NONRESIDENT
TRAINING
COURSE

August 1989

Aviation Structural Mechanic E 2

NAVEDTRA 14020

Although the words “he,” “him,” and “his” are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1989 Edition Prepared by
AMCS Harrington P. Bonds

Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER

NAVSUP Logistics Tracking Number
0504-LP-026-6970

Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n315.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1713
DSN: 922-1001, Ext. 1713
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N315)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions:

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N331)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you will receive retirement points if you are authorized to receive them under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 15 points. Points will be credited in units upon satisfactory completion of the assignments as follows:

Unit 1: 12 points upon satisfactory completion of assignments 1 through 7.

Unit 2: 3 points upon satisfactory completion of assignments 8 and 9.

(Refer to *Administrative Procedures for Naval Reservists on Inactive Duty*, BUPERSINST 1001.39, for more information about retirement points.)

COURSE OBJECTIVES

By completing this nonresident training course, you will demonstrate a knowledge of the following subject matter: Utility systems; canopy systems; pressurization and air-conditioning systems; oxygen systems; oxygen support equipment; and ejection seat systems.

Student Comments

Course Title: *Aviation Structural Mechanic E 2* ________________

NAVEDTRA: 14020 ________________ **Date**: ________________

We need some information about you:

Rate/Rank and Name: ________________ SSN: __________ Command/Unit ________________

Street Address: ________________ City: __________ State/FPO: ________ Zip ________

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00)

CHAPTER 1

UTILITY SYSTEMS

Terminal Objectives: Upon completion of this chapter, you will have a working knowledge of bleed-air, liquid cooling, windshield wiper/washer, rain repellant, fire extinguishing, and thermal radiation protection utility systems.

The utility systems of an aircraft provide an additional measure of flight safety, pilot comfort and convenience, and contributes to the overall mission capability of the aircraft. Those utility systems of primary concern to you that are included in this chapter are the various bleed-air, liquid cooling, fire extinguishing, and thermal radiation protection systems.

AUXILIARY BLEED-AIR SYSTEMS

Learning Objective: Recognize the operating principles and functions of auxiliary bleed-air utility systems.

An aircraft's auxiliary bleed-air system furnishes supply air for air-conditioning and pressurization systems, as well as for electronic equipment cooling, windshield washing, anti-icing, and anti-g systems. The bleed-air system also pressurizes fuel tanks, hydraulic reservoirs, and radar waveguides 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 (205°C) at pressures of up to 125 psi. Because each type of aircraft has a somewhat different approach in system design, temperatures, and pressures, the systems 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 used to perform aircraft maintenance. For the most up-to-date information, refer to the proper Maintenance Instructions Manual (MIM) for the system concerned.

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.

System Control

The system is electrically controlled and pneumatically operated. There are three modes of operation controlled by the windshield anti-ice/rain removal switch.

1. OFF. The anti-ice/rain removal air control regulating valve is closed, and there is no airflow over the windshield.

2. RAIN. Low-pressure (2.5 psig) and low-volume (20 lbs/min) air at 250°F directed across the windshield through the anti-ice/rain removal nozzle.

3. ANTI-ICE. High-pressure (16 psig) and high-volume (57 lbs/min) air at 250°F directed across the windshield through the anti-ice/rain removal nozzle.

Low Limit Temperature Control

Refer to figure 1-1 for component location. The supply air temperature is controlled to a lower limit of 290°F by the warm air temperature control valve and the warm air temperature sensor. If air temperature supplied by the air cycle ACS exceeds 290°F, the warm air temperature control valve will close and stop airflow from the bleed-air system. The 290°F supply temperature is cooled as it passes through the ducting to approximately 250°F at the nozzle. The 250°F temperature provides enough heat for windshield deicing, yet is low enough to prevent damage to the windshield.

High Limit Temperature Control

The warm air overtemperature sensor actuates when supply air temperature reaches 375°±25°F and signals the flow/temperature limiting anti-ice modulating valve. This valve regulates airflow supply, which reduces bleed airflow through the primary heat exchanger and reduces airflow supply temperature to below 375°±25°F. The combined action of the warm air overtemperature sensor and flow/temperature limiting anti-ice modulating valve also provides the required protection against a defective warm air temperature control valve.

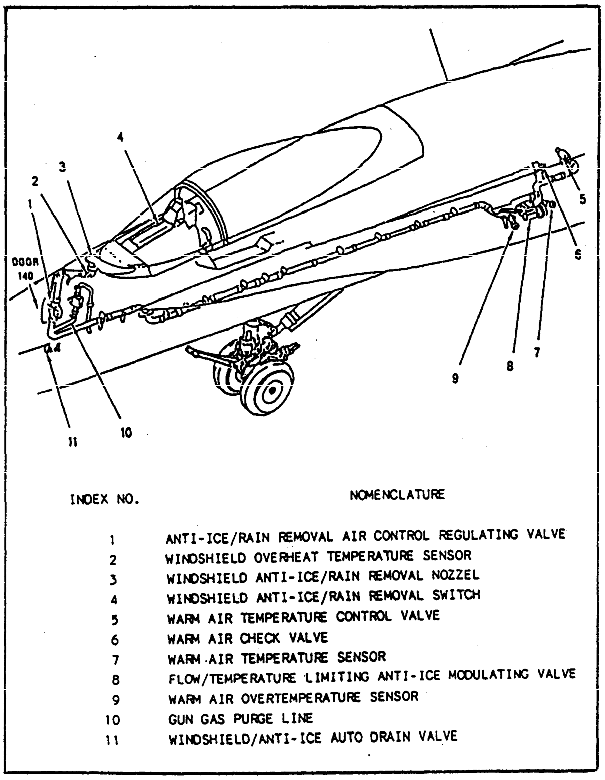


Figure 1-1.—Windshield Anti-ice and rain removal system component locator.

Anti-Ice/Rain Removal Air Control Regulating -Valve

The anti-ice/rain removal air control regulating valve completes the final pressure regulation and flow control before airflow reaches the anti-ice/rain removal nozzle. The valve regulates pressure and flow rate depending on the 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, which causes the digital display indicator to display a (WDSHLD HOT) caution message.

ANTI-G SYSTEM

The anti-g system supplies and controls the flow of air pressure to the pilot's anti-g suit to compensate for forces exerted upon the human body during flight conditions. This system is designed to accomplish the following:

1. Provide protection against grayout, blackout, and unconsciousness

2. Alleviate fatigue and decreased mental alertness, which may result from repeated accelerations below the blackout level

3. Provide a method by which the pilot may relieve leg stiffness and physical tension during flight

4. Provide the pilot with a physical indication of the approximate acceleration to which the aircraft is being subjected

Typical Anti-G System

Most anti-g systems are similar to the one illustrated in figure 1-2. 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.

Pressure Regulating (Anti-G) Valves

There are two types of anti-g valves used on the various naval aircraft. One type has a dual pressure range (HI or LO) that maybe controlled by the pilot. The other type has a fixed pressure output that corresponds roughly to the high (HI) pressure output of the dual pressure valve. Both valves perform the dual functions of regulating the air pressure received from the aircraft's bleed-air system and metering this pressure in varying amounts proportional to the g forces exerted upon the aircraft and its occupants.

Newer aircraft are designed with an anti-g system that has a single-stage pressure regulating valve (fig. 1-3). This valve begins to open at approximately 1.5 g's, and pressure is supplied to the suit at the rate of 1.5 psi for each additional g. The valve is designed to receive air pressure from the bleed-air system at varying pressures and to meter a maximum of 10 psi to the anti-g suit. A relief valve bleeds off the excess air pressure

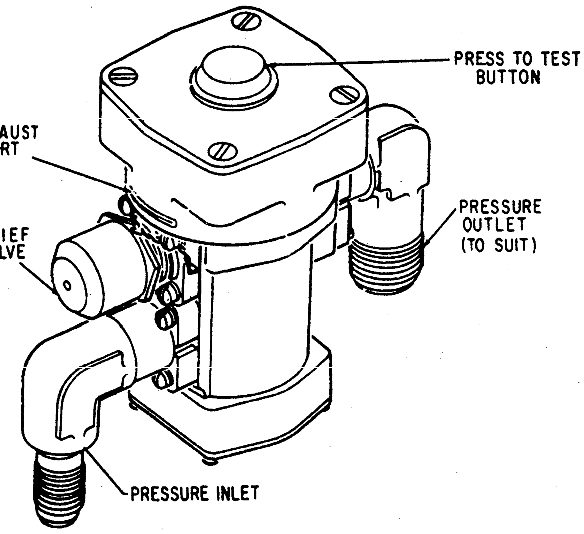


Figure 1-3.—Anti-g pressure regulating valve (single stage)

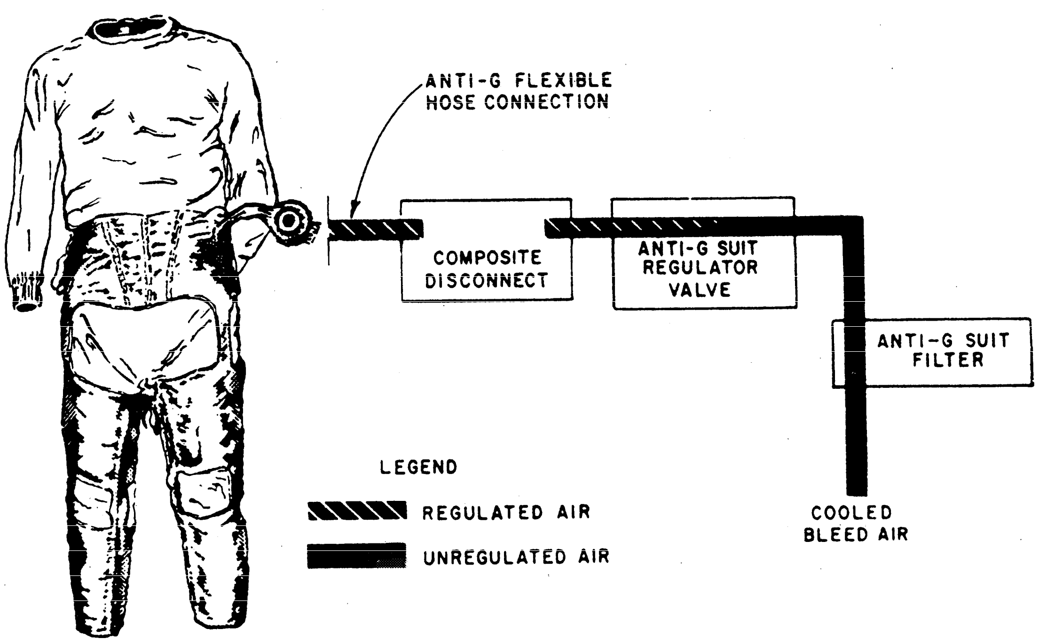


Figure 1-2.—Anti-g system.

and maintains a maximum of 9 to 11 psi in the valve outlet chamber. Figure 1-4 illustrates the operation of the single-stage anti-g valve.

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. 1-4, 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. 1-4, view B). The demand valve closes under pressure of the heavier 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

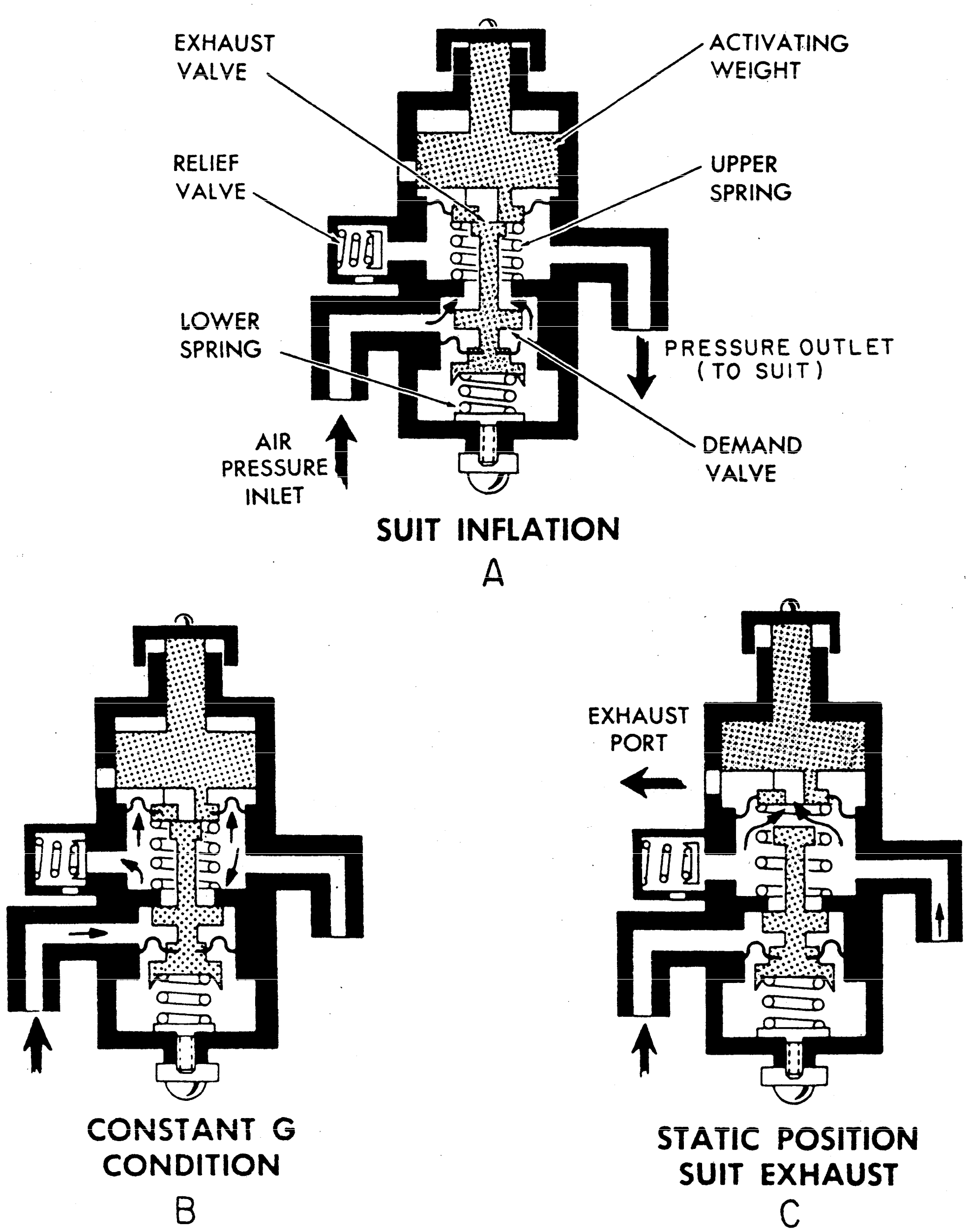


Figure 1-4.—Anti-g valve operation (single stage).

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. 1-4, view C) into the cockpit.

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, as shown in figure 1-2, or it may be attached to the anti-g valve on the inlet side. A typical anti-g system filter is shown in figure 1-5.

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 pressure regulating valve. This disconnect may be l 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.

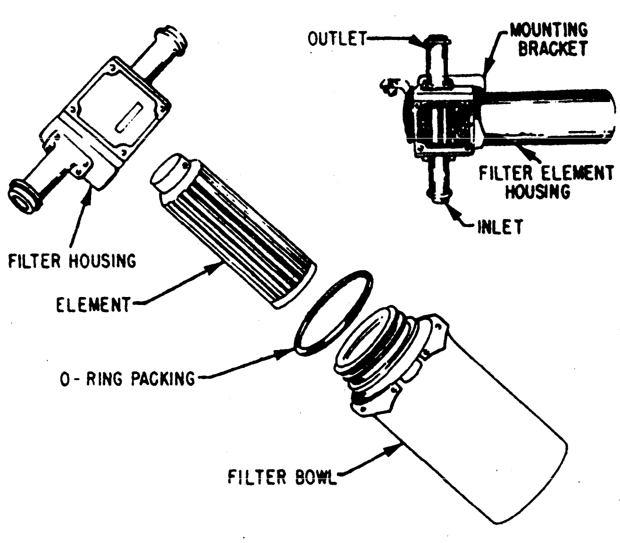


Figure 1-5.—Anti-g system filter.

Anti-g System Maintenance

Maintenance of the anti-g system consists mainly of removal and installation of valves and lines and servicing the filter. Component repair of the anti-g valve is limited because of the equipment necessary to test the valve. Component repair of the dual range anti-g valve is not recommended. The single-stage anti-g valve may be repaired at intermediate maintenance activities that have the necessary test equipment.

SERVICING.— Replace the anti-g filter element at periodic intervals, or when the element becomes clogged or dirty. The replacement interval is specified in the applicable maintenance requirement cards. If the filter is removed from the aircraft, ensure the filter is reinstalled properly. The inlet and outlet ports are identified as IN and OUT to facilitate installation for proper direction of airflow. After replacing the filter element, make a thorough check to ensure that no air leaks exist.

OPERATIONAL CHECK.— Perform an operational check of the anti-g system with the aircraft engine running by pressing the test button on top of the valve to determine if there is proper airflow from the system. When the test button is depressed, the amount of airflow from the disconnect should be proportional to the amount the button is depressed. Greater airflow with increased button depression indicates that the anti-g valve is operating properly on aircraft with dual range anti-g valves. This test should be performed in both the high (HI) and low (LO) ranges.

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 antiexposure suit when worn by the pilot and/or crew members. The system provides a measure of personal comfort, offsetting the discomfort caused by the wearing of the antiexposure suit or heat created by cockpit equipment and resulting high-temperature ambient air.

Some vent-air systems, such as the one installed in the A-4 model aircraft, supply air to only one individual and operate on a small independent motor-driven air blower. Most newer aircraft use engine bleed air that has been cooled in the aircraft's air-conditioning system auxiliary heat exchanger as a primary source of ventilation air. A schematic of the A-6 aircraft vent-air system that operates off engine bleed air is illustrated in figure 1-6.

The A-6 vent-air system is supplied cooled bleed air from the refrigeration unit of the aircraft's cabin air-conditioning and pressurization system and hot bleed air from the hot bleed-air ducting just downstream of the engine bleed-air shutoff valve. The hot and cold bleed-air lines converge into one conditioned air duct that is connected directly to the pilot's and bombardier/navigator's flow controllers and the personnel services disconnect.

Temperature control of the vent-air system is regulated between 50°F and 100°F by the vent suit temperature selector, the temperature control valve, a temperature sensor, and the cabin and vent suit temperature controller. The components of the temperature control system cause the temperature control valve to cycle between open and close. Thus, temperature control is maintained by governing the flow of hot engine bleed air that is being mixed with cool air from the refrigeration unit.

The vent-air system is turned on by the vent suit switch. This switch is an integral part of the pilot's flow controller. When the flow control valve thumbwheel is rotated slightly from the OFF position, the circuit between the temperature sensor and the cabin and vent suit controller is completed. The controller responds to signals

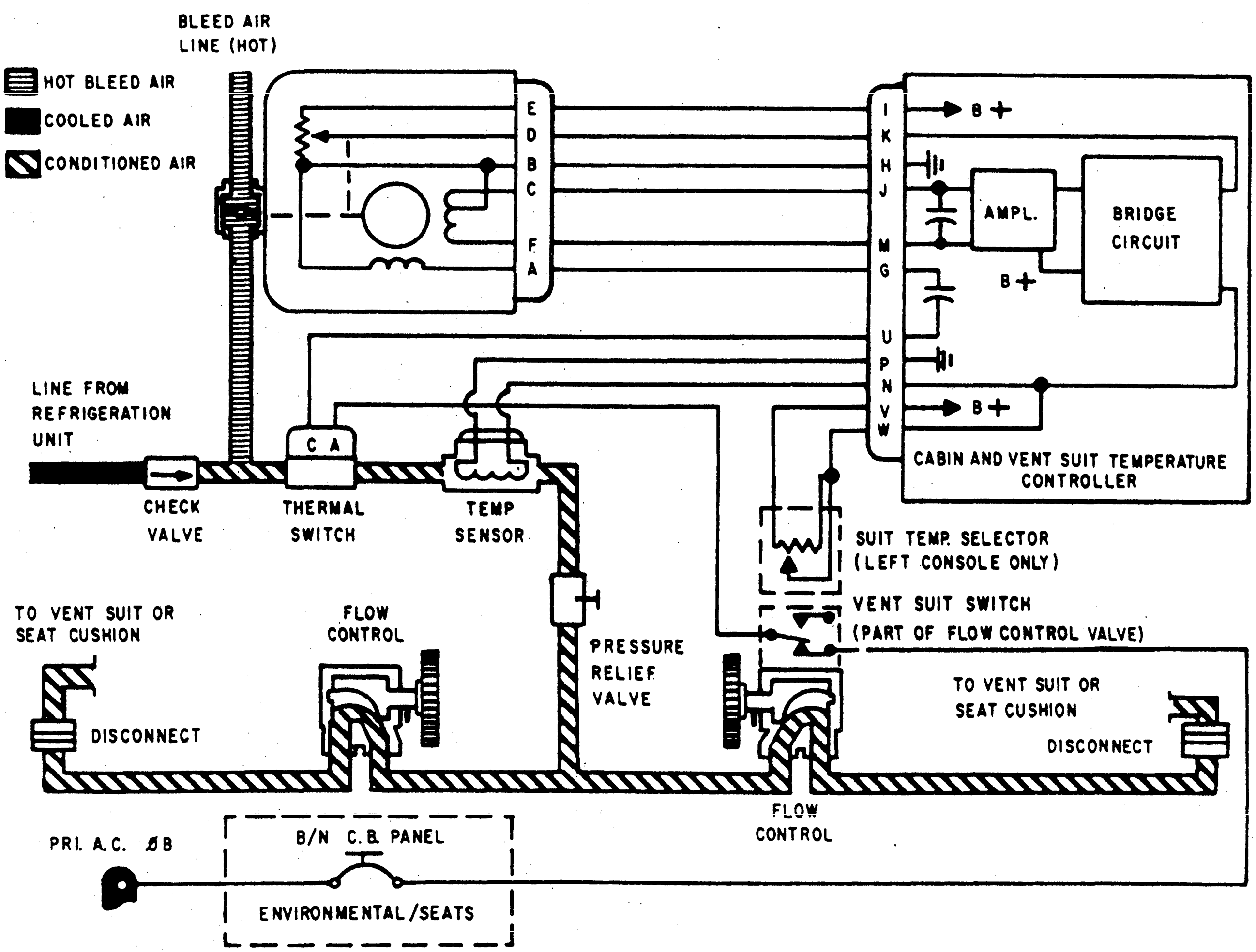


Figure 1-6.—Vent-air system.

from the temperature sensor and the temperature selector and supplies open and close signals, as appropriate, to the vent suit temperature control valve.

The vent-air flow controllers, as the name implies, control the flow of air from the vent-air system ducting to the personnel services disconnects and the seat cushion or the vent connection of the antiexposure suit. One controller is provided for each crew member. The controller has an inlet connector, an outlet connector, and a thumbwheel-operated flow controller. The thumbwheel shaft connects to a rotating plug, which gradually opens or closes off the outlet port as it rotates up to a maximum of 180 degrees. The flow controller will be fully open when turned to the full counterclockwise position.

The temperature selector is a thumbwheel-operated potentiometer, located on the pilot's console, aft of the flow controller thumbwheel. One temperature selector serves both vent suit outlets. The thumbwheel is numbered 1 through 14, and the console is labeled HOT and COLD. Turning the thumbwheel clockwise to the lower numbered settings lowers the temperature of vent-air system air. Counterclockwise movement towards the hot position and the higher numbered settings increases the temperature.

Response to temperature changes initiated by repositioning the temperature selector thumbwheel will be noticeable at the disconnect outlet within a few seconds after making a selection change. When the aircraft is in a stabilized flight condition (maintaining a steady altitude), the temperature of vent air will be monitored and controlled within a ±2°F tolerance of the temperature selected by the temperature selector thumbwheel. When the aircraft is changing altitude, the temperature is maintained within a ± 10°F tolerance.

The thermal switch senses any abnormally high temperatures not compensated for by the temperature sensor and will provide a signal, via the cabin and vent suit temperature controller, to the temperature control valve to drive it towards the closed position.

The system pressure relief valve protects the system from accidental overpressurization. The relief valve will open as necessary to prevent vent-air system ducting pressure from exceeding 10 psi.

The check valve prevents conditioned air from backing up into the environmental control system ducting. Cooled air flows through the check valve, is mixed with the appropriate amount of hot bleed air, and is forced into the vent-air system ducting.

DEICE/ANTI-ICING SYSTEMS

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 supercooled 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 the 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 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 create two basic hazards: (1) the resulting malformation of the airfoil, which could decrease the amount of lift; and (2) 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.

Presently there are two methods for removing or preventing ice. One method, deicing, employs a mechanical system to break up and remove the ice after it has formed. The second method, anti-icing, uses heated bleed air to prevent the formation of ice. Deicing systems are common to older aircraft, and are now generally being replaced by anti-icing systems.

Deice Boot Systems

The deice system for the wing, horizontal, and vertical stabilizer leading edges of E-2 aircraft is an example of a typical deice boot system. The system removes accumulated ice from the wing surfaces through the use of rubber deice boots, which are bonded to the leading edges. The cells or tubes of the deice boots (fig. 1-7) are inflated and deflated alternately by applying pressure and suction, causing a wavelike motion that cracks the formed ice and allows it to be carried away by the airstream.

The E-2A deice boot system shown in figure 1-8 is pneumatically operated and electrically controlled. Engine bleed air provides the necessary air pressure. The bleed air is regulated by the pressure regulator and relief valve. Suction is provided by the ejector and regulated by the suction relief valve. Suction and pressure gages provide a means of monitoring system readings that indicate proper or improper system operation.

The deice system consists of the following main components: electronic timer, three distributor valves, pressure regulator and relief valve, ejector, suction relief valve, the deice boot sections, and pressure and suction gages.

ELECTRONIC TIMER.— A timer controls the inflation and deflation of the deice boots by alternately energizing and de-energizing the solenoids of the distributor valves in a specific sequence. Pressure and suction are applied to the boots in the following sequence: the inboard wing boots, the outboard wing boots, the outboard stabilizer and vertical fin boots, and the inboard stabilizer and fin boots.

Each group of boots is inflated for approximately 5 seconds, and the succeeding group begins inflating approximately 10 seconds after the first group begins deflating. The total time for the complete inflation cycle to all four boot groups is approximately 1 minute. The timer is a sealed unit and is maintained by personnel in the AE rating.

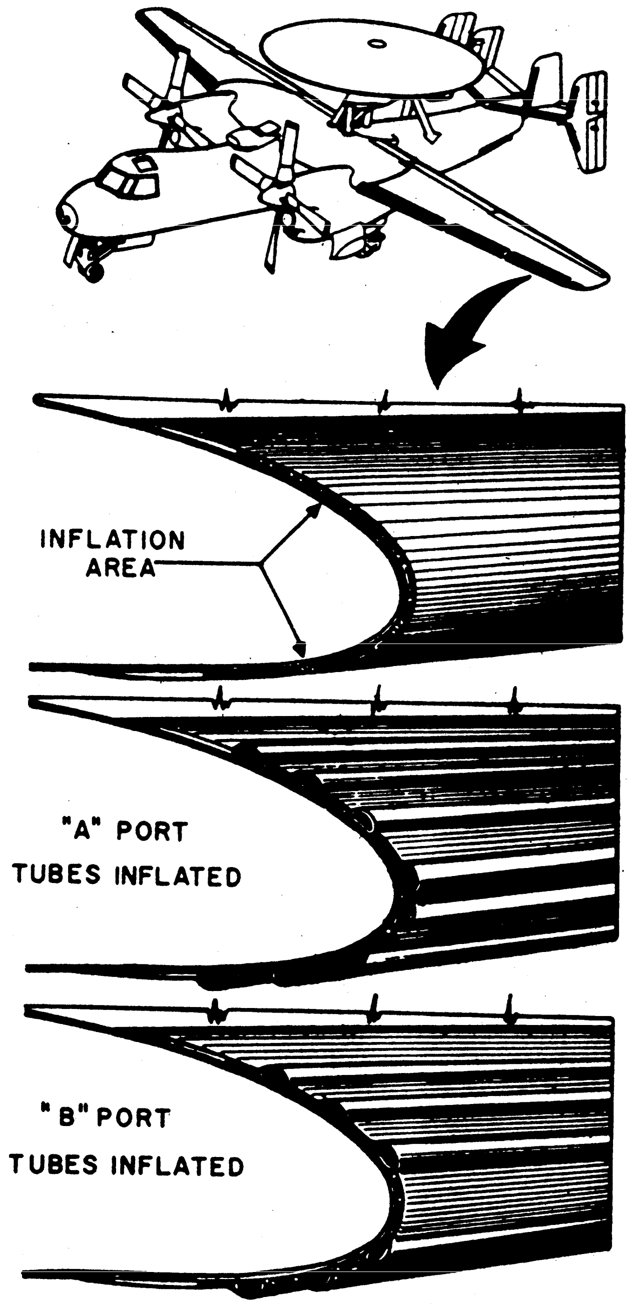
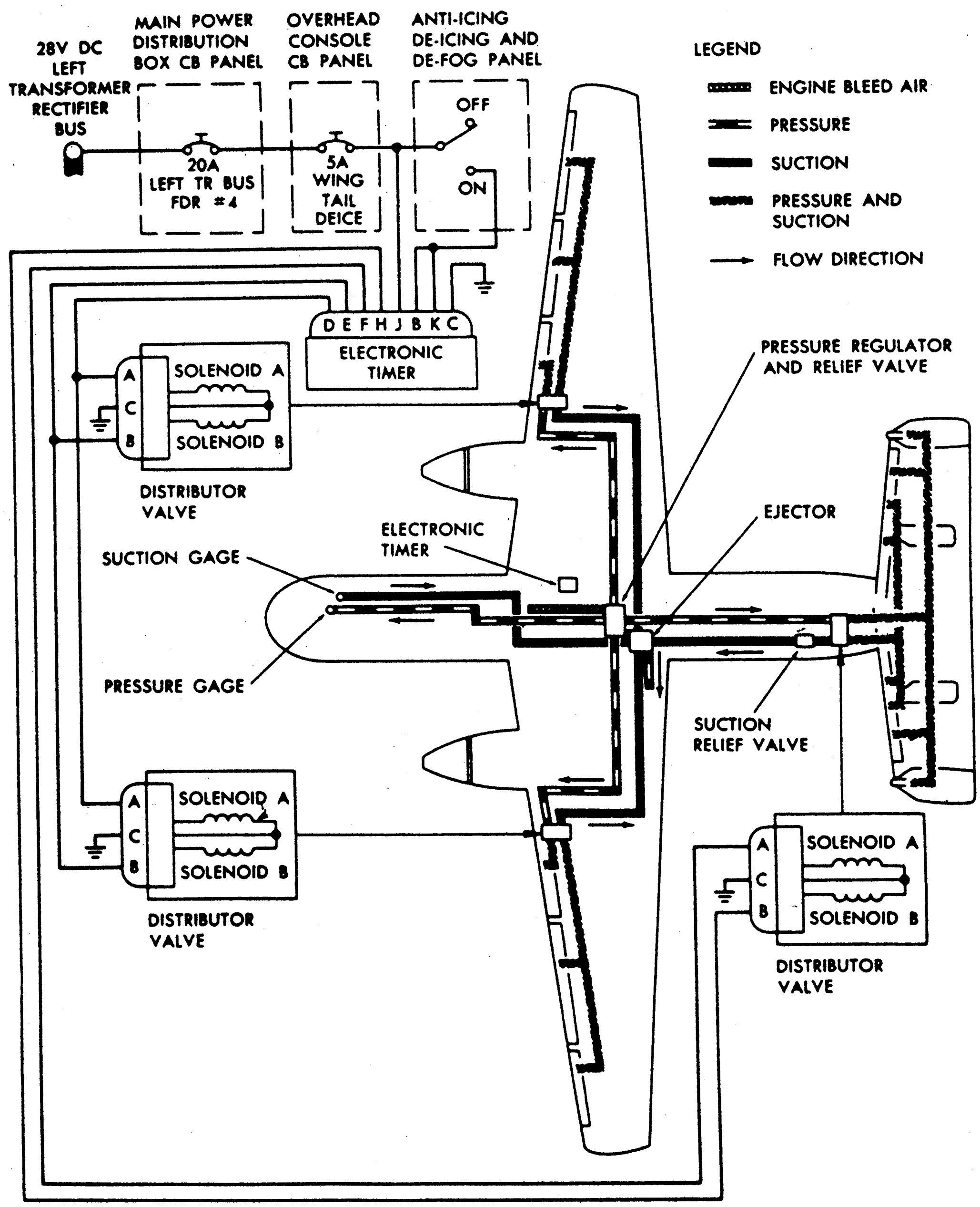


Figure 1-7.—Deice boot location/operation.

DISTRIBUTOR VALVES.— Each of the deice system's three distributor valves (fig. 1-8) has a pressure inlet port, a suction inlet port, two outlet ports to the deice boots, and an exhaust port. The exhaust port routes air returning to the distribution valve in the deflation cycle overboard to a low-pressure area. The low-pressure exhaust area creates a slight suction to assist in deflation of the boot. The pressure inlet port is connected to the engine bleed-air manifold pressure line. The suction port is connected to the main suction line from the ejector. Approximately 4 in Hg. suction is available at all times to the distributor valves. Each distributor valve has two solenoids that, when energized, allow air pressure to inflate their respective boot tubes, as was shown in figure 1-7. When the solenoids are de-energized, the valves allow suction to be applied to the boots, holding them down (deflated) in flight.



213.143

Figure 1-8.—Deice boot system.

When the deice system is operating and one of the solenoids is energized by an electrical signal from the electronic timer, it causes the distributor valve servo controlled by that solenoid to change the inlet to the boots from suction to pressure. The boot tubes served by that outlet will inflate for the predetermined time interval controlled by the timer.

When the solenoid is de-energized, air from the boot tubes flow through an-integral check valve in the distributor valve and out the exhaust port until the pressure drops to approximately 1 in. Hg. At this time the boot is again ported to the suction manifold, through the distributor valve, and any remaining air is evacuated, fully collapsing the boot tubes, as shown in figure 1-7.

PRESSURE REGULATOR AND RELIEF VALVE.— This valve (fig. 1-9) converts the uncontrolled bleed air to a regulated air pressure of approximately 18 psi and routes it to the three distributor valves and the pressure gage.

The combination valve is basically separate regulator and relief valves with the two valve bodies brazed together. A sensing line allows air downstream of the valve to be ported to the diaphragm in the valve's regulating chamber.

As pressure builds up downstream, the diaphram raises, compresses the regulating spring, and raises the inlet valve toward its seat. When the predetermined outlet pressure is reached, the inlet valve is fully seated, shutting off the flow of bleed air through the valve. When the downstream pressure drops below the regulator setting, it reduces the air pressure under the diaphragm and the regulating spring forces the inlet valve off its seat, allowing inlet air to restore the system operating pressure.

The relief valve section of the valve is held in the seated position by spring pressure until the air pressure in the outlet port exceeds a predetermined safe pressure.

In the event that the regulator diaphragm ruptures or the regulating portion of the valve fails for any reason, the relief valve can function as a pressure regulator as well as a relief valve to temporarily protect the downstream deice system components from excessive pressure.

EJECTOR.— The ejector unit consists of a pressure port, a venturi, an overboard port, and a suction port. As air pressure from the pressure manifold enters the inlet. pressure port, it creates

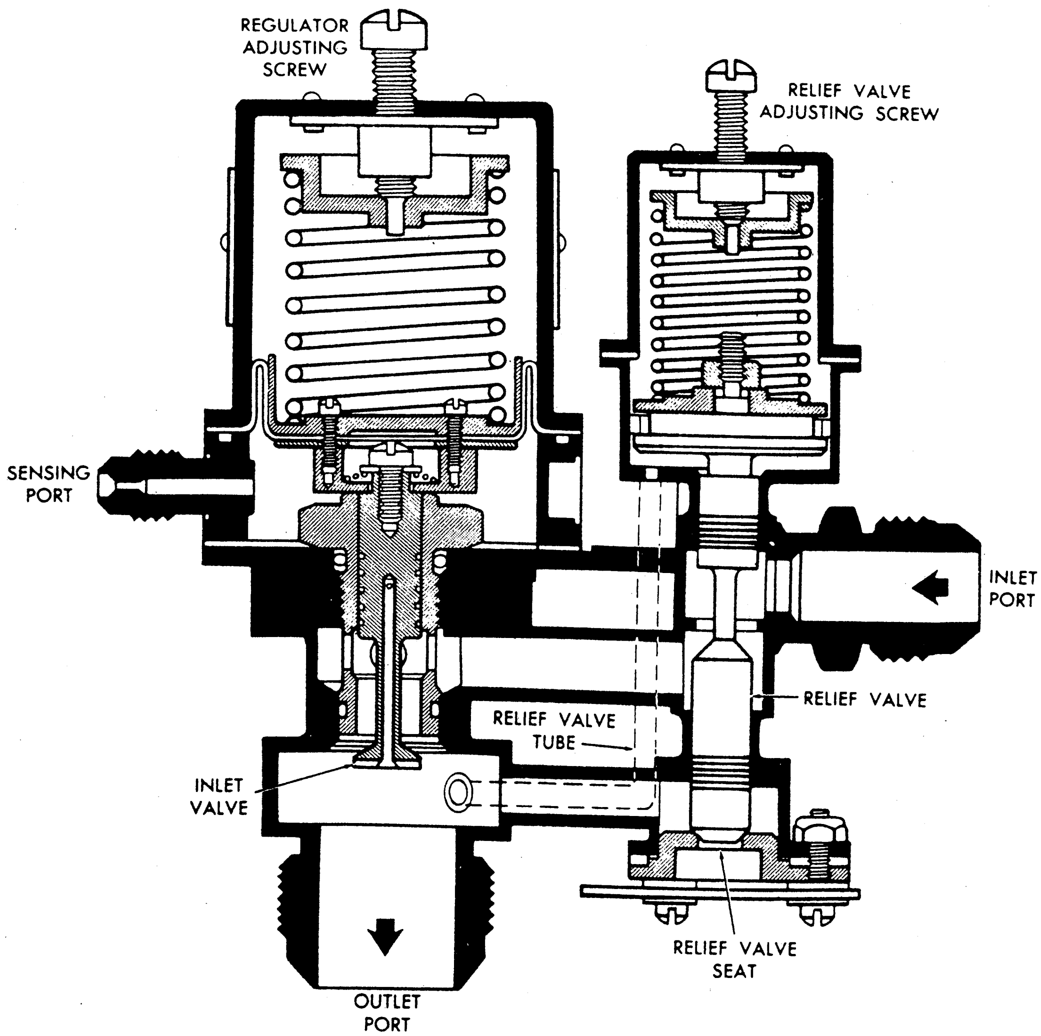


Figure 1-9.—Deice system pressure regulator and relief valve.

the necessary suction at the suction port and in the main suction line to the distributor valves for deflating the deice boots.

SUCTION RELIEF VALVE.— The suction relief valve installed in the suction manifold lines leading from the ejector to the tail section distributor valve regulates deice system suction. When suction in the manifold lines becomes excessive, the spring tension that seats the relief valve is overcome, and the valve opens to permit compartment air into the suction manifold lines until the suction pressure is reduced to approximately 6 in. Hg.

An adjusting nut on the relief valve is used to adjust the tension on the spring that seats the relief valve. "On aircraft" adjustment is generally prohibited.

DEICE BOOTS.— The rubber deice boots (fig. 1-7) are attached to the leading edge surfaces with cement or fairing strips and screws, or a combination of both. On the E-2A, they are bonded to the leading edges with cement and tapered slightly to provide a smooth airflow over the boot and wing, when the boots are deflated.

PRESSURE GAGE.— The deice system cockpit-mounted pressure gage indicates the pressure available for inflating the deice boots when the system is operating. The gage is calibrated from 0 to 20 psi in 1 psi increments. Normal system operation is indicated by a slight pressure fluctuation of the pointer. This fluctuation is caused by a momentary drop in pressure at the beginning of each inflation period for each deice boot group. A steady reading of 18 psi on the gage indicates a nonoperating condition.

SUCTION GAGE.— The deice system cockpit-mounted suction gage indicates the suction available for deflating the deice boots. The 0 to 10 in. Hg gage is calibrated in major increments of 1 in. Hg and minor increments of 0.2 in. Hg. Slight pointer fluctuation indicates proper system operation, as was the case with the pressure gage. A steady reading of 6 in. Hg on the gage indicates a nonoperating condition.

Deice Boot System Maintenance

Maintenance of deice boot systems is normally performed by personnel of the AE, AME, and AMS ratings. Personnel of the AMS rating are primarily concerned with the removal, installation, and miscellaneous repairs of the deice boots. AE personnel are concerned with removal, replacement, and repair of deice system electrical components. The AME is generally responsible for all other components of the deice system. AME personnel assigned to the organizational level of maintenance are responsible for removal and replacement of malfunctioning components, maintenance of associated plumbing, and rendering of assistance to senior personnel in the performance of operational checkouts and troubleshooting.

Some steps of the operational check, as outlined in the applicable MIM, are performed using external electrical power and an external air supply. The air supply is connected to the bleed-air line test connection and must be capable of supplying a pressure of 50 to 90 psi. Remaining steps of the operational checkout require that one of the aircraft's engines be started.

NOTE: Personnel turning up naval aircraft must be fully qualified, designated in writing, and carry a current turnup card in accordance with OPNAV 4790.2.

All steps of the operational checkout must be performed in the sequence outlined in the MIM. When a malfunction occurs during a step, it must be corrected before proceeding to the next step.

Troubleshooting, removal and replacement of components, and the operational checkout should always be accomplished in accordance with the specific instructions provided in the applicable MIM with appropriate emphasis on quality workmanship and inspection.

DEICE AND ANTI-ICING SYSTEMS FOR THE S-3 AIRCRAFT

The S-3 aircraft ice protection system provides deicing of wing leading edge flaps and horizontal stabilizer leading edges and anti-icing of the air-conditioning ram air inlet, engine nacelle, and parts of the engine. The bleed air temperature control anticipator and thermostat, the deice temperature control regulator valve, and the engine anti-icing valve interface with the ice protection system.

The deice function of the ice protection system removes ice that forms on the leading edges of the wing and horizontal stabilizer. The vertical stabilizer leading edge is not deiced. Bleed air from the engine compressor's 10th stage is the basic source of heat. One requirement of the bleed-air supply subsystem, in addition to supplying deice air, is to control the temperature of that supply. The high-stage bleed-air regulator valve primarily maintains a set pressure schedule in the bleed-air manifold. During deice operations this function is expanded to maintain a temperature of 500°±25°F (260°±14°C) (or maximum 14th stage temperature, if less than 500°F).

