the g-forces decrease, the downward force on the activating weight diminishes to a point at which the upper spring lifts the weight off the exhaust valve. The pressure in the suit is then vented through the exhaust port (fig. 5-14, view C) into the cockpit.

Pressing the button at the top of the valve manually operates the anti-g valve. This button should be used to test the anti-g system prior to takeoff. Intermittent manual operation of the anti-g valve is performed during flight to relieve leg stiffness and static fatigue.

Anti-G System Filter

Most anti-g systems use a filter to prevent particles of dust, trash, and other foreign material from entering the regulating valve. This filter may be located in the supply line or it may attach to the anti-g valve on the inlet side. A typical anti-g system filter is shown in figure 5-15.

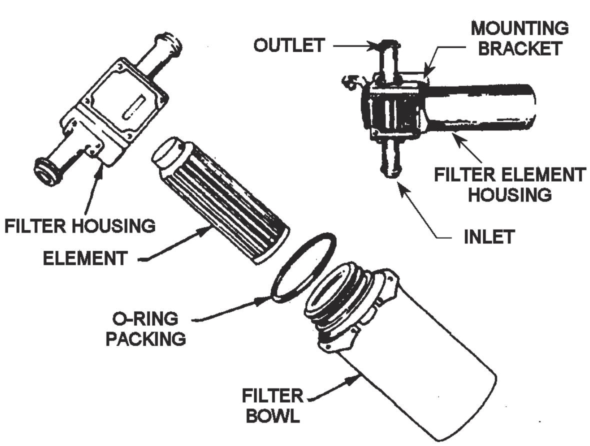


Figure 5-15.—Anti-g system filter.

Quick-Disconnects

The anti-g suit is connected to the anti-g system by means of a quick-disconnect coupling. This quick-disconnect may be either a single unit that connects the anti-g suit only, or it may be a composite quick-disconnect that connects the pilot to the various personal service lines (oxygen, ventilating air, anti-g system, and communications).

The anti-g system quick-disconnect is used on aircraft that are not equipped with a composite quick-disconnect attached to the ejection seat. This disconnect is on a hose that protrudes through the pilot's console. It is attached by a flexible hose to the outlet port of the anti-g valve. This disconnect may be pulled up to a bumper stop to aid in connecting the anti-g suit hose. A spring-loaded cover on the disconnect prevents the entry of foreign material when the system is not in use.

OPERATION

As high-g conditions occur, the anti-g valves activating weight is forced down to close the exhaust valve and open the demand valve. This allows cooled engine bleed air from the refrigeration system service heat exchanger to flow through the anti-g valve, where it is regulated, to inflate the g-suit. Pressure to the g-suit is varied in proportion to the g-force acting upon the aircraft and crewmembers, to a maximum of 10 psi. As g-forces decrease, the activating weight is forced upward by spring tension. This reduces the pressure of the airflow to the g-suit and exhausts excess suit pressure into the cabin. As this occurs, the demand valve closes, blocking air from the g-suit.

Q5-19. Identify the purpose of an anti-g system.

Q5-20. Most anti-g systems consist of what components?

Q5-21. The anti-g valve regulates high-pressure bleed air to what maximum pressure for delivery to the g-suit?

Q5-22. Describe the operation of an anti-g system.

VENT-AIR SYSTEM

LEARNING OBJECTIVE: Recognize the components and operating principles for a vent-air system.

Vent-air systems provide a flow of air to the aircraft's seat or back cushions or to the ventilating air connection of the anti-exposure suit when worn by the pilot and/or crewmembers. The system provides a measure of personal comfort, offsetting the discomfort caused by the wearing of the anti-exposure suit or heat created by cockpit equipment and resulting high-temperature ambient air.

The vent-air system for the F-18 aircraft supplies temperature controlled and pressure regulated air to the pilot's vent suit from the air cycle air-conditioning system.

COMPONENTS

The vent-air system components include a vent suit temperature valve and sensors, a regulating and a relief valve, and a vent suit air hose assembly.

Vent Suit Temperature Valve

The vent suit temperature valve is normally closed, pneumatically actuated, torque motor controlled, dual poppet valve, which mixes warm and cold air. The location of the valve is shown in figure 5-16, item A. The vent suit temperature valve torque motor regulates muscle pressure to control hot and cold airflow. The ACS temperature/flow controller controls the torque motor. The torque motor control in this valve can be overridden by a vent suit over temperature sensor, which vents muscle pressure to close the valve if an over temperature condition exists.

Vent Suit Temperature Sensor

The temperature sensor is located in a manifold downstream of the vent suit temperature valve (fig. 5-16, item B). The sensor sends signals to the ACS temperature/flow controller.

Vent Suit Over-Temperature Sensor

The over-temperature sensor is a pneumatic bleed-off sensor, located in a manifold downstream of the vent suit temperature valve (fig. 5-16, item C). If manifold temperature reaches 120°±15°F, the sensor vents muscle pressure from the vent suit temperature valve, causing the valve to close.

Vent Suit Pressure Regulating Valve

The valve is located downstream of the sensor manifold and limits flow rate of 14 cubic feet per minute (cfm) at a pressure of 3 psi above cabin pressure. The flow rate can be manually reduced below maximum by use of the manual flow control on the vent suit air hose assembly.

Vent Suit Pressure Relief Valve

The pressure relief valve is a tube assembly containing an integral spring-loaded poppet valve, which prevents rupture of the vent suit air hose assembly by a failed vent suit pressure regulator. The

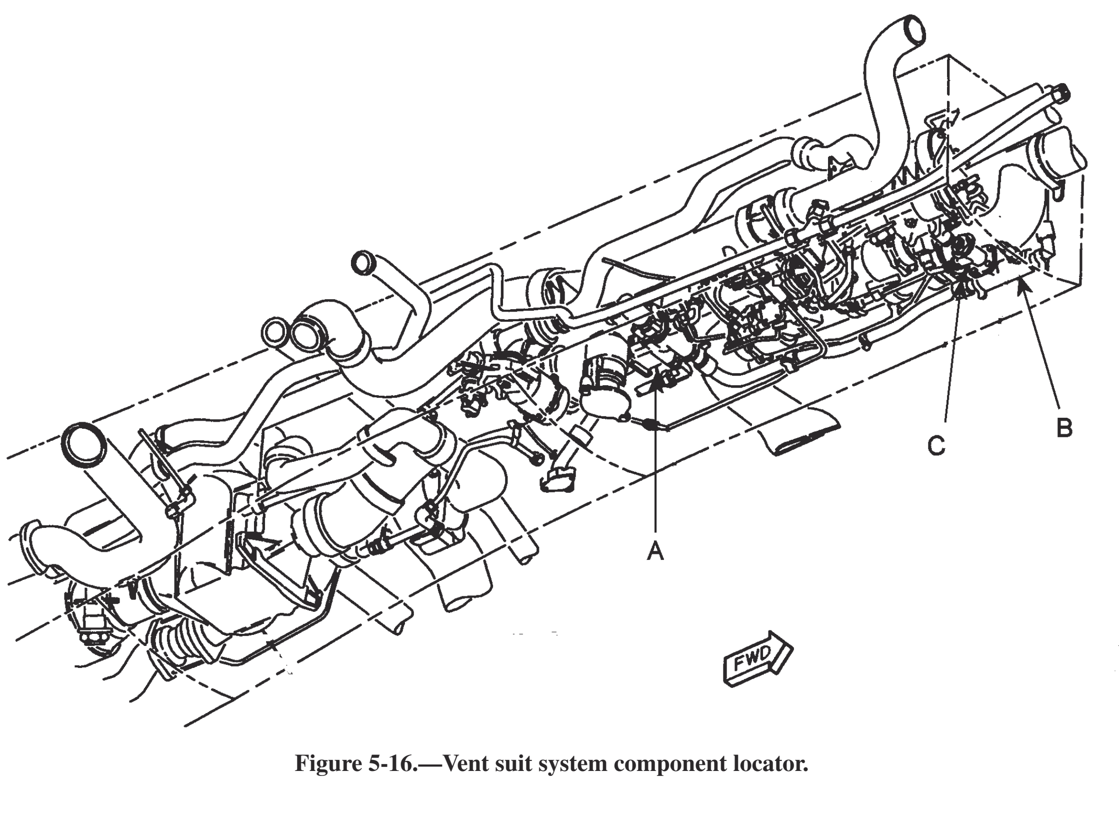


Figure 5-16.—Vent suit system component locator.

pressure relief valve begins to open at 10 psi and is fully open at 18 psi.

Vent Suit Air Hose Assembly

The air hose assembly located on the left console is made up of a manual flow control and a vent suit disconnect. The manual flow control allows the pilot to manually regulate airflow entering the vent suit through the vent suit disconnect.

OPERATION

The F-18 vent suit system operates when the air cycle air-conditioning system is on. Vent suit system operation is switched from automatic to manual when the environmental control system (ECS) MODE switch on the ECS panel assembly (fig. 5-17) is set from AUTO to MAN.

Automatic Mode

When the ECS MODE switch is in AUTO position, the ACS temperature/flow controller modulates the vent suit temperature control valve as required to maintain a constant temperature in the vent suit sensor manifold. The vent suit temperature sensor signals the controller if manifold temperature changes and the controller makes torque motor current adjustments to the temperature valve accordingly. In this mode, the temperature selected on the SUIT TEMP control is maintained without manual adjustments.

Manual Mode

When the ECS MODE switch is in MAN position, the ACS temperature/flow controller adjusts and holds the vent suit temperature valve torque motor in position determined by the SUIT TEMP control knob. In this mode, input from the vent suit temperature sensor is not used by the ACS temperature/flow controller and SUIT TEMP control may have to be adjusted periodically to maintain desired temperature. Also, in this mode the vent suit system can be operated in a wider temperature range.

Q5-23. A vent-air system is used for what purpose?

Q5-24. Where is the vent suit temperature sensor located?

Q5-25. Identify the six major components of a vent-air system.

Q5-26. What are the two modes of operation for a vent-air system?

RADAR LIQUID COOLING SYSTEM

LEARNING OBJECTIVE: Describe the radar liquid cooling system and its components.

The F-18 aircraft radar liquid cooling system (fig. 5-18) circulates liquid coolant to remove heat from the radar transmitter high-voltage RF energy modules. Coolant heated by the transmitter is routed through a closed loop system to a heat exchanger. The heat exchanger converts heated coolant to cooling air. A temperature control valve is integral to the heat exchanger to maintain a minimum coolant temperature level. One of the three sources of air is induced across the heat exchanger to provide coolant temperature control. During normal flight operations, ram air is induced across the heat exchanger by an electrically powered ram air scoop. At high ram air temperature conditions (hot day-low altitude or high speed-high altitude), the ram air scoop is closed by a signal from the air data computer (ADC), and conditioned air from the ACS is delivered to the heat exchanger. For ground operation, with aircraft weight on wheels, a cooling fan supplies cooling air to the heat exchanger. When cooling air is supplied from the ACS, a coolant temperature sensor operates through the

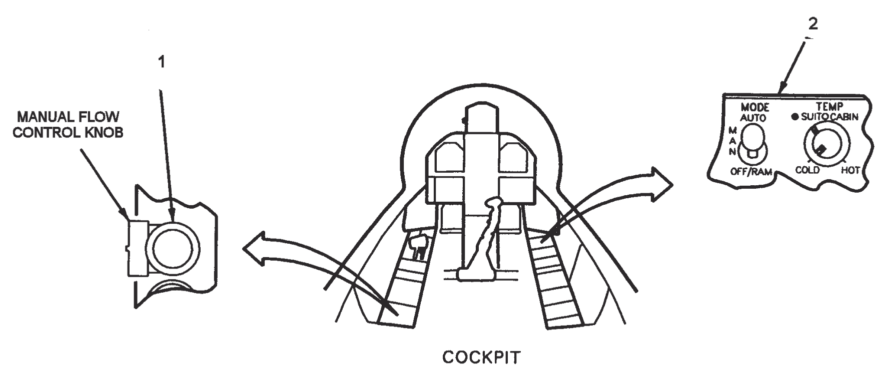


Figure 5-17.—ECS panel assembly, ECS MODE switch suit/cabin temp control.

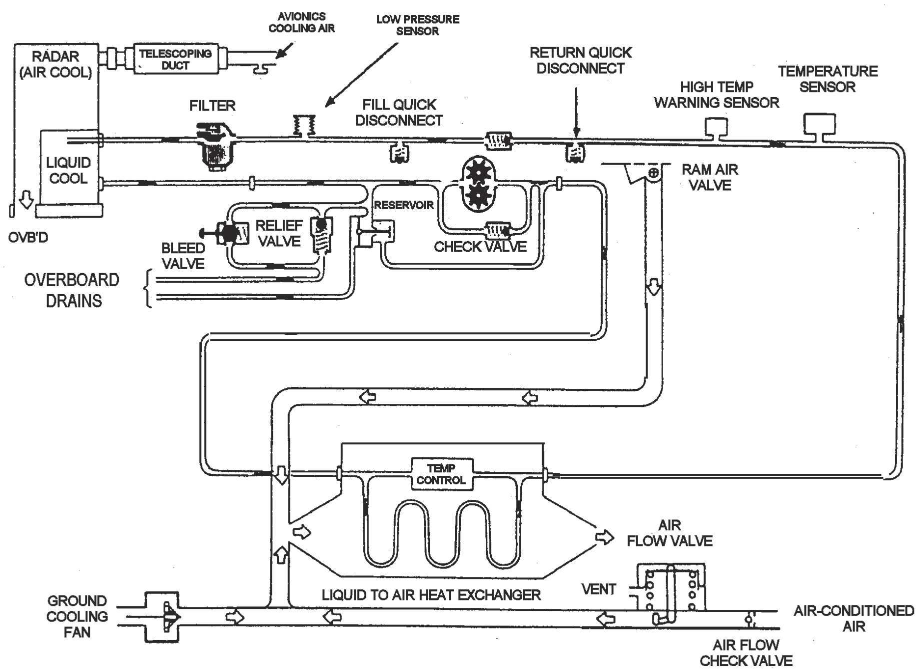


Figure 5-18.—Radar liquid cooling system.

temperature/flow controller to modulate an airflow valve and limit preconditioned air to the heat exchanger. The coolant is filtered and the system monitored for filter contamination, ram air door actuator position, low pressure, high temperature, and coolant quantity.

COMPONENTS

Components of the radar liquid cooling system include a cooling liquid-to-air heat exchanger, a liquid coolant pump, an airflow valve, a ground cooling fan, a filter, a low-pressure sensor, and temperature sensors.

Cooling Liquid-to-Air Heat Exchanger

The liquid-to-air heat exchanger (fig. 5-19, item A) extracts heat from the liquid coolant that flows through the two pass counter flow channels within the heat exchanger. A single-pass air circuit dissipates heat extracted by the heat exchanger. A thermostatic temperature control valve is mounted in the inlet/outlet manifold of the heat exchanger, and senses coolant temperature. The control valve mixes bypass and core fluid to maintain a delivery temperature of 80° to 90°F to the radar transmitter. In the cold position (bypass valve fully closed), a bleed flow of 0.05 to 0.10 gallons per minute (gpm) is provided to aid in purging the core during system servicing.

Liquid Coolant Pump

The liquid coolant pump (fig. 5-19, item B) assembly is a self-priming, submerged, centrifugal pump with a cylindrical two-section reservoir and a fill level gauging mechanism. Air bleeding of the reservoir is done by manually actuating a bleed valve connected to the reservoir. The gauging mechanism in the pump unit combines inputs from coolant temperature and reservoir piston position to change a fluid level indicator on the service panel and produces a signal to the digital display indicator (DDI) to display a low fluid maintenance code.

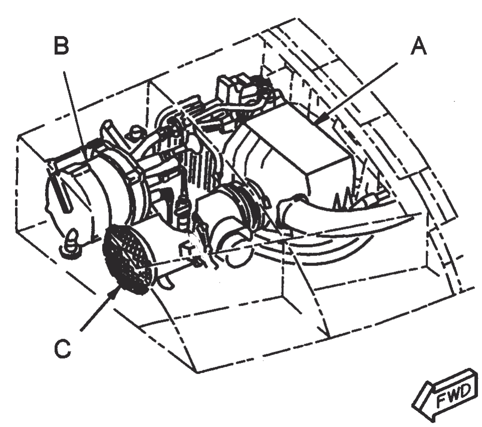


Figure 5-19.—Radar liquid cooling system component locator.

Airflow Valve

The airflow valve (fig. 5-20, item A) is pneumatically modulated to limit, as necessary, conditioned air to the radar liquid cooling liquid-to-air heat exchanger. The ACS temperature/flow controller supplies electrical power to the airflow valve torque motor, which opens or closes muscle pressure to the airflow valve. The airflow valve is spring-loaded closed, and a built-in test is monitored by the ACS temperature/flow controller. If the airflow valve fails, the ACS temperature/flow controller produces a signal to produce a faulty maintenance code in the DDI.

Ground Cooling Fan

The ground cooling fan (fig. 5-19, item C) is electrically powered and supplies a flow of ambient air for heat transfer from the liquid cooling heat exchanger during aircraft ground operations.

Coolant System Filter

Coolant is filtered before passing through the radar transmitter. When the replaceable filter element (fig. 5-21, item A) is contaminated, resulting differential pressure will extend a manually reset indicator on the filter assembly, providing a visual contamination indication.

Low-Pressure Sensor

The low-pressure sensor (fig. 5-20, item B), located in the coolant line, provides a ground to the maintenance status display and recording system until the coolant pressure falls below presets limits. The loss of ground causes a weapon system fail code in the DDI.

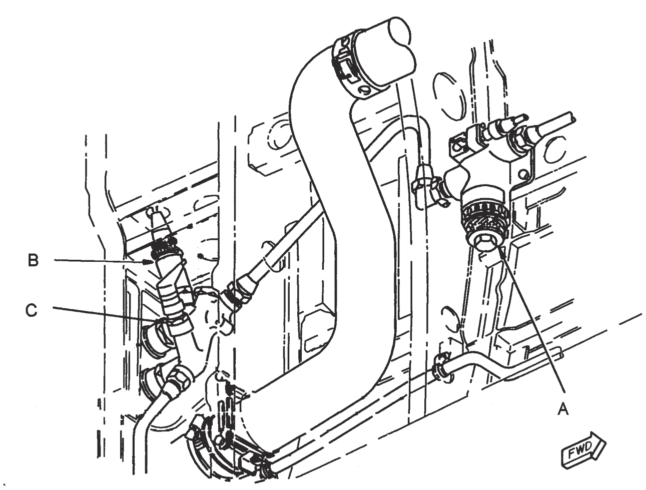


Figure 5-20.—Radar liquid cooling system component locator.

High-Temperature Sensor

The coolant high-temperature sensor (fig. 5-20, item C), located in the coolant line, provides a ground to the maintenance status display and recording system until coolant temperature rises above preset limits. The loss of ground causes a weapon system fail code in the DDI.

Coolant Temperature Sensor

The coolant temperature sensor (fig. 5-21, item B), located in the coolant line, provides coolant temperature reading to the ACS temperature/flow controller, allowing the controller to modulate the airflow valve.

Q5-27. Describe the purpose of the F-18 aircraft radar liquid cooling system.

Q5-28. During ground operation, what component supplies cooling air for the heat exchanger?

Q5-29. Name the eight major components of the radar liquid cooling system.

Q5-30. Describe the operation of the ground cooling fan.

FIRE-EXTINGUISHING SYSTEM

LEARNING OBJECTIVES: Describe a fire-extinguishing system and its components. Identify an auxiliary power unit fire detection and extinguishing system.

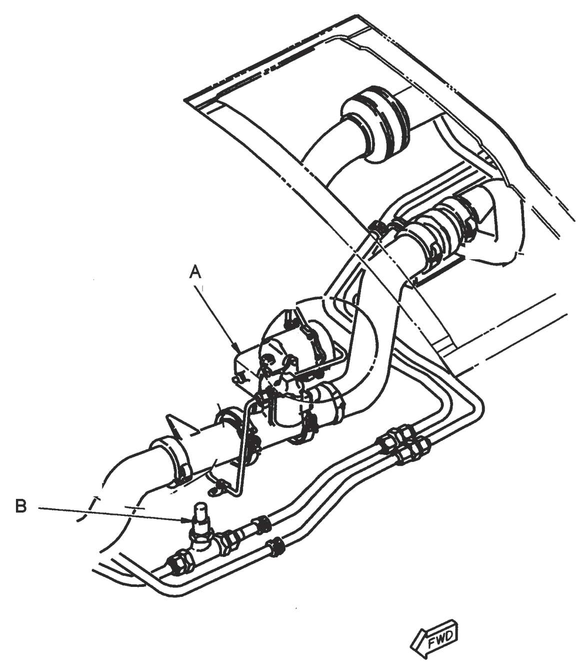


Figure 5-21.—Radar liquid cooling system component locator.

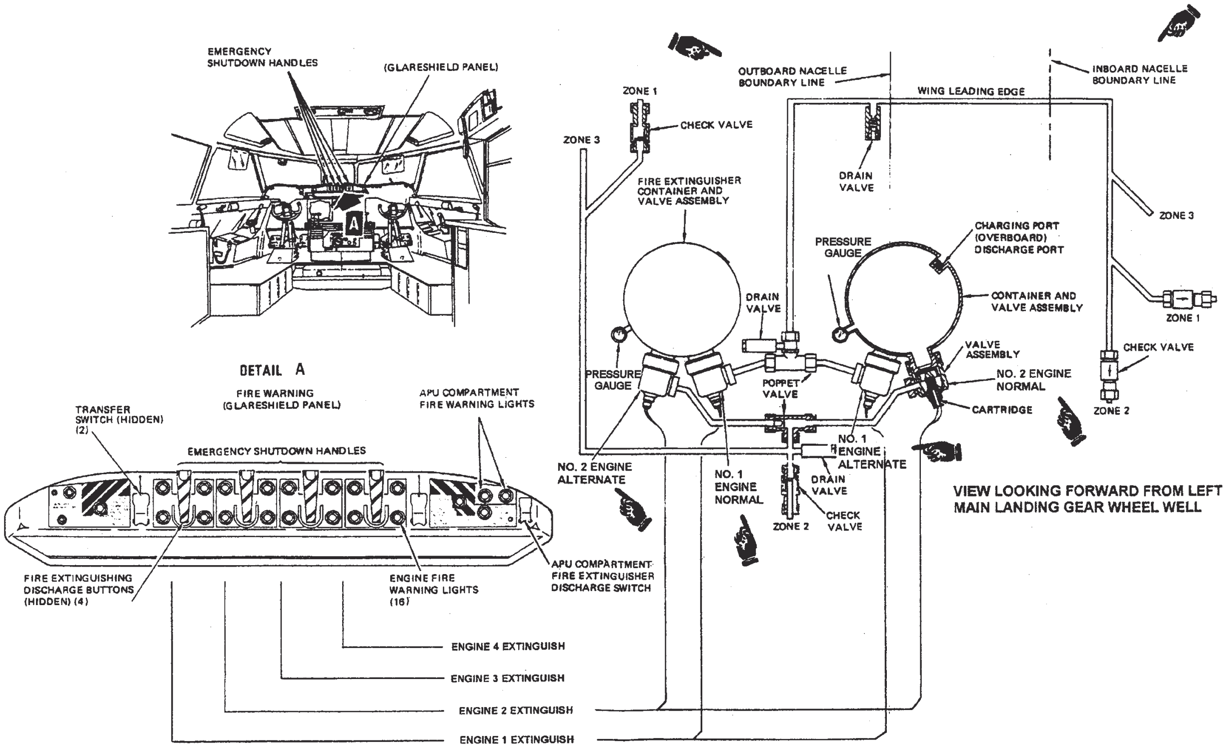


Figure 5-22.—P-3 Engine fire extinguishing system.

CF_3BR (the chemical symbol for triflourobromomethane) is a fluorinated hydrocarbon. It is the most common extinguishing agent used in aircraft fire-extinguishing systems. It is a more efficient extinguishing system than CO_2, and under normal atmospheric pressure and temperature, it is an odorless and tasteless gas. CF_3BR exists as a liquid only when contained under pressure. CF_3BR is nontoxic, non-corrosive, leaves no residue, does not deteriorate with age, is an electrical insulator, and goes farther than CO_2.

NOTE: CF_3BR is very volatile. It is nontoxic, but a danger of suffocation exists because, like carbon dioxide, CF_3BR replaces oxygen when breathed. Among the many fire-extinguishing agents, only CF_3BR will be discussed in this chapter. The P-3 aircraft uses a typical CF_3BR fire-extinguishing system.

The P-3 fire-extinguishing system (fig. 5-22) controls fires within the engines and nacelles and is equipped with two similar independent electrically controlled fire-extinguishing systems, no. 1 and no. 2. One system is used for fire extinguishing in no. 1 and no. 2 engines and nacelles. The second system is used for no. 3 and no. 4 engines and nacelles. Both systems are electrically controlled from the flight station.

Each system utilizes two fire-extinguishing system container and valve assemblies located in the inboard nacelles. The fire-extinguishing system container and valve assemblies are accessible through the main landing gear wheel wells and an access door on the power plant firewall. A pressure gage mounted on each container is visible under a hinged access door on the firewall. Each container is pressurized to 600 (+25, –0) psi and charged with 10.5 (+25, –0) pounds of fire-extinguishing agent. A chart with a minimum pressure versus container temperature curve is shown in table 5-1.

There are no plumbing interconnections between the two fire-extinguishing systems, no. 1 (left wing,

Table 5-1.—Engine and APU Fire Extinguisher Container and Valve Assembly Minimum Pressure Versus Temperature

NOTE

Pressures listed are minimum for known temperature of container to ensure proper operation of the system. Ambient temperature may be used to determine container temperature, if at least 4 hours have elapsed since last engine operation. If pressure gauge reads in excess of 100 psig above minimum, container must be removed not later than next phased inspection. A pressure reading of 50 psig maximum below chart pressure is acceptable for container use.

CONTAINER TEMPERATURE																		
°C	–51	–40	–29	–18	–7	–1	5	10	16	21	27	32	38	43	49	51	60	65
°F	–60	–40	20	0	20	30	40	50	60	70	80	90	100	110	120	130	140	150

no. 1 and no. 2 engine nacelles) or no. 2 (right wing, no. 3 and no. 4 engine nacelles). Each system has only two containers; one container for each engine or two containers for the same engine. Either system is no longer effective for fire extinguishing after the two containers in the system have been discharged. The two main plumbing lines from each container for a system are connected to transfer check valves and then to outlets in the engine fire zones. Installed in the plumbing between container and transfer check valve is a test plug.

COMPONENTS

Fire-extinguishing system components include transfer check valves, drain valves, check valves, and a container assembly.

Transfer Check Valve

A transfer check valve (fig. 5-23, item A) has two inlet ports and one outlet port, and a poppet that shuts off one inlet port. Therefore, only one inlet port is utilized for the direct position, and the other inlet port is used for transfer position. There is no restriction on the outlet port.

Drain Valves

Drain valves (fig. 5-23, item B) are provided in the plumbing immediately forward and aft of each transfer check valve, and when the tubing is routed from an inboard engine to the wing front beam. A drain valve constructed in the same manner as a check valve is spring-loaded to the open position to drain any condensation at the low points in the system plumbing. When a container is discharged, pressure of the agent overcomes the spring force and closes the drain valve, allowing all agents to go to the engine outlets. As pressure is relieved in the tubing, the drain valve opens under spring force.

Check Valve

Each engine nacelle zone has one fire-extinguishing outlet. The outlets for zones 1 and 2 incorporate a check valve (discharge nozzle) (fig. 5-23, item C) installed at the end of the plumbing outlet. Zone 3 has an unrestricted outlet.

Container Assembly

The container (fig. 5-24) is a welded steel sphere approximately 9 inches in diameter, and is cadmium

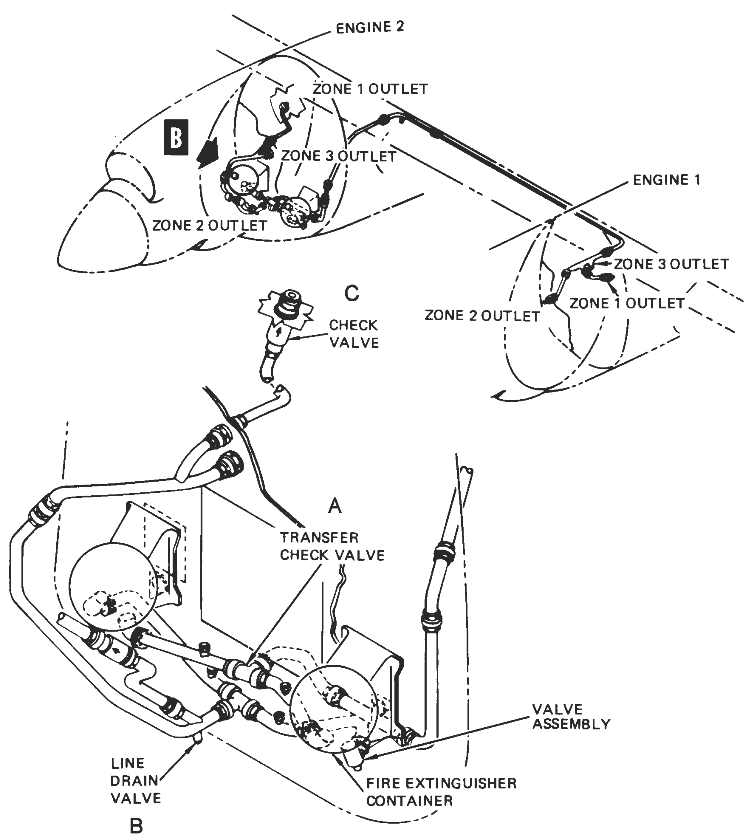


Figure 5-23.—Engine fire extinguishing system schematic diagram.

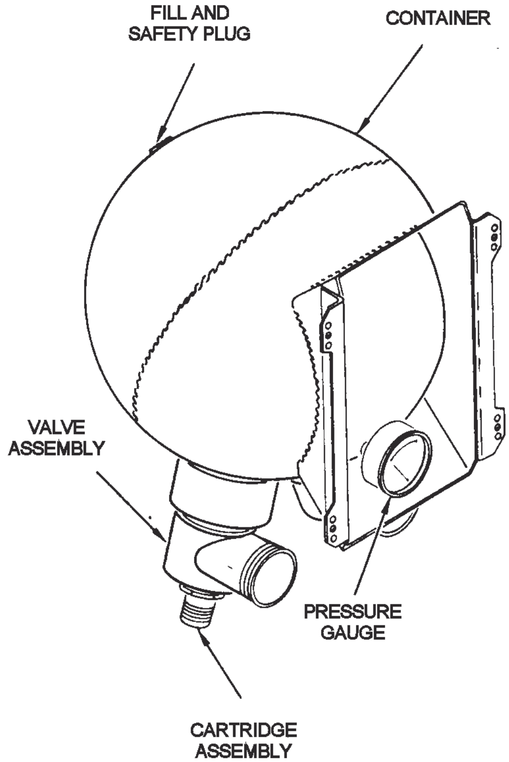


Figure 5-24.—Fire extinguishing system container and valve assembly.

plated for corrosion prevention. The internal volume of the container is 400 (+20, -15) cubic inches. The container is filled with 10.5 (+0.25, -0.00) pounds of fire-extinguishing agent and pressurized with nitrogen to 600 (+25, -0) psi. Total weight of the charge is 10.81 to 11.22 pounds including 0.47 pounds of nitrogen. A mounting bracket, which is welded to the container, attaches to the forward face of the firewall and protrudes through the aft side of the firewall. Each container is equipped with two valve assemblies to discharge a container; however, only one assembly is fired at any one time to discharge a container. Each valve assembly contains a high-temperature electrically controlled dual squib cartridge with a slug attached.

OPERATION

When a fire-extinguishing discharge switch is actuated to complete the circuit, the cartridge is electrically fired to allow its slug to rupture the frangible disc in the neck of a container. A screen adjacent to the disc retains the six frangible disc segments when the cartridge is fired. The extinguishing agent is expelled from the container. A safety disc plug is installed inside the overboard discharge port and has a burst range of 1450 to 1800 psi at 200°F.

There are eight circuit breakers used in the engine fire-extinguishing system. These circuit breakers are located at the forward load center and supply 28 Vdc, when a closed electrical path has been provided through the discharge switch to ignite the cartridges in the fire-extinguishing container and valve assembly.

Four emergency shutdown handles and four fire-extinguishing discharge switches arm and discharge the system. Normally, a discharge switch is not actuated until the respective emergency shutdown handle for that engine has been pulled aft. A protective guard around the switch prevents inadvertent actuation of the discharge button although the switch can be pushed. With an engine fire indicated by the fire warning lights on the fire-extinguishing control panel, the respective and individual emergency engine shutdown handle is pulled aft approximately 6 inches to gain access to the discharge switch for the engine nacelle indicating the fire.

As a specific example, if a fire is indicated in no. 3 engine nacelle, pull no. 3 engine emergency handle aft and press the no. 3 engine fire-extinguishing discharge button. If the fire persists and it becomes necessary to discharge the second container of the same fire-extinguishing system into no. 3 engine nacelle, the transfer switch, which is guarded and shear-wired in the DIRECT TO ENGINES position, must be set to TRANSFER TO ADJACENT ENGINES, and the no. 3 engine fire-extinguishing discharge button must be pressed again. This action electrically ignites the cartridge in the transfer container valve assembly of the second fire-extinguishing container in that system.

The rate of discharge of a fire-extinguishing system is approximately 0.4 seconds. All containers, distribution lines, nozzles, and fittings are of stainless steel.

AUXILIARY POWER UNIT (APU) FIRE DETECTION AND EXTINGUISHING SYSTEM

The APU compartment fire detection and extinguishing system provides automatic fire control on the ground and in flight. The automatic system is backed up by audible and visual warnings and manual release of the extinguishing agent. The warning light and MAN REL AUX PWR UNIT EXTINGUISHER switch are located adjacent to the no. 4 nacelle discharge switch on the glareshield APU FIRE WARNING AND EXTINGUISHER panel. In addition to the flight station warning horn, another identical horn is located at the main load center, which is operable on the ground only. The automatic extinguisher system is a dual channel system energized from the detector signal. The primary channel fires a dual cartridge squib by means of a limit switch that actuates when the APU exhaust door is fully closed (approximately 15 seconds is required for exhaust door closure). If the primary channel fails to operate, the secondary channel, through a time delay relay, fires the cartridge in approximately 20 seconds. The glareshield-mounted MAN REL AUX PWR UNIT EXTINGUISHER switch may be used to energize both fire extinguisher channels and thus bypass the detector system. In addition to operating the warning light, horns, and extinguisher automatic discharge, the detector system also provides output signals to accomplish complete electrical shutdown of the APU. This includes intake and exhaust door closure, fuel valves closed, fuel pumps off, and ignition circuit deenergized. The fire detector is armed from the aircraft ac-dc distribution system at all times that the aircraft generator or ground power is available. In the absence of ac power, the detector is armed from the aircraft battery. The detector is disarmed when the battery is disconnected. A maintenance switch accessible through an access door may disarm the detector and the extinguisher functions. Closure of the access door rearms the system. An APU TEST switch is mounted adjacent to the four nacelle test switches on the overhead panel in the cockpit. Upon setting the APU TEST switch, the fire warning lights will come on and the horn will sound, indicating the system is working properly.

Q5-31. Under normal atmospheric pressure and temperature, describe the characteristics of CF_3BR.

Q5-32. How many independent fire-extinguishing systems does a P-3 aircraft use?

Q5-33. List the different ports for a transfer check valve.

Q5-34. What is the internal volume of a P-3 fire-extinguishing container?

Q5-35. Describe the procedures if a fire is indicated in no. 3 engine nacelle.

Q5-36. Describe the purpose of an auxiliary power unit.

Q5-37. What is/are the indication(s) given if a fire is present in the APU?

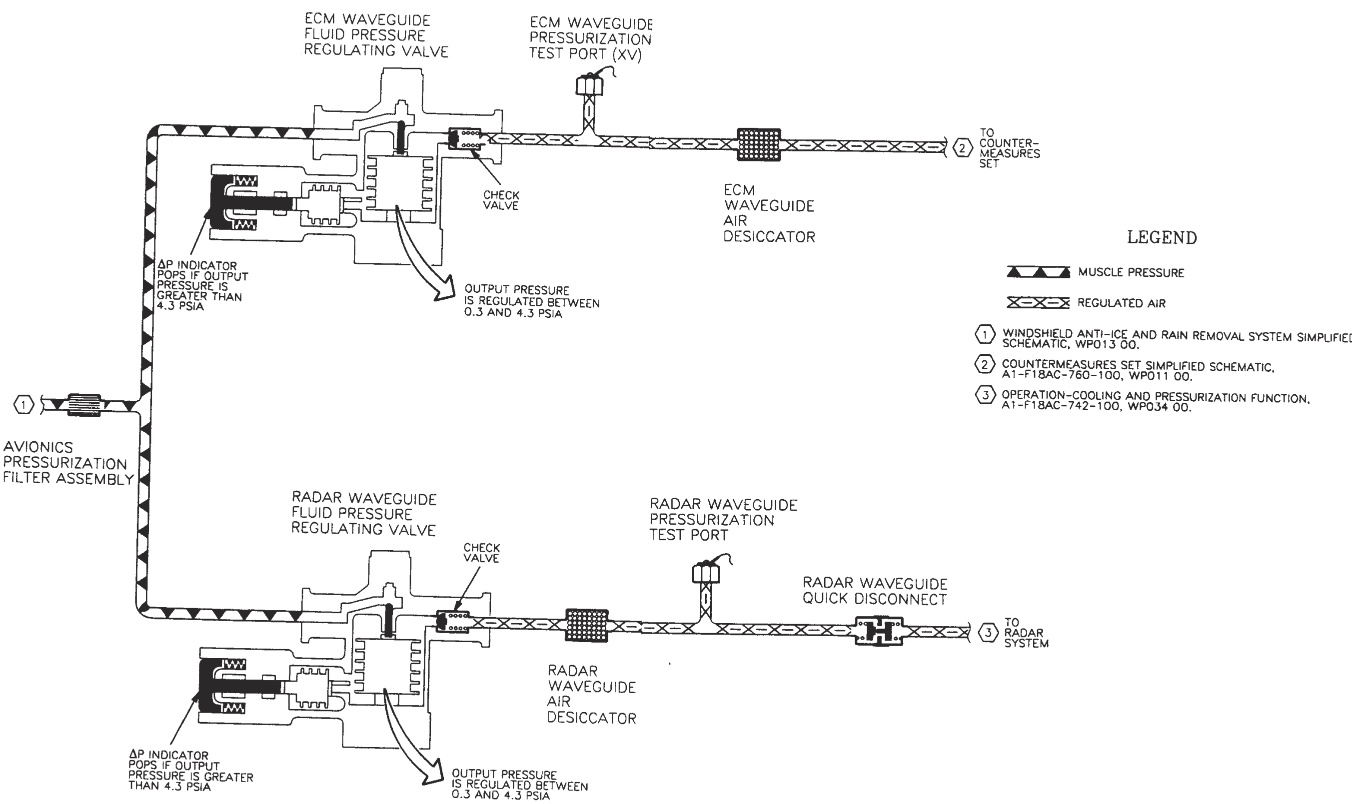


Figure 5-25.—Waveguide pressurization system.

WAVEGUIDE PRESSURIZATION SYSTEM

LEARNING OBJECTIVE: Identify the waveguide pressurization system and its components.

The purpose of the F-18 waveguide pressurization system (fig. 5-25) is to contain and transport the regulated, filtered, dry air to the radar and electronic countermeasures (ECM) waveguide cavities.

COMPONENTS

The waveguide pressurization system is made up of a filter, two pressure regulating valves, two desiccators, two ground test ports and tubing.

Avionics Pressurization Filter Assembly

The avionics pressurization filter assembly (fig. 5-26, item A) in the nose wheelwell is made up of a filter element and a relief valve. During normal operation, regulated muscle pressure from the flow/temperature limiting anti-ice modulating valve (windshield anti-ice/rain removal system) passes through the filter element, which removes 100 percent of particles larger than 25 microns and 98 percent of particles larger than 10 microns. When the filter element is contaminated, a pressure differential of 4 to 5 psi will open a relief valve and bypass air around the filter element without interrupting system operation.

Waveguide Fluid Pressure Regulating Valve

The ECM (fig. 5-26, item B) and radar (fig. 5-26, item C) waveguide pressure regulating valves are located in the nose wheelwell and function identically. One is for the ECM waveguide and the other is for the radar waveguide. These waveguide fluid pressure regulating valves receive filtered muscle pressure airflow and regulate this airflow from 0.3 to 4.3 pounds per square inch absolute (psia) outlet pressure. Each waveguide fluid pressure regulating valve has two aneroid assemblies to regulate air pressure. Primary aneroid assembly force is balanced against spring force through an orifice on which a ball is seated. An auxiliary aneroid assembly functions as an added adjustment and as a trigger assembly to allow internal pressure relief to atmosphere if regulated pressure exceeds 4.3 psia. A resettable indicator is visible when an overpressure condition has occurred. A check valve next to the outlet port of the waveguide fluid pressure regulating valve closes to maintain waveguide pressure during an overpressure condition.

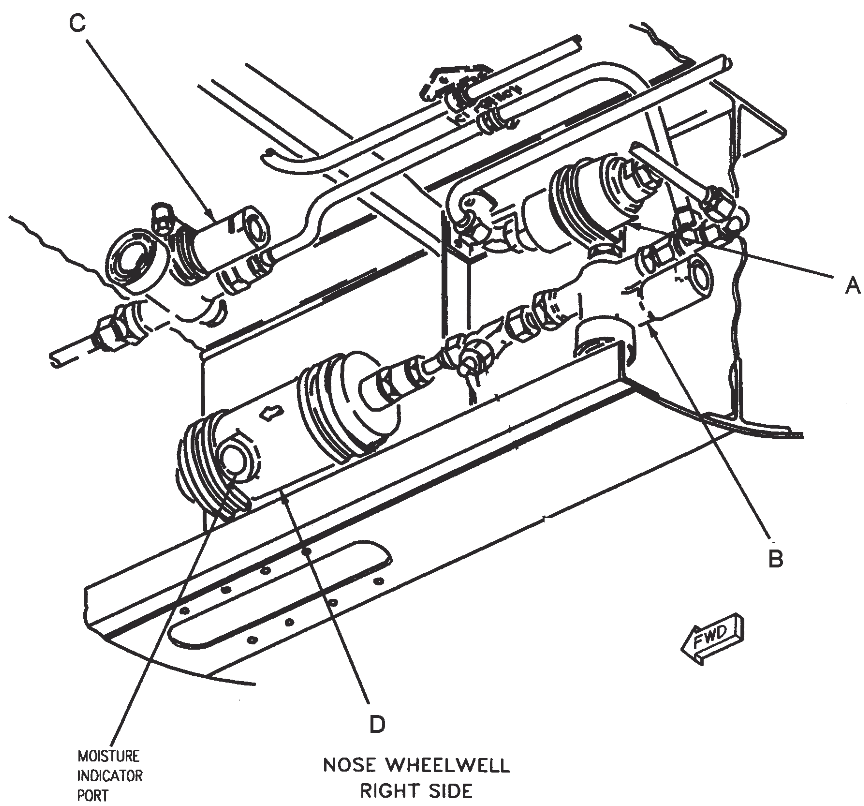


Figure 5-26.—Waveguide pressurization system component locator.

Air Desiccators

There are two waveguide air desiccators in the system. One is for ECM (fig. 5-26, item D) and one is for radar (fig. 5-27). They are located downstream from the waveguide fluid pressure regulating valves. The waveguide air desiccators contain a blue desiccant and silica gel material, which absorbs moisture as airflow passes through the waveguide air desiccators. When the desiccant and silica gel material becomes saturated with moisture, the material color changes from blue to pink. The silica gel is visible through a moisture indicator port on the housing of the waveguide air desiccators.

Test Ports

The waveguide pressurization system has two test ports: one for ECM and one for radar. The test ports are located downstream from the regulators and are used as gauge connection points when testing system pressure.

OPERATION

The waveguide pressurization system provides regulated, filtered dry air to the ECM and radar waveguide cavities. The waveguide fluid pressure regulating valves controls this air pressure. Each waveguide fluid pressure regulating valve has an indicator that pops out and vents downstream pressure in excess of 4.3 psia. The indicator remains popped until manually reset. The system functions automatically whenever source air pressure (muscle pressure) is on.

Q5-38. What is the purpose of an F-18 waveguide pressurization system?

Q5-39. What percentage of particles will the filter assembly remove if they are 25 microns or larger?

Q5-40. The waveguide pressure regulating valve has how many aneroid assemblies to regulate air pressure?

MISSILE LIQUID COOLING SYSTEM

LEARNING OBJECTIVE: Identify the operating principles and maintenance safety precautions for the missile liquid cooling utility system.

The missile liquid cooling system in the F-14 aircraft provides thermal conditioning for the radar system of the weapon control system (WCS) and missile. The temperature control system consists of a WCS cooling loop for the radar system and a missile cooling loop for the missile system; both loops are controlled by a common controller. In each loop, a motor-driven pump circulates a dielectric coolant fluid. The fluid is filtered to remove air, moisture, and foreign matter. The right Phoenix missile fairing (fig. 5-28) contains the missile coolant pump assembly and the missile-air-moisture contaminant remover. When the missile cooling loop is not required, the fairing is removed from the aircraft. The ultimate heat sink is ram air and/or refrigeration system air for cooling; hot air from the bleed manifold 400°F temperature control system provides heating. The WCS/missile temperature control system also uses cooling air from the ground cooling system when ground operation is required.

COMPONENTS

Components of the missile liquid cooling system include a cold and a hot air modulating valve, an air-to-coolant heat exchanger, a coolant pump, a coolant fluid expansion tank, a bypass valve, an air-moisture-contaminant remover, a missile controller, a coolant temperature sensor, a fairing interlock switch, and a liquid cooling control panel.

Missile Cold Air Modulating Valve

The cold air modulating valve (fig. 5-29) is mounted on the air-to-coolant heat exchanger. The

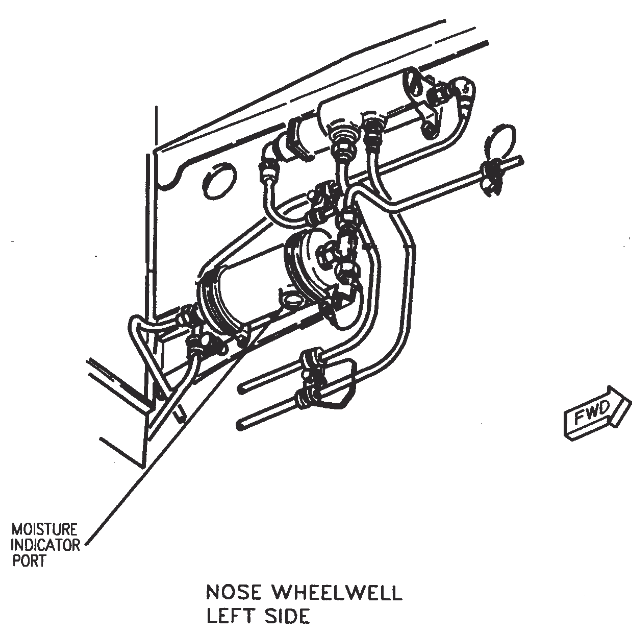


Figure 5-27.—Radar air desiccator.