Pneumatic signals from the bleed-air control temperature thermostat and anticipator are fed to the deice temperature control regulator valve (fig. 1-10), which, in turn, signals the high-stage bleed-air regulator valve to open, as necessary, to satisfy either the pressure schedule or the 500°F requirement, whichever needs the larger amount of 14th stage bleed air. Both engines are connected by the cross-bleed manifold, which provides a flow path for bleed air from either one or both engines. The total deice system is controlled by the timing control, which uses pressure regulator valves and cyclic valves to direct bleed air in the proper sequence to each of the eight deice segments. Sequencing minimizes bleed-air consumption. Bleed air is ported from the cross-bleed manifold to each of the pressure regulator valves. The pressure regulator valves are energized by setting the DEICING switch on the environmental panel on the center console to WING EMP (wing and empennage). Setting this switch energizes a solenoid that ports pressure from the bleed-air supply to open the pressure regulator valve. Duct pressure is regulated by the pressure regulator valve to 26 ±2 psi. In the de-energized position, the pressure regulator valves are pneumatically

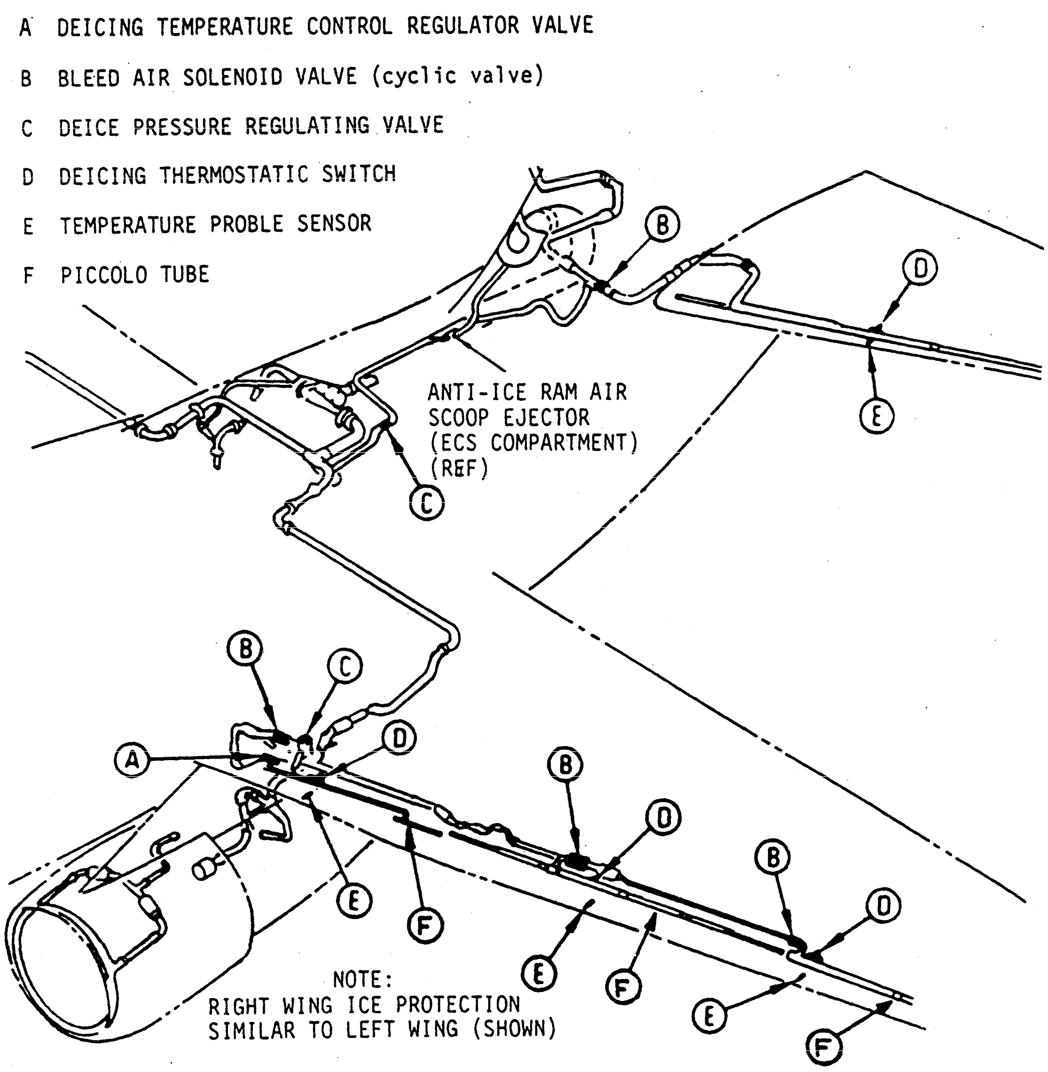


Figure 1-10.—Ice protection system.

and spring-actuated to the closed position and serve as system shutoff.

With the pressure regulator valves in the energized position, bleed air flows through ducting to the cyclic valves. Any time the empennage pressure regulator valve is open, the ram air scoop ejector is provided with a continuous flow of bleed air for anti-icing. The cyclic valve solenoid, when energized, ports pressure to the inlet side of the cyclic valve, and vents the outlet side of its pilot valve to atmosphere. Pneumatic pressure from the inlet side causes the cyclic valve to open. Bleed air will then flow through the ducting for that segment to the respective piccolo tube, where it is directed to flow onto the inner skin surface to raise the skin temperature above freezing. On the wing, bleed air flows along the contour of the skin, and is vented overboard between the leading edge flap lower seal and the fixed wing. For the horizontal stabilizer, the bleed air, after leaving the piccolo tube, flows spanwise in the leading edge plenum, and flows overboard at the tips.

To ensure that the flow of bleed air is directed to the appropriate points regardless of the positions of movable surfaces such as leading edge flaps and the horizontal stabilizer, extension ducts and leakproof rotary joints are incorporated. Also, a special wing fold seal permits wing folding while providing a leakproof junction when the wings are spread.

The timing control provides electrical signals to operate the pressure regulator valves and the cyclic valves in the proper sequence. The sequence is as follows: left outboard wing, right outboard wing, left center wing, right center wing, left inboard wing, right inboard wing, left horizontal stabilizer, and right horizontal stabilizer. Electric power (28 Vdc) is applied to the timing control by setting the deice switch on the environmental panel on the center console to WING EMP for continuous operations, or to SINGLE CYCLE for operation of the system, through one complete sequence. Setting the deice switch to WING EMP energizes the solenoids on the pressure regulator valves, which causes all three pressure regulator valves to open if a bleed-air pressure of 30 psi or more is available. This pressure allows bleed air to flow to the eight cyclic valves. If the wings are folded, the wing pressure regulator valves will not be energized because the wing fold interrupt switch will be in the open position. When the wings are extended, the timing control energizes the cyclic valves in proper sequence. Each solenoid is energized for 30 seconds, which causes each cyclic valve to be pneumatically opened by bleed air, to allow hot bleed air to flow through the piccolo tube for 30 seconds or until the skin reaches 60°± 3°F (15°± 1.6°C) as sensed by the temperature sensor. When the skin temperature exceeds 60°±3°F, the temperature sensor provides a signal to the timing control to de-energize the solenoid for that cyclic valve.

For in-flight operation, setting the deice switch to SINGLE CYCLE will cause the system to operate in the same way as it does when the deice switch is set to WING EMP except that upon completion of one sequence, the switch will return to the OFF position. For ground operation and checkout of the deice system, setting the deice switch to SINGLE CYCLE will permit the system to function through one complete cycle even if the skin temperatures exceed 60°±3°F. The interrupt feature of the temperature sensors is disabled only in the single-cycle mode and only when the aircraft is on the landing gear.

If a cyclic valve fails to fully open when scheduled, a mechanical position switch signals the timing control, which causes the DEICE FAIL indicator light on the annunciator panel on the center instrument panel to come on. This indicator light will go off when the 30-second interval for that cyclic valve is completed. If the pressure regulator valve fails in the closed position, bleed air will not be available to actuate the cyclic valve. Again, the DEICE FAIL indicator light will come on for each cyclic valve downstream from the malfunctioning pressure regulator valve.

If a temperature sensor fails or a cyclic valve fails while open, which results in the skin temperature exceeding 200°± 5°F (93°± 2°C), a thermo switch closes, and the DEICE HOT indicator light on the annunciator panel comes on.

The WING EMP deicer system is functional during all normal flight operating conditions. During the engine-start cycle and during single-engine operations, the deice system is functionally inhibited. Normal deicing becomes available when both engines are operating. When operating on a single engine, deice can be recovered by setting the air-conditioning and deice switches on the environmental panel to OFF/RESET and WING EMP, respectively.

Engine and engine nacelle inlet anti-icing (fig. 1-11) is accomplished by 14th stage bleed air, which is separated, in each engine pylon, from 14th stage air being used for other environmental control system (ECS) purposes. The anti-ice switch on the environmental panel on the center console, when set to the ENG & PITOT position, opens both engine anti-icing valves by de-energizing their solenoids to direct 14th stage bleed air, regulated to 22.5 ± 2.5 psi, to the engine nacelle leading edges and engine anti-icing systems. The position of each anti-ice valve is shown on the copilot's advisory panel; 1 A-ICE ON and 2 A-ICE ON indicator lights come on whenever the anti-ice valves are open. The engine anti-ice switch also opens the empennage pressure regulator valve to provide a source of constant bleed air to the ram air inlet duct anti-icing shroud (unless the deice system is being operated, the empennage cyclic valves will remain inactive/closed). The engine anti-icing valve activates the entire deice system. The deice system cannot be operated until the anti-ice switch is set to the ENG & PITOT position.

The bleed-air deice/anti-icing system consists of deice pressure regulating valves, bleed-air solenoid valves, a WING & EMP deice timing controller, a probe sensor temperature transmitter, and a deice thermostatic switch.

Deice Pressure Regulating Valve

The system (fig. 1-12) uses three pressure regulating valves. One pressure regulating valve

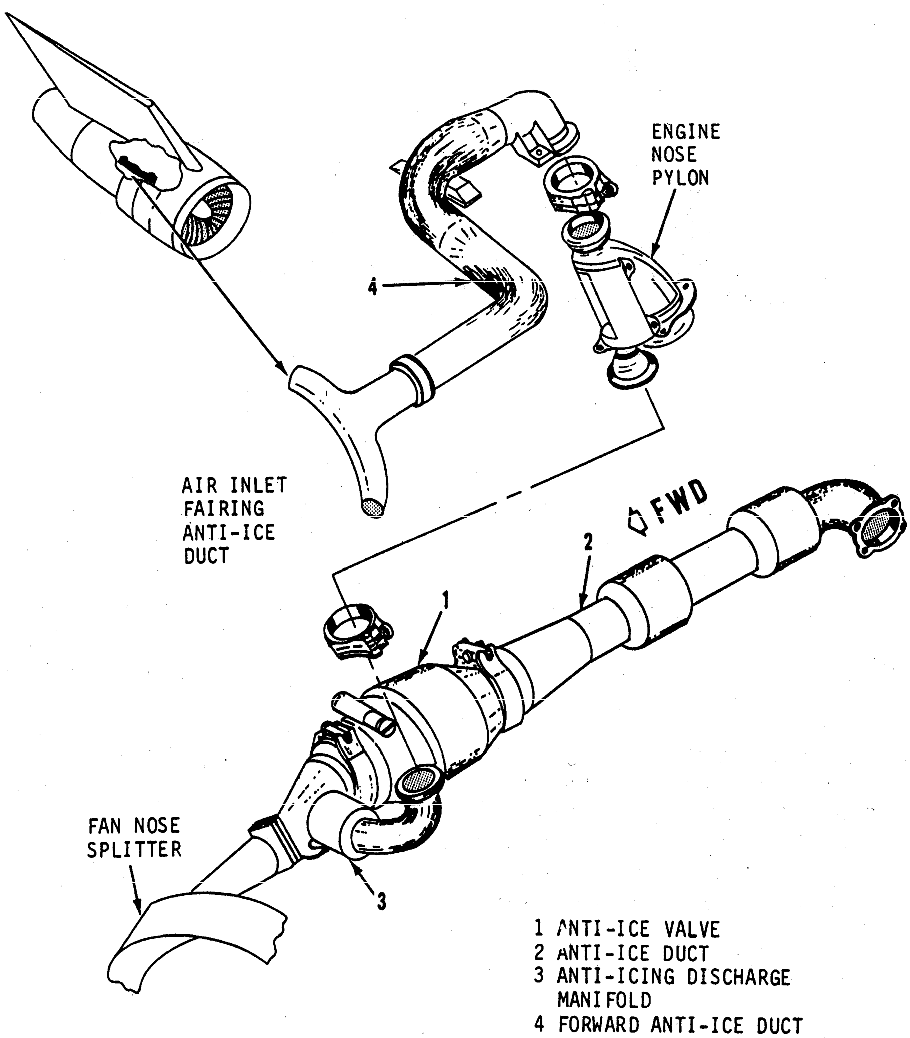
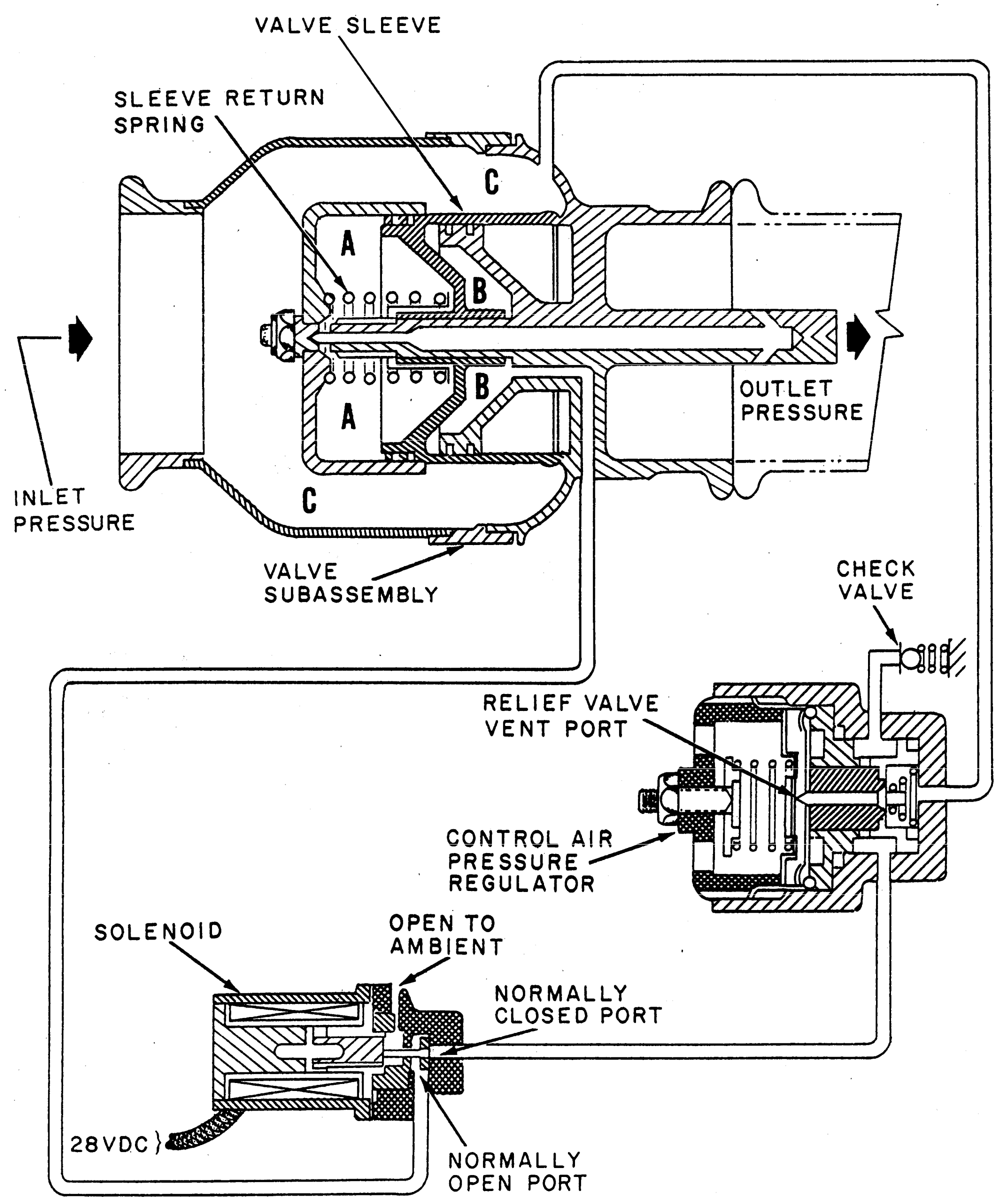


Figure 1-11.—Engine anti-icing system.

is located in each engine pylon, and one is located in the forward upper left section of the ECS compartmen. The pressure regulating valve is normally closed, and is electrically controlled and pneumatically actuated. The pressure regulator valve has two functions; to regulate deice air pressure when energized and to shut off deice air when de-energized. The pressure regulator valve functions on differential pressure to maintain an outlet duct pressure of 26±2 psi. Acuation of the pressure regulator valve to the regulating function is accomplished by setting the deice switch on the ENVIRONMENTAL panel on the center console to WING EMP.

The pressure regulator valve is normally closed because the valve sleeve is spring-loaded closed. Inlet air pressure (chamber C) is sensed by the control air pressure regulator, which, when the deice system is operating, maintains an output of constant reference pressure to control the opening side of the sleeve (chamber B). Chamber A is the closing side of the valve sleeve and is vented to the pressure regulating valve outlet pressure.



213.102.4

Figure 1-12.—Deice pressure regulating valve.

When the solenoid is not energized, chamber B is vented to ambient pressure and the valve sleeve remains in the closed position. To activate the system, the solenoid is energized, which enables reference control air pressure to reach chamber B to overcome sleeve spring force and start to open the valve sleeve. If the inlet pressure is only ambient pressure, the sleeve remains fully closed. A 2 psi margin of inlet pressure over outlet pressure starts the sleeve opening action. When inlet pressure reaches 30 psi absolute (psia) and outlet pressure is at the 26±2 psia setpoint, the valve sleeve opens. Further increase of inlet pressure, which would otherwise cause an increase in outlet pressure, is sensed in chamber A, which adds to the closing force of the valve sleeve. As the valve sleeve moves toward a more closed position, the outlet pressure is reduced and the 26±2 psia setpoint is maintained. Continued increase of inlet pressure results in continued valve sleeve closure until the pressure regulator valve is completely closed, thereby preventing outlet pressure from exceeding 28 psia.

Bleed-Air Solenoid Valve

Eight cyclic valves are used in the deice system. Two cyclic valves are located in each outboard wing, one in each inboard wing, and one in each horizontal stabilizer. The cyclic valve is normally spring-loaded closed, electrically controlled, and pneumatically actuated. The cyclic valve controls the cyclic distribution of bleed air to the appropriate segment of the deice system piccolo tubes.

The cyclic valve is pneumatically controlled by a bleed-air solenoid valve (fig. 1-13). When the solenoid is not energized, the spring keeps the cyclic valve closed, and inlet pressure is vented to ambient and to the closing side of the valve (chamber A). When the solenoid is energized, the inlet pressure is blocked, and when it builds to

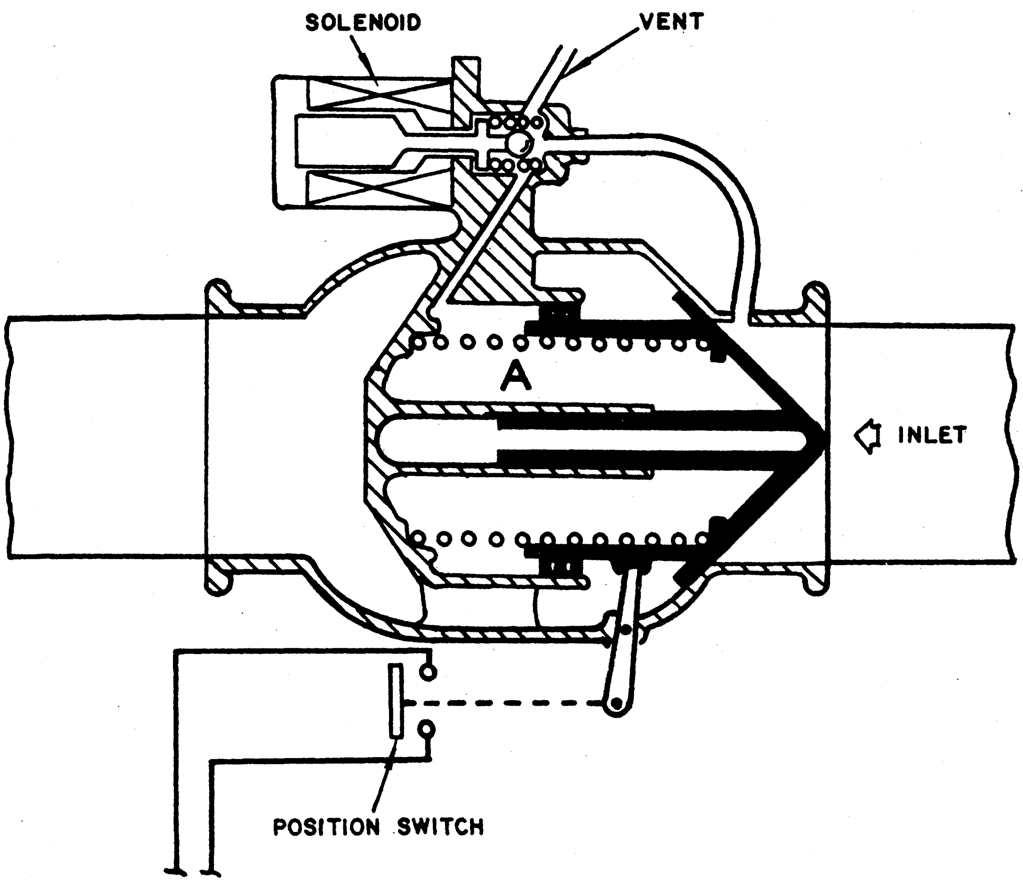


Figure 1-13.—Bleed-air solenoid valve.

16 psi, it overcomes the spring and opens the cyclic valve.

Wing and Empennage Deice Timing Controller

The timing controller is located in the left load center. This device collects logic information necessary to provide control signals to the cyclic valves through solid-state sequence switching. The controller provides 30-second sequential control signals to each cyclic valve. It also receives the 60° temperature sensor indication and interrupts the valve-open cycle when aircraft skin and structural temperatures exceed 60°±3°F (15°±1.6°C). The timing controller collects logic signals to control deice operations in various failure modes.

Probe Sensor Temperature Transmitter

The temperature sensor is a solid-state semiconductor thermistor whose resistance varies with temperature. There are eight temperature sensors, positioned just inside wing and horizontal stabilizers leading edge skins. Each is located to correspond to one of the eight deice piccolo tubes. When a leading edge skin temperature reaches 60°± 3°F, an electrical signal, furnished by a temperature sensor to the timing control, interrupts the operating sequence of the related cyclic valve. Deice air to the particular piccolo tube sensed by that temperature sensor is shut off.

Deice Thermostatic Switch

The thermostatic switch consists of a conventional bimetallic element that closes at a temperature of 200°±5°F (93°±2°C). Eight thermostatic switches, mounted on structural components away from the piccolo tube outlets, detect possible overheating of area structures. Any thermostatic switch closure causes the DEICE HOT warning indicator light on the annunciator panel to come on, but it does not disable a deice component.

ENGINE ANTI-ICING SYSTEM

A typical aircraft engine anti-icing system is designed to allow hot 14th stage bleed air to be distributed to portions of the engine to prevent the formation of ice.

The S-3 engine anti-icing system, shown in fig. 1-11, is controlled by a solenoid-operated anti-icing valve actuated by the anti-icing switch on the environmental control panel. The anti-icing valve opens when electrical power is removed. A pressure switch, located on the anti-icing valve, senses pressure downstream from the valve, closes the circuit to the A-ICE ON light when the anti-icing switch is in ENG & PITOT (valve open), and opens when the switch is in OFF (valve closed).

When the anti-icing switch is positioned in ENG & PITOT, hot 14th stage compressor bleed air is ducted to the fan nose splitter and air inlet fairing via the engine nose pylon.

The anti-icing valve regulates the output air pressure. It includes a backup pressure regulator in case of failure of the primary element. A pop-out button on the valve indicates primary pressure regulating element malfunction.

Air from the anti-icing valve is directed to the anti-icing discharge manifold where it is split into two flows. One flow is for engine anti-icing, the other is directed to the engine air inlet anti-icing connection.

The engine anti-icing system consists of an anti-icing valve, anti-icing discharge manifold, anti-ice external air duct, and a forward anti-ice duct.

Anti-Icing Valve

The anti-icing valve is a solenoid-operated valve actuated by the three-position anti-icing switch. The anti-icing valve is de-energized open. Failure of electrical power causes the system to remain in or revert to the anti-icing ON condition.

Anti-Icing Discharge Manifold

The anti-icing discharge manifold is connected to the anti-icing valve and provides for the distribution of the hot 14th stage bleed air to the air inlet fairing and to portions of the engine.

Anti-Ice External Air Duct

The anti-ice external air duct is connected to the inlet of the anti-icing valve and to the 14th stage of the engine to provide hot 14th stage bleed air to the anti-icing system.

Forward Anti-Ice Duct

The forward anti-ice duct is connected to the engine nose pylon and the air inlet fairing anti-ice duct to provide hot 14th stage bleed air to the air inlet fairing.

BLEED-AIR LEAK DETECTION

The S-3 aircraft bleed-air leak detection system 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 and 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.

The bleed-air leak detection system is powered by single-phase, 400-Hz, 115-Vac power from the essential ac bus. The test circuit uses 28 Vdc from the essential dc 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 LB 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 (107°C), 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 that 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.

The bleed-air leak detection system consists of a bleed-air leak detector control, bleed-air leak 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.

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 255°F (107°C). Its purpose is to detect leakage from the engine ground start port in the event of a check valve failure. The leak detectors wired in parallel with the loop 2 (2 BL LEAK) sensing elements.

INTERNAL STORES HEATING SYSTEM

The S-3 aircraft internal stores heating subsystem is shown in figure 1-14. Crew compartment exhaust air from the cabin outflow valve is directed into the sonobuoy compartment ducting. Part of the exhaust air goes to the cross-fuselage manifold for channeling into the three sonobuoy compartments. The balance branches forward through the bomb bay heating ducting to feed the two bomb bays. The bomb bay duct separates into two branches, one to each bomb bay. Air enters the bomb bays at the aft end, traverses the bomb bay, and exits through louvres at the forward end of each bomb bay. In overheat conditions, a bomb bay overheat thermal switch lights a warning indicator on the annunciator panel. Air enters each sonobuoy compartment through the sonobuoy support channels around the top of the sonobuoys. Exhaust air from the sonobuoy compartments is restricted by its passage through the plenum panels, creating a pressure differential between the sonobuoy compartments and the outside ambient air. This internal pressure inhibits cold ambient air inflow through the plenum panel openings.

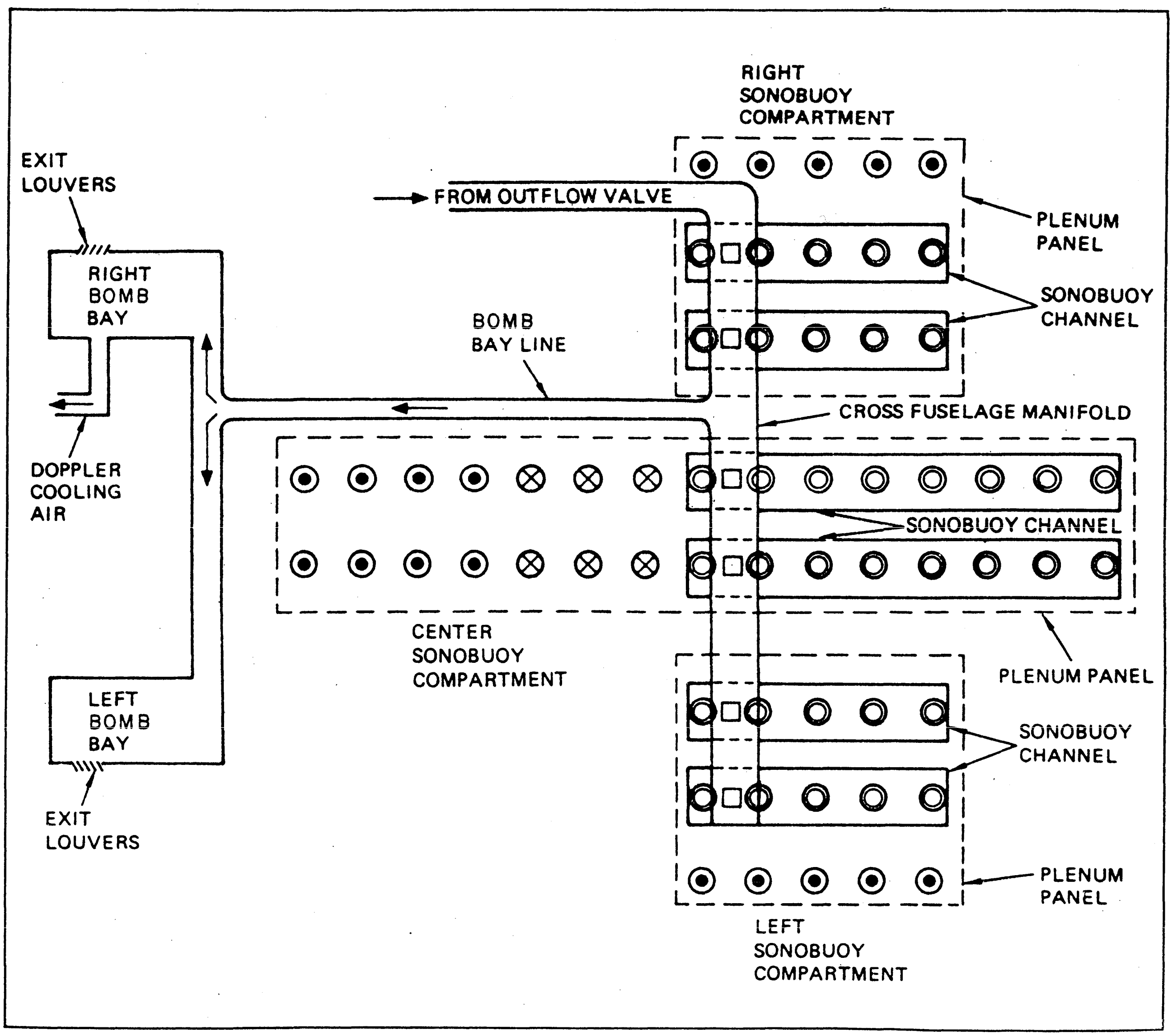


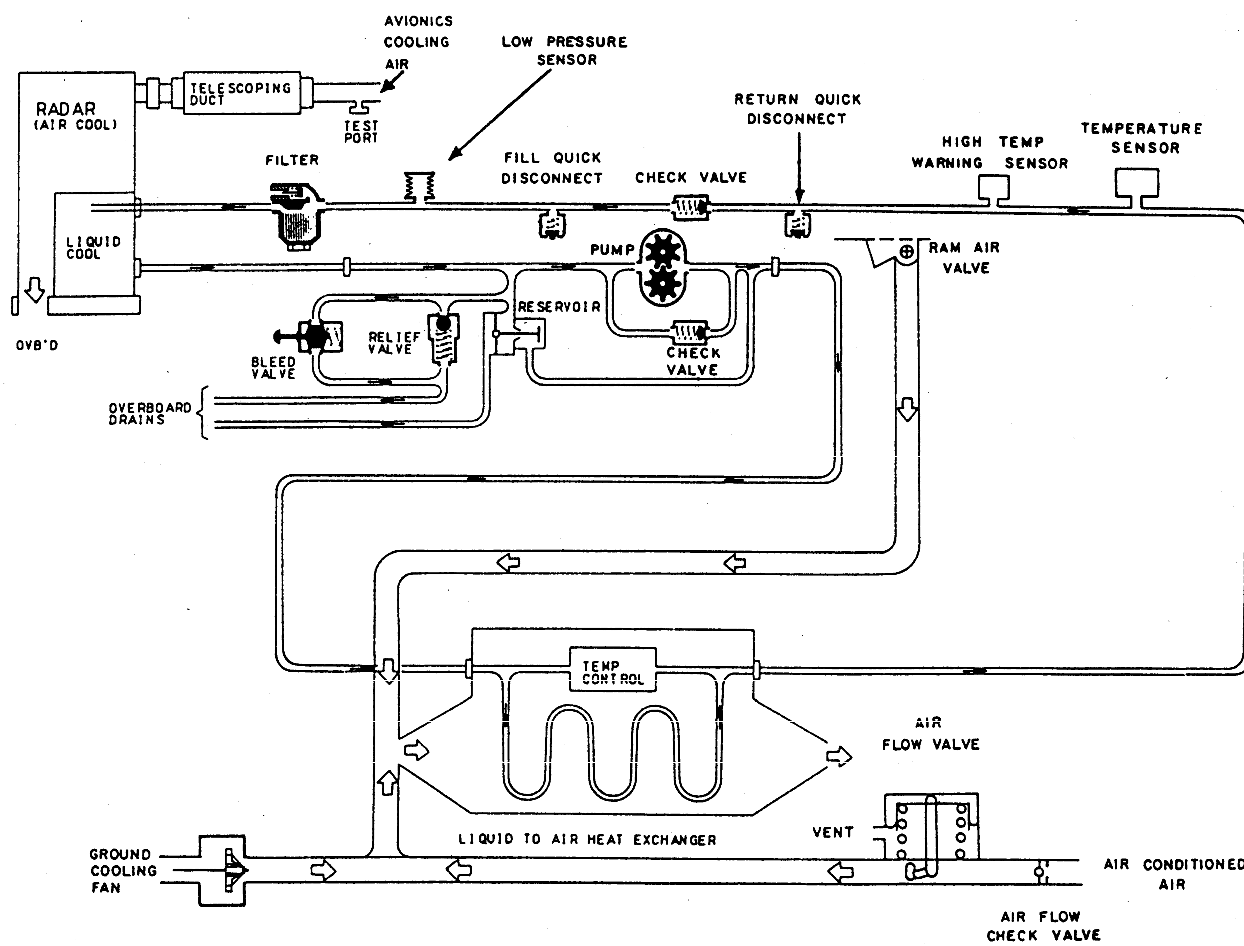
Figure 1-14.—Internal stores heating subsystem.

RADAR LIQUID COOLING SYSTEM

The F-18 aircraft radar liquid cooling system (fig. 1-15) 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 subjects heated coolant to cooling air, and the coolant is returned by a pump. (A temperature control valve is integral to the heat exchanger to maintain a minimum coolant temperature level.) One of 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, and conditioned air from the air cycle 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 air cycle ACS, a coolant temperature sensor operates through the ACS 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.

A system servicing panel and quick-disconnect fittings are located in the left fuselage. Quick-disconnect fittings are also provided in the coolant lines at the radar transmitter high-voltage module to aid in transmitter replacement by a preserviced unit.

The radar liquid cooling system is made up of a liquid-to-air heat exchanger, a liquid coolant



213.102.7

Figure 1-15.—Radar liquid cooling system.

pump, a ram air valve, a ground cooling fan, a coolant filter, a low-pressure sensor, a high-temperature sensor, a coolant temperature sensor, and an airflow valve.

Liquid-To-Air Heat Exchanger

The liquid-to-air heat exchanger 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, mounted in the inlet/outlet manifold of the heat exchanger and set in parallel with the heat exchanger core, senses coolant temperature. The control valve mixes bypass and core fluid to maintain a delivery temperature of 80° to 90°F (27° to 32 °C) to the radar transmitter. In the cold position (bypass valve fully closed), a bleed flow of 0.05 to 0.10 gpm is provided to aid in purging the core during system servicing.

Liquid Coolant Pump

The liquid coolant pump 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 guaging 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 supply a signal to the Digital Display Indicator to latch a fluid low code.

Ram Air Valve

An actuator opens and closes the ram air valve. The motor is switched off at the end of each stroke by internal limit switches, which also set up circuitry to reverse actuator travel upon the next power application. The actuator drives the valve closed when a ground is supplied through either a weight on wheels relay or the air data computer when ram air is hot. The actuator drives the valve open when both grounds are lost. A failure in the actuator operation causes a weapons system fail code to latch in the Digital Display Indicator in the nosewheel well.

Ground Cooling Fan

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.

Coolant System Filter

Coolant is filtered before passing through the radar transmitter. When the replaceable filter element 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 located in the coolant line provides a ground to the maintenance status display and recording system until coolant pressure falls below preset limits. The loss of ground causes a weapon system fail code to latch in the Digital Display Indicator.

High-Temperature Sensor

The coolant high-temperature sensor, 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 to latch in the digital display indicator in the nosewheel well.

Coolant Temperature Sensor

The coolant temperature sensor located in the coolant line provides coolant temperature readings to the ACS temperature/flow controller, allowing the controller to modulate the airflow valve.

Airflow Valve

The radar liquid cooling airflow valve is pneumatically modulated to limit, as necessary, conditioned air to the heat exchanger. The ACS controller supplies electrical power to the airflow valve torque motor, which controls pneumatic pressure to the airflow valve. The valve is spring-loaded closed.

WAVEGUIDE PRESSURIZATION SYSTEM

The F-18 aircraft waveguide pressurization system (fig. l-16) provides regulated, filtered, dry air to the radar and electronic countermeasures waveguide cavities. The air is supplied by either the ACS or ground air cooling through a waveguide test port. The system is made up of a filter, two pressure regulating valves, two air desiccators, two ground test ports, and tubing to contain and transport the regulated air.

Filter System

The filter assembly is made up of a filter element and pressure relief valve. During operation, air passes through the filter element, which removes 98% of particles larger than 10 microns and 100% of particles larger than 25 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 the system operation.

Pressure Regulating Valves

The waveguide pressurization system contains two pressure regulating valves, one for electronic countermeasures and one for radar waveguide. Each valve regulates air to 19 psia. The valves use two aneroids to regulate air pressure. Primary aneroid force is balanced against spring force through an opening on which a ball is seated. An auxiliary aneroid functions as an added adjustment and as a trigger assembly to allow internal pressure relief to atmosphere when regulated pressure exceeds 19 psia. A resettable indicator is visible when an overpressure condition has occurred. A check valve next to the outlet port of the regulating valve closes to maintain

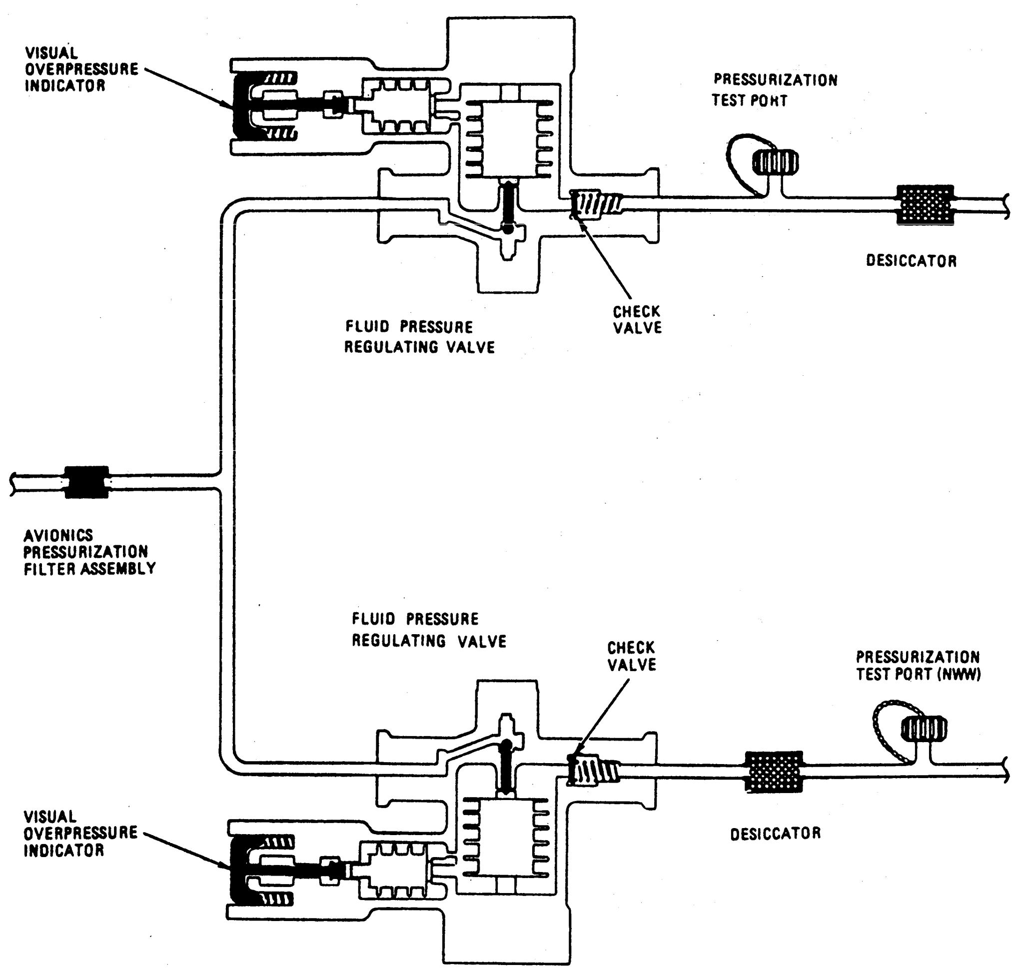


Figure 1-16.—Waveguide pressurization system.

waveguide pressure during an overpressure condition.

Air Desiccators

The waveguide pressurization system contains two air desiccators. The desiccators remove moisture from the regulated air. The desiccators contain desiccant to absorb moisture and a silica gel for an indicating agent. During normal operation, the silica gel is blue. When moisture saturation occurs, the gel turns pink. The color change is visible through an inspection window on the housing of the desiccator.

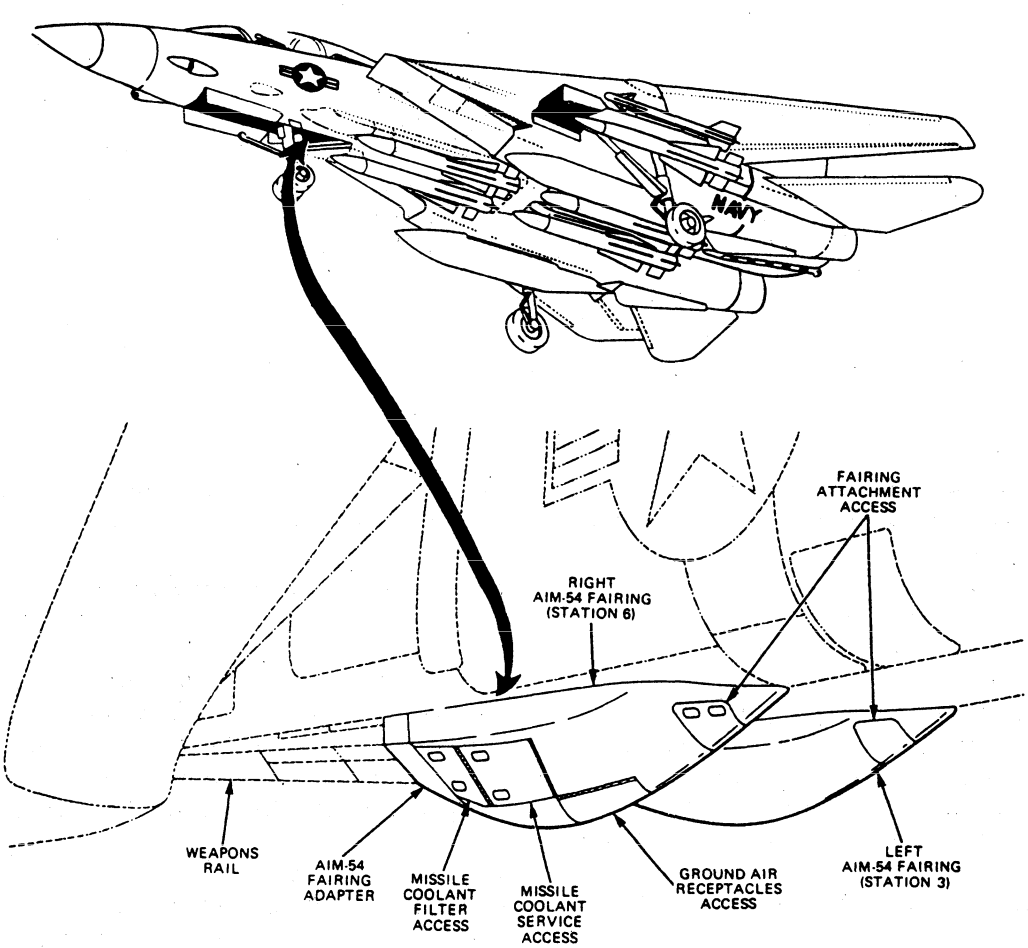
Ground Test Ports

The waveguide pressurization system contains two test ports, one for electronic countermeasures and one for the radar waveguide. The two test ports provide a method of using a ground air source to pressure test the system.

MISSILE LIQUID COOLING UTILITY SYSTEM

Learning Objective: Identify operating principles and maintenance safety precautions for missile liquid cooling utility systems.

The liquid cooling system in the F-14 aircraft is used with both the radar and missile systems. The cooling system heats and cools the Phoenix missile. The temperature control system consists of a weapons control system (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 dielectric coolant fluid is circulated by a motor-driven pump. The fluid is filtered to remove air, moisture, and foreign matter. The right Phoenix missile fairing (fig. 1-17) contains the missile coolant pump assembly and the missile



214.164

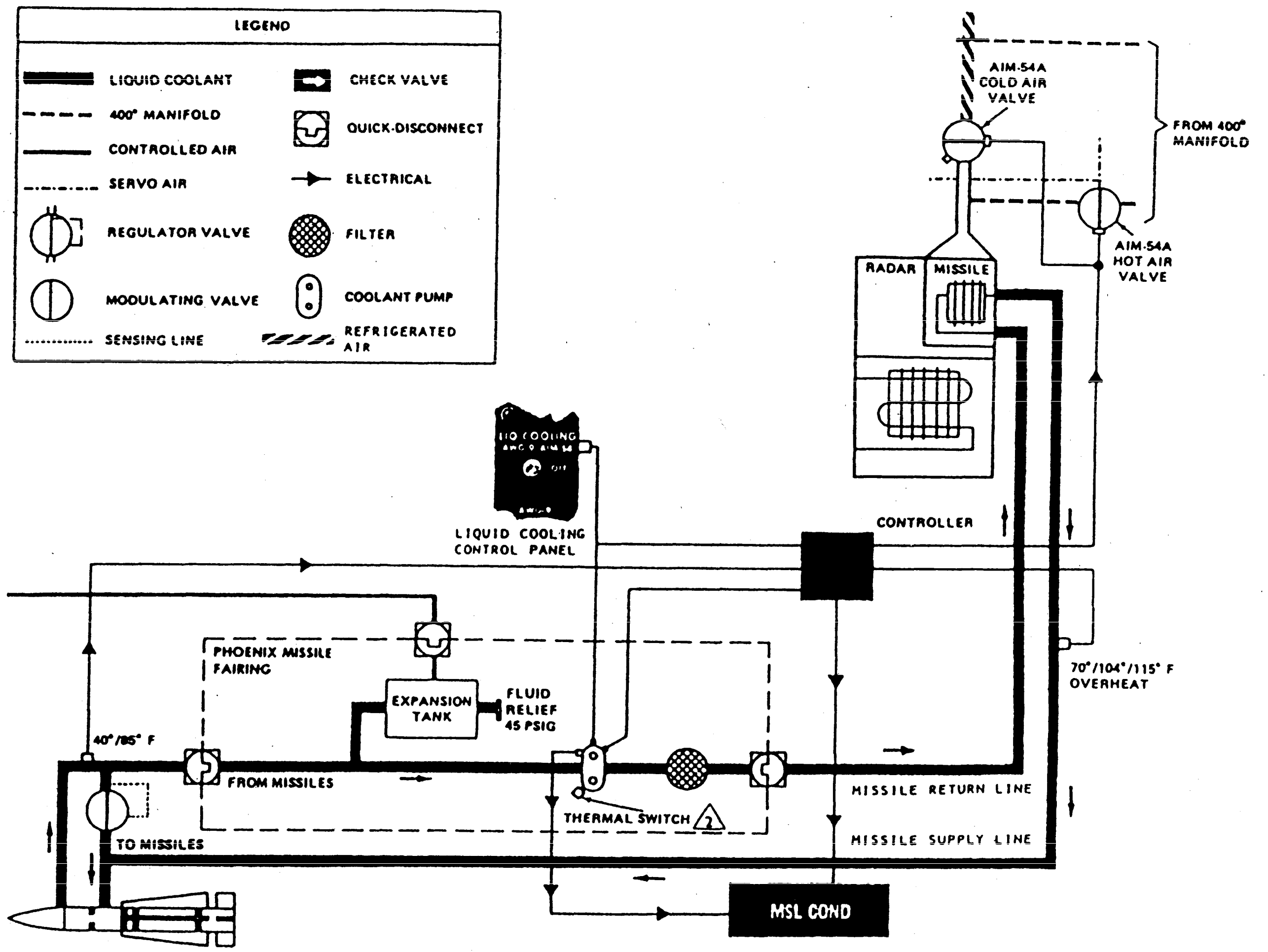
Figure 1-17.—Missile fairing.

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.

SYSTEM OPERATION

Setting the liquid cooling switch to the AWG-9/AIM-54 position starts the missile coolant pump motor. The pump circulates 18 gallons of coolant per minute through the missile air-moisture-contaminant remover, heat exchanger, weapon rails, left and right pylons, launchers, and 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



214.165

Figure 1-18.—Missile cooling system.

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 air 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 overtemperature 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 pressure downstream of the pump increases to 89±5 psi, the missile bypass valve opens to return the fluid to the pump inlet.

The missile cooling system consists of a cold air modulating valve, hot air modulating valve, air-to-coolant heat exchanger, coolant pump, coolant fluid expansion tank, bypass valve, air-moisture-contaminant remover, controller, coolant temperature sensor, fairing interlock switch, and liquid cooling control panel. Each of these components is discussed in the following paragraphs. The functional relationship of the components is represented in figure 1-18.

Missile Cold Air Modulating Valve

The cold air modulating valve is mounted on the air-to-coolant heat exchanger. It varies the flow of refrigeration system air to the heat exchanger. The valve has a butterfly, a diaphragm-type pneumatic actuator that is mechanically linked to the butterfly, an electromagnetic 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 or air pressure is interrupted, the valve closes.

Missile Hot Air Modulating Valve

The missile hot air modulating valve is mounted on the air-to-coolant heat exchanger. The valve varies 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 consists of two sections: weapons control system (radar) loop, and missile loop. The heat exchanger is similar to an automobile radiator. The coolant flows through 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 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 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 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 37 psi at the pump inlet. Should pressurization reach 45.0±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 located at fuselage station 372. It is used to bypass the missile when the fluid pressure within the missile reaches 89 + 0, – 5 psid. When this 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 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.

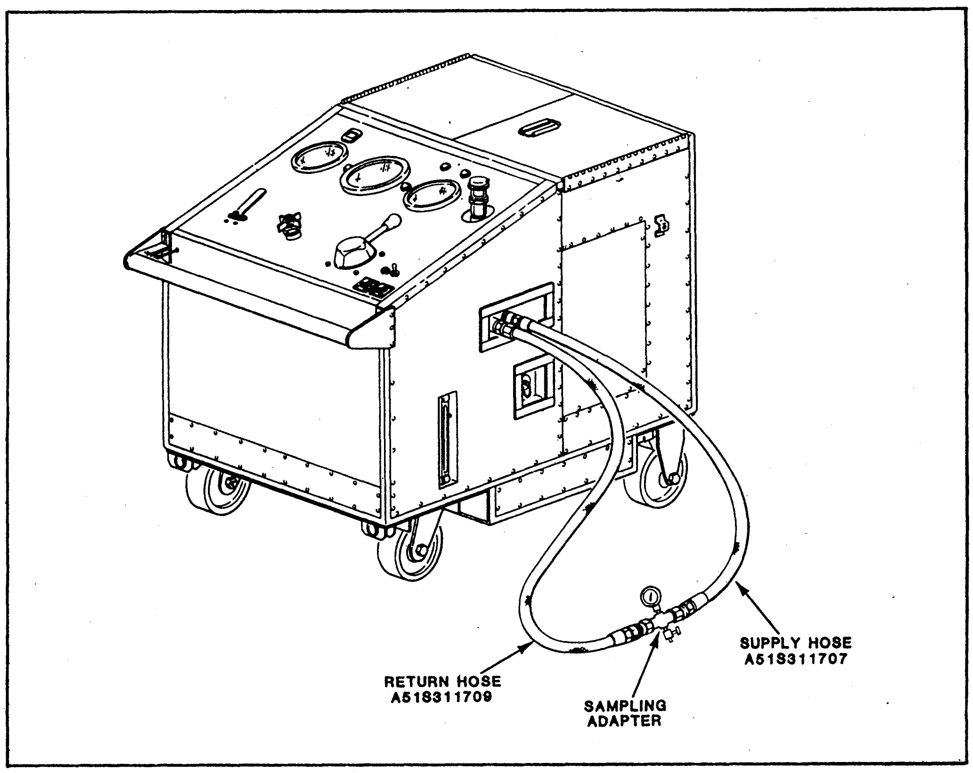
If the pressure drop across the filter element exceeds 16 ± 3 psi, the red differential pressure indicator button extends to warn of a clogged filter. If the pressure drop exceeds 21 to 25 psi, the relief valve passes coolant around the filter element. When the filter bowl is removed, an automatic shutoff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

Missile Controller

The controller 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 air 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 element



214.166

Figure 1-19.—Liquid coolant service unit.

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 right 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 cooling switch is set to the AWG-9/AIM-54 position, it activates both the radar and missile cooling loops of the 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.

1. 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) shown in figure 1-19. For detailed LCSU operating procedures, you should refer to the applicable MIM.

2. 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 splashproof goggles and gloves.

3. 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 splashproof goggles and gloves. The task should be performed in an area with forced ventilation. Smoking is prohibited in the area where this chemical is being handled. Keep the trichlorotrifluoroethane from coming in contact with your skin, eyes, and clothes. Do not breathe the toxic vapors.

4. To prevent contamination of the temperature control system and possible damage to its componenets, absolute cleanliness of your equipment, work area, and coolant must be maintained. You should ensure that dust caps, flushing jumpers, hoses, and bleed lines are thoroughly cleaned with trichlorotrifluoroethane and a 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.

5. When adding coolant with the fluid makeup unit (fig. 1-20), add the coolant slowly. Rapid pumping may cause the pressure relief valves on the makeup unit and in the aircraft to open.

6. 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.

7. 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.

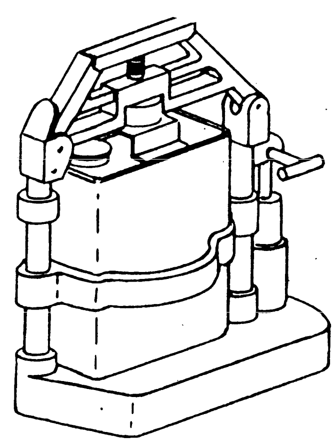


Figure 1-20.—Liquid coolant fluid makeup unit.

WINDSHIELD WIPER UTILITY SYSTEM

Learning Objective: Recognize motor and converter assembly components for windshield wiper utility systems.

The windshield wiper system on the S-3 aircraft is typical of this system and provides visual clearance for the pilot and copilot in adverse flight conditions up to speeds of 300 knots. The windshield wiper system consists of a motor assembly, converter assembly, an arm assembly, a blade assembly, and an anti-icing and windshield control panel assembly.

The motor assembly is a three-phase, two-speed electrically driven motor, which provides the source of power to the converter assembly.

The converter assembly is a motion converter, which converts the circular motion of the motor to the oscillating motion required by the windshield wiper arm.

The arm assembly uses the oscillating motion of the converter assembly to impart a sweeping motion to the windshield wiper blade assembly.

The blade assembly consists of a spring-loaded holder subassembly and a rubber wiper blade. The blade assembly uses the motion of the arm assembly to sweep rain from the windshield.

The anti-icing and windshield control panel provides mounting for bleed-air, wiper, rain repel, washer, and heat control switches. The windshield panel consists of a mounting plate, an edge-lighted panel, six switches, and a wiring harness.

WINDSHIELD WASHER UTILITY SYSTEM

Learning Objective: Recognize reservoir pump and nozzle assembly components and capabilities for windshield washer utility systems.

The windshield washer utility system (fig. 1-21) on the S-3 aircraft is typical of this system and is located in the unpressurized nose compartment at the base of the windshield. The washer switch on the windshield panel, mounted on the overhead panel, is a two-position switch. When the washer switch is set to ON, the pump motor is energized to cause fluid to be sprayed on both windshields. The spray continues as long as the switch is held in the ON position. The washer pump supplies fluid for approximately 6 minutes when the fluid reservoir is full. A reservoir fillercap dipstick indicates fluid quantity. Washer fluid consists of 80% isopropyl alcohol and 20% distilled water.

The windshield washer system consists of a reservoir pump assembly and nozzle assemblies.

RESERVOIR PUMP ASSEMBLY

The reservoir pump assembly provides storage for a supply of windshield washer fluid and for mounting of the motor/pump subassembly (with filter element), the pump housing subassembly, and the fillercap/dipstick subassembly. The motor/pump subassembly, which is mounted submerged in the windshield washer reservoir, provides a flow of windshield washer fluid in sufficient quantity and pressure to wash the windshield.

When the washer switch on the windshield panel is set to ON, dc power from the left primary dc bus is applied to actuate the K57 relay switch in the left load center. The relay switch, in turn, applies an ac voltage to the motor/pump subassembly, which pumps washer fluid out through the nozzle assembly and on to the windshield.

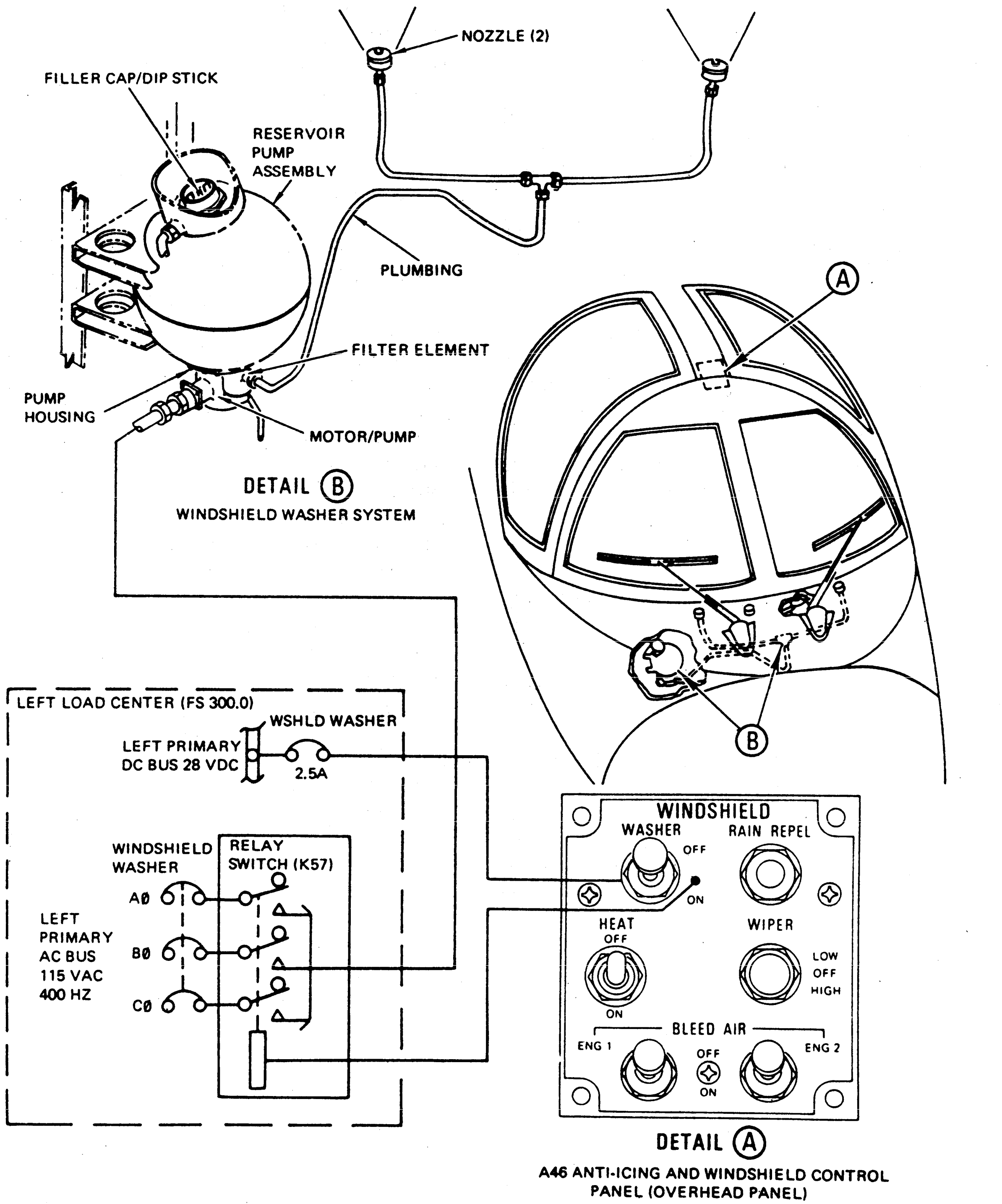
NOZZLE ASSEMBLY

A nozzle assembly is mounted at the base of each windshield. When the windshield washer system is in operation, the nozzle assemblies spray washer fluid onto the windshields.

RAIN REPELLENT UTILITY SYSTEM

Learning Objective: Identify functions and components for rain repellent utility systems.

The rain repellent system discharges fluid onto the pilot's and copilot's windshields from a



213.102.9

Figure 1-21.—Windshield washer system.

nozzle located at the base of each windshield. A timer circuit regulates the sequence of flow. The rain repellent fluid is distributed over the windshield surface by the windshield wipers and free stream air. A transparent film is formed that greatly reduces water adhesion. The film causes the water to form into streams, thereby preventing production of a vision-distorting film.

The rain repellent system is actuated by setting the wiper switch on the windshield panel to HIGH (fig. 1-22). This is done to minimize the possibility of rain repellent fluid discharge on a near-dry windshield, which could impair visibility.

When the rain repel switch is depressed, both valve nozzle assemblies open, and the timer is energized. Rain repellent fluid flows from the nitrogen-pressurized container, through the manifold and plumbing, and out through the two valve/nozzle assembly solenoid shutoff valves onto the windshields. The valve nozzle assemblies are energized by 28-Vdc power from the left primary dc bus. The rain repel switch must be released and again depressed for additional applications of rain repellent fluid. Approximately 60 applications are available from a full container. The rain repellant system consists of a rechargeable container and manifold, valve/nozzle assembly, and plumbing.

RECHARGEABLE CONTAINER AND MANIFOLD

Rain repellent fluid is stored in a nitrogen-pressurized rechargeable container located behind the pilot's seat. Container capacity is approximately 0.9 pint. Container pressure varies from 75 psi (full) to approximately 30 psi (nearly empty). A manifold is mounted on the container. The manifold incorporates a pressure gage that indicates pressure in the container.

VALVE/NOZZLE ASSEMBLY

Two valve/nozzle assembly solenoid shutoff valves, one for each windshield, are located at the base of the windshields. An adjustable timer circuit governs the amount of fluid released onto the windshields.

PLUMBING

Plumbing consists of tube assemblies that connect the container to the valve/nozzle assemblies. A drain cap is located at the low point of the plumbing.

FIRE EXTINGUISHING UTILITY SYSTEMS

Learning Objective: Identify operating principles, components, and maintenance procedures for fire extinguishing utility systems.

As a general rule, fire extinguishing systems are incorporated only in multiengined aircraft. These systems are designed primarily for extinguishing engine fires; however, on some aircraft, provision is made for protecting the aircraft heater (or heaters), as well as the engines.

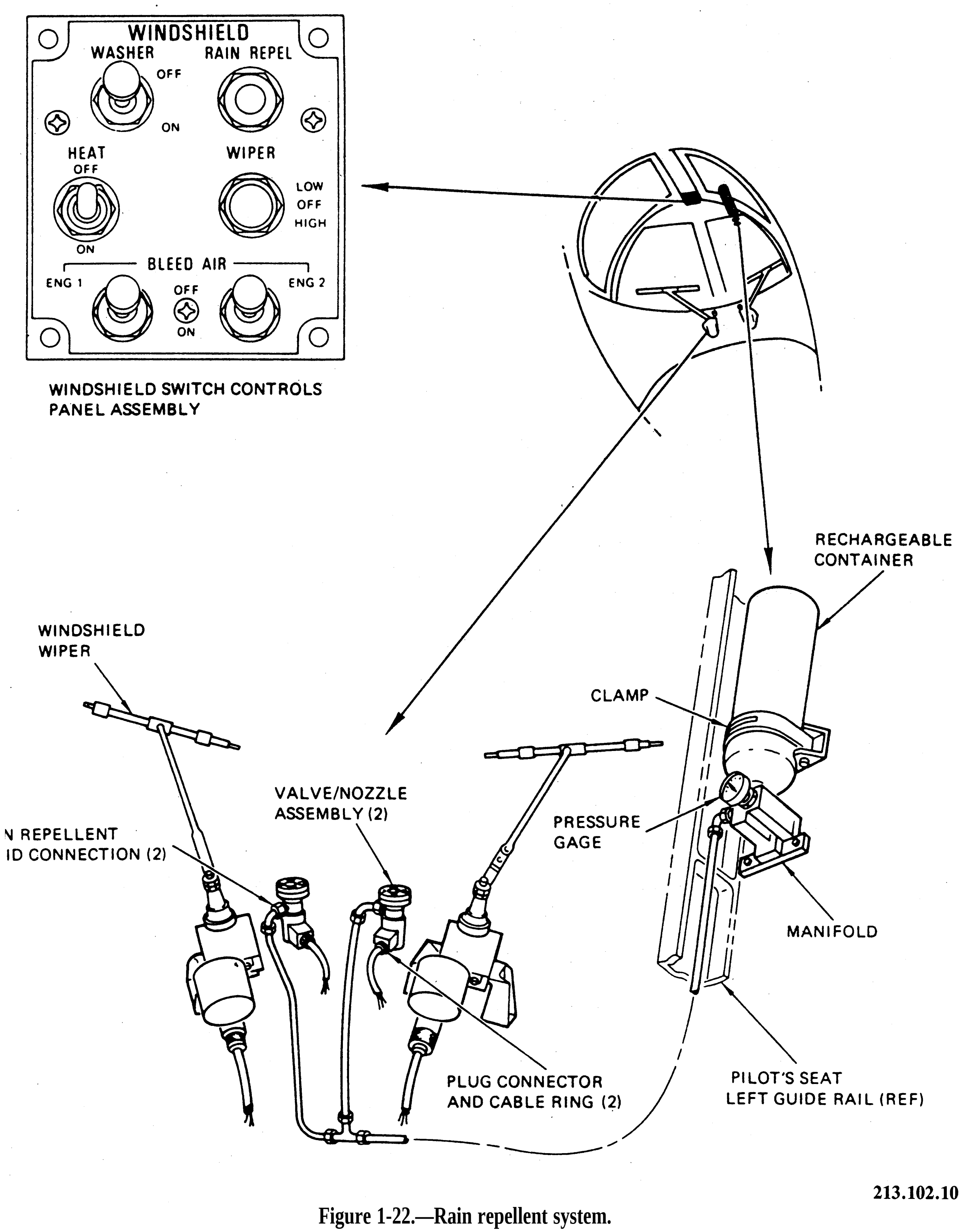
The extinguishing agent is stored in cylinders mounted at various places within the fuselage, wings, nacelles, or landing gear wells, and is directed to the area of fire through a system of tubing and various control valves. A switch or pull' handle, located at the pilot's or flight engineer's station, is used in releasing the extinguishing agent when a fire occurs.

The inspection and maintenance of aircraft fire extinguishing systems is an important responsibility of the AME.

TRIFLUOROBROMOMETHANE (CF_3Br)

CF_3Br (the chemical symbol for trifluorobromomethane) is a fluorinated hydrocarbon. It is the most common extinguishing agent used in aircraft fire extinguishing systems. It is a more efficient extinguishing agent than CO_2, and under normal atmospheric pressure and temperature, it is a colorless, odorless, and tasteless gas. It exists as a liquid only when contained under pressure. CF_3Br is nontoxic, noncorrosive, 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



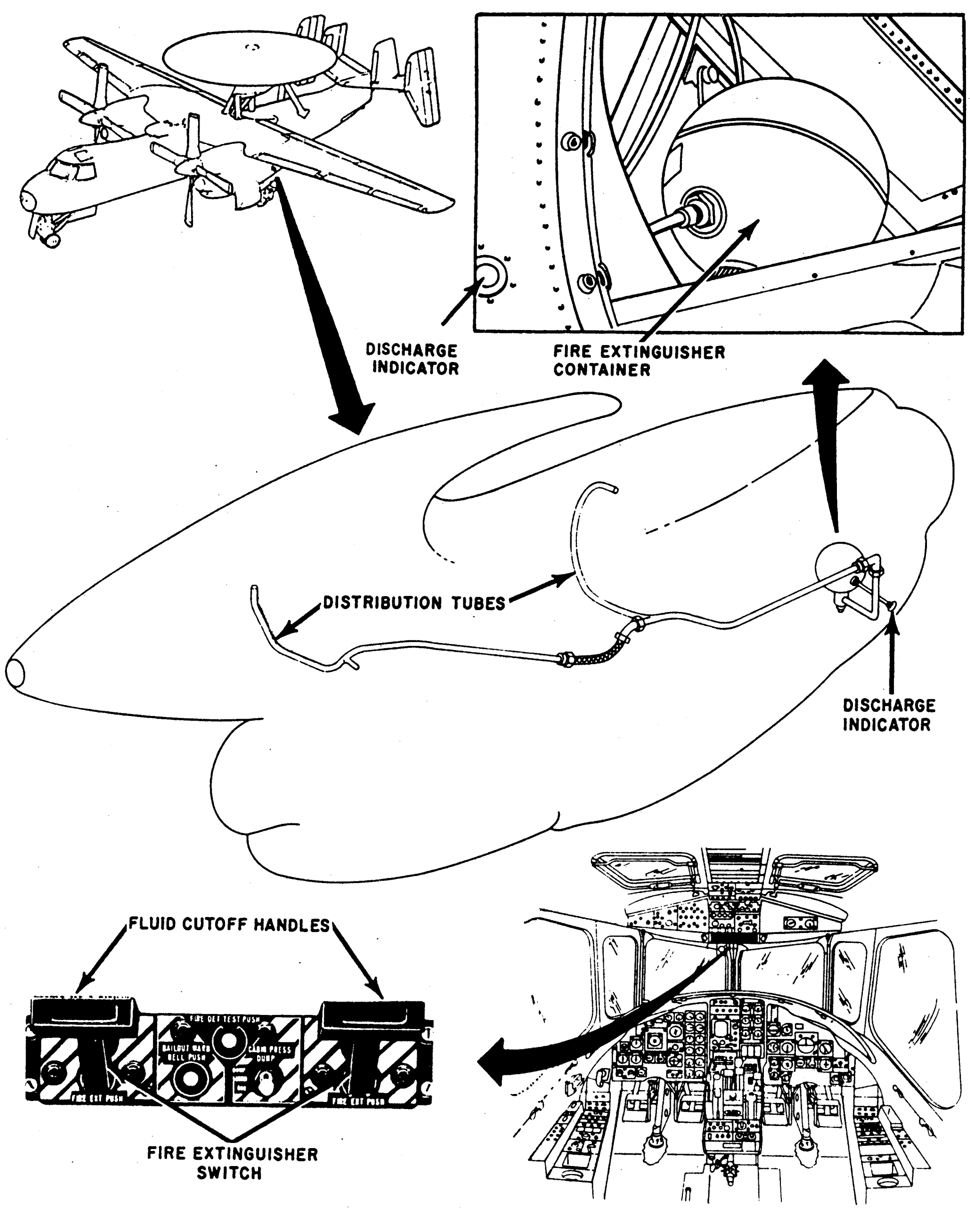
213.102.10

Figure 1-22.—Rain repellent system.

agents, only CF_3Br will be discussed in this chapter. The E-2 aircraft uses (fig. 1-23) a typical CF_3Br fire extinguishing system. The system consists of a container assembly, distributing tube assemblies, discharge indicators, and necessary tubing and electrical equipment.

SYSTEM OPERATION/COMPONENTS

To activate the E-2 aircraft CF_3Br fire extinguishing system shown in figure 1-23, pull the fluid cutoff handle for the affected engine. This action turns off combustible fluids, feathers the propeller, and shuts down the engine. Pulling this handle exposes the fire extinguisher switch. Pressing the fire extinguisher switch completes the electrical circuit necessary to detonate the explosive change in the bonnet assembly of the container (fig. 1-24). This explosion ruptures the frangible disc in the container and allows CF_3Br to flow into the



213.113

Figure 1-23.—Typical CF_3Br fire extinguishing system.

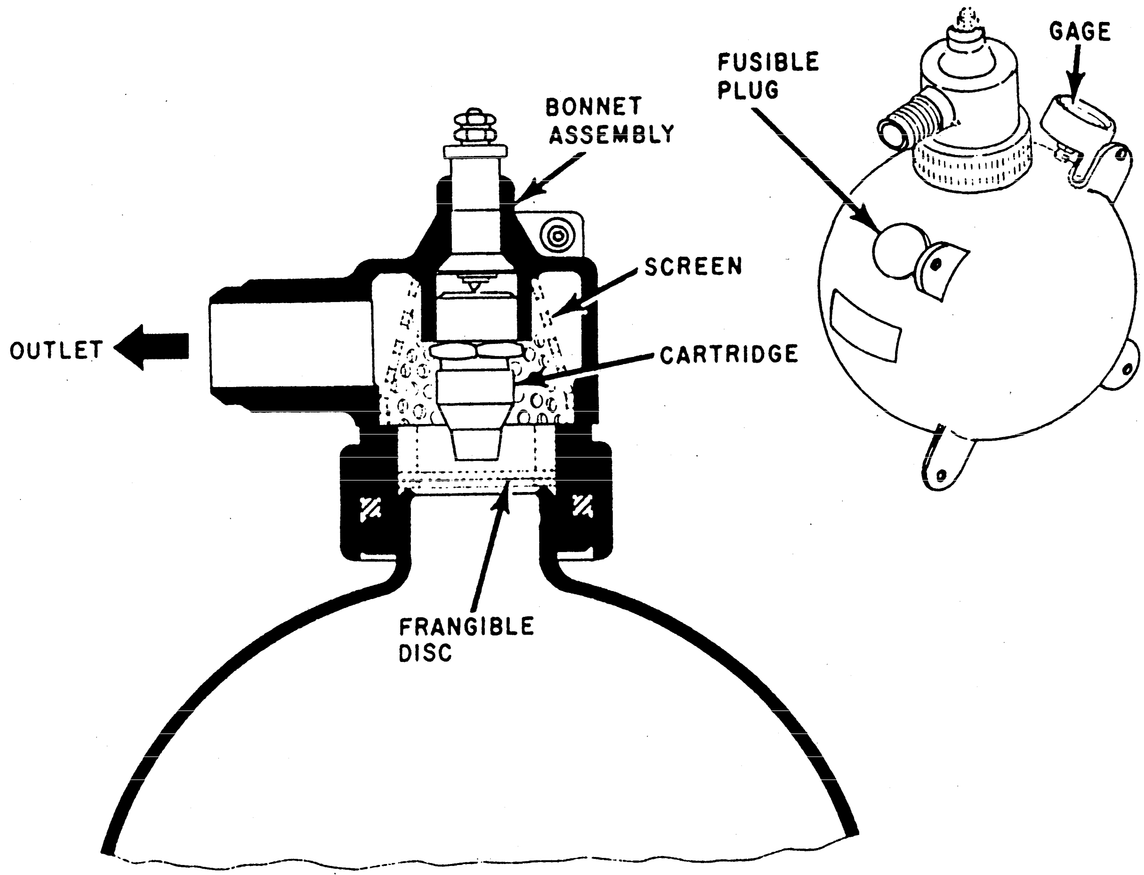


Figure 1-24.—CF_3Br container assembly.

engine nacelle. A screen in the bonnet (fig. 1-24) prevents the segments of the shattered disc from being expelled into the distributing assembly. The CF_3Br agent discharges from the distributing assembly as a spray, which (in the presence of heat) turns into a dense gas. This gas reduces the oxygen supply content of the area and effectively smothers the fire.

Container Assembly

Each container assembly (fig. 1-24) consists of the following components: A fusible plug, pressure gage, frangible disc, cartridge, bonnet, and the container itself. The container is a spherical assembly, designed to contain 6.5 pounds of CF_3Br and a precharge of 600 psi of nitrogen at (70°F).

NOTE: The capacity and precharge of the container assembly will vary with the type of installation.

The combined nitrogen charge and CF_3Br is retained in the container by the frangible disc and the fusible plug. The fusible plug protects the container from possible damage by excess pressure caused by an increase in ambient temperature. The metal of the fusible plug melts at temperatures between 208° and 220°F, releasing the contents of the container overboard.

Discharge Indicator

One discharge indicator is mounted on each nacelle as shown in figure 1-23. The indicator consists of a red disc and an aluminum alloy tube that connects to the container at the fusible plug. If thermal expansion in the container is great enough to rupture the fusible disc, the red disc will rupture and the CF_3Br will flow overboard through the line to the indicator. Therefore, when the discharge indicator is missing, the container must be checked for proper pressure.

Some CF_3Br containers have a relief valve in place of the fusible plug. On some, the fusible plug is called a safety plug. The relief valve relieves the excess pressure in the container instead of completely emptying the container.

Some larger aircraft use more than one fire extinguishing agent container to direct the agent to several points within an area. With cockpit switches set at various positions, the agent can be released through specific discharge outlets; and if the fire persists, the switch positions can be changed to release agent from a second container to different discharge outlets within the same area.

The fire extinguishing system of the P-3 aircraft is an example of this type of system. The containers used in the P-3 system are also equipped with two-valve (bonnet) assemblies for discharging the container; however, only one assembly is fired at any one time to discharge the container. This dual arrangement provides a secondary means of discharging a cylinder in the event a cartridge fails for any reason to fire and discharge the container.

MAINTENANCE

Maintenance of the CF_3Br fire extinguishing system at the organizational level of maintenance consists of replacement of faulty components and discharged or below pressure containers, maintenance of associated plumbing, and performing operational checks.

Containers should be replaced when the pressure falls below that indicated on the container or in the applicable MIM. Each container has a pressure indicating gage. Suspected leakage in system plumbing requires disconnection of the container(s) and pressure leakage testing of all lines by using nitrogen pressure and a leakage tester. The leakage tester measures pressure drop over a specified period of time, as outlined in the MIM.

The operational checkout of the fire extinguishing system, primarily a checkout of electrical circuitry such as wiring continuity checks, proper switch operation, etc., is performed by personnel of the AE rating.

THERMAL RADIATION PROTECTION UTILITY SYSTEMS

Learning Objective: Recognize the purpose of the thermal radiation protection system.

Naval aircraft used for special weapons delivery have means of protecting the pilot and crew members from the effects of heat and light that such weapons emit. Several of the Navy attack aircraft are equipped with a thermal radiation protection system and flak protection curtains.

The A-6, for example, can be equipped with radiation enclosures for the windshield and canopy. These enclosures shield off the see-through portions of the cockpit, which gives the flight crew protection from the extreme heat and light created by a special weapons delivery.

The radiation shields consist of fixed and sliding fiber glass panels mounted on each side of the canopy. The sliding panels are equipped with rollers and suspended on a system of tracks between the fixed side panels and the canopy center overhead spline structure.

The sliding panels for each side of the canopy move independently of each other and are manually positioned by the pilot or bombardier/navigator. The shield is closed by pulling the forward sliding panel towards the canopy forward arch. The forward panel is equipped with a lip, which engages on the lip of the aft sliding panel, drawing it forward at the same time.

The sliding panels will automatically lock in one of three positions; open, closed, or half open, as desired. A latch handle on each forward sliding panel releases the detent pins, unlocking the panels.

If the panels are closed and ejection becomes necessary, it may be initiated through the closed shields.

The windshield curtain is a fiber glass cloth assembly with an aluminized coating. It is fastened between the instrument panel glare shield and the windshield bow structure to close off the entire windshield area. Springs pull the windshield curtain down flat on the glare shield for stowage when the curtain is unzipped.

Flak curtains, similar to the canopy curtain, are mounted beside the pilot and bombardier/navigator foot area, cockpit side area, and along the lower portion of the canopy. They provide a limited measure of protection from flak and small arms fire when making low-level attacks on enemy positions.

The canopy-mounted curtain is a sandwich-type pad constructed on vinyl-coated glass cloth with a nylon center. The cockpit area side panels are basically of the same construction with the outboard vinyl coating deleted. The foot guard panel is constructed of a metal plate with a nylon curtain riveted to the outboard side. Installation of the flak curtains prior to takeoff will depend upon mission requirements.

The radiation protection system on the A-7 aircraft is similar to that of the A-6 except that it may be opened or closed manually or closed automatically using pneumatic system pressure. The A-7 protective closure consists of one fixed and three movable fiber glass segments, which enclose the entire cockpit viewing area when extended. The forward segment of the closure presses against the instrument panel cowl so that a windshield curtain is not necessary.

In the open position, the movable segments are retracted within the contour of the fixed segment so that they do not restrict the pilot's vision.

An overcenter spring on each side of the closure holds the panels in either the open or closed positions.

The automatic closing sequence is accomplished in 0.2 second. A lock on the left-hand canopy frame locks the closure open and prevents extension until it is manually released.

Interference tolerances between the ejection seat and the closure panels require that the seat be within 1/4-inch of the full down position prior to closure operation.

Manual actuation of the system is initiated by placing the thermal closure switch to the CLOSE position. This will cause the ejection seat to be automatically lowered to provide proper clearance. As the seat lowers, it actuates a seat position switch, which directs current to the closure selector valve. The energized valve releases 1,000 psi pneumatic system pressure through a restrictor to the two closure actuators, rapidly extending the closure panels.

When the thermal closure switch is released, it returns to the OFF position, de-energizing the closure selector valve and blocking pneumatic system pressure to the actuator extend lines. De-energizing of the selector valve also vents the extend lines so that the closure panels may be manually opened or closed as necessary.

In the automatic mode of operation, the thermal closure system operates in the same manner except the solenoid of the closure selector valve is grounded through a switching demodulator unit rather than the thermal closure switch. The switching unit energizes the closure selector valve and turns on the white cockpit floodlights when the system is initiated (triggered) by a nuclear flash sensor.

The nuclear flash sensor is mounted on the pilot's flight helmet. When activated by high-intensity light, such as that created by a nuclear blast, the sensor energizes the closure selector valve for approximately 3 seconds. The closures extend, are held closed for the 3-second interval, and then the valve is de-energized and the actuator lines are vented to allow manual opening and closing of the panels.

NOTE: When flying a special weapons mission in the A-7, the pilot's helmet is equipped with a flash-blindness protective (ELF) lens. When the nuclear flash sensor that closes the radiation panels is activated, current is also directed to detonate a very small explosive charge contained in the lens. The exploding charge releases a light-blocking graphite suspension to the inner core of the lens to protect the pilot's eyes from thermal flash while the closure panels are extending. The ELF lenses are normally stored in containers in the cockpit when not in use.

CHAPTER 2

CANOPY SYSTEMS

Terminal Objective: Upon completion of this chapter, you will be able to identify the types of canopy systems; recognize cartridge and cartridge-activated devices (CAD), service life, and expiration dates; identify CAD maintenance policy; and identify the reason for the ordnance certification program.

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.

Three types of canopies are present on naval aircraft. Two types of canopies—the clamshell type and the sliding type—are commonly used on naval aircraft. The clamshell type used on the F-14 aircraft is hinged aft and opens at the forward end like a clamshell. The sliding type used on the A-6 aircraft rests on tracks on the fuselage and opens and closes by a sliding action. Figure 2-1 illustrates these two types of canopies. A third canopy type, the frangible canopy, is less common, is used on the S-3 aircraft, and has many unique features. All three types will be presented in this chapter.

Aircraft manufacturers have designed various methods of actuating the canopy. Normal opening and closing may be accomplished 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.

CLAMSHELL CANOPY SYSTEM

Learning Objective: Identify the types of canopy systems and their purpose; recognize the function, operation, and purpose of the components in the F-14 aircraft canopy system.