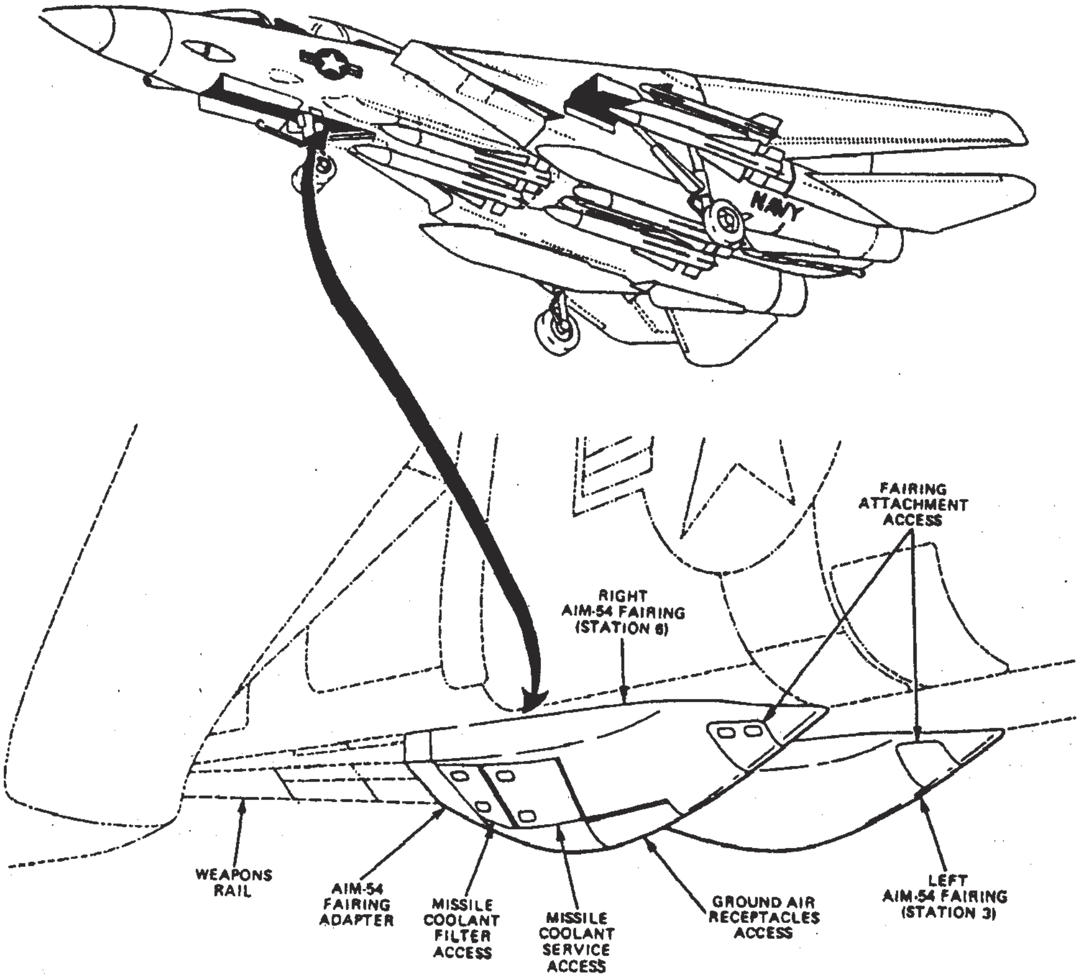


Figure 5-28.—Missile fairing.

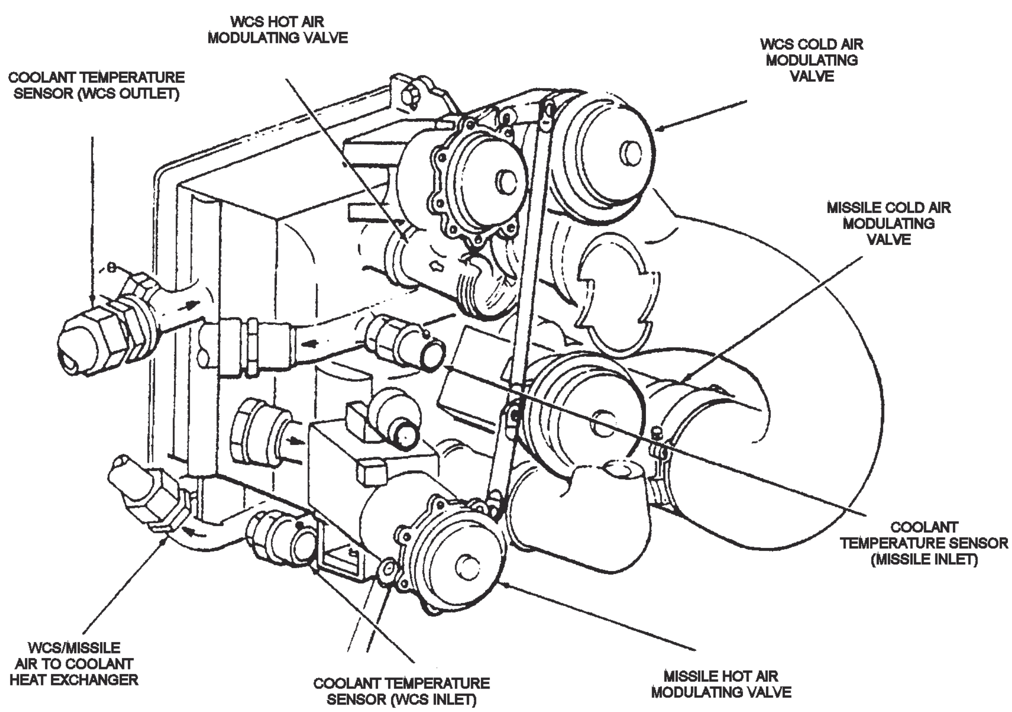


Figure 5-29.—Missile cooling system component locator.

valves modulate the flow of refrigeration system air to their respective heat exchanger section in response to electrical signal from the WCS/missile controller. The valve has a butterfly, a diaphragm-type pneumatic actuator that is mechanically linked to the butterfly, an electro-magnetic torque motor, and butterfly position switches. Electrical signals from the missile controller govern the torque motor, which allows regulated air pressure to be vented. The smaller the amount of air pressure vented, the larger the valve opening. If the electrical power of air pressure is interrupted, the valve closes.

Missile Hot Air Modulating Valve

The missile hot air modulating valve (fig. 5-29) is mounted on the air-to-coolant heat exchanger. The valve modulates the flow of hot air from the 400°F bleed manifold temperature control system in response to electrical signals from the controller. The hot air heats the coolant during system warm-up. The operation of the valve is the same as the missile cold air-modulating valve.

Missile Air-to-Coolant Heat Exchanger

The air-to-coolant heat exchanger (fig. 5-29) consists of two sections: weapons control system (radar) loop, and missile loop. The heat exchanger is similar to an automobile radiator. The coolant flows though the core while air flows around the core. When the radar portion of the heat exchanger is being used, the missile cold and hot air modulating valves are closed to prevent reverse flow through the missile section.

Missile Coolant Pump

The coolant pump (fig. 5-30) is a single-stage, centrifugal pump driven by a low-slip, two-pole induction motor. When the pump is operating, it circulates 18 gallons of coolant per minute through the system. The pump is lubricated and cooled by a small portion of the coolant, which is circulated through the motor. A pressure switch in the pump outlet opens when the pump output pressure drops to 60 ±5 psi. The pressure switch causes the MSL COND (missile

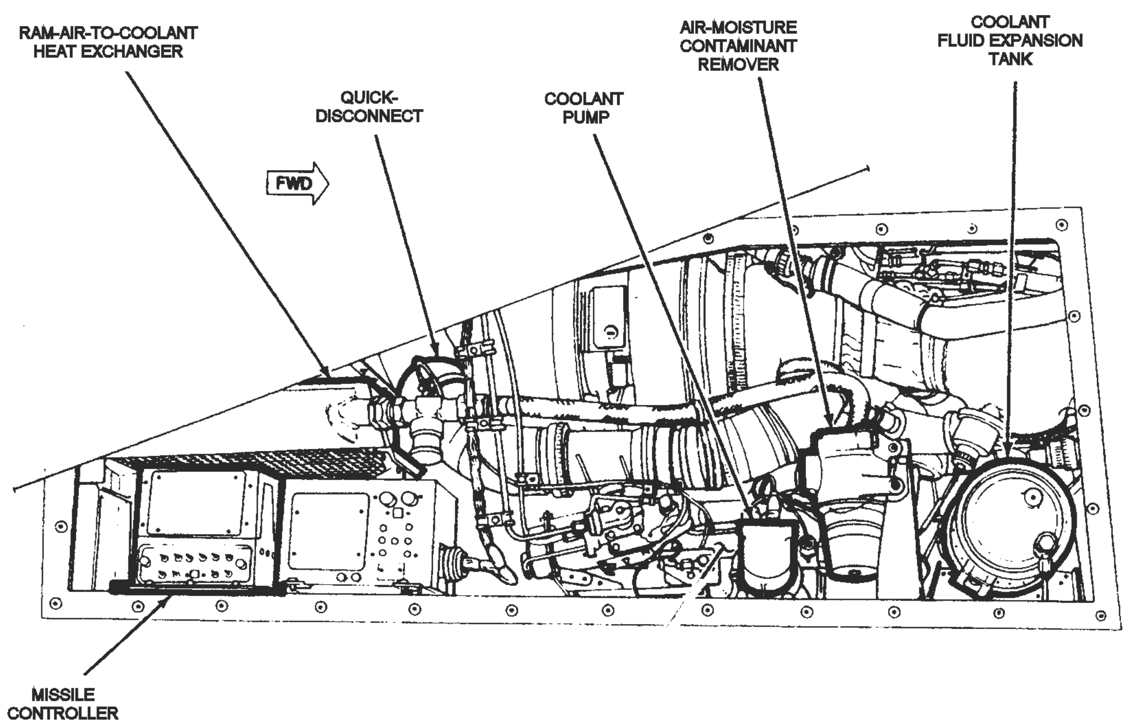


Figure 5-30.—Missile cooling system component locator.

condition) advisory light to illuminate. Also, a thermal switch will open when 230° ±5°F is reached. This switch causes the pump to stop and also illuminates the MSL COND light. The coolant pump is located in the right Phoenix fairing.

Coolant Fluid Expansion Tank

The expansion tank (fig. 5-30) is located in the right Phoenix fairing. The tank maintains a constant coolant fluid pressure at the pump inlet, accommodates thermal expansion of the coolant, and provides a coolant reserve for the missile loop in case of leakage. The tank has a bellows, fluid sight and level indicator, fluid relief valve, and a pneumatic pressure indicator. The bellows is pressurized to maintain a positive fluid pressure of 30 to 70 psi at the pump inlet. Should pressurization reach 45 ±2.3 psi, the fluid pressure relief valve will open and vent fluid. The fluid sight and level indicator displays fluid level, and the pneumatic pressure indicator extends to indicate air pressure by temperature degrees.

Missile Bypass Valve

The missile bypass valve is used to bypass the missile when the fluid pressure within the missile reaches 89 +0, -5 psi. When the condition exists, the bypass valve opens. This allows a portion of the coolant fluid to flow from the supply line to the return line without passing through the missile.

Missile Air-Moisture-Contaminant Remover

The remover (fig. 5-30) is mounted in the right Phoenix fairing. It removes air, moisture, and foreign particles from the coolant, but it does not remove standing water. The remover consists of a cleanable filter element, a replaceable removal cartridge, a fail-safe valve and indicator, a relief valve, and an automatic shutoff valve. If the removal cartridge fails, the fail-safe valve prevents coolant loss by securing the air-water removal overboard port. If this occurs, a yellow indicator button is released to warn of cartridge failure.

If the pressure drop across the filter element exceeds 16 ±3 psi, the red differential pressure indicator button extends to warn of a clogged filter. If the pressure drop exceeds 21 to 25 psi, the relief valve passes coolant around the filter element. When the filter bowl is removed, an automatic shutoff valve closes to prevent loss of coolant.

Missile Controller

The controller (fig. 5-30) is the brain of the liquid cooling system. It receives electrical input from the sensors and controls component operation. It keeps the hot and cold modulating valves from opening at the same time. The controller also provides electrical signals to the naval flight officer (NFO) caution advisory indicator.

Coolant Temperature Sensor

Two sensors are located in the cooling loop. The sensors are isolated from the coolant by being installed in wells that are filled with thermal grease. Both sensors are identical in construction, but each has a different purpose in the system. One sensor is mounted in the missile return line. The other sensor is in the missile supply line of the missile loop. Each sensor contains two sensing elements. One performs the primary sensing function, and the other is used for the built-in test (BIT).

Fairing Interlock Switch

The fairing interlock switch provides an electrical connection for the missile coolant pump motor and pressure switch circuits. The switch is closed when the Phoenix fairing is installed.

Liquid Cooling Control Panel

The liquid cooling control panel is located on the NFO's left side console. When the liquid coolant switch is set to the AWG-9/AIM-54 position, it activates both the radar and missile cooling loops of the system.

The functional relationship of the components is represented in figure 5-31.

OPERATION

Setting the LIQ COOLING (liquid cooling) switch to the AWG-9/AIM-54 position starts the missile coolant pump motor. The pump circulates 8 gallons of coolant per minute through the missile air-moisture-contaminant remover, the missile section of the WCS/missile air-to-coolant heat exchanger, the weapons rails, left and right pylon, missile launchers, and through as many as six Phoenix missiles. The heat absorbed by the coolant from the missiles is removed in the air-to-coolant heat exchanger. When the loop is operating in the cooling mode, the missile inlet coolant temperature sensor controls the fluid temperature at 70° ±3°F by opening or closing the cold air modulating valve. The valve varies the amount of cold air flowing from the refrigeration system through the missile heat exchanger.

When the temperature of the coolant fluid returning from the missile is below 40° ±3°F, as sensed by the missile outlet coolant temperature sensor, the cooling system automatically switches to the warm-up mode. In this mode, the cold air modulating valve closes and the hot air modulating valve opens. This valve varies the amount of hot air from the 400°F bleed manifold temperature control system used to warm the coolant fluid.

When the heat exchanger outlet fluid temperature reaches 104° ±4°F and the missile outlet fluid temperature reaches 85° ±3°F, the hot air modulating valve will close. This prevents the cold and hot modulating valves from being open simultaneously.

The missile supply line sensor, located at the outlet of the heat exchanger, is also used to sense an over-temperature condition. If the coolant temperature exceeds 115° ±3°F, the missile condition (MSL COND) advisory indicator light illuminates. The hot or cold air-modulating valve will close. If the missile pump pressure drops to 60 ±5 psi, a pressure switch causes the MSL COND light to illuminate. If coolant pressure downstream of the coolant pump increases to 89 ±5 psi, the missile bypass valve opens to return the fluid to the pump inlet.

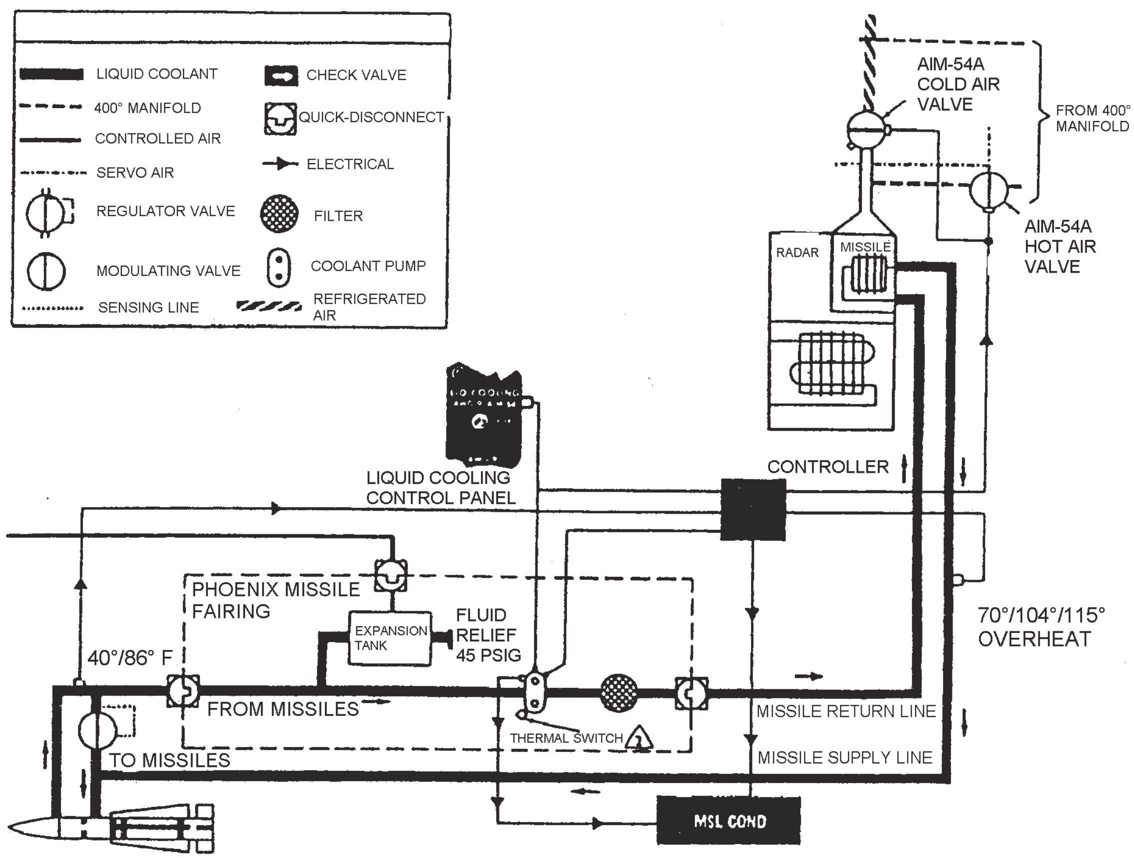


Figure 5-31.—Missile cooling system.

MAINTENANCE SAFETY PRECAUTIONS

The Phoenix missile requires a completely contaminant-free cooling system. Keeping the system clean requires the use of toxic fluids that must be used with special care. It is important to handle this system with the same care as you would handle an oxygen system. The following information is of special interest and should be kept in mind when working on this system.

- If more than 1 gallon of coolant is required to fill the expansion tank, you should flush and refill the system, using the liquid coolant service unit (LCSU). For detailed LCSU operating procedures, you should refer to the applicable MIM.

- The cooling system should only be serviced with Flo-cool 180, Coolanol 25, or Coolanol 25-R. If you use another type of coolant, you may damage the missile components. It is a requirement that you wear a respirator or work in an area with forced ventilation while working with these coolants. Additionally, you must wear chemical splash-proof goggles and gloves.

- When you use trichlorotrifluoroethane, MIL-C-81302, type I or II, to clean fittings and hoses, exercise extreme caution. You must wear a respirator and chemical splash-proof goggles and gloves. The task should be performed in an area with forced ventilation. Smoking is prohibited in the area where the chemical is being handled. Keep trichlorotrifluoroethane from coming in contact with your skin, eyes, and clothes. Do not breathe the toxic vapors.

- To prevent contamination of the temperature control system and possible damage to its components, absolute cleanliness of your equipment, work area, and coolant must be maintained. You should ensure the dust caps, flushing jumpers, hoses, and bleed lines are thoroughly cleaned with trichlorotrifluoroethane and lint free cloth. The cleaned components should be air dried before installation. Do not allow O-ring seals to soak in cleaning fluid before or after cleaning because this will cause hardening of the O-rings and premature failure.

- When adding coolant with the fluid make-up unit, add the coolant slowly. Rapid pumping may cause the pressure relief valves on the make-up and in the aircraft to open.

- Coolant spilled on the aircraft can damage the paint. Spillage should be wiped up immediately. Spillage on a coaxial cable may cause the cable to come apart.

- To take a coolant sample, the coolant must have been circulated for at least 5 minutes by the aircraft powered pump. This circulation ensures that the sample will be representative of coolant in the entire system. The sample should be taken from the AIM-54 supply bleed port.

Q5-41. Describe the purpose of the missile liquid cooling system.

Q5-42. What is the purpose of the missile hot air modulating valve?

Q5-43. The coolant pump circulates what amount of coolant per minute?

Q5-44. What type of protective measures must you take when servicing the missile liquid cooling system?

Q5-45. Prior to taking a coolant sample, the coolant must have circulated for what amount of time?

CHAPTER 5

ANSWERS TO REVIEW QUESTIONS

A5-1. Air-conditioning, pressurization systems, electronic cooling, windshield washing, anti-icing, and anti-g systems

A5-2. 125 psi

A5-3. Consists of four loops of bleed air leak sensing elements located close to the auxiliary power unit, bleed air ducts, and an engine start port leak detector located near the engine ground start port

A5-4. In normal operation, when the temperature of a section or short segment of the sensing element exceeds 255°F, the chemical in the tube conducts electric current, which completes a transformer circuit to ground similar to the test relay. The indicator light on the annunciator panel will come on to indicate the loop is overheating.

A5-5. Bleed air leak detector control, bleed air leak sensing elements, and an engine start port leak detector

A5-6. Two

A5-7. An anti-icing system is designed to prevent ice from forming on the aircraft. A deicing system is designed to remove ice after it has formed.

A5-8. Electrical heaters, hot air, or a combination of both

A5-9. Shutoff valves, modulating valves, thermostats, and leading edge skin temperature indicator and overheat circuit caution light circuit

A5-10. When the bleed air valve is open 2 degrees or more

A5-11. To provide airflow over the external surface of the windshield for rain removal and windshield anti-icing

A5-12. Warm air temperature control valve, warm air temperature sensor, flow/temperature limiting anti-ice modulating valve, warm air over-temperature sensor, anti-ice/rain removal air control regulating valve, windshield overheat temperature sensor, and windshield anti-ice/rain removal switch

A5-13. Warm air temperature control valve

A5-14. WINDSHIELD ANTI-ICE/RAIN removal switch

A5-15. 50 percent water-methyl alcohol mixture

A5-16. Solenoid-operated valve

A5-17. The relief valve inside the windshield-washing shutoff valve opens and pressure in the tank is reduced.

A5-18. 1 1/2 gallons

A5-19. Reduces the fatiguing effect of repeated exposure to positive or negative g-forces, also provides a method by which the crewmember can relieve fatigue and physical tension during extended flight

A5-20. Anti-g valve, anti-g system filter, and quick disconnects

A5-21. 10 psi

A5-22. As high-g conditions occur, the anti-g valves activating weight is forced down to close the exhaust valve and open the demand valve. This allows cooled engine bleed air from the refrigeration system service heat exchanger to flow through the anti-g valve, where it is regulated, to inflate the g-suit. Pressure to the g-suit is varied in proportion to the g-force acting upon the aircraft and crewmembers, to a maximum of 10 psi. As g-forces decrease, the activating weight is forced upward by spring tension. This reduces the pressure of the airflow to the g-suit and exhausts excess suit pressure into the cabin. As this occurs, the demand valve closes, blocking air from the g-suit.

A5-23. Provides a measure of personal comfort, offsetting the discomfort caused by the wearing of the anti-exposure suit or heat created by cockpit equipment and resulting high-temperature ambient air

A5-24. In a manifold downstream of the vent suit temperature valve

A5-25. Vent suit temperature valve, over-temperature sensor, pressure regulating valve, pressure relief valve, and air hose assembly

A5-26. Automatic and manual

A5-27. Circulates liquid coolant to remove heat from the radar transmitter high-voltage RF energy modules

A5-28. Ground cooling fan

A5-29. Cooling liquid-to-air heat exchanger, liquid coolant pump, airflow valve, ground cooling fan, coolant system filter, low-pressure sensor, high-temperature sensor, and coolant temperature sensor

A5-30. The ground cooling fan is electrically powered and supplies a flow of ambient air for heat transfer from the liquid cooling heat exchanger during aircraft ground operations.

A5-31. It is a more efficient extinguishing system than CO_2, and under normal atmospheric pressure and temperature, it is odorless and tasteless.

A5-32. Two

A5-33. Two inlet ports and one outlet port, and a poppet that shuts off one inlet port

A5-34. 400 (+20, -15) cubic inches

A5-35. If a fire is indicated in no. 3 engine nacelle, pull no. 3 engine emergency handle aft and press the no. 3 engine fire-extinguishing discharge button. If the fire persists and it becomes necessary to discharge the second container of the same fire-extinguishing system into no. 3 engine nacelle, the transfer switch, which is guarded and shear-wired in the DIRECT TO ENGINES position, must be set to TRANSFER TO ADJACENT ENGINES, and the no. 3 engine fire-extinguishing discharge button must be pressed again. This action electrically ignites the cartridge in the transfer container valve assembly of the second fire-extinguishing container in that system.

A5-36. Provides detection and extinguishing for the APU compartment on the ground and in flight

A5-37. A horn sounds and a warning light illuminates

A5-38. To contain and transport the regulated, filtered, dry air to the radar and electronic countermeasures (ECM) waveguide cavities

A5-39. 100 percent

A5-40. Two

A5-41. To provide thermal conditioning for the radar system of the WCS and missile

A5-42. The valve heats the coolant during system warm-up

A5-43. 18 gallons

A5-44. Respirator or an area with forced ventilation, and chemical splash-proof goggles and gloves

A5-45. 5 minutes

CHAPTER 6

AIR-CONDITIONING AND PRESSURIZATION SYSTEMS

The combined pressurization system and air-conditioning of the cabin is the function of the aircraft pressurization and air-conditioning system, now in all naval aircraft. The inspection and maintenance of this system is one of the important duties of the AME.

EARTH'S ATMOSPHERE

LEARNING OBJECTIVE: Recognize the effect high-altitude flight could have on flight personnel because of decreased atmospheric pressure.

Transferring a human being from their natural environment on the Earth's surface to the environment at 40,000 feet places them in surroundings in which they cannot survive without artificial aids. Even at half that altitude, breathing becomes very rapid, and above 25,000 feet, unconsciousness occurs, quickly followed by death. A brief study of Earth's atmosphere tells us why this condition exists.

The envelope of atmosphere surrounding the Earth is a gaseous mixture consisting chiefly of nitrogen and oxygen. There are traces of other gases, but they have no significance as far as body functions are concerned. Chemical analysis has shown that the proportions of nitrogen and oxygen are constant throughout the thickness of the atmosphere, up through 200,000 feet or more.

ATMOSPHERIC PRESSURE

Although the chemical content of the atmosphere remains fairly constant, the density (mass per unit volume) of the atmosphere varies with altitude. At 18,000 feet, the density is about one-half of the density at sea level, and at 36,000 feet, it is only about one-fourth of the density at sea level. The atmospheric pressure also varies with altitude. The pressure exerted by the atmosphere may be compared to the pressure of a column of water. If holes are made in the container of the column, the force with which the water spurts out of the upper holes will be considerably less than that at the bottom of the column. Similarly, the pressure exerted by the atmosphere is much greater near the surface of the Earth than it is at high altitudes. For example, the pressure of the atmosphere at sea level is 14.7 pounds per square inch (psi), while the pressure at 40,000 feet above sea level is 2.72 psi, and at 60,000 feet is 1 psi.

As an aircraft ascends to higher altitude, the resulting decrease in atmospheric pressure may affect flight personnel in several ways. The most noticeable effect is in breathing.

Breathing is a mechanical process that depends heavily on atmospheric pressure. When a person inhales, they automatically raise their ribs and depress their diaphragm so that the chest cavity is enlarged. This reduces the air pressure within the cavity below that of the atmosphere outside. Air is thus pushed into the lungs. When they exhale, they reduce the chest cavity, increasing the pressure within it. This pushes the air out of the lungs.

When low atmospheric pressures are encountered, the lungs are not filled so completely when inhaling. With lower density, a person gets fewer molecules of air in each breath. If they get fewer molecules of air in each breath, they also get fewer molecules of oxygen, and no person can live unless they get a sufficient amount of oxygen.

This problem may be solved up to certain altitudes by the proper use of oxygen equipment; however, at extremely high altitudes (above 35,000 feet), the atmospheric pressure is so low that the pressure of the blood and other liquids in the body are no longer balanced. The human body then tends to burst. In some cases, blood vessels near the surface may burst, causing hemorrhages in the ears, eyes, and breathing passages.

The outside air temperature also changes with altitude. For example, at approximately 18,000 feet, the outside air temperature will be –4°F (–20°C), and at approximately 37,000 feet the outside air temperature will be –67°F (–55°C). Above 37,000 feet, the air continues to thin, but the air temperature will remain constant for several miles and then begin to rise slowly. Thus, the lowest outside air temperature to be encountered by an aircraft could occur at a height of about 7 miles.

NOTE: To convert Fahrenheit to Celsius (centigrade), use 5/9(F–32).
For example, –4°F is converted as: 5/9(–4 – 32) = 5/9 X –36 = –20ºC.

Celsius to Fahrenheit is converted using 9/5°C + 32.
For example, –55°C is converted as: 9/5(–55) + 32 = –99 + 32 = –67°F.

The aircraft manufacturer considers these variations in outside air temperature and atmospheric pressure when designing the aircraft.

ATMOSPHERIC CONSIDERATIONS

Pressurization and air-conditioning of aircraft are necessary at high altitudes. With operational ceilings now in excess of 50,000 feet, flight personnel, and in some cases aircraft components, are supplied with an artificial means of maintaining a reasonable pressure around the entire body and/or equipment. This is done by sealing off the entire cabin/cockpit and any equipment area that may require pressurization and maintaining an inside air pressure equivalent to that at substantially lower altitudes. This is known as a pressurized cabin, cockpit, or compartment, as applicable.

In addition to pressurizing them, the cabin, cockpit, and some compartments are also air-conditioned, if the aircraft is to fly at high speeds. This requirement is partly due to the difference in temperatures at various altitudes and also to aerodynamic heating. For example, an aircraft flying at supersonic speeds at an altitude of 35,000 feet may generate a temperature on its skin of 200°F, and twice that temperature at altitudes near sea level.

In addition to aerodynamic heating, other factors affecting cabin/cockpit temperatures are engine heat, heat from the sun (solar heat), heat from electrical units, and heat from the body. Through research and test, it was determined that the average total temperature of these five heat sources will raise cabin/cockpit temperature to approximately 190°F (88°C). Through experiments it was determined that the maximum temperature that a person can withstand and maintain efficiency for extended periods is 80°F (27°C); therefore, air-conditioning of the cabin/cockpit area is just as essential as pressurization. Under low-speed operating conditions at low temperature, cabin/cockpit heating may be required.

The proper operation of much of today's aircraft electronic equipment is also dependent on maintaining a reasonable operating temperature that will prolong the life of various components. In most cases, equipment cooling is provided by teeing off the ducting from the cabin/cockpit system. On other aircraft, a separate cooling system may be used primarily for equipment cooling.

Q6-1. What is the atmospheric pressure at sea level?

Q6-2. As an aircraft ascends to higher altitude, the decrease in atmospheric pressure may affect flight personnel. What is the most noticeable effect?

Q6-3. The atmospheric pressure above 35,000 feet is extremely low. This condition may cause what effect on the human body?

ENVIRONMENTAL CONTROL SYSTEMS

LEARNING OBJECTIVE: Recognize the need for environmental control systems (ECS).

The environmental control systems of most aircraft include cabin air-conditioning and pressurization, equipment cooling, defogging, windshield washing and rain removal, and equipment pressurization sub- systems.

Coverage in this chapter is limited to air cycle air-conditioning and pressurization. There are five requirements necessary for the successful functioning of a pressurization and air-conditioning system:

- The cabin must be designed to withstand the necessary pressure differential. This is primarily an airframe engineering and manufacturing problem.

- There must be a means of limiting the maximum pressure differential to which walls will be subjected. This is provided by the cabin safety valve.

- The aircraft must have an adequate supply of compressed air. This is provided through the compressor section of the jet engine. A separate compressor or supercharger is used on aircraft having reciprocating engines. On all jet aircraft, the air is taken directly from the compressor section of the jet engine. This is generally referred to as bleed air.

- There must be a means of cooling the bleed air before it enters the cabin. This is provided by an aircraft refrigeration unit.

- There must be a means of controlling the cabin pressure. This is provided by the cabin pressure regulator, which regulates the outflow of air from the cabin.

In addition to the major components, various valves, controls, and other related units are necessary to complete an aircraft pressurization and air-conditioning system. The design, construction, and use of these components may vary somewhat with different manufacturers; however, the systems on all jet aircraft operate on the same principles.

Q6-4. List the five requirements necessary for successful functioning of a pressurization and air-conditioning system.

Q6-5. List three systems that are included in the environmental control system.

AIR CYCLE AIR-CONDITIONING SYSTEMS

LEARNING OBJECTIVE: Recognize the components and operating principles of air cycle air-conditioning systems (ACS).

Most naval aircraft are designed with an air cycle ACS because it is efficient for the weight and space required and is relatively trouble-free. The name *air cycle* or *air-to-air* comes from the principle of cooling the air without the use of refrigerants by compression and expansion of bleed air. The P-3 air cycle ACS is an example of this type of system.

DESCRIPTION

The P-3 air-conditioning system is comprised of two independent air cycle cooling systems of identical capacity, each with its own temperature control system, and fresh air sources. Fresh air sources are comprised of two engine-driven compressors (EDCs) and the air multiplier package (AMP).

Fresh Air Sources

In order for the air-conditioning system to function, air at the proper temperature and flow volume must be available. The fresh air sources are the EDCs and the AMP. The EDCs are single-stage compressors with fully automatic controls. They supply air to the air cycle cooling systems during flight and are operable only when no. 2 and no. 3 engines are running. The EDCs also serve as a secondary air source for the air cycle cooling systems during ground operations. The AMP is the primary air source for the air cycle cooling systems only during static ground operations when the auxiliary power unit (APU) is running. The AMP interacts with the APU to such an extent that it is referred to as the APU/AMP combination.

EDCs

The P-3 aircraft has two EDCs (fig. 6-1), to supply air to each of the two air cycle cooling systems. During EDC operation, there is no interconnect between the flight station and cabin systems until well downstream in the air distribution and exhaust system. The no. 2 engine EDC supplies air to the right (flight station) air cycle cooling system and the no. 3 EDC supplies air to the left (cabin) air cycle cooling system. The duct crossover is in the APU compartment and allows the ducts some flexibility for expansion. The EDC is mounted to a drive pad on the left side of the engine reduction gearbox assembly. The EDCs are adjusted for a maximum power requirement of 81 horsepower (hp) to deliver 60 pounds of air per minute at sea level.

APU/AMP

The APU/AMP combination supplies air to the air cycle cooling systems during ground operation only. It

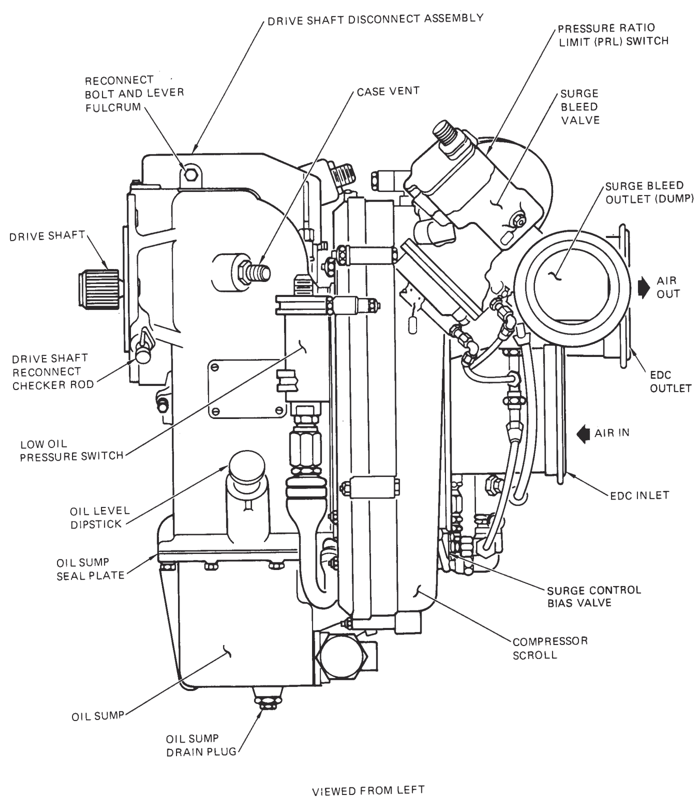


Figure 6-1.—EDC view from left.

serves as a single source of air with a flow rate equal to that supplied by the two EDCs. With the engines operating at normal revolutions per minute (rpm), each EDC supplies air to its respective air cycle cooling system at the rate of approximately 60 pounds per minute (lb/min). The APU/AMP combination supplies air to a duct common to both air cycle cooling systems at a rate of approximately 125 lb/min. The air volume divides in the air cycle cooling system interconnection duct, with half going to the flight station air cycle cooling system and half to the cabin air cycle cooling system.

An air-conditioning system that employs a single source of air to supply two air cycle cooling systems that operate at different back-pressures will have air flow problems unless a control is added to balance airflow. If airflow is not properly balanced, the air cycle cooling system with the lower back-pressure (as the result of more air bypass) will rob air from the unit with the higher back-pressure. Two flow-limiting venturis are used to balance airflow when the APU/AMP combination is the air supply source. Figure 6-2 shows an AMP installation.

COMPONENTS

Components include a heat exchanger package, turbine refrigeration unit, water separator, water spray system, and a flow-limiting venturi.

Heat Exchanger Package

The function of the heat exchanger package (fig. 6-3) is to reduce the temperature of the supply air furnished by the EDC or AMP. Two heat exchanger packages, each consisting of a primary and secondary section, electric fan assembly, check valve, and ram air duct check valve are installed on each side of the nose wheel well. The left heat exchanger package supplies air for the cabin systems and the right package cools flight station air.

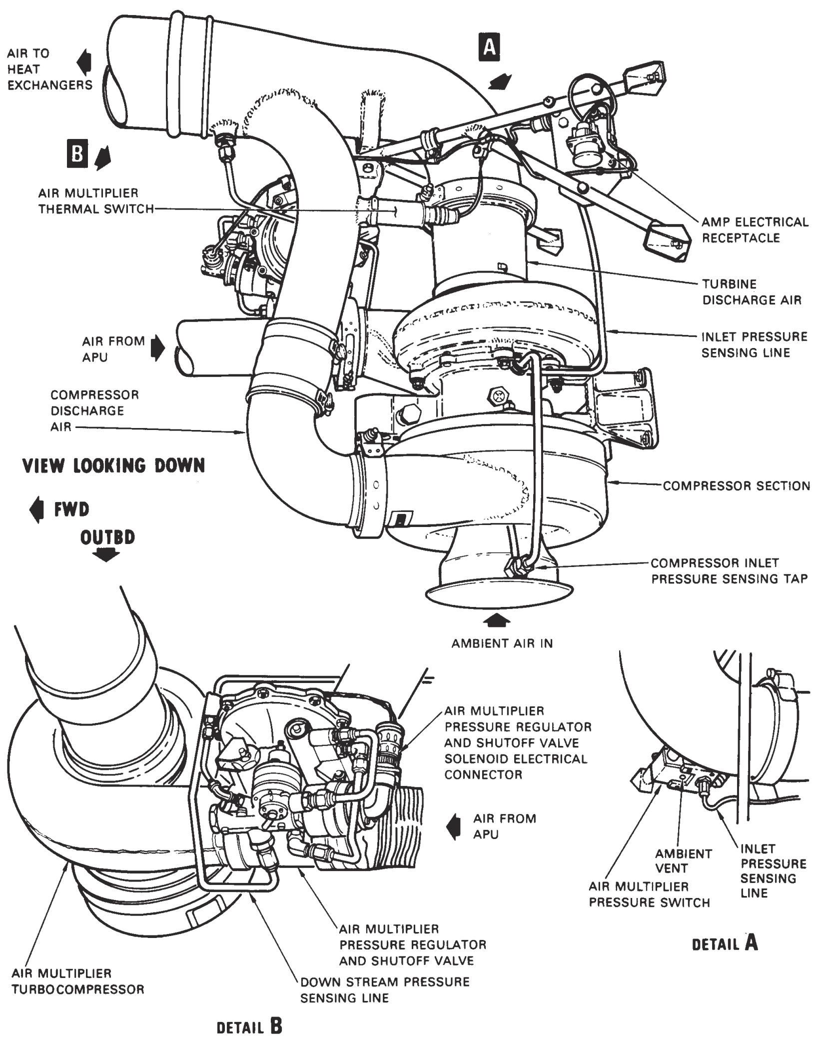


Figure 6-2.—AMP installation.

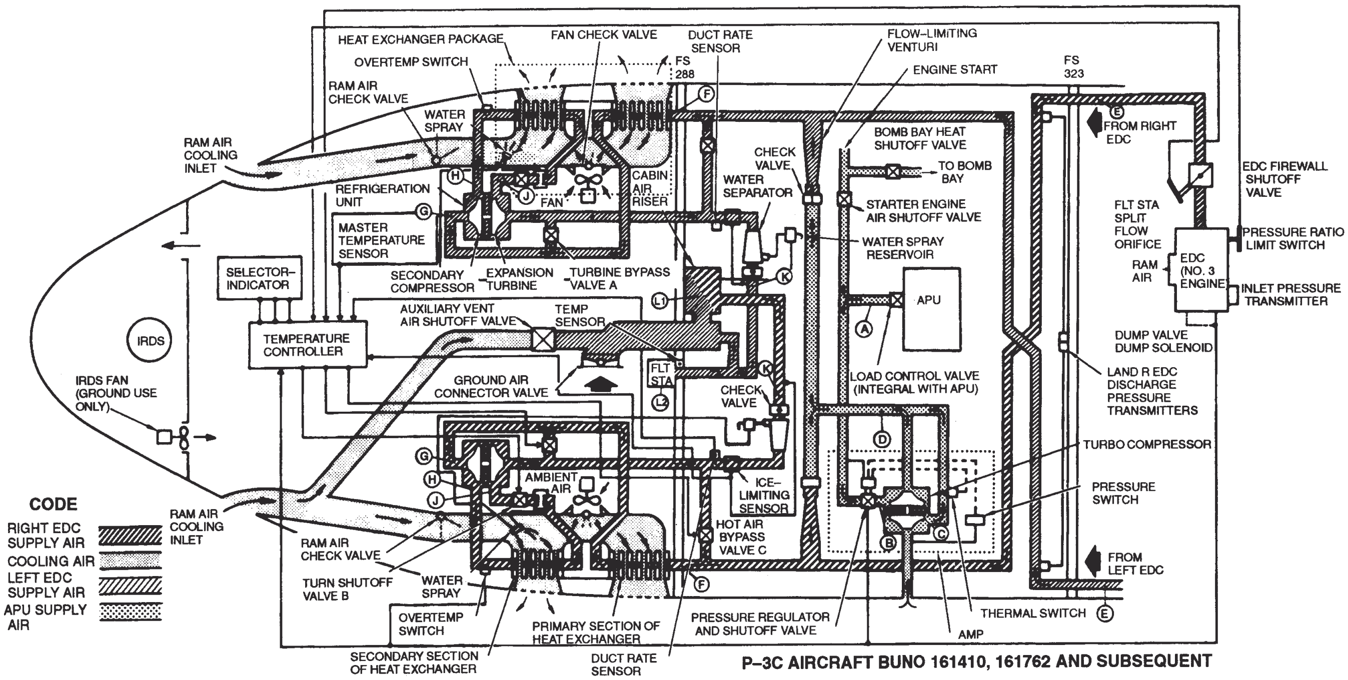


Figure 6-3.—P-3 air-conditioning system schematic diagram.

The heat exchanger unit is constructed of a brazed core, which contains a series of metal plates separated by layers of fins that form a passage for cooling air and separate passage for supply air.

During ground operation, the fan assembly installed on the heat exchanger forces ambient air through the heat exchanger and overboard. A check valve, installed at the fan outlet, directs ambient airflow in the heat exchanger. Another check valve, located in the ram air inlet duct, closes, preventing ambient air from spilling overboard through the ram air duct check valve. The heat exchanger check valve closes, and the ram air is used to cool the supply air.

Turbine Refrigeration Unit

Each air cycle cooling system has a turbine refrigeration unit (fig. 6-4) installed on each side of the

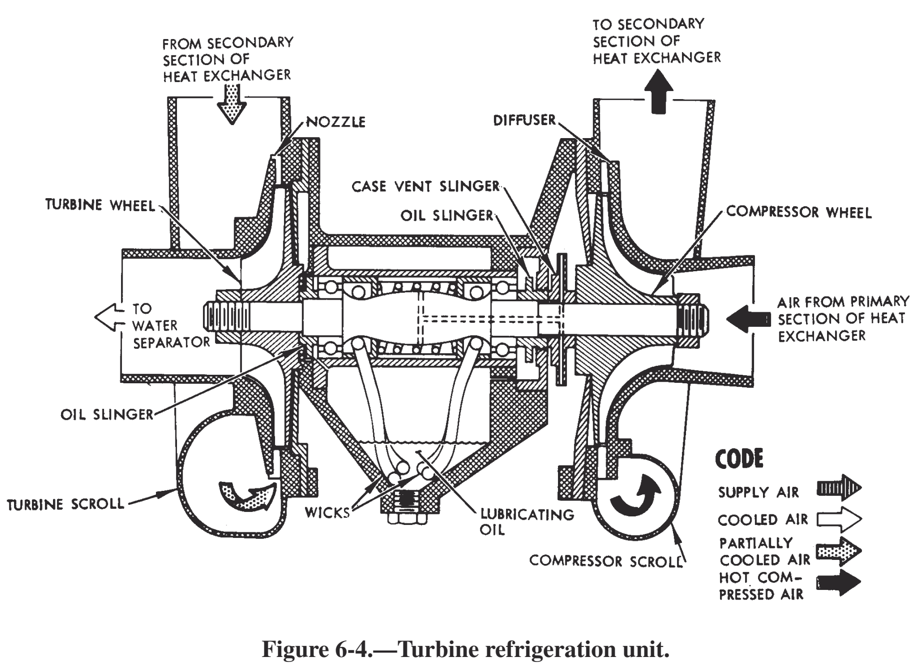


Figure 6-4.—Turbine refrigeration unit.

aircraft nose wheel well. The refrigeration unit, along with the secondary section of the heat exchanger, lowers the temperature of supply air so that it may be used for aircraft cooling. The refrigeration unit consists of a rotating assembly and a housing assembly. The rotating assembly mounts a turbine scroll and a compressor scroll, enclosing the rotating assembly. The bottom of the bearing support housing forms a sump for lubricating oil. A sight gauge is provided in the sump for determining the level of lubrication oil. Each of the three sections formed by the housing assembly is sealed to prevent air and oil leakage.

Compressed supply air, after it has passed through the primary section of the heat exchanger, is ducted into the compressor section of the turbine where it is further compressed as it passes through the compressor scroll. The compressed air, with a temperature slightly above that of ambient air, is then routed to the secondary section of the heat exchanger, where it is cooled to a lower temperature. Returning from the heat exchanger, the compressed air enters the turbine scroll, expanding as it flows from the nozzle through the turbine wheel to the outlet duct. As the air is expanded, it drives the turbine wheel at high speed. Mechanical energy, which is extracted from the air to drive the turbine wheel, is transmitted to and absorbed by the compressor wheel. This mechanical energy reduces the supply air pressure and temperature to the point where the air becomes usable for aircraft cooling.

Lubrication of the rotating assembly bearings is accomplished by an air-oil mist. Oil is absorbed by wicks, which extend from the oil sump to the shaft of the rotating assembly. Oil is distributed on the rotating assembly shaft as a result of capillary action in the wicks. Rotation of the shaft causes the oil to diffuse into an air-oil mist. The action of the oil slingers causes the air-oil mist to pass through the bearings, providing lubrication.

Water Separator

The water separator (fig. 6-5) removes moisture from the air before it is distributed within the aircraft. Two water separator units are installed in the APU compartment. The cabin system unit is located in the aft upper left section of the APU compartment and the flight station unit is located in the forward upper right section.

The water separator consists of a condenser assembly and a collector assembly. The condenser assembly is a coalescer. An ice-limiting sensor is installed in the inlet section of the unit to protect against icing and a check valve is installed in the water separator outlet to prevent reverse airflow through the unit.

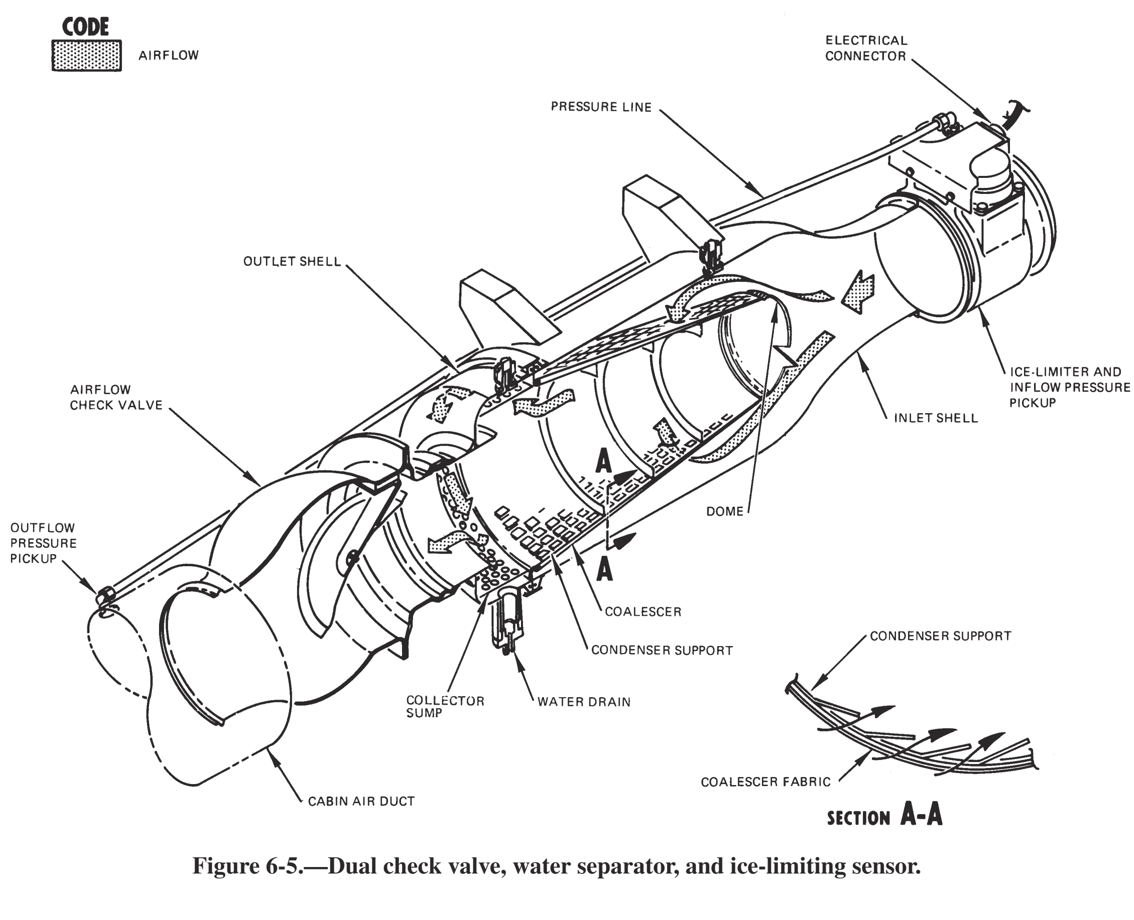


Figure 6-5.—Dual check valve, water separator, and ice-limiting sensor.

As supply air passes through the coalescer, moisture particles are condensed into droplets. After the air has passed through the coalescer, hundreds of small vanes create a swirling motion of the air and the airborne water droplets. This swirling motion centrifuges most of the water droplets from the air into the coalescer sump, where the water accumulates and drains overboard. The air, relieved of approximately 70 percent of its moisture, is then ducted into the aircraft and distributed.

Water Spray System

The water spray system increases basic cooling capacity of the air cycle cooling system by spraying water separator discharge water into the ram air, cooling it by evaporation before the ram air passes through the heat exchanger's secondary section.

Flow-Limiting Venturi

Each air cycle cooling system has a flow-limiting venturi installed in the left and right sides of the APU compartment in the air distribution duct between the AMP and the EDC air ducts. The venturi is sized to limit airflow to 67 lb/min from the AMP to the air cycle cooling system to ensure proper flow division and to prevent excessive flow through the aircraft during the heating mode. It functions to limit flow through the refrigeration unit in the event the other refrigeration unit is operating at a different bypass setting; that is, one refrigeration unit is in maximum cooling while the other is modulated toward heating. A check valve is located in the outlet of each venturi to prevent reverse EDC airflow through the venturi.

CABIN AND FLIGHT STATION TEMPERATURE CONTROL SYSTEM

There are two independent temperature control systems on the aircraft designed to control the temperature of the air cycle cooling system output air. Each system (fig. 6-6) is composed of a selector-indicator, a temperature controller, a master temperature sensor, a duct rate sensor, an ice-limiting

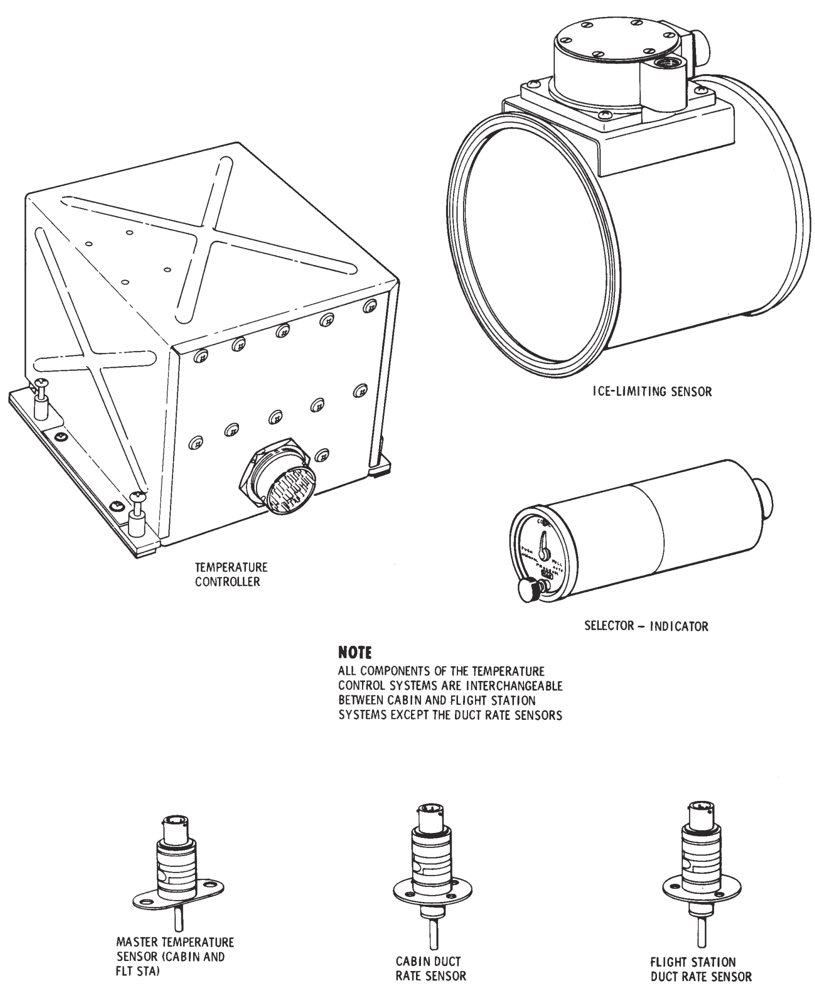


Figure 6-6.—Temperature control system components.

sensor, a pressure ratio limiter, and three airflow control valves.

Air supplied from the ground-air connection or from the auxiliary ventilation system does not pass through the air cycle cooling system, so the aircraft temperature control system has no control of incoming air from these sources.

Temperature control is achieved, either automatically or manually, through the three modulating valves. These valves route supply air through the various cooling components to produce the desired output air temperature. The three airflow control valves are driven by servomotors that are controlled by servo-amplifiers. The airflow valve schedule is the same for both manual and automatic modes of operation. The basic difference in operating modes is the method of applying sensing control to the servo-amplifiers.

Temperature Control System Selector-Indicator

Air-conditioning system control input signals are selected with the selector-indicator. The selector-indicator contains a push-pull knob, a cursor at the edge of the indicator face, an indicator needle, and an indicator flag. Sets of dot markings, one-dot, two-dot, and three-dot, are on the indicator face to facilitate temperature or program selection.

The mode of operation is selected by moving the push-pull knob: push for manual operation, pull for automatic. The indicator flag indicates which mode has been selected (MAN or AUTO). The system control voltage (manual) or operating temperature (automatic) is selected by rotating the push-pull knob, clockwise for warmer, counterclockwise for cooler. This moves the cursor at the edge of the instrument face to indicate the program position (automatic) or temperature selection (manual). The indicator needle in the center of the dial is the indicator of the voltmeter that is connected to the temperature controller circuitry.

There are three potentiometers inside the selector-indicator assembly. In manual mode, each potentiometer provides a command signal to each of the three airflow control valves (valves A, B, and C) by way of the temperature controller. When an automatic mode is selected, valve A potentiometer provides the temperature controller with the command signal for all three airflow control valves.

Temperature Controller

The temperature controller is the heart of the temperature control system. It receives and integrates the signals from the selector-indicator, master temperature sensor, duct rate sensor, ice-limiting sensor, and pressure ratio limiter. These signals are used to position the three airflow control valves.

The temperature controller is composed of four modules: a programming amplifier module and three transistorized servo-amplifier modules. The programming amplifier contains the temperature control system automatic mode control circuitry. When automatic mode is engaged, this module integrates the sensor signals with the selector-indicator command signal, and produces the appropriate command signals for the three valve servo-amplifiers. In manual mode, the programming amplifier contributes nothing to system operation. The servo-amplifiers control the operation of the airflow valves and are identified as valve A, B, and C servo-amplifiers. In manual mode, the servo-amplifiers respond to command signals from the three potentiometers in the selector-indicator. In automatic mode, command signals come from the programming amplifier module.

Master Temperature Sensor

A master temperature sensor is mounted in each system exhaust air duct to sense cabin or flight station air temperatures. The flight station master temperature sensor is in an exhaust duct above and aft of the pilot position. The cabin temperature sensor is in the exhaust duct above the tactical coordinator (TACCO) station.

In automatic mode, the sensor senses the temperature within the aircraft. The heart of the sensor is the thermistor, whose electrical resistance varies inversely with its temperature. The changes of resistance provide reference signals to the temperature controller. The controller combines these signals with the signals from the duct rate sensor and the selector-indicator, and produces a command signal. The command signal is used by the temperature controller to regulate the temperature within the aircraft, by positioning the airflow control valves.

Duct Rate Sensor

A duct rate sensor is installed in the duct upstream of each ice-limiting sensor. It senses the temperature output air from the air cycle cooling system and the hot air bypass valve (valve C). In automatic mode, the duct rate sensor signals are integrated with the master temperature sensor and selector-indicator signals to regulate system temperature.

Ice-Limiting Sensor

The purpose of the ice-limiting sensor is to eliminate ice formation in the water separator. An ice-limiting sensor is installed in the inlet of each water separator. Electrical signals from the ice-limiting sensor are sent to the programming amplifier in the temperature controller. The programming amplifier directs the signals to valve A servo-amplifier. The servo-amplifier directs the signals to the servomotor that drives the valve toward an open position. This allows warm air to enter the water separator, which eliminates ice formation in the water separator. The ice-limiting sensor is operative in the manual or automatic mode.

Ice formation on the water separator coalescer causes a pressure drop between the water separator inlet and outlet, which is sensed by the ice-limiting sensor. As this pressure drop increases to 2.9 inches of mercury, low-pressure (yellow) relay K3 is actuated. This relay removes voltage to valve A servo-amplifier, which allows only an opening signal to be received. If ice buildup increases differential pressure to 4.1 inches of mercury, high-pressure (red) relay K5 is actuated. This relay removes servo-amplifier signals routed to valve A and supplies a signal to the valve in the open direction only. This causes the valve to open, allowing hot air to enter the water separator and circulate, thus removing ice.

Pressure Ratio Limiter Assembly

The pressure ratio limiter is mounted on the EDC, and is part of the EDC surge control system. Its function is to relieve or eliminate that part of the total EDC back pressure imposed by the turbine refrigeration units and water separators when the EDC is operating at maximum capacity or is overloaded. It is intended to function above 18,000 feet or during climb and descent.

Airflow Control Valves

There are three airflow control valves installed in each air cycle system. Their function is to control system air output. The turbine bypass valves (valve A) are located in the nose wheel well in the primary of each heat exchanger outlet to turbine bypass duct. The turbine shutoff valves (valve B) are located in the nose wheel well in the secondary section of each heat exchanger outlet to turbine inlet duct. The hot air bypass valves (valve C) are located in the forward left and right sides of the APU compartment. Valve C controls the amount of hot primary compressor discharge air that is bypassed around the air cycle cooling system. Valve A controls the amount of warm air that is bypassed around the bootstrap refrigeration unit. Valve B controls the volume of air flowing through the refrigeration turbine for cooling. The 3 1/2-inch diameter valves B and C are identical and have the same part number. Valve A has a diameter of 4 1/2 inches.

Each valve assembly consists of a butterfly type valve, an alternating current (ac) servomotor, a planetary gear train, and a follow-up potentiometer. The servomotor, gear train, and potentiometer are combined into a single unit called the actuator assembly, which is mounted on the valve housing. The actuator assembly receives signals from the temperature controller to position the butterfly valve during temperature control system operation.

TEMPERATURE INDICATOR

The selectors, controls, and monitoring equipment for temperature control are mounted in the upper portion of the panel grouping (fig. 6-7). Control of cabin and flight station temperature is achieved through modulation of the two air cycle cooling systems.

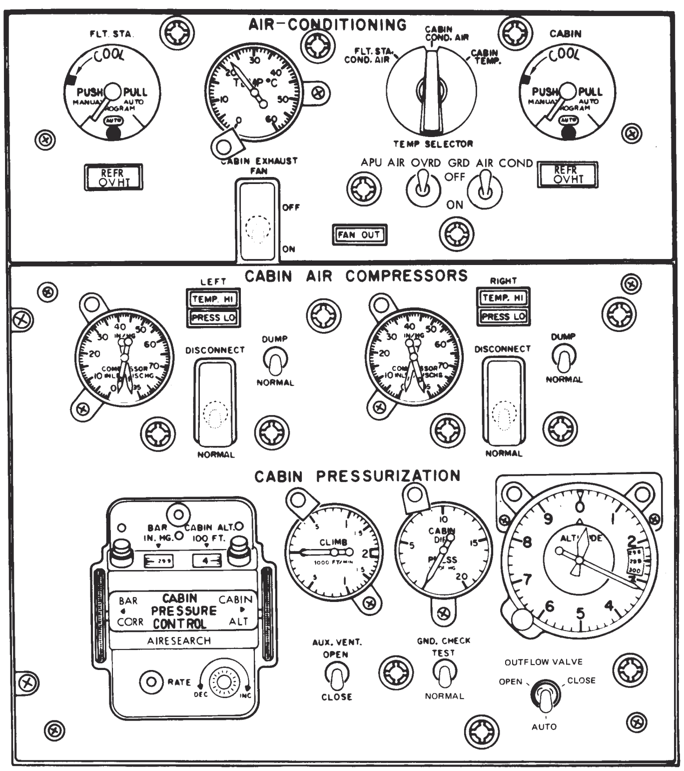


Figure 6-7.—Air-conditioning, cabin air compressors, and cabin pressurization control panels.

The temperature indicator, TEMP °C, and the three-position TEMP SELECTOR switch are connected to read three different temperature sources as follows:

- FLT STA COND AIR position. Temperature of the conditioned air leaving the air cycle cooling system, which is controlled to meet flight stations requirements.

- CABIN COND AIR position. Temperature of the conditioned air leaving the air cycle cooling system, which is controlled to meet cabin requirements.

- CABIN TEMP position. Temperature of the air leaving the cabin, exhaust air temperature, which is actual cabin temperature.

OPERATION

The P-3 aircraft is equipped with two temperature control systems, one for the flight station and one for the main cabin area. Each temperature control system consists of a temperature controller, a selector-indicator, a master temperature sensor, a duct rate sensor, and three airflow control valves.

To operate the temperature control system, the flight crew sets the selector-indicator at the desired temperature (fig. 6-8). This information is transmitted to the temperature controller, along with signals from the sensors that provide the actual cabin or flight station temperature and the rate of temperature change at the water separator inlet. The temperature controller then positions the three airflow control valves in a programmed schedule to properly blend the hot, warm, and cool air flowing in the air cycle cooling system to obtain the selected flight station or cabin temperature.

The temperature control system employs the basic air cycle cooling system, two valve-controlled bypass ducts, and one shutoff valve. The hot air bypass valve (valve C) controls the amount of hot primary compressor discharge air that will be bypassed around the air cycle cooling system. The turbine bypass valve (valve A) controls the amount of warm air that will be bypassed around the turbine refrigeration unit. The turbine shutoff valve B controls the volume of air flowing through the turbine refrigeration unit for cooling.

When full cold is commanded, all of the airflow into the air cycle cooling system is being cooled in the turbine refrigeration unit. If the control system demands heating, warm or hot air will bypass various portions of the air cycle cooling system until the desired temperature is obtained. The valve B and C operation schedules are similar in response, but opposite in direction. On the other hand, valve A has a relatively complicated operation schedule. This is because valve A controls the bypass of air that is warm, but close to a comfortable temperature.

Under certain atmospheric conditions, water separator bag icing will cause reduced airflow and high

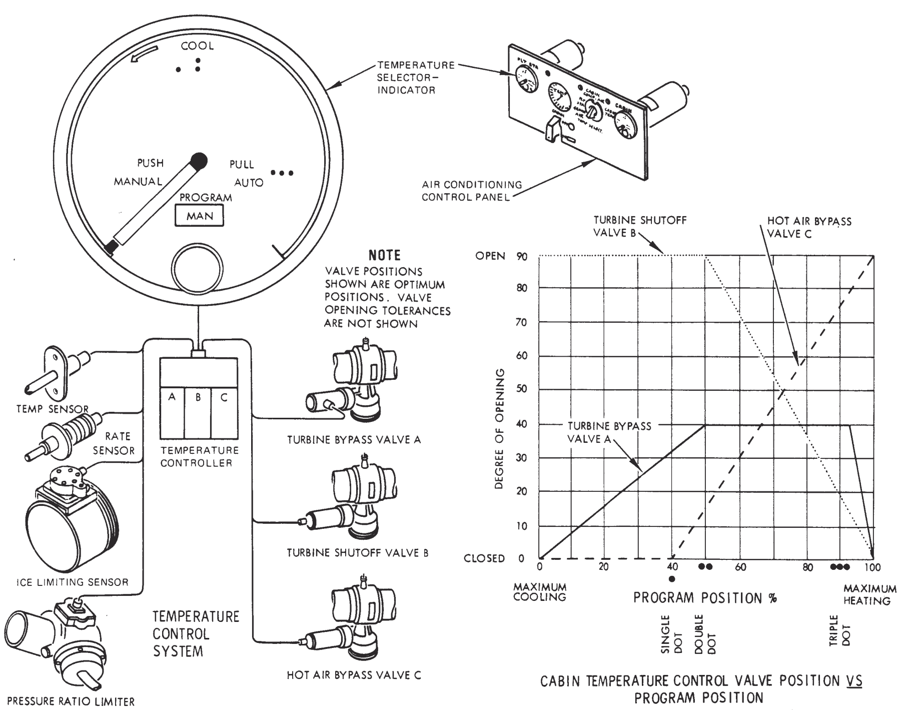


Figure 6-8.—Selector-indicator.

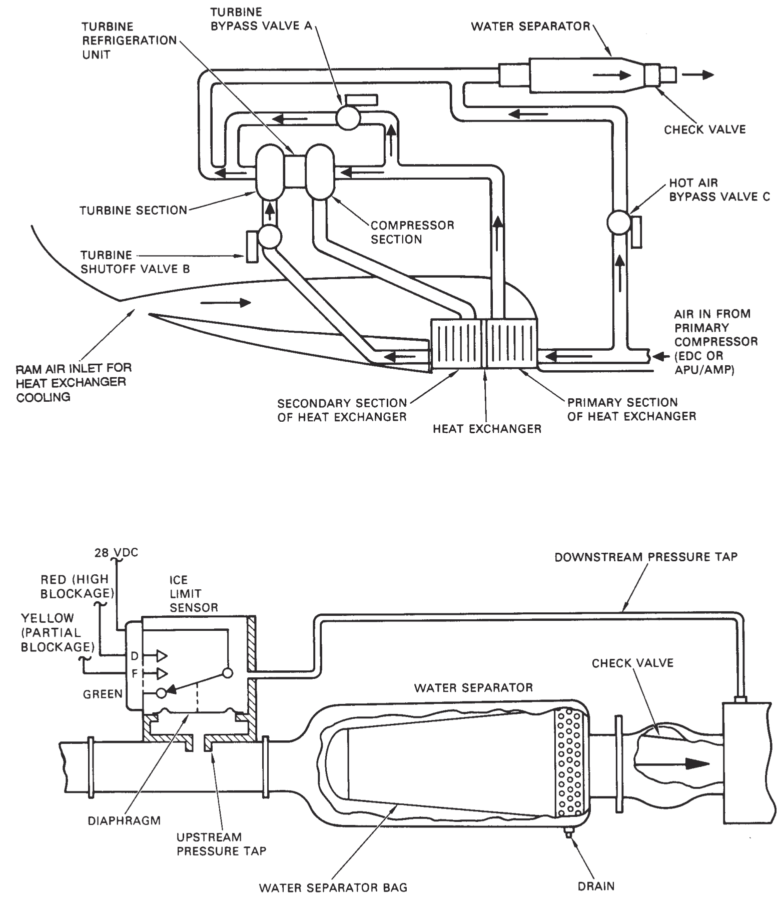


Figure 6-9.—Air cycle cooling schematic diagram.

back-pressure on the air cycle cooling system. High back-pressure from the air cycle cooling system will cause the pressure ratio across the EDC to exceed its design limits and cause a compressor surge condition. The compressor surge may cause a loss of cooling air at the dump valve or damage the EDC. The ice limit sensor, a pressure switch, senses the pressure differential across the water separator. One side of the pressure switch senses the air pressure upstream from the water separator bag, and the other side senses the air pressure downstream from the water separator bag. When the bag is covered with ice, the airflow is impeded and a greater-than-normal pressure drop develops across the bag. When the pressure differential exceeds 2.9 inches mercury (Hg), a switch actuates in the ice limit sensor ice limiter indicating partial blockage (yellow condition) of the water separator (fig. 6-9). If the water separator icing condition worsens and the ice limiter senses an increase in pressure drop across the water separator bag to 4.1 inches Hg, the high-pressure switch actuates in the ice limit sensor, indicating heavy blockage (red condition) of the water separator. These ice limiting sensor signals are used by the temperature control system, during the automatic mode only, to control water during icing. Figure 6-10 shows the ECS flow.

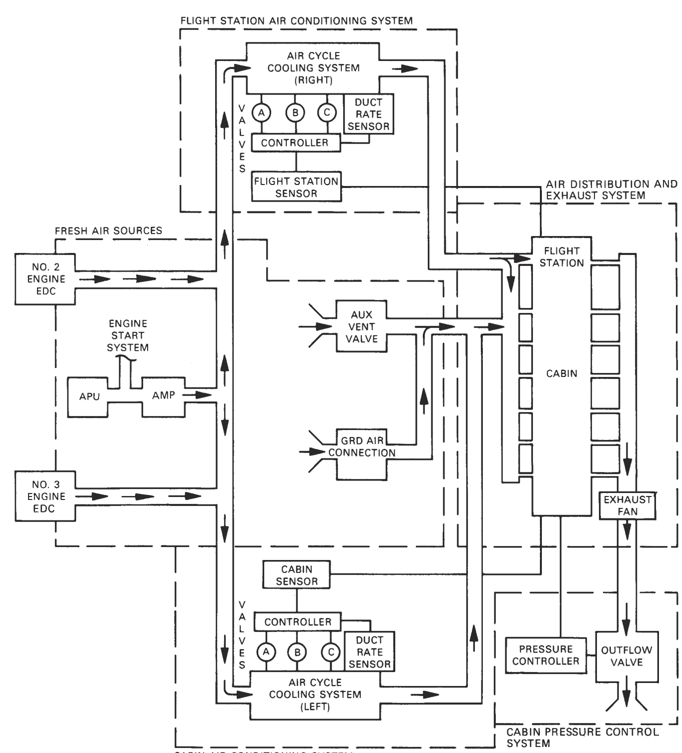


Figure 6-10.—ECS block diagram.

Automatic Mode

The automatic mode of operation regulates the cabin or flight station environment at a temperature setting between 65°F (18°C) (full cold, AUTO) and 85°F (29°C) (full hot, AUTO) depending on the setting of the selector bug. The face of the selector-indicator has reference marks on it at settings of 70°F (21°C) (one dot), 73°F (23°C) (two dots), and 80°F (27°C) (three dots).

In the automatic mode, the temperature controller receives three inputs and uses them to determine the proper control valve positions. First, the flight crew uses the selector-indicator to select the desired temperature. This tells the controller what the flight crew wants. The master temperature sensor provides the second input to the temperature controller. This device senses the current flight station or cabin ambient temperature.

The temperature controller amplifier compares the temperature requested by the flight crew (selector-indicator) with the actual cabin or flight station temperature (master temperature sensor), and develops an output called the program voltage. This signal is a dc voltage command for the three servo-amplifiers to drive the airflow control valves. The selector-indicator needle, called the program position indicator (PPI), is positioned by the command from the program amplifier. The PPI tells the flight crew what the system is going to produce, regardless of the position of the selector bug.

The duct rate sensor senses the rate of temperature change in the air supply duct, then it sends a third signal that is proportional to this rate of change to the controller program amplifier. This signal enables the temperature controller to prevent temperature instability when the actual temperature approaches the desired temperature. The duct rate sensor is mounted in the system supply duct at the control valve blending location. This is the point where the hot air bypass, the warm turbine bypass, and the cold turbine refrigeration unit air discharges are blended. As the three airflow control valves move in response to changes in program voltage or position, the temperature of the air will change at a proportional rate.

Manual Mode

The manual mode of operation for the temperature control system is a backup mode in case the automatic mode fails. In the manual mode, the selector bug commands control valve position rather than setting a temperature. If the flight crew is uncomfortable, the valve positions must be changed by moving the selector bug. The PPI needle should follow the selector bug closely (within one needle width) as the bug is moved. The master temperature sensor, duct rate sensor, and program amplifier inputs are not used in the manual mode.

Q6-6. The term air-to-air comes from what principle?

Q6-7. The cabin air cycle cooling system EDC is mounted on what engine?

Q6-8. What component balances airflow in case of back-pressure?

Q6-9. The water separator removes what percentage of moisture?

Q6-10. What component is the heart of the temperature control system?

Q6-11. When selecting full cold, all of the airflow into the air cycle cooling system is being cooled by what component?

Q6-12. What are the modes of operation for the P-3 air cycle cooling system?

AIRCRAFT PRESSURIZATION SYSTEMS

LEARNING OBJECTIVE: Recognize the purpose and function of an aircraft pressurization system to include maintenance and troubleshooting operations.

As aircraft became capable of obtaining altitudes above that at which flight crews could operate efficiently, a need developed for complete environmental systems.

Air conditioning could provide the proper temperature and supplemental oxygen could provide sufficient breathable air. The one problem was that not enough atmospheric pressure exists at high altitude to aid in breathing, and even at lower altitudes the body must work harder to absorb sufficient oxygen through the lungs to operate at the same level of efficiency as at sea level. This problem was solved by pressurizing the cockpit/cabin area.

PRESSURIZATION SYSTEM

The area of an aircraft to be pressurized must be free from all air leaks. This is accomplished by use of seals around tubing, ducting, bolts, rivets, and other hardware that pass through or pierce the pressure-tight area. All panels and large structural components are assembled with sealing compounds. Access and removable doors and hatches have integral seals. Canopies are constructed with inflatable seals. The pressurizing air is the air from the aircraft ACS.

The S-3 aircraft incorporates a cabin pressurization subsystem. This regulates the outflow of air from the cabin to control the cabin pressures according to a predetermined schedule. Cabin air is drawn through the internal avionics racks by the cabin exhaust fan and is modulated by the cabin pressure regulator valve. A cabin pressure regulator control provides the pressurization schedule.

SYSTEM OPERATION

The cabin pressurization subsystem is managed on the pressure regulator control, which provides five modes of operation: unpressurized, isobaric, differential cabin-to-ambient pressure, dump, and re-pressurization.

The cabin pressure schedule is designed to satisfy the requirements of a maximum cabin pressure-to-ambient differential of 6.7 (±0.1) psi and a 5,000 feet cabin altitude at flight altitudes between 5,000 and 25,000 feet. The cabin is normally unpressurized below 5,000 feet. Table 6-1 shows cabin pressures and altitudes with actual flight altitude.

During the unpressurized mode of operation, the pressure regulator control directs low-pressure air to the pressure regulator valve to command it to the full open position. This mode of operation occurs at all altitudes below 4,350 feet. In this mode, cabin pressure is maintained at a near ambient pressure. The pressure is slightly above ambient because of the duct pressure losses, the quantity of air flowing into the cabin, and the pressure across the internal avionics ventilation subsystem.

During flight operations between 5,000 and 24,000 feet, the isobaric mode maintains the cabin altitude between 4,350 and 5,000 feet. The pressure regulator control, using the sensed ambient pressure as a low-pressure source and the sensed cabin pressure as the high-pressure source, modulates the pressure regulator open or closed to maintain cabin pressure at the specific altitude.

The differential mode of operation overrides the isobaric mode when the aircraft is flying at altitudes in excess of 24,000 feet. As cabin-to-ambient differential pressure reaches 6.7 ±0.1 psi, a spring-loaded diaphragm in the pressure regulator control positions a poppet valve to supply this differential pressure as a control pressure to the pressure regulator valve. The

Table 6-1.—Cabin Altitude vs Flight Altitude Schedule

Flight Altitude (ft)	Cabin Pressure Differential		Cabin Pressure Altitude	
	Min (psi)	Max (psi)	Min (ft)	Max (ft)
0	0	0.25	–500	0
5,000	0	0.30	4,350	5,000
10,000	2.12	2.42	4,350	5,000
15,000	3.94	4.24	4,350	5,000
20,000	5.48	5.78	4,350	5,000
*24,300	6.60	6.80	4,500	5,000
25,000	6.60	6.80	5,000	5,380
30,000	6.60	6.80	7,400	7,870
35,000	6.60	6.80	9,600	10,100
40,000	6.60	6.80	11,520	12,050
*Maximum flight altitude for a 5,000 feet cabin altitude				

pressure regulator valve compares this control pressure to cabin pressure, and it positions the butterfly to maintain the required differential pressure.

The cabin pressurization system also makes provision for dumping cabin pressure in an emergency. By setting the cabin pressure switch on the environmental control panel to the DUMP position, the latching solenoids on both the cabin outflow pressure regulating valve and on the cabin safety valve are actuated to the dump position. In addition, the re-circulation air shutoff valve will be actuated to the full open position, provided electrical power is available. A secondary method of achieving cabin depressurization is to turn the air-conditioning switch to the OFF/RESET position and select the auxiliary vent mode. This selection will cause the cabin outflow pressure regulator valve to open, but it will not actuate the cabin safety valve to the open position.

The re-pressurization mode of operation is used when returning to the normal mode from the dump mode or during a rapid descent in excess of 4,000 feet per minute. In this mode, the pressure regulator control modulates the rate of cabin re-pressurization with an integral isobaric and differential pressure control system. The pressure regulator control compares the existing cabin pressure to a lagging cabin pressure reference. If the result of this comparison exceeds the calibrated rate, control pressure output from the pressure regulator control is reduced. This causes the pressure regulator valve to sense a relatively higher pressure on the opening side of its actuating diaphragm, allowing the diaphragm to open the pressure regulator valve butterfly. This reduces cabin pressure and the rate of pressurization.

Precautions for operating the S-3 cabin pressurization subsystem on the ground, where the elevation is 5,000 feet or higher, are required because the cabin pressurization subsystem does not have provisions for automatic depressurization. Therefore, the cabin will pressurize whenever the ground elevation is above 5,000 feet.

To ensure adequate cooling of the internal avionics during operations at ground elevations above 5,000 feet, one of the following steps must be used:

- Keep the cabin pressurized as in flight.
- Set CABIN PRESS switch to DUMP to ensure a full-open pressure safety valve.
- Turn AUX VENT selector to ON if outside air temperature is below 80°F, and open the cabin entry door to ensure an adequate supply of cooling air.

COMPONENTS

The S-3 cabin pressurization subsystem consists of five primary components (figs. 6-11 and 6-12). Four of them are shown in figure 6-11. The fifth component is located in the cockpit. Each component is discussed in the following paragraphs. If you are to troubleshoot effectively, it is important to know the relationship of each component to the system as a whole.

Cabin Pressure Regulator Valve

The cabin pressure regulator is a pneumatically actuated butterfly valve mounted in the cabin exhaust ducting downstream of the cabin exhaust fan. The butterfly is spring-loaded to the closed position. The pressure regulator valve consists of the butterfly valve, which is actuated by a pressure-controlled diaphragm, and a solenoid valve to control the air pressure on the

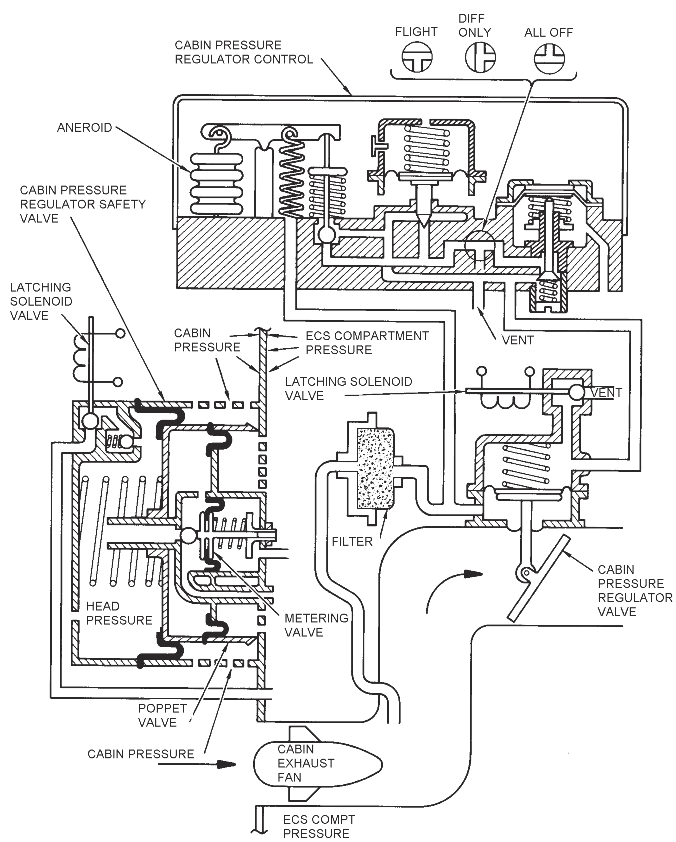


Figure 6-11.—Cabin pressurization subsystem schematic.

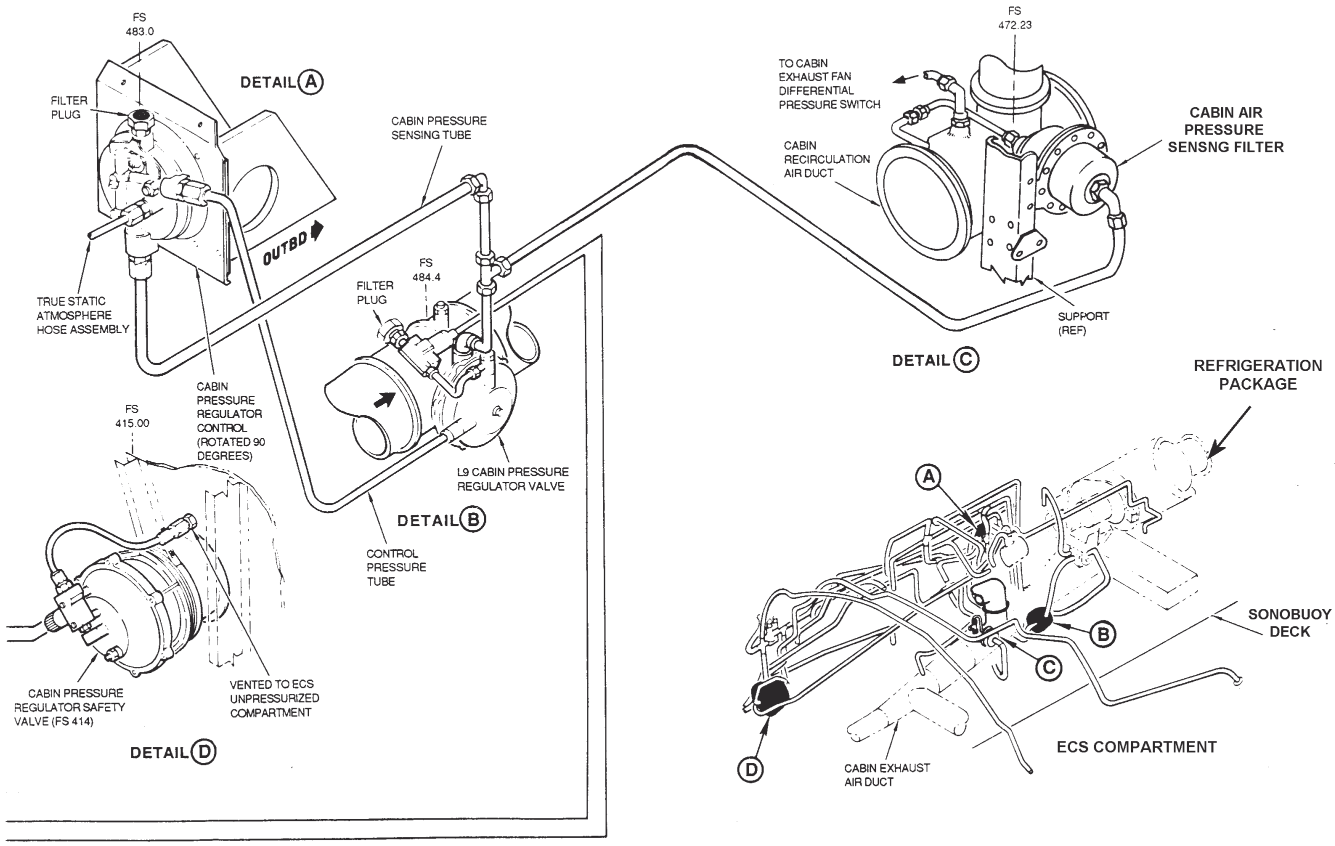


Figure 6-12.—Cabin pressurization components.

diaphragm. The solenoid valve is electronically connected to the cabin pressurization switch on the environmental control panel (fig. 6-13).

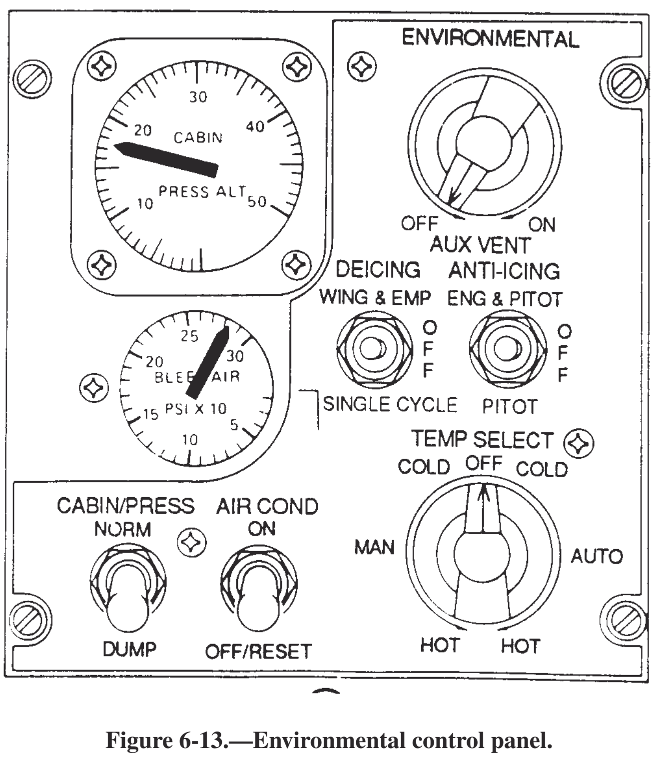


Figure 6-13.—Environmental control panel.

There are three ports leading into the pressure regulator valve diaphragm chamber. The first port is located on the spring-loaded closing side of the diaphragm. It admits pressure from the cabin pressure regulator control. The second port is the ambient vent port. It is also located on the spring-loaded closing side of the diaphragm. The third port is located on the opening side of the diaphragm. A sensing line is attached to the third port to connect the cabin pressure regulator control and the cabin pressure exhaust duct. The pressure admitted to the diaphragm through the third port is equivalent to cabin air pressure. The difference between them causes the pressure regulator valve to modulate between the open and closed positions.

Cabin Pressure Regulator Safety Valve

The pressure regulator safety valve is an independent, pneumatically operated, balanced type of poppet valve that limits cabin-to-ambient pressure differentials to 7.07 (+0.2 and –0.0) psi. If the difference between cabin pressure and ambient pressure reaches the calibrated limit, the change in pressure acting on the limit control diaphragm overcomes the metering valve spring-load and allows the metering valve to open. This also opens a passage in the cabin pressure safety valve head, which causes the head pressure to be slightly lowered. Since the cabin pressure is greater than head pressure, it opens the pressure-balanced main poppet to allow cabin air to be vented overboard. When the cabin pressure differential is restored to normal, the limit control metering valve closes, and the pressure safety valve returns to its normally closed position.

Cabin Pressure Regulator Control

The pressure regulator control is a pneumatic control that provides four modes of cabin pressure operation. In addition to the modes of operation, a test valve is included with three manually set positions (FLIGHT, DIFF ON, and ALL OFF). The test valve is normally lockwired in the FLIGHT position for all cabin pressurization modes. The DIFF ON position permits a ground test of the normal delta-P setpoint. The ALL OFF position permits a ground test of the set point of the pressure safety valve. These test are accomplished with pressure supplied by support equipment.

Four pneumatic ports are provided on the pressure regulator control for interfacing with various sensed pressures and the pressure regulator valve. These ports are different sizes to prevent improper plumbing connections.

The pressure regulator control contains an isobaric bellows, which is calibrated to maintain an aircraft cabin pressure of 5,000 feet while the aircraft is flying at altitudes between 5,000 and 24,000 feet. The isobaric bellows, which modulates a control pressure, uses cabin air as a pressure source and low pressure in the environmental control system compartment as a negative pressure. Control pressure is delivered to one side of the pressure regulator valve diaphragm, and cabin pressure is connected to the opposite side. Because control pressure is normally less than cabin pressure, the pressure regulator valve becomes more open to decrease cabin pressure.

The pressure regulator control contains provisions for controlling the rate of cabin re-pressurization when recovering cabin pressure after using the cabin dump mode, or during a rapid descent in altitude. The control pressure modulated by the isobaric bellows is further modulated by the re-pressurization diaphragm to limit cabin re-pressurization to an equivalent 4,000 feet per minute change. The pressure regulator valve is held open until normal pressure characteristics are sensed.

Cabin Low-Pressure Switch

The low-pressure switch is installed below the center console to sense cabin absolute pressure. The normally open low-pressure switch closes at 13,000 (±500) feet and reopens at 11,000 (±500) feet. The CAB PRESS indicator light on the annunciator panel illuminates when the low-pressure switch closes. The indicator light goes off when the low-pressure switch reopens.

Cabin Air Pressure Sensing Filter

The air pressure-sensing filter is located in the line that connects the cabin exhaust air duct, the cabin pressure regulator control, and the cabin pressure regulator valve. The replaceable filter element, which is connected to the air sensing tube, is mounted with clamping rings on the fuselage frame. The filter element is a cylindrical plug of treated paper and fabric in a metal housing. The clamping rings confine the air entry to the dome-shaped end to trap the entry of tobacco tar and dust particles greater than 10 microns in diameter.

MAINTENANCE AND INSPECTION

Very little maintenance is required on most pressurization and ACSs other than making the required periodic inspections and operational checks. In most instances, a maladjusted or malfunctioning component simply must be removed and replaced. There are, however, certain components that require periodic servicing, cleaning, and inspection so the component will function properly and efficiently. Specific requirements for servicing, cleaning, and inspection are listed in the daily, postflight, and special/conditional maintenance requirement card (MRC) decks as well as the maintenance instruction manual (MIM) for each aircraft.

Electrical Failures

Since all pressurization and ACSs have electrically controlled components, maintenance of these systems must include the related electrical circuits. Although an Aviation Electrician's Mate (AE) is generally called upon to locate and correct electrical troubles, the AME should be able to check circuits for loose connections, and even perform continuity checks when necessary. A knowledge of electrical symbols and the ability to read circuit diagrams is therefore necessary. Figure 6-14

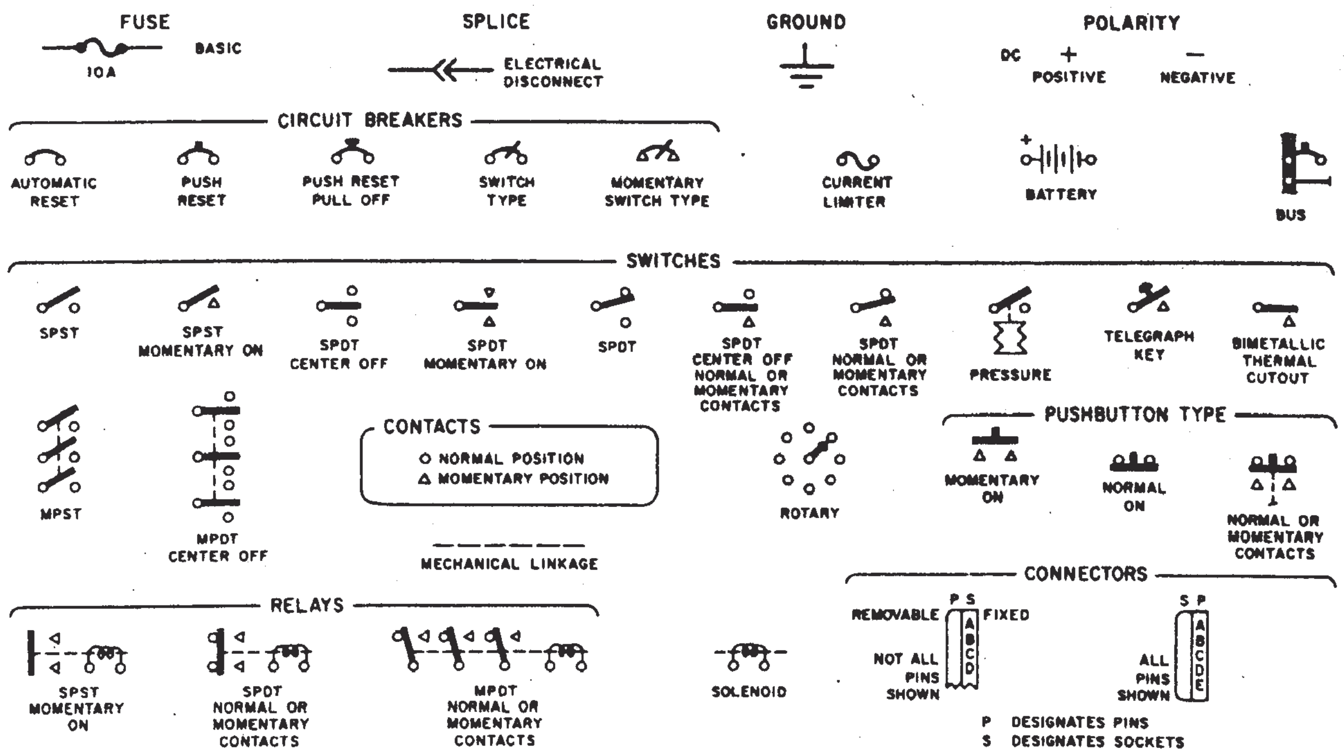


Figure 6-14.—Electrical symbols.

illustrates the electrical symbols commonly found in schematic diagrams.

Loose connections are located by checking all connectors in the circuit. A connector that can be turned by hand is loose and should be tightened hand-tight.

A continuity check is simply a matter of determining whether the circuit to the valve or other electrically controlled unit is complete. To perform a continuity check, the connector at the electrically controlled unit is first disconnected. Then, with all necessary switches and circuit breakers closed, a test lamp is connected into the circuit at the electrical connector. The lamp indicates whether or not the circuit is complete.

Continuity checks may also be made with the use of a multimeter, an instrument used for measuring resistance, voltage, or amperage.

Troubleshooting

Troubleshooting is the process of locating a malfunctioning component or other unit in a system or mechanism. For the AME, troubleshooting is an important responsibility and one which will require a lot of squadron time.

When a malfunction is reported concerning any of the components or systems that are maintained by the AME, the difficulty must be located and corrected quickly.

To troubleshoot intelligently, the AME must be familiar with the system(s) at hand, knowing the function of each component in the system and with a mental picture of the location of each component in the system in relation to other components, as well as the location of the component in the aircraft. This can be achieved best by studying the installation and schematic diagrams of the system found in the applicable MIM.