The clamshell canopy is a transparent cockpit enclosure consisting of two acrylic panels in a metal frame. During normal operation, a

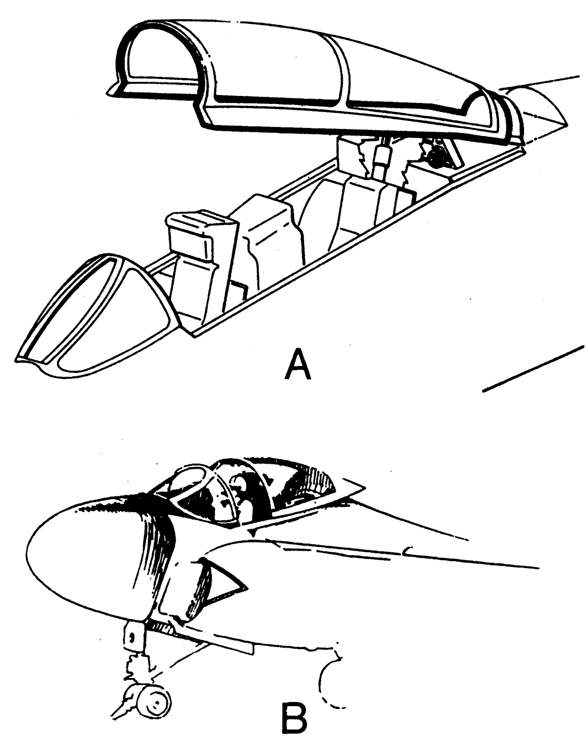


Figure 2-1.—Types of canopies. (A) clamshell (B) sliding.

pneumatically controlled canopy hydraulic actuator opens and closes the canopy. A canopy-lock pneumatic actuator moves the canopy to the locked or unlocked position. The canopy is locked in the closed position by locking hooks that engage latches on the cockpit sill. An inflatable rubber seal in the canopy frame forms a pressure-tight enclosure when the canopy is closed and locked. Three rearview mirrors are mounted on the pilot's forward canopy frame and one on the naval flight officer's (NFO) forward canopy frame. The canopy can be jettisoned for an emergency on the ground and during the ejection sequence.

The clamshell canopy pneumatic system provides normal opening and closing of the canopy. 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 supply the power for the different modes of canopy operation. The canopy can also be manually opened and closed. A reference mark is painted on the fuselage and canopy, and when the canopy is closed and locked, the marks are aligned.

SYSTEM OPERATION

The F-14 aircraft uses the clamshell canopy system. This pneumatic system is operated by setting any one of the three canopy control handles, This action 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.

Normal Opening Mode

Figure 2-2 (a foldout at the end of this chapter) shows a schematic of the F-14 pneumatic canopy system. Setting the pilot canopy control handle to open pulls the lock lockpin and positions valves No. 1,2, and 6 within the control module to direct nitrogen at 325 psi through the C 1 and C3 ports of the module, to the timer check valve, and to the 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 the 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 a torque tube, cranks, and links, moves the canopy aft to unlock it from the sill 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 lockpin 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. The final closing motion of the canopy actuates the pneumatic timer to direct 325-psi nitrogen from valve No. 2 of the control module to the lock port of the canopy-lock pneumatic actuator, unlatching the ball locks. The actuator piston retracts and, by reverse action, moves the canopy forward to engage the canopy hooks in the sill locks. With the canopy in its full forward positions, the lock lockpin engages and prevents aft movement of the canopy. The final motion of the lock lockpin opens the canopy switch, breaks the circuit to the canopy caution indicator light on the caution advisory indicators, and the lights go off.

Boost Closing Mode

To close the canopy under high headwind conditions, the canopy control handle must be moved to BOOST. On aircraft not modified by AFC 95, the control handle must be rotated outboard to move the handle pasta stop to BOOST. Valve No. 4 in the control module is positioned to direct 790-psi nitrogen through the C2 port of the canopy hydraulic actuators to the close transfer cylinder. This nitrogen, acting against the transfer cylinder piston, causes the hydraulic fluid on the opposite side of the piston to retract the actuator. The other valves in the control module are positioned the same as when CLOSE is selected, and the system functions in the same manner to lock the closed canopy. The closing time for this mode of operation is also controlled by the flow regulators in the open and close control modules of the hydraulic actuator.

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 No. 6 in the control module. The canopy must now be unlocked by activating the auxiliary opening mode. To set the canopy control handle to AUX OPEN on aircraft not modified by AFC 95, the handle must be rotated outboard to move past a stop (the handle will remain in the AUX OPEN position). 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 this reservoir flows through a 325-psi pressure reducer, through the release valve and pneumatic unlock shuttle valve, to shift position of the shuttle valve 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 the open transfer cylinder of the canopy hydraulic actuator. This low-pressure nitrogen, acting against the transfer cylinder piston, counter-balances the weight of the canopy. The canopy can then be easily opened and closed manually. The canopy cannot be locked closed under these conditions. To return the system to normal operation, the control handle must be set to OPEN and, on aircraft not modified by AFC 95, rotated outboard to move past a stop. 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.

SYSTEM COMPONENTS

The purpose of each of the major components of the F- 14 clamshell canopy system is presented in the following paragraphs. Refer to figure 2-2 to see how each component fits into the overall system.

Canopy Hydraulic Actuator

The canopy hydraulic actuator opens and closes the canopy. It consists of a double-acting hydraulic cylinder, two transfer cylinders, and two hydraulic control modules. The transfer cylinders convert 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. Thermal relief valves relieve pressure from the double-acting cylinder to the transfer 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 Pneumatic Actuator

The canopy-lock pneumatic actuator 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 to 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 pneumatic control module to the open side of 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 Restrictors

The lock actuator restrictors regulate the speed of the canopy-lock pneumatic actuator during canopy locking and unlocking.

Canopy Pneumatic Timer

The canopy pneumatic timer 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 regulates pressure from the canopy pneumatic reservoir and directs it to the canopy pneumatic timer, timer check valve, canopy hydraulic actuator, and canopy-lock pneumatic actuator. The module contains a filter, restrictor, two pressure reducers, two relief valves, low-pressure sensor, and control valves. If canopy pneumatic reservoir pressure drops below 225 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. This allows manual opening and closing of the canopy. Canopy unlocking is accomplished by the auxiliary unlock mode.

Canopy Pneumatic Reservoir

The reservoir 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 accomplished through the pneumatic servicing charging module, which is remote from the reservoir.

Reservoir Check Valve

The reservoir check valve is in the servicing line to the canopy pneumatic reservoir. The valve prevents nitrogen flow from the reservoir to the pneumatic servicing charging module.

Reservoir Relief Valve

The reservoir relief valve, 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 is in the nosewheel well. This module contains a filler valve, filter, two check valves, and two pressure gauges. The filler valve allows filling both the canopy pneumatic reservoir and the emergency landing gear reservoir from a single point. The check valves prevent reverse flow when one reservoir has a lower pressure than the other.

Canopy Switch

The canopy switch is actuated by the canopy locking mechanism lock lockpin; the switch closes when the canopy unlocks. This completes a circuit to the canopy caution indicator light on the pilot and NFO CAUTION ADVISORY indicators. When the canopy locks, the switch opens.

Auxiliary Pneumatic Reservoir

The auxiliary pneumatic reservoir, aft of the canopy, 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 a filler manifold, to 3,000 psi.

Auxiliary Pneumatic Reservoir Filler Manifold

The auxiliary pneumatic reservoir filler manifold 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, adjacent to the auxiliary pneumatic reservoir, is connected to the reservoir outlet port. It is a spring-loaded poppet valve that prevents overpressurization of the auxiliary pneumatic reservoir. Valve cracking pressure is 4,500 psi; full flow occurs at 5,100 psi. The valve reseats when the auxiliary pneumatic pressure drops to 4,100 psi.

Auxiliary Pressure Reducer

The auxiliary pressure reducer, located downstream of the auxiliary pneumatic reservoir, reduces pneumatic pressure (to 325 psi) applied to the auxiliary unlock pneumatic release valve.

Auxiliary Unlock Pneumatic Release Valve

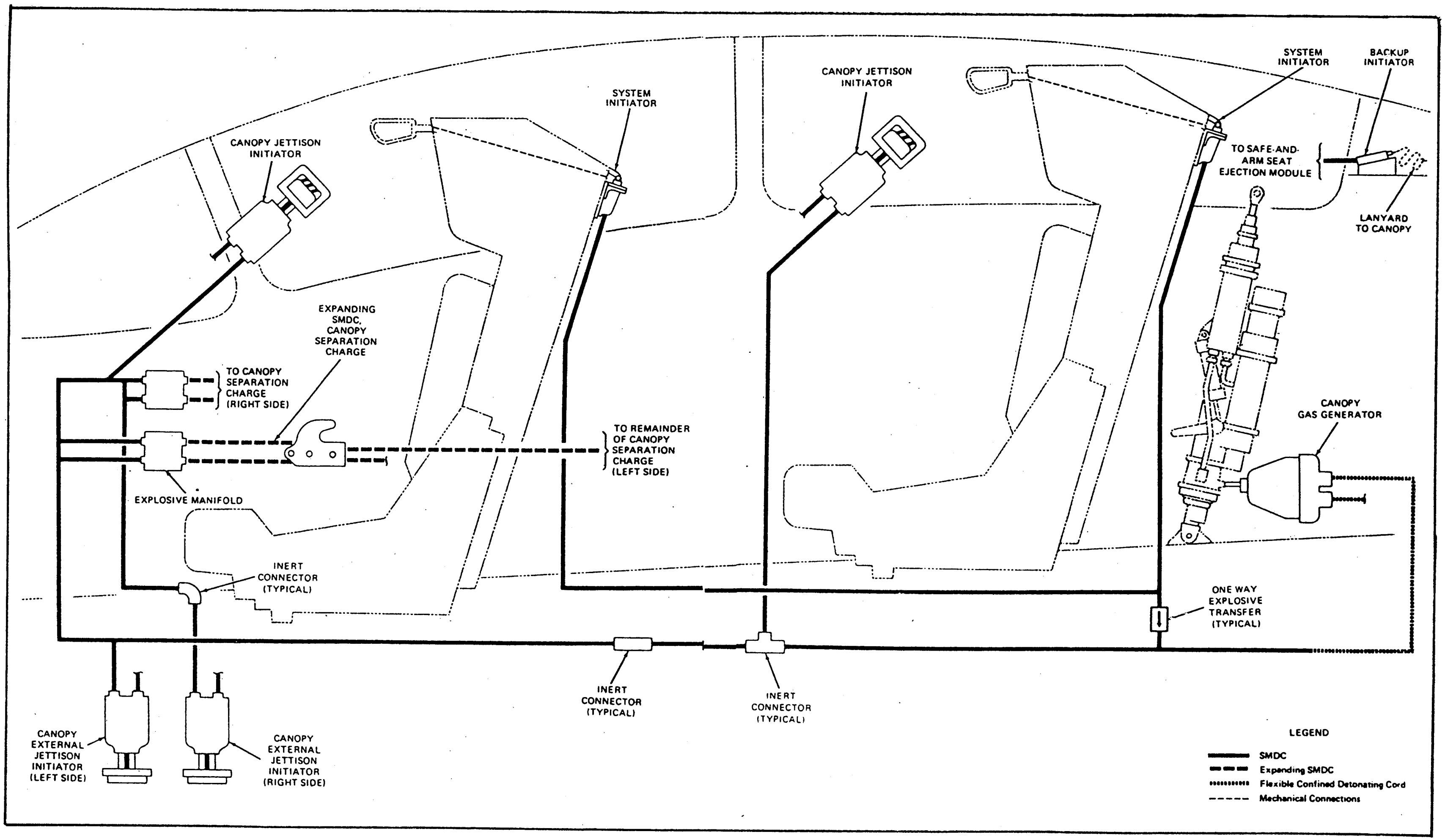
The auxiliary unlock pneumatic release valve, aft of the canopy, is a lever-operated shutoff valve that is connected by a cable-and-pulley assembly to the canopy control handle in the pilot and NFO stations. It is a two-position valve operated by an eccentric cam mechanism and detented to maintain the 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 the 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, aft of the canopy, 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-lock pneumatic actuator.

EMERGENCY CANOPY JETTISON SYSTEM

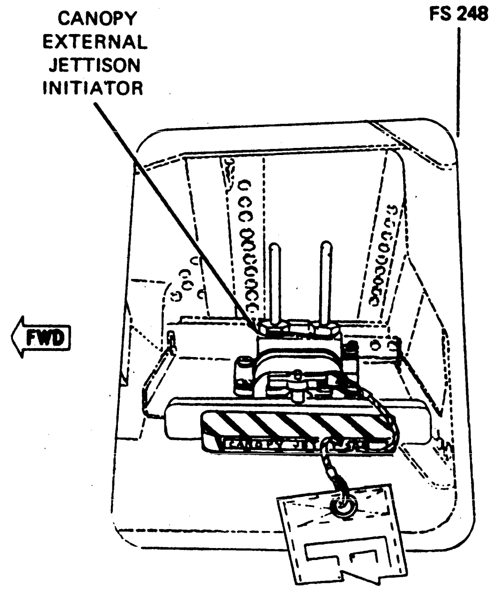
The emergency canopy jettison system (fig. 2-3) jettisons the canopy clear of the cockpit



213.290

Figure 2-3.—Canopy emergency jettison system.

during emergency conditions that require emergency ground egress, seat ejection, or ditching. The canopy must be clear of the cockpit before seat ejection. Through the use of pyrotechnics, the canopy is automatically unlocked and jettisoned when seat ejection is initiated. The canopy may be jettisoned without initiating seat ejection by pulling a canopy emergency jettison initiator handle (fig. 2-4), located inside the aircraft or externally (fig. 2-5) on either side of the aircraft.



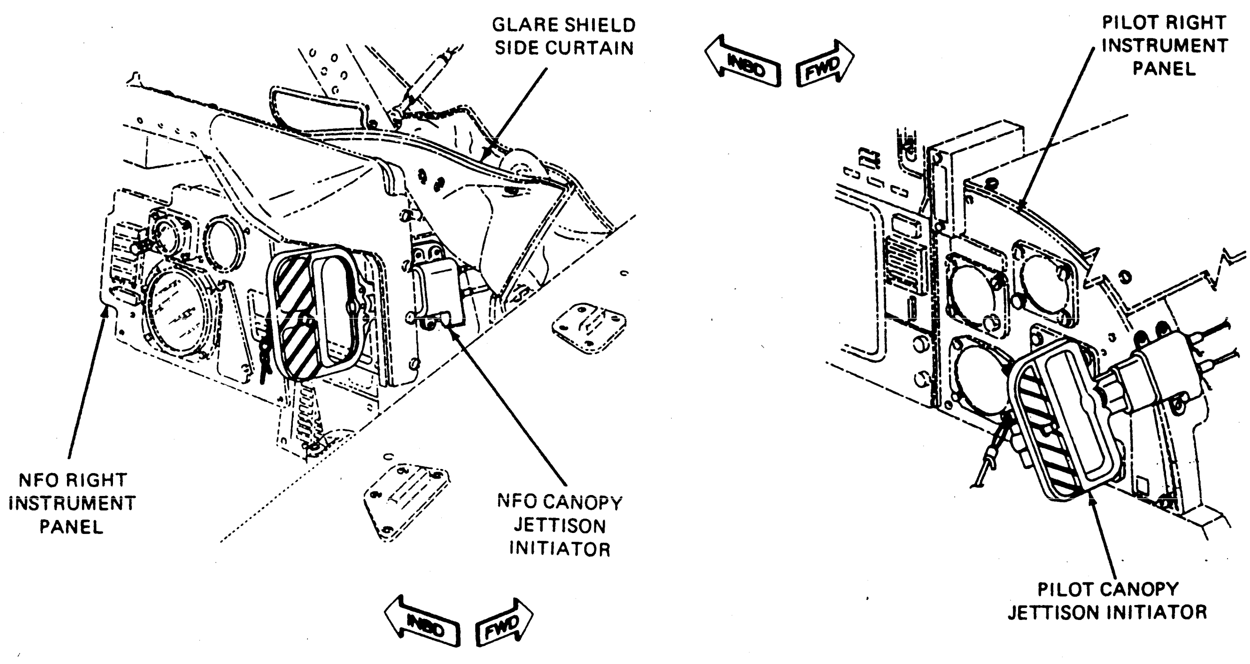
213.292

Figure 2-5.—Canopy external jettison initiator handle.

System Operation

Pulling the pilot or NFO face curtain or secondary firing control handle initiates seat ejection (fig. 2-3). A system initiator is fired by sear removal. This sends an explosive signal through shielded mild detonating cord (SMDC) lines to the safe-and-arm firing pins, canopy-separation charge expanding SMDC, and canopy gas generator. Expanding SMDC lines, routed through the latch hooks, break the canopy latch frangible bolts and allow the hooks to rotate upward, releasing the canopy.

The canopy gas generator produces high-pressure gas that forces the canopy hydraulic actuator shaft upward, ballistically jettisoning the canopy. As the canopy leaves the aircraft, the lanyard for the backup initiator becomes taut and actuates linkage to remove the backup initiator sear. This fires the initiator to send an explosive signal through a 1.1-second time delay. This signal positions an explosive charge within



213.291

Figure 2-4.—Canopy emergency jettison initiator handles.

the safe-and-arm seat ejection module for use if the lanyard-operated firing mechanism of the module fails.

As previously mentioned, during emergency ground egress, seat ejection, or ditching conditions, the canopy may be jettisoned by pulling either an internal or external canopy emergency jettison initiator handle. During emergency ground egress, without seat ejection, 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 bulkheads, straight runs, tee connections, and 90-degree bends. Explosive manifolds, within SMDC line runs, allow output SMDC lines to be initiated from one SMDC input. This assures system redundancy by providing dual-line initiation for the canopy-separation charge.

Canopy Jettison Initiators

Two canopy jettison initiators enable the aircrewman to jettison the canopy during emergency conditions, without initiating seat ejection. The canopy may be jettisoned by pulling the canopy emergency jettison initiator handle on either the pilot's or NFO's right instrument panel.

Canopy External Jettison Initiators

Canopy external jettison initiators enable the ground crew to jettison the canopy during ground emergency conditions. Each initiator is manually actuated by pulling its canopy external jettison initiator handle.

System and Backup Initiators

The system has two system initiators and one backup initiator. One system initiator is located behind each ejection seat. These initiators are actuated by pulling the face curtain or secondary firing control handle. They provide the initial explosive signal for canopy jettison and seat ejection. The backup initiator is on the cockpit turtle deck. This initiator performs a backup function for the safe-and-arm seat ejection module. It is actuated by a lanyard attached to the canopy and the initiator sear linkage. As the canopy is jettisoned, the lanyard actuates linkage to remove the sear and fire the initiator, sending an explosive signal through a 1.1-second time delay to the safe-and-arm module.

Canopy Gas Generator

The canopy gas generator is attached to the lower end of the canopy hydraulic actuator. The canopy gas generator provides high-pressure gas to the actuator, to jettison the canopy.

Inert Connectors

Inert connectors installed throughout SMDC line runs permit interconnection of the SMDC lines.

Explosive Manifolds

Explosive manifolds installed within SMDC line runs incorporate an internal explosive crossover that permits either 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 installed within SMDC line runs provide unrestricted explosive transfer in one direction only. If an explosive signal is introduced in the opposite direction, it is blocked.

SLIDING CANOPY SYSTEM

Learning Objective: Recognize the operation, emergency jettison procedures, and components of the sliding canopy system.

An example of the sliding canopy system is found on the A-6 aircraft. The A-6 cockpit is covered by a sliding canopy powered by a canopy system consisting of the components required for normal operation and emergency jettison of the canopy. The entire system is hydraulically operated with the exception of the jettison device. The A-6 uses a pneumatic jettison concept. Hydraulic power for operation of the system is furnished by the combined (both engines) hydraulic system or the hand pump system (fig. 2-6).

SYSTEM OPERATION

Hydraulic flow to open or close the canopy is controlled through a canopy selector valve, which is in the nosewheel well under the cockpit

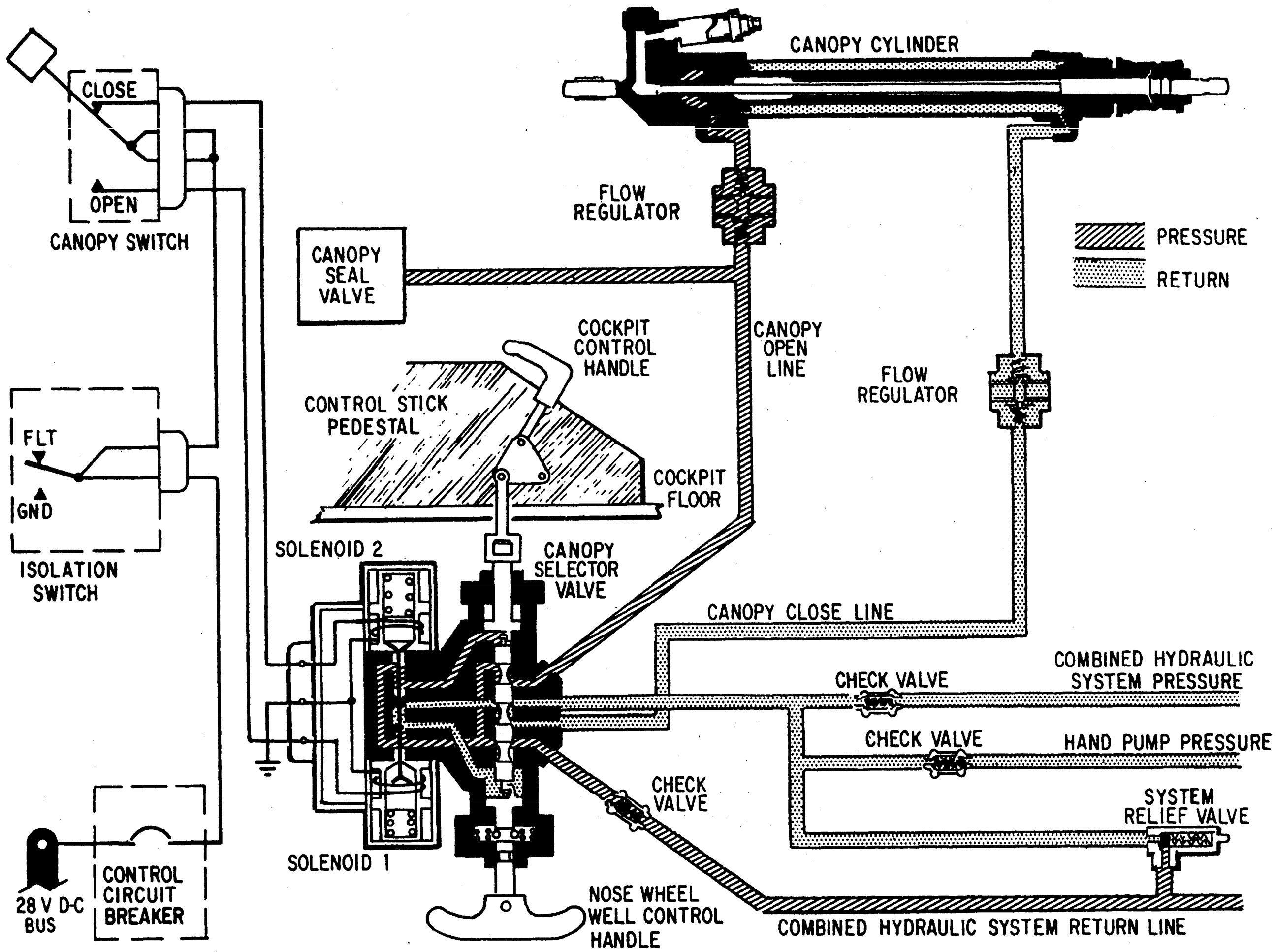


Figure 2-6.—Hydraulic canopy operation.

floor. This selector valve may be operated either electrically or manually from the cockpit or the nosewheel well. Normal operation is electrical through the canopy switch on the pilot's instrument panel. This switch controls the selector valve whenever the engines are operating or whenever external electrical and hydraulic power is applied to the aircraft. Manual opening of the canopy is conducted using a hand pump system that pumps the canopy into position when combined hydraulic system power is not available on the aircraft. The hand pump is in the nosewheel well and can be operated either from there or from the cockpit.

When the selector valve closes, hydraulic pressure from either the combined hydraulic system or the hand pump system flows through the selector valve into the canopy close line. Pressure in this line is delivered through a flow regulator to the rod end of the canopy actuating cylinder, causing the piston and rod to retract and close the canopy. Opening of the canopy is the reverse of the closing operation.

NOTE: Maintenance of the hydraulic portion of the A-6 canopy actuation system is the responsibility of the AMH rating.

EMERGENCY CANOPY JETTISON SYSTEM

The A-6 canopy jettisoning system is not actuated as part of the seat ejection sequence, but must be manually selected separately from the ejection process. Canopy jettison is a separate function because the normal procedures for using the ejection seat require ejection through the canopy unless special conditions dictate a deviation is necessary. In the A-6, a jettison sleeve is housed in the canopy actuator rod. Passages within the canopy actuator connect to a jettison cartridge that is mounted on the side of the cylinder head end. When the cartridge is fired, expanding gases create the necessary pressure to unlock the jettison sleeve from the rod end and force it and the canopy aft and off the aircraft (fig. 2-7). The jettison cartridge is fired by pneumatic pressure from a small (14.6 cu in.) air bottle pressured with nitrogen to 2,450 psi at 70°F prior to takeoff.

Three air release valves are installed in the aircraft for jettisoning the canopy. One valve is actuated from the cockpit, the other two by their respective RESCUE handle on the engine intake air ducts. Opening any one of these valves directs nitrogen pressure from the bottle to the canopy actuator cap assembly (fig. 2-7) and fires the pneumatic jettison cartridge.

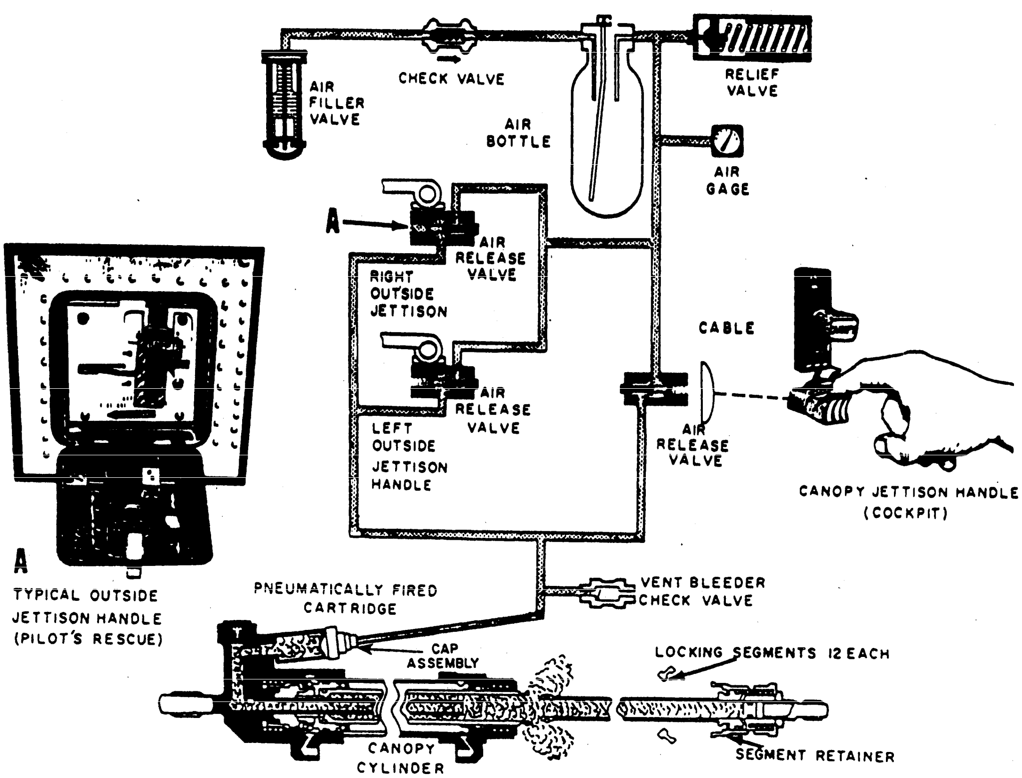
To manually release the canopy actuator from the canopy attachment, pull either of the manual release handles located under access doors on the aft end of the canopy shell or the single manual release handle located on the canopy overhead center beam.

SYSTEM COMPONENTS

The main components of the canopy jettison system are shown in figure 2-6. The relief valve prevents excessive air bottle pressure increases due to thermal expansion and over-pressurization during charging. The valve cracks to relieve pressure at 3,800 psi and reseats at 3,400 psi.

The air gauge provides a means of checking proper system precharge. The gauge is tapped into the pressure line between the air bottle and the cockpit air release valve.

The vent bleeder check valve is located on the forward side of the left boarding ladder well. The valve is located downstream of the three air release valves and vents any low-pressure nitrogen that may have leaked past the air release valves, thus preventing inadvertent cartridge actuation. The vent bleeder check valve is normally open at 40 to 80 psi. When an air release valve is actuated, the bleeder valve closes and remains closed throughout the jettison operation. The bleeder valve will reopen when the pressure in the system is reduced below 40 psi. The bleeder valve also has a manual override that permits bleedoff of nitrogen pressure after jettison system testing as required during periodic inspections.



213.196

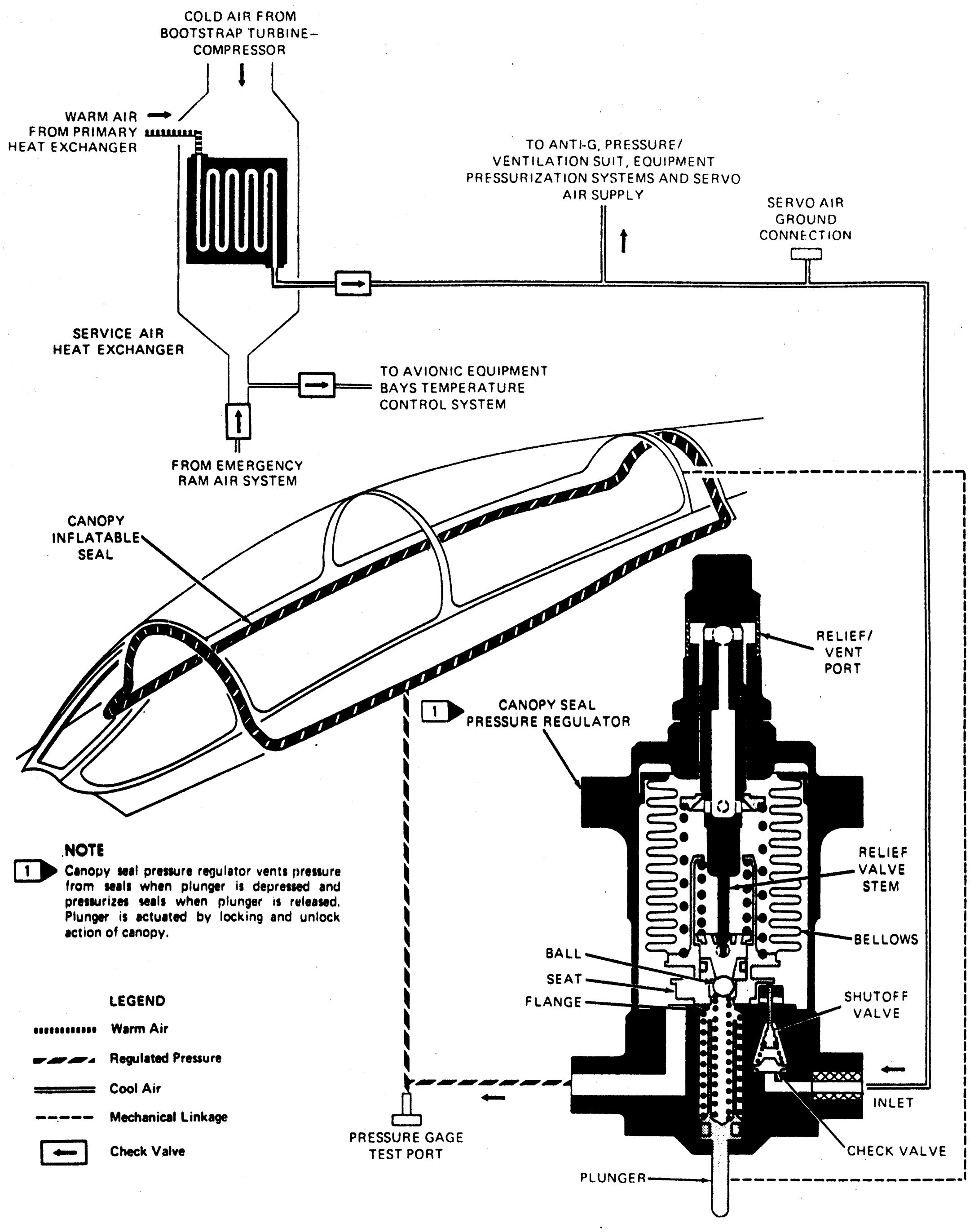
Figure 2-7.—Canopy jettison schematic.

NOTE: The canopy actuating and jettisoning cylinder is a primary concern of personnel in the AMH rating. However, during AME removal and/or installation of the canopy, the cylinder can become damaged if the procedures provided in the MIM are not strictly followed.

CANOPY SEAL SYSTEM

Learning Objective: Recognize the purpose and operation of the canopy seal system.

A canopy seal system (fig. 2-8) provides an airtight seal between the canopy assembly and the



213.293

Figure 2-8.—Canopy seal system.

aircraft structure to maintain cockpit pressurization. The system, using cooled engine bleed air from the air-conditioning system, inflates the canopy seal in response to movement of the canopy locking linkage. The system deflates the seal when the canopy is unlocked. There are many different types/designs of pressure-maintaining seals used on naval aircraft. The main difference between canopy seal systems is the type of canopy seal pressure regulator used, electrical or mechanical. The F-14 inflatable seal will be discussed in the following paragraphs. The A-6 operates in a similar manner, but will not be covered in detail here. Refer to maintenance manuals for specifics.

SYSTEM OPERATION

The canopy seal pressure regulator 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, and 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 will

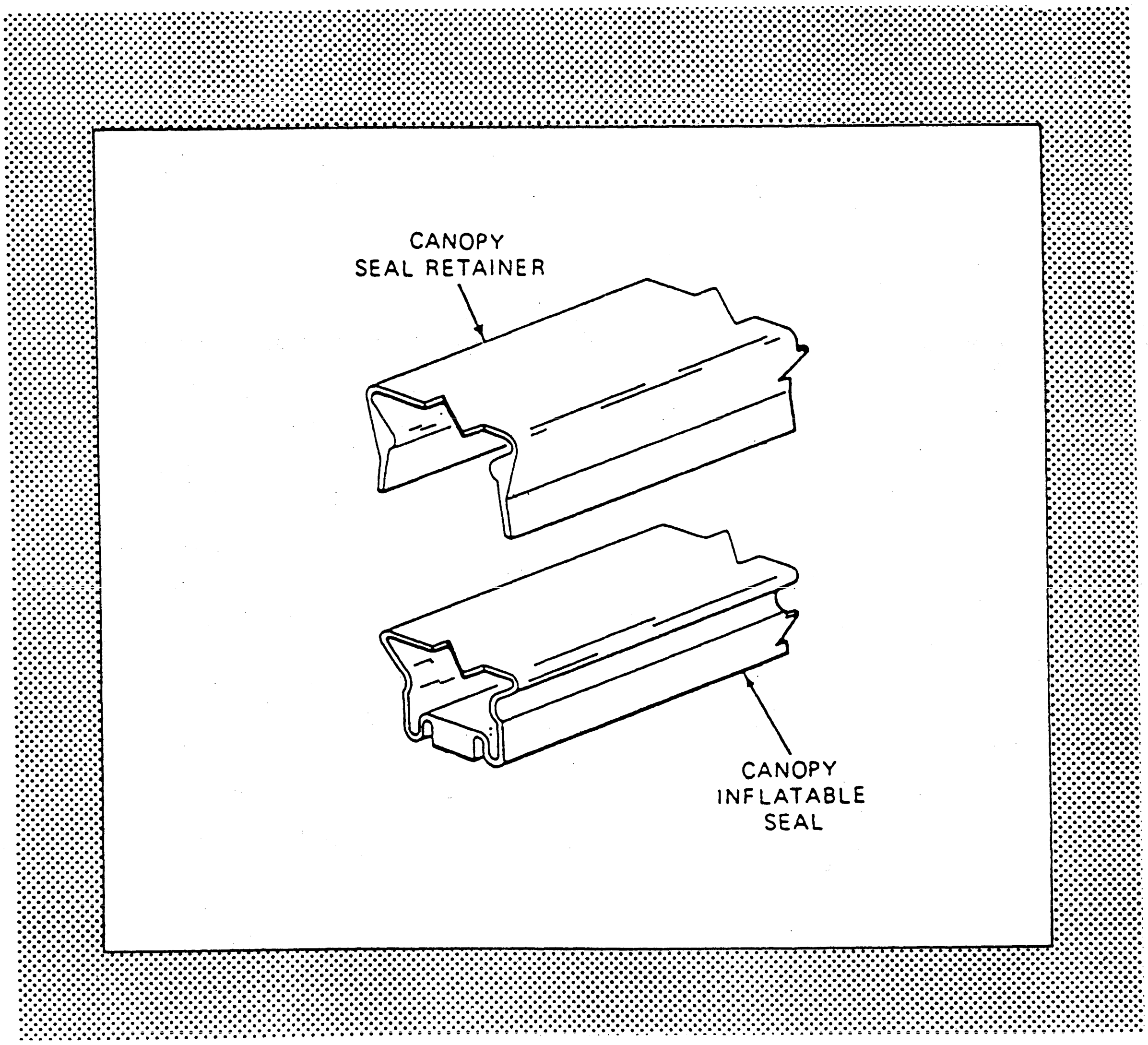


Figure 2-9.—Typical canopy inflatable seal (removed).

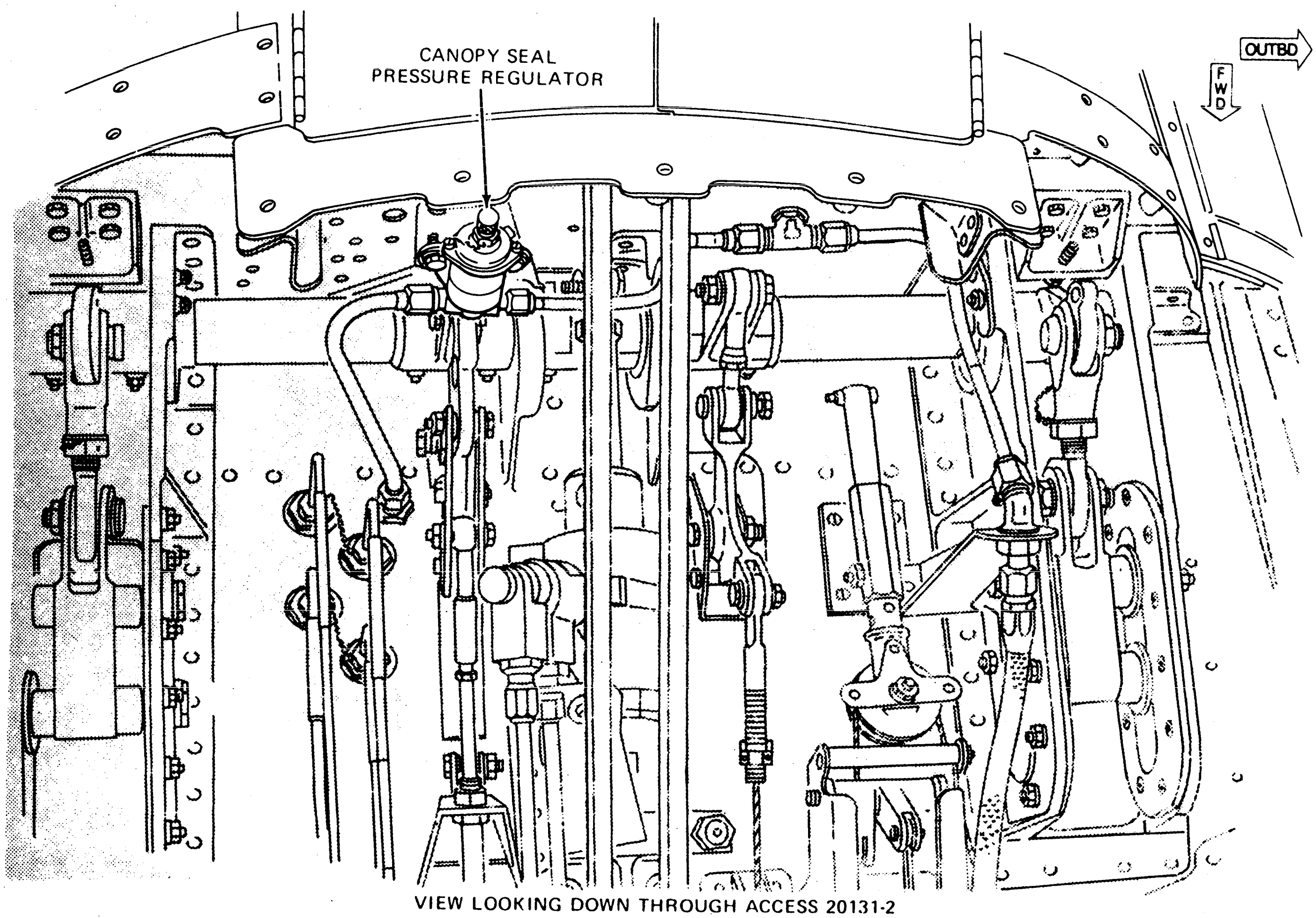
have moved sufficiently to seat the shutoff valve and stop flow through the regulator. The inflated seal then fills the gap between the canopy frame and the mating aircraft structure, preventing loss of cockpit pressure. If pressure downstream of the regulator increases to 6 to 8 psi above the regulated 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 downsteam pressure through the relief/vent port. The components of the canopy seal system are discussed in the following paragraphs.

Canopy Inflatable Seal

The hoselike rubberized canopy inflatable seal (fig. 2-9) 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.