Troubleshooting procedures are similar in practically all applications. The procedures covered in this section are adaptable to almost all aircraft systems. Auto mechanics use these steps to find and repair automobile malfunctions. The AME can use these procedures to find and repair malfunctions within aircraft systems.

There are seven distinct steps to follow during troubleshooting, as follows:

1. Conduct a visual inspection. This inspection should be thorough and searching—checking all lines, linkages, and components for obvious damage,

evidence of leakage, looseness, security, material condition, and proper installation; and servicing when applicable.

2. Conduct an operational check. The malfunctioning system or subsystem is checked for proper operation. This may be done by using special support equipment such as the environmental control test set or by using aircraft power and equipment with the engine running. Each aircraft maintenance manual provides the steps to be taken in performing the operational checkout of all the aircraft's systems. The operational checks and troubleshooting charts for each system are numbered so that when a malfunction occurs during a step in the operational checkout, the malfunction can be located under the same step number in the troubleshooting chart. The troubleshooting chart will provide a list of possible causes of the malfunction in the order of probability, along with a recommended remedy. In any case, the AME must check the system out thoroughly, observing proper operation, sequence of events, etc.

3. Classify the trouble. Malfunctions usually fall into three basic categories—electrical, mechanical, and/or improper installation. Using the information acquired in steps 1 and 2, the AME determines under which category the malfunction occurs. Proper use of the test set or multimeter will identify whether the trouble is electrical or mechanical. Use of the MIM when performing all maintenance tasks should prevent improper installation. Something affecting the flow of gas or liquid (as could be the case in a vapor cycle ACS) could be categorized as a combination electrical/mechanical failure. Most mechanical failures should be found on the visual inspection; however, drive shaft failure is not readily apparent until the valve is operated. In some cases it may even be necessary to disconnect the valve from the ducting so that the butterfly valve can be observed through the end opening. The position indicator on some valves can indicate that the valve is changing positions, which can be a false indication if the shaft is broken after the indicating mechanism, or if the butterfly valve was damaged in such a manner that the shaft would rotate without actually repositioning the valve.

4. Isolate the trouble. This step calls for sound reasoning and a full and complete knowledge of how the system and each component operate. During this step, the AME can make full use of their knowledge and the system schematics to trace system operation and systematically eliminate components. They can arrive at a reasonable conclusion concerning the cause of the malfunction based on facts and deductive reasoning. Usually the trouble can be pinned down to one or two areas. By checking each individual area or component, the trouble can be isolated.

5. Locate the trouble. This step is used to eliminate unnecessary parts removal, saving time, money, and man-hours. Once the AME has isolated the trouble to a certain area or component, a closer observation of the valve or component in operation should provide some obvious indication that it is not operating as specified in the MIM. If all evidence indicates that the problem is electrical, the assistance of an AE should be requested.

6. Correct the trouble. This step is performed only after the trouble has been definitely pinpointed and there is no doubt that the AME's diagnosis is correct. Removal and replacement, or repair of the unit or system is done using the instructions provided in the applicable aircraft MIM.

NOTE: While performing maintenance on any system, ensure the step-by-step procedures outlined in the MIM, including cautions, warnings, and safety notes concerning the specific procedures, are strictly complied with.

7. Conduct a final operational check. The affected component or system must be given an operational check following installation or repair to verify proper system or component operation. The MIM will provide the procedures for conducting the operational check. It will usually require operation of the system in various modes (manual and automatic for air-conditioning and pressurization systems) or through several cycles, as applicable. Specified steps throughout the repair procedure and operational check must be observed and certified by a quality assurance representative or a collateral duty quality assurance representative from the work center performing the work. These steps are usually identified in the MIM by underlining, italics, or some other obvious method.

Q6-13. In order for the human body to operate at the same level of efficiency as at sea level, what solution was developed?

Q6-14. The area of an aircraft to be pressurized must be free from all air leaks. How is this accomplished?

Q6-15. For the S-3 pressurization system, what component provides the pressurization schedule?

Q6-16. During flight operations between 5,000 and 24,000 feet, what mode maintains the cabin altitude between 4,350 and 5,000 feet?

Q6-17. When is the re-pressurization mode used?

Q6-18. The S-3 cabin pressurization system will pressurize whenever ground elevation is above what altitude?

Q6-19. The S-3 cabin pressurization subsystem consists of how many primary components?

Q6-20. The pressure regulator safety valve limits cabin-to-ambient pressure differentials to what psi?

Q6-21. The pressure regulator control maintains cabin pressure of 5,000 feet while the aircraft is flying between what altitudes?

Q6-22. State the purpose of performing a continuity check.

Q6-23. How many distinct steps should be followed during troubleshooting?

Q6-24. Malfunctions usually fall into three basic categories. What are they?

Q6-25. During troubleshooting, all evidence indicates that the problem is electrical. Whom should you call for assistance?

CHAPTER 6

ANSWERS TO REVIEW QUESTIONS

A6-1. 14.7 psi

A6-2. Breathing

A6-3. The human body tends to burst. In some cases, blood vessels near the surface may burst, causing hemorrhages in the ears, eyes, and breathing passages.

A6-4. 1. The cabin must be designed to withstand the necessary pressure differential. This is primarily an airframe engineering and manufacturing problem.

2. There must be a means of limiting the maximum pressure differential to which walls will be subjected. This is provided by the cabin safety valve.

3. The aircraft must have an adequate supply of compressed air. This is provided through the compressor section of the jet engine. A separate compressor or supercharger is used on aircraft having reciprocating engines. On all jet aircraft, the air is taken directly from the compressor section of the jet engine. This is generally referred to as bleed air.

4. There must be a means of cooling the bleed air before it enters the cabin. This is provided by an aircraft refrigeration unit.

5. There must be a means of controlling the cabin pressure. This is provided by the cabin pressure regulator, which regulates the outflow of air from the cabin.

A6-5. The environmental control systems of most aircraft include cabin air-conditioning and pressurization, equipment cooling, defogging, windshield washing and rain removal, and equipment pressurization subsystems.

A6-6. The name air cycle or air-to-air comes from the principle of cooling the air without the use of refrigerants by compression and expansion of bleed air.

A6-7. No. 3

A6-8. Two flow-limiting venturis

A6-9. 70 percent

A6-10. Temperature controller

A6-11. Turbine refrigeration unit

A6-12. Automatic and manual

A6-13. Pressurizing the cockpit/cabin area

A6-14. By the use of seals around tubing, ducting, bolts, rivets, and other hardware that pass through or pierce the pressure tight area. All panels and large structural components are assembled with sealing compounds.

A6-15. Cabin pressure regulator

A6-16. Isobaric

A6-17. When returning to the normal mode from the dump mode or during a rapid descent in excess of 4,000 feet per minute.

A6-18. 5,000 feet

A6-19. Five

A6-20. 7.07 (+0.2 and –0.0) psi

A6-21. 5,000 and 24,000 feet

A6-22. To determine whether or not the circuit to the component is complete

A6-23. Seven

A6-24. Electrical, mechanical, and/or improper installation

A6-25. An AE

CHAPTER 7

OXYGEN SYSTEMS

A dependable supply of oxygen is an essential element for maintaining life. Oxygen systems aboard naval aircraft sustain the lives of the pilot and aircrew so they can perform their missions. AME personnel service and maintain aircraft oxygen systems. Therefore, it is important that AME personnel understand how and why oxygen systems function as they do. This chapter provides an overview of the operating characteristics and maintenance requirements for several aircraft oxygen systems, stressing safety and use of the applicable maintenance instruction manual (MIM).

IMPORTANCE OF OXYGEN

LEARNING OBJECTIVE: Identify the importance of oxygen to include types, characteristics, and effects of a lack of oxygen.

No one can live without sufficient quantities of food, water, and oxygen. Of the three, oxygen is by far the most urgently needed. If necessary, a well-nourished person can go without food for weeks, living on what is stored in the body. The need for water is more immediate, but still does not become critical for several days. The supply of oxygen in the body is limited to a few minutes. When the supply is exhausted, death is inevitable.

Oxygen starvation affects a pilot or aircrewman in much the same way that it affects an aircraft engine. Both the body and the engine require oxygen for the burning of fuel. An engine designed for low-altitude operation loses power and performs poorly at high altitudes. High-altitude operation demands a means of supplying air at higher pressure to give the engine enough oxygen for the combustion of fuel. A super-charger or compressor satisfies the engine's demands. What about the demands of the human body?

The combustion of fuel in the human body is the source of energy for everything the aviator is required to do with muscles, eyes, and brain. As the aircraft climbs, the amount of oxygen per unit of volume of air decreases, and the aviator's oxygen intake is reduced. Unless the aviator breathes additional oxygen, the eyes, brain, and muscles begin to fail. The body is designed for low-altitude operation and will not give satisfactory performance unless it is supplied the full amount of oxygen that it requires. Like the engine, the body requires a means of having this oxygen supplied to it in greater amounts or under greater pressure. This need is satisfied by use of supplemental oxygen supplied directly to the respiratory system through an oxygen mask, and by pressurizing the aircraft to a pressure equivalent to that at normal safe-breathing altitudes, or both.

For purposes of illustration, an aviator's lungs are like a bag of air since the air in the lungs behaves in the same way. If an open bag is placed in an aircraft at sea level, air will escape from it continuously as the aircraft ascends. The air pressure at 18,000 feet is only half that at sea level; therefore, at 18,000 feet the bag will be subjected to only half the atmospheric pressure it was subjected to at sea level. For this reason, it will contain only half the oxygen molecules it had when on the ground. Similarly, an aviator's lungs contain less and less air as the aircraft ascends, and correspondingly less oxygen. Thus the use of supplemental oxygen is necessary on high-altitude flights.

Up to approximately 35,000 feet, an aviator can keep sufficient oxygen in the lungs to permit normal activity by use of oxygen equipment that supplies oxygen upon demand (inhalation). The oxygen received by the body on each inhalation is diluted with decreasing amounts of air up to approximately 33,00 feet. Above 33,000 feet and up to approximately 35,000 feet, this equipment provides 100 percent oxygen. At approximately 35,000 feet, inhalation through the demand oxygen system alone will NOT provide enough oxygen.

Above 35,000 feet and up to 43,000 feet, normal activity is only possible by use of *pressure demand* equipment. This equipment consists of a super-charger arrangement by which oxygen is supplied to the mask under a pressure slightly higher than that of the surrounding atmosphere. Upon inhalation, oxygen is forced (pressured) into the mask by the system. Upon exhalation, the oxygen pressure is shut off automatically so that carbon dioxide can be expelled from the mask. Above 43,000 feet, the only adequate provision for the safety of the aviator is pressurization of the entire body.

TYPES OF OXYGEN

Aviators breathing oxygen (ABO) (MIL-0-27210) is supplied in two types—type I and type II. Type I is gaseous oxygen and type II is liquid oxygen. Oxygen procured under this specification is required to be 99.5 percent pure. The water vapor content must not be more than 0.02 milligrams per liter when tested at 21.1°C (70°F) and at sea level pressure.

Technical oxygen, both gaseous and liquid, is procured under specification BB-O-925A. The moisture content of technical oxygen is not as rigidly controlled as is breathing oxygen; therefore, the technical grade should never be used in aircraft oxygen systems.

The extremely low moisture content required of breathing oxygen is not to avoid physical injury to the body, but to ensure proper operation of the oxygen system. Air containing a high percentage of moisture can be breathed indefinitely without any serious ill effects. The moisture affects the aircraft oxygen system in the small orifices and passages in the regulator. Freezing temperatures can clog the system with ice and prevent oxygen from reaching the user. Therefore, extreme precautions must be taken to safeguard against the hazards of water vapor in oxygen systems.

CHARACTERISTICS OF OXYGEN

Oxygen in its natural state is a colorless, odorless, and tasteless gas. Oxygen is considered to be the most important of all the elements to life. It forms about 21 percent of the atmosphere by volume and 23 percent by weight. The remainder of the atmosphere consists of nitrogen (78 percent) and inert gases (1 percent), of which argon is the most abundant.

Of all the elements in our environment, oxygen is the most plentiful. It makes up nearly one-half of the Earth's crust and approximately one-fifth of the air we breath.

Oxygen combines with most of the other elements. The combining of an element with oxygen is called oxidation. Combustion is simply rapid oxidation. In almost all oxidations, heat is given off. In combustion, the heat is given off so rapidly it does not have time to be carried away; the temperature rises extremely high, and a flame appears.

Some examples of slow oxidation are rusting of iron, drying of paints, and the change of alcohol into vinegar. Even fuels in storage slowly oxidize, the heat usually being rapidly carried away. However, when the heat cannot easily escape, the temperature will rise and a fire may break out. This fire is the result of spontaneous combustion.

Oxygen does not burn, but it does support combustion. Nitrogen neither burns nor supports combustion. Therefore, combustible materials burn more readily and vigorously in oxygen than in air, since air is composed of about 78 percent nitrogen by volume and only about 21 percent oxygen.

In addition to existing as a gas, oxygen can exist as a liquid and as a solid. Liquid oxygen is pale blue in color. It flows like water, and weighs 9.52 pounds per gallon.

EFFECTS OF LACK OF OXYGEN

A decrease in the amount of oxygen per unit volume of air results in an insufficient amount of oxygen entering the bloodstream. The body reacts to this condition rapidly. This deficit in oxygen is called *hypoxia*. When the body regains its normal oxygen supply, one may recover from hypoxia. A complete lack of oxygen, which results in permanent physical damage or death, is called *anoxia*.

Hypoxia

There is an enormous increase in oxygen requirements caused by an increase in physical activity. Strenuous exercise like long distance running greatly increases the need for oxygen, which is evidenced by deep and rapid breathing. Even mild exercise like getting up and walking around a room may double the air intake. In the case of the aviator, leaking of an oxygen mask, which may go completely unnoticed while the wearer is at rest, may lead to collapse and unconsciousness when an attempt is made to move from one station to another in the aircraft. A walkaround (portable) oxygen bottle that is sufficient for 24 minutes of quiet breathing may be emptied by 17 minutes of use when the user is moving around inside the aircraft.

Effects of Hypoxia

People differ in their reactions to hunger, thirst, and other sensations. An individual's reactions vary from time to time under similar circumstances. Illness, pain, fear, excessive heat or cold, and many other factors govern what the response will be in each particular case. The same thing is true of individual reactions to oxygen starvation. The effects of hypoxia on a given person cannot be predicted accurately. For example, a person may be relatively unaffected one day, but highly susceptible the next.

It is difficult to detect hypoxia, because its victims are seldom able to judge how seriously they are affected, or if they are affected at all. The unpleasant sensations experienced in suffocation are absent in the case of hypoxia. Blurring of vision, slight shortness of breath, a vague weak feeling, and a little dizziness are the only warnings. Even these may be absent or so slight as to go unnoticed.

While still conscious, the aviator may lose all sense of time and spend the last moments of consciousness in some apparently meaningless activity. In such a condition, a person is a menace to the crew as well as to himself. Since the aviator understands that it is the reduced air pressure at higher altitudes that determines the effect on the body, dependence should be upon the altimeter rather than sensations or judgment to determine when oxygen is needed. The effects of hypoxia at various altitudes are discussed in the following paragraphs.

BELOW 10,000 FEET.—At or below 10,000 feet, some effects of hypoxia may be present. Generally, the eye is the first part of the body to suffer effects of hypoxia. Even at a relatively low altitude of approximately 5,000 feet, where no other effect of hypoxia can be detected, night vision may be affected, due to mild oxygen starvation. Thus, the use of supplemental oxygen on night flights above 5,000 feet is required. Although hypoxia affects the eyes in the daytime as well as at night, the results during the day are usually not as noticeable below 10,000 feet.

BETWEEN 10,000 AND 15,000 FEET.—Although efficiency may be considered impaired at 10,000 to 15,000 feet, death from oxygen starvation at these altitudes is virtually unknown. The greatest dangers are from errors in judgment or performance due to drowsiness or mental confusion. At these altitudes, long flights without oxygen produce persistent drowsiness and excessive fatigue for many hours afterward. Frequently, persistent headaches develop soon after completion of the flight. For these reasons, the use of oxygen on flights above 10,000 feet is required. Portable oxygen systems are available for aircraft that do not have oxygen equipment.

BETWEEN 15,000 AND 20,000 FEET.—Flights at 15,000 to 20,000 feet, even for short periods, must never be attempted without the use of oxygen. Collapse and unconsciousness are common. Failure to use oxygen could result in death, especially when the situation is complicated by loss of blood in combat or by shock due to pain or fear.

BETWEEN 20,000 AND 25,000 FEET.—During World War II, most military flying was done in unpressurized aircraft at altitudes of between 20,000 and 25,000 feet. Most of the resulting anoxia deaths occurred in this altitude range. The general symptoms of drowsiness, mental confusion, dim vision, and dizziness occur here, as at lower altitudes, but they come on much more quickly, allowing less opportunity for corrective action. Consequently, under no circumstances should aircraft ascend to these altitudes, even for short periods, without the use of oxygen by all persons aboard. The movement of personnel in the aircraft requires the constant use of walk-around equipment. Unusual actions or failure of a crewmember to respond quickly and clearly when called require immediate investigation.

BETWEEN 25,000 AND 30,000 FEET.—Between 25,000 and 30,000 feet, collapse, unconsciousness, and death quickly follow interruption of the oxygen supply. Mask leakage at these altitudes may cause a degree of hypoxia that, although not noticed during flight, can produce considerable fatigue and have serious cumulative effects.

ABOVE 30,000 FEET.—Above 30,000 feet, unconsciousness and death strike rapidly and often without warning. At such altitudes, it is imperative that all oxygen equipment is functioning correctly and that each breath is taken through a properly fitted oxygen mask. Above a pressure altitude of 35,000 feet, pressure breathing oxygen equipment is required.

Q7-1. As an aircraft climbs, what effect occurs to the volume of air?

Q7-2. Unless an aviator breathes additional oxygen, which three main systems on the body begin to fail?

Q7-3. Above 33,000 feet to approximately 35,000 feet, oxygen equipment provides what percentage of oxygen?

Q7-4. Above 43,000 feet, what requirement is the only adequate provision for the safety of an aviator?

Q7-5. Oxygen procured under MIL-0-27210 is required to be what minimum percent pure?

Q7-6. What color is liquid oxygen?

Q7-7. A complete lack of oxygen is referred to by what medical term?

GASEOUS OXYGEN SYSTEMS

LEARNING OBJECTIVE: Identify safety precautions, components, and maintenance procedures for gaseous oxygen systems.

Gaseous oxygen systems are used primarily in large, multi-place aircraft where space and weight limitation are less important items and the systems are used only occasionally.

HANDLING/SAFETY PRECAUTIONS

The pressure in gaseous oxygen supply cylinders should not be allowed to fall below 50 pounds per square inch (psi). If the pressure falls much below this value, moisture is likely to accumulate in the cylinder and could be introduced into the oxygen system of the aircraft, causing component malfunction.

All oxygen under pressure is potentially very dangerous if handled carelessly. Personnel servicing or maintaining oxygen systems and components must be extremely careful about preventing grease, oil, hydraulic fluid, or similar hydrocarbons as well as other contamination from coming in contact with lines, hoses, fittings, and equipment, as this contact presents a fire and explosion hazard.

If, because of hydraulic leaks or some other unpreventable malfunction, components of the oxygen system do become externally contaminated, they should be cleaned using only approved oxygen system cleaning compounds. While some MIMs specify the use of a variety of cleaning compounds, the preferred compound is oxygen system cleaning compound type I conforming to Military Specification MIL-C-81302.

The following safety precautions should be adhered to:

- Under no circumstances should a non-approved cleaning compound be used on any oxygen lines, fittings, or components.
- When handling oxygen cylinders, the valve protection cap should always be in place. Before removing the cap and opening the valve, ensure that the cylinder is firmly supported. A broken valve may cause a pressurized cylinder to be propelled like a rocket.
- Do NOT use oxygen in systems intended for other gases or as a substitute for compressed air.
- Cylinders being stored for use on gaseous oxygen servicing trailers or any other use must always be properly secured. Do not handle cylinders or any other oxygen equipment with greasy hands, gloves, or other greasy materials. The storage area should be located so that oil or grease from other equipment cannot be accidentally splashed or spilled on the cylinders.

Additional safety precautions may be found in the publications of technical manual *NAVAIROSH Requirements for the Shore Establishments*, NAVAIR A1-NAOSH-SAF-000/P-5100; *Aviators Breathing Oxygen (ABO) Surveillance Program Laboratory Manual and Field Guide*, A6-3332AO-GYD-000; and *Aviator Crew Systems Technical Manuals*, NAVAIR 13-1-6.4 series.

SYSTEM COMPONENTS

Basically, all gaseous oxygen systems consist of the following:

- Containers (cylinders) for storing oxygen supply
- Tubing to route the oxygen from the main supply to the users
- Various valves for directing the oxygen through the proper tubing
- Metering devices (regulators) to control the flow of oxygen to the user
- Gauges for indicating the oxygen pressure
- Masks to direct the oxygen to each user's respiratory system

Cylinders

Gaseous oxygen cylinders used in naval aircraft systems are generally high-pressure and non-shatterable, meaning that the cylinder is designed to resist shattering when punctured by a foreign object, such as gunfire, at a pressure of 1,800 psi. The resistance to shattering is generally achieved by the use of a heat-treated alloy or wire wrapping applied to the outside of the cylinder. The two most common cylinder sizes are 514 and 295 cubic inches.

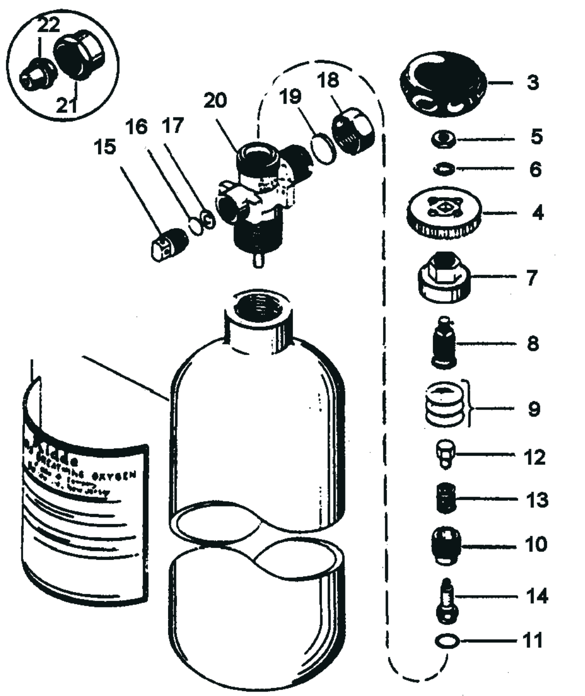
The main advantage of the high-pressure cylinder is that it minimizes space used for storing gaseous oxygen. All high-pressure oxygen cylinders are painted green in accordance with the established color codes provided in MIL-STD-101A.

Cylinders come equipped with either a manually operated handwheel valve or an automatic self-opening valve (figs. 7-1 and 7-2). Opening the handwheel operated valve assembly releases the contents of the cylinder. The handwheel has four 5/15-inch diameter holes for the attachment of remote operation equipment, if needed.

The valve is equipped with a fusible metal safety plug and a safety disc to release the contents of the cylinder if the pressure becomes excessive because of high temperature. The safety plug is filled with a fusible metal designed to melt at temperatures ranging from 208°F to 220°F (97.8°C to 104.5°C).

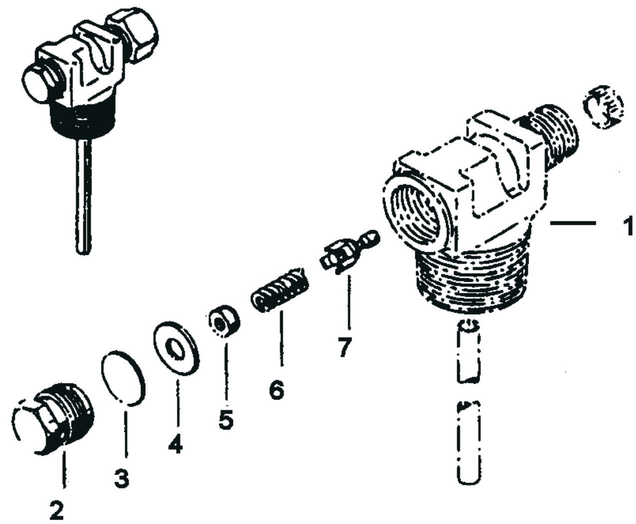
The cylinder and valve assembly is connected to the oxygen tubing by soldering the tubing to a coupling nose and securing the nose to the valve outlet with a coupling nut.

The self-opening (automatic) oxygen cylinder valve is automatically opened when it is connected to the oxygen line. The use of this type of valve permits



1. CYLINDER
2. LABEL–INSTRUCTION ON WALTER KIDDE CYLINDERS
3. HANDGRIPS
4. HANDWHEEL
5. NUT, HANDWHEEL
6. WASHER, LOCK EXTENSION TEETH, BRONZE, NO. 10
7. CAPS, VALVE
8. STEM, UPPER
9. DIAPHRAGM (SET OF 3)
10. BUSHING
11. GASKET, BUSHING
12. CAP, SPINDLE
13. SPRING
14. SEAT, VALVE
15. PLUG, SAFETY
16. DISC, SAFETY
17. WASHER, SAFETY DISC
18. CAP, OUTLET
19. WASHER, OUTLET CAP
20. BODY, VALVE
21. NUT, COUPLING
22. NOSE, COUPLING

Figure 7-1.—Gaseous oxygen cylinder and handwheel valve assembly.



1. SELF-OPENING HIGH-PRESSURE OXYGEN VALVE ASSEMBLY
2. SAFETY PLUG ASSEMBLY
3. SAFETY DISC
4. DISC WASHER
5. SPRING NEST
6. SPRING
7. ASSEMBLY CHECK

Figure 7-2.—Self-opening oxygen cylinder valve.

remote location of the oxygen cylinder to places less vulnerable during combat and more readily accessible for servicing.

Regulators

The success or failure of high-altitude flight depends primarily on the proper functioning of the oxygen breathing regulator. Acting as a metering device, the regulator is the heart of the oxygen system. To perform successfully in an aircraft system, a regulator must deliver the life-supporting oxygen in the quantities demanded throughout its entire range of operation.

Although personnel of the Aircrew Survival Equipmentman (PR) rating are primarily responsible for maintenance of regulators, the AME is responsible for performing operational checks in the aircraft and for removal and installation. In other words, the AME removes a malfunctioning regulator from the aircraft and delivers it to the shop where the PR determines the trouble and makes the necessary repairs. When the trouble is corrected, the AME reinstalls the regulator in the aircraft.

Tubing

Two types of tubing are used in aircraft oxygen systems. Low-pressure aluminum alloy tubing is used in lines carrying pressures up to 450 psi. High-pressure copper or aluminum alloy tubing is used in lines carrying pressure above 450 psi.

Lines running from the filler valve to each of the cylinders are called *filler lines*. Those running from the cylinders to the regulators are called *distribution* or *supply lines*.

Oxygen lines, like all other lines in the aircraft, are identified by strips of colored tape. The strips of tape are wrapped around each line near each fitting and at least once in each compartment through which the line runs. The color code for oxygen lines is green and white with the words *Breathing Oxygen* printed in the green portion, while black outlines of rectangles appear in the white portion.

Resistance to fatigue failure is an important factor in oxygen line design because the line pressure in a high-pressure system will at times exceed 1,800 psi, and at other times be as low as 300 psi. Because of these varying pressures and temperature, expansion and contraction occur all the time. These fluctuations cause *metal fatigue*, which must be guarded against in both the design and the construction specifications for tubing. Steps are taken during installation to prevent fatigue failure of the tubing. Tubing is bent in smooth coils wherever it is connected to an inflexible object, like a cylinder or a regulator. Every precaution is taken to prevent the accidental discharge of compressed oxygen because of faulty tubing or installation. Although simple in construction and purpose, tubing is the primary means by which oxygen is routed from the cylinders to the regulator stations.

High-pressure tubing is used between the oxygen cylinder valve and the filler connection in all systems, between the cylinder valve and the regulator inlet in high-pressure systems, and between the cylinder valve and pressure reducer in reduced high-pressure systems.

To connect high-pressure copper tubing, adapters and fittings are silver-soldered to the tubing ends. Due to the high pressures involved, the security (leak tightness) of all high-pressure lines relies primarily on a metal-to-metal contact of all its fitting and connections. A fitting properly silver-soldered to the end of a length of copper tubing will not come loose or leak.

Valves

Various types of valves are installed in gaseous oxygen systems. Among the most commonly used are check valves, pressure-reducing valves, and filler valves.

CHECK VALVES.—Check valves are installed at various points in the oxygen system. Their purpose is to permit the flow of oxygen in one direction only and to prevent the loss of the entire oxygen supply in the event a cylinder or line is ruptured.

Various styles of single, dual, and triple check valves are available, as shown in figure 7-3. The arrows embossed on the valve casting indicates the direction of flow through the valve.

PRESSURE-REDUCING VALVES.—Pressure-reducing valves (or pressure reducers) are used in certain oxygen systems for the purpose of reducing high cylinder pressure to a working low pressure. In most installations the pressure reducers are designed to reduce the pressure from 1,800 psi to a working pressure of 60 to 70 psi. They are always located in the oxygen distribution lines between the cylinders and the flight station outlets. Figure 7-4 illustrates a typical pressure-reducing valve.

FILLER VALVES.—All oxygen systems are designed so the entire system can be serviced (refilled) through a common filler valve. The filler valve is

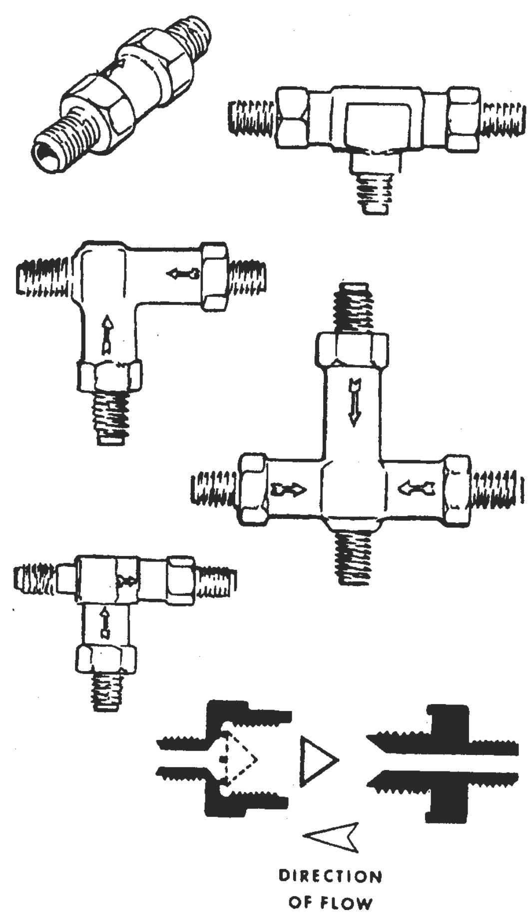


Figure 7-3.—Oxygen system check valves.

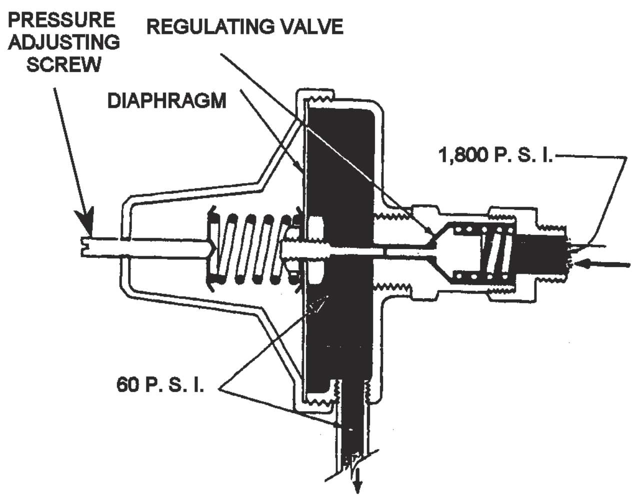


Figure 7-4.—Pressure-reducing valve.

generally located so it may be reached by a person standing on the ground or wing. The filler valve contains a check valve, which opens during the filling operation and closes when filling is completed. A dust cap keeps out dust, dirt, grease, and moisture.

Gauges

Gauges are used in gaseous oxygen systems to indicate the oxygen pressure in pounds per square inch. All systems are equipped with at least one gauge that indicates the amount of oxygen in the cylinders. The gauge also indicates indirectly how much longer the oxygen will last.

The volume of any gas compressed in a cylinder is directly proportional to the pressure. If the pressure is half, the volume is half, etc. Therefore, if 900 psi of oxygen remains in a 1,800-psi system, half the oxygen is left.

A pressure gauge is always mounted at each flight station, usually on the regulator. These gauges are calibrated to indicate from 0 to 2,000 psi on high-pressure systems and 0 to 500 psi on reduced high-pressure systems.

TYPICAL GASEOUS OXYGEN SYSTEMS

As previously stated, naval aircraft equipped with high-pressure oxygen systems are designed for approximately 1,800 psi, with working pressures reduced to 60 to 70 psi by a reducer or regulator. Systems equipped with a pressure reducer are referred to as reduced high-pressure systems. The reduced high-pressure gaseous oxygen system shown in figure 7-5 is typical of high-pressure cylinders and supplies three regulators—one each for the pilot, copilot, and flight engineer.

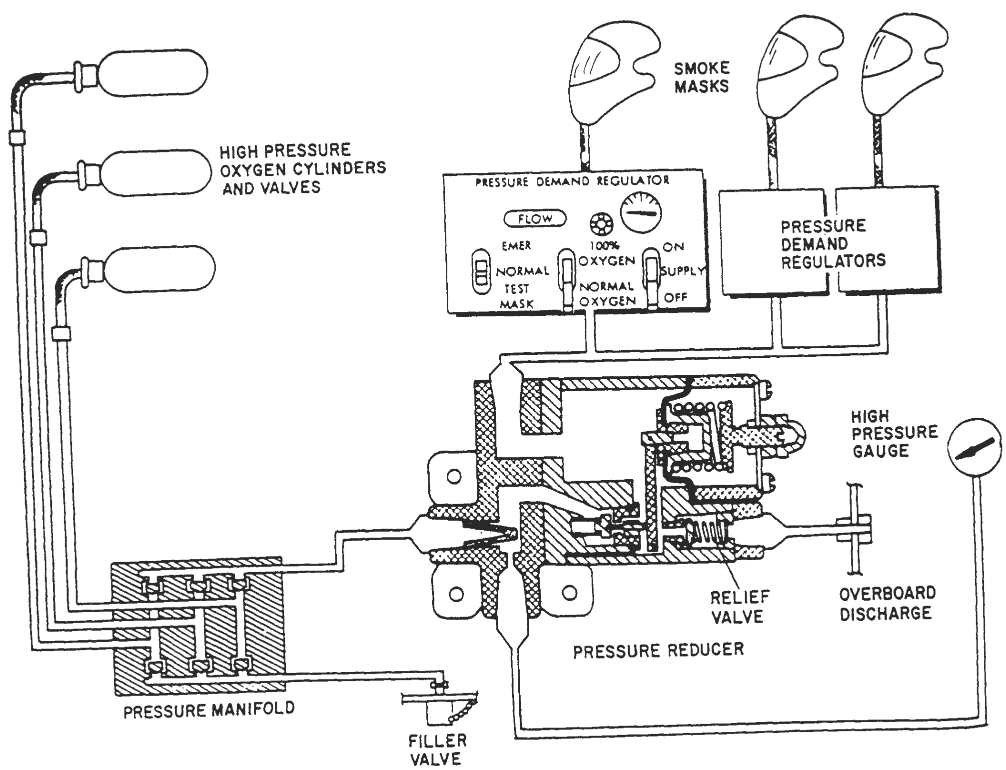


Figure 7-5.—Reduced high-pressure oxygen system schematic.

SYSTEM OPERATION

The pressure manifold, which is equipped with internal check valves, receives oxygen flow from the cylinders, directs the flow into a common line, and routes it to the pressure reducer. The manifold assembly also connects to a filler line, allowing the three cylinders to be recharged simultaneously from an external supply. The pressure reducer decreases the pressure to 65 psi. Incorporated on the low-pressure side of the pressure reducer is a relief valve, which connects through tubing to an overboard discharge indicator. In the event of excessive pressure developing within the low-pressure section of the pressure reducer, the excess pressure will flow through the relief valve and out the overboard discharge line. This flow will rupture the green disc in the discharge indicator, giving a visual indication of a malfunctioning pressure reducer.

A line from the high-pressure side of the pressure reducer connects to a gauge in the cockpit. This gauge gives the pilot an indication of pressure in the three storage cylinders.

Portable Oxygen Systems

Portable oxygen systems include walkaround cylinders, survival kits, and bailout units. These systems are used primarily to maintain crew functions in the event of failure of the fixed oxygen systems. The survival kit oxygen system also performs the same function during descent after bailout. All of these are small, lightweight, high-pressure, self-contained gaseous systems, which are readily removed from the aircraft.

Walkaround cylinders are standard equipment on many transport, patrol, and early warning aircraft, and are used separately or in addition to a permanently installed oxygen system. Each system consists of a reducer and regulator assembly mounted directly on a small oxygen cylinder.

Figure 7-6 illustrates a high-pressure walkaround oxygen system. It is a 295- or 514-cubic-inch capacity, 1,800-psi cylinder equipped with a regulator, which is connected to the cylinder with a short coiled length of copper tubing. A short flexible breathing tube, clamped to the outlet of the regulator at one end and fitted with a connector at the other end, provides the assembly for the attachment of the demand mask tube. Straps fastened to the cylinder bracket provide the means for securing the unit to the user's seat or part of the aircraft's structure. The cylinder bracket may be placed horizontally or stood on end while in use. The straps can be used as a handle to carry it from place to place. Because of its weight, the walkaround unit should not be carried by its breathing tube, regulator, or copper tubing.

SYSTEM MAINTENANCE

The maintenance procedures discussed in this section are general in nature. Consult the applicable MIM prior to performing any maintenance on each specific type of aircraft. Routine maintenance includes servicing of cylinders, checking the system and regulators for leaks, operationally checking the system, and troubleshooting malfunctions.

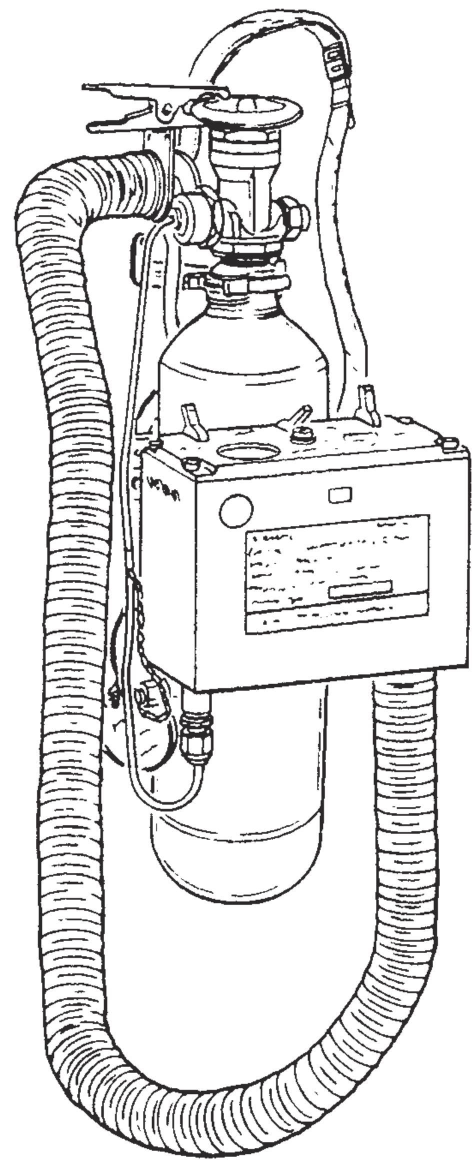


Figure 7-6.—Portable oxygen system.

Malfunctions may become apparent during inspections, testing, or actual use of the oxygen system. The remedies for some malfunctions will be quite obvious, while in other cases it may require extensive time and effort to pinpoint the actual cause. The effectiveness of corrective action will be dependent on an accurate diagnosis of the malfunction.

Troubleshooting of the gaseous oxygen system, as with the other systems, is the process of locating a malfunctioning component or unit in a system or mechanism. To troubleshoot intelligently, you must be familiar with the system and know the function of each component within the system. You can study the schematic diagrams of the system provided in the MIM to gain a mental picture of the location of each component in relation to other components. By learning to interpret these diagrams, you can save time in isolating malfunctioning components. The schematic diagram does not indicate the location of components in the aircraft; however, it will provide the means to trace the oxygen flow from the cylinder through each component to the mask.

Installation diagrams provided in either the MIM or the illustrated parts breakdown (IPB) will assist you in locating the particular component in the aircraft.

The MIMs provide a variety of troubleshooting charts, which are intended to aid you in discovering the cause of malfunction and its remedy. Table 7-1 illustrates one type of chart. The discrepancy is listed in the first column with the probable cause in the second and the remedy in the third. The list of probable causes is arranged in the order of probability of occurrence.

Q7-8. The pressure in gaseous oxygen supply cylinders should not be allowed to fall below what level?

Q7-9. What is the preferred compound for use in oxygen system cleaning?

Q7-10. True or False. Oxygen systems can be used as a substitute for compressed air.

Q7-11. What component is used to direct the oxygen to the user's respiratory system?

Q7-12. What are the two most common cylinder sizes?

Table 7-1.—Gaseous Oxygen System Troubleshooting

Discrepancy	Probable Cause	Remedy
Excessive leakage of system pressure.	Filler valve leaking.	Replace filler valve.
	Leak in lines.	Check tubing, fittings, and connections and repair or replace as necessary.
	Flexible hose leaking.	Replace hose.
	Regulator not shut off.	Shut off regulator.
Crewmember receives insufficient oxygen at high altitude.	Improperly functioning regulator.	Replace regulator.
	Ill-fitting mask.	Refit or replace mask.
	Mask flapper valve not operating properly.	Check mask exhaust valve.
	Flexible tubing to mask crushed or kinked.	Replace tubing as necessary.
No pressure reading at the regulator	Defective regulator.	Replace regulator.
	Oxygen supply turned off.	Turn on cylinder hand valve if so equipped.
	System not charged.	Replenish oxygen supply.
Regulator pressure gauge indications are incorrect.	Gauge defective.	Replace gauge.
Regulator flow indicator not functioning.	Indicator defective.	Replace regulator.

Q7-13. High-pressure copper or aluminum alloy tubing can withstand what amount of pressure?

Q7-14. What is the purpose of oxygen check valves?

LIQUID OXYGEN (LOX) SYSTEMS

LEARNING OBJECTIVE: Identify safety precautions, components, installation and testing of components, and operating procedures for liquid oxygen (LOX) systems.

Liquid oxygen, commonly referred to as *LOX*, is normally obtained by a combined cooling and pressurization process. When the temperature of gaseous oxygen is lowered to –182°F under 720 psi pressure, it will begin to form into a liquid. When the temperature is lowered to –297°F, it will remain a liquid under normal atmospheric pressure.

Once converted into a liquid, oxygen will remain in its liquid state as long as the temperature is maintained below –297°F. The liquid has an expansion ratio of about 862 to 1, which means that one volume of LOX will expand about 862 times when converted to a gas at atmospheric pressure. Thus, 1 liter of LOX produces about 862 liters of gaseous oxygen.

SAFETY PRECAUTIONS

As already mentioned, the main dangers of LOX are the extremely low temperature of the liquid, its expansion ratio, and its support of violent combustion. The liquid is nontoxic, but will freeze (burn) the skin severely upon contact.

Use extreme caution not to touch implements containing LOX unless gloves are worn. Without gloves, bare skin would immediately stick and freeze to the metal surface.

Personnel who could be exposed to accidental spillage of LOX must wear a face shield, coveralls, gloves, and oxygen safety shoes to prevent skin and vision damage. Open gloves, low-cut shoes, trousers with cuffs, and similar improper clothing that can form pockets capable of holding a quantity of LOX present a severe hazard. All personnel handling LOX must wear the protective clothing specified in the protective clothing section of NAVAIR 13-1-6.4.

A greater danger than freezing is the combustion-supporting potential of oxygen. When LOX is used, it is possible to build up high concentrations of oxygen quickly. Many materials such as cloth, wood, grease, oil, paint, or tar will burn violently when saturated with oxygen, provided an ignition source is supplied. A static electric discharge or spark can serve as an igniter. Once an oxygen-enriched fire is started, it is virtually impossible to extinguish until the oxygen supply is cut off.

An added danger exists if a combustible material is saturated with oxygen at low temperatures. Many materials, especially hydrocarbons, tar, etc., will burn with explosive violence when saturated or subjected to very mild shock or impact.

Extreme care must be taken not to splash or spill LOX on clothing. When LOX comes in contact with cloth, an ideal and deadly situation for a fire exists—a fire that cannot be put out.

LOX by itself will not burn, but mixing with the smallest amount of almost any material will cause the liquid to boil and splash violently, making combustion possible. If splashed out of a container, LOX will break into many parts upon contact with the floor/deck. It must be poured slowly from one container to another to avoid splashing, and to allow the gaining receptacle to cool sufficiently without thermal breakage.

NEVER seal or cap the vent port of a liquid oxygen system, because liquid oxygen at atmospheric pressure will generate up to 12,000 pounds of pressure if allowed to evaporate in a sealed container or system that has no relief provisions.

Access to oxygen supply/storage areas should be limited only to personnel familiar with proper handling procedures. The area should be adequately ventilated and free of any materials that could present a fire hazard. All pressure-type containers, plumbing, and pressure-relief devices should conform to the applicable maintenance manual and be kept in good repair. The vents on LOX containers are designed to have a sufficient flow capacity to carry away any oxygen that may boil off in case of accidental loss of insulation. Do NOT cap such vents or cause the opening to be restricted in any way.

The pressure relief assembly in LOX system storage cylinders consists of a reseatable relief valve and rupture disc in parallel. The assembly is designed so that the relief valve relieves first, with the rupture disc acting as a safety backup in the event the relief valve malfunctions or its relieving capacity is exceeded.

LOX converters and servicing trailers should be stowed or parked so that they are protected from excessive heat and direct rays of sunlight as much as is practical. All LOX should be segregated from containers of other gases or liquids and all flammable materials. Hydrocarbons such as oil and grease in the oxygen handling area could result in death, serious injury, and property damage.

Smoking, open flames, or sparks are not permitted in any oxygen handling area. When transferring oxygen, provide adequate ventilation to prevent the formation of an oxygen-enriched atmosphere.

Avoid spilling LOX on floors or deck areas. In case of accidental spillage, ventilate the area. Intentional draining of LOX from a system or container must be caught in a clean drain pan and allowed to evaporate in a suitable open area that will not present a hazard.

In the event that LOX is spilled on clothing, separate clothing from skin contact immediately and thoroughly air clothing for 1 hour to allow dilution of the oxygen concentration. When an uninsulated container of LOX is touched or when there is any reason to suspect some part of the body has been frozen or chilled, the area should be thoroughly washed or immersed in clean water that is slightly above body temperature (approximately 104°F to 113°F). The exposed area should then be loosely wrapped with a clean, dry dressing, and medical aid should be sought immediately.

When servicing and maintaining LOX systems, the AME will be required to transfer LOX from servicing trailers to aircraft converters, and occasionally from the converter to the drain pan. The AME also will be required to remove and install converters and other components of LOX systems. All servicing and maintenance of LOX systems must be done in accordance with instructions contained in the applicable aircraft MIM. All safety precautions concerning the handling of LOX must be adhered to.

When a completely empty system is being serviced, the LOX should be added slowly to cool the converter down to the storage temperature (–297°F). The converter could otherwise be damaged by thermal shock or rapid pressure buildup.

Additional gaseous and liquid oxygen safety precautions and handling procedures are provided in the following publications:

- NAVAIR A1-NAOSH-SAF-000/P5100/1, *NAVAIROSH Requirements for the Shore Establishment*
- NAVAIR 06-30-501, *Technical Manual of Oxygen/Nitrogen Cryogenic Systems*

All personnel handling oxygen and maintaining gaseous or liquid oxygen systems should be thoroughly familiar with all precautions and procedures listed in the latest revisions to these publications. They also should be familiar with the specific precautions provided in the applicable aircraft MIM and those pertaining to the type of equipment being used to service such systems.

SYSTEM COMPONENTS

Aircraft LOX systems are similar to gaseous oxygen systems except that the several cylinders of gaseous oxygen are replaced by one or more LOX converters. The use of more than one converter provides for an adequate supply of oxygen on long-range flights or where there is more than one crewmember using the oxygen systems. In addition to the converters, most LOX systems contain a heat exchanger; filler, pressure control, relief, and shutoff valves; quick-disconnect couplings; low-pressure switch; oxygen lines and regulators; and quantity indicating units. See figure 7-7 for a schematic diagram of a LOX system.

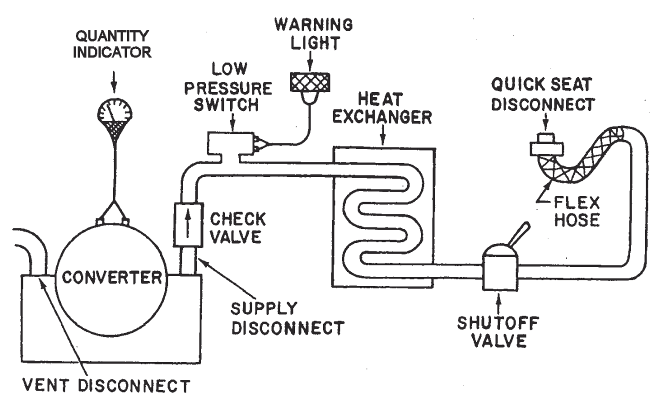


Figure 7-7.—LOX system schematic.

Container

The LOX converter (fig. 7-8) consists of an inner and outer shell of stainless steel separated by a vacuum. A blowout disc provides a margin of safety from explosion if a leak occurs in the inner shell.

Filler Valve

The filler valve is a combination filler, vent, and buildup valve. The filler portion of the valve is essentially a spring-loaded check valve (fig. 7-9). When the servicing hose of the LOX cart is coupled to the filler connection, the poppet is displaced. This seals the supply port and allows container pressure to be relieved through the vent port. At the same time, oxygen flows through the filler connection and fill port to the container. When the container is full, the liquid flows from the container through the gas port and then through the vent port. In the normal position, the spring in the filler connection holds the poppet in place, forming a gastight seal. There is a check valve in the fill port that acts as a backup seal in the event the filler connection develops a leak. The vent port also is sealed in this position, allowing the gaseous boil-off (from the top of the container) to flow through the gas port to the supply port and into the oxygen system.

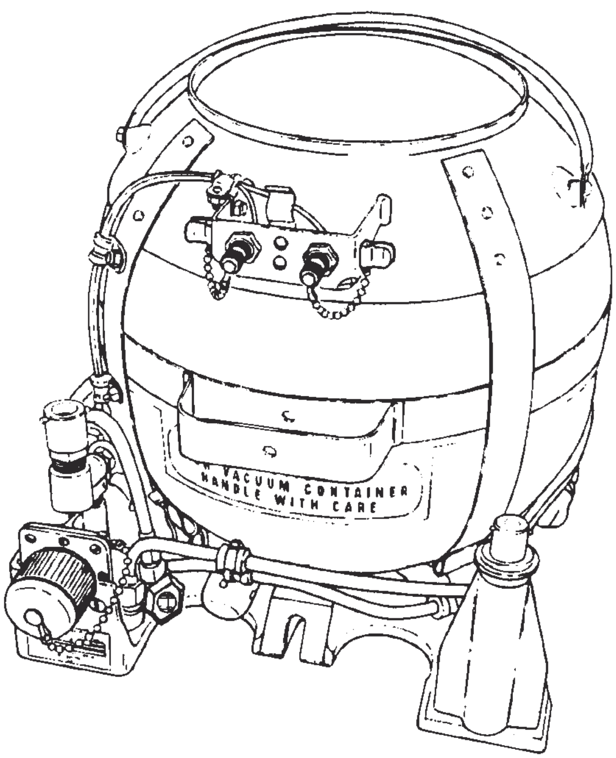


Figure 7-8.—Liquid oxygen converter assembly.

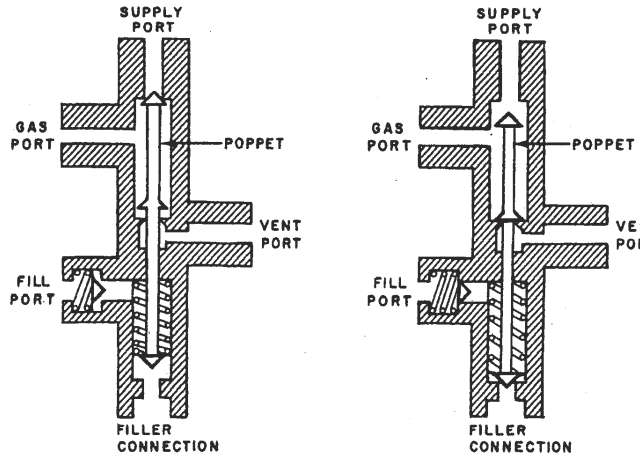


Figure 7-9.—Filler valve.

Pressure Control Valve

The pressure control valve used on most converters is a combination opening and closing valve (two valves contained within one housing). These valves are controlled by spring-loaded bellows. The pressure-closing valve is spring-loaded open and the pressure-opening valve is spring-loaded closed. The pressure-opening valve controls the flow of gaseous oxygen into the supply line. If the pilot's demand for oxygen becomes greater than the capability of the pressure opening valve to deliver, there is a differential check valve that opens and allows liquid oxygen to flow directly into the supply line. It is transformed into gaseous oxygen during its passage through the oxygen system supply lines.

Relief Valves

A relief valve is provided in the converter to relieve excessive pressure buildup in the event of a malfunction in the pressure control valves. It also relieves normal pressure buildup when the system is not in use. This normal buildup pressure is caused by heat entering the system, and will cause a loss of 10 percent of the system's capacity every 24 hours; for example, approximately 1 liter of loss will be experienced from a 10-liter converter.

Quick-Disconnect Couplings

Liquid oxygen systems are designed for the rapid removal of the LOX converter for ease of servicing and maintenance. This is accomplished by the use of supply and vent quick-disconnect couplings, a single point converter retainer wing nut hold down, and quick-disconnect quantity indicator lead disconnects (fig. 7-10).

The vent and supply quick-disconnect couplings are of two-piece construction. The male half is mounted on the LOX converter, and the female half is attached to the flexible oxygen supply and vent lines.

The coupling for the supply line contains a spring-loaded check valve, which closes automatically when the supply line is uncoupled from the converter. This prevents contaminating the aircraft oxygen system when the converter is removed for servicing. The vent coupling has no check valve; however, it forms a positive seal between the vent port of the converter and overboard vent line.

Heat Exchanger

The lungs would be damaged if gaseous oxygen were breathed at the temperature at which it exits the LOX converter. The purpose of the air-to-oxygen heat exchanger is to increase the temperature of the gaseous oxygen after it leaves the LOX converter. The heat exchanger is located in the cockpit area of the aircraft to expose it to a temperature capable of warming the gaseous oxygen regardless of the altitude of the aircraft. The heat exchanger is aluminum with a large interior surface area (fig. 7-11).

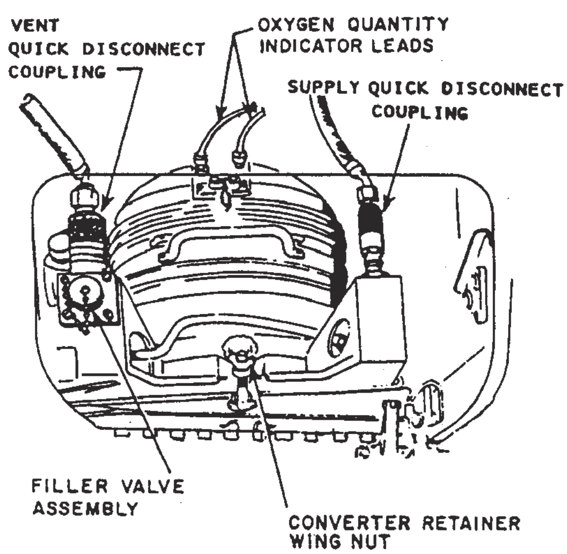


Figure 7-10.—LOX converter installation.

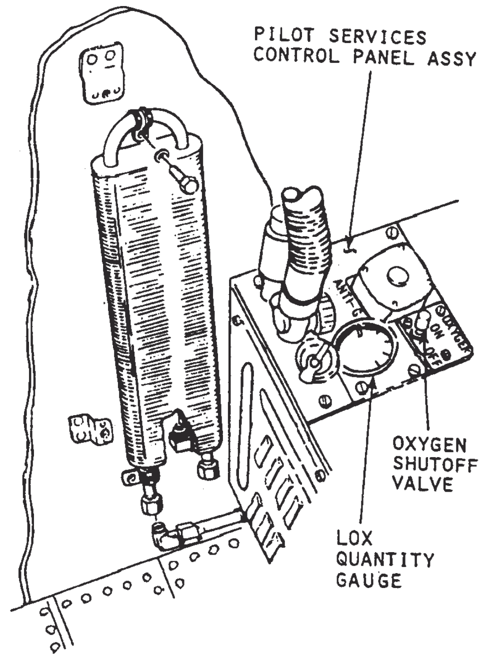


Figure 7-11.—Aircraft air-to-oxygen heat exchanger.

Low-Pressure Switch

The low-pressure switch is located in the oxygen supply line. It indicates to the flight crew, through a caution light in the aircraft cabin, when system pressure falls below minimum operating pressure of the system. This alerts and allows the pilot to descend to a safe altitude.

Quantity Indicating System

The quantity indicating system consists of a quantity gauge and a warning light in the cockpit. A quantity probe is also a part of the liquid oxygen converter.

This probe senses the amount (quantity) of liquid in the converter. This information is transmitted to the quantity gauge by an electrical coaxial cable. The quantity gauge is marked in liters from zero to the system's maximum storage capacity (0 to 10). The gauge constantly shows the remaining liquid in the converter. The low-quantity warning light is also connected to the coaxial cable and illuminates when the quantity of liquid in the converter falls below 1 liter.

Oxygen Shutoff Valve

The oxygen shutoff valve is installed in the system to control the flow of oxygen to the pilot or flight crew, as required. Figure 7-12 illustrates a typical manually operated two-position valve. This valve has an inlet port, outlet port, and a relief port. The pressure-relief valve is located in the inlet chamber to protect the oxygen regulator and crewmember from excessive system pressure if there is a malfunction of the liquid oxygen converter. Also, this valve relieves excessive pressure due to thermal expansion of gaseous oxygen trapped within the system when not in use. If the oxygen system incorporates a console-mounted regulator, the shutoff valve is part of the regulator.

Composite Quick-Disconnect Coupling

The purpose of the composite quick-disconnect coupling is to provide a single-point connection for quickly connecting and disconnecting the pilot with aircraft oxygen, anti-g, communications, and ventilation air services.

Oxygen Lines

LOX systems are classed as low-pressure systems. As such, low-pressure tubing is used in manufacture and repair of LOX lines. All low-pressure tubing used in LOX systems is aluminum alloy 5052 tubing and is non-heat treatable. It is manufactured in seamless, round lengths, and is annealed to provide greater flexibility. Aircraft oxygen systems are fitted with 5/16-, 3/8-, and 1/2-inch sizes. Low-pressure tubing also is installed from the pressure reducer outlets in reduced high-pressure oxygen systems.

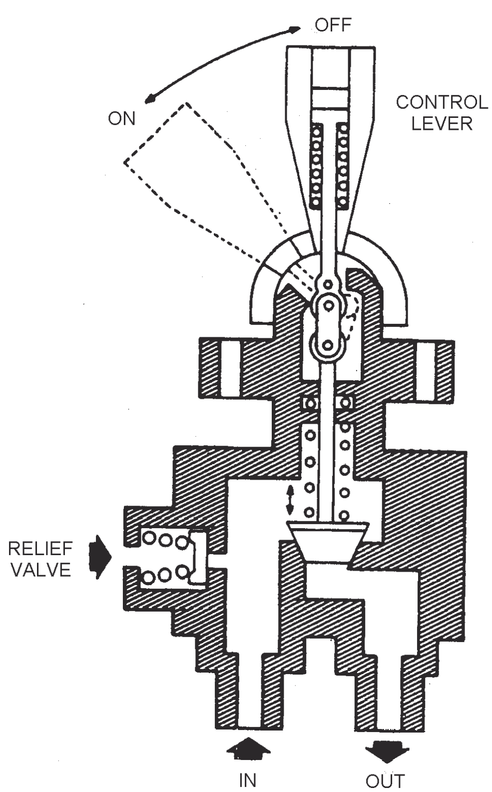


Figure 7-12.—Oxygen shutoff valve.

Oxygen Regulators

Regulators used with LOX systems are either console-mounted or miniature mask-mounted. The miniature mask-mounted regulator was especially designed for use with aircraft that have ejection seats. The console-mounted regulator is normally used in large non-ejection seat-equipped multi-place aircraft such as the E-6B and P-3.

MINIATURE OXYGEN BREATHING REGULATOR.—The miniature mask oxygen regulator, shown in a cutaway view in figure 7-13, is intended primarily for use in aircraft having a low-pressure LOX system and ejection seats. It is often referred to as a miniature mask-mounted regulator. Since it weights only 2.3 ounces and measures approximately 2 5/8-inches in length and width, it is easily mounted on the oxygen mask or user's torso harness. It is designed so that with an inlet pressure of 40 to 120 psi, it will deliver 100-percent oxygen automatically to the user between the altitudes of 0 and 50,000 feet.

Oxygen at system pressure, warmed to a comfortable temperature, flows into the regulator inlet port to the demand valve diaphragm. A small passage from the inlet line sends this pressure to the backside of the diaphragm; thus, the demand valve diaphragm is

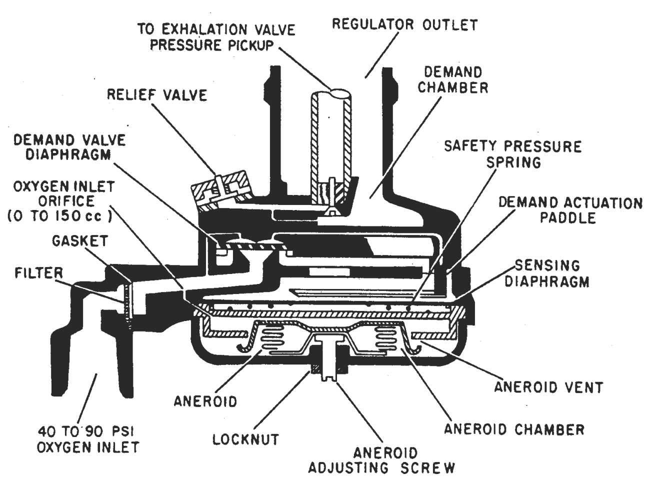


Figure 7-13.—Cutaway view of a miniature oxygen regulator.

pressure balanced except for the light imbalance caused by an area advantage on the backside of the diaphragm, which provides a positive sealing force.

The vacuum caused by inhalation causes the sensing diaphragm to tilt downward, pushing down the demand-actuating paddle. As the paddle is forced downward, its base is lifted from a seat, which seals a second passageway from the backside of the demand valve diaphragm. Raising the paddle base allows flow from this area, which causes a pressure drop behind the demand valve diaphragm and allows inlet pressure to lift the diaphragm from its seat, and oxygen flow occurs.

Safety pressure is obtained by the safety pressure spring, which deflects the sensing diaphragm, causing flow through the unit until the force created by mask pressure equals the force of the spring. This returns the sensing diaphragm to a balanced condition.

Automatic pressure breathing is obtained by diverting a small volume bleed from the inlet passage to the aneroid chamber. This bleed is normally vented from the aneroid cavity past the area labeled *aneroid vent*. At the altitude at which pressure breathing is to begin, the lip of the aneroid comes in contact with the seat, closing off the aneroid vent and building up pressure, which reacts on the sensing diaphragm. The pressure lifts the sensing diaphragm, causing flow until the mask pressure exerts a force on the sensing diaphragm equal to the force exerted by pressure buildup in the aneroid chamber.

The relief valve on the unit acts as a pilot device to open the exhalation valve of the mask. This is done by isolating the pressure pickup of the exhalation valve with the tube in the outlet port of the unit, so that only the pressure sent to it by the exhalation valve pickup tube compensates the exhalation valve.

AIRCRAFT-MOUNTED OXYGEN REGULATORS.—The MD series regulator is being used in several multi-place naval aircraft. There are two types of regulators in this series—the MD-1 (low-pressure) (fig. 7-14) and the MD-2 (high-pressure) (fig. 7-15). The only difference found in these regulators is operating pressure. The operating pressure of the MD-1 regulator is 50 to 500 psi. The pressure gauge reads 0 to 500 psi. The operating pressure of the MD-2 regulator is 50 to 2,000 psi. The pressure gauge reads 0 to 2,000 psi.

The following controls and indicators are located on the front panel of the regulator. The small oblong-shaped window area on the left side of the panel marked FLOW indicates the flow of oxygen through the regulator by a visible blinking action. The pressure gauge is on the upper right and indicates inlet pressure to the regulator. The regulator has three control levers. A supply valve controller lever, on the lower right corner, is used to control the supply of oxygen to the regulator; a diluter control lever, on the lower center of the panel, has two positions—100% OXYGEN and NORMAL OXYGEN; an emergency pressure control lever, on the lower left of the panel, has three positions—EMERGENCY, NORMAL, and TEST MASK, and with the diluter lever in the 100% OXYGEN position, the regulator delivers 100 percent oxygen upon inhalation by the user. In the NORMAL OXYGEN position, the regulator delivers a mixture of air and oxygen with the air content decreasing until a cabin altitude of approximately 30,000 feet is reached. Above this altitude, 100 percent oxygen is delivered to the user upon inhalation.

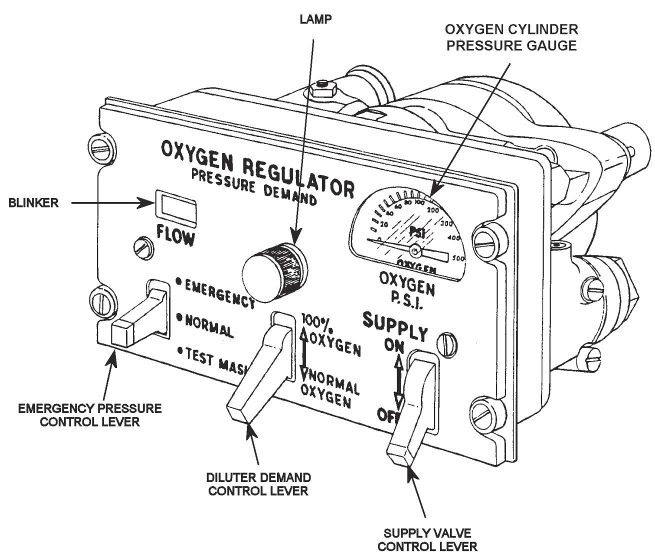


Figure 7-14.—Aircraft panel mounted oxygen regulator, type MD-1.

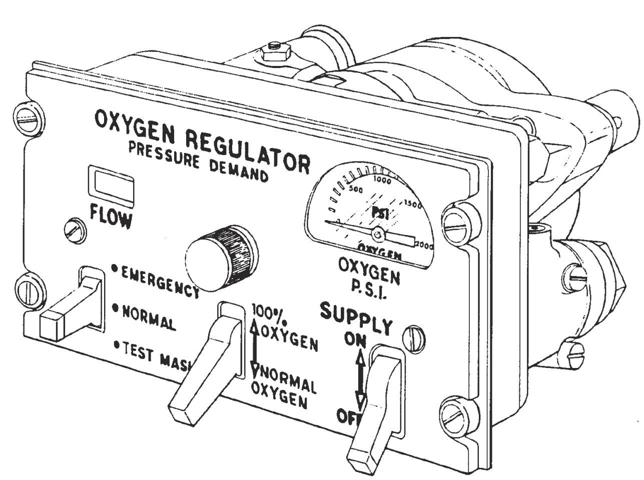


Figure 7-15.—Aircraft panel mounted oxygen regulator, type MD-2.

With the emergency pressure control lever in the EMERGENCY position, the regulator delivers positive oxygen pressure to the outlet at altitudes when positive pressure is not automatically delivered. In the TEST MASK position, oxygen is delivered to the mask under pressure too high to breathe and is used for checking the fit of the mask. The switch must be in the NORMAL position for normal system operation.

Refer to figure 7-16 for the operation of an MD type regulator.

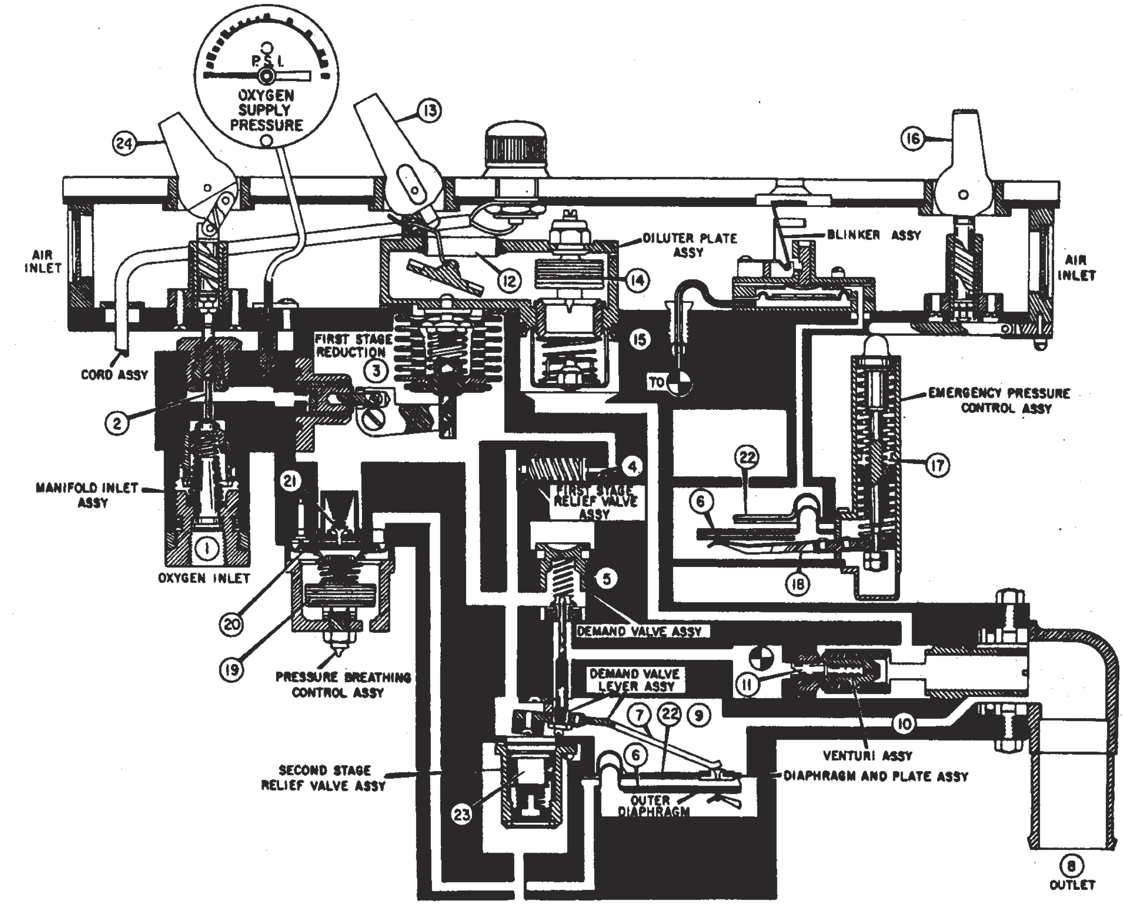
1. Supply oxygen entering through the oxygen inlet (1) is filtered and passes through the manifold inlet assembly into the inlet supply valve (2) and then into the first-stage reduction chamber (3) by action of the inlet supply valve control lever (24). The pressure of the flowing oxygen is registered on the oxygen supply pressure gauge.

2. The reduction chamber incorporates the first-stage relief valve assembly (4) to protect the regulator against overpressures.

3. The demand valve assembly (5) is opened when the pressure across demand outer diaphragm (6) forces the demand valve lever assembly (7) down. The pressure differential exists during the inhalation cycle of the user by creating a reduction in the pressure outlet (8).

4. Reduction in pressure at the pressure outlet is sensed in the demand diaphragm chamber (9) through the sensing port (10).

5. During periods of flow, the oxygen passes through the venturi assembly (11). At the venturi assembly, the flow of oxygen mixes with ambient air, which enters the regulator through the inlet ports (12).



1. INLET
2. INLET SUPPLY VALVE
3. REDUCTION CHAMBER
4. RELIEF VALVE
5. DEMAND VALVE
6. DIAPHRAGM
7. DEMAND VALVE LEVER
8. OUTLET
9. DEMAND DIAPHRAGM CHAMBER
10. SENSING PORT
11. VENTURI ASSEMBLY
12. INLET PORT
13. DILUTER CONTROL LEVER
14. DILUTER ANEROID
15. CHECK VALVE
16. EMERGENCY PRESSURE CONTROL LEVER
17. TEST SPRING
18. CONTROL LEVER
19. ANEROID
20. DIAPHRAGM
21. PRESSURE BREATHER VALVE
22. PLATE ASSEMBLY
23. RELIEF VALVE
24. SUPPLY VALVE CONTROL LEVER

Figure 7-16.—MD regulator operational drawing.

6. The addition of ambient air to oxygen is controlled by the manual diluter control lever (13) and by the diluter aneroid assembly (14), which automatically produces a 100-percent oxygen concentration at altitudes above 32,000 feet.

7. The aneroid check valve assembly (15) prevents a flow of oxygen out through the inlet ports.

8. The emergency pressure control lever (16) applies force to the emergency pressure control test spring (17), which mechanically loads the emergency pressure diaphragm through the control lever and center assembly (18). Mechanical loading of the emergency pressure diaphragm provides positive pressure at the regulator outlet.

9. Both automatic safety pressure and pressure breathing at altitudes above 30,000 feet are provided through pneumatic actuation of the aneroid assembly (19). This function begins near 27,000 feet altitude. The force exerted on the diaphragm assembly (20) by the aneroid assembly actuates the pressure breather valve assembly (21), and the oxygen flows to the diaphragm and the plate assembly (22), which is pressure loaded by this volume of oxygen acting on the demand valve lever assembly to the extent that the positive pressure is built up at the pressure outlet as the altitude increases.

10. Additional safety is obtained through the inclusion of the second-stage relief valve assembly (23) in the regulator.

TURNAROUND/PREFLIGHT/POSTFLIGHT/ TRANSFER INSPECTIONS.—These inspections are visual inspections performed in conjunction with the inspection requirements for the aircraft in which the regulators are installed. Refer to table 7-2 for assistance in troubleshooting.

Visually inspect the following:

- Electrical performance of the panel light
- Legibility of all marking
- Plastic lighting plate for cracks and discoloration
- Low or improper reading on regulator pressure gauge
- Emergency pressure control lever in NORMAL position

Table 7-2.—Gaseous Oxygen System Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Oxygen cylinder pressure gauge fails to indicate proper pressure	Defective gauge	Replace regulator
	Blocked or leaking supply line	Replace or clean supply line to regulator
	Low cylinder pressure	Refill
	Defective manifold inlet assembly	Replace regulator
Oxygen not available at mask with proper pressure source to regulator and other than emergency setting on regulator	Regulator controls improperly positioned	Correct position of controls
	Hose to mask is kinked	Straighten hose and reposition outlet
	Regulator not functioning properly	Replace regulator
Oxygen not available at mask with proper pressure source to regulator and regulator controls set at EMERGENCY	Kink or other malfunction between hose and mask	Replace or readjust equipment as necessary
	Faulty linkage from emergency pressure control lever	Replace regulator
Oxygen available at mask but flow is not indicated	Defective blinker assembly	Replace regulator
Gauge pressure drops when regulator is not in use	Loose or leaking connections	Tighten or replace connections as necessary
	Defective manifold inlet assembly	Replace regulator
Panel light fails to light	Burned out lamp	Replace regulator
	Faulty light assembly	Replace lamp
	Faulty electrical hookup to power source	Repair electrical hookup

• Diluter control lever in 100% OXYGEN position

• Supply valve control lever in OFF position

• Regulator and surrounding area free of dirt and hydrocarbons

• Delivery hose and connector for cuts, fraying, kinking, hydrocarbons, and general condition

If discrepancies are found or suspected, maintenance control should be notified. Regulators that do not pass inspection and cannot be repaired in the aircraft are removed and replaced by ready-for-issue (RFI) regulators. Non-RFI regulators are forwarded to the nearest maintenance activity having repair capability.

SYSTEM OPERATION

The LOX system shown in figure 7-7 is an example of a typical system. This system converts LOX to gaseous oxygen and then delivers it to the crew. The oxygen source of this system is a supply of LOX stored in a 10-lilter converter. System pressure is maintained at 75 to 110 psi by a pressure control valve and a pressure relief valve.

Through a process of controlled evaporation within the converter assembly, LOX is converted to gaseous oxygen as required by the occupant of the aircraft. The oxygen is delivered to the pilot after being warmed to a safe breathing temperature in the heat exchanger. The flow of oxygen is controlled in the cockpit by the shutoff valve.

The units that make up the converter assembly control the major part of the operation of the LOX system automatically. The LOX converter has three sequences of operation—fill, buildup, and supply (fig. 7-17). In the supply sequence, the converter alternates between the economy and demand modes of operation.

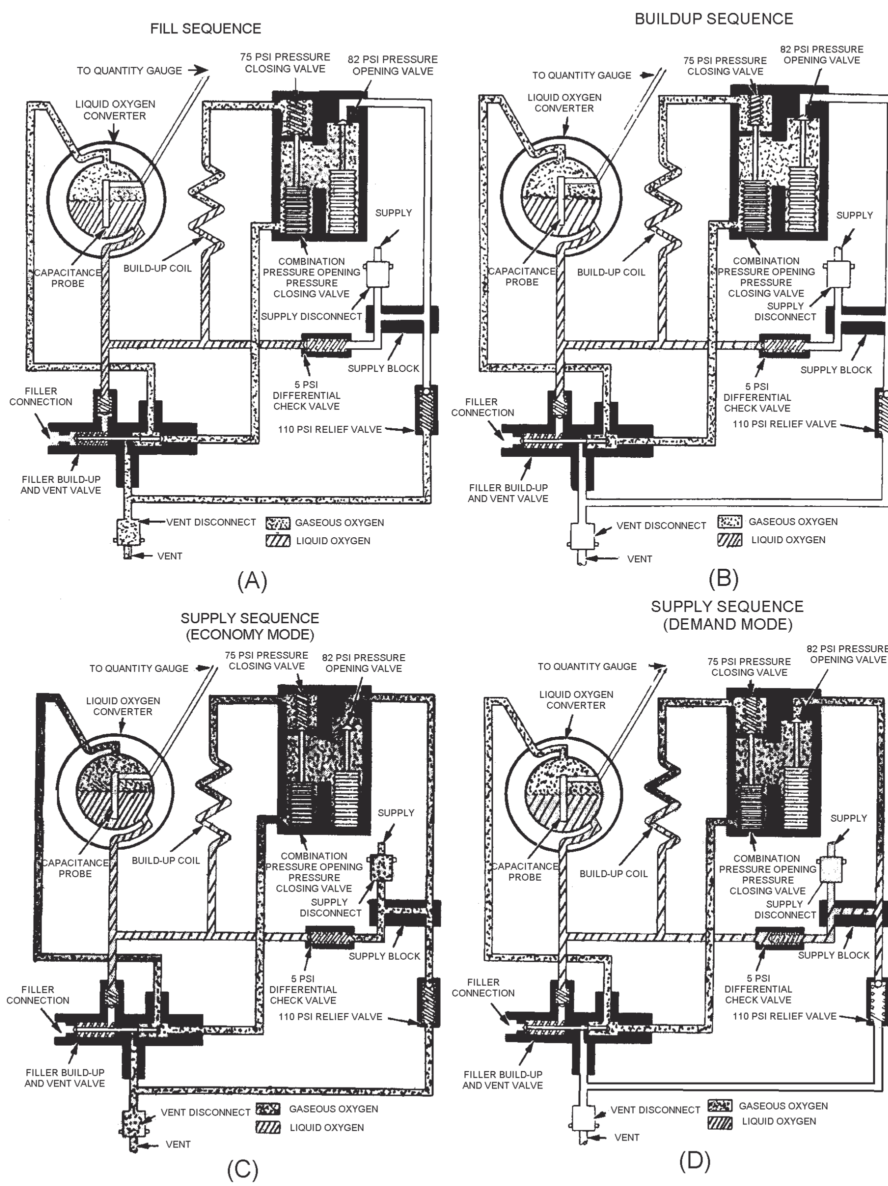


Figure 7-17.—Liquid oxygen converter operation.

Fill Sequence

The fill sequence begins automatically when the servicing trailer hose filler nozzle is connected to the filler port on the filler, buildup, and vent valve. The hose nozzle, when attached to the fill valve, actuates a plunger within the valve, which places the valve in the fill and vent condition (fig. 7-17, fill sequence, view A). The valve, when in this position, provides an opening from the top of the converter to the atmosphere. This opening is used to vent gaseous oxygen during filling and liquid oxygen after the converter is full.

During transfer, liquid oxygen flows into the converter through a passage located in the bottom of the converter. This arrangement allows gaseous oxygen to vent through the converter top as it is being displaced by liquid flow in the bottom. When the converter is full, liquid flows overboard through the vent line, giving an indication that the converter is full. Removal of the filler hose nozzle from the fill valve automatically places the converter in the buildup sequence.

Buildup Sequence

The buildup sequence (fig. 7-17, buildup sequence, view B) begins when the filler hose is removed from the converter. This sequence provides for rapid pressure buildup to system operating pressure.

During this sequence, LOX from the converter fills the buildup coil by gravity feed. Liquid in the coil absorbs heat from the ambient air around the coil and vaporizes, causing the pressure to build up. The gaseous oxygen formed in the coil then circulates through the pressure-closing valve and back to the top of the converter. This causes more fluid to flow into the buildup coil. This circulation continues to build up pressure until approximately 75 psi is reached. At this pressure, the pressure-closing valve is forced closed. Pressure continues to build up within the system at a slower rate, and at approximately 82 psi, the pressure-opening valve opens. When this occurs, oxygen is available at the supply outlet. A pressure relief valve, which is set at approximately 110 psi, is installed in the converter system to relieve excessive pressure.

Supply Sequence

The supply sequence of the liquid oxygen system consists of two modes of operation—the economy mode, in which gaseous oxygen is fed from the converter, and the demand mode, in which oxygen flows from the converter as a liquid and vaporizes to a gas in the feed line.

In the economy mode of operation (fig. 7-17, supply sequence, view C), limited demand upon the system allows the converter to supply gaseous oxygen directly as a result of drawing off the gaseous oxygen stored within the top of the converter. At approximately 82 psi, the pressure-opening valve unseats and allows gaseous oxygen to flow from the converter to the supply system. Oxygen then flows from the upper (gas) portion of the converter, rather than the liquid side. When the amount of oxygen demanded by the crew exceeds the supply of the economy mode, the pressure-opening valve closes. As the crew continues to draw upon the oxygen supply, the supply system pressure becomes lower than that of the converter. When a pressure differential of 5 psi occurs, the differential check valve opens (fig. 7-17, supply sequence, views C and D) and allows liquid oxygen to flow into the supply line, creating the demand mode. Converter pressure will build up while the system is operating in the demand mode. As the pressure again approaches 82 psi, the pressure-opening valve will again unseat, switching the supply sequence back into the economy mode. The converter automatically switches itself back and forth between the economy and demand modes while supplying oxygen to the crew.

SYSTEM MAINTENANCE

Extreme care must be exercised when installing units in an oxygen system. The life of the pilot and crew depends on the thoroughness with which the AME does this job. All maintenance of LOX systems must be done in accordance with the instructions contained in the applicable MIM. The AME assigned to do the LOX system maintenance also should be familiar with the various instructions pertaining to handling LOX and maintenance of the related equipment.

The actual removal and installation procedures used in maintaining LOX systems will vary from one aircraft to another; however, the following precautions will apply to almost any aircraft system.

1. Use only tubing assemblies that have been tested, cleaned, capped, and properly identified as oxygen lines.

CAUTION

If lines are fabricated locally, ensure that only clean, oil-free tubing and fittings are used. Also, ensure that no hydraulic fluid is used in the fabrication procedure.

2. Use only the type of fittings specified for the particular oxygen system. Never use fittings with pitted or otherwise disfigured cones or imperfect threads.

3. It is MANDATORY that EXTREME CAUTION be exercised with regard to cleanliness of hands, clothing, and tools. It must be emphasized that all items that come into contact with the oxygen system must be free of dirt, oil, or grease.

4. Use thread anti-seize tape that is approved under specification MIL-T-27730.

5. When installing tubing assemblies between fixed units, the tube assembly should align without the use of undue force.

6. The torque values specified for the particular oxygen system should be strictly adhered to when tightening the fittings.

7. If a section of line is left open or disconnected during an installation, the open fittings must be covered with suitable caps or plugs. When making connections, be certain that no lint, dust, chips, or other foreign material is allowed to enter the oxygen system.

8. Upon completion of the installation of a tube assembly or component, a pressure check of the system should be conducted. The system should be pressurized and the connections checked with a leak-test solution conforming to specification MIL-L-25567. After the connections have been checked, the leak-test solution should be washed off with clean water.

9. The aircraft liquid oxygen system should be purged after the replacement of any component or tubing assembly.

10. The type of clothing and footwear that is worn when maintaining and servicing a liquid oxygen system is an extremely important factor. Do not wear anything that will produce sparks or static electricity, such as nylon clothing or shoes with steel taps or hobnails. Oxygen-permeated clothing will burn vigorously—a most painful way to die.

11. When servicing a liquid oxygen system, ensure that only oxygen conforming to specification MIL-0-27210 is used. Oxygen procured under Federal Specification BB-0-925A is intended for technical use and should NOT be used in aircraft oxygen systems.

12. After the completion of repairs, always perform an operational check of the system and make the required test to ensure that the oxygen is safe for use by the pilot and crew.

Q7-15. When the temperature of gaseous oxygen is lowered to –182°F under 720 psi pressure, what transformation will occur?

Q7-16. True or False. When working with LOX, the wearing of trousers with cuffs is authorized.

Q7-17. A sealed container of LOX can generate up to what amount of pressure?

Q7-18. What component on a LOX converter provides a margin of safety from explosion?

Q7-19. In a 24-hour period, a normal LOX system will lose what amount of pressure?

Q7-20. Where is the low-pressure switch for a LOX system located?

Q7-21. What are the three sequences of operation for a LOX converter?

Q7-22. An aircraft liquid oxygen system should have what type of maintenance performed after replacement of any component or tubing assembly?

ONBOARD OXYGEN GENERATING SYSTEM

LEARNING OBJECTIVE: Identify the system components and operation of the onboard oxygen generating system.

The onboard oxygen generating system (OBOGS) is an alternative to liquid oxygen. When compared to a LOX system, the OBOGS has several advantages. First, its availability may be as high as 99 percent. There are no requirements for depot-level maintenance. The OBOGS has no daily servicing requirements, and scheduled preventive maintenance occurs at 2,000 hours. Incorporation of the OBOGS eliminates the need to store and transport LOX, and it eliminates the need for LOX support equipment. The potential for accidents related to LOX and high-pressure gases is greatly reduced.

SYSTEM COMPONENTS

The basic components of the OBOGS are the concentrator, oxygen monitor, and control panel assembly.

Oxygen Concentrator

The oxygen concentrator (fig. 7-18) produces an oxygen-rich gas by processing engine bleed air through two sieve beds. It is an electrical/mechanical device that is made up of a rotary valve, two molecular sieve beds, drive/servo motor, plenum assembly, air heater, inlet filter, over-temperature sensor indicator, pressure reducer, and insulating shroud.

Oxygen Monitor

The oxygen monitor (fig. 7-19) senses the partial pressure of the gas and if necessary, provides a low-pressure warning to the pilot. It is an electronic processor made up of an oxygen sensor, processing electronics, built-in test (BIT), a circuit heater, and a pressure-controlled sensing chamber.

Control Panel Assembly

The control panel assembly (fig. 7-20) houses the controls to operate the OBOGS system. It contains the following controls:

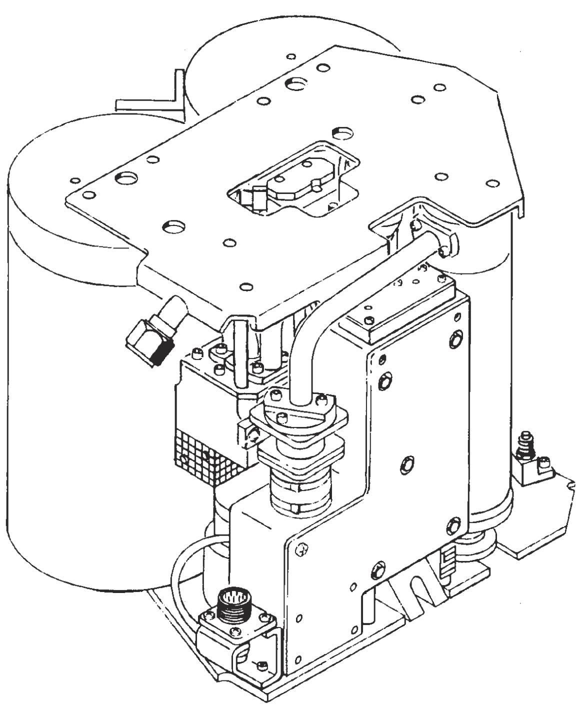


Figure 7-18.—Oxygen concentrator.

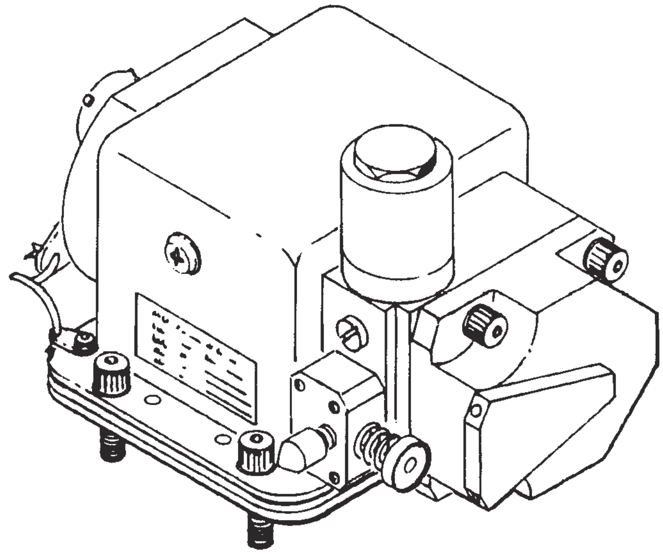


Figure 7-19.—Oxygen monitor.

- OBOGS ON/OFF control switch (electrical)
- OXY FLOW ON/OFF control valve (mechanical)

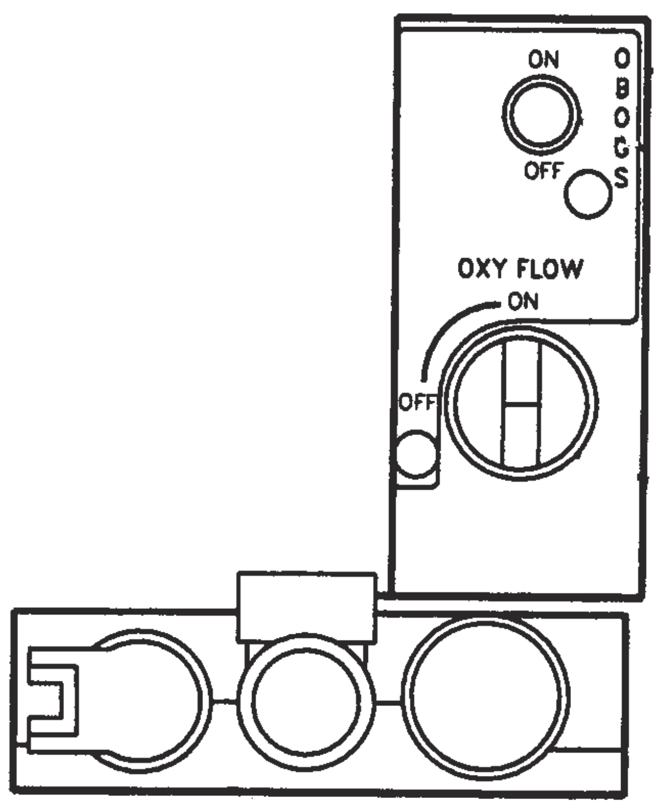


Figure 7-20.—Control panel assembly.

SYSTEM OPERATION

The OBOGS, shown in figure 7-21, receives engine bleed air from the outlet of the air-conditioning heat exchanger. The partially cooled air passes through an air temperature sensor to a pressure reducer assembly. The air is then routed to the concentrator. The concentrator has a rotary valve that alternates the airflow over the molecular sieve beds. The sieve beds absorb the nitrogen and allow the oxygen and argon to pass through. Two molecular sieve beds are used in the concentrator so that while one is absorbing, the other is desorbing (releasing) nitrogen. This method allows a continuous flow of oxygen to the system. After the concentrator, the oxygen flows to a plenum assembly that acts as a surge tank and an accumulator. The plenum also functions as a heat exchanger to heat or cool the oxygen to approximately cockpit temperature. Before the oxygen reaches the oxygen regulator, the oxygen performance monitor senses the partial pressure of the gas, and provides a signal to the pilot whenever the pressure exceeds prescribed limits. The oxygen then flows through the regulator to the pilot's mask.

Q7-23. An OBOGS system availability may be as high as what percent?

Q7-24. True or False. An OBOGS system has a reduced chance for potential accident.

Q7-25. What are the three basic components of an OBOGS system?

Q7-26. What component has a built-in test?

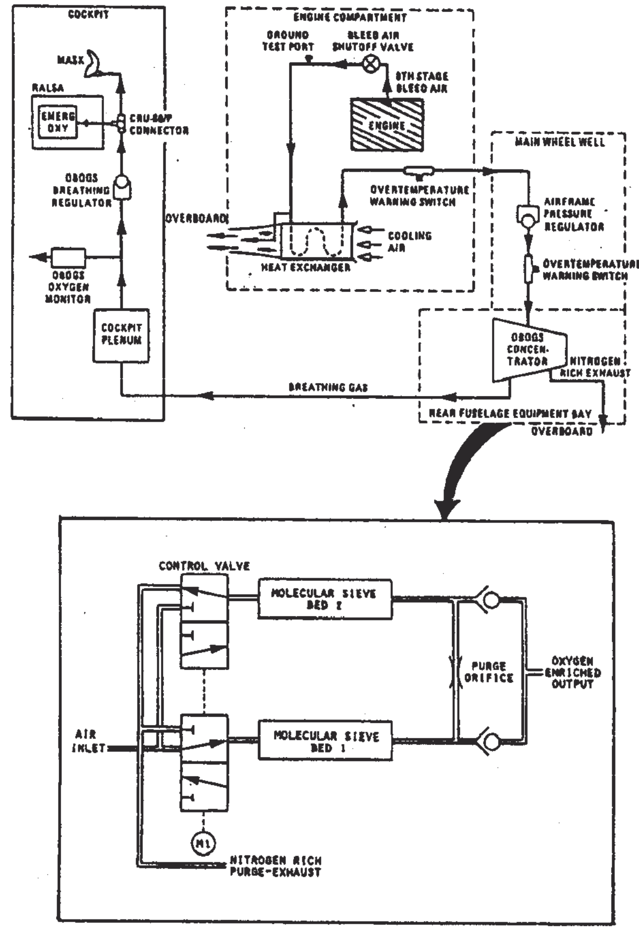


Figure 7-21.—Onboard oxygen generating system (OBOGS) schematic.

Q7-27. During OBOGS operation, when one sieve bed is absorbing, what is the other sieve bed releasing?