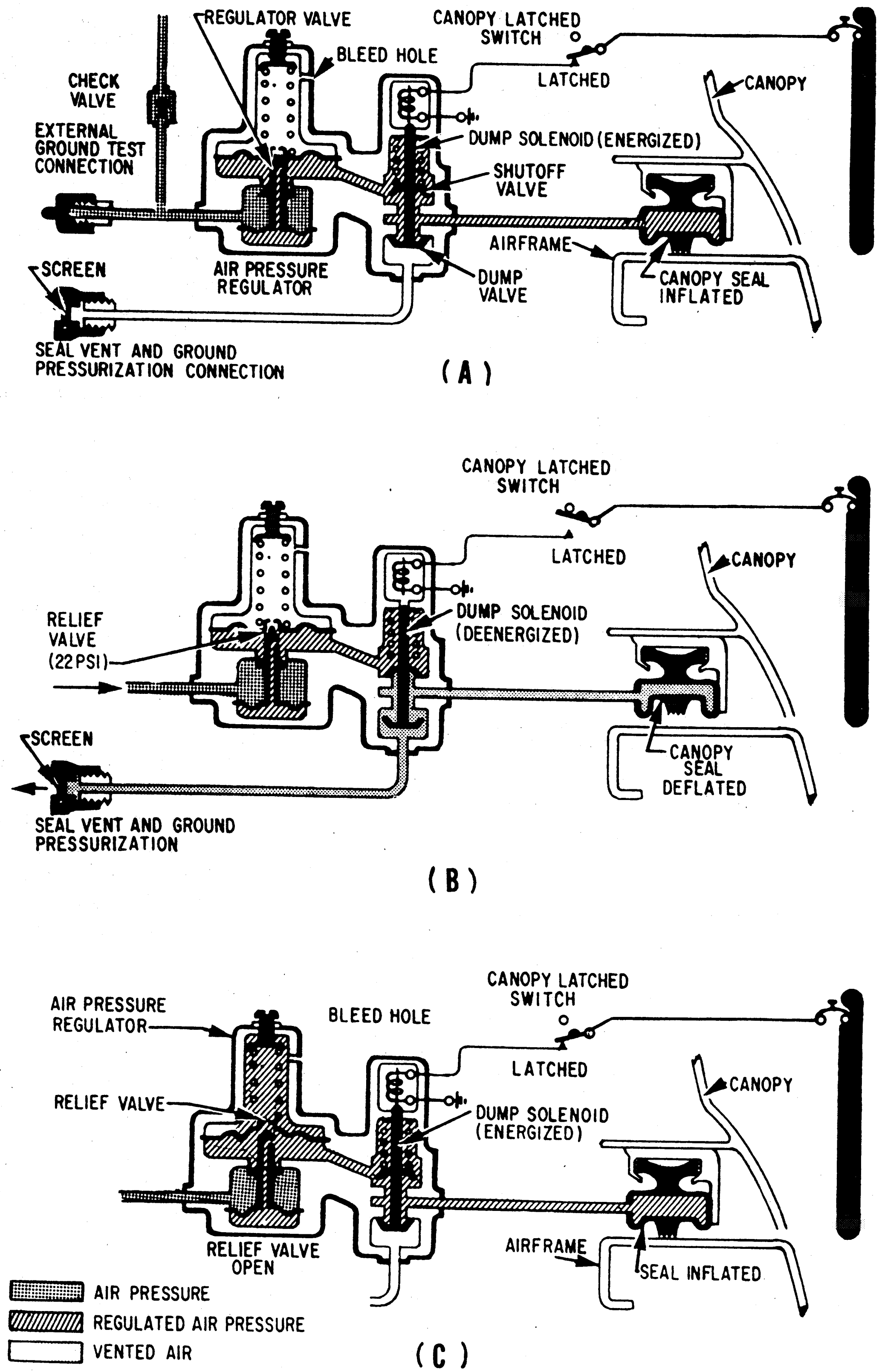
Canopy Seal Pressure Regulator

The canopy seal pressure regulator is on the turtle deck (fig. 2-10). 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 relieves pressure in excess of 6 to 8 psi above the regulated value.



213.295

Figure 2-10.—Canopy seal pressure regulator location.



213.105

Figure 2-11.—Electrically actuated canopy pressure seal system.

Electrically Actuated Canopy Seal

An electrically actuated canopy pressure seal system is shown in figure 2-11. This type of system is controlled by a pressure regulator and dump valve assembly, which consists of a pressure regulator, a solenoid poppet shutoff and vent valve, and a relief valve.

Electrically Actuated Canopy Pressure Seal Regulator Valve

The canopy pressure seal regulator valve controls the pressurizing and depressurizing of the canopy seal, depending upon the canopy position. The pressure regulator consists of a spring-loaded diaphragm, which controls a poppet valve to admit the correct air pressure to the canopy seal. An adjustment screw is provided at the top of the regulator housing to adjust the output of air pressure.

The shutoff and dump valve consists of a solenoid-operated poppet valve, which is spring-loaded to the closed position. When the solenoid is energized (fig. 2-11, view A), the dump valve closes the vent port and opens the regulator shutoff to permit inflation of the canopy seal. The outlet pressure is maintained at approximately 20 psi by the pressure regulator.

When the solenoid is de-energized by the opening of the canopy (fig. 2-11, view B), the dump valve opens the vent port, closes the regulator shutoff to stop the flow of supply air, and dumps the pressure in the canopy seal overboard through the vent line. The relief valve feature of the pressure regulator prevents seal pressure from becoming excessive during rapid altitude changes by venting the seal pressure overboard when the pressure reaches a maximum of 22 psi (fig. 2-11, view C).

In case of an electrical failure, the regulator valve is spring-loaded in the dump position.

Ground Test Connections

Most canopy pressure seal systems have ground test connections that are used to ground test the system and to pressurize the system during carrier deck storage. The ground test connections (fig. 2-12) are usually located on the cabin air pressure test panel. One connection is used for ground test, and the other, which is normally the seal vent, is used for ground pressurization of the canopy seal.

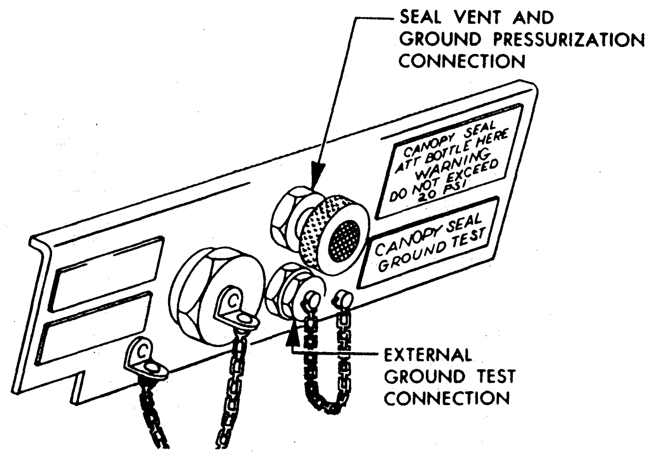


Figure 2-12.—Cabin air pressure test panel.

MAINTENANCE

Maintenance of the canopy system consists of servicing, troubleshooting, and removal and installation of components. The applicable aircraft maintenance instructions manual (MIM) furnishes such information as proper procedure, manpower requirements, materials lists, tool and equipment lists, quality assurance instructions, and maintenance-level instructions for the disposition of defective parts.

Servicing

Servicing is limited to cleaning the canopy seal, ground inflating the canopy seal, and periodic inspections for visible defects, dirt, and foreign material accumulations. All major components of the system are self-sustaining and require no general servicing between overhaul periods for normal operation.

When pressurized aircraft are stowed on the carrier flight deck without canopy covers, the canopy seal should be inflated externally to protect the cabin area. Ground pressurization of the canopy seal is accomplished by attaching an external air source to the canopy seal vent and ground pressurization connection (fig. 2-13). Since air pressure applied to this fitting bypasses the system regulator, the air source must be controlled to less than 20 psi to avoid rupturing the seal.

NOTE: Some aircraft are equipped with canopy rain seals that protect the cabin area. In aircraft so equipped, the canopy seal does NOT have to be inflated for the cabin to be protected. Rain seals do not maintain cockpit pressurization.

Troubleshooting

Troubleshooting charts similar to the one in table 2-1 are found in most aircraft MIMs. The troubleshooting chart is provided as an aid in determining the cause, isolation procedure, and remedy for the more common malfunctions within the canopy seal system. When a malfunction is suspected, always ensure that the proper controls have been activated to provide operating potential to the unit to be inspected.

Removal and Installation Procedures

The MIM provides the instructions and visual aids necessary to remove and install the various components of the canopy seal system. In addition to instructions, information such as disposition of defective parts, tools and equipment requirements, and quality assurance instructions is provided. When removing a unit from the aircraft, always ensure that proper measures are taken to prevent the entry of dirt and foreign material into ports and ducts that have been opened to accommodate removal.

FRANGIBLE ESCAPE CANOPY SYSTEMS

Learning Objective: Recognize the purpose and operation of a frangible escape system.

A frangible escape system is an explosively operated system that cuts an exit through the canopy directly over the head of each occupant. The S-3A canopy removal system is an example of this type system, and it employs shielded mild detonating cord (SMDC) in lieu of hot gas and flexible linear shaped charge (FLSC) in lieu of actuators found in other hot gas explosive systems.

Normal entry and exit of the S-3A aircraft is through an entrance hatch vice a canopy, as in other ejection seat type of aircraft. Therefore, the S-3A canopy removal system is used primarily for emergency ground egress and water rescue. Normal seat ejection is through the canopy glass for the front seats and through the hatch glass for the rear seats. In both cases, exit is made without benefit of having the glass removed or cut because the seats are equipped with glass crashers. Breaker plates are installed on each canopy and hatch to assist the seat during ejection. A brief description of the frangible escape canopy system components is provided in the following paragraphs.

EXTERNAL CANOPY AND HATCH JETTISON INITIATOR

Two external jettison initiators are installed inside access doors, one on each side of the aircraft just below and forward of each windshield

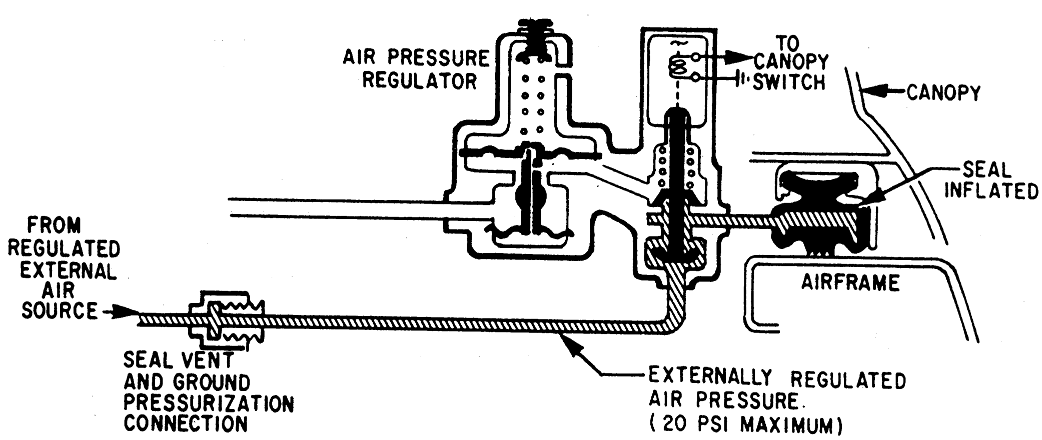


Figure 2-13.—Ground inflation of the canopy seal system.

Table 2-1.—Troubleshooting Chart For Electrically Actuated Canopy Seal System

Probable cause	Isolation procedure	Remedy
TROUBLE: SEAL WILL NOT INFLATE DURING NORMAL OPERATIONS		
Ruptured seal.	Check the canopy seal by applying an internal air pressure source to the ground test fitting and operating the canopy seal system.	Replace defective seal.
Improperly adjusted or defective canopy latched switch.	Check the adjustment of the canopy latched switch or continuity.	Properly adjust canopy latched switch or replace defective switch.
Defective canopy seal regulator power supply circuit.	Check continuity.	Personnel in the AE rating will repair or replace electrical wire or components as necessary.
Defective canopy seal regulator.	Check continuity.	Replace defective canopy seal regulator.
Canopy seal ground test fitting cap loose or missing.	Check visually.	Tighten or replace the cap.
Canopy seal ground test fitting cap and canopy seal vent fitting reversed.	Check visually.	Reverse fittings.
TROUBLE: SEAL WILL NOT INFLATE DURING GROUND TESTING		
Check valve defective.	Ground test the canopy seal system.	Replace check valve O-rings or replace check valve.
Defective canopy seal regulator.	Check continuity of electrical solenoid. Check canopy seal.	Replace canopy seal regulator.
Ruptured seal.	Check canopy seal.	Replace defective seal.
Defective canopy seal regulator power supply circuit.	Check continuity.	Personnel in the AE rating will repair or replace electrical wire or components as necessary.

(fig. 2-14). The initiator consists of a mechanically actuated sealed explosive device containing a handle, four locking balls, a 10-foot wire lanyard, a mechanical firing mechanism, a transfer booster assembly, body shield, and a ball lock mechanism. The 10-foot wire lanyard attaches the handle to a mechanical firing mechanism. The firing mechanism consists of a sear pin, cap, spring, and firing pin enclosed in the body of the initiator. The transfer booster assembly contains a percussion primer, an initiation explosive charge, and an output explosive charge. The transfer booster assembly produces a detonation wave that initiates the SMDC assembly, which is screwed into the initiator's outlet port.

When the initiator handle is pulled, the locking balls will retract and release the handle from the shield. The handle and attached lanyard are pulled the length of the lanyard (10 feet) from the initiator. With the wire lanyard extended to its full length, an additional 0.75-inch movement of the handle will allow the firing pin to separate from the sear pin. The firing pin, which is now disengaged and under spring tension, strikes the percussion primer, which is installed in the transfer booster assembly. The primer ignites the initiation and output explosive charges, producing a detonation. The detonation wave initiates the SMDC assembly, which is installed in the outlet port of the initiator.

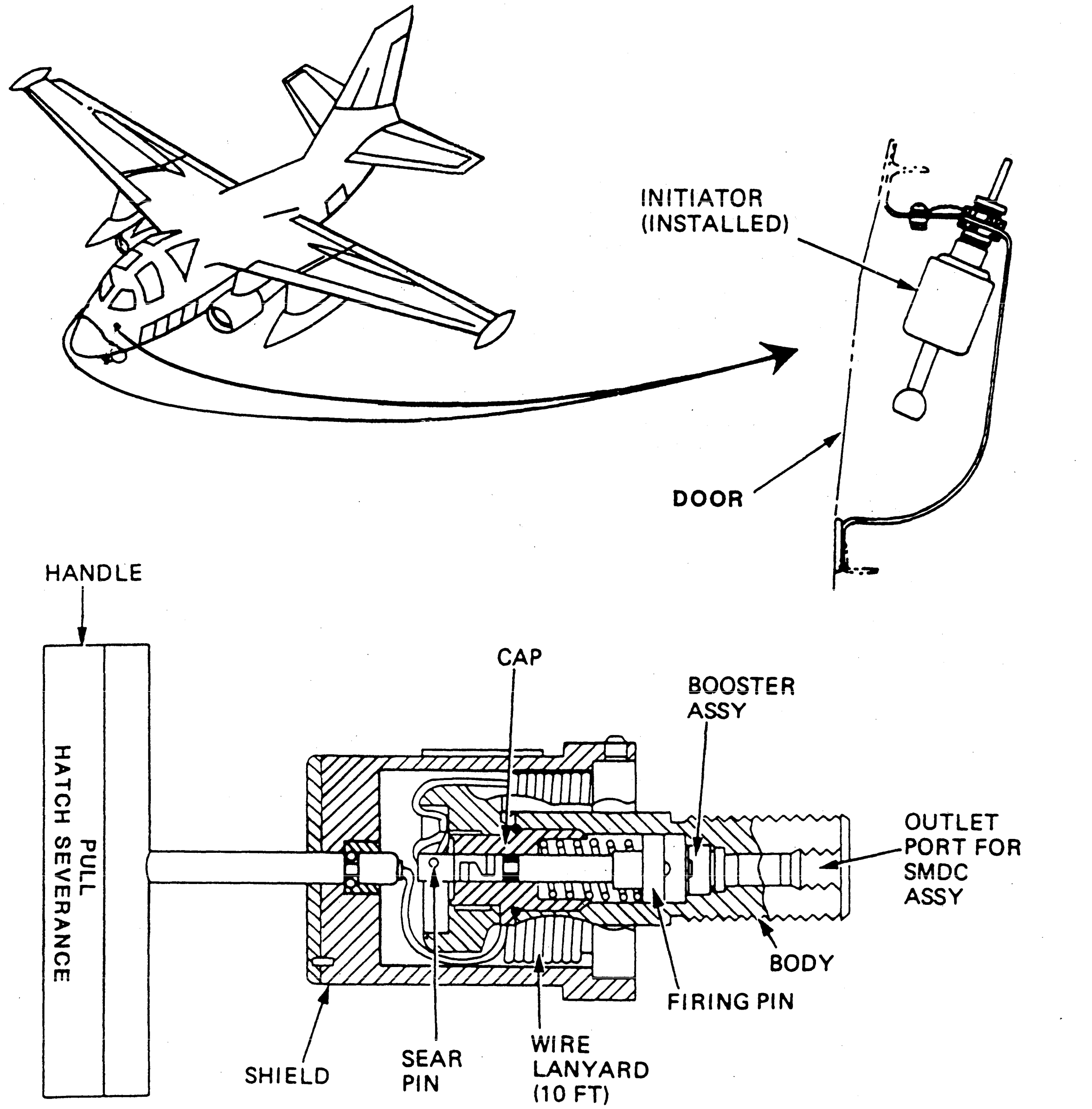


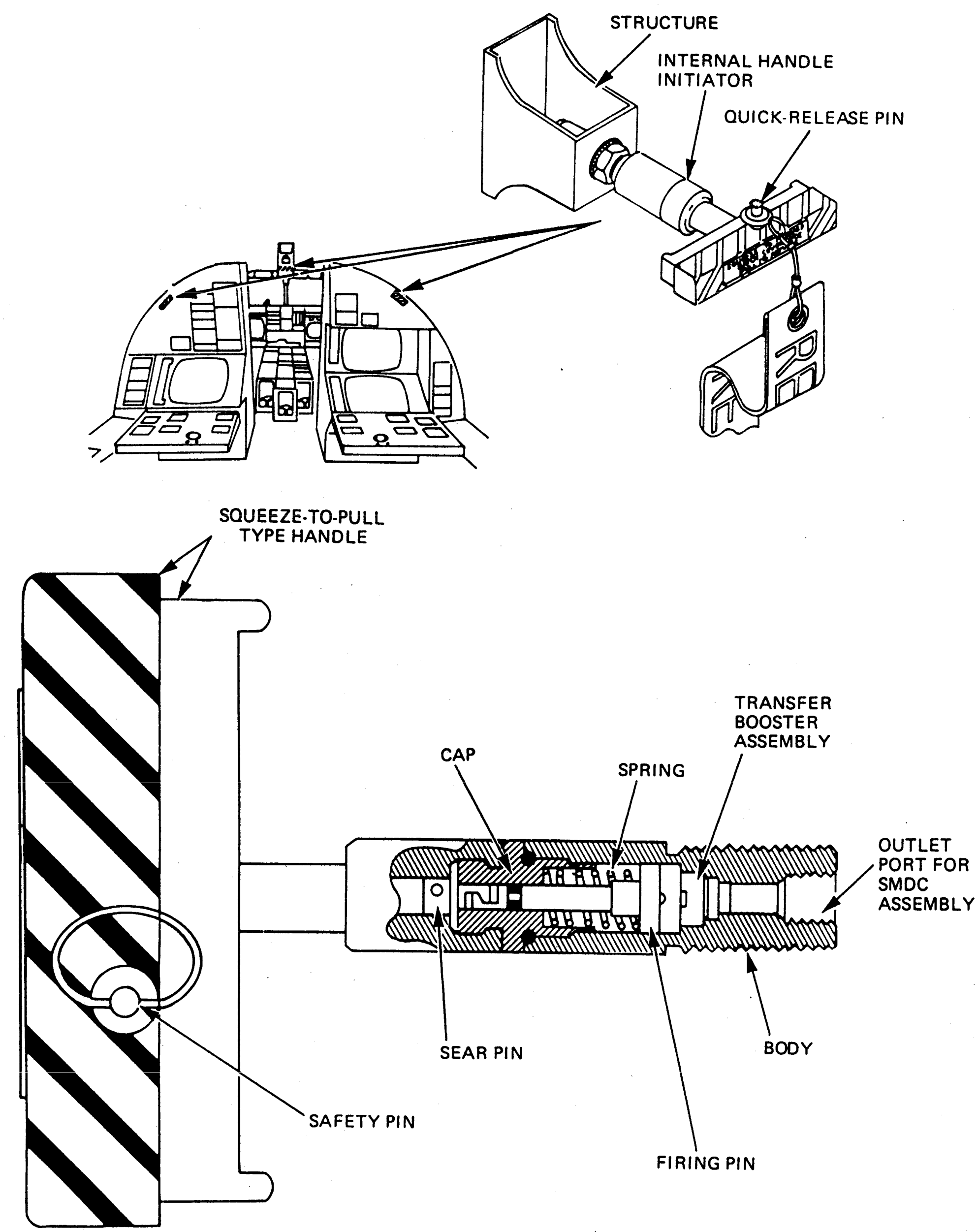
Figure 2-14.—External canopy and hatch jettison initiator.

The external initiators have no safety pins as such, but rely upon the 10-foot lanyard to protect them against inadvertent initiation. Operation of either external handle will cause all four hatches, fillets, and supports to be blown away from the aircraft. Partial withdrawal of any handle is cause for rejection and replacement.

INTERNAL CANOPY AND HATCH JETTISON INITIATOR

The internal initiator is used to actuate the canopy and hatch system without activating the ejection seat system. Three internal initiators are located in the S-3A aircraft crew compartment. One initiator is located in the overhead between the pilot and copilot. The other two are located at the TACCO and SENSO positions on the outboard side of each instrument panel (fig. 2-15).

The initiator is a mechanically actuated sealed-in device containing a squeeze-to-pull type of handle (fig. 2-1 5), a mechanical firing mechanism, and a transfer booster assembly. The mechanical firing mechanism and transfer booster assembly are identical to those used in the external system.



214.175

Figure 2-15.—Internal canopy and hatch jettison initiator.

The firing mechanism is secured in the safe position by a safety pin that passes through the handle. The safety pin prevents the handle from being squeezed and pulled.

When the initiator handle is squeezed and pulled for a distance of 0.75 inch, the firing pin separates from the sear pin. From this point, the sequence is identical to the external canopy and hatch jettison sequence.

SHIELDED MILD AND FLEXIBLE CONFINED DETONATING CORDS

The SMDC and FCDC segments act as the plumbing for the emergency egress system. They provide all internal and external jettison initiators with manifolds and one-way transfers to all explosive charges. Some S-3A aircraft have been modified to incorporate FCDC in place of the SMDC at the four locations where the canopies and/or hatches meet the airframe. The use of the FCDC alleviates the installation problems encountered with SMDC. The SMDC and FCDC focus extremely high velocity and pressures onto the ends of adjacent SMDC segments.

The high reaction speed of 8,000 to 9,000 feet per second makes the SMDC very difficult to unintentionally detonate from extraneous sources such as sawing, filing, drilling, and hammering because the speed of these operations does not approach the 8,000 to 9,000 feet per second requirement. From the standpoint of manufacturing and maintenance personnel, the system is virtually inert when safety pins are installed.

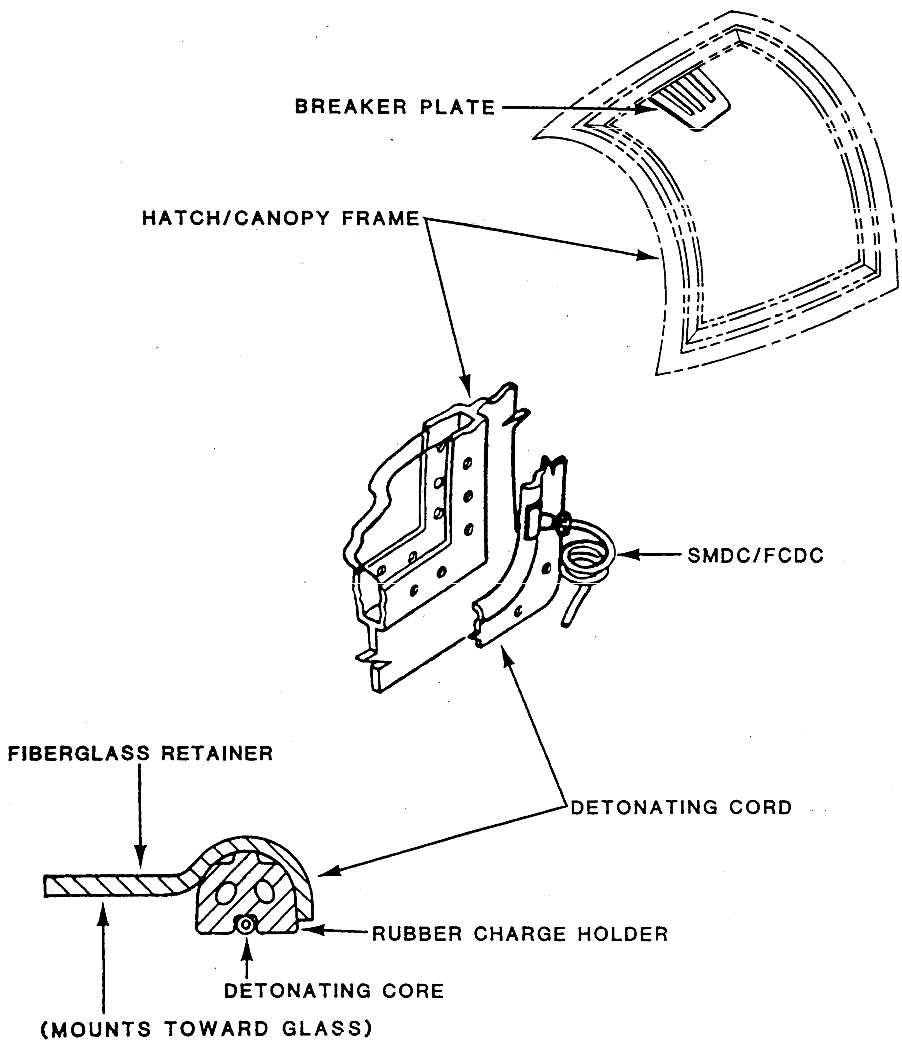


Figure 2-16.—Hatch/canopy detonating cord assembly.

The ends of the SMDC, while in storage or not connected in the aircraft, must be capped at all times. Any scaring or deformation of the transfer tip is cause for rejection. Any deformity here will affect the direction the blast force will travel. The tips of the SMDC act as both donor and acceptor to receive and transfer the charge from one SMDC segment to another. The tips contain Hexanitrostilbene II (HSN II) while the cord charge itself is Hexanitrostilbene I, a less sensitive material.

CANOPY AND HATCH EXPLOSIVE CHARGE

An explosive charge is attached to the periphery of the pilot and copilot canopies and the TACCO and SENSO hatches. The explosive charge is a detonating cord, and it is applied directly to the glass on the canopies and/or hatches. Each detonating cord assembly is held in place by a silicone rubber charge holder and fiber glass retainer (fig. 2-16). The detonating cord consists of a continuous explosive charge contained in an O-shaped seamless lead sheath. A threaded inlet port (transfer block) is mounted on the fiber glass retainer to allow attachment of the SMDC or FCDC assembly. An SMDC or FCDC connects to the transfer block at the lower front corner of each charge.

Actuation of an external or internal canopy and hatch jettison initiator detonates the SMDC or FCDC screwed into the inlet port of the detonating cord assembly. The detonation wave impacts and initiates the explosive booster charge, which, in turn, initiates the detonating cord. Initiation of the detonating cord fractures the stretched-acrylic canopy or hatch along its periphery. The first half of the glass is vaporized by the heat of the flame, which slices a very narrow and deep incision halfway through it. At this point, the shock wave is sufficient to fracture the remaining thickness and spatter the glass outward.

FILLET SEVERANCE EXPLOSIVE SHAPED CHARGE

During emergency ground egress, FLSC assemblies sever the S-3A aircraft's left and right upper wing-to-fuselage fillet supports. The FLSC cuts the attached fillet from the aircraft to allow complete egress through the respective hatch.

The FLSC assembly is enclosed in a silicone rubber charge holder, which is held in place by a fiber glass retainer (fig. 2-17). The FLSC is a continuous explosive charge contained in a V-shaped seamless lead sheath. The silicone rubber shaped charge holder is extremely vulnerable to external damage because of the softness of the material and 0.02-inch material thickness in the area of the FLSC. A cut or tear of the charge holder, which allows the lead sheathed shaped charge to become exposed, destroys the environmental seal and requires replacement of the FLSC assembly.

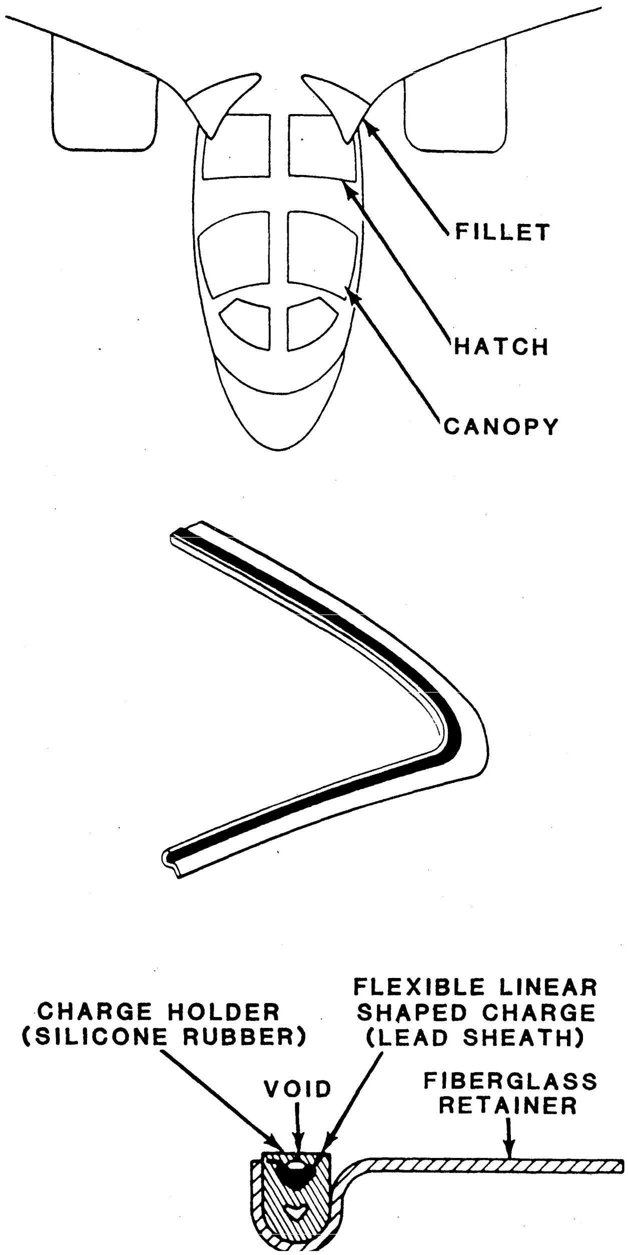


Figure 2-17.—Fillet FLSC assembly.

SMDC 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 that houses a sealed receptacle for dual-shaped charges. Any detonation entering the inlet ports will transfer to the outlet 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 their respective hatch. The remaining two windows and the opposite hatch would not be affected.

SYSTEM OPERATION

The S-3A aircraft canopy and hatch severence system contains two external and three internal SMDC initiator handles (fig. 2-18). Actuation of the pilot's or copilot's internal handle or either of the two external handles severs the pilot and copilot canopies, TACCO and SENSO hatches, right and left upper wing-to-fuselage fillets, and the right and left wing fillet supports.

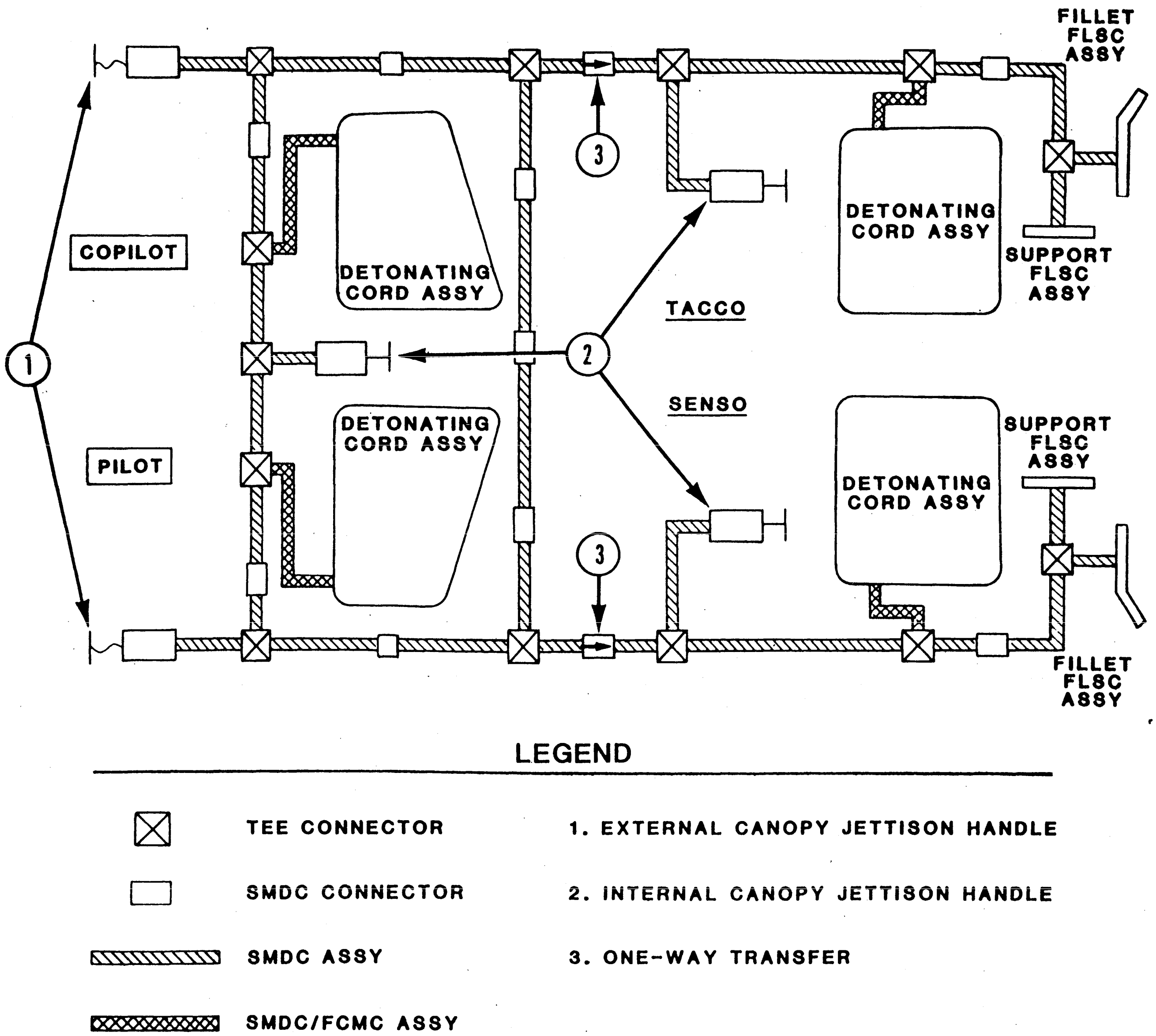


Figure 2-18.—Emergency egress schematic.

The pilot's and copilot's internal initiator handles transfer a detonation wave signal to the connecting SMDC assemblies, which are routed throughout the cockpit area. In turn, the SMDC assemblies initiate four detonating cord assemblies, which are mounted on the periphery of the two canopies and the two hatches. The detonating cord assemblies sever or fracture the stretched acrylic canopies and hatches. FLSC assemblies, which are simultaneously initiated, sever the two wing fillet supports and the two upper wing-to-fuselage fillets, which extend into the TACCO and SENSO hatch area.

Actuation of the TACCO or SENSO internal SMDC initiator will sever only the hatch, the upper wing-to-fuselage -fillet, and the wing fillet support at the crew station in which the initiator was activated. Explosive one-way transfers located forward of the TACCO and SENSO crew stations prevent the detonation wave from severing the pilot and copilot canopies.

It is virtually impossible to initiate the system at any point other than an initiator handle. As compared to hot-gas systems, this system maybe considered immune to ordinary shop hazards. The system is self-sufficient and independent. It depends upon no other system for aid or assistance, and it does not contribute aid, assistance, or sequence to any other aircraft system. The S-3A system is much less susceptible to inadvertent actuation than hot-gas systems, and hence more convenient and safe for maintenance personnel.

CARTRIDGES AND CARTRIDGE-ACTUATED DEVICES (CAD)

Learning Objective: Recognize the service life and expiration dates of cartridges and cartridge-activated devices.

The types of explosive devices incorporated in egress systems are varied. The AME working with these devices must know how they function, their characteristics, how to identify them, their service-life limitations, and all safety precautions.

The AME who understands the importance of all of these factors and who correctly uses the maintenance manuals is better equipped to supervise and train others. The following manuals are required for the AME to meet the above requirements:

1. *Description, Preparation for Use, and Handling Instructions, Aircrew Escape Propulsion System (AEPS) Devices,* NAVAIR 11-85-1
2. *General Use Cartridges and Cartridge Actuated Devices for Aircraft and Associated Equipment (CADS),* NAVAIR 11-100-1.1, NAVAIR 11-100-1.2, and NAVAIR 11-100-1.3
3. Specific aircraft MIMs
4. OP 4, *Ammunition Afloat*
5. OP 5, *Ammunition and Explosives Ashore*

SERVICE LIFE

The service life of a CAD is the specific period of time that it is allowed to be used. These periods of time are affected by various environmental conditions, which have resulted in the assignment of time limits or overage requirements. These limits are shelf life and installed life.

The establishment of service-life limits is based upon design verification tests, qualification tests, and surveillance evaluations. The established limits are approved by the Naval Air Systems Command. Therefore, the establishment of service-life time limits is not arbitrary and must be adhered to as specified.

Prior to deployment to areas that do not permit ready supply and servicing of cartridges or cartridge-actuated devices, an inspection must be made of all CAD's service-life expiration dates. If, during this inspection, it is determined that a CAD will become overage during the period of the deployment, the CAD must be replaced prior to the deployment. Before installation of any CAD, the service-life expiration date of the unit must be checked to ensure that the unit is not overage and will not become overage prior to the next periodic maintenance cycle of the aircraft.

During standard depot level maintenance (SDLM), the expiration dates of all installed CADs must be checked. Those CADs assigned to organizational level for maintenance and that have expiration dates prior to the next scheduled inspection after the aircraft is returned to its custodian must be replaced. CADs assigned to depot level for maintenance that have expiration dates falling prior to the next scheduled SDLM should also be replaced. The exception is systems replaced exclusively through the use of a field modification team. Adherence to these procedures will prevent loss of aircraft mission capability due to CAD service-life expiration.

EXPIRATION DATES

To determine service-life expiration dates, both the shelf life and installed life must be computed. First, compute the shelf life of the CAD by using its lot number to determine the month and year of manufacture. Refer to table 2-2 to ensure correct interpretation of the lot number since there are currently two methods used to derive lot numbers. Obtain the established shelf life (number of months and years) for the individual CAD from the NAVAIR 11-100-1 series manual. Add this figure (shelf life) to the month and year of manufacture determined from the CAD lot number. The resulting sum (date) is the shelf-life expiration date of the CAD in question.

Example:

Lot number/date of manufacture	0579
+ Shelf life in Years	+ 6
Shelf-life expiration date	0585

Table 2-2.—Derivation of Lot Number

KEY	DEFINITION
a	Lot sequence number
b	Manufacturer's identification symbol
c	Month of production (two digit)
d	Year of production (two digit)
e	Month of production (single alpha) JAN - A MAY - E SEP - J FEB - B JUN - F OCT - K MAR - C JUL - G NOV - L APR - D AUG - H DEC - M
f	Interfix number
g	Lot suffix (alpha)

Example:
Lot Number, Method 1: 11 ABC 0578
Key: (a) (b) (c)(d)
(Note that (c) and (d) will be used to compute service life.)

Example:
*Lot Number, Method 2: XYE 78 E 001-011A
Key: (b) (d) (e) (f) (a)(g)
(Note that (d) and (e) will be used to compute service life.)
*Further details of explanation are available in MIL-STD-1168A.

Next, determine the installed-life expiration date of the CAD by referring to the NAVAIR 11-100-1 series manual. Obtain the installed-life figure (number of months or years) and add that figure to the date (month) the CAD's hermetically sealed container was opened. The resulting sum (date) will be the installed-life expiration date for the CAD in question.

Example:

Date opened	0879
+ Installed life in months	+42
Installed-1ife expiration date	0283

Then, compare the two dates derived (shelf life and installed life). Whichever date occurs first is the CAD service-life expiration date.

Example:

Shelf life	0585
Installed Life	0283
Service-life expiration date	0283

Since only the month and year are used in computing service-life dates, the date the hermetically sealed container is opened and the expiration date must be computed to the last day of the month involved. If the date the sealed container was opened is not available, the installed life must be computed from the date of manufacture as determined from the lot number.

MARKING EXPIRATION DATES

Before installing a CAD in an aircraft system, both CAD service-life expiration dates (shelf life and installed life) must be known. The time limit that is exceeded first is the service-life expiration date of the CAD. This date must be entered into the aircraft logbook.

Use permanent indelible ink for marking CADS with container open dates and service-life expiration dates. Do not scribe, scratch, or electroetch these dates, as damage will occur to the CAD's corrosion-resistant surface. The marking pen, NSN 7520-00-043-3408, is available from GSA supply and is recommended for this purpose.

When you install a CAD in an aircraft system, a log entry must be made on OPNAV Form 4790/26A as directed by OPNAV-INST 4790.2. When a CAD's hermetically sealed container is opened, the container open date and the service-life expiration date (month and year) must be marked with indelible ink on the container and on each CAD in the container.

SERVICE-LIFE EXTENSION

Contingency service-life extensions for the CADS listed in the NAVAIR 11-100-1, not to exceed 30 days, may be granted by the commanding officer or his authorized representative. These extensions may be applied to a specific CAD on a one-time-only basis when replacements are not available and failure to extend the service life would disrupt flight operations. The contingency authority is granted on the condition that Naval Ordnance Station (NAVORDSTA), Indian Head, Maryland; NAVAIRSYSCOM, Washington, D.C.; and SPCC, Mechanicsburg, Pennsylvania be immediately notified by message or speed letter when such authority is exercised.