CHAPTER 7

ANSWERS TO REVIEW QUESTIONS

A7-1. Decreases

A7-2. The eyes, brain, and muscles

A7-3. 100 percent

A7-4. Pressurization of the entire body

A7-5. 99.5 percent

A7-6. Pale blue

A7-7. Anoxia

A7-8. 50 psi

A7-9. Type I conforming to Military Specification MIL-C-81302

A7-10. False

A7-11. Mask

A7-12. 514 and 295 cubic inches

A7-13. Above 450 psi

A7-14. To permit the flow of oxygen in one direction only

A7-15. The oxygen will begin to form into a liquid

A7-16. False

A7-17. 12,000 pounds of pressure

A7-18. Blowout disc

A7-19. 10 percent

A7-20. In the oxygen supply line

A7-21. Fill, buildup, and supply

A7-22. Purged

A7-23. 99 percent

A7-24. True

A7-25. Concentrator, oxygen monitor, and control panel assembly

A7-26. Oxygen monitor

A7-27. Nitrogen

CHAPTER 8

OXYGEN SUPPORT EQUIPMENT

Oxygen systems on naval aircraft require several types of support equipment to ensure their safe and satisfactory operation. AMEs are concerned with support equipment that is used for storage and servicing of oxygen. In this chapter, storage tanks and servicing equipment are discussed.

As an AME it is your responsibility to know and understand the safety precautions that are involved when working with or handling liquid or gaseous oxygen and its support equipment.

This information should not stop with just the personnel of your rate, but it should be stressed to all aviation maintenance personnel, so they won't mishandle or mistreat AME support equipment. Examples include playing with valves of service trailers, standing or sitting on trailers, hauling tools and equipment on them, spilling oils and other fluids on them, etc. Their awareness will reduce the possibility of creating hazardous conditions that could cause serious injury to themselves or others.

Safety precautions also can be found in NAVAIR 06-30-501, *Technical Manual of Oxygen/Nitrogen Cryogenic Systems*.

LIQUID OXYGEN SERVICING EQUIPMENT

LEARNING OBJECTIVE: Describe liquid oxygen-servicing equipment to include safety precautions, LOX servicing trailers, and system servicing.

Oxygen servicing equipment for both liquid and gaseous oxygen systems are discussed in this section. Since AMEs operate this equipment, they must be familiar with purging and sampling procedures as well as operation of the equipment while servicing aircraft oxygen systems.

SAFETY PRECAUTIONS

The following safety precautions must be observed when handling liquid oxygen (LOX):

- Never allow LOX to contact your skin. The extremely low temperature of the liquid quickly freezes skin, and severe frostbite results. If your skin is splashed with LOX, immediately flush the area thoroughly with water, and then obtain first aid.

- Always store LOX with the vent valve open. Relief valves on the tank protect the tank in case of malfunction, and are not to be used as pressure regulators.

- Never confine LOX in piping or a container without adequate safety devices. When the liquid expands to a gas, the pressure buildup will rupture most piping, tubing, or containers.

- Comply with all safety directives. Fifty feet away is the safe distance to permit smoking, open flames, or sparks in a LOX handling area. Assure that painting and markings on the LOX tank are maintained as required. Oxygen gas does not burn, but it vigorously supports combustion of any material that does burn.

- Keep LOX away from absorbent materials, loose clothing, or rags. These materials can trap oxygen gas and later be ignited by a spark, cigarette, or match.

- When LOX equipment is in use, keep it in a well-ventilated area away from all gasoline, kerosene, oil, grease, and other hydrocarbons. These substances are not compatible with LOX. Spontaneous ignition may result from contact with these substances.

TMU-70/M, LOW LOSS, CLOSED LOOP LIQUID OXYGEN SERVICING TRAILER

The primary purpose of portable transfer equipment is to provide a means of servicing oxygen systems installed in aircraft. This section will cover the TMU-70/M low loss, closed loop trailer (fig. 8-1).

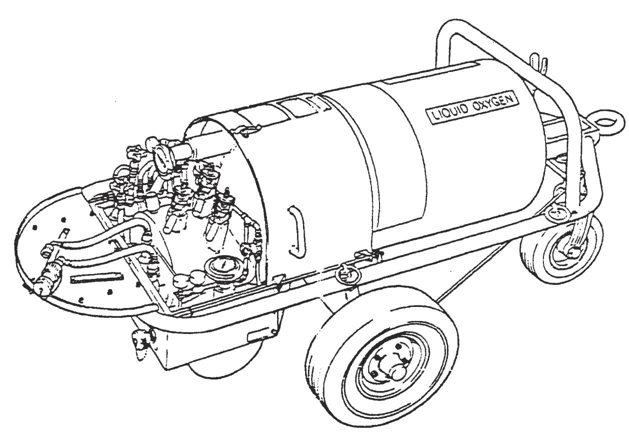


Figure 8-1.—TMU-70/M low loss, closed loop, liquid oxygen servicing trailer.

During LOX servicing of aircraft converters, a lot of oxygen is lost because of the way the transfer is carried out. In addition to the economic loss, a safety hazard is created when LOX or oxygen vapors are released into the atmosphere near operating equipment and personnel. The low loss, closed loop system was designed to significantly reduce these losses and eliminate the safety hazards associated with venting oxygen in critical areas.

Description

The TMU-70/M is a completely self-contained unit with three major components: a 50-gallon Dewar tank, a 15-liter Dewar transfer tank, and a low loss, closed loop (LLCL) system of transfer lines. Separate liquid level and pressure gauges, as well as pressure relief devices, are provided for each tank. These components are permanently mounted on a portable three-wheel trailer, which is equipped with a manually operated parking brake and retractable caster wheel.

The primary purpose of the TMU-70/M is to service aircraft LOX converters. The LLCL system is designed to recycle oxygen vapor caused by heat losses during transfer to the aircraft converter. The oxygen vapors vented from the transfer tank and aircraft converter are returned to the storage tank for cooldown and retention.

Components

Components include a storage tank, transfer tank, and transfer lines and piping system.

STORAGE TANK.—The storage tank is a 50-gallon (U.S.) capacity, double-walled Dewar. The space between the double walls of the storage tank and transfer tank is evacuated down to 5 microns or lower and contains a multi-layer, high-vacuum insulation to minimize heat gain and boil-off of the LOX.

TRANSFER TANK.—The 15-liter capacity transfer tank is a double-walled, vacuum insulated Dewar, permanently attached to the storage tank. It is self-contained and gravity-filled from the storage tank. The transfer tank is equipped with a pressure buildup coil, relief valve, rupture disc, and controls. The primary function of the transfer tank is to hold small volumes of LOX and to utilize cold gas pressure from the pressure buildup unit to transfer LOX to the aircraft converter.

TRANSFER LINES AND PIPING SYSTEM.—These lines carry the LOX from the storage tank to the transfer tank, and then to the aircraft converter. They also carry the vented oxygen gas from the aircraft's converter to the storage tank.

The closed loop system of the transfer lines contains the vented oxygen gas during filling operations. The interconnected liquid and return gas lines are vacuum-jacketed wherever practical and are a minimum length to reduce cooldown and heat leak losses.

The piping system consists of a fill line for storage tank filling, a vent system for overboard venting of excess liquid or gas, and a pressure relief valve system connected to the vent system.

Controls And Indicators

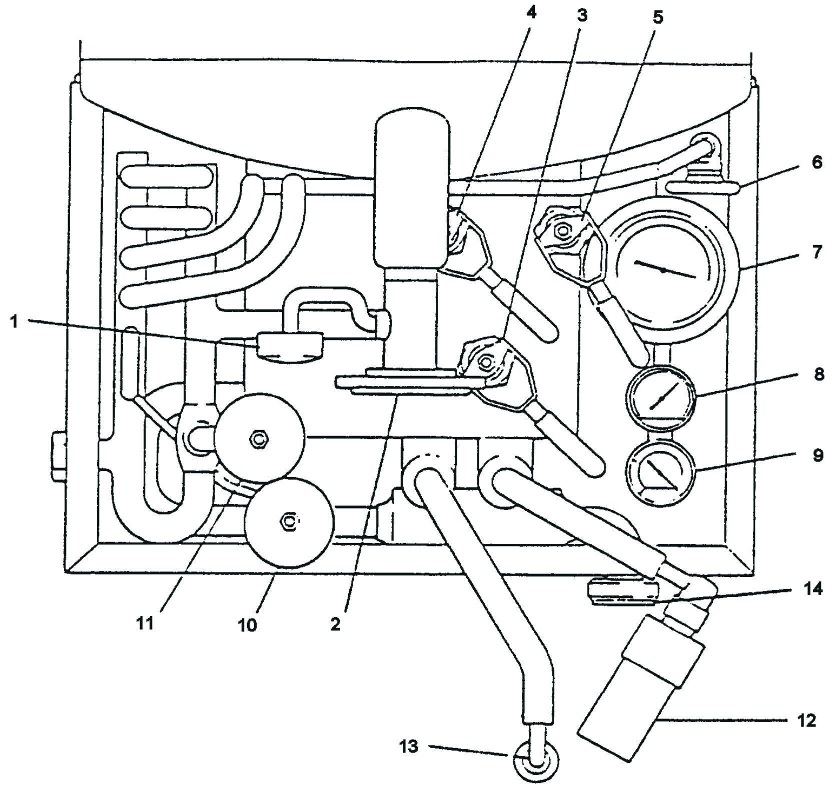
The controls and indicators of the TMU-70/M are illustrated in figure 8-2. The functions of the controls are as follows:

STORAGE TANK PRESSURE GAUGE.—(Fig. 8-2, item 1). The pressure gauge indicates the pressure in the inner storage tank. The gauge is calibrated to read from 0 to 100 pounds per square inch gauge (psig). A green band on the gauge face indicates safe operating pressure of 0 to 50 psig; a red band indicates unsafe operating pressure of 50 to 100 psig.

STORAGE TANK LIQUID LEVEL GAUGE.—(Fig. 8-2, item 2). The liquid level gauge directly indicates the level of liquid oxygen in the inner tank when the tank is sitting level. The gauge dial is magnetically and mechanically coupled to a float sensor inside the storage tank. The gauge is calibrated in gallons. Safe operating levels of up to 50 gallons are indicated in green; unsafe operating levels of more than 50 gallons are indicated in red.

CONVERTER VENT LINE SHUTOFF VALVE.—(Fig. 8-2, item 3). The vent valve controls the flow of oxygen gas vapors from the converter being filled to the storage tank and prevents the loss of storage tank gas when the converter is not being filled.

TRANSFER TANK VENT LINE SHUTOFF VALVE.—(Fig. 8-2, item 4). The vent valve controls the flow of oxygen gas vapors from the transfer tank to the vapor space of the storage tank.



1. STORAGE TANK PRESSURE GAUGE (P-1)
2. STORAGE TANK LIQUID LEVEL GAUGE (LG-1)
3. CONVERTER VENT LINE SHUTOFF VALVE (GV-4)
4. TRANSFER TANK VENT LINE SHUTOFF VALVE (GV-3)
5. TRANSFER TANK FILL LINE SHUTOFF VALVE (LV-2)
6. TRANSFER TANK PRESSURE BUILDUP VALVE (GV-5)
7. TRANSFER TANK LIQUID LEVEL GAUGE (LG-2)
8. TRANSFER TANK PRESSURE GAUGE (P-2)
9. CONVERTER FULL INDICATOR GAUGE (F1)
10. FILL-DRAIN LINE SHUTOFF VALVE (LV-1)
11. STORAGE TANK VENT LINE SHUTOFF VALVE (GV-6)
12. FILLER VALVE (C-2)
13. CONVERTER VENT LINE CONNECTION (C-3)
14. FILL-DRAIN LINE COUPLING (C-1)

Figure 8-2.—Liquid oxygen servicing trailer controls and indicators.

TRANSFER TANK FILL LINE SHUTOFF VALVE.—(Fig. 8-2, item 5). The valve is used to control the gravity flow of liquid oxygen from the storage tank to the transfer tank.

TRANSFER TANK PRESSURE BUILDUP VALVE.—(Fig. 8-2, item 6). The pressure buildup valve controls the flow of liquid oxygen from the bottom of the transfer tank to the pressure buildup (PBU) coil. The PBU coil is a heat exchanger where the liquid oxygen is exposed to ambient temperature and is converted to gas. As the liquid changes to gas it expands. The output gas of the PBU coil is fed back to the transfer tank vapor space, providing pressure to discharge liquid to the converter. This valve is open only when pressure is required to fill the converter.

TRANSFER TANK LIQUID LEVEL GAUGE.—(Fig. 8-2, item 7). The liquid level gauge indicates the level of liquid oxygen in the transfer tank. The gauge is magnetically and mechanically coupled to a float sensor inside the transfer tank. The gauge is calibrated in percent of full.

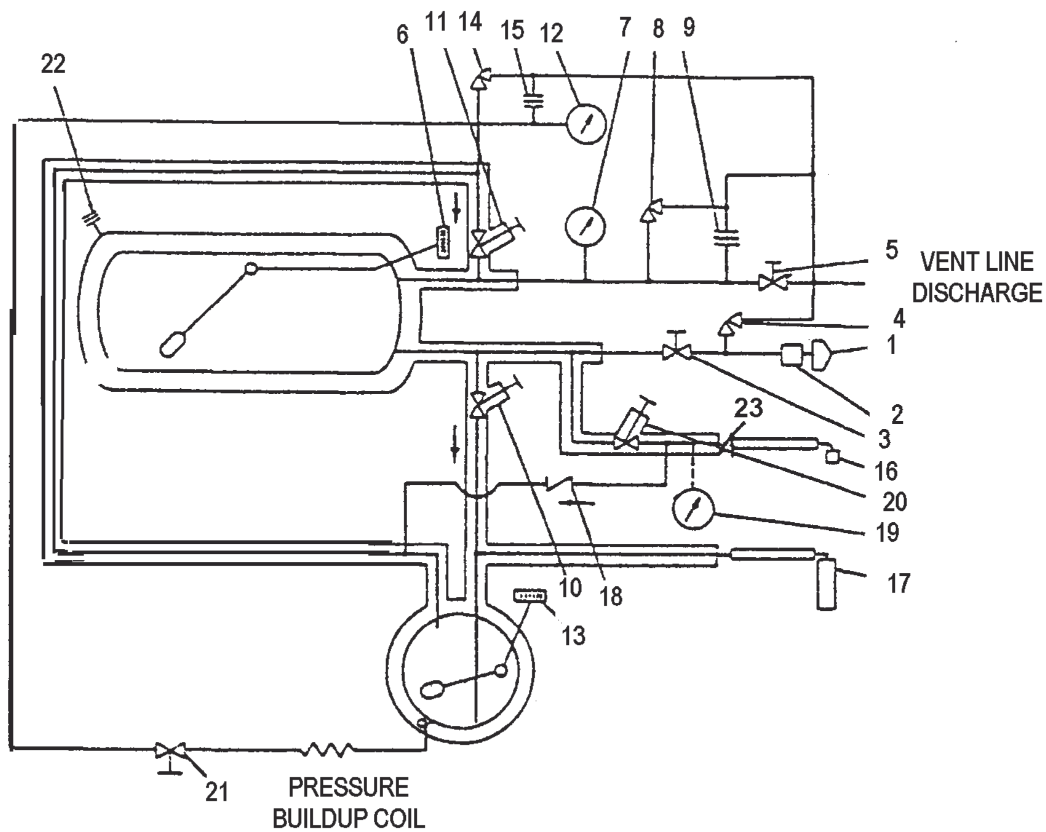
TRANSFER TANK PRESSURE GAUGE.—(Fig. 8-2, item 8). The pressure gauge indicates the pressure in the transfer tank. The pressure in the transfer tank must be greater than the pressure in the storage tank to achieve transfer of liquid since the converter is vented into the storage tank during converter fill operation. The gauge is calibrated to read 0 to 160 psig. Safe operating pressure is 0 to 90 psig and is indicated by a green band; a red band indicates unsafe pressure of 90 to 160 psig.

CONVERTER FULL INDICATOR GAUGE.—(Fig. 8-2, item 9). The full indicator gauge (marked LIQUID-GAS) is a vapor pressure thermometer that monitors the converter vent line temperature. During transfer of liquid to a converter, the gauge indicates GAS temperature in the converter fill line. When the converter is full, the vent line is filled with liquid oxygen overflow. The converter vent line temperature drops and the gauge indicator moves to the LIQUID position and indicates a full converter.

> **CAUTION**
>
> The fill-drain line shutoff valve is not used to control flow. Restricting transfer flow may create a dangerous back-pressure on the supply line used for filling. Control of transfer flow should be maintained with the service valve of the central supply tank.

FILL-DRAIN LINE SHUTOFF VALVE.—(Fig. 8-2, item 10). The fill valve is used during the storage tank filling operation to permit the flow of oxygen from a central supply tank. The shutoff valve is opened completely during the filling function and then closed after the transfer has been completed.

STORAGE TANK VENT LINE SHUTOFF VALVE.—(Fig. 8-2, item 11). The vent valve is used to control the release of gaseous vapors from the storage tank to the vent-piping manifold. The valve is open during filling to vent all pressure from the storage tank. During normal idle storage, the valve is left in the open position to vent all vapors generated by normal liquid oxygen boil-off. When the cart is not in use, the valve is left closed to prevent oxygen contact with flammable liquids or vapors.



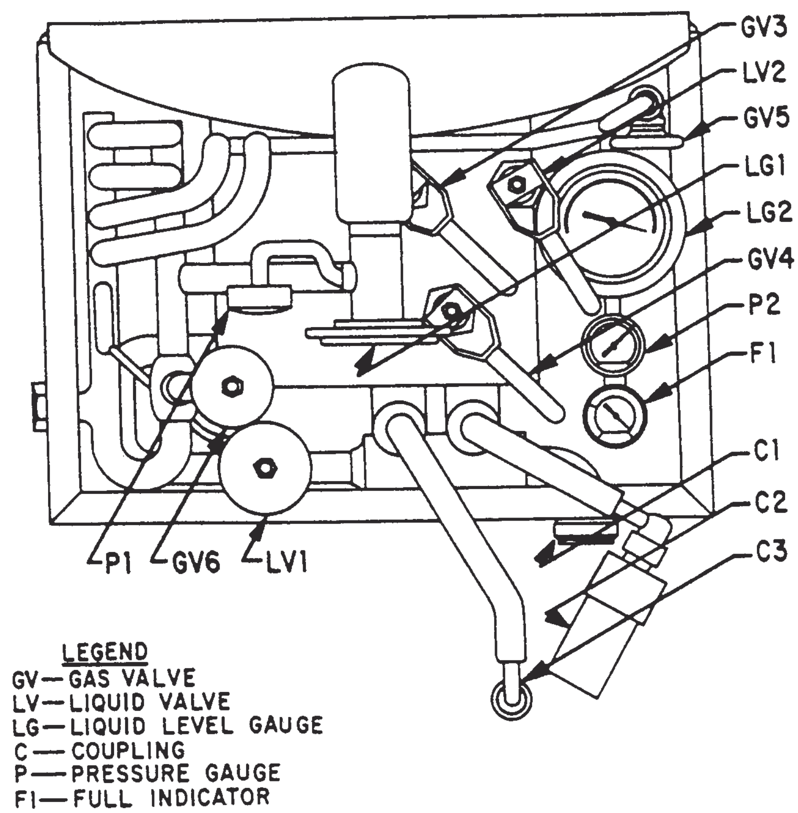
1. FILL-DRAIN LINE COUPLING (C-1)
2. FILL-DRAIN LINE FILTER (LF-1)
3. FILL-DRAIN LINE SHUTOFF VALVE (LV-1)
4. FILL-DRAIN LINE RELIEF VALVE (RV-3)
5. STORAGE TANK VENT LINE SHUTOFF VALVE (GV-6)
6. STORAGE TANK LIQUID LEVEL GAUGE (LG-1)
7. STORAGE TANK PRESSURE GAUGE (P-1)
8. STORAGE TANK INNER SHELL RELIEF VALVE (RV-1)
9. STORAGE TANK INNER SHELL RUPTURE DISC (SD-1)
10. TRANSFER TANK FILL LINE SHUTOFF VALVE (LV-2)
11. TRANSFER TANK VENT LINE SHUTOFF VALVE (GV-3)
12. TRANSFER TANK PRESSURE GAUGE (P-2)
13. TRANSFER TANK LIQUID LEVEL GAUGE (LG-2)
14. TRANSFER TANK INNER SHELL RELIEF VALVE (RV-2)
15. TRANSFER TANK INNER SHELL RUPTURE DISC (SD-3)
16. CONVERTER VENT LINE CONNECTOR (C-3)
17. FILLER VALVE (C-2)
18. CONVERTER VENT LINE CHECK VALVE (CV-1)
19. CONVERTER FULL INDICATOR GAUGE (F1)
20. CONVERTER VENT LINE SHUTOFF VALVE (GV-4)
21. TRANSFER TANK PRESSURE BUILDUP VALVE (GV-5)
22. OUTER SHELL RELIEF DEVICE (SD-2)
23. CONVERTER VAPOR RETURN CHECK VALVE (CODE C AND D)

Figure 8-3.—TMU-70/M liquid oxygen servicing trailer schematic diagram.

Operation

The following procedures describe LOX flow in connection with filling the TMU-70/M storage tank and the servicing of an aircraft converter, using the trailer. The flow description is keyed to figure 8-3. Figure 8-4 shows the operating instructions from the plate attached to the trailer.

When the servicing trailer is received from the factory or from an overhaul activity, it is normally ready to be filled with LOX and pressurized for immediate use. The annular space is evacuated to the point



CLOSE ALL VALVES BEFORE STARTING ANY OPERATIONS

FILL MAIN TANK

1. CONNECT C1 TO SUPPLY TANK
2. OPEN GV6 & LV1 & OBSERVE LG1
3. WHEN TANK IS FULL CLOSE LV1 & DISCONNECT C1

FILL TRANSFER TANK

1. OPEN LV2 & GV3 & OBSERVE LG2
2. WHEN TANK IS FULL CLOSE LV2 & GV3

EMPTY TRANSFER TANK

1. OPEN GV5 & LV2 & OBSERVE LG2
2. WHEN TANK IS EMPTY CLOSE LV2 & GV5

FILL CONVERTER

1. FILL TRANSFER TANK
2. OPEN GV5 & OBSERVE P2 PRESSURIZE 80-100 PSIG
3. CONNECT C3 & C2 TO CONVERTER
4. OPEN GV4 & OBSERVE F1
5. WHEN F1 INDICATES LIQUID DISCONNECT C2
6. CLOSE GV4 & DISCONNECT C3
7. CLOSE GV5

Figure 8-4.—Operating instructions for TMU-70/M.

desirable for a warm and empty tank. Prior to filling or pressurizing the tank, perform the inspection procedures indicated in table 8-1.

FILLING.—Normally the servicing trailer is filled from central supply tanks. These tanks have transfer hoses terminating in couplings that match the fill-drain line coupling on the trailer. Operation of the supply tank should be in accordance with the procedures in its operation manual.

Filling consists of the following procedures. Ensure that all required safety equipment is in use and all safety precautions have been taken. Place the trailer on a level surface or ensure that the tank has a level position. Close all control valves on the storage tank. Pressurize the LOX supply tank to the required pressure for transfer to the TMU-70/M. Remove the dust cover from the supply tank transfer line and purge hose. After purging, connect the fill-drain line coupling (1) (fig. 8-3) to the transfer hose. Open the TMU-70/M's storage tank vent line shutoff valve (5) and fill drain line shutoff valve (3).

Table 8-1.—Periodic Inspection

ITEM	INSPECTION	FREQUENCY
Exterior	Inspect for obvious physical damage, missing parts, illegible decals or plates, and missing or insecure attaching parts.	Daily while in use
Piping and valves	Inspect for dents, nicks, or scratches; security of brazed or threaded connections; ease of valve movement, and adequate seating and security of packings.	Daily while in use
Gauges	Inspect for cracked dial face and security of installation.	Daily while in use
Cabinet	Inspect for smooth hinge and guide operation and correct functioning of latches and legibility of decals and plates.	Daily while in use
Tires	Inspect for correct inflation, tread wear, sidewall cracks or abrasions, and proper positioning of valve stems.	Daily while in use
Wheel assemblies	Inspect for warps or dents in rims and freedom of rotation.	Daily while in use
Retractable caster	Inspect for proper operation and undue wear or damage.	Daily while in use
Controls	Inspect for loose, missing, or cracked handles; obvious physical damage.	Daily while in use
Brake and cross shaft assemblies	Inspect for physical damage, missing parts, and ease of operation.	Daily while in use
Converter fill and vent line hoses	Inspect for frayed wire in braid and worn or damaged fill and vent couplings.	Daily while in use
Exterior cleanliness	Inspect visually for such contaminants as oil, grease, metal chips or scale.	Weekly
Operation	Perform operational checkout	Monthly or on receipt of new or repaired equipment

CAUTION

Pressure should not be allowed to rise above 55 pounds per square inch (psi) in the storage tank. Monitor the storage tank pressure gauge (7) closely during cooldown.

Open the service valve on the supply tank slowly, and allow only a partial flow of LOX through the transfer hose and into the trailer. Considerable vaporization will take place until the transfer hose, fill-drain line, and storage tank on the trailer have cooled down. When these have sufficiently cooled and are able to handle a full flow of LOX, open the service valve on the supply tank completely.

During filling, LOX flow is through the fill-drain line filter (2) and shutoff valves (3) to the storage tank. The relief valve (4) is provided to prevent excessive pressure if the fill-drain line shutoff valve and the service valve on the supply tank are closed with cold gas or liquid trapped within the supply line.

The relief valve (4) is connected to the vent line for safe discharge overboard. The vent line shutoff valve (5) is opened during filling and normal storage where safe overboard discharge is provided. Storage tank conditions are monitored and indicated by the liquid level gauge (6) and pressure gauge (7).

The inner shell relief valve (8) and rupture disc (9) are provided in case of excessive pressure in the storage tank. Monitor the storage tank liquid level gauge (6) during filling. When it indicates 50 gallons or LOX starts to flow out the vent manifold, close the servicing valve on the supply tank. Close the fill-drain line shutoff valve (3) to relieve internal pressure.

CAUTION

Use extreme caution when disconnecting the transfer hose. Even though the hose has been drained and the pressure relieved, some LOX will still remain. Do not direct the hose toward personnel or other equipment.

Disconnect the supply tank transfer hose, immediately drain the LOX that remains, and replace the coupling cap loosely. Tighten the cap after ensuring that all LOX has vaporized and bled off. Close all control valves on the service trailer except the storage tank vent valve (5).

NOTE: Observe the time required to fill the TMU-70/M. Filling will vary with each supply tank and supply system. Under normal conditions and 30 psi transfer pressure, the storage tank should fill within a period of 5 to 10 minutes. Deviation from the average filling time should be cause for investigation.

TRANSFER.—The transfer of LOX from the storage tank of the trailer to an aircraft converter can be done in the following manner. Ensure that all safety equipment is in use. Close all control valves (3, 5, 10, 11, 20, and 21, as show in figure 8-3). Observe storage tank liquid level gauge (6) and pressure gauge (7) to ensure sufficient LOX supply and safe operating pressure. Open the transfer tank fill valve (10) and vent valve (11) to allow the transfer tank to fill.

When the transfer tank is full, as indicated by the liquid level gauge (13), close the shutoff valves (10) and (11). Connect the converter vent line connector (16) to the converter vent fitting. Connect the air force (AF) filler valve (17) to the converter fill fitting, using a two-step procedure. First, position the valve against the purge fitting and turn the housing clockwise, locking the valve in place. Second, push the knurled knob forward and rotate clockwise, locking the valve in the open position. Open the transfer tank pressure buildup valve (21) momentarily and observe the tank pressure gauge (12).

When pressure rises to approximately 90 psig, close valve (21). If necessary, maintain desired pressure by regulating pressure buildup valve (21) during converter servicing. Open the converter vent line shutoff valve (20) and observe the converter full indicator gauge (19). The gauge will indicate GAS as the converter is filling, and when full, it will indicate LIQUID.

As soon as it indicates LIQUID, disconnect the AF filler valve (17), close the transfer tank pressure valve (21), close the converter vent valve (20), and then disconnect the converter vent line connector (16).

If no other converters are to be serviced, empty the transfer tank, open the fill line shutoff valve (10), and then the pressure buildup valve (21), if necessary, and observe the liquid level gauge (13). When the transfer tank is empty, close the pressure buildup valve (21) and then the fill line shutoff valve (10). Close all valves except the storage tank vent valve (5).

The flow of LOX from the storage tank to the aircraft converter is done as follows and can be traced using figure 8-3. The flow of LOX from the storage tank to the transfer tank is by gravity. It first passes through the transfer fill line shutoff valve (10) to the transfer tank. During this process, the gaseous oxygen produced by cooldown of the tank is vented back to the storage tank through the vent line shutoff valve (11). Conditions of the transfer tank are monitored and indicated by pressure gauge (12) and liquid level gauge (13).

When the transfer tank is filled to the desired level, as indicated by the liquid level gauge, valves (10) and (11) are closed. The converter lines are connected to the vent line connector (16) and filler valve (17). The filler valve is opened to allow the pressure in the converter and transfer tank to equalize. The transfer tank PBU coil is used to increase the pressure in the transfer tank to approximately 90 psig. This pressure is regulated by the pressure buildup valve (21) as required to maintain as high a pressure as possible during the servicing operation.

WARNING

The rate of pressure buildup depends on the liquid level in the transfer tank. In a full tank, the pressure will build extremely fast because of the small amount of vapor space to be filled. Use extreme caution in building the pressure, and never allow the pressure to exceed 90 psig. Open transfer tank vent valve (11) to relieve the excessive pressure into the storage tank. This will avoid the opening of the relief valve (14) and the resultant undesirable discharge of gaseous oxygen from the vent line.

LOX is now able to flow from the transfer tank into the converter. When the converter full indicator gauge (19) indicates full, the overflow is returned to the storage tank by passing through the converter vent line shutoff valve (20). The filler valve (17) is then removed, the transfer tank pressure buildup valve (21) is closed, vent valve (20) is closed, and then vent line connector (16) is disconnected.

The preceding process is repeated either until the storage tank is empty or the maximum operating pressure, as indicated on the storage tank pressure gauge (7), has been replaced.

Maintenance

Information and instructions for maintenance of the TMU-70/M storage tank are found in NAVAIR 19-25D-26. The maintenance section is organized to provide information and instructions for the three levels of maintenance responsibility: organizational, intermediate, and depot. The capability of the using or supporting activity will be the limiting factor as to the level of maintenance that can be performed on the equipment. If maintenance of the equipment is beyond the assigned maintenance responsibility of the using or supporting activity, the next higher level will perform the maintenance.

AMEs are only responsible for the organizational maintenance of LOX trailers, which includes those functions normally performed in support of daily operations. Normal operational maintenance functions include inspection and preventive maintenance. Table 8-1 will assist you in understanding these functions.

System Servicing

Aircraft systems and LOX converters should be serviced in accordance with the appropriate maintenance instructions manual (MIM).

Only LOX conforming to MIL-0-27210, type II, may be used in aircraft LOX systems. The firefighting agents below are prohibited from use in conjunction with LOX-enriched fires.

- Soda-acid extinguishers
- Mechanical (liquid) foam
- Methyl bromide
- Carbon tetrachloride

Q8-1. Open flames, smoking, or sparks should be kept what minimum distance away from a LOX handling area?

Q8-2. True or False. Oxygen will burn when ignited.

Q8-3. Identify the three major components of the TMU-70/M.

Q8-4. Explain the primary function of the transfer tank.

Q8-5. What is the function of the transfer tank pressure buildup valve?

Q8-6. Using the fill-drain shutoff valve to control LOX flow may cause what type of hazard?

Q8-7. Exterior cleanliness of the TMU-70/M LOX cart should be performed at what interval?

Q8-8. Information and instructions for maintenance of the TMU-70/M are found in what publication?

Q8-9. What type of LOX must be used to service aircraft LOX systems?

CONTAMINATION CONTROL

LEARNING OBJECTIVE: Describe contamination control procedures for oxygen equipment to include detection, purging, and purging equipment.

The importance of using uncontaminated LOX in aircraft systems cannot be overstressed. Because of this, the Navy has established the *Aviators Breathing Oxygen (ABO) Surveillance Program Laboratory and Field Guide* (A6-332SAO-GYD-000). For additional information on contamination control, oxygen sampling, and oxygen system purging, refer to that manual.

LOX produced by generating plants contains contaminants, which are not completely removed by the generating process. Atmospheric air, from which LOX is generated, is the primary source of contamination. Additional sources of contamination are the compressors and other equipment of the generating plants. Airborne contaminants and those added by the generating plants are partially removed by a system of filters, absorbers, driers, and heat exchangers before the air is finally liquefied. When the LOX separates from the liquefied air it carries with it those contaminants that are not completely removed.

The variety and concentration of contaminants that separate with the LOX depend on how effective their removal has been during the generating process. Generating plants are designed to remove contamination to the lowest limits possible, both for safety of operation and for quality of product. The contamination limits of LOX produced by any generating plant for the Navy and Marine Corps as breathing oxygen are specified as procurement limits. Procurement limits and the ultimate use limits of contamination are based on the types and significance of contaminants, and the sources of increasing contamination in liquid oxygen during storage, handling, and transfer.

DETECTION

LOX contamination is detected by means of an odor test, sampling, and analysis. Only the odor test will be discussed in this chapter because all other tests and analysis must be performed in a laboratory.

An odor test will be performed on LOX trailers after the first filling of the day, or each 6 days when the trailer is not in service. Aircraft LOX systems require an odor test to be performed as soon as possible after an aircraft accident/incident or a report of in-flight odors by pilots or aircrew. The sample taken after an accident/incident must be sent to a test site for analysis with details of the incident, including history of the supply source of the LOX.

Odor Test

The odor test is performed by pouring a 200-milliliter (6.8 oz) sample into a clean 400-milliliter (13.8 oz) beaker or similar container after covering the bottom of the beaker with clean, dry filter paper or other absorbent paper. A watch glass cover or some other means of partially covering the top of the beaker will be provided as the 200 milliliters evaporates to dryness. This will prevent atmospheric elements from being absorbed by the exposed liquid. The liquid is permitted to evaporate to dryness and warm up to approximately room temperature in an area free from air currents or extraneous odors. When the liquid has completely evaporated, the watch glass is removed and the beaker contents smelled at frequent intervals until the accumulated frost on the outside of the beaker has completely melted. Odors will be most prevalent when the beaker has warmed to nearly room temperature. If odors are present, the LOX container or system will be purged in accordance with existing directives.

Sampling

Sampling and analysis of LOX is required any time contamination is suspected. Contamination of oxygen used in aircraft can cause many problems, from fire hazards to death of the crewmember using the oxygen system. The most dangerous contaminate is hydrocarbons. The presence of hydrocarbons in LOX constitutes a potential fire and explosive hazard as well as causing psychological and physiological dangers to aircrews. Psychologically, the effects may be uneasiness, apprehension, or possible panic resulting from detection of odors. Physiologically, the effects may be nausea, illness, intoxication, or possibly asphyxia. Acetylene is the most hazardous hydrocarbon contaminate because it is highly insoluble in LOX, changing into a solid at extremely low concentrations. Once in its solid form, it can readily be set off into ignition, and since it is chemically unstable, it can decompose under certain conditions and become its own source of ignition. The presence of acetylene in

LOX has caused several major LOX generating plant explosions.

Inert solids are small contaminants that do not react with oxygen to create a fire or explosion, such as rust, dust, and fibers. They may cause mechanical malfunctions or failures by plugging filters, lines, or valves. Other contaminants commonly found in oxygen are water vapor, carbon dioxide, nitrous oxide, and halogenated compounds (Freons).

PURGING

Purging and other maintenance of LOX trailers is performed by the Aviation Support Equipment Technician (AS) rating. Purging is the cleansing of impurities from oxygen systems and containers. There are two ways to purge oxygen containers: LOX wash and gas purging.

The LOX wash method is used on large containers, such as storage tanks and LOX trailers, to lower the contamination to acceptable levels by replacing the contaminated LOX with LOX known to be un-contaminated.

Gas purging is used on aircraft LOX converters if the system pressure is allowed to deplete or if odor is detected. Gas purging of aircraft LOX systems must be done if any maintenance is performed on the system that opens it to the atmosphere.

Q8-10. What manual should you refer to for information on contamination control for oxygen?

Q8-11. What is the primary source of contamination for LOX?

Q8-12. State the three ways LOX contamination is detected.

Q8-13. An odor test will be performed on a LOX cart if it has not been in service for what amount of time?

Q8-14. When is LOX sampling performed?

Q8-15. Of all the hydrocarbons associated with LOX, why is acetylene the most dangerous?

Q8-16. List four contaminants commonly found in oxygen.

Q8-17. What rate is responsible for purging of LOX trailers?

GASEOUS OXYGEN SERVICING TRAILERS

LEARNING OBJECTIVE: Identify components and operating procedures for gaseous oxygen servicing trailers.

There are several different models of gaseous oxygen servicing trailers currently in use by naval activities. This section will discuss the type No-2 and the A/U26U-1A oxygen servicing unit.

TYPE NO-2 GASEOUS OXYGEN SERVICING TRAILER

The type No-2 servicing trailer is shown in figure 8-5. Equipment provided on the trailer includes six manifold control valves with pressure gauges, an upper and lower manifold, two pressure regulators, a recharge valve, four shutoff valves, a drier assembly, six cylinders and connecting flexible hoses, and a servicing hose fitted with a line servicing valve fitted with a high-pressure charging adapter. The function of each of these components is described in the following text.

Components

Complete familiarity with the following trailer components is a basic prerequisite for safe operation.

MANIFOLD CONTROL VALVES.—The six manifold control valves serve to shut off the flow of oxygen from the cylinders to the system being charged. These valves are lever-type valves. The manifold control valves should not be used as a shutoff for long-time storage. Always use the hand-wheel type valves located on the cylinders.

UPPER MANIFOLD.—The upper manifold provides connections/mounting for the six manifold control valves with pressure gauges (each connected to a supply cylinder), a recharge valve, and two upper/inlet shutoff valves that connect to the inlet side of the regulators.

PRESSURE REGULATORS.—The pressure regulator controls the charging pressure when the trailer is being used to service aircraft oxygen systems. Only one pressure regulator is used during operation. The spare is provided to ensure uninterrupted operation should one fail.

RECHARGE VALVE.—The recharge valve is provided as a means of recharging the trailer cylinders directly through the upper manifold without the

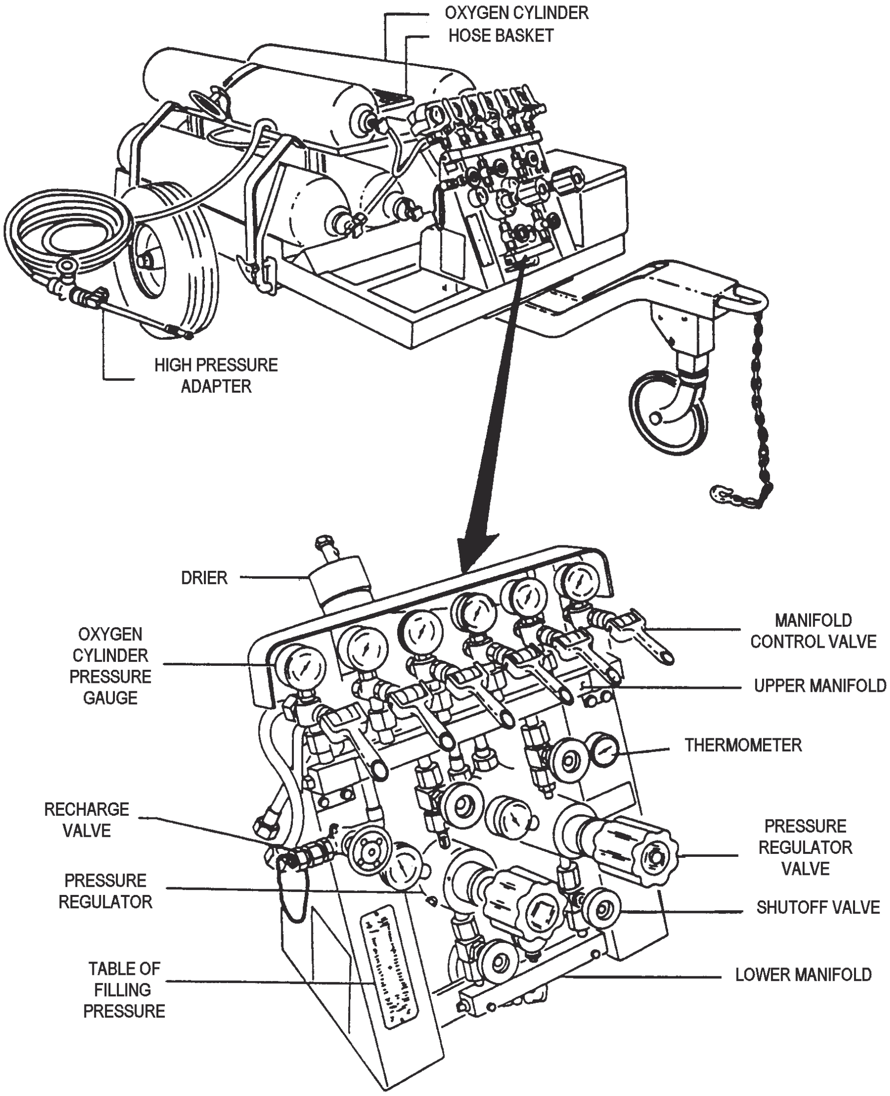


Figure 8-5.—Type No-2 gaseous oxygen servicing trailer.

necessity of removing the cylinders. When not in use, the valve adapter should be fitted with a dust cap.

SHUTOFF VALVES.—There are four shutoff valves, one on the inlet side of each pressure regulator and one on the outlet side of each regulator. These shutoff valves control the flow of oxygen from the upper manifold to the lower manifold, via the regulator.

When the shutoff valves on the inlet and outlet sides of the regulator are open, the pressure regulator is ready for use. By turning the regulator control handle clockwise, the pressure (as read on the gauge attached to the regulator) will increase. Turning the control handle counterclockwise decreases pressure.

LOWER MANIFOLD.—The lower manifold provides connections/mountings for the two lower/outlet shutoff valves from the outlet side of the regulators, a delivery pressure gauge, and a flexible hose that connects the lower manifold to the drier assembly.

DRIER ASSEMBLY.—The drier assembly is a reservoir containing a chemical drying agent through which oxygen must pass before going through the servicing hose. This chemical drier is provided to remove any moisture in the oxygen supply. The oxygen flows into the bottom of the drier, passes up through the drying agent, and out through the servicing hose.

SERVICING HOSE AND LINE VALVE.—The servicing hose is a high-pressure, non-linking, metallic flexible hose. The line-servicing valve is attached to the servicing hose and is used to control the flow of oxygen to the system being charged.

Operation

The six supply cylinders are connected by means of flexible hoses to their respective control valves (fig. 8-6). The six control valves are attached to the upper manifolds. A pressure gauge is screwed into each control valve at a point below the seat. This allows each cylinder pressure to be easily read.

The oxygen flows from the upper manifold through either of two pressure regulators via two shutoff valves.

The oxygen is collected in the lower manifold where a gauge registers the pressure of the delivery side of the system. The lower manifold is connected by flexible hose to a drier that filters and dries the oxygen. The servicing hose connects directly to the drier and has a line-servicing valve on the terminal end. The line-servicing valve is fitted with a standard oxygen cylinder connection.

Loading Cylinders

The servicing trailer is capable of having its cylinders recharged without removal. However, many operating activities replace the empty cylinders with full cylinders.

NOTE: NEVER completely expend the supply of oxygen from a cylinder. Always leave a residual pressure in excess of 50 psi.

REMOVAL OF EMPTY CYLINDERS.—When the trailer has been in use and cylinder pressure is low, the cylinders are removed as described below.

1. Close all lever valves on the manifold prior to removing any cylinders.
2. Close the cylinder shutoff valves.
3. Disconnect the flexible hose that connects the cylinder to the manifold.
4. Loosen the clamping arrangement that holds the cylinders to the trailer.
5. Install the cylinder safety caps.
6. Remove the empty cylinders.

CAUTION

Do not attempt to remove empty cylinders while charging.

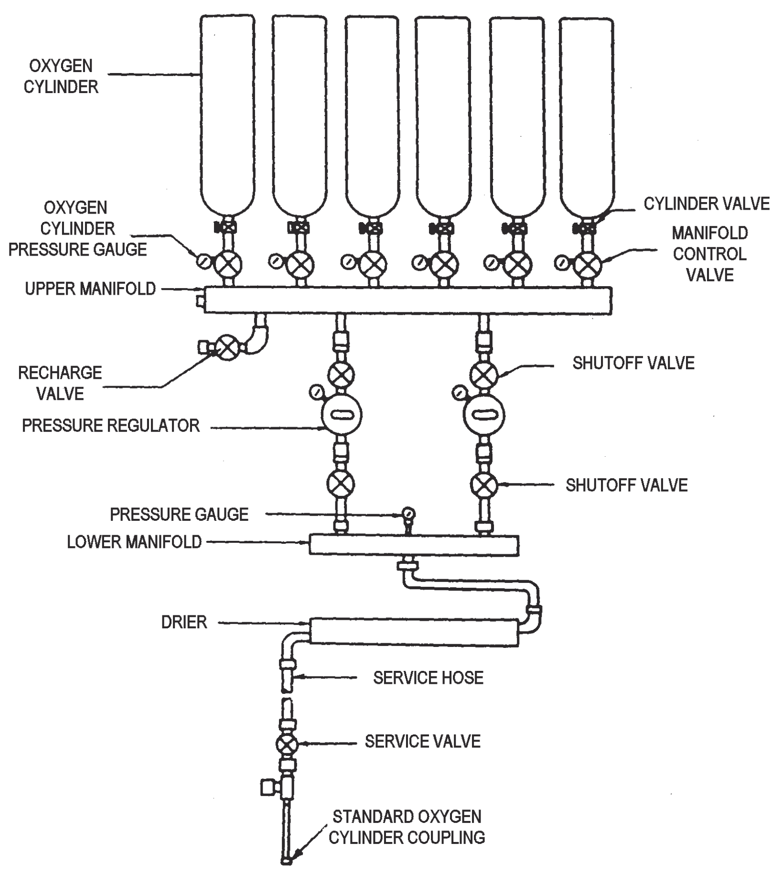


Figure 8-6.—Type No-2 gaseous oxygen servicing trailer (schematic).

INSTALLATION OF FULL CYLINDERS.—The trailer should be loaded with cylinders while fastened to a towing vehicle. If a towing vehicle is not available, the rear stand should be let down and hand brakes applied so the weight of the cylinders will not cause the trailer to tilt backwards. The retractable swivel wheel should be down if the trailer is not hooked to a towing vehicle. (When the trailer is hooked to the towing vehicle, the swivel wheel should be retracted). Cylinders should be loaded from the rear and should be handled with safety caps in place. Standing cylinders should be brought to within 4 feet of the rear end of the trailer. If the cylinders are lying down, the safety cap end of the cylinder should be just below the rear of the trailer. The safety cap end of the cylinder should be lifted or lowered and placed in the appropriate channel. The bottom of the cylinder should be raised and the cylinder worked into place.

Ensure that the cylinder is in its forward-most position and firmly seated against the forward cylinder stop. Remove the cylinder safety cap. Position the cylinder so that the cylinder valve outlet may easily be connected to the flexible hose without causing undue strain on the hose. Prior to connecting the hose to the cylinder, open the cylinder valve slightly to blow any foreign matter from the outlet valve, then close the valve. Connect the flexible hose nut to the power cylinder valve. As soon as the cylinders are in place and the hoses connected, the clamping arrangements should be tightened.

The bottom four cylinders are clamped in pairs by a wheel while the top two cylinders are each held in place by a single strap.

After tightening the coupling nuts on the hoses, the hoses should be free of twisting strain. Gripping the hose with one hand and twisting slightly in a clockwise direction while tightening the coupling nut can prevent twisting. After replacing the empty cylinders, the cylinder valves on the full cylinders should not be opened until the trailer is positioned for servicing an aircraft.

CAUTION

To eliminate the danger of an explosion, do not interchange parts between oxygen servicing equipment and air/nitrogen equipment.

REPLACEMENT OF DRYING AGENT.—The chemical drier should be inspected after every 12 cylinders are used, and the chemical agent should be replaced at the first sign of change in the indicator. The blue-colored indicating agent is applied on top of the white drying agent. When moisture is present, the indicating agent will change color from blue to pink. The indicating agent can be easily inspected by removing the servicing hose and unscrewing the top cap of the drier container.

CAUTION

Relieve all pressure prior to inspection or replacement of the chemical agent.