When the situation warrants, an additional service-life extension beyond the 30-day contingency extension may be requested by message from the NAVORDSTA. All extensions beyond 30 days must be approved by the NAVORDSTA or NAVAIRSYSCOM. All approved additional service-life extensions will be transmitted by message to the activity making the request. When a service-life extension is granted, an entry must be made in the aircraft logbook. When an aircraft is transferred with a service-life extension in effect, the gaining activity must be notified, and no new contingency service-life extensions may be granted by the commanding officer of the gaining activity.

SERVICE-LIFE CHANGE

The permanent service life of a CAD may be changed only by a rapid action change (RAC), interim rapid action change (IRAC), or formal change to NAVAIR 11-100-1 as directed by Commander, Naval Air Systems Command (COMNAVAIRSYSCOM), Washington, D.C. If the change affects those items installed in an aircraft, the change will be recorded in the aircraft's logbook.

A line will be drawn through the service-life expiration date shown and the new computed expiration date entered citing the authority for the change; for example, message number, rapid action change number, or change number. Each new expiration date will supersede the previous date. The latest expiration date entered in the aircraft logbook will always be the final date the CAD may remain installed in the aircraft.

When a contingency service-life extension has been authorized for a specific CAD, the new computed service-life expiration date (month and year) will be added to the original aircraft logbook entry for that CAD. When an additional service-life extension has been granted for a specific CAD, the new service-life expiration date (month and year) will be added to the original aircraft logbook entry.

CAD MAINTENANCE POLICY

Learning Objective: Identify CAD maintenance policy to include SMDC and FCDC maintenance and inspection requirements and safety precautions.

CAD maintenance policy prohibits unauthorized maintenance or adjustment to a CAD at any of the three levels of maintenance: organizational, intermediate, or depot. Authorized maintenance actions are limited to removal, inspection, and replacement unless specifically detailed in the aircraft MIM or by a technical directive.

CADS and items of equipment in ejection systems are for one-time use only. They are never to be refurbished or used again after firing. This is equally true of functional equipment, rigid lines, plumbing lines, and hoses. Ejection seats and escape system components that have been used in an ejection or fired, regardless of apparent condition, are prohibited from reuse and must be disposed of as directed by OPNAVINST 4790.2, OPNAVINST 3750.6, and the applicable CAD and rocket manual.

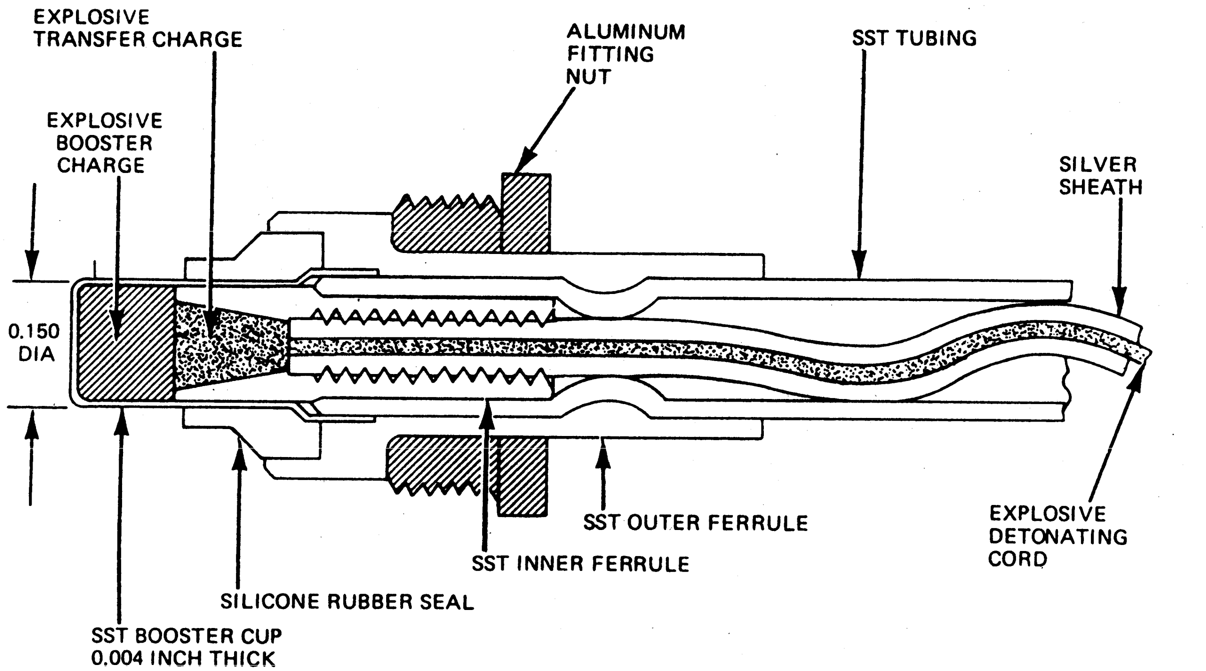
Because of the extreme stress and strain to the ejection seats and escape system components during ejection, they cannot be reused. This stress could reduce the structural or mechanical reliability y of these items. In the case of an inadvertent firing of a cartridge or CAD, all contaminated ballistic lines and devices must be replaced because of the corrosive nature of the explosive.

The service life of wire-braid, teflon-lined hoses installed in ballistic applications is the same as that of the aircraft in which it is installed, unless it is used. A hose is considered to be used if the device to which it is attached is fired, either intentionally or accidentally. If this occurs, the hose and related fittings must be replaced. Before you install a hose or fitting (line, T, elbow, etc.), make sure that it is not contaminated by hydraulic fluid, oil, or a similar type of contaminant. All hoses in the escape system must be inspected for accidental damage at every phased inspection, upon seat removal, after removal of any part of the escape system, and for disconnection of any hose.

When CADs are not installed in an aircraft, the inlet and outlet ports must be sealed with protective closures to prevent the entrance of moisture and foreign matter. For shipping purposes, the safety pins and protective closures provided with the replacement CAD must be returned with the replaced CAD to ensure it is in a safe condition during handling and storage. During ejection system maintenance actions, all disconnected CADs and associated ballistic lines must be protected with flexible plastic plugs that conform to MIL-C-5501/l0A and flexible plastic caps that conform to MIL-C-5501/l1. NAVAIR 11-100-1.1 provides information relating to these caps and plugs.

SMDC AND FCDC MAINTENANCE AND INSPECTION REQUIREMENTS

The major components of an SMDC assembly are the stainless steel tubing (SST), outer and inner ferrules, a silicone rubber seal, a 0.004-inch thick SST booster cup, an explosive booster charge, and a sheathed explosive detonating cord. A sectioned drawing of a standard SMDC/FCDC tip assembly is shown in figure 2-19. The SMDC assemblies used in the canopy and hatch severance system are similar in design and construction except for the length and bend configuration of the stainless steel tubing and silver sheathed explosive detonating cord.



214.179

Figure 2-19.—Standard SMDC/FCDC tip assembly.

To properly inspect SMDCs and FCDCs, you should adhere to the following requirements and precautions:

1. Ensure ground safety devices required during maintenance are correctly installed.

2. To prevent damage to the SMDC and FCDC booster tips, you should use extreme caution during removal and installation. All open connections must be capped with protective covers to prevent damage to SMDC and FCDC booster tips and contamination of open fittings.

3. Inspect each SMDC and FCDC assembly fitting nut for deformation, flattening, or wrench cutting.

4. There must be no corrosion, cracks, discoloration, flatness, gouges, holes, improper bends, kinks, sharp dents, splits, swelling, or wrinkles in an SMDC or FCDC assembly.

5. Smooth dents or slight depressions in SMDC or FCDC assemblies, tubing, or hoses are permitted if they do not exceed specified damage limits (fig. 2-20). If the limits are exceeded, the SMDC or FCDC assembly must be replaced.

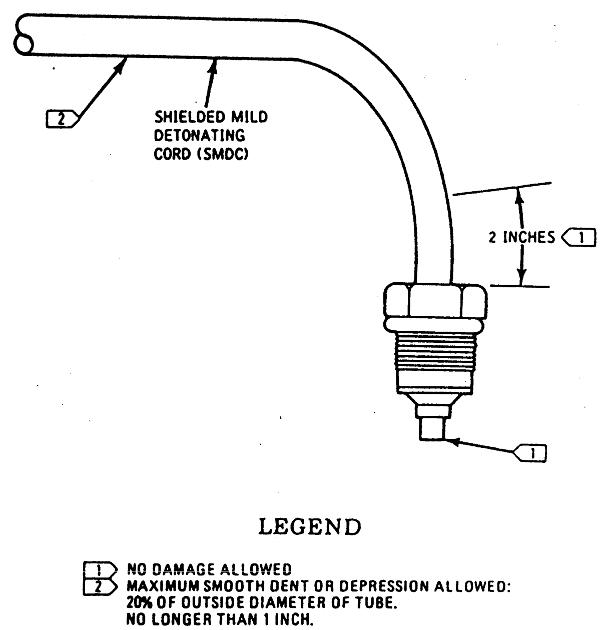


Figure 2-20.—SMDC damage limits.

6. SMDC and FCDC assemblies that do not pass inspection must be replaced. Repair of SMDC tubing is not permitted.

7. Proper clamp spacing (fig. 2-21) must be maintained to prevent damage to SMDCs due to vibration. Improper clamp spacing may result in failure of the SMDC.

SMDC Clearance

Correct clearances must be maintained between SMDCs, SMDC and adjacent structures, and tubing and operating mechanisms. Insufficient clearances may result in damage to or failure of the SMDC. You must ensure SMDCs are installed with proper clearances as listed below:

1. Minimum required clearance between any supported section of SMDC and the adjacent structure is 1.00 inch.
2. Minimum required clearance between any straight, unsupported section of SMDC and an adjacent structure is 0.25 inch.
3. Minimum required clearance between any two parallel SMDCs is 0.10 inch.
4. Minimum required clearance between any two supported nonparallel SMDCs is 0.10 inch.
5. Minimum required clearance between any two unsupported nonparallel SMDCs is 0.10 inch.
6. Minimum required clearance between any supported section of SMDC and any operating mechanism is 1.00 inch.

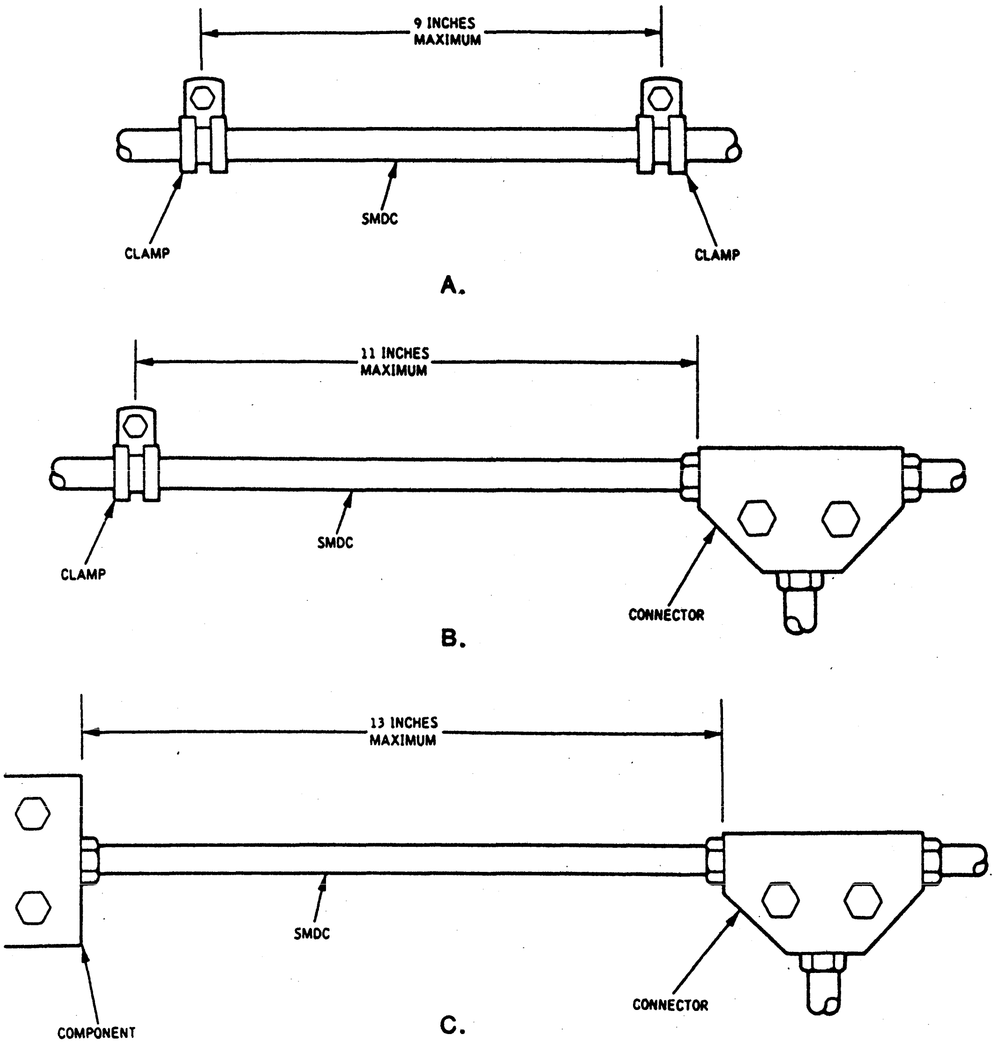


Figure 2-21.—SMDC clamp spacing.

7. Minimum required clearance between any unsupported section of SMDC and any operating mechanism is 1.00 inch throughout the full operating range of the mechanism.

8. Minimum required clearance between any supported section of SMDC and an electrical wire bundle is 0.25 inch, if both are clamped in the same vicinity.

9. Minimum required clearance between any unsupported section of SMDC and an electrical wire bundle is 0.25 inch above the wire bundle or 1.00 inch below the wire bundle.

Booster Tip and Ferrule Inspection

Inspection requirements for SMDC booster tips are as follows:

1. No damage, however slight, is permitted on SMDC or FCDC booster tips or skirted ferrules. If any damage is observed, the SMDC or FCDC must be replaced. Shiny surfaces on booster tips are permitted.

2. If the ferrule is loose or partially swivels, the SMDC or FCDC must be replaced. This may be determined by holding the skirted ferrule and attempting to rotate it radially.

Detonating Cord Inspection Gauge Set

The SMDC or FCDC booster tip must be inspected for correct length and alignment (fig. 2-22). Use the detonating cord inspection gauge set, part number A51562680-1, in the following manner:

1. Use the correct size gauge for booster tip inspection.

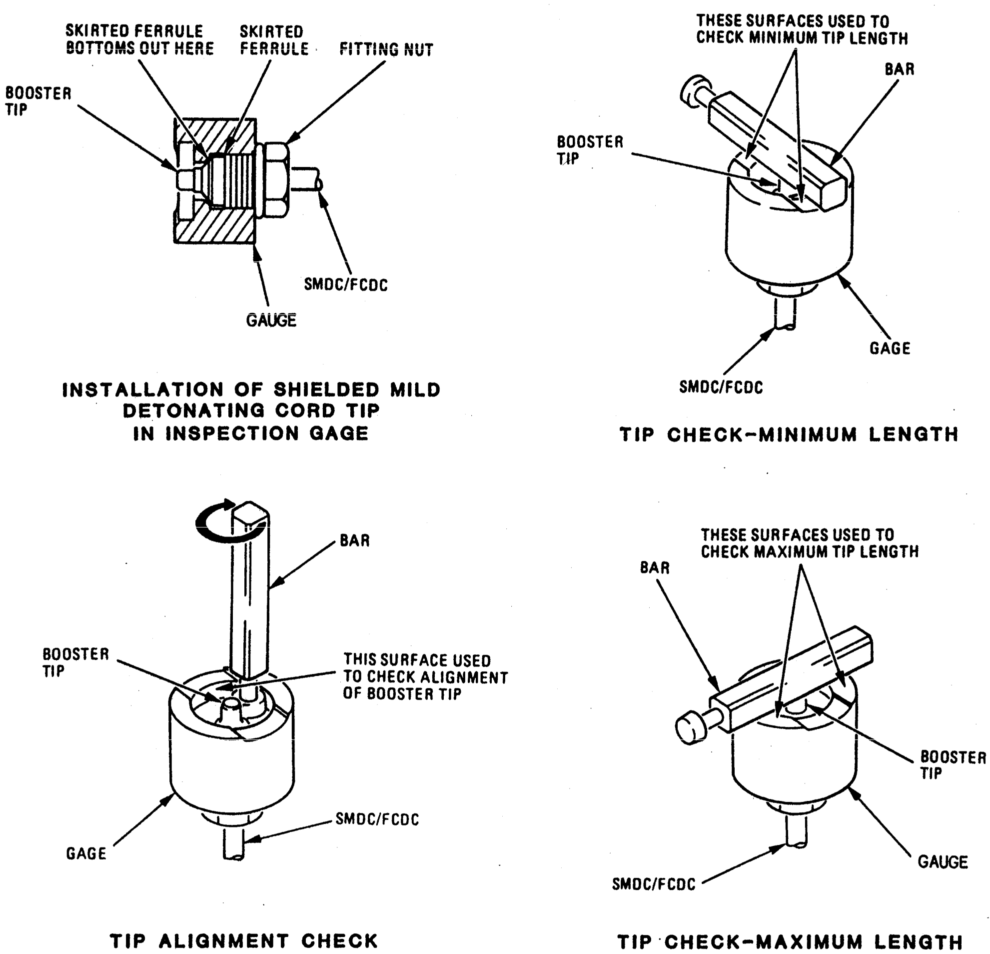


Figure 2-22.—SMDC/FCDC booster tip inspection.

2. Screw the detonating cord inspection gauge onto the fitting nut until the skirted ferrule bottoms in the gauge.

3. Place the flat surface of the bar against the recessed portion of the gauge. If the booster tip is too short, the bar will contact flats on both sides of the gauge. In this case, the SMDC or FCDC must be replaced.

4. Place the flat surface of the bar against the raised portion of the gauge. If the booster tip is too long, the bar will contact the tip and one side of the gauge. Again the SMDC or FCDC must be replaced.

5. Place the cylindrical end of the bar in the space between the gauge and the booster tip. If the booster tip is not concentric within 0.010-inch tolerance in radius, the bar will not pass completely around the booster tip. The SMDC or FCDC must be replaced.

6. If a condition exists that requires the SMDC or FCDC to be replaced, tag it as defective.

Booster Tip Repair

Repair of SMDC booster tips is limited to replacement of packings on the tips and replacement of a damaged seal (fig. 2-23.) The following instructions apply to the repair of booster tips:

1. Visually inspect the seal.
2. If it is damaged, remove the seal.
3. Use a clean cloth moistened with Nozel No. 18 solvent to clean the existing adhesive.
4. Apply a thin coat of RTV-102 adhesive to the inside diameter of the skirted ferrule. Ensure that the adhesive does not come in contact with the booster tip.
5. Install the seal on the tip.
6. Allow the tip to dry and reinstall the SMDC. Tighten the SMDC with your fingers to prevent stripping of the nut.
7. Tighten the SMDC or FCDC fitting nut to the proper torque in accordance with the MIMs and safety it with lockwire.
8. Quality assurance personnel will inspect all SMDC and FCDC fitting nut torquing and safetying.

SAFETY PRECAUTIONS

Cartridges used in cartridge-actuated personnel escape devices must function perfectly the first time. Malfunction of the device, or failure to fire when needed, usually results in severe injury to or death of the pilot and crew member(s), and damage to or destruction of the aircraft.

Cartridges are carefully designed and manufactured, but their performance in cartridge-actuated devices is dependable only when they have been properly handled and installed. Care must be observed to maintain the devices in perfect condition.

Since individual cartridges cannot be tested, the responsibility for proper functioning is in the

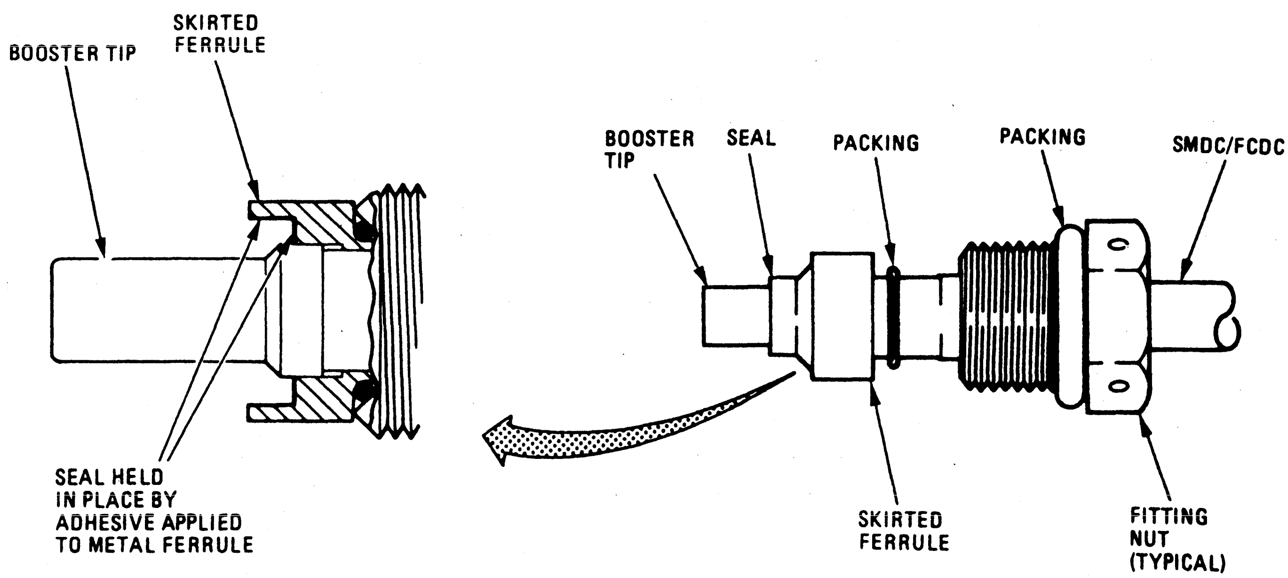


Figure 2-23.—SMDC/FCDC booster tip repair.

hands of the supervisor and the personnel who maintain them. The quality and reliability of an ejection system are largely dependent on the supervisors and the mechanics who maintain the systems. Because the safety precautions presented in this chapter are basic and general in nature, you should consult other publications for the specifics related to the task at hand.

Smoking

Smoking must be prohibited in any magazine, building, vehicle, or other conveyance or area containing explosives or ammunition; where operations involving such material are conducted; and in the immediate vicinity of handling or loading operations involving explosives or ammunition. Smoking areas maybe designated by the commanding officer.

Magazines

Naked lights, matches, lighters or other spark, flame, or heat-producing devices must NEVER be taken or stowed in magazines or other areas containing explosives.

Cartridges

If a cartridge is removed from a cartridge-actuated device, it should be marked for identification so it can be reinstalled in the same device. A deformed or dented cartridge or CAD might not fit properly in the equipment for which it was designed; therefore, in handling, special care must be exercised to prevent them from being struck or dropped.

Assistance

Under no circumstances should any person reach within or enter an enclosure for the purpose of servicing or adjusting explosive equipment without the immediate presence or assistance of another person capable of rendering aid.

Contamination

Operational activities must not apply anti-corrosive materials to CADs. When anticorrosive material is being applied to any item in the vicinity of CADs or associated equipment, every precaution will be exercised to prevent contamination of the CADs or associated equipment. Contamination of CADs can have a detrimental effect on the function of the system.

Shock

Electrically initiated cartridges must be kept away from stray electrical currents. Under certain conditions, dangerous potentials can be stored in circuits after the power source has been disconnected because of charges retained by capacitors. To avoid casualties, you should always disconnect the power source and discharge and ground circuits prior to touching them.

Reporting

All malfunctions, discrepancies, and accidents involving CADs must be reported by message to NAVORDSTA, Indian Head, Maryland in accordance with OPNAVINST 4790.2. If the suspected defect is with the CAD, the message must be addressed to NAVORDSTA for action. If the report describes an inadvertent actuation of an aircraft system resulting in the CAD functioning normally, the action copy of the report must be submitted to the cognizant field activity (CFA) for the aircraft with an information copy to NAVORDSTA, Indian Head, Maryland. Accidents and incidents involving CADS may require reporting in accordance with OPNAVINST 3750.6 in addition to the OPNAVINST 4790.2. Submission of the reports required by the maintenance instruction does not satisfy the requirements of the safety instruction. If dual reporting is required, you should ensure the reports are adequately cross-referenced to satisfy the requirements of all commands involved.

All CADs suspected of being inconsistent, of malfunctioning, or of being involved in an accident or incident must be clearly identified and turned in to the station or ship's ordnance or weapons department. Mark the item "hold for 30 days for engineering investigation (EI) pending disposition instructions." The report should contain the turn-in document number and identify the activity holding the material. If CFA response is requested, NAVORDSTA will respond with complete disposition and shipping instructions. If a response is not received within 15 days, a follow-up message must be sent to NAVORDSTA to verify their receipt of the original report.

All cartridges and cartridge-actuated devices must be handled as live ammunition. Cartridges or cartridge-actuated devices that have been fired may retain an explosive residue capable of presenting a hazardous condition. The ejection seat, parachutes, and survival equipment with installed CADs must be stored and handled by authorized personnel only. They must be stored and handled only in an area designated and approved by the maintenance officer.

Safety devices and pins must be kept in good condition and used only with the individual CAD for which they were designed. When a loaded cartridge-actuated device is not in use, the safety device or pin must be installed. Substitute materials must not be used to replace safety pins installed in CADs. If inlet and outlet ports are present in a CAD, they must be covered with a protective cap. If a protective cap is not available, you should use the shipping cap when the device is not installed.

Except in an emergency and by proper authority, CADs must not be installed in or removed from aircraft during fueling or defueling operations.

CADs installed on or in ejection seats, parachutes, or survival equipment that remain installed during maintenance evolutions do not require removal prior to storage in the maintenance space. CADs removed from ejection seats, parachutes, or survival equipment must be properly safetied and protective caps and plugs must be installed as required. Removed CADs must be stored in a ready-service magazine approved for Class C ammunition storage unless they are required for reinstallation on the same day; in which case, they must be stored in the area approved by the maintenance officer.

Markings

When the sealed inner container of a CAD is opened, all CADs in the container must be stenciled with indelible ink to show the computed container open date and expiration date. Before inserting a cartridge in a cartridge-actuated device, the cartridge expiration date must be checked to ensure the cartridge will not become overage before the next periodic maintenance of the aircraft in which it is to be installed.

Problem Areas

The Naval Safety Center receives messages of interest to AMEs. The following paragraphs contain a few examples of some of the problems that have been received by the safety center related to ejection seats.

Several instances have been reported concerning cartridges stuck in ejection seat systems. This problem is not new, but it still warrants concern as the problem still exists. Some of the causes of stuck CADs are overtorquing during installation, incorrect tools used for removal and installation, and the use of incorrect seals or lubricants. To avoid stuck CADs, you should ensure that correct procedures and parts are used during installation. If correct procedures are followed, the CADs should not stick and removal with the prescribed tool should be possible.

Another message described two ejection seats that required 150 man-hours each to treat for corrosion. This is a tremendous amount of time to spend for corrosion control on ejection seats. If a unit waits until a major inspection cycle to treat a system for corrosion, it will require extensive man-hours to remove corrosive properties that have formed. Most metals will corrode, but the corrosion can be controlled. Remember, the 7-, 14-, and 28-day inspections provide the opportunity to discover corrosive areas and to treat them before they become major problems.

Ejection seats and ejection system components that have been used in an ejection or fired are prohibited from being used to locally construct squadron or unit training services. The policy of the Chief of Naval Operations (CNO) is that ejection seat maintenance and aircrew training will be provided in a formally structured course of instruction.

An aircraft's ejection system is an aviator's last resort to save his/her life when disaster is imminent. The system must be maintained with the highest standards of workmanship possible.

ORDNANCE CERTIFICATION PROGRAM

Learning Objective: Identify the reason for the ordnance certification program.

All personnel involved in the handling, preparation, inspection, or adjustment of live ammunition must be qualified and certified for the task involved in accordance with OPNAVINST 8023.2, as augmented by the fleet commander, type commander, and NAVSEA Instructions. Only reliable, mentally sound, and physically fit personnel will be permitted to work with or use explosives and ammunition. The procedures and circumstances for revocation of an individual's qualification and certification are set forth in OPNAVINST 8023.2.

All personnel must be frequently instructed in the safety precautions, methods of handling, storage, and uses of the ammunition or explosives they handle. No one will be permitted to inspect, prepare, or adjust live ammunition and explosives until the duties, preparations, and hazards involved are thoroughly understood.

Personnel assigned to operate ordnance equipment must receive, prior to commencing operation, a thorough indoctrination in general safety precautions applicable to ordnance and in the specific precautions applicable to the equipment. New or inexperienced personnel must not be permitted to work independently on explosive ordnance of any kind. They must be under the direct and constant supervision of skilled, experienced, and certified personnel until adequate experience is acquired.

Familiarity with any work, even though dangerous, may lead to carelessness. Therefore, personnel who supervise or perform work in connection with the handling, inspection, installation, and care of cartridges must observe the following restrictions:

1. Ensure that all applicable regulations are rigidly observed.
2. Carefully supervise the activities of all subordinate personnel.
3. Inform all personnel of the constant need for using the utmost vigilance in the performance of their work.

AME supervisors that are assigned to commands that handle ordnance or ejection seats should be thoroughly knowledgeable about aircraft logbooks and the aeronautical equipment service record (AESR) of the logbooks. These are covered in the *Aviation Maintenance Ratings 1 & C*, NAVEDTRA 10343, and OPNAVINST 4790.2.

The AME supervisor should keep records of explosive devices and their expiration dates. Some commands incorporate local cards or sheets that include the functional checks, pin protrusions, torque valves, and CDI and QAR requirements. Blank cards or sheets are provided for individuals to sign upon completion. MRC numbers can be incorporated for assignment to ensure that each step is completed before the next step is started. This procedure is advantageous during a shift change or work stoppage.

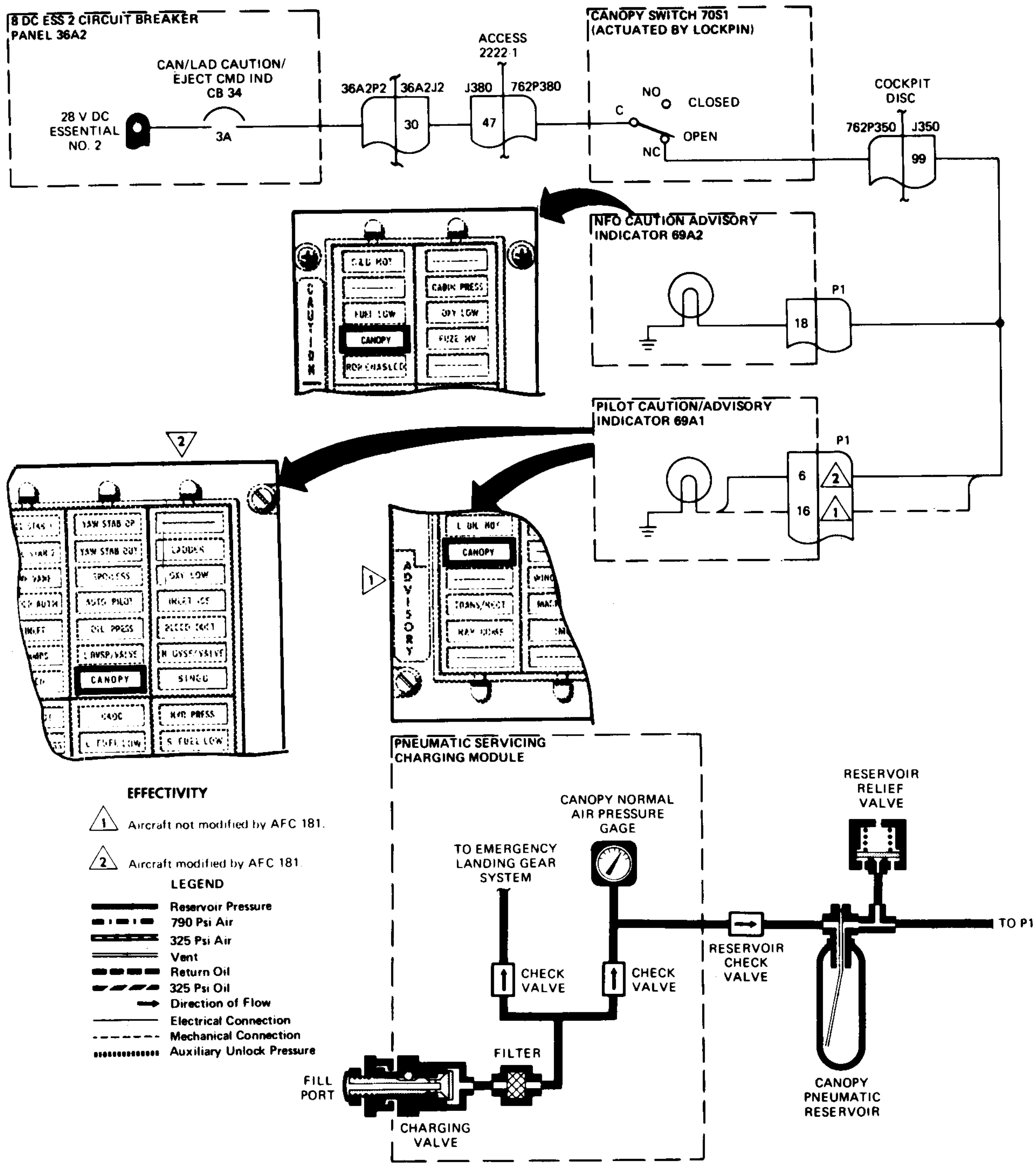


Figure 2-2A.—Pneumatic canopy system (normal opening mode).

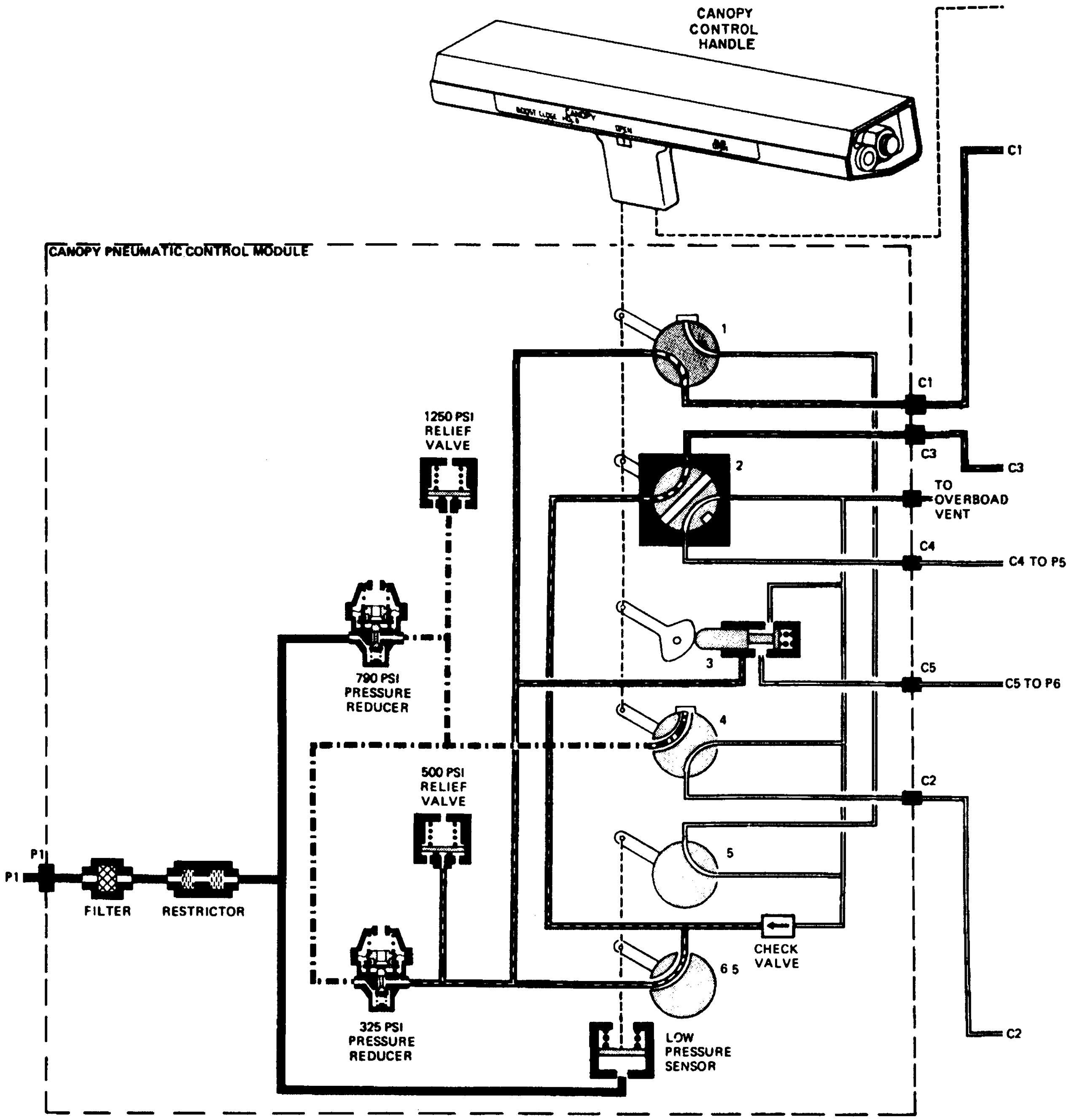


Figure 2-2B.—Pneumatic canopy system (normal opening mode)-Continued

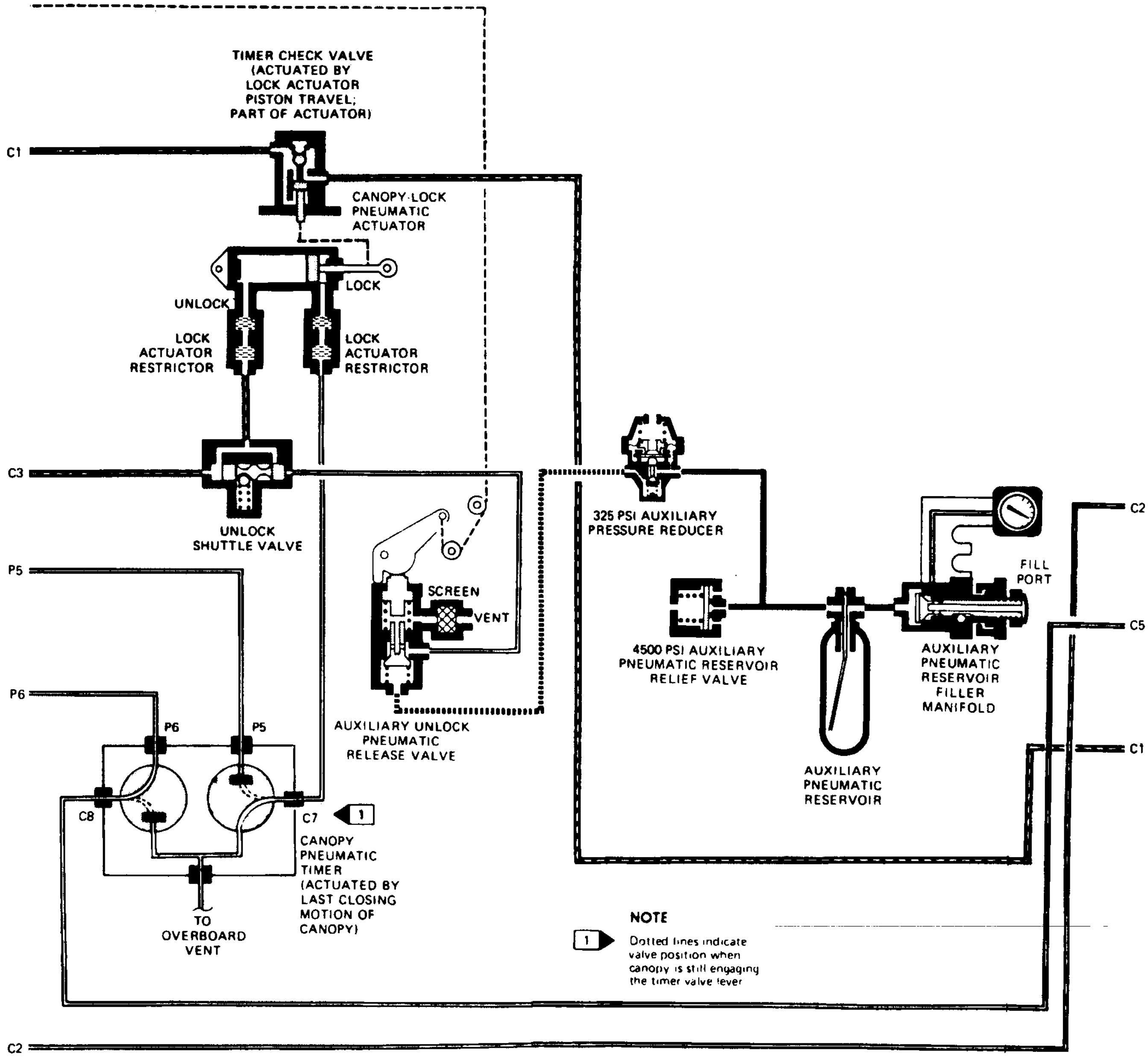


Figure 2-2C.—Pneumatic canopy system (normal opening mode)-Continued

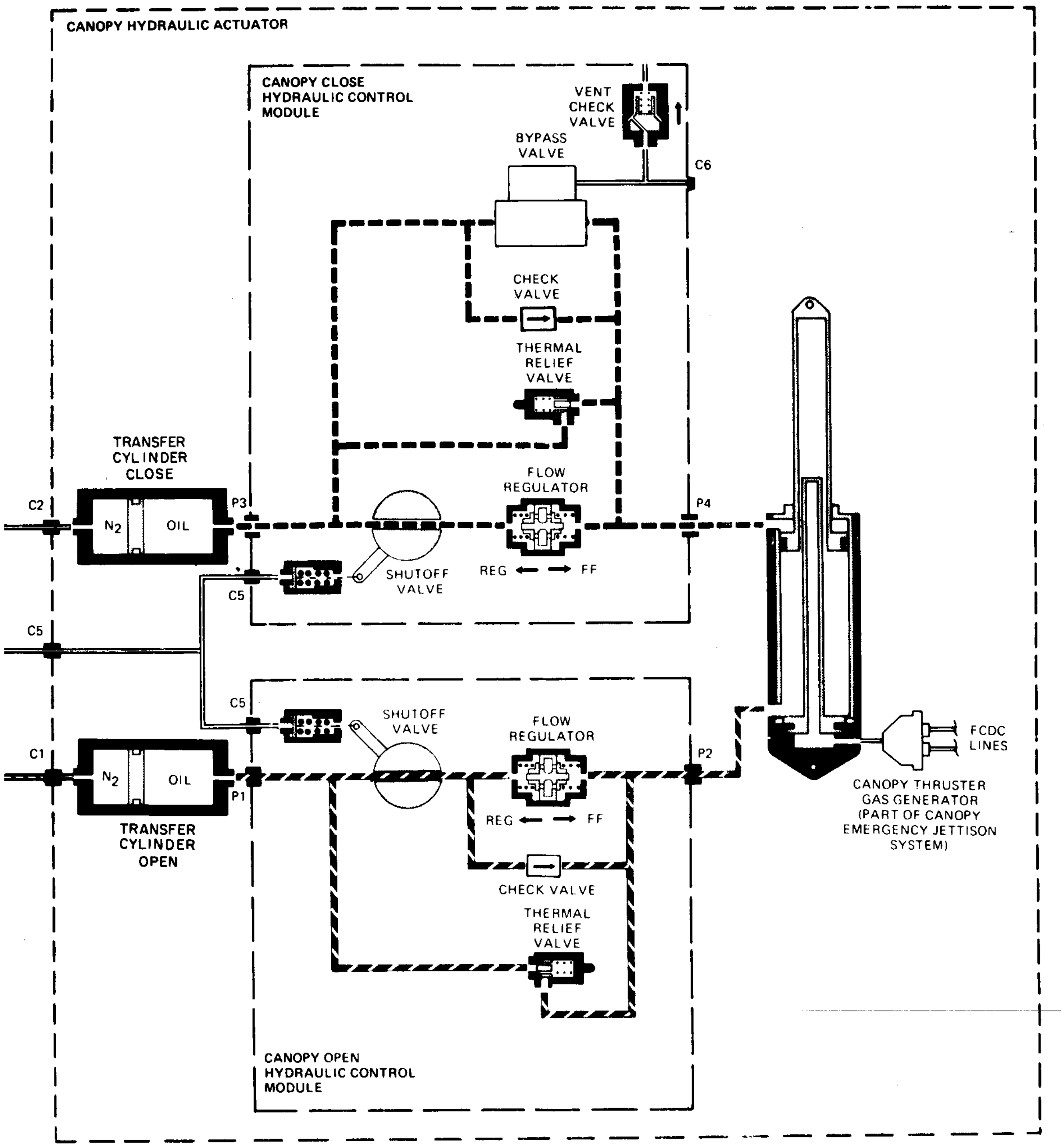


Figure 2-2D.—Pneumatic canopy system (normal opening mode)-Continued

CHAPTER 3

PRESSURIZATION AND AIR-CONDITIONING SYSTEMS

Terminal Objective: Upon completion of this chapter, you will be able to recognize the operational and component differences between air cycle and refrigerant cycle air-conditioning systems (ACS).

Transferring a human being from his natural environment on the earth's surface to the environment existing at 40,000 feet places him in surroundings in which he 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 the earth's atmosphere tells us why this condition exists.

STRUCTURE OF THE ATMOSPHERE

Learning Objective: Recognize the affect high altitude flight could have on flight personnel because of decreased atmospheric pressure.

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 the 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 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, he automatically raises his ribs and depresses his 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 he exhales, he reduces 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 he gets fewer molecules of air in each breath, he also gets fewer molecules of oxygen, and no person can live unless he gets 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 would occur at a height of about 7 miles.

NOTE: The conversion formula for converting Fahrenheit to Celsius (centigrade) is $\frac{5}{9}$ (F-32).

For example, – 4°F is converted as

$$\frac{5}{9}(-4 - 32) = \frac{5}{9} \text{ of } -36 = -20\,^{\circ}\text{C}.$$

Conversion of a Celsius temperature to a Fahrenheit reading is accomplished using the following formula:

$$\frac{9}{5}{}^{\circ}\text{C} + 32$$

For example, – 55°C is converted as

$$\frac{9}{5}(-55) + 32 = -99 + 32 = -67\,^{\circ}\text{F}.$$

Remember not to drop the + and – signs when converting.

These variations in outside air temperature and atmospheric pressure are considered by the aircraft manufacturer 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 be 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 the 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 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 the electrical units, and heat from the body. Through research and tests, it was determined that the average total temperature of these five heat sources will raise the 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 todays 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 with ducting from the cabin/cockpit system. On other aircraft a separate cooling system may be used primarily for equipment cooling.

ENVIRONMENTAL CONTROL SYSTEMS

Learning Objective: Recognize the need for environmental control systems.

The combined pressurization and air conditioning of the cabin is the function of the aircraft pressurization and air-conditioning system; a system now in all naval aircraft. The inspection and maintenance of this system is one of the important duties of the AME. There are five requirements necessary for the successful functioning of a pressurization and air-conditioning system.

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 the cabin 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.

In addition to the major components, various valves, controls, and other allied 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. The system used as an example in this text is in the F-18 aircraft.

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.

Coverage in this section is limited to air cycle cabin and equipment pressurization and air conditioning.

BLEED-AIR SYSTEM

Bleed air is supplied by the last compressor section of each engine (fig. 3-1, a foldout at the end of this chapter). This bleed air flows from the engines through two engine bleed-air pressure regulation and shutoff valves. The valves are spring-loaded closed when the system is not in use. When air conditioning is selected, the valves open and regulate bleed air to a predetermined pressure. The bleed air then passes through two engine bleed-air check valves, which prevent reverse flow from one engine to the other. At this point the bleed air from both engines enters a common duct and flows through the engine bleed-air secondary pressure-regulating and shutoff valve. This valve is spring-loaded open and regulates the pressure of the combined flow of bleed air from both engines. The regulated bleed air then flows into the primary heat exchanger of the ACS.

There are two overpressure switches (primary and secondary) incorporated in the system to prevent overpressure damage to system components in case of a pressure regulator malfunction. An air isolation valve is located in the system to provide a means of providing bleed air to the ACS when required and during cross starting of engines. These bleed-air components are discussed in the following paragraphs.

Engine Bleed-Air Pressure Regulation and Shutoff Valve

These two valves (fig. 3-1) act as system shutoff valves when air conditioning is not required. They are spring-loaded closed. When air conditioning is selected, an electric solenoid is energized, which unseats a poppet from the vent line. As air flows from the engine, a line downstream of the butterfly valve routes a small amount of the bleed air to the butterfly diaphragm. This air is called control air since its action on the diaphragm is the controlling force for the valve. As pressure builds on the diaphragm, it overcomes spring pressure holding the butterfly closed and the valve opens. As the bleed air passes through the valve, another line upstream of the butterfly routes bleed air to the regulator portion of the valve. As pressure builds and overcomes spring pressure, a poppet is reseated, allowing some of the control air pressure from the open side of the butterfly diaphragm to bleed off. Spring pressure can now start closing the butterfly, thus lowering the bleed-air pressure downstream of the butterfly. In this manner bleed-air pressure is controlled to 75 ± 15 psi.

Engine Bleed-Air Check Valve

These dual-flapper check valves are located downstream of the pressure regulator and shutoff valves (fig. 3-1). They prevent cross-flow of bleed air from one engine to the opposite engine in the event of single engine operation.

Engine Bleed-Air Secondary Pressure-Regulating And Shutoff Valve

This valve is located in the common ducting upstream of the bleed-air check valves (fig. 3-1).

It operates in the same manner as the two engine pressure regulation and shutoff valves with the following exceptions. The valve is normally spring-loaded open and regulates at a set pressure of 110 ± 5 psi, thus acting as a safety regulator in the event one or both engine regulators fail and allow pressure to build up in excess of system design.

Primary Bleed-Air Overpressure Switch

This switch is located downstream of the bleed-air check valves (fig. 3-l). This switch activates at 250 psi and provides a signal to the Digital Display Indicator (DDI). The DDI is located in the nosewheel well of the aircraft and stores failed systems/component code numbers. These code numbers are used in troubleshooting the aircraft after flight, and aids in pinpointing malfunctions rapidly.

Secondary Bleed-Air Overpressure Switch

The pressure switch is mounted in the ducting downstream of the secondary bleed-air regulator. If bleed-air pressure at this point exceeds 150±10 psi, the overpressure switch provides a signal to close the three pressure regulator and shutoff valves as well as store a failed system code number in the DDI.

Air Isolation Valve

The sir isolation valve serves two purposes. First, it is used to cross start engines. After starting one engine on the auxiliary power unit (APU) or ground air, with the APU switch in the off position, the engine crank switch will automatically open the air isolation valve when starting the other engine. Bleed air from the engine running is routed through the air isolation valve to the engine starter control valve (fig. 3-1) of the engine to be started. As the engine accelerates to a self-sustaining speed, the switch automatically returns to the off position. The air isolation valve is then closed by spring pressure.

The air isolation valve can also be used to route APU air to augment the bleed-air supplv to the air-conditioning system at times when engine output is low. This could be when waiting to launch, with engines at idle power and air temperatures high and humid.

BLEED-AIR LEAK DETECTION

The bleed-air leak detection system warns the pilot of a leak in the bleed-air distribution lines or shuts down the system, as necessary. The leak detection system consists of a control unit and nine detectors. When one of the detectors senses an overheat condition, it sends a signal through the control unit. The control unit signals the respective bleed-air pressure regulator to close and lights a warning light on the advisory panel in the cockpit, giving the location of the detector sensing the overheat condition.

AIR CYCLE AIR-CONDITIONING SYSTEMS

Learning Objective: Recognize the operating principles and components 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 hot bleed air. The F-18 air cycle ACS is an example of this type system (fig. 3-2, a foldout at the end of this chapter).

SYSTEM OPERATION

The air cycle ACS was designed to operate by passing hot engine bleed air through the primary heat exchanger where ram air, forced across the heat exchanger by the aircrafts forward motion, absorbs heat from the bleed air, reducing the air temperature. On the ground and during low-speed operation, ram air is pulled across the heat exchangers by hot air ejected into the heat exchanger exit ducts by the primary and secondary heat exchanger ejectors. The cooled bleed air then passes to the flow modulating system pressure regulator valve where, controlled by electrical and pneumatic sensors, the downstream pressure is maintained by regulator modulation. The air enters the compressor end of the refrigeration turbine/compressor assembly where it is compressed to approximately twice its inlet temperature. The compressed air enters the secondary heat exchanger where ram air absorbs the heat acquired through compression. From the secondary heat exchanger, air enters the refrigeration cycle. The cycle is made up of a reheater heat exchanger and a condenser/vent suit heat exchanger and water extractor, which removes 90 percent of the moisture content through repeated heating and cooling. The conditioned dry air is transported to the turbine end of the refrigeration turbine/compressor assembly where it is cooled by rapid expansion. Both the turbine and compressor are protected from overheat damage by the turbine and compressor protective temperature sensors. As the cold dry air leaves the turbine, it is mixed with warm air from the environmental control and related systems, and then it is routed to cockpit and avionics compartments to satisfy environmental control requirements. Air cycle ACS components are discussed in the following paragraphs.

Primary Heat Exchanger

The primary heat exchanger (fig. 3-2) is a cross-flow, air-to-air heat exchanger that uses ram air to initially cool hot engine bleed air. It operates on the same principle as the radiator in an automobile with the bleed air replacing the liquid. Hot bleed air is transported through the heat exchanger core where ram air, forced across the core by aircraft forward motion, absorbs the heat from the bleed air, reducing the air temperature. During ground and low-speed operation, cooling air is pulled across the heat exchanger core by ejecting hot air into the heat exchanger exit duct. The ejected air is controlled by the primary ejector valve in response to signals from the Air Data Computer (ADC). The cooled air exiting the heat exchanger is divided into two ducts that provide air at varying temperatures for use in related systems. The temperature difference occurs because of the distance the bleed air travels through the heat exchanger core.

Primary Ejector Valve

The primary ejector valve is a normally open, in-line poppet, pneumatically actuated, solenoid-controlled shutoff valve. The valve controls the flow of bleed air to the primary heat exchanger ejector in the primary heat exchanger exit duct. The hot bleed air flowing through the ejector nozzles causes an area of low pressure to form at that point. This causes ambient air to flow across the core of the heat exchanger from the high pressure side to the area of low pressure. The valve is controlled by an electrical signal from the ADC. At airspeeds below 100 knots, the ADC provides an electrical ground that energizes the primary ejector control relay to remove power from the valve solenoid, allowing differential pressure to hold the valve open. At airspeeds above 100 knots, the ADC ground is lost. This de-energizes the primary ejector control relay to apply power to the valve solenoid, allowing spring tension to close the valve.

Flow Modulating System Pressure Regulator Valve

The flow modulating system pressure regulator valve is a combination butterfly, modulating valve, and solenoid shutoff valve. The modulating valve is normally open and pneumatically actuated. The valve is in the distribution ducting between the primary heat exchanger and the refrigeration turbine/compressor assembly. The valve uses electrical signals from the avionics temperature/flow sensor by way of the ACS temperature/flow controller to modulate downstream pressure. The valve is also connected pneumatically to the turbine and compressor protective temperature sensors, which override all other valve functions to close the valve to protect the refrigeration turbine/compressor assembly from heat damage during overtemperature conditions. The solenoid shutoff is controlled by the environmental control system (ECS) mode switch, which allows the valve to be opened or closed by dumping control air from the butterfly diaphragm chamber. The valve also includes a visual position indicator. The indicator is built into the valve housing and shows the position of the butterfly.

Avionics Ram Air Servo

The avionics ram air servo monitors the differential pressure of bleed air upstream and downstream of the flow modulating system pressure regulator valve. If the upstream pressure is less than 35 psi and the differential pressure is less than 10 psi, the avionics ram air servo drives the avionics ram air valve open. If downstream pressure is less than 4 psi, the avionics ram air servo drives the avionics ram air valve open. The operation of this valve, though not a part of the ACS, ensures that avionics will receive sufficient cooling air in the event of a low or no airflow condition from the ACS.

Compressor Protective Temperature Sensor

The compressor protective temperature sensor is a pneumatic bleed off thermostat, which contains a fluid-filled sensing element and a ball metering valve. The unit is in the duct upstream of the turbine/compressor assembly. The thermostat is connected pneumatically to the flow modulation system pressure regulator valve and responds to air temperature. As the air temperature increases, the fluid in the sensing element expands and opens the ball metering valve, which vents control pressure from the flow modulating valve. This causes the regulator to close, decreasing the bleed-air flow, which slows the rpm of the turbine assembly, thus protecting it from damage because of overtemperature.

Turbine Protective Temperature Sensor

The turbine protective temperature sensor is identical to the compressor protective temperature sensor except for calibrated temperature and location. The turbine protective temperature sensor is in the turbine inlet duct.

Secondary Heat Exchanger

The secondary heat exchanger is a cross-flow, air-to-air heat exchanger. Hot, high-pressure air, discharged from the compressor end of the refrigeration turbine/compressor assembly, is transported through the core of the heat exchanger where ram air, augmented by water spray, is forced across the core by aircraft forward motion, absorbing heat from the air and reducing the air temperature. During ground and low-speed operation, cooling air is pulled across the heat exchanger core by ejecting hot air into the heat exchanger exit duct. The ejected air is controlled by the secondary ejector valve in response to signals from the ADC.

Secondary Ejector Valve

The secondary ejector valve is a normally open in-line poppet, pneumatically actuated, solenoid-controlled shutoff valve. The valve controls the flow of bleed air to the secondary heat exchanger ejector in the secondary heat exchanger exit duct. The valve is controlled by an electrical signal from the ADC. At airspeeds below 165 knots, this valve operates on the same principle as the primary ejector valve.

Water Spray Nozzle

The water spray nozzle is used to form a mist in the secondary heat exchanger ram air inlet, which aids in cooling the air. Water is extracted from the conditioned air in the water extractor. The water is transported to the water spray nozzle into the secondary heat exchanger ram air inlet. The nozzle directs a jet of water onto a pin, forming a fine sheet of water before breaking up into a mist. The mist is forced across the heat exchanger with the ram airflow.

Reheater Heat Exchanger

The reheater heat exchanger is a single-pass, cross-flow, air-to-air heat exchanger. The reheater heat exchanger cools air from the secondary heat exchanger before moisture removal in the condenser/vent suit heat exchanger and water extractor and simultaneously reheats the dried air before expansion through the turbine end of the refrigeration turbine/compressor assembly. The function of the reheater is to decrease the amount of cooling provided by the condenser heat exchanger and increase turbine inlet temperature, which results in increased turbine power.

Condenser/Vent Suit Heat Exchanger

The condenser/vent suit heat exchanger is a cross-flow, air-to-air heat exchanger, which uses cold turbine discharge air from the refrigeration turbine/compressor assembly to cool and condense moisture from the bleed air before circulation through the water extractor. The heat exchanger inlet receives partially cooled air from the hot side of the reheater and directs it across the condenser core where it is cooled until the water vapor is condensed into large size droplets. The air and water droplets are directed to the water extractor. A separate vent suit heat exchanger is in the condenser assembly. The vent suit heat exchanger receives dry air from the water extractor and cools it by heat exchange with turbine exhaust air for use in the vent suit system.

Water Extractor

The water extractor is an in-line, integral duct device that uses a helix and a water shave-off collector. Moisture-laden air from the condenser enters the water extractor and is given a swirling motion by the helix. The heavy water particles are centrifuged to the duct wall and shaved off into the annular section between the duct wall and reentrant discharge duct. Approximately 3 percent of the total airflow is also shaved off as scavenge air. The scavenge air/water enters the outer chamber, which is surrounded by a perforated muff. In this chamber the water droplets are separated from the scavenge air. The dry scavenge air flows into an end chamber, through a baffle and out through the scavenge port. The water flows through the perforations into a sump and out through the drain port to the water spray nozzle where it is used to augment ram air cooling in the secondary heat exchanger.

Refrigeration Turbine/ Compressor Assembly

The refrigeration turbine/compressor assembly is a centrifugal compressor with a turbine wheel mounted at each end of a common shaft. The compressor end receives partially conditioned air from the flow modulating system pressure regulator valve, where it is compressed to approximately double its inlet value. The air is transported through the secondary heat exchanger, reheater heat exchanger, condenser/vent suit heat exchanger, and water extractor before entering the turbine end of the refrigeration turbine/compressor assembly. The conditioned, dry air flows through turbine nozzles to the turbine wheel where heat energy is changed to mechanical energy, driving the compressor. The expanded, cold air exhausting from the turbine is transported back through the reheater heat exchanger, into ducting, where it is used for environmental control.

Anti-Ice Add Heat Valve

The anti-ice add heat valves is a normally closed, electrically controlled, pneumatically actuated, modulating valve. The valve is between the windshield anti-ice/rain removal manifold and the turbine outlet. The valve is controlled by electrical signals from the ACS temperature/flow controller and differential pressure sensed across the condenser/suit vent heat exchanger. This valve maintains the turbine outlet temperature as required to prevent icing by adding hot air to the conditioned, cold air.

SYSTEM TESTING

Air-conditioning test sets (testers) are used to test ACSs for proper operation and to troubleshoot system malfunctions. Some newer aircraft being introduced into the fleet have an aircraft installed tester. This built-in tester (BIT) performs many tests of the system in flight. The following is an example of the F-18 automatic test sequence.

The ACS BIT starts when electric power is applied to the ACS temperature/flow controller. In-flight BIT is a complete sequence of tests on the ACS temperature/flow controller and 10 electrically interfacing components. Nine seconds are required for a complete BIT sequence, and the BIT sequence is repeated every 90 seconds. If the same test indicates a failure on two consecutive BIT sequences, the BIT processor removes a ground from the signal data converter, and a maintenance code is recorded. After a maintenance code is recorded, BIT is inhibited until electrical power is removed and reapplied. When the aircraft is on the ground, BIT operation is the same as in-flight BIT except that only part of the BIT sequence is performed.

BIT tests the flow modulating system pressure regulator valve to produce the following indications:

BIT tests for OPEN CIRCUITS in the valve torque motor and position feedback transducer during any mode of operation, and will produce a failure signal if an open circuit is detected.

BIT tests for VALVE STUCK OPEN condition by comparing a high avionics airflow condition with a high torque motor current (closing signal to valve). When both of these indications exist, a failure signal is produced.

BIT tests for VALVE STUCK CLOSED when airflow to the cabin and avionics are low. The BIT failure signal is inhibited if the valve position transducer indicates the valve is full open.

COMMON AIR-CONDITIONING COMPONENTS

Some components and hardware are common to all ACSs. Bleed-air ducting is manufactured from stainless steel and can withstand pressures up to 450 psi and temperatures up to 800°F (425°C). These ducts are covered with high-temperature insulation (fig. 3-3) to protect aluminum structures and electrical lines near the ducting. Bellows assemblies are manufactured for two functions. The tolerance compensator (fig. 3-4) can be adjusted in length and allows for easier removal and replacement of the bleed-air duct. The thermal compensator (fig. 3-5) allows for thermal expansion throughout the bleed-air ducting. To support and brace the ducting, flexible mounting brackets are used (fig. 3-6). The use of these and other types of support brackets will vary with location and type of duct used. Air-conditioning distribution lines are manufactured from aluminum alloy and are subjected to relatively low pressures and temperatures.

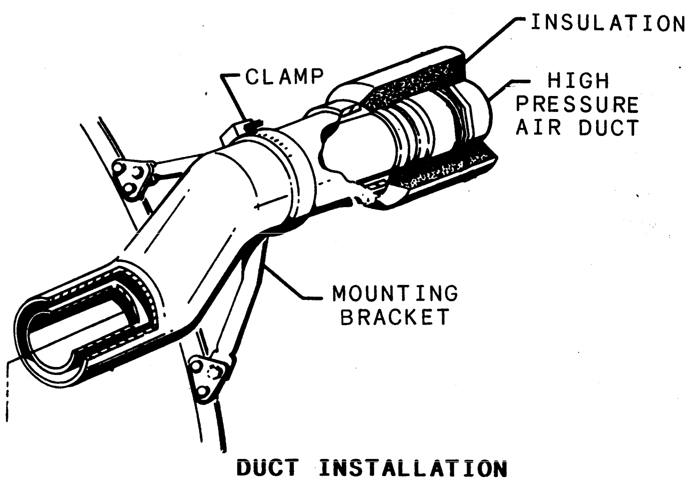
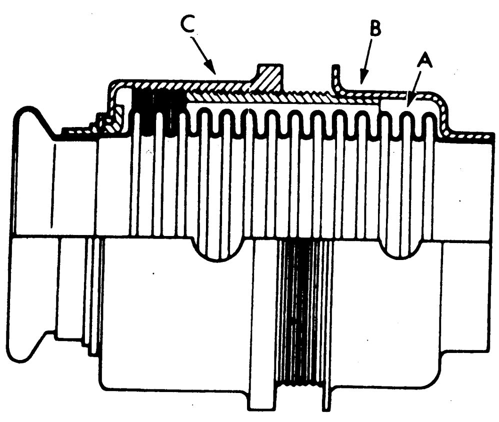
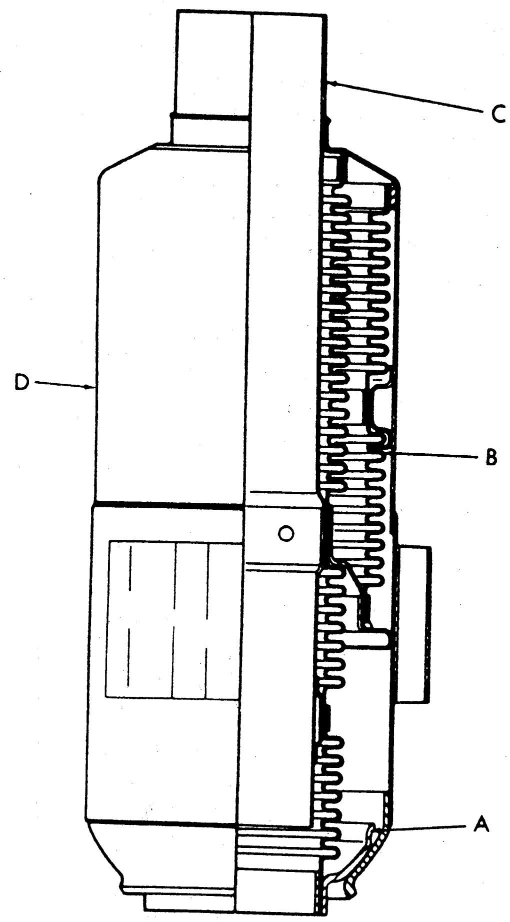


Figure 3-3.—Bleed-air ducting.



A. Bellows assembly
B. Adapter
C. Coupler

Figure 3-4.—Tolerance compensator.



A. Swivel joint
B. Bellows assembly
C. Inner tube
D. Outer chamber

Figure 3-5.—Thermal compensator.

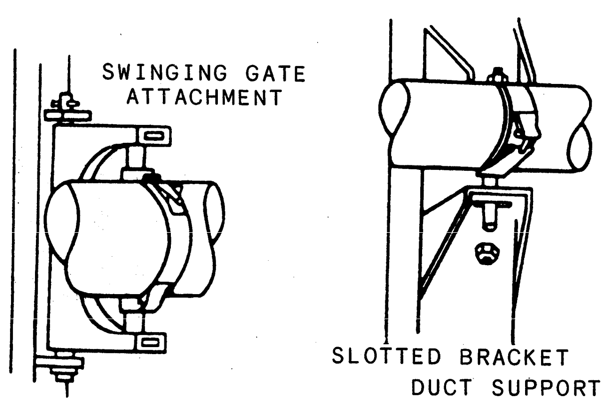


Figure 3-6.—Flexible mounting brackets.

A variety of clamping devices are used in connecting aircraft environmental control system ducting sections to each other or to various components. Whenever lines, components, or ducting are disconnected or removed for any reason, install plugs, caps, or coverings on the openings to prevent the entry of foreign materials. Tag the various parts to ensure correct reinstallation. Care should be exercised during handling and installation to ensure that flanges are not scratched, distorted, or deformed. Flange surfaces should be free of dirt, grease, and corrosion. The protective flange caps should be left on the ducting until the installation progresses to the point where removal is necessary to continue with the installation.

In most cases it is mandatory to discard and replace seals and gaskets. Ensure that seals and gaskets are properly seated and that mating and alignment of flanges are fitted so that excessive torque is not required to close the joint and impose structural loads on the clamping device. Adjacent support clamps and brackets should remain loose until installation of the coupling has been completed.

Marman type clamps commonly used in ducting systems should be tightened to the torque value indicated on the coupling. Tighten all couplings in the manner and to the torque value as specified on the clamp or in the applicable MIM.

Some of the most commonly used plain band couplings (flexible line connectors) are illustrated in figure 3-7. When installing a hose between two

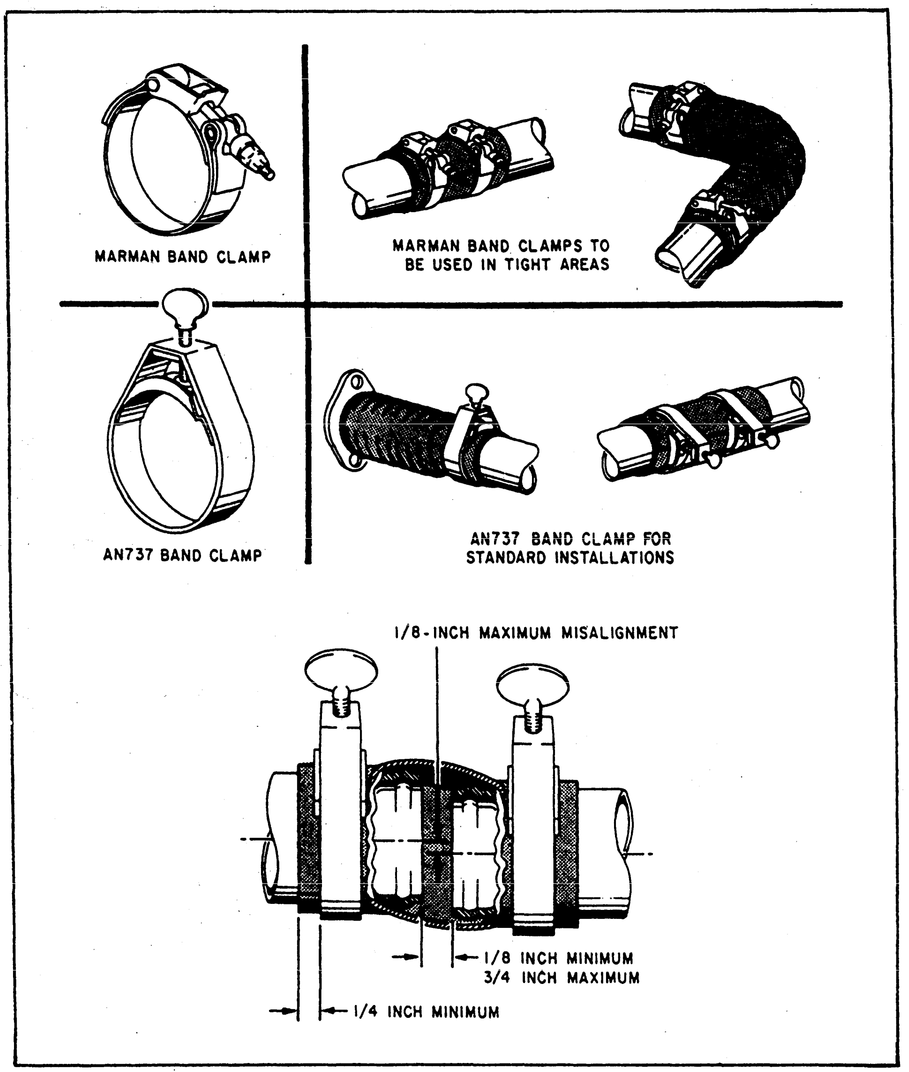


Figure 3-7.—Flexible line connectors.

duct sections, as illustrated in figure 3-7, the gap between the duct ends should be 1/8 inch minimum to 3/4 inch maximum. When installing the clamps on the connection, the clamp should be 1/4 inch minimum from the end of the connector. Misalignment between the ducting ends should not exceed 1/8 inch maximum.

When installing flexible line connectors, such as the one illustrated in figure 3-8, follow the steps listed below to assure proper installation and security:

1. Fold back half of the sleeve seal and slip it onto the sleeve.

2. Slide the sleeve (with the sleeve seal partially installed) onto the line.

3. Position the split sleeves over the line beads.

4. Slide the sleeve over the split sleeves and fold over the sleeve seal so that it covers the entire sleeve.

5. Install the coupling over the sleeve seal and torque to correct value.

NOTE: Torque values for the various sizes and types of couplings maybe found by referring to the applicable MIM. Some couplings will have the correct torque value marked on the outside of the band.

When installing rigid line couplings, follow the steps listed below and illustrated in figure 3-9:

1. Slip the V-band coupling over the flanged tube.

2. Place a gasket into one flange. One quick rotary motion assures positive seating of the gasket.

3. Hold the gasket in place with one hand while the mating flanged tube is assembled into the gasket with a series of vertical and horizontal motions to assure the seating of the mating flange to the gasket.

NOTE: View B of figure 3-9 illustrates the proper fitting and connecting of a rigid line coupling, using a metal gasket between the ducting flanges.

4. While holding the joint firmly with one hand, install the V-band coupling over the two flanges.

5. Press the coupling tightly around the flanges with one hand while engaging the latch.

6. Tighten the coupling firmly with a ratchet wrench. Tap the outer periphery of the coupling with a plastic mallet to assure proper alignment of the flanges in the coupling. This will seat the sealing edges of the flanges in the gasket. Tighten again, making sure the recommended torque is not exceeded.

7. Check the torque of the coupling with a torque wrench and tighten until the specified torque is obtained.

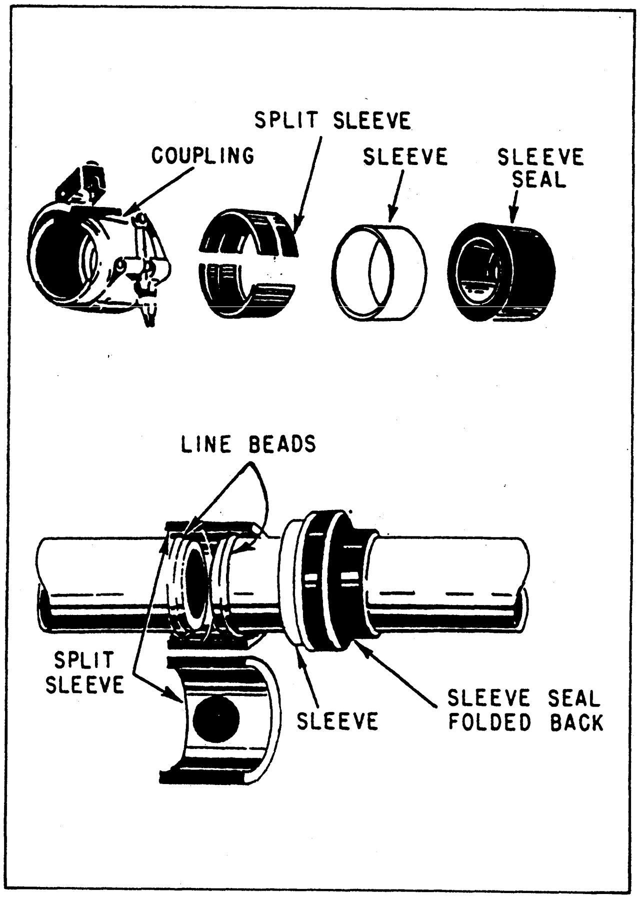


Figure 3-8.—Installation of flexible line connectors.

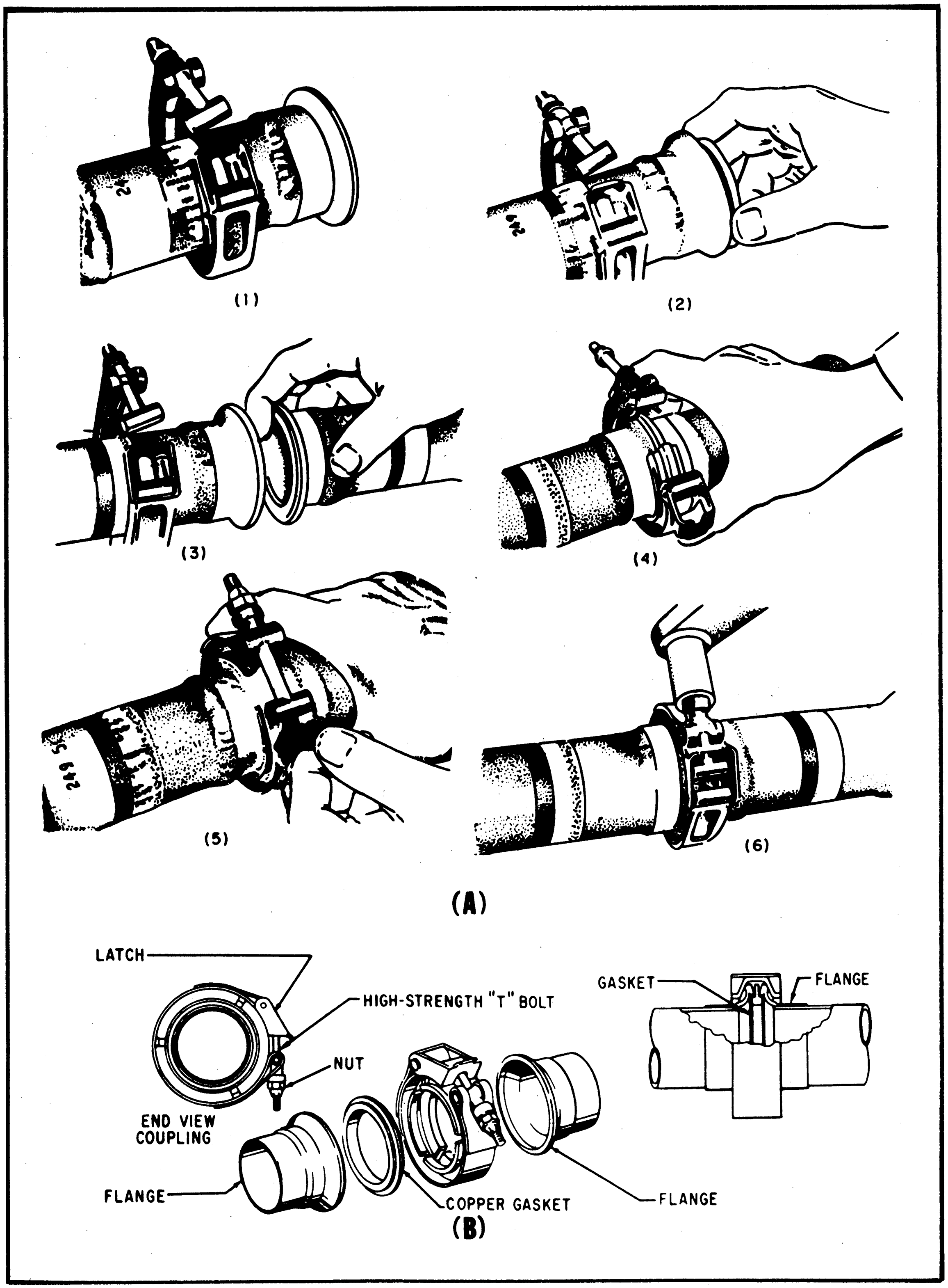


Figure 3-9.—Installation of rigid line couplings.

CABIN COOLING AND ANTIFOG SYSTEMS

Learning Objective: Recognize the components and functions of cabin cooling and antifog systems.

The F-18 aircraft cabin cooling and antifog system (fig. 3-10) controls and transports conditioned air to the cabin. Conditioned air from the air cycle ACS is transported to the cabin flow valve where cabin inlet airflow is controlled by signals from the cabin airflow/temperature sensor through the ACS temperature/flow controller. Air leaving the cabin flow valve is mixed with hot air from the cabin add heat valve through signals from the suit/cabin temperature control, cabin airflow/temperature sensor, and the ACS temperature/flow controller. The conditioned air is divided between cabin air and windshield defog air by the cabin defog plenum distribution valve through the control handle and linkage and push-pull control.

Cabin cooling and antifog components are discussed in the following paragraphs.

CABIN FLOW VALVE

The cabin flow valve is a normally open, electropneumatically controlled modulating valve. The valve responds to signals from the cabin airflow/temperature sensor and the ACS temperature/flow controller to maintain cabin inlet airflow at a differential pressure above cabin pressure. A control circuit in the ACS temperature/flow controller compares the signal from the cabin airflow/temperature sensor with a preset reference and produces the required signal to modulate the cabin flow valve to satisfy the flow requirements. A position indicator is visible on the valve body.

CABIN ADD HEAT VALVE

The cabin add heat valve is an electropneumatic, butterfly, modulating valve. The valve modulates hot airflow into the cabin inlet duct in response to electrical signals from the cabin airflow/temperature sensor through the ACS temperature/flow controller and suit/cabin temp control. As cabin inlet air temperature decreases to below the required level, as selected by the suit/cabin temp control, the cabin airflow/temperature sensor and ACS temperature/flow controller provide an electrical signal to the valve torque motor, allowing regulated air pressure to open the valve. When electrical current to the valve is below a minimum, the valve is held closed by spring pressure. If a cabin air supply overtemperature occurs, the cabin air overtemperature sensor vents control pressure from the valve, allowing it to close. A position indicator is visible on the valve body.

CABIN AIR OVERTEMPERATURE SENSOR

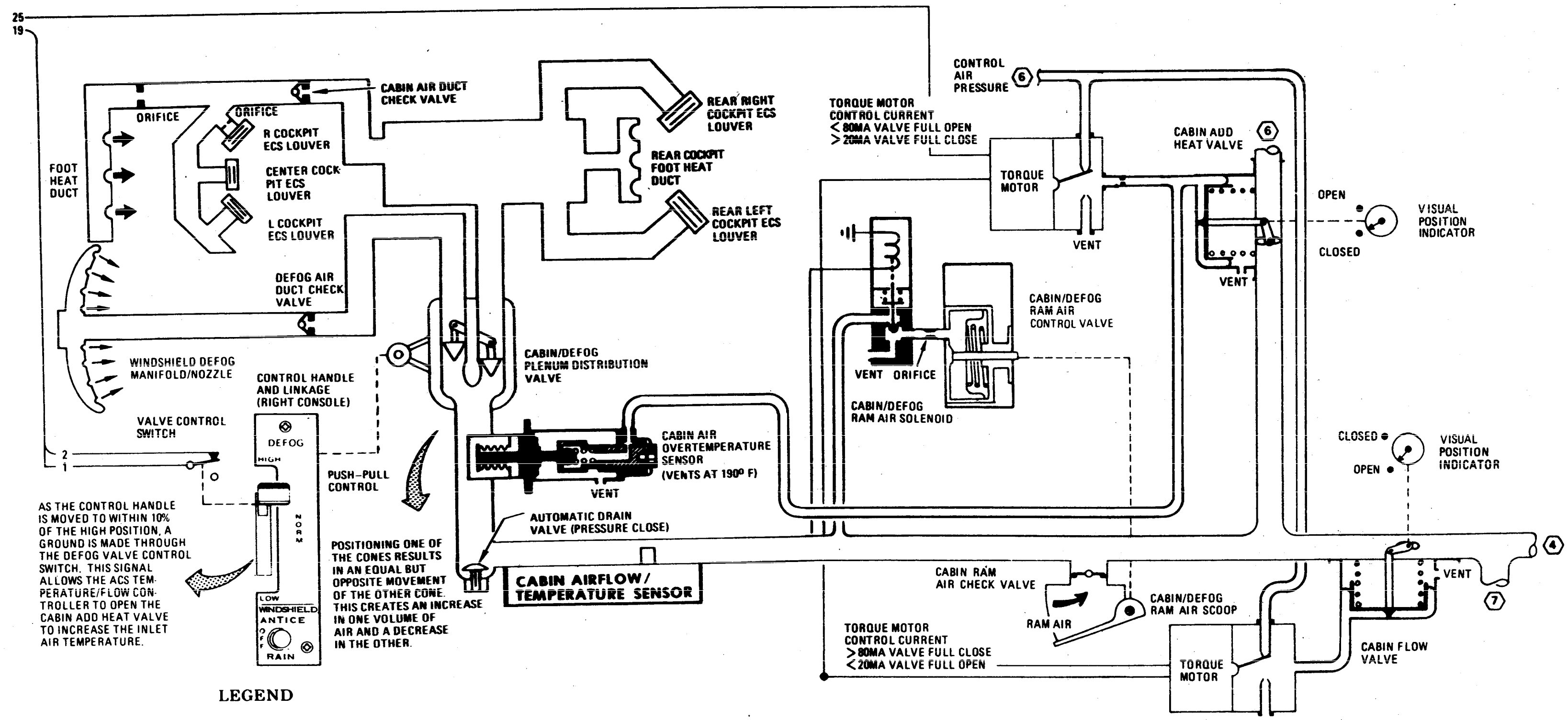
The cabin overtemperature sensor is a pneumatic bleedoff type. It is installed in the cabin distribution duct downstream of the cabin add heat valve. At a preset temperature, the expansion bellows unseats a ball. Control head pressure is vented overboard allowing the cabin add heat valve to close.