The drying agent is removed by removing the hose connecting the lower cap and the lower manifold and unscrewing the drier lower cap. All traces of the contaminated agent should be removed and the lower cap replaced, and the lower manifold connected. The drying agent should be quickly placed in the drier so that it does not pick up moisture from the air. Care should be given to the replacement of the indicating agent. The top cap should be screwed in place immediately after observing the condition of the indicator so that moisture or humid air does not cause the indicator to change color.

The caps on the drier should be screwed down until they hit bottom. The caps should be removed and replaced by hand only. It is not necessary to tighten the caps extremely tight; the caps are sealed with O-ring packings. If leakage occurs, the O-rings should be replaced.

NOTE: All maintenance on the oxygen-servicing trailer should be performed in accordance with the instructions contained in the applicable operation and service instructions manual or set of maintenance requirement cards.

OXYGEN SERVICING UNIT A/U26U-1A

The oxygen servicing unit A/U26U-1A is a configuration of four major components consisting of a trailer assembly, gas storage system, gas servicing system, and interface/servicing equipment. Figures 8-7 and 8-8 illustrate the relationship of major components and location of information plates and reflective tape.

Components

Components include a trailer assembly, gas storage system, gas servicing system, and interface/servicing equipment.

TRAILER ASSEMBLY.—The trailer assembly is designed to support and transport the gas storage system, gaseous oxygen/nitrogen modules, and interface/servicing equipment including the grounding reel cable assembly. The trailer contains three wheels and a tow bar. The tow bar is used to attach the trailer to a towing vehicle. A rotatable, retractable swivel caster wheel supports the tow bar when the trailer is uncoupled from a tow vehicle.

The wheel release handle holds the swivel caster wheel in the up position when the trailer is being towed. When uncoupled, the caster wheel is locked in the down position with the wheel release handle. The trailer is equipped with a mechanical parking brake operated by a hand brake lever.

GAS STORAGE SYSTEM.—The gas storage system is used to store oxygen and nitrogen. It consists of one cylinder of oxygen and two cylinders of gaseous nitrogen (oil free). The storage system is designed to operate at 225-3850 psig for nitrogen and 200 to 2640 psig for oxygen. Nitrogen is used to drive an oxygen boost pump when compressed air is not available.

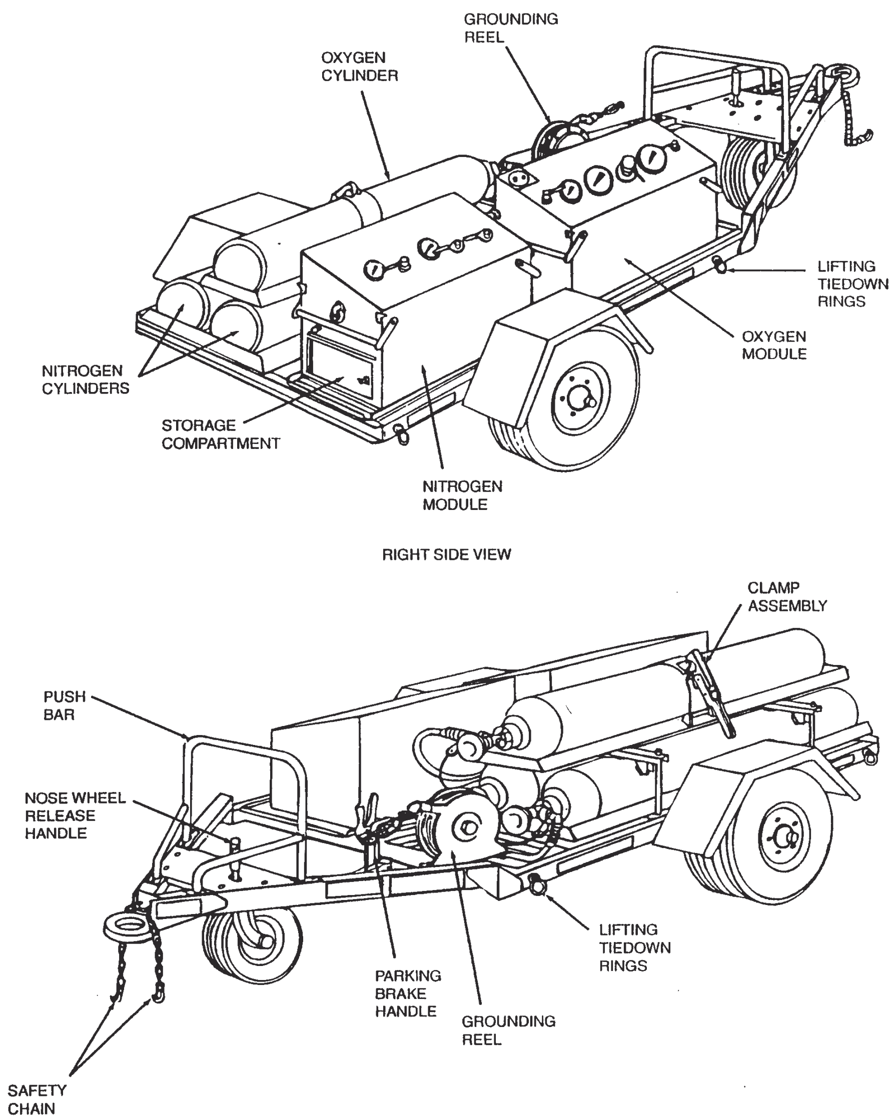
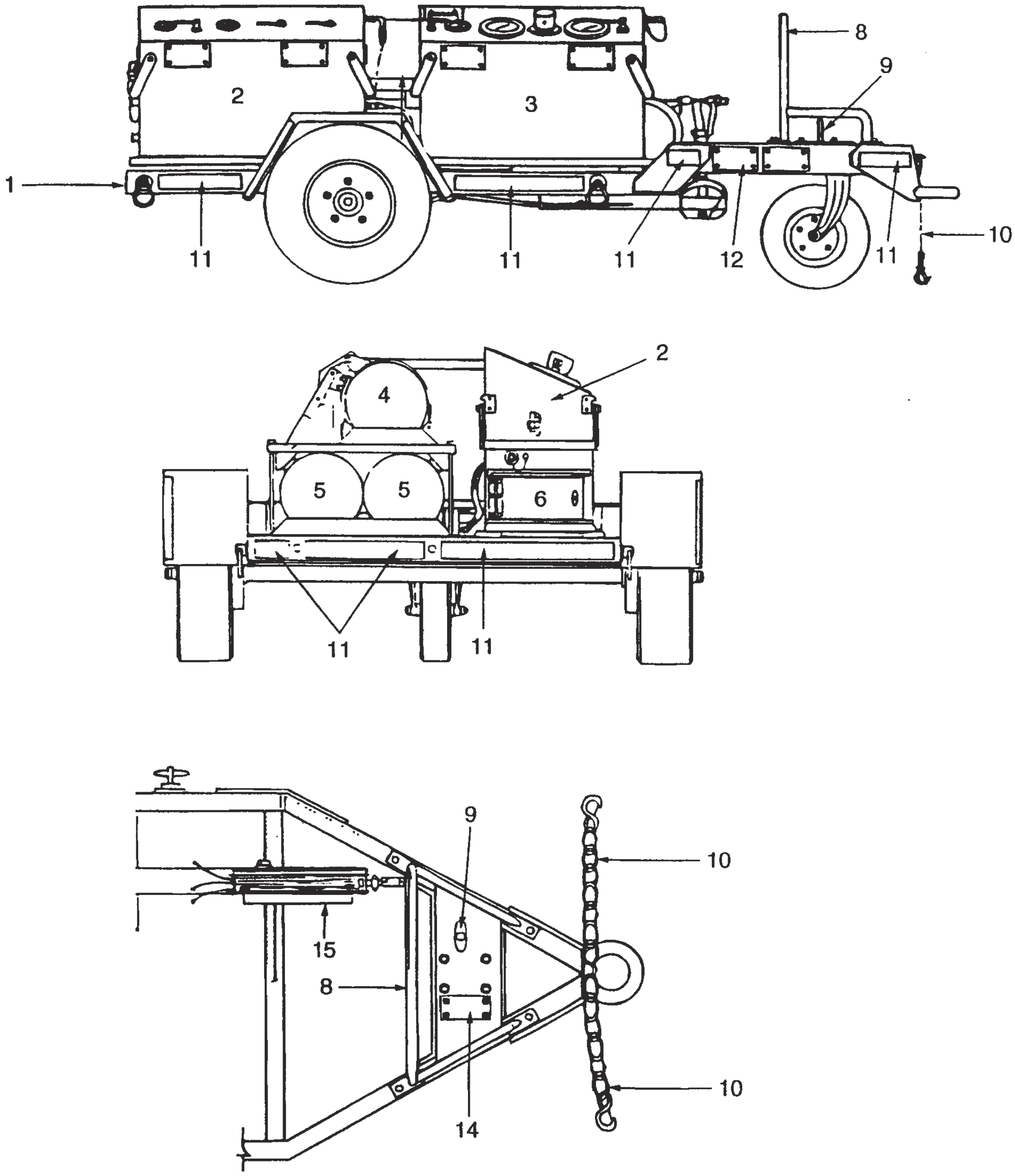


Figure 8-7.—Oxygen servicing unit A/U26U-1A.



1. TRAILER ASSEMBLY
2. NITROGEN MODULE
3. OXYGEN MODULE
4. OXYGEN STORAGE CYLINDER
5. NITROGEN STORAGE CYLINDER
6. SERVICING/INTERFACE EQUIPMENT STORAGE
7. PARKING BRAKE HANDLE
8. PUSH BAR
9. NOSE WHEEL RELEASE HANDLE
10. SAFETY CHAIN AND HOOK
11. RETRO-REFLECTIVE TAPE
12. LIFTING INSTRUCTION PLATE
13. TRANSPORTATION DATA PLATE
14. IDENTIFICATION PLATE
15. GROUNDING REEL CABLE ASSEMBLY

Figure 8-8.—Oxygen servicing unit A/U26U-1A.

GAS SERVICING SYSTEM.—The gas servicing system is used to supply oxygen to an aircraft oxygen storage system. The system consists of the gaseous oxygen module and nitrogen module.

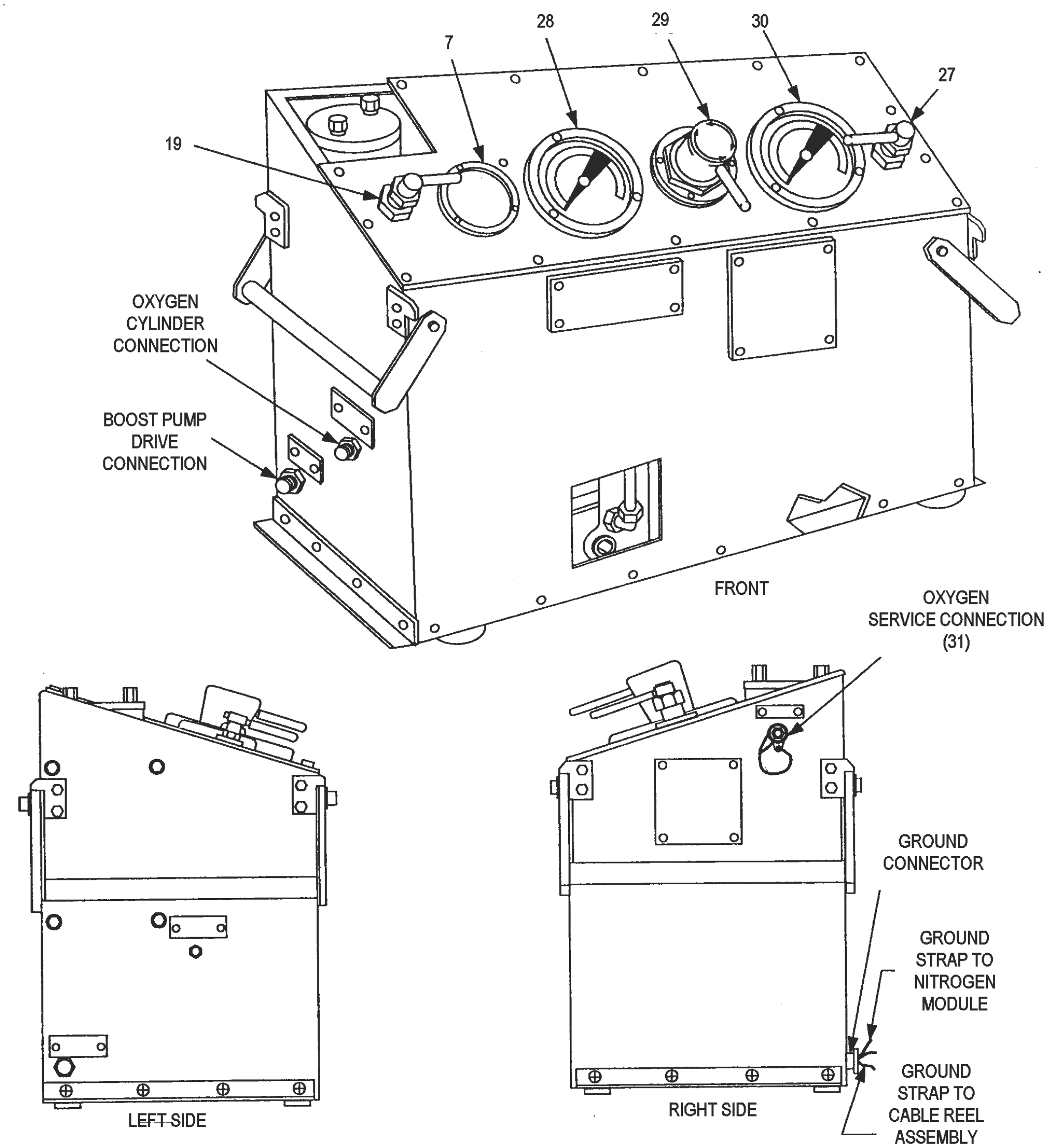
CAUTION

Compressed air used to drive the oxygen gas boost pump must be clean and moisture free.

Gaseous Oxygen Module.—The gaseous oxygen module (fig. 8-9) transfers oxygen from the gas storage system by equalizing pressure or by boosting with a pump driven by compressed air or gaseous nitrogen. The two oxygen delivery pressures provided are for high pressure (HP) and low pressure (LP) aircraft oxygen serving. During aircraft oxygen servicing, the oxygen module is grounded to the nitrogen module and trailer grounding reel. Gaseous oxygen (aviator's breathing) used with this unit shall conform to the current military specification MIL-0-27210, type I (gaseous, 99.5 percent pure).

WARNING

Do not interchange parts between nitrogen module and oxygen module.



7. OXYGEN SUPPLY PRESSURE GAUGE (0-3000 PSIG)
19. SELECTOR VALVE
27. OXYGEN VENT VALVE
28. REGULATOR INLET PRESSURE GAUGE (0-3000 PSIG)
29. OXYGEN REGULATOR
30. REGULATOR OUTLET PRESSURE GAUGE (0-3000 PSIG)

Figure 8-9.—Gaseous oxygen module.

Gaseous Nitrogen Module.—The gaseous nitrogen module (fig. 8-10) supplies unregulated compressed air (90 to 150 psig) or regulated gaseous nitrogen (120 to 130 psig) to the oxygen module for oxygen boost pump drive. Compressed air is the primary drive source for the boost pump. Gaseous nitrogen will only be used as a drive source for boost pump when compressed air is not available. Gaseous nitrogen used for recharging this unit shall conform to federal specification BB-N-411, type 1 (gaseous), Class 1 (oil free), Grade B (99.5 percent pure, low moisture content).

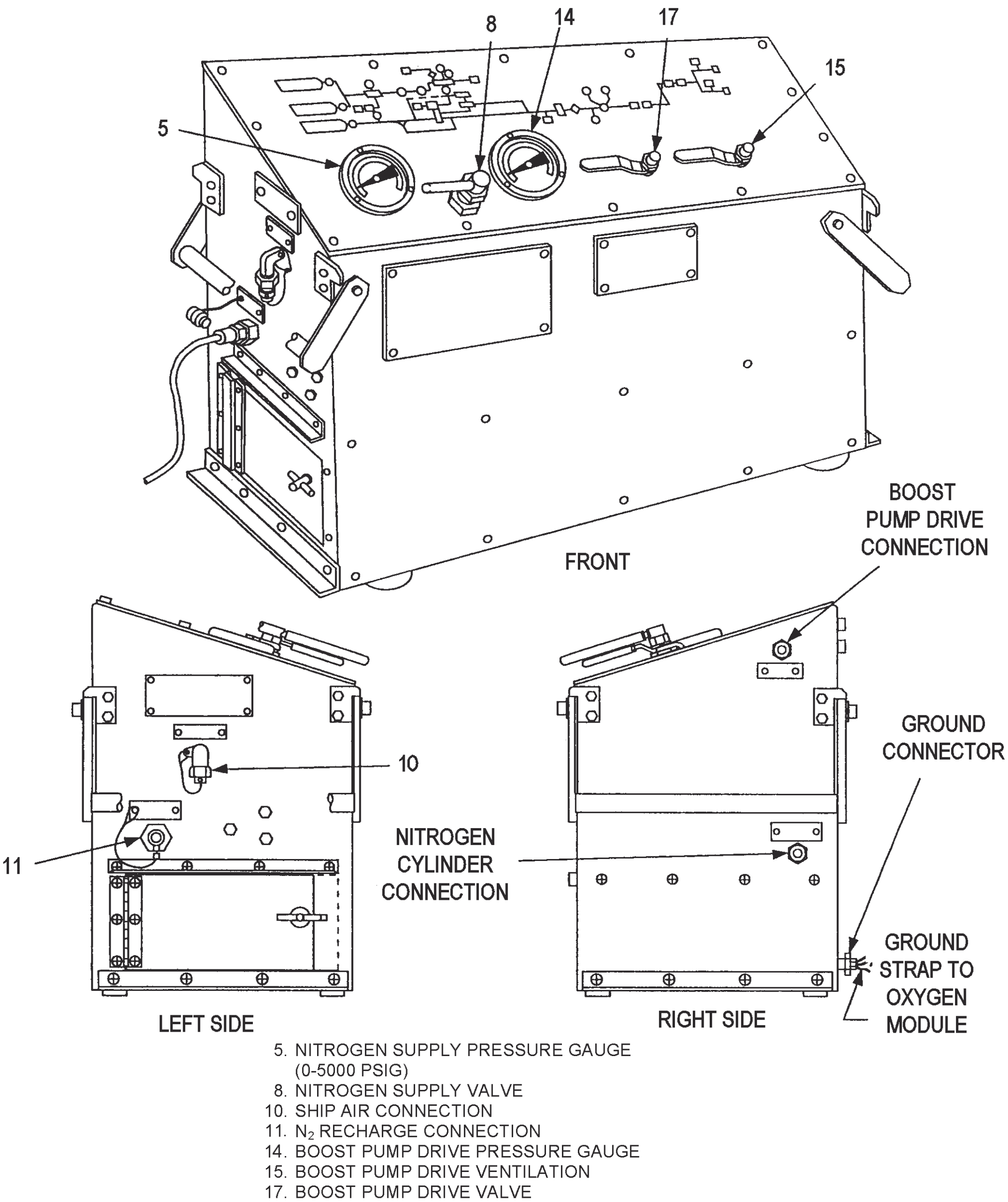
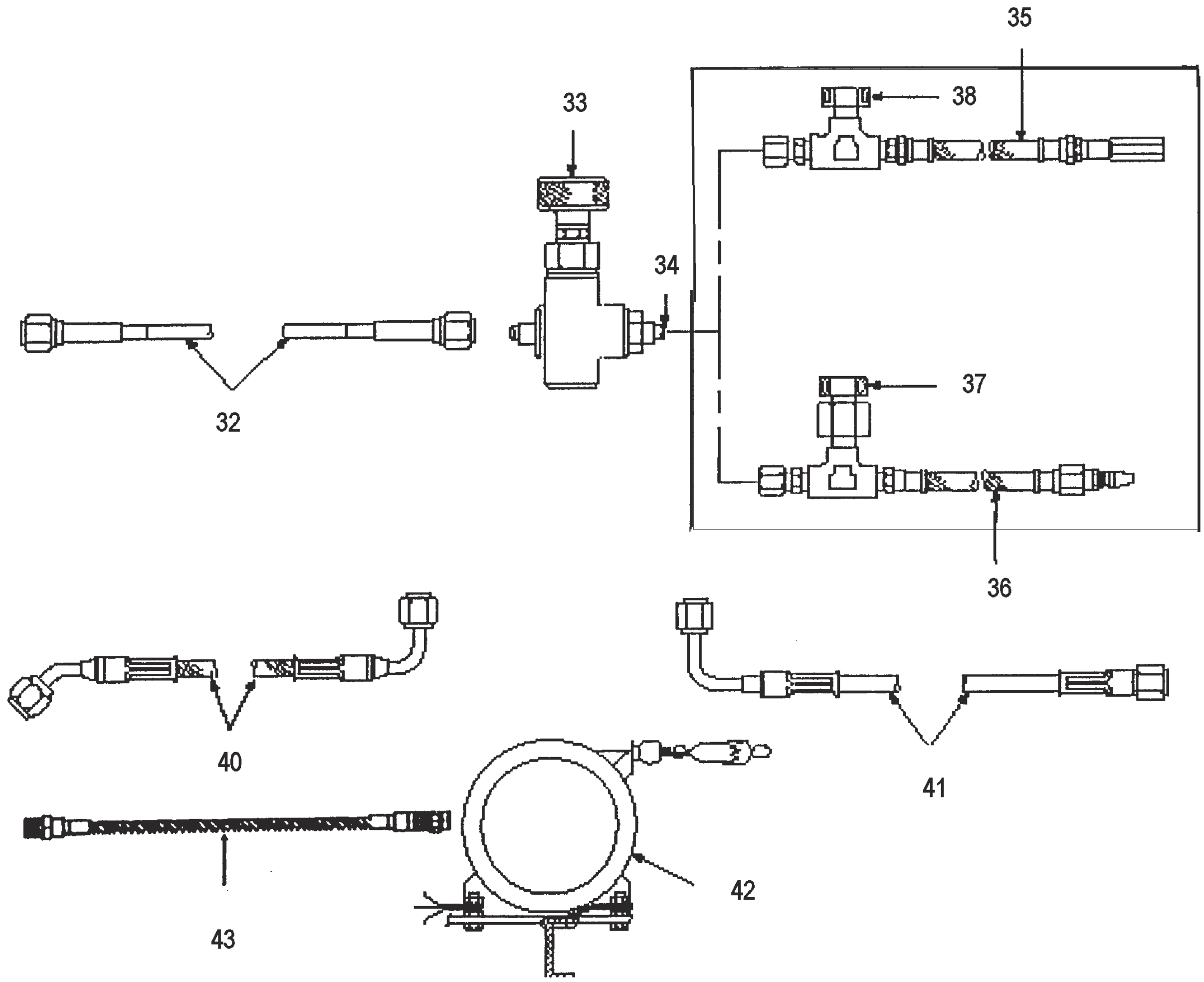


Figure 8-10.—Gaseous nitrogen module.

INTERFACE/SERVICING EQUIPMENT.— The interface/servicing equipment (fig. 8-11) consists of those parts required to connect the oxygen-servicing unit to the aircraft oxygen storage system and includes the grounding cable reel assembly. The servicing equipment provides an HP and LP oxygen supply connection for aircraft oxygen storage cylinders and emergency bailout systems. The interface equipment consists of connecting hoses between oxygen/nitrogen modules, which convey air or nitrogen to drive the oxygen boost pump.

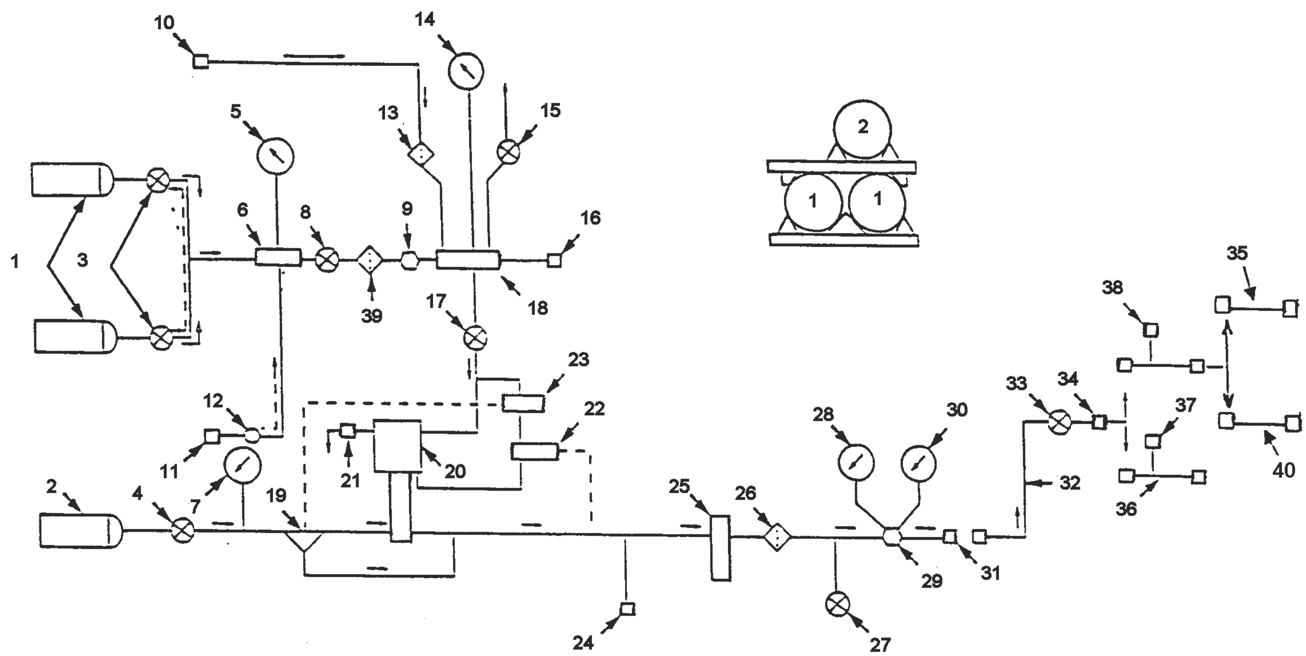


32. OXYGEN SERVICE HOSE PN 1828AS137-1
33. OXYGEN SERVICE VALVE PN 1828AS179-1
34. SERVICE ADAPTER CONNECTION PN MS33656E4
35. HP SERVICE ADAPTER PN 1828AS138-1
36. LP SERVICE ADAPTER PN 1828AS139-1
37. LP ADAPTER BURST DISC PN 1828AS177-1
38. HP ADAPTER BURST DISC PN 1828AS178-1
40. BOOST PUMP DRIVE HOSE PN 1828AS143-1
41. OXYGEN BENCH SUPPLY HOSE (SHIP/SHOP PN 1828AS140-1
42. GROUNDING CABLE REEL ASSEMBLY PN ML-2930-34 (61349)
43. HP SERVICE ADAPTER (AIRCRAFT) PN 1426AS136-1

Figure 8-11.—Oxygen/nitrogen interface/servicing equipment.

Operation

The operational functions of the oxygen-servicing unit are HP and LP aircraft oxygen servicing, HP and LP oxygen shop servicing, and gaseous nitrogen recharging. Aircraft servicing shall be performed in ambient temperatures of –30°F to 125°F in various environmental conditions. Figure 8-12 illustrates the



1. NITROGEN STORAGE CYLINDERS
2. OXYGEN STORAGE CYLINDER
3. NITROGEN CYLINDER VALVES
4. OXYGEN CYLINDER VALVE
5. NITROGEN SUPPLY PRESSURE GAUGE (0-5000 PSIG)
6. HP MANIFOLD
7. OXYGEN SUPPLY PRESSURE GAUGE (0-3000 PSIG)
8. NITROGEN SUPPLY VALVE
9. PRE-SET REGULATOR
10. SHIP AIR CONNECTION
11. N_2 RECHARGE CONNECTION
12. RECHARGE CHECK VALVE
13. FILTER
14. BOOST PUMP DRIVE PRESSURE GAUGE (0-200 PSIG)
15. BOOST PUMP DRIVE VENT
16. LP BURST DISC (180 PSIG)
17. BOOST PUMP DRIVE VALVE
18. LP MANIFOLD
19. SELECTOR VALVE
20. BOOST PUMP
21. EXHAUST
22. NO PILOT VALVE
23. NC PILOT VALVE
24. RELIEF VALVE (2900 PSIG)
25. PURIFIER
26. FILTER
27. OXYGEN VENT VALVE
28. REGULATOR INLET PRESSURE GAUGE (0-3000 PSIG)
29. OXYGEN REGULATOR
30. REGULATOR OUTLET PRESSURE GAUGE (0-3000 PSIG)
31. OXYGEN SERVICE CONNECTION
32. SERVICE HOSE
33. SERVICE VALVE
34. SERVICE ADAPTER CONNECTION
35. HP SERVICE ADAPTER
36. LP SERVICE ADAPTER
37. LP ADAPTER BURST DISC (600 PSIG)
38. HP ADAPTER BURST DISC (2590 PSIG)
39. PRE SET REGULATOR FILTER
40. HP SERVICE ADAPTER (AIRCRAFT)

Figure 8-12.—Air/nitrogen boost pump drive and oxygen servicing flow schematic.

component locations and the oxygen flow; table 8-2 describes the functions of the servicing controls and indicators as shown in figure 8-12.

HP AND LP AIRCRAFT SERVICING.—The HP and LP aircraft oxygen servicing operational function involves the mobile servicing of aircraft

Table 8-2.—Servicing Controls and Indicators

ITEM	NAME	FUNCTION
3	Hand valves on nitrogen gas storage cylinders	Isolates the nitrogen storage cylinders.
4	Hand valve on oxygen gas storage cylinder	Isolates the oxygen gas storage cylinder.
5	Nitrogen supply pressure gauge on nitrogen module	Displays nitrogen cylinder gas pressure.
7	Oxygen supply pressure gauge on oxygen module	Displays oxygen cylinder gas pressure.
8	Nitrogen supply valve on nitrogen module	Prevents nitrogen flowing to a pre-set pressure regulator when recharging the nitrogen gas storage cylinder.
14	Boost pump drive pressure gauge on nitrogen module	Displays nitrogen gas or air pressure being delivered to the boost pump.
15	Boost pump drive valve on nitrogen module	Vents the boost pump drive gas pressure and nitrogen module gas line pressure for parts disconnecting.
16	LP burst disc	Prevents the boost pump drive air pressure from exceeding 180 psig.
17	Boost pump drive valve on nitrogen module	Provides positive control of air or nitrogen gas to the boost pump.
19	Selector valve on oxygen module	Provides control of oxygen delivered to the boost pump or bypasses oxygen around the boost pump. Also, provides system off control.
24	Relief valve in oxygen module	Relieves excess pressure if boost pump outlet pressure exceeds 2900 psig.
27	Oxygen vent valve on oxygen module	Vents oxygen gas upstream of regulator.
28	Regulator inlet pressure gauge on oxygen module	Displays inlet gas pressure to the oxygen regulator.
29	Oxygen regulator in oxygen module	Regulates oxygen delivery pressure to the aircraft oxygen gas storage system.
30	Regulator outlet pressure gauge on oxygen module	Displays outlet gas pressure of oxygen regulator.
33	Service valve on service equipment	Positive control for ON-OFF delivery to aircraft storage system. Vents upstream pressures for parts disconnect.
37	Low pressure service adapter burst disc	Prevents low pressure aircraft oxygen gas storage system from exceeding 600 psig.
38	High pressure service adapter burst disc	Prevents high pressure aircraft oxygen gas storage system from exceeding 2400 psig.

oxygen storage systems to a HP of 1800 psig and LP of 500 psig.

NITROGEN RECHARGING.—This operational function involves charging two gaseous nitrogen cylinders. The nitrogen cylinders have a pressure range of 225 to 3850 psig. When recharging the cylinders, the nominal pressure is 3500 psig to a maximum of 3850 psig.

Q8-18. The type No-2 gaseous oxygen-servicing trailer has how many manifold control valves?

Q8-19. What component on the type No-2 cart controls the charging pressure when the trailer is servicing aircraft oxygen systems?

Q8-20. An oxygen cylinder should never be completely drained. How much residual pressure should be kept in the cylinder?

Q8-21. True or False. Parts for a No-2 cart can be interchanged with those on a nitrogen cart.

Q8-22. The A/U26U-1A gaseous nitrogen module supplies what amount of regulated gaseous nitrogen to the oxygen module?

Q8-23. Gaseous nitrogen on the A/U26U-1A shall conform to what federal specification?

Q8-24. When using the A/U26U-1A, what is the maximum allowable ambient temperature when servicing aircraft?

CHAPTER 8

ANSWERS TO REVIEW QUESTIONS

A8-1. Fifty feet

A8-2. False

A8-3. A 50-gallon Dewar storage tank, 15-liter Dewar transfer tank, and a low loss, closed loop system of transfer lines

A8-4. Holds small volumes of LOX and uses cold gas pressure from the pressure buildup unit to transfer LOX to the aircraft converter

A8-5. Controls the gravity flow of liquid oxygen from the storage tank to the transfer tank

A8-6. Dangerous back-pressure

A8-7. Weekly

A8-8. NAVAIR 19-25D-26

A8-9. Only LOX conforming to MIL-0-27210, type II

A8-10. Aviators Breathing Oxygen (ABO) Surveillance Program Laboratory and Field Guide (A6-332SAO-GYD-000)

A8-11. Atmospheric air

A8-12. Odor test, sampling, and analysis

A8-13. Six days

A8-14. Whenever contamination is suspected

A8-15. It is highly insoluble in LOX, and changing into a solid form, it can be readily set off into ignition. Since it is chemically unstable, it can decompose under certain conditions and become its own source of ignition.

A8-16. Water vapor, carbon dioxide, nitrous oxide, and halogenated compounds (Freons)

A8-17. AS rate

A8-18. Six

A8-19. Pressure regulators

A8-20. 50 psi

A8-21. False

A8-22. 120 to 130 psig

A8-23. Federal Specification BB-N-411, Type 1 (gaseous), Class 1 (oil free), Grade B (99.5 percent pure, low moisture content)

A8-24. 125°F

APPENDIX I

GLOSSARY

ABO—Aviators breathing oxygen.

ACS—Air-conditioning system.

ADC—Air data computer.

AIMD—Aircraft intermediate maintenance department.

ALLOY—A metal that is a mixture of two or more metals.

AMBIENT—Surround; adjacent to; next to. For example, ambient conditions of the immediate area such as ambient temperature, ambient humidity, ambient pressure, etc.

AMP—Auxiliary power unit.

ANOXIA—A complete lack of oxygen in the blood stream.

APU—Auxiliary power unit.

AUR—All up round.

BIT—Built-in test.

BLEED AIR—Hot, high-pressure air, taken from the compressor section of a jet engine.

BRU—Barostatic release unit.

CAD/PAD—Cartridge-activated device/propellant-actuated device.

CAG—Carrier air group.

CAUTION—An operating procedure, practice, etc., that if not strictly observed could result in damage to or destruction of equipment.

CDI—Collateral duty inspector.

CELSIUS—A temperature scale using 0 as the freezing point of water and 100 as the boiling point. The scale has 100 equal divisions between the 0 and 100 with each division designated a degree. A reading is usually written in an abbreviated form; e.g., 75°C. Formerly known as the centigrade scale, it was renamed for Andres Celsius, the Swedish astronomer who devised the scale.

CF_3BR—Triflourobromomethane.

CFM—Cubic feet per minute.

CIWS—Close-in weapons system.

CNO—Chief of Naval Operations.

CO/OIC—Commanding officer/Officer-in-charge.

COMNAVAIRSYSCOM—Commander Naval Air Systems Command.

CONREP—Connected replenishments.

CONTAMINANT—An impurity such as harmful foreign matter in a fluid.

CTR—Center.

DDI—Digital display indicator.

ECMO—Electronic countermeasures officer.

ECS—Environmental control system.

EDC—Engine driven compressors.

EED—Electrically activated explosive device.

EI—Engineering investigation.

EOD—Explosive ordnance disposal.

EPA—Electronics package assembly.

FCDC—Flexible confined detonating cord.

FLSC—Flexible linear shaped charge.

GPM—Gallons per minute.

Hg—Mercury.

I—Individual.

IFF—Identification friend or foe.

IMA—Intermediate maintenance activity.

IMP—Multi-purpose initiator.

INBD—Inboard.

IPB—Illustrated parts breakdown.

JULIAN DATE—The year and numerical day of the year identified by four numeric characters. The first character indicates the year and the remaining three characters specify the day of the year. For example, 2030 indicates the 30th day of 2002.

KEAS—Knots equivalent airspeed.

KIAS—Knots indicated airspeed.

KINKED—A twist or curl, as in a cable, wire, or tubing, caused by its doubling or bending upon itself.

LCSU—Liquid coolant service unit.

LH—Left hand.

LOX—Liquid oxygen.

MAINTENANCE—The function of retaining material in or restoring it to a serviceable condition.

MBEU—Martin-Baker ejection unit (seat).

MIM—Maintenance instruction manual.

MLM—Marine location marker.

MRC—Maintenance requirement card.

MULTIMETER—An instrument used for measuring resistance, voltage, or amperage.

NADEP—Naval aviation depot.

NATOPS—Naval Air Training and Operating Procedures Standardization.

NAVAIRSYSCOM—Naval Air Systems Command.

NAWMU-1—Naval Airborne Weapons Maintenance Unit One.

NFO—Naval flight officer.

NOMENCLATURE—A system of names; systematic naming.

NOTE—An operating procedure, condition, etc., which, because of its importance, is essential to highlight.

NSN—National stock number.

OBOGS—Onboard oxygen generating system.

OJT—On-the-job training.

OPNAV—Office of the Chief of Naval Operations.

OUTBD—Outboard.

OXIDATION—That process by which oxygen unites with some other substance, causing rust or corrosion.

PDRM—Parachute deployment rocket motor.

PPI—Program position indicator.

PRESSURE—The amount of force distributed over each unit of area, expressed in pounds per square inch (psi).

PSI—Pounds per square inch.

PSIA—Pounds per square inch absolute.

PSIG—Pounds per square inch gauge.

QA—Quality assurance.

QUAL/CERT PROGRAM—Qualification/certification program.

RAC—Rapid action change.

RFI—Ready for issue.

RH—Right hand.

SAFETY WIRE/LOCKWIRE—A wire set into a component to lock movable parts into a safe, secure position.

SDLM—Standard depot-level maintenance.

SE—Support equipment. All the equipment on the ground needed to support aircraft in a state of readiness for flight.

SEAWARS—Seawater activated release system.

SENSO—Sensor operator.

SERVICING—The filling of an aircraft with consumables such as fuel, oil, and compressed gases to predetermined levels, pressure, quantities, or weights.

SMDC—Shielded mild detonating cord.

SOP—Standard operating procedure.

TACCO—Tactical coordinator.

TENSION—A force of pressure exerting a pull or resistance.

TL—Team leader.

TM—Team member.

TORQUE—A turning or twisting force.

TOXIC—Harmful, destructive, deadly; poisonous.

TYCOM—Type commander.

VAC—Volts alternating current.

VDC—Volts direct current.

VOLATILE LIQUIDS—Liquids that are readily vaporizable at relatively low temperatures. Explosive liquids.

WAM—Weapons assembly manual.

WARNING—An operating procedure, practice, etc., that if not followed correctly could result in personal injury or loss of life.

XSMDC—Expanding shielded mild detonating cord.

APPENDIX II

REFERENCES

NOTE: Although the following references were current when this Nonresident Training Course (NRTC) was published, their continued currency cannot be assured. When consulting these references, keep in mind that they may have been revised to reflect new technology or revised methods, practices, or procedures; therefore, you need to ensure that you are studying the latest references.

CHAPTER 1

Escape and Survival Systems, NAVAIR 01-85ADC-2-5, Naval Air Systems Command, Patuxent River, MD, August 2000.

CHAPTER 2

Escape Systems, NAVAIR 01-F14AAD-2-2-3, Naval Air Systems Command, Patuxent River, MD, January 2000.

Seat, Canopy, Survival Equipment, and Boarding Ladder, A1-F18AC-120-100, Naval Air Systems Command, Patuxent River, MD, December 1999.

CHAPTER 3

Environmental Control Systems, NAVAIR 01-F14AAA-2-2-2, Naval Air Systems Command, Patuxent River, MD, March 2001.

Escape and Survival Systems, NAVAIR 01-S3AAA-2-2.8, Naval Air Systems Command, Patuxent River, MD, January 1992.

Escape Systems, NAVAIR 01-F14AAD-2-2-3, Naval Air Systems Command, Patuxent River, MD, January 2000.

General Use Cartridges and Cartridge Actuated Devices for Aircraft and Associated Equipment, NAVAIR 11-100-1.1, Naval Air Systems Command, Patuxent River, MD, January 2002.

CHAPTER 4

Explosives Handling Personnel Qualification and Certification Program, OPNAVINST 8020.14, Chief of Naval Operations, Washington, DC, October 1999.

General Use Cartridges and Cartridge Actuated Devices for Aircraft and Associated Equipment, NAVAIR 11-100-1.1, Naval Air Systems Command, Patuxent River, MD, January 2002

The Naval Aviation Maintenance Program (NAMP), OPNAV 4790 series, Volume 1, Chief of Naval Operations, Washington, DC, June 2001.

CHAPTER 5

Environmental Control Systems, A1-F18AC-410-100, Naval Air Systems Command, Patuxent River, MD, April 2000.

Environmental Control Systems, NAVAIR 01-S3AAA-2-2.7, Naval Air Systems Command, Patuxent River, MD, December 1998.

Environmental Control Systems, NAVAIR 01-85ADC-2-6, Naval Air Systems Command, Patuxent River, MD, May 1997.

Environmental Control Systems, NAVAIR 01-F14AAA-2-2-2, Naval Air Systems Command, Patuxent River, MD, March 2001.

Utility Systems, NAVAIR 01-75PAA-2-2.4, Naval Air Systems Command, Patuxent River, MD, March 2001.

CHAPTER 6

Environmental Control Systems, A1-F18AC-410-100, Naval Air Systems Command, Patuxent River, MD, April 2000.

Environmental Control Systems, NAVAIR 01-S3AAA-2-2.7, Naval Air Systems Command, Patuxent River, MD, December 1998.

Environmental Control Systems, NAVAIR 01-F14AAA-2-2-2, Naval Air Systems Command, Patuxent River, MD, March 2001.

Utility Systems, NAVAIR 01-75PAA-2-2.4, Naval Air Systems Command, Patuxent River, MD, March 2001.

CHAPTER 7

Aviators Breathing Oxygen (ABO) Surveillance Program and Field Guide, A6-332A0-GYD-000, Naval Air Systems Command, Patuxent River, MD, June 1997.

Environmental Control Systems, NAVAIR 01-F14AAA-2-2-2, Naval Air Systems Command, Patuxent River, MD, March 2001.

NAVAIROSH Requirements for the Shore Establishment, NAVAIR A1-NASOH-SAF-0001P-5100-1, Naval Air Systems Command, Patuxent River, MD, October 1998.

Oxygen Equipment (Aircraft Equipment Mask and Other Systems), NAVAIR 13-1-6.4-1, Naval Air Systems Command, Patuxent River, MD, April 2001.

Oxygen Equipment (Regulators), NAVAIR 13-1-6.4-2, Naval Air Systems Command, Patuxent River, MD, April 2001.

Oxygen Equipment (Converters), NAVAIR 13-1-6.4-4, Naval Air Systems Command, Patuxent River, MD, April 2001.

Safety and Survival, NAVAIR 01-75PAA-2-2.3, Naval Air Systems Command, Patuxent River, MD, June 2000.

CHAPTER 8

Gaseous Oxygen Servicing Trailer, NAVAIR 19-25D-1, Naval Air Systems Command, Patuxent River, MD, June 1998.

Oxygen Servicing Unit A/U26U-1A, NAVAIR 19-25D-31, Naval Air Systems Command, Patuxent River, MD, November 1999.

Servicing Trailer, Liquid Oxygen Low Loss, Closed Loop, Type TMU-70/M, NAVAIR 19-25D-26, Naval Air Systems Command, Patuxent River, MD, September 2000.

ASSIGNMENT 1

Textbook Assignment: Chapter 1 – Martin-Baker MK-GRUEA-7 Ejection Seat and Chapter 2 – Navy Aircrew Common Ejection Seat (NACES)

1-1. The MK-GRUEA-7 seat provides crewmembers with completely automatic escape at ground level at what minimum knots?

1. 60
2. 70
3. 80
4. 90

1-2. How many Martin-Baker MK-GRUEA-7 seats are on the EA-6B?

1. One
2. Two
3. Three
4. Four

1-3. What difference, if any, do the MK-GRUEA-7 ejection seats have from each other?

1. Time delay firing mechanisms
2. Seat height
3. Seat color
4. None

1-4. What component provides an automatic backup mode of separating the parachute from the crewmember?

1. Emergency release handle
2. Guillotine breech
3. SEAWARS
4. Time-release mechanism

1-5. What type of aircraft uses the Martin-Baker MK-GRUEA-7?

1. E-6B
2. EA-6B
3. S-3
4. F-14

1-6. Which of the following seats ejects first during ejection?

1. ECMO #1
2. ECMO #2
3. ECMO #3
4. Pilot

1-7. What color is the murphy-proof bracket for ECMO #2 seat?

1. Orange
2. Brown
3. Purple
4. White

1-8. Who is the primary person to initiate ejection?

1. ECMO #1
2. ECMO #2
3. ECMO #3
4. Pilot

1-9. With the CMD EJECT SELECT handle in the NORM position, what individual(s) is/are able to initiate ejection?

1. Pilot and ECMO #1
2. Pilot and ECMO #2
3. ECMO #1 and #2
4. ECMO #3 only

1-10. The lanyards for the ejection seat safety pins are what color?

1. Green
2. Red
3. Orange
4. Yellow

1-11. Prior to entering an aircraft cockpit that has an ejection seat, personnel should ensure which of the following guidelines is met?

1. Electrical power is applied
2. Safety pins are installed
3. Proper safety precautions are followed
4. Both 2 and 3 above

1-12. Who may work on ejection seats?

1. E5 and above
2. E5 and below
3. Any AME
4. Qualified personnel only

1-13. How many tubes are attached to the center body of the rocket motor?

1. 8
2. 10
3. 12
4. 14

1-14. What precautions, if any, are used to ensure the correct rocket motor is installed on the proper seat?

1. Color coded tubes
2. Varied size motors
3. Varied size bolts
4. None

1-15. The rocket motor initiator has how many compartments?

1. One
2. Two
3. Three
4. Four

1-16. What is the main structural frame on the MK-GRUEA-7 ejection seat?

1. Catapult assembly
2. Main beam assembly
3. Rocket motor assembly
4. Cross-beam bracket

1-17. What component secures the seat in the aircraft?

1. Top latch mechanism
2. Time-release mechanism
3. Drogue gun assembly
4. Main beam assembly

1-18. The time-release mechanism provides automatic harness release separation at what altitude range?

1. 10,500 to 13,000 feet
2. 11,000 to 15,000 feet
3. 11,500 to 14,500 feet
4. 12,000 to 14,500 feet

1-19. What component provides visual indication of a properly installed MK-GRUEA-7 ejection seat?

1. Murphy-proof bracket
2. Top latch mechanism
3. Drogue gun assembly
4. Time-release mechanism

1-20. The SEAWARS is designed to release the parachute from the crewmember during seawater entry within how many seconds?

1. 1
2. 2
3. 3
4. 4

1-21. Which of the following is NOT a main assembly of the NACES?

1. Main beams
2. Catapult assembly
3. Parachute assembly
4. Rocket motor assembly

1-22. What component secures the NACES to the aircraft?

1. Main beams
2. Catapult assembly
3. Seat bucket assembly
4. Tie rods

1-23. Smooth movement of the seat bucket is provided by what component?

1. Seat bucket slippers
2. Roller bearings
3. Guide arms
4. Guide bushings

1-24. What component takes the full thrust of the catapult during ejection?

1. Inner tube
2. Outer tube
3. Main cross-beam
4. Top cross-beam

1-25. The seat structure is secured to the catapult by what component?

1. Top latch assembly
2. Inner tube
3. Outer tube
4. Interference arms

1-26. The drogue deployment catapult is mounted at what location?

1. Inboard of the RH main beam
2. Outboard of the RH main beam
3. Outboard of the center cross-beam
4. Inboard of the center cross-beam

1-27. What controls the firing of the drogue catapult?

1. Altitude
2. Airspeed
3. Time release mechanism
4. Electronic sequencer

1-28. What is the diameter of the drogue chute?

1. 36 in.
2. 48 in.
3. 57 in.
4. 72 in.

1-29. The PDRM is mounted at what location?

1. Underside of the parachute assembly
2. Left side of the main beam
3. Left side of the catapult
4. Right side of the catapult

1-30. Which of the following is NOT a component of the electronic sequencing system?

1. Two thermal couples
2. Two thermal batteries
3. Two pitot assemblies
4. Two sequencer start switches

1-31. The sequencer controls which of the following ejection events?

1. Canopy deployment
2. Seat deployment
3. Man/seat separation
4. Emergency oxygen activation

1-32. What component(s) supplies/y gas pressure to operate the underseat rocket motor?

1. Electronic sequencer
2. Time release mechanism
3. Catapult assembly
4. Multipurpose initiators

1-33. What component ensures the seat occupant is correctly positioned and locked in for ejection?

1. Shoulder harness reel
2. Lap belt assembly
3. Occupant retaining assembly
4. G-limiter assembly

1-34. Due to aircraft installation requirements, what different characteristics, if any, do the SJU-17(V)1/A, 2/A, and 9/A seat buckets have compared to the SJU-17(V)3/A thru 6/A assemblies?

1. Different color
2. 1 inch wider
3. 1 inch taller
4. None

1-35. The underseat rocket motor has which of the following differences in features to prevent incorrect installation between forward and aft seats on the F-18 aircraft?

1. Angle alignments
2. Shear pin sizes
3. Mounting bolt sizes
4. Colors

1-36. The SAFE/ARMED handle shows what color when in the ARMED position?

1. Yellow and black
2. Black and red
3. Yellow and red
4. Red

1-37. What difference, if any, do the canopy penetrators on the forward seat have between the aft seats?

1. Width
2. Length
3. Color
4. None

1-38. How many different NACES seat bucket survival kit variations are there?

1. One
2. Two
3. Three
4. Four

1-39. The emergency oxygen system is automatically activated during ejection by what component or event?

1. Time release mechanism
2. Extension of a lanyard
3. Altitude reaches 5,000 feet
4. Altitude reaches 13,500 feet

1-40. What color are the manual deployment handles on the survival kit?

1. White
2. Green
3. Orange
4. Yellow

1-41. When the ejection control handle is pulled, the sears are withdrawn from the seat initiator firing mechanisms followed by what event?

1. Two impulse cartridges are fired
2. Electronic sequencer is activated
3. Time release mechanism is activated
4. Rocket motor initiates

1-42. During ejection, what component withdraws a piston from engagement in the lower operating link of the emergency restraint release mechanism?

1. Rocket motor
2. Time delay mechanism
3. RH cartridge
4. LH cartridge

1-43. During ejection, what feature provides an even increase in gas pressure to eliminate excessive g-forces?

1. Telescopic design of the rocket
2. Delayed firing of the rocket cartridges
3. Tubular rings in the catapult
4. Staggered firing of the catapult cartridges

1-44. During ejection, once the leg restraint lines are freed from the aircraft, what component or condition restrains the remaining lines, preventing forward movement of the legs?

1. Harness locks
2. Snubbers
3. Negative g's
4. Positive g's

1-45. During ejection, sequencer timing commences during what condition?

1. Closure of the start switches
2. When the catapult reaches 23-inch extension
3. When the catapult reaches 36-inch extension
4. At 350 knots

1-46. When ejecting in MODE 3 between 500-600 keas, at what time interval does the sequencer fire the drogue deployment catapult?

1. 0.14 seconds
2. 0.22 seconds
3. 0.31 seconds
4. 0.33 seconds

1-47. When ejecting in MODE 1 between 0-300 keas, at what time interval does the sequencer fire the barostatic release unit cartridge and release harness locks?

1. 0.65 seconds
2. 1.30 seconds
3. 1.50 seconds
4. 3.10 seconds

1-48. When the ejection seat is fired, two onboard thermal batteries are immediately energized, supplying usable electrical power to the sequencer within what time frame?

1. 0.19 seconds
2. 0.23 seconds
3. 0.27 milliseconds
4. 100 milliseconds

1-49. At approximately what distance of seat travel are the two pyrotechnic cartridges actuated?

1. 18 inches
2. 24 inches
3. 32 inches
4. 42 inches

1-50. To maintain a uniform vertical acceleration profile on the seat and occupant, what component begins to operate just as the seat separates from the catapult?

1. Underseat rocket motor
2. Time delay mechanism
3. Sequencer start switch
4. Altitude sensor

ASSIGNMENT 2

Textbook Assignment: Chapter 3 – Canopy Systems and Chapter 4 – Explosives Handling Personnel Qualification and Certification Program

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2-1. On the F-14 aircraft, what force provides normal opening and closing of the canopy?

1. Electric
2. Manual
3. Hydraulic
4. Pneumatic

2-2. The externally serviced reservoirs that supply power for the different modes of canopy operation contain what type of pressure?

1. Freon
2. Hydraulic
3. Oxygen
4. Pneumatic

2-3. How many acrylic panels make up the F-14 canopy?

1. One
2. Two
3. Three
4. Four

2-4. What locks the canopy in the closed position?

1. Locking hooks
2. Detent pins
3. Clevis bolts
4. Metal straps

2-5. What component actually opens and closes the canopy?

1. Pneumatic actuator
2. Piston assembly
3. Hydraulic actuator
4. Hydraulic valve

2-6. What component locks and unlocks the canopy?

1. Lock actuator restrictor
2. Canopy lock pneumatic actuator
3. Canopy hydraulic actuator
4. Canopy lock and unlock switch

2-7. What is the function of the lock actuator restrictor?

1. To lock the canopy in the open position
2. To lock the canopy in the closed position
3. To prevent inadverdent closing of the canopy
4. To regulate the speed during locking and unlocking of the canopy

2-8. The canopy pneumatic control module contains how many pressure reducers?

1. One
2. Two
3. Three
4. Four

2-9. The canopy pneumatic reservoir is serviced to what maximum pressure?

1. 1,000 psi
2. 2,000 psi
3. 3,000 psi
4. 3,500 psi

2-10. What is the total cubic inch capacity of the canopy pneumatic reservoir?

1. 225
2. 275
3. 325
4. 375

2-11. The reservoir relief valve opens at what minimum pressure?

1. 2,500 psi
2. 3,200 psi
3. 4,500 psi
4. 4,700 psi

2-12. The auxiliary pneumatic reservoir is serviced to what maximum pressure?

1. 1,500 psi
2. 2,000 psi
3. 3,000 psi
4. 3,500 psi

2-13. What component reduces pneumatic pressure to the auxiliary unlock pneumatic release valve?

1. Auxiliary bypass valve
2. Auxiliary pressure reducer
3. Auxiliary check valve
4. Auxiliary flow valve

2-14. How many ports are there on the unlock shuttle valve?

1. One
2. Two
3. Three
4. Four

2-15. What component prevents nitrogen from venting overboard?

1. Auxiliary pressure reducer
2. Unlock pneumatic release valve
3. Unlock shuttle valve
4. Lock actuator check valve

2-16. How many control handles are there for use in canopy operation?

1. One
2. Two
3. Three
4. Four

2-17. Which of the following is NOT a method of canopy operation?

1. Emergency mode
2. Holding mode
3. Boost closing mode
4. Normal opening mode

2-18. During normal opening mode, the shutoff valves in the open and close modules are vented to atmosphere through what port of the actuator?

1. C5
2. C2
3. C3
4. C4

2-19. During normal opening mode, nitrogen on the opposite side of the piston is vented overboard through what valve of the control module?

1. No. 5
2. No. 2
3. No. 3
4. No. 4

2-20. During the BOOST closing mode, valve no. 4 in the control module is positioned to direct what maximum pressure through the C2 port?

1. 475 psi
2. 560 psi
3. 645 psi
4. 790 psi

2-21. After 3 minutes in BOOST closing mode, the nitrogen pressure will decrease to what minimum pressure on a system serviced to 3,000 psi?

1. 1,000 psi
2. 800 psi
3. 600 psi
4. 500 psi

2-22. When should you use the auxiliary opening mode to unlock the canopy?

1. No electrical power
2. Anytime
3. Pneumatic system pressure drops below 225 psi
4. Emergency

2-23. What air source is used to inflate the canopy seal system?

1. Cooled engine bleed air
2. Vented cabin air
3. Ram air
4. Ambient air

2-24. Where is the canopy seal pressure regulator located?

1. Under the pilot's seat
2. In the nose wheelwell
3. In the port wheelwell
4. On the turtledeck

2-25. The canopy pressure seal receives cooled engine bleed air at approximately what pressure?

1. 40 psi
2. 60 psi
3. 80 psi
4. 100 psi

2-26. How many types of pyrotechnic cords are used in the F-14 canopy emergency jettison system?

1. One
2. Two
3. Three
4. Four

2-27. The term XSMDC stands for what type of pyrotechnic cord?

1. Explosive shielded mild detonating cord
2. Expanding shielded mild detonating cord
3. Extreme shielded mild detonating cord
4. Extra shielded max detonating cord

2-28. What component prevents the explosive signal provided by the canopy jettison initiator from entering the SMDC lines of the seat ejection system?

1. One-way explosive transfer
2. Manifold check valve
3. Jettison relief valve
4. SMDC relief valve

2-29. The S-3 frangible escape system uses what type of explosives instead of hot gas?

1. SMDC
2. FSDC
3. MK 90
4. MK 53

2-30. Instead of safety pins, the external jettison handle uses what item to protect from inadvertent firing?

1. Clevis bolts
2. Safety guard
3. 10-foot lanyard
4. Trigger switch lock

2-31. The window-severance explosive charge is actuated by what crewmember(s)'s initiator?

1. TACCO
2. Pilot only
3. Copilot only
4. Either the pilot or copilot

2-32. Why is an SMDC explosive system more favorable than a hot gas system?

1. Cost effective
2. More reliable
3. Slower
4. Higher initiating pressure

2-33. Which of the following was a factor in the ordnance mishap onboard the USS ORISKANY?

1. Faulty ordnance
2. Faulty maintenance
3. Lack of training
4. Fatigue

2-34. DELETED

2-35. What instruction governs the Qual/Cert program?

1. OPNAVINST 8020
2. OPNAVINST 9600.2
3. NAVAIR 11-100-1
4. NAVAIR 11-85-1

2-36. What term refers to the physcial act of transporting or moving explosives/explosive devices afloat or ashore?

1. Storage/stowage
2. Handling
3. Load/download
4. Assembly/disassembly

2-37. Which of the following individuals may NOT sign as board chairman on the ordnance certification form?

1. CO
2. OIC
3. Division officer
4. XO

2-38. DELETED

2-39. Which of the following is required on the ordnance certification form when an individual certification is revoked?

1. Revoked stamped in red on form
2. Signature of individual in red pen
3. Signature of board chairmen in red pen
4. Diagonal red line on Qual/Cert form

2-40. DELETED

2-41. The Qual/Cert program is NOT applicable to which of the following personnel?

1. Security force
2. Contractors
3. Civilians
4. EOD

2-42. What individual may revoke certification?

1. CO
2. XO
3. MO
4. LPO

2-43. What is required when an explosive mishap is caused by an individual's failure to follow authorized procedures?

1. Reduction in paygrade
2. Forfeiture of pay
3. Page 13 record entry
4. Assignment to administrative duties

2-44. Qual/Cert is valid for how many years?

1. 1
2. 2
3. 3
4. 4

2-45. In the Qual/Cert program, which of the following individuals must the CO certify in writing?

1. Certification board members
2. Team members
3. Team leaders
4. All of the above

2-46. The Qual/Cert board consists of which of the following individuals?

1. Department head
2. At least two E-7 and above personnel
3. Quality assurance representative
4. LPO

2-47. If seniority requirements cannot be met on the Qual/Cert board within a command, what activity may grant a waiver?

1. CNO
2. Local wing
3. TYCOM
4. NAVAIR

ASSIGNMENT 3

Textbook Assignment: Chapter 5 – Utility Systems

3-1. Which of the following systems does NOT get its air from an auxiliary bleed air system?

1. Air-conditioning
2. Pressurization
3. Anti-icing
4. Liquid oxygen

3-2. A bleed air system can reach up to what temperature?

1. 100°F
2. 250°F
3. 375°F
4. 400°F

3-3. An S-3 aircraft bleed air leak detection system consists of how many loops?

1. 5
2. 2
3. 3
4. 4

3-4. The sensing elements for a bleed air leak detection system are mounted between ducts and the aircraft structure for what reason?

1. The bleed air temperature is high
2. The bleed air temperature is low
3. The clearance is greater
4. The accessibility is greater

3-5. In a bleed air leak detection system, what causes a chemical reaction in the sensing element?

1. Humidity
2. Moisture
3. Heat
4. Pressure

3-6. An S-3 bleed air leak detection system is powered by what bus?

1. Essential ac
2. Essential dc
3. Auxiliary generator
4. 200-Hz

3-7. During a test of an S-3 bleed air leak detection system, a ground circuit is completed to turn on which of the following lights?

1. 1A BL LEAK
2. 2 BL LEAK
3. FLT LB LEAK
4. AUX BL LEAK

3-8. Which of the following is NOT a component of a bleed air leak detection system?

1. Leak detector control
2. Sensing elements
3. Flow valves
4. Engine start port leak detector

3-9. Bleed air sensing elements are mounted within what distance of ducts?

1. 1-2 inches
2. 1-3 inches
3. 2-5 inches
4. 2-8 inches

3-10. The engine start port leak detector completes a ground circuit in excess of what temperature?

1. 150°F
2. 175°F
3. 200°F
4. 225°F

3-11. What type of ice on aircraft surfaces is smooth and hard to detect visually?

1. Glazed
2. Rime
3. Black
4. Clear

3-12. Frost is a result of which of the following factors?

1. Ice crystals are oxidized
2. The air is thin
3. The air is heavy
4. Water vapor is turned into a solid

3-13. Which of the following systems is designed to remove ice after it has formed?

1. Deice boot system
2. Anti-ice system
3. Removal ice system
4. Hot air system

3-14. A P-3 aircraft gets its air source for anti-icing from what stage of an engine compressor?

1. 10th
2. 12th
3. 14th
4. 16th

3-15. A P-3 aircraft ice detector warning light is located where?

1. Pilot's instrument panel
2. Copilot's instrument panel
3. Center instrument panel
4. Monitorial ac bus panel

3-16. The shutoff valve for a wing deice system has an indicator to show valve position. Where is this indicator located?

1. In the nosewheel well
2. In the flight station indicator gauge
3. On the valve flywheel
4. On top of the valve housing

3-17. What component controls the valve opening for an anti-ice modulating valve?

1. Thermostat
2. Overheat caution circuit
3. Plenum probe
4. Modulating valve sensor

3-18. The thermostats in the outboard leading edge plenum areas are set at what temperature?

1. 95°F
2. 110°F
3. 125°F
4. 145°F

3-19. The wing inboard and center section thermostat are set at what temperature?

1. 120°F
2. 140°F
3. 160°F
4. 180°F

3-20. The airfoil temperature sensor amplifier is powered by what component?

1. LEAD EDGE TEMP
2. LE HOT
3. OVHT WARNING
4. WING LEADING EDGE SKIN

3-21. High temperature within the leading edge is generally caused by which of the following conditions?

1. Faulty probe
2. Faulty modulator valve
3. Condensation
4. Humidity

3-22. Which of the following positions is NOT a selection for the ice protection panel rotary switch?

1. INBD
2. CTR
3. OUTBD
4. WING

3-23. The OPEN light on the ice protection panel illuminates when what condition occurs?

1. Bleed air valve opens
2. Modulating valve opens
3. Thermostat opens
4. Overheat in wing occurs

3-24. The fuselage bleed air shutoff valves are normally in what position during normal deicing operation?

1. Fully open
2. Open 2 degrees
3. Open 8 degrees
4. Closed

3-25. When performing a leak test on the anti-ice system, the time delay relay will illuminate the ACCEPT light after how many seconds?

1. 6
2. 8
3. 10
4. 12

3-26. The warm air temperature control valve for a windshield anti-ice system is modulated by what type of force?

1. Hydraulic
2. Electrical
3. Muscle
4. Suction

3-27. The flow/temperature limiting anti-ice valve is what type of valve?

1. Single function
2. Dual function
3. Temperature sensitive
4. Manual

3-28. The warm air over temperature sensor opens if duct temperature reaches what temperature, ±25°F?

1. 200°F
2. 250°F
3. 325°F
4. 375°F

3-29. The windshield overheat temperature sensor closes when airflow drops to what temperature?

1. 225°F ±5°F
2. 280°F ±5°F
3. 320°F ±10°F
4. 380°F ±10°F

3-30. The windshield anti-ice/rain removal switch has how many positions?

1. One
2. Two
3. Three
4. Four

3-31. An EA-6B aircraft windshield washing system uses what percentage of methyl alcohol?

1. 50 percent
2. 20 percent
3. 30 percent
4. 40 percent

3-32. The EA-6B windshield washing system has how many nozzles?

1. 5
2. 6
3. 7
4. 8

3-33. What component is NOT a part of the windshield washing shutoff valve?

1. Pressure reducer
2. Check valve
3. Dump valve
4. Temperature solenoid

3-34. When the windshield washing shutoff valve is energized, how much air pressure is regulated to the windshield washing tank?

1. 8 ±1 psig
2. 10 ±1 psig
3. 13 ±0.5 psig
4. 15 ±1 psig

3-35. The windshield switch is what type of switch?

1. Single-pole, two-position
2. Single-pole, three-position
3. Double-pole, two-position
4. Double-pole, three-position

3-36. Holding the WINDSHIELD switch to WASH routes what amount of voltage to open the shutoff valve?

1. 20 Vdc
2. 24 Vdc
3. 28 Vdc
4. 32 Vdc

3-37. The anti-g internal relief valve maintains what maximum pressure?

1. 5 psi
2. 7 psi
3. 9 psi
4. 11 psi

3-38. Pressing the button on top of an anti-g valve performs which of the following functions?

1. Manually operates the anti-g valve
2. Closes the anti-g valve
3. Causes emergency shutdown of system
4. Releases hose assembly

3-39. Where is the vent suit temperature sensor located?

1. Downstream of the vent suit regulating valve
2. Downstream of the heat exchanger
3. Upstream of the vent suit valve
4. Downstream of the vent suit valve

3-40. The vent suit pressure regulating valve limits flow rate to how many cfm?

1. 10
2. 14
3. 18
4. 22

3-41. The vent suit pressure relief valve begins to open at what pressure?

1. 10 psi
2. 12 psi
3. 16 psi
4. 18 psi

3-42. The vent suit pressure relief valve is fully open at what pressure?

1. 12 psi
2. 15 psi
3. 18 psi
4. 21 psi

3-43. How is the radar liquid cooling system airflow valve operated?

1. Electrically
2. Manually
3. Hydraulically
4. Pneumatically

3-44. Which of the following is NOT a characteristic of CF_3BR?

1. Odorless
2. Tasteless
3. Toxic
4. Non-corrosive

3-45. The ram air scoop for the radar liquid cooling system closes from a signal from what component?

1. Air data computer
2. Airflow valve
3. Liquid coolant pump
4. Scoop controller

3-46. The P-3 fire extinguisher container assembly is pressurized with what amount of nitrogen?

1. 400 psi
2. 600 psi
3. 800 psi
4. 875 psi

3-47. A safety disc plug on the fire extinguisher container has a burst range of what pressure?

1. 1000 to 1350 psi
2. 1450 to 1800 psi
3. 1850 to 2000 psi
4. 2050 to 2200 psi

3-48. When operating the APU TEST switch, which of the following is an indication that the system is working properly?

1. Horn sounds
2. Gauge fluctuates
3. Warning light goes off
4. Circuit switch is energized

3-49. The avionics pressurization filter removes what percentage of particles larger than 10 microns?

1. 88 percent
2. 93 percent
3. 95 percent
4. 98 percent

3-50. A waveguide air desiccator turns what color when moisture is present?

1. Blue
2. Red
3. Pink
4. White

3-51. The missile cold air modulating valve receives electrical signals from what component?

1. Heat exchanger
2. Solenoid motor
3. Temperature valve
4. Missile controller

3-52. A pressure switch on the missile coolant pump opens when the output pressure drops to which of the following pressures?

1. 35 psi
2. 48 psi
3. 62 psi
4. 72 psi

ASSIGNMENT 4

Textbook Assignment: Chapter 6 – Air-Conditioning and Pressurization Systems

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4-1. At 18,000 feet, the density of the Earth's atmosphere is about what amount compared to that at sea level?

1. One-quarter
2. One-half
3. Three-quarters
4. No difference

4-2. What is the atmospheric pressure at sea level?

1. 9.7 psi
2. 12.2 psi
3. 14.7 psi
4. 14.9 psi

4-3. What is the atmospheric pressure at 60,000 feet?

1. 1 psi
2. 2 psi
3. 3 psi
4. 4 psi

4-4. At approximately 37,000 feet, what is the outside air temperature?

1. –65°C
2. –55°C
3. –30°C
4. –20°C

4-5. The lowest outside air temperature that an aircraft can encounter could occur at what height?

1. 10,000 feet
2. 20,550 feet
3. 32,650 feet
4. 37,000 feet

4-6. An aircraft flying at supersonic speed at an altitude of 35,000 feet may generate what temperature on its skin?

1. 120°F
2. 200°F
3. 280°F
4. 320°F

4-7. Which of the following is NOT a heat source that will raise cabin/cockpit temperature?

1. Solar heat
2. Heat from electrical units
3. Body heat
4. Aileron heat

4-8. Experiments have proven that a person can withstand and maintain efficiency for extended periods at what maximum temperature?

1. 80°F
2. 87°F
3. 92°F
4. 98°F

4-9. How many requirements are there for the successful functioning of a pressurization and air-conditioning system?

1. 6
2. 5
3. 3
4. 4

4-10. On all jet aircraft, the air used for an ECS is taken from what section of the jet engine?

1. Turbine
2. Fan
3. Compressor
4. Inlet

4-11. The cooling of bleed air before it enters the cabin is provided by what component?

1. Discharge valve
2. Bleed air cooling valve
3. Bleed air mixture unit
4. Refrigeration unit

4-12. The term air-to-air comes from the principle of cooling the air without the use of what component or additive?

1. Compressors
2. Cooling valves
3. Refrigerants
4. Antifreeze

4-13. A P-3 air-conditioning system is comprised of how many independent air cycle cooling systems?

1. One
2. Two
3. Three
4. Four

4-14. Which of the following components is a fresh air source for a P-3 ACS?

1. AMP
2. Bleed valve
3. Turbine shutoff valve
4. Refrigeration cooling valve

4-15. EDCs are what type of compressor units?

1. Single stage
2. Dual stage
3. Multi-stage
4. Manual stage

4-16. What component is the primary air source for the ACS during static ground operations?

1. Refrigeration unit
2. No. 2 engine
3. No. 3 engine
4. AMP

4-17. The EDCs are adjusted for a maximum power requirement of what horsepower?

1. 69 hp
2. 76 hp
3. 81 hp
4. 94 hp

4-18. The air volume in the APU/AMP divides at what section?

1. Distribution duct
2. Spread out duct
3. Outflow duct
4. ACS interconnection duct

4-19. When the APU/AMP is the air supply source, what component is used to balance airflow?

1. Equalizer valve
2. Flow-limiting venturi
3. Combination valve
4. Back-pressure valve

4-20. What component in the ACS removes moisture from the air prior to its entering the cabin?

1. Water separator
2. Water remover
3. Water extractor
4. Water drain

4-21. The flow-limiting venturi is sized to limit airflow to what amount per minute?

1. 32 pounds
2. 43 pounds
3. 56 pounds
4. 67 pounds

4-22. On a flow-limiting venturi, reverse EDC airflow is prevented by what component?

1. Block off plate
2. Mesh screen
3. Check valve
4. Reverse valve

4-23. Which of the following is NOT a component of a cabin temperature control system?

1. Master temp sensor
2. Duct rate sensor
3. Control temp sensor
4. Ice-limiting sensor

4-24. The temperature control system selector-indicator has how many sets of dot markings?

1. One
2. Two
3. Three
4. Four

4-25. Rotating the push-pull knob counterclockwise on the selector-indicator performs what function?

1. Provides cooler air
2. Provides warmer air
3. Increases airflow
4. Decreases airflow

4-26. The temperature controller is composed of what number of modules?

1. One
2. Two
3. Three
4. Four

4-27. What component in the temperature controller controls the automatic mode control circuitry?

1. Selector amplifier
2. Automatic amplifier
3. Programming amplifier
4. Passive amplifier

4-28. The cabin master temperature sensor is at what location?

1. Above pilot
2. Above copilot
3. Above sensor operator
4. Above TACCO

4-29. Elimination of EDC back-pressure is provided by what component?

1. Pressure ratio limiter
2. Ice limiter
3. Back-pressure valve
4. Relief valve

4-30. The pressure ratio limiter is intended to function at what altitude?

1. Below 10,000 feet
2. Between 11,200 and 13,300 feet
3. Between 12,600 and 14,800 feet
4. Above 18,000 feet

4-31. In order for aircrew personnel to operate at the same level of efficiency as at sea level, what solution was developed?

1. Increasing oxygen capacity
2. Pressurizing the cockpit/cabin area
3. Modifying outflow valve
4. Modifying air-to-air system

4-32. The area of an aircraft that is pressurized must be free from which of the following things?

1. FOD
2. Personnel
3. Heated components
4. Air leaks

4-33. The S-3 pressurization system regulates what type of air to control cabin pressure?

1. Inflow
2. Outflow
3. Pneumatic
4. Pressurized

4-34. The S-3 pressurization system consist of how many modes of operation?

1. Five
2. Two
3. Three
4. Four

4-35. Which of the following is NOT a mode of pressurization operation?

1. Unpressurized
2. Isobaric
3. Dump
4. Constant

4-36. At a flight altitude of 15,000 feet, what is the minimum cabin pressure differential?

1. 3.02 psi
2. 3.56 psi
3. 3.94 psi
4. 4.19 psi

4-37. At a flight altitude of 25,000 feet, what is the maximum cabin pressure altitude?

1. 5,000 feet
2. 5,380 feet
3. 5,600 feet
4. 5, 869 feet

4-38. At a flight altitude of 40,000 feet, what is the minimum cabin pressure altitude?

1. 8,340 feet
2. 9,600 feet
3. 11,520 feet
4. 12,050 feet

4-39. During flight operations between 5,000 and 24,000 feet, what mode of operation is in effect?

1. Unpressurized
2. Isobaric
3. Differential
4. Repressurization

4-40. The differential mode of operation overrides the isobaric mode when the aircraft is flying in excess of what altitude?

1. 10,000 feet
2. 14,000 feet
3. 18,000 feet
4. 24,000 feet

4-41. During the dump mode of operation, the re-circulation valve is actuated to what position?

1. 45° open
2. 65° open
3. Full open
4. Closed

4-42. The repressurization mode of operation is used for what purpose?

1. When returning from the dump mode
2. When returning from the isobaric mode
3. When returning from the differential mode
4. To close the outflow valve

4-43. The S-3 pressurization system will begin to pressurize whenever the ground elevation is above what altitude?

1. 2,300 feet
2. 3,200 feet
3. 4,000 feet
4. 5,000 feet

4-44. To ensure adequate cooling of the avionics system during ground operations at altitudes above 5,000 feet, which of the following is a step that must be adherred to?

1. Set CABIN PRESS to isobaric mode
2. Set CABIN PRESS to flight mode
3. Turn AUX VENT selector to ON
4. Turn OUTFLOW selector to OFF

4-45. How is the cabin pressure regulator valve actuated?

1. Pneumatically
2. Hydraulically
3. Electrically
4. Manually

4-46. How many ports lead into the pressure regulator valve diaphragm chamber?

1. One
2. Two
3. Three
4. Four

4-47. Which of the following is NOT a position on the cabin pressure regulator control?

1. ALL OFF
2. AUX
3. FLIGHT
4. DIFF ON

4-48. The cabin pressure regulator control has how many pneumatic ports?

1. One
2. Two
3. Three
4. Four

4-49. The cabin low-pressure switch closes at what altitude?

1. 11,000 (±500) feet
2. 12,000 (±250) feet
3. 13,000 (±500) feet
4. 14,000 (±250) feet

4-50. The cabin air pressure sensing filter traps dust particles greater than what minimum diameter?

1. 2 microns
2. 4 microns
3. 8 microns
4. 10 microns

ASSIGNMENT 5

Textbook Assignment: Chapter 7 – Oxygen Systems

5-1. A minimum of 50 psi must be maintained in a gaseous oxygen supply cylinder. What could be the result of not maintaining this pressure?

1. The oxygen regulators would not function properly
2. The crewmember's mask would not function properly
3. Cockpit odors would be allowed to enter the oxygen cylinders
4. Moisture would be allowed to accumulate in the cylinders

5-2. Personnel servicing or maintaining oxygen systems and components must be very careful to protect systems from which of the following substances?

1. Grease and oil
2. Hydraulic fluid
3. Both 1 and 2
4. Type 1 trichlorotrifluoroethane

5-3. All high-pressure oxygen cylinders are painted what color in accordance with the established color codes?

1. Gray
2. Green
3. Blue
4. Yellow

5-4. Oxygen cylinder valves are equipped with a safety plug filled with a fusible metal designed to melt within what temperature range?

1. 190°F to 207°F
2. 208°F to 220°F
3. 222°F to 245°F
4. 246°F to 270°F

5-5. The self-opening (automatic) oxygen cylinder valve is automatically opened under what conditions?

1. When the pilot inhales
2. When a lever is positioned to ON
3. When the pressure is over 500 psi
4. When it is connected to the oxygen line

5-6. Which of the following regulator maintenance tasks are NOT performed by AMEs?

1. Removal
2. Installation
3. Repairs
4. Operational checks

5-7. The tubing used in aircraft high-pressure oxygen systems is made from which of the following types of material?

1. Copper
2. Steel
3. Bronze
4. Cadmium

5-8. What lines run from the oxygen cylinders to the regulators?

1. Filler
2. Cylinder
3. Regulator
4. Distribution

5-9. Oxygen lines are identified by strips of what color paint and/or tape?

1. White paint
2. Green paint
3. Green and white tape
4. Blue and white tape

5-10. For which of the following connections is high-pressure tubing NOT used?

1. The cylinder valve and the regulator inlet in high-pressure systems
2. The cylinder valve and the pressure reducer in reduced high-pressure systems
3. The pressure reducer and the outlets in reduced high-pressure systems
4. The oxygen cylinder valve and the filler connection in both high- and low-pressure systems

5-11. Adapters and fittings are connected to the ends of copper tubing in high-pressure oxygen systems in what manner?

1. Silver soldered
2. Flared
3. Electric arc welded
4. Tin and lead soldered

5-12. If a line in a gaseous oxygen system ruptures, the loss of the entire oxygen supply is prevented by which of the following valves?

1. Filler
2. Check
3. Shutoff
4. Pressure-reducing

5-13. Check valve castings have arrows embossed on them to provide what information?

1. The direction of the master oxygen supply
2. The direction of the flow through the valve
3. The section of the valve to be mounted facing aft
4. The section of the valve to be mounted facing forward

5-14. In some oxygen systems, high cylinder pressure is changed to a low working pressure by which of the following valves?

1. Pressure-reducing
2. Manifold control
3. Cylinder control
4. Filler control

5-15. Pressure reducers are always in what location?

1. Oxygen distribution lines
2. Cylinder outlet caps
3. Filler valve inlets
4. Regulator outlets

5-16. What valve, located within the common filler valve, opens during the oxygen system filling operation and closes when filling is complete?

1. Regulator
2. Shutoff
3. Check
4. Pressure-reducing

5-17. If the pressure gauge on a 500 psi low-pressure system indicates 125 psi, what fractional part of the oxygen is left?

1. One-fourth
2. One-half
3. Two-thirds
4. Three-fourths

5-18. High-pressure gaseous oxygen system pressure gauges mounted at each flight station are calibrated to indicate pressure ranging from 0 to what maximum pressure?

1. 500 psi
2. 1,500 psi
3. 1,800 psi
4. 2,000 psi

5-19. In the reduced high-pressure oxygen system, a malfunctioning pressure reducer will be indicated by which of the following actions?

1. Rapid decline of quantity on the quantity gauge
2. Illumination of the low quantity light
3. Both 1 and 2
4. Rupture of the green disc in the discharge indicator

5-20. What items or devices should be used as a handle to carry the portable oxygen walkaround unit?

1. Regulator
2. Straps
3. Breathing tube
4. Copper tubing

5-21. Liquid oxygen will remain a liquid under normal atmospheric pressure at what minimum temperature?

1. –182°F
2. –220°F
3. –297°F
4. –320°F

5-22. What is the expansion ratio of liquid oxygen to gaseous oxygen?

1. 962:1
2. 862:1
3. 782:1
4. 692:1

5-23. The combustion-supporting potential of oxygen is a greater danger than freezing.

1. True
2. False

5-24. When transferring LOX from one container to another, which of the following precautions should be taken?

1. Pour slowly to avoid splashing the liquid out of the container
2. Pour slowly to allow the receiving receptacle to cool sufficiently without thermal breakage
3. Both 1 and 2
4. Minimize LOX from venting into the atmosphere by pouring as rapidly as possible

5-25. How many psi of pressure will LOX generate if it is allowed to evaporate at atmospheric pressure in a sealed container that has no relief provisions?

1. 10,000 psi
2. 12,000 psi
3. 14,000 psi
4. 16,000 psi

5-26. The pressure relief assembly in a LOX system storage vessel consists of which of the following items?

1. A rupture disc
2. A reseatable relief valve
3. Both 1 and 2 above in series
4. Both 1 and 2 above in parallel

5-27. Which of the following statements is correct concerning the stowage of LOX containers?

1. Hydrocarbons in the vicinity of stowed LOX containers do not present a hazardous condition
2. LOX containers should not be stowed in the vicinity of flammable gases or liquids
3. Because of the insulation in LOX containers, open outside stowage is desirable
4. Stowage of LOX containers must be in refrigeration spaces

5-28. When dealing with LOX leakage or spillage, which of the following actions should be taken?

1. Immediately mop up the LOX and hose down with water
2. Immediately hose the area with water
3. Dilute the LOX with a caustic soda and hose down with water
4. Ventilate the leakage or spillage to allow LOX to evaporate into the atmosphere

5-29. What action should be taken when an article of clothing you are wearing comes in contact with LOX?

1. Separate the article of clothing from skin contact immediately, and thoroughly air clothing to allow dilution of the oxygen
2. Apply large quantities of water to the clothing area that has come in contact with the LOX
3. Remove the contaminated article of clothing and discard
4. Remove the contaminated article of clothing for washing

5-30. For what reason must a completely empty aircraft LOX converter be serviced slowly?

1. To allow the system to be completely filled
2. To prevent possible damage to the converter by thermal shock
3. To allow the safety valves in the system time to adjust to the servicing
4. To prevent the thermal relief valve from operating prematurely

5-31. What is the advantage of using liquid oxygen systems over gaseous oxygen systems on aircraft?

1. Liquid systems are less dangerous
2. One LOX converter replaces several of gaseous oxygen
3. Liquid systems are more efficient
4. Liquid oxygen is more economical to manufacture

5-32. An explosion could occur if a leak should develop in the inner shell of a LOX converter. Which of the following components prevents an explosion from occurring?

1. Pressure isolating valve
2. Two-way check valve
3. Filler valve
4. Blowout disc

5-33. During servicing of an aircraft LOX system, a means for venting is needed. What valve in the oxygen system provides this venting?

1. Filler valve
2. Pressure relief valve
3. Vent valve
4. Spring-loaded check valve

5-34. What is the purpose of the heat exchanger in a LOX system?

1. To cool the LOX leaving the servicing cart to prevent damage to the aircraft's LOX converter
2. To increase the temperature of the LOX leaving the aircraft's converter
3. To prevent damage to the lungs of the crewmember breathing the oxygen
4. To convert the LOX to gaseous oxygen

5-35. What is the purpose of the low-pressure switch in an aircraft's oxygen supply line?

1. To operate the oxygen caution light
2. To cut off oxygen servicing when the aircraft system is full
3. To warn personnel servicing the aircraft that the system is approaching full
4. To complete the electrical circuit to the LOX quantity indicator

5-36. How does a crewmember know when the LOX system is in a low state?

1. By checking the quantity indicator
2. By the illumination of a low quantity light
3. By both 1 and 2
4. By checking the oxygen pressure gauge

5-37. What is incorporated in the LOX system to protect the pressure regulator and crewmember from excessive pressure should the LOX converter malfunction?

1. A thermal expansion valve located between the LOX converter and the oxygen regulator
2. A thermal expansion valve located in the LOX converter
3. A relief valve located in the LOX converter
4. A relief valve located in the oxygen shutoff valve

5-38. Which of the following types of tubing is used in LOX systems aboard aircraft?

1. Low-pressure aluminum alloy
2. High-pressure aluminum alloy
3. Low-pressure stainless steel
4. High-pressure stainless steel

5-39. Which of the following type of aircraft would use a miniature oxygen regulator?

1. P-3
2. C-130
3. F-18
4. MH-53

5-40. The miniature oxygen regulator will deliver 100 percent oxygen automatically when the inlet pressure does not exceed what psi?

1. 120 psi
2. 130 psi
3. 140 psi
4. No pressure limitations; will deliver 100 percent at any psi

5-41. What is the operating pressure of the MD-1 regulator?

1. 0 to 500 psi
2. 50 to 500 psi
3. 0 to 2000 psi
4. 50 to 2000 psi

5-42. Oxygen flow on an MD-type regulator is indicated by what type of action?

1. Fluctuation quantity gauge
2. Light illuminated
3. Horn sounded
4. Blinking action on FLOW indicator

5-43. Which of the following is NOT a toggle position on the emergency pressure control lever of an MD-2 regulator?

1. EMERGENCY
2. NORMAL
3. 100% OXYGEN
4. TEST MASK

5-44. On an MD-type regulator, at what minimum altitude will the regulator provide 100 percent oxygen?

1. 15,000 feet
2. 23,000 feet
3. 28,000 feet
4. 33,000 feet

5-45. An MD-type regulator is protected against overpressure by what component?

1. First stage relief valve
2. Second stage relief valve
3. Flow limiting valve
4. Overpressure valve

5-46. Which of the following is NOT a probable cause if the panel light on an MD-1 regulator fails?

1. Burned out lamp
2. Over-serviced system
3. Faulty light assembly
4. Faulty electrical hookup to power source

5-47. The buildup sequence on a LOX converter begins when what action occurs?

1. The filler hose is removed from the converter
2. The filler hose is connected to the converter
3. Pressure reaches 100 psi
4. Pressure drops to 50 psi

5-48. At approximately what pressure will the pressure-opening valve unseat and allow gaseous oxygen to flow from the converter to the supply system?

1. 32 psi
2. 50 psi
3. 63 psi
4. 82 psi

5-49 Scheduled preventive maintenance for an OBOGS occurs at what time interval?

1. 28 days
2. 256 days
3. 2000 hours
4. 3000 hours

5-50. Which of the following is a position on an OBOGS control panel assembly?

1. OXY FLOW
2. 100% OXYGEN
3. STANDBY
4. EXHAUST

ASSIGNMENT 6

Textbook Assignment: Chapter 8 – Oxygen Support Equipment

6-1. Open flames and smoking should be kept what minimum distance from a LOX handling area?

1. 10 feet
2. 25 feet
3. 35 feet
4. 50 feet

6-2. What may occur, if anything, if LOX is mixed with gasoline, kerosene, oil, or other hydrocarbons?

1. Spontaneous ignition
2. Strong odor
3. High fume content
4. Nothing will happen

6-3. What type of LOX system was developed to eliminate the safety hazards of venting oxygen?

1. Low loss, open loop
2. Low loss, closed loop
3. High loss, closed loop
4. High loss, open loop

6-4. What is the capacity of the transfer tank for the TMU-70/M?

1. 25 liters
2. 15 liters
3. 25 gallons
4. 15 gallons

6-5. What it the primary purpose of the TMU-70/M LOX cart?

1. To store LOX
2. To convert LOX to gaseous oxygen
3. To service oxgyen bottles
4. To service LOX converters

6-6. On the TMU-70/M, the vented oxygen vapors are returned to what component?

1. Transfer tank
2. Transfer lines
3. Storage tank
4. Storage lines

6-7. The storage tank on the TMU-70/M is what type of walled system?

1. Single
2. Double
3. Titanium
4. Vacuum cooled

6-8. The safe operating pressure on the storage tank pressure gauge is indicated by what psi?

1. 0 to 25 psi
2. 0 to 50 psi
3. 0 to 75 psi
4. 0 to 100 psi

6-9. On the TMU-70/M, what component indicates the level of liquid oxygen in the inner tank?

1. Storage tank pressure gauge
2. Storage tank oxygen gauge
3. Storage tank liquid pressure gauge
4. Storage tank liquid level gauge

6-10. What component controls the flow of oxygen gas vapors from the transfer tank to the vapor space of the storage tank?

1. Transfer tank vent line shutoff valve
2. Transfer tank fill line shutoff valve
3. Transfer tank pressure buildup valve
4. Converter vent line shutoff valve

6-11. On the TMU-70/M, what component controls the flow of oxygen from the bottom of the transfer tank to the pressure buildup coil?

1. Transfer tank vent line shutoff valve
2. Transfer tank fill line shutoff valve
3. Transfer tank pressure buildup valve
4. Converter vent line shutoff valve

6-12. The transfer tank pressure gauge is indicated by a green band and what psig reading?

1. 0 to 30 psig
2. 0 to 60 psig
3. 0 to 90 psig
4. 0 to 120 psig

6-13. During transfer of liquid to a converter, the converter full indicator gauge displays what reading?

1. Gas
2. Liquid
3. Servicing
4. Full

6-14. During filling, the fill-drain line shutoff valve is set in what position?

1. Liquid
2. Gas
3. Open
4. Closed

6-15. Controlling the release of gaseous vapors from the storage tank to the vent piping manifold is the responsibility of what component?

1. Transfer tank fill line shutoff valve
2. Transfer tank pressure buildup valve
3. Fill-drain line shutoff valve
4. Storage tank vent line shutoff valve

6-16. During filling operations on the TMU-70/M, the storage tank should not be allowed to rise above what pressure?

1. 25 psi
2. 38 psi
3. 55 psi
4. 73 psi

6-17. When the storage tank liquid level gauge indicates 50 gallons, what component should be closed?

1. Transfer tank shutoff valve
2. Transfer tank buildup valve
3. Transfer tank servicing valve
4. Supply tank servicing valve

6-18. Under normal conditions and 30 psi transfer pressure, the storage tank should fill within what time period?

1. 2 to 5 minutes
2. 2 to 10 minutes
3. 5 to 10 minutes
4. 5 to 15 minutes

6-19. Which of the following valves should be opened to allow the transfer tank to fill?

1. Transfer tank fill line shutoff valve
2. Fill-drain line shutoff valve
3. Converter vent line check valve
4. Converter vent line shutoff valve

6-20. As soon as the converter full indicator gauge reads LIQUID, which of the following valves should be closed?

1. Transfer tank fill line shutoff valve
2. Fill-drain line shutoff valve
3. Converter vent line check valve
4. Converter vent line shutoff valve

6-21. The transfer tank pressure buildup coil is used to increase the pressure in the transfer tank to what psi?

1. 70 psi
2. 90 psi
3. 110 psi
4. 123 psi

6-22. Maintenance information for the TMU-70/M is found in what publication?

1. A6-32AO-GYD-000
2. NAVAIR 19-25D-14
3. NAVAIR 19-25D-22
4. NAVAIR 19-25D-26

6-23. Which of the following fire agents is NOT prohibited for use on LOX-enriched fires?

1. Water
2. Soda-acid extinguishers
3. Mechanical (liquid) foam
4. Methyl bromide

6-24. Which of the following contamination tests is NOT required to be performed at a laboratory?

1. Sampling
2. Density
3. Volume
4. Odor

6-25. When performing a LOX odor test, how much of the LOX is needed?

1. 100 milliliters
2. 200 milliliters
3. 300 milliliters
4. 400 milliliters

6-26. When performing a LOX odor test, when will an odor be most prevalent?

1. As soon as the LOX is poured into a beaker
2. When the beaker has warmed to nearly room temperature
3. When the beaker has reached –20°F
4. When the LOX has set for 24 hours

6-27. Which of the following is the most dangerous contaminate of LOX?

1. Hydrocarbons
2. Water
3. Dust
4. Pollen

6-28. Which of the following is a method used in purging oxygen containers?

1. Oil-based nitrogen
2. Oil-based oxygen
3. LOX wash
4. LOX drying

6-29. The type No-2 cart contains how many oxygen cylinders?

1. Six
2. Eight
3. Three
4. Four

6-30. On the type No-2 cart, what valve is used to control the flow of oxygen from the cylinders to the system being serviced?

1. Cross control valve
2. Manifold control valve
3. Servicing control valve
4. Recharge valve

6-31. Which of the following components is NOT mounted on the upper manifold?

1. Recharge valve
2. Manifold control valve
3. Gauges
4. Drier assembly

6-32. How many shutoff valves does the type No-2 cart have?

1. One
2. Two
3. Three
4. Four

6-33. On the type No-2 cart, what component is used to remove moisture from the system?

1. Filter assembly
2. Drier assembly
3. Vent assembly
4. Moisture removal assembly

6-34. What amount of residual pressure should be kept in an oxygen cylinder?

1. 10 psi
2. 15 psi
3. 30 psi
4. 50 psi

6-35. When installing full cylinders on a type No-2 cart, which of the following is an ideal safety practice?

1. The cart should be connected to a towing vehicle
2. There should be a total of four personnel involved
3. Quality assurance personnel should be present
4. The installation should occur when the outside temperature is a maximum of 75°F

6-36. The two top cylinders on a type No-2 cart are attached by what means?

1. Cylinder wheel
2. Spot tie
3. Harness locks
4. Single strap

6-37. Interchanging of components with air/nitrogen equipment is authorized during what event, if any?

1. War time
2. Operational necessity
3. Parts ordered are not available from supply
4. Never

6-38. The chemical drying agent on the type No-2 cart should be inspected after how many cylinders are used?

1. 8
2. 12
3. 14
4. 16

6-39. What color will the chemical drying agent turn when moisture is present?

1. Pink
2. Blue
3. Green
4. Yellow

6-40. Which of the following components is NOT a major component on the A/U26U-1A oxygen servicing unit?

1. Trailer assembly
2. Gas storage system
3. Gas servicing system
4. Moisture removal assembly

6-41. The A/U26U-1A oxygen trailer contains how many wheels?

1. One
2. Two
3. Three
4. Four

6-42. The parking brake on the A/U26U-1A is operated by what means?

1. Hydraulic
2. Pneumatic
3. Electrical
4. Mechanical

6-43. The gas storage system on A/U26U-1A consists of how many oxygen bottles?

1. One
2. Two
3. Three
4. Four

6-44. The oxygen storage system on the A/U26U-1A is designed to operate at what maximum pressure?

1. 2000 psig
2. 2430 psig
3. 2640 psig
4. 2935 psig

6-45. The nitrogen storage system on the A/U26U-1A is designed to operate at what minimum pressure?

1. 125 psig
2. 175 psig
3. 200 psig
4. 225 psig

6-46. When compressed air is not available on the A/U26U-1A, what source, if any, can be used as an alternative?

1. Oxygen
2. Nitrogen
3. Helium
4. No other source is authorized

6-47. Compressed air used to drive the oxygen gas boost pump on the A/U26U-1A must be what percent moisture free?

1. 100 percent
2. 90 percent
3. 80 percent
4. 75 percent

6-48. The aviators oxygen used on the A/U26U-1A must conform to what military specification?

1. MIL-0-13270
2. MIL-0-27210
3. MIL-0-37420
4. MIL-0-48320

6-49. The gaseous nitrogen module on the A/U26U-1A supplies what minimum amount of unregulated compressed air?

1. 35 psig
2. 50 psig
3. 75 psig
4. 90 psig

6-50. The low pressure service adapter burst disc prevents the low pressure aircraft oxygen gas storage system from exceeding what pressure?

1. 600 psig
2. 800 psig
3. 1000 psig
4. 1200 psig