ECS RAM AIR ACTUATOR ASSEMBLY

The actuator part of the ram air system supplies mechanical force to extend the ram air scoop. The actuator is connected to the ram air scoop through linkage. It is held closed when air pressure is applied and the ECS ram air solenoid is de-energized. The actuator opens when there is a loss of air pressure or when the solenoid is energized.

ECS RAM AIR SOLENOID ASSEMBLY

The solenoid assembly is mounted in the duct upstream of the actuator for the ram air scoop.



LEGEND

1. ALL WIRE NUMBERS, SPLICE POINTS AND GROUND POINTS ARE SHOWN IN A1-F18A( )-WDM-000.

(2) SUIT VENTILATION SYSTEM SIMPLIFIED SCHEMATIC WP011 00.

(3) RADAR LIQUID COOLING SYSTEM SIMPLIFIED SCHEMATIC WP013 00.

(4) AIR CYCLE AIR CONDITIONING SYSTEM SIMPLIFIED SCHEMATIC WP005 00.

(5) CABIN PRESSURIZATION SYSTEM SIMPLIFIED SCHEMATIC F-18A WP003 00.

(6) WINDSHIELD ANTI-ICE AND RAIN REMOVAL SYSTEM SIMPLIFIED SCHEMATIC WP012 00.

(7) AVIONICS COOLING SYSTEM SIMPLIFIED SCHEMATIC – EXCEPT COCKPIT WP007 00.

(8) MAINTENANCE STATUS DISPLAY AND RECORDING SYSTEM, NON AVIONICS MAINTENANCE CODES SIMPLIFIED SCHEMATIC, A1-F18AA-580-100, WP003 00.

(9) AIR DATA COMPUTER SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-560-100, WP003 00.

(10) LANDING GEAR CONTROLLED RELAYS SIMPLIFIED SCHEMATIC A1-F18AA-130-100, WP003 00.

(11) GROUND POWER SWITCHING SIMPLIFIED SCHEMATIC A1-F18AA-420-100, WP005 00.

(12) AIR CONDITIONING SYSTEM BIT STARTS WHEN ELECTRIC POWER IS APPLIED TO THE ACS TEMPERATURE/FLOW CONTROLLER. INFLIGHT BIT IS A COMPLETE SEQUENCE OF TESTS ON THE ACS TEMPERATURE/FLOW CONTROLLER AND TEN ELECTRICALLY INTERFACING COMPONENTS. NINE SECONDS IS REQUIRED FOR A COMPLETE BIT SEQUENCE, AND THE BIT SEQUENCE IS REPEATED EVERY 90 SECONDS. IF THE SAME TEST INDICATES A FAILURE ON TWO CONSECUTIVE BIT SEQUENCES, THE BIT PROCESSOR REMOVES A GROUND FROM SIGNAL DATA CONVERTER CV-3493/ASM-612, AND A MAINTENANCE CODE IS RECORDED. AFTER A MAINTENANCE CODE IS RECORDED, BIT IS INHIBITED UNTIL ELECTRICAL POWER IS REMOVED AND REAPPLIED. WHEN THE AIRCRAFT IS ON THE GROUND, BIT OPERATION IS THE SAME AS INFLIGHT BIT EXCEPT THAT ONLY A PARTIAL BIT SEQUENCE IS DONE.

213.256

Figure 3-10.—Cabin cooling and antifog system.

The solenoid is electrically controlled, and when energized, it allows air pressure to be vented and the ram air scoop opens.

CABIN AIRFLOW/TEMPERATURE SENSOR

The cabin airflow/temperature sensor is a flow sensor and a temperature sensor in a single unit. The sensor is installed in the cabin air inlet duct and provides electrical signals to the ACS temperature/flow controller based on air temperature and flow. The electrical signals are used by the ACS temperature/flow controller for automatic operation of the cabin flow valve and cabin add heat valve.

AUTOMATIC DRAIN VALVE

The automatic drain valve, located in the cabin air supply duct, is open to drain moisture from the supply duct. The valve closes when air pressure is applied to the system.

CABIN DEFOG PLENUM DISTRIBUTION VALVE

The cabin defog plenum distribution valve, located in the cabin inlet duct, is a manually controlled valve that divides the flow of cabin inlet air between cabin cooling and windshield defog. The valve contains two movable, shaft-mounted cones that regulate airflow. Movement of one cone causes an equal and opposite movement of the other cone. This causes an increase in one volume of air and a decrease in the other. The valve is controlled by the cockpit-mounted control handle and linkage, through the push-pull control.

CONTROL HANDLE AND LINKAGE

The control handle and linkage allows the pilot to set the cabin defog plenum distribution valve to control the flow of windshield defog and cabin cooling air. An electrical limit switch is installed in the control handle housing. The switch is activated when the handle is within 10 percent of HIGH defog. When activated, the switch sends a signal to the ACS temperature/flow controller to increase the temperature of the defog air by opening the cabin add heat valve.

PUSH-PULL CONTROL

The push-pull control connects the control handle and linkage with the cabin defog plenum distribution valve. Movement of the control handle and linkage is transmitted to the cabin defog plenum distribution valve by the push-pull control.

SUIT/CABIN TEMPERATURE CONTROL

The suit/cabin temp control contains two dual section potentiometers. The potentiometers have an outer shaft and control knob for cabin temperature control and an inner shaft and control knob for vent suit temperature control. The cabin temperature control potentiometer provides electrical signals to the ACS temperature/flow controller for automatic temperature control and directly controls the position of the cabin add heat valve for manual temperature control.

AUTOMATIC TEMPERATURE CONTROL

Automatic temperature control is selected by setting the ECS mode switch to AUTO. In the auto mode, the pilot selects the cabin temperature by adjusting the cabin knob of the suit/cabin temp control. The ACS temperature/flow controller produces a reference signal in relation to the setting selected on the suit/cabin temp control. A control circuit in the ACS temperature/flow controller compares a signal from the temperature sensing element of the cabin airflow/temperature sensor with the reference signal and modulates a control signal to the cabin add heat valve to maintain the selected temperature.

MANUAL TEMPERATURE CONTROL

Manual temperature control is selected by setting the ECS mode switch to MAN. In the manual mode, adjusting the cabin knob of the suit/cabin temp control determines the control signal sent to the cabin add heat valve.

EQUIPMENT COOLING SYSTEMS

Learning Objective: Recognize the source for avionics cooling air; identify components of avionics cooling systems and the function of each component.

As electronics and avionics in naval aircraft became more common and more sophisticated, it was discovered that the heat generated by this equipment was becoming excessive for proper operation. A means of keeping the avionics at a proper operating temperature was needed. To overcome this problem, some aircraft have. separate ACS for equipment cooling, while others use conditioned air diverted from the environmental ACS.

If the equipment ACS is an air-to-air type, its operation is the same as the environmental ACS discussed at the beginning of this chapter. Only operating temperatures will be different. The other type of equipment air conditioning (vapor cycle) operates on the same principal as a home ACS and will be discussed later in this chapter.

AIR-TO-AIR SYSTEM

The F-18 aircraft avionics cooling system (fig. 3-11, a foldout at the end of this chapter) controls and transports conditioned air to the various avionics packages and equipment bays. Conditioned air from the air cycle ACS is transported to the avionics flow valve where inlet pressure and airflow is controlled in response to signals from the avionics flow/temperature sensor through the ACS temperature/flow controller. Airflow rates are matched to the individual cooling requirements of each equipment package or bay.

Ground cooling of the avionics equipment bays is provided by an avionics ground cooling fan. The cockpits avionics equipment cooling is done by four cockpit avionics cooling fans, two in the forward cockpit and two in the rear cockpit.

Emergency ram air cooling for essential avionics equipment is provided by an emergency ram air scoop and avionics ram air valve.

The avionics cooling components are discussed in the following paragraphs.

Avionics Airflow Valve

The avionics airflow valve is a normally open, pneumatically actuated and controlled pressure regulating valve. The valve is in the avionics supply line and maintains a pressure differential of 1.5 psi between an externally sensed upstream duct pressure and an externally sensed cabin duct pressure. Actuator spring pressure holds the valve butterfly to full open. Cabin pressure is sensed on one side of the control diaphragm and upstream valve pressure is sensed on the other side. If no pressure is applied to the control diaphragm, the feedback spring holds the control nozzle closed. Any external supply pressure applied under this condition overrides the actuator spring pressure and closes the valve.

Avionics Flow/Temperature Sensor

The avionics flow/temperature sensor is made up of a flow sensor and temperature sensor enclosed in a single unit. The sensor is in the supply line downstream of the avionics airflow valve. The sensor provides signals to the flow sensing and anti-ice temperature sensing bridges in the ACS temperature/flow controller for automatic operation of the flow modulating system pressure regulator valve and anti-ice add heat valve.

Avionics Ram Air Valve

The avionics ram air valve is a normally open, pneumatically closed, remote-controlled shutoff valve. It is between the secondary heat exchanger ram air inlet and the avionics supply line. The valve provides ram air augmentation for avionics cooling if cooling airflow drops below an established limit. The valve is closed by pneumatic pressure and is opened by pneumatic signals from a remotely located avionics ram air servo. Pressure is supplied from the servo to hold the valve closed. When externally supplied pressure from the servo drops below a specified value, the valve opens and supplies ram air.

ECM Cooling Air Control Valve

The ECM cooling air control valve is a two-position solenoid controlled valve. The valve provides a high flow of cooling air to the electronic countermeasure (ECM) package when de-energized and a low flow when energized. The valve is energized when the ECM mode switch on the ECM control panel assembly is selected to OFF or STBY.

Avionics Ground Cooling Fan

The avionics ground cooling fan is an electrically driven axial flow fan that provides a flow of ambient air for direct avionics cooling during aircraft ground operation, taxi, takeoff, and landing. The fan is in the nose wheelwell and is powered by an induction motor.

Avionics Ground Cooling Fan Check Valve

The avionics ground cooling fan check valve is made up of two spring-loaded flappers hinged around a central shaft. The check valve is located between the upper and lower plenums, and it functions to prevent cooling air from escaping through the avionics ground cooling fan during flight.

Avionics Fan Control Pressure Switch

The avionics fan control pressure switch is a pneumatically operated switch in the ducting downstream of the primary heat exchanger. This switch controls the avionics ground cooling fan operation to provide supplemental air for avionics equipment cooling.

Emergency Ram Air Scoop

The emergency ram air scoop is a spring-loaded scoop on the forward fuselage. The scoop is held closed by a solenoid, which releases the scoop when energized. A linkage arrangement, connected to the scoop, closes a flapper on the avionics cooling plenum and directs ram air to the essential avionics when the scoop is opened. The FCS cool switch, on the right vertical console, activates the scoop release solenoid when set to EMERG.

Avionics Undercool Warning Temperature Sensor

The avionics undercool/warning temperature sensor is made up of two temperature sensing elements, one is self-heated. On detecting an undercool condition of avionics cooling air, the sensor sends a signal to the signal data converter, which displays the AV AIR HOT caution message on the left digital display indicator.

Avionics Cooling Fans

The two avionics cooling fans in the cockpit are axial flow fans driven by electric motors. Both fans operate continuously with any ground power switch to A ON or B ON or flt cent switch to ON. Individual cockpit fan operation can be verified by setting the fan test switch on the fan test control panel assembly to A LEFT or B RIGHT.

Rear Cockpit Avionics Cooling Fans

The rear cockpit avionics cooling fans are identical in design and function to the cockpit avionics cooling fans. Individual rear cockpit fan operation can be verified by setting the fan test switch on the fan test control and utility light panel assembly to A LEFT or B RIGHT.

VAPOR CYCLE AIR-CONDITIONING SYSTEM

Vapor cycle systems make use of the scientific fact that a liquid can be vaporized at any temperature by changing the pressure above it. Water at sea level barometric pressure of 14.7 psi will boil at 212°F. The same water in a closed tank under a pressure of 90 psi will not boil at less than 320°F. If the pressure is reduced to 0.95 psi by a vacuum pump, the water would boil at 100°F. If the pressure is reduced further, the water would boil at a still lower temperature; for instance, at 0.12 psi, water will boil at 40°F. Water can be made to boil at any temperature if the pressure corresponding to the desired boiling temperature can be maintained.

Liquids that boil at low temperatures are the most desirable for use as refrigerants. Comparatively large quantities of heat are absorbed when liquids are evaporated; that is, changed to a vapor. For this reason, liquid Freon 12 or 22 is used in most vapor cycle refrigeration units whether used in aircraft or in home air conditioners and refrigerators.

If liquid Freon 12 were poured into an open container surrounded by standard sea level pressure, it would immediately begin to boil at temperatures above -22°F (-30°C). There would be a continuous flow of heat from the warm surrounding air through the walls of the container to the boiling Freon. Moisture from the air would condense and freeze on the exterior of the container.

This open container system would work satisfactorily insofar as cooling alone is concerned. A drum of Freon could be connected to a coil and the vaporized Freon piped outdoors. A system such as this would provide satisfactory refrigeration, but the cost of continuously replacing the refrigerant would be prohibitive. Because of the cost involved, it is desirable to use the refrigerant over and over. To accomplish this, additional equipment, over and above that already mentioned, is required.

Vapor Cycle Theory

Refrigerant used in the vapor cycle refrigeration system occurs as both a liquid and as a vapor. Conversion from a liquid to a vapor will occur at temperatures above – 21°F (– 34°C) at sea level. If the refrigerant pressure is increased, conversion to a vapor will occur at higher temperatures. Maximum heat transfer efficiency occurs when the refrigerant is at the boiling point (the point at which the liquid will vaporize).

The refrigerant must be delivered to the evaporator as a liquid if it is to absorb large quantities of heat. Since it leaves the evaporator in the form of a vapor, some way of condensing the vapor is necessary. To condense the refrigerant vapor, the heat surrendered by the vapor during condensation must be transferred to some other medium. For this purpose, water or air is ordinarily used. The water or air must be at a temperature lower than the condensing temperature of the refrigerant. At any given pressure, the condensing and vaporizing temperature of a fluid are the same. If a refrigerant that vaporizes at 40°F (5°C) is to be condensed at the same temperature, water or air at a lower temperature is needed. Obviously, if water or air at this lower temperature were available, mechanical refrigeration would not be required. As the temperature of available water or air is usually always higher than the temperature of the boiling refrigerant in the evaporator, the refrigerant must be condensed after it leaves the evaporator. To condense the vapor, its pressure must be increased to a point that its condensing temperature will be above the temperature of the water or air available for condensing purposes. For this purpose a compressor is needed. After the pressure of the refrigerant vapor has been increased sufficiently, it may be liquefied in the condenser with comparatively warm water or air.

In a practical refrigeration circuit, liquid flows from the receiver to the expansion valve, which is essentially nothing more than a needle valve. The compressor maintains a difference in pressure between the evaporator and the condenser. Without the expansion valve, this difference in pressure could not be maintained. The expansion valve separates the high-pressure part of the system from the low-pressure part. It acts as a pressure reducing valve because the pressure of the liquid flowing through it is lowered. Only a small trickle of refrigerant fluid flows through the valve into the evaporator. The valve is always adjusted so that only the amount of liquid that can be vaporized in the evaporator passes through it.

The liquid that flows through the evaporator is entirely vaporized by the heat flowing through the walls of the evaporator. This heat has been removed from the air being cooled.

After leaving the evaporator, the vaporized refrigerant flows to the compressor where its pressure is raised to a point where it can be condensed by the condenser airflow available. After being compressed, the vapor flows to the condenser. Here, the walls of the condenser are cooled by the water or air; and as a result, the vapor is liquefied. Heat is transferred from the condensing vapor to the water or air through the walls of the condenser. From the condenser the liquid refrigerant flows back to the receiver, and the cycle is then repeated.

Operations and Components

The Grumman Aerospace Corporation chose a Freon 12 vapor cycle ACS to provide avionics equipment cooling in the E-2 "Hawkeye" aircraft. This system, the VEA6-1, is described in this section. The basic difference between the basic vapor cycle system and the VEA6-1 system is the method of compensating for the variations in ram air temperature and the variation in the flow of ram air, which is dependent on aircraft speed. Figure 3-12 is a schematic diagram of the VEA6-1 vapor cycle ACS.

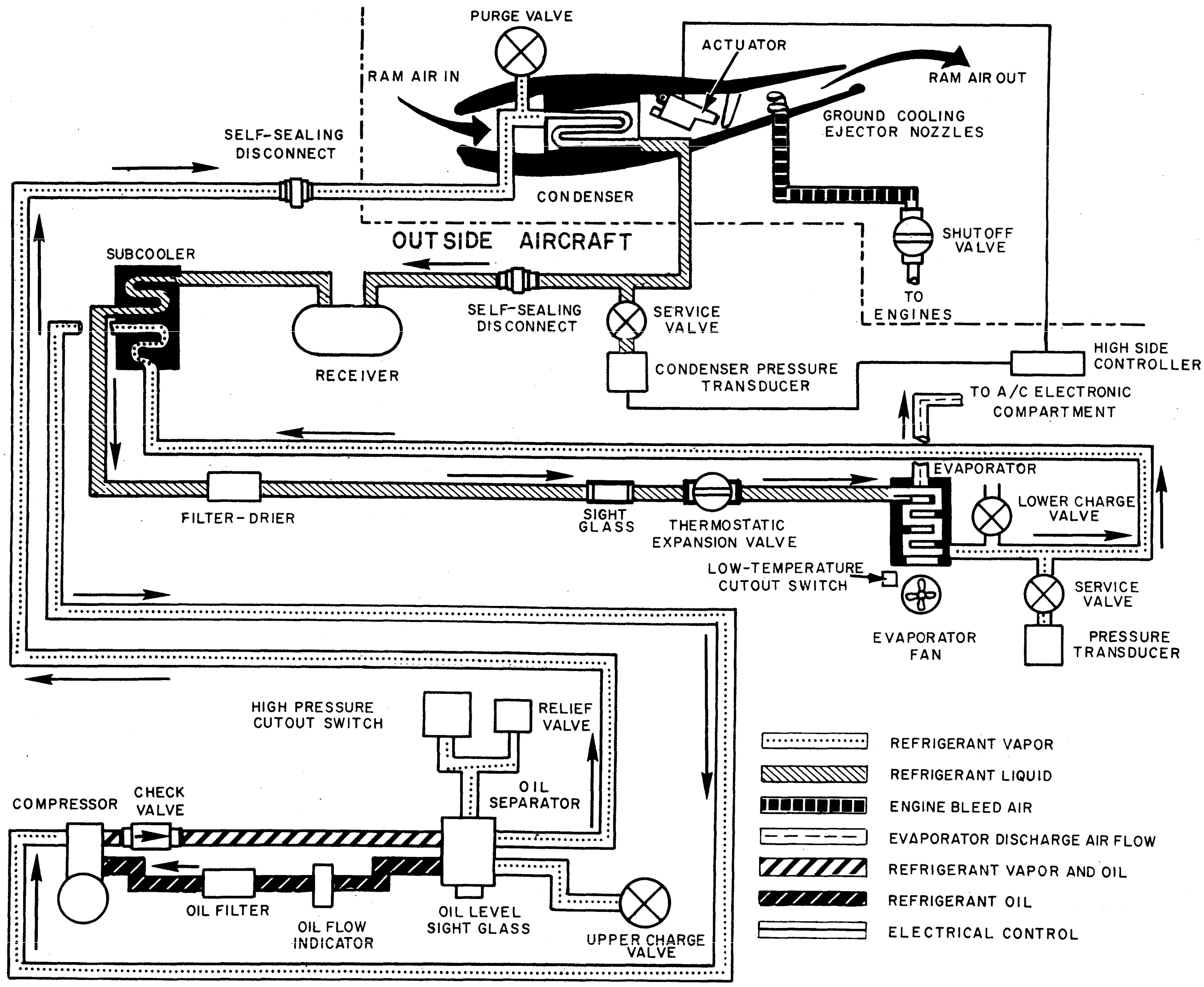
In the E-2 configuration, the vapor cycle system cools, filters, and distributes avionics compartment air at a temperature of 38°±5°F.

The system consists of a vapor cycle cooling scoop assembly, an evaporator group assembly, and air distribution ducting interconnected by refrigerant lines and electrical wiring.

The evaporator assembly (fig. 3-13) is a compact, quick-change package that can be easily installed, removed, and serviced as a unit. The assembly is composed of five quick-disconnect couplings; two shock mounts; temperature controls; a hydraulic, motor-driven, self-lubricating Freon compressor; a receiver; a subcooler; a thermostatic expansion valve; an evaporator; hydraulic motor-driven fan; and an oil separator.

The vapor cycle cooling scoop assembly is mounted on the top of the fuselage and consists of a condenser assembly, ejector nozzles, an actuator and flap, and a refrigerant pressure actuator control switch.

The Freon 12 in the closed system is the primary coolant. The forced air that is drawn through the evaporator in a continuous cycle is the secondary coolant. The electronic equipment is cooled by the secondary coolant, which removes heat by direct contact with the equipment to be



213.47

Figure 3-12.—Vapor cycle air-conditioning system.

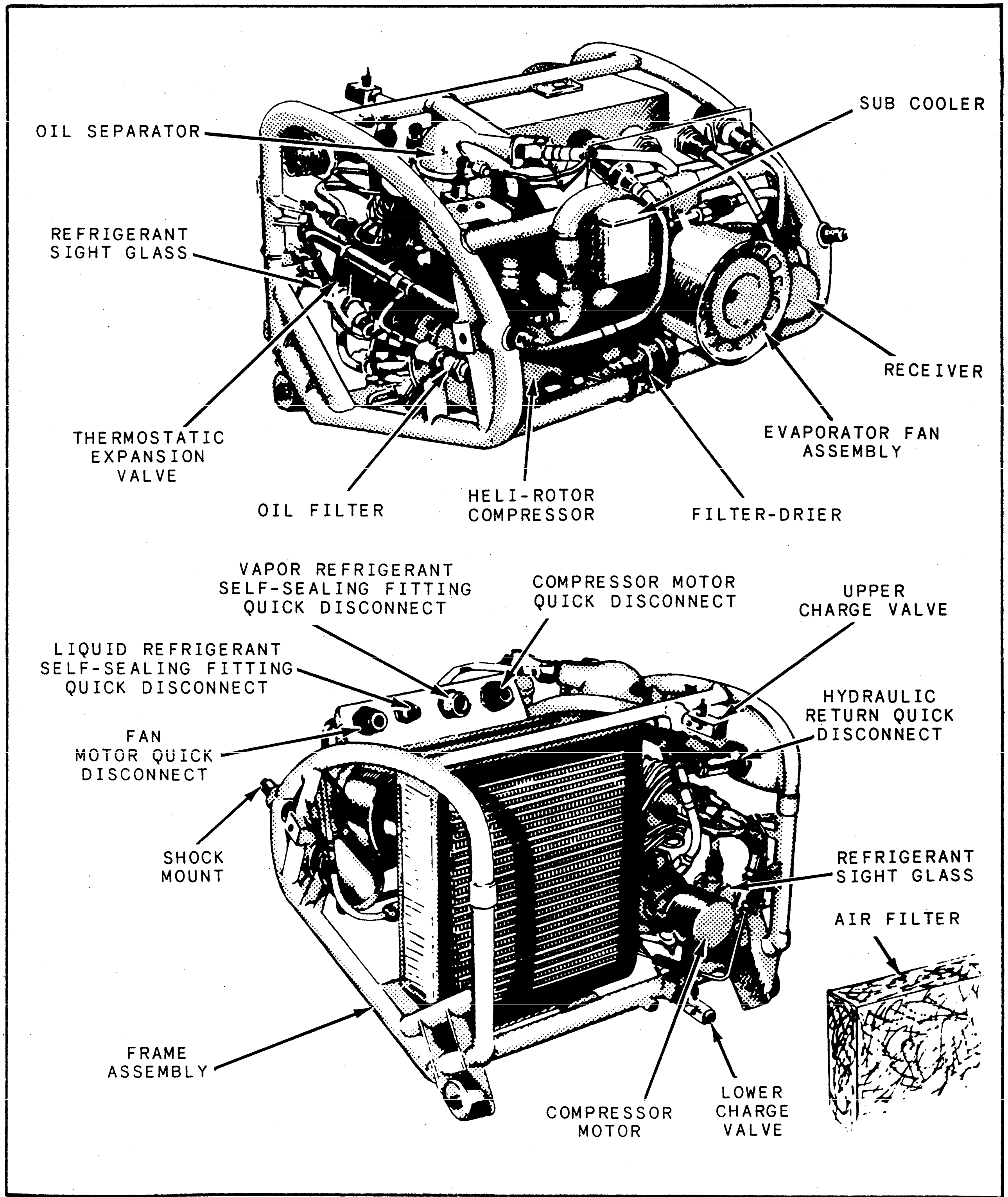


Figure 3-13.—Evaporator assembly.

cooled and the transfer of this heat to the primary coolant through the evaporator assembly.

A header assembly attached to the discharge side of the evaporator assembly directs the secondary coolant air to distribution ducts throughout the electronic equipment compartment. A filter between the header assembly and the evaporator assembly removes dirt and dust particles and traps moisture from the air.

The closed system consists of the evaporator group assembly and the condenser group assembly. The coolant circulates between the evaporator group assembly (where it absorbs heat) and the condenser group assembly where it discharges or dissipates the heat to the atmosphere through the vapor cycle scoop.

During flight, ram air flowing through the scoop cools the condenser group assembly. The airflow through the scoop is controlled by a condenser pressure control system. The actuator in the scoop modulates the airflow through the scoop to provide sufficient cooling for condensation of the refrigerant.

When the aircraft is on the ground with engines running and ram airflow is insufficient for cooling, a condenser ejector air shutoff valve opens to permit engine bleed air to discharge through the ejector assembly. The ejector consists of a set of tubes that permit bleed air to escape into the ram air duct behind the condenser. The escaping bleed air creates a negative pressure (suction) area behind the condenser and causes ambient air to be drawn into the scoop and across the condenser.

If the heat load applied to the evaporator and the ram air temperature and flow were constant, a simple opening would be all that was required to control the boiling point of the refrigerant entering the evaporator. Since these three factors are not constant, they must be compensated for. In the model VEA6-1 system, if the heat load is changed, the flow of refrigerant is changed by using a thermostatic expansion valve in place of a fixed opening. The pressure of the refrigerant in the evaporator is maintained constant, regardless of the refrigerant flow, by varying the speed of the compressor.

When the EQUIPMENT COOLING switch is set to ON, solenoid-operated shutoff valves are energized and hydraulic pressure is directed to the evaporator fan motor and the compressor motor. The compressor motor will be automatically shut off when either aircraft engine is in autofeather and the landing gear is down. The evaporator fan motor will continue to operate.

With the evaporator fan and compressor motors operating, low-pressure, low-temperature refrigerant Freon 12 vapor enters the compressor assembly through the low-pressure line leading from the evaporator assembly outlet. The vapor entering the compressor inlet combines with lubricating oil that is fed to the compressor. The oil-refrigerant mixture is compressed to raise its condensing temperature. From the compressor, the high-temperature, high-pressure mixture flows to the oil separator, where the oil is removed from the refrigerant vapor, filtered, and fed back to the compressor.

If the refrigerant vapor pressure exceeds 250 ± 5 psi in the line downstream from the oil separator, the high-pressure cutoff switch will cause the cockpit EQUIP COOLING caution light to illuminate and the compressor motor solenoid valve to shut off hydraulic pressure to the compressor motor, thus shutting down the compressor. If the cutout switch failed to operate properly, the relief valve in the compressor discharge line would relieve the system of pressure in excess of 325 psi.

Refrigerant vapor from the oil separator next enters the condenser assembly where ram air lowers its temperature and changes the vapor to a liquid. Refrigerant pressure on the high side of the system is controlled by regulating the amount of cooling air flowing across the condenser. A pressure transducer in the high side refrigerant line provides a signal to a control amplifier, which, in turn, causes the control actuator and flap to open and close as necessary to regulate pressure. The system is calibrated so that the condenser flap is fully closed when high side pressure is 107± 3 psi; fully opened at 151 ± 3 psi condensing pressure; and modulates the flap travel for intermediate pressures within that range.

If the cooling air is inadequate to maintain the pressure at 151 ± 3 psi with the flap fully open, the system pressure will exceed the control range. When the pressure reaches 250 ± 5 psi, the high--pressure cutout switch will shut down the vapor cycle system.

From the condenser assembly, liquid Freon flows to the receiver in the evaporator group assembly. The receiver stores surplus refrigerant and thereby prevents surges in the refrigerant flow rate. Liquid refrigerant flowing from the receiver passes through a subcooler and then through a filter drier, where foreign matter and water are removed. Before entering the thermostatic expansion valve, the liquid refrigerant passes through a sight glass, which provides a visual indication of flow and proper refrigerant charge. The refrigerant is metered by the thermostatic expansion valve, and then enters the evaporator assembly. The hydraulic motor-driven evaporator fan forces warm electronic equipment compartment air through the evaporator assembly, where it is cooled by transfer of heat to the refrigerant. The refrigerant leaves the evaporator as a superheated vapor.

The temperature of evaporator discharge air to the equipment compartment is controlled by controlling the speed of the compressor motor. The evaporator pressure control system maintains the refrigerant pressure within a specified range so that the average temperature range of the refrigerant is between 29.8° and 32.9° ± 0.6°F. This temperature range consequently controls air temperature to approximately 38°. The difference between the air and refrigerant temperatures is due to the efficiency of the heat exchanger.

If the equipment compartment temperature increases, refrigerant pressure on the low side will also increase. The increase in pressure is sensed by a pressure transducer located in the compressor inlet line, and a signal is sent to the evaporator pressure control system amplifier. The amplifier, in turn, sends an appropriate signal to the servo portion of the compressor hydraulic motor calling for a speed increase to prevent pressure increase and thus maintain a constant refrigerant pressure. If the temperature increase calls for a compressor motor speed above a maximum of 12,000 rpm, the temperature rise cannot be compensated for and the refrigerant pressure will rise. At 250 ± 5 psi compressor discharge pressure, the high side cutout switch will shut the vapor cycle system down.

If the equipment compartment temperature drops, a reverse situation exists. Compressor motor speed will decrease to a minimum of 4,000 rpm. If the temperature at the fan inlet continues to drop beyond the range that can be compensated (30°F), the low-temperature cutoff switch de-energizes the compressor power relay and shuts down the compressor motor. The refrigerant stops flowing while the evaporator fan motor continues to circulate compartment air. When the fan inlet temperature rises to 40° ± 2°F, the compressor is cut in and refrigerant flows through the evaporator and the subcooler and returns to the compressor to repeat the cycle.

The purpose of each major component in the vapor cycle system is discussed in the following paragraphs.

SUBCOOLER.— The subcooler (fig. 3-14) is a heat exchanger containing passages for liquid Freon 12 from the receiver on its way to the evaporator and cold Freon gas leaving the evaporator on its way to the compressor.

The purpose of the subcooler is to increase the efficiency of the system by cooling the refrigerant after it leaves the receiver, thereby preventing premature vaporization or flash off after passage through the expansion valve and before it reaches the evaporator. As stated previously, the refrigeration effect takes place when the Freon changes state from liquid to gas. Premature flash off would result in keeping additional refrigerant from evaporating and would have no useful effect on the primary cooling load required of the package.

The liquid on the way to the thermostatic expansion valve is relatively warm in comparison to the cold gas leaving the evaporator. Although the gas leaving the evaporator has absorbed heat from the air being circulated through the evaporator, its temperature is still in the vicinity of 40°F. This cool gas is fed through the subcooler where it picks up additional heat from the relatively warm liquid Freon 12 that is flowing from the receiver. This heat exchange causes the liquid to be subcooled to a level that ensures little or no flash gas on its way to the evaporator.

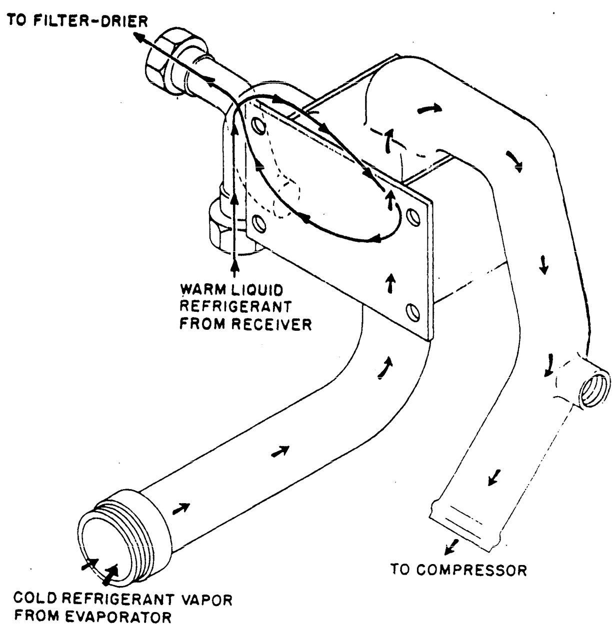


Figure 3-14.—Subcooler.

RECEIVER.— The receiver acts as a reservoir for the liquid Freon 12 refrigerant. The fluid level in the receiver varies with system demands. During peak cooling periods, there will be less liquid than when the load is light. The purpose of the receiver is to ensure that the thermostatic expansion valve is not starved for refrigerant under heavy cooling load conditions.

FILTER DRIER.— A filter drier unit (fig. 3-15) is installed in the plumbing between the sub-cooler and the sight glass. The unit is essentially a sheet metal housing with inlet and outlet connections and containing alumina desiccant, a filter screen, and a filter pad. Its purpose is to filter all contaminants and dry any moisture that may be present in the Freon 12 on its way to the expansion valve. The alumina desiccant acts as a moisture absorbent medium. The conical screen and fiber glass pad act as filtering devices, removing contaminants.

Clean refrigerant at the expansion valve is necessary because of the critical clearances involved. Moisture may freeze at the expansion valve, causing it to hang up with a resulting starvation or flooding of the evaporator.

The filter-drier unit is a "throwaway type" and is replaced whenever the charge is dumped from the unit or when filter-drier operation is doubtful.

SIGHT GAUGE.— To aid in determining whether servicing of the refrigerating unit is required, a sight gauge is installed in the line between the filter-drier and the thermostatic expansion valve. The gauge assembly consists of a fitting having windows on both sides, permitting a view of fluid passing through the line.

During refrigeration unit operation, if a steady flow of Freon refrigerant is observed through the sight glass, this is an indication that a sufficient charge is present. If the unit requires additional refrigerant, an indication will be the presence of bubbles in the sight glass. Since Freon is a colorless gas or liquid, a red-colored dye may be added to the liquid to facilitate leak detection. This is usually accomplished upon initial charging of the system.

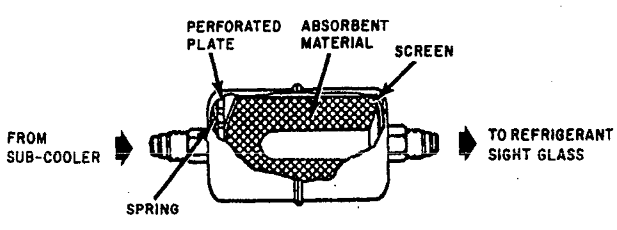


Figure 3-15.-Filter drier.

THERMOSTATIC EXPANSION VALVE.— The thermostatic expansion valve (fig. 3-16) is mounted close to the evaporator and meters the flow of refrigerant into the evaporator, depending upon system demand. Efficient evaporator operation is dependent upon the precise metering of liquid refrigerant into the heat exchanger for evaporation. As was previuosly stated, if heat loads on the evaporator were constant, a fixed opening size could be calculated and used to regulate the refrigerant supply. However, since the system encounters varying heat loads, a variable opening device is needed to prevent starvation or flooding of the evaporator, which would seriously affect the evaporator and system efficiency. This variable opening effect is accomplished by the thermostatic expansion valve, which senses evaporator conditions and meters refrigerant to satisfy them. By sensing the temperature and the pressure of the gas leaving the evaporator, the expansion valve prevents the evaporator from being flooded, and thereby returning liquid refrigerant to the compressor.

The valve consists of a housing containing an inlet port, an equalizer port, and 25 outlet ports. The flow of refrigerant to the outlet ports is controlled by positioning a metering valve pin. Valve pin positioning is controlled by the pressure created by the remote sensing bulb in the power section, the superheat spring setting, and the evaporator discharge pressure as supplied by the external equalizer port.

The remote sensing bulb is a closed system and is filled with refrigerant. The bulb itself is placed in a well, attached to the evaporator. The pressure within the bulb corresponds to the pressure of the refrigerant leaving the evaporator. This force is felt on top of the diaphragm in the power head section of the valve, and any increase in pressure will cause the valve to move towards an open position. The bottom side of the diaphragm has the forces of the superheat spring and the external equalizer port pressure acting in a direction to close the valve pin. The valve position at any instant is determined by the resultant of these three forces.

If the temperature of the gas leaving the evaporator increases above the desired superheat value, it will be sensed by the remote bulb. The

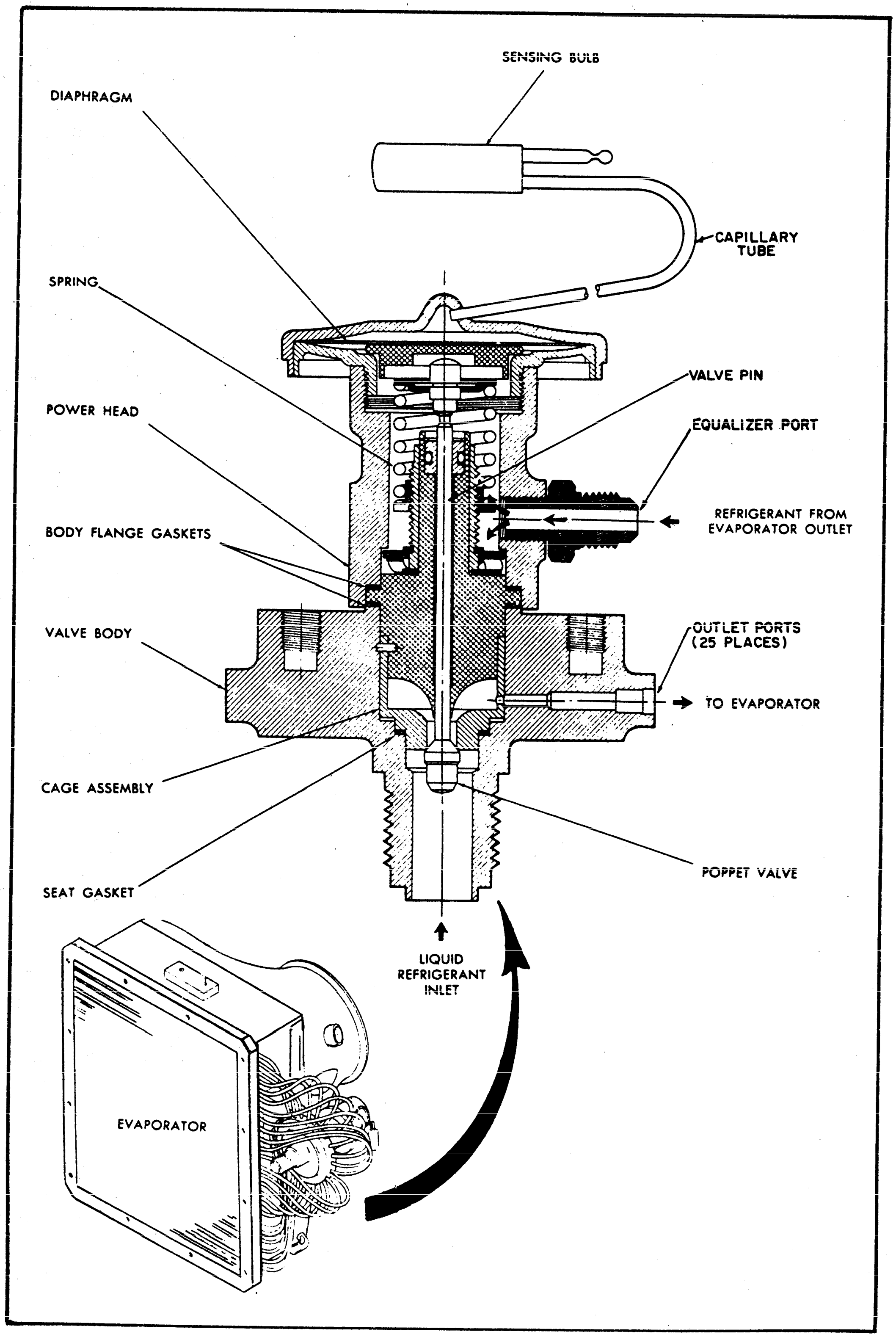


Figure 3-16.—Evaporator and thermostatic expansion valve.

pressure generated in the bulb is transmitted to the diaphragm in the power section of the valve, causing the valve pinto open. A decrease in the temperature of the gas leaving the evaporator will cause the pressure in the remote bulb to decrease, and the valve pin will move toward the closed position.

The superheat spring is designed to control the amount of superheat in the gas leaving the evaporator. A vapor is superheated when its temperature is higher than that necessary to change it from a liquid to a gas at a certain pressure. This ensures that the Freon returning to the compressor is in the gaseous state. The superheat spring is adjustable and is factory set to provide approximately 9° of superheat in this particular vapor cycle system. Superheat setting is calculated in relation to evaporator size and heat loads applied; therefore, it should never be tampered with in the field as serious inefficiencies will result.

The equalizer port is provided to compensate for the effect the inherent evaporator pressure drop has on the superheat setting. The equalizer senses evaporator discharge pressure and reflects it back to the power head diaphragm, adjusting the expansion valve pin position to hold the desired superheat value.

The purpose of the multioutlet configuration of the valve is to ensure an even distribution of the refrigerant in the evaporator.

EVAPORATOR.— The evaporator (fig. 3-16) is a plate fin heat exchanger forming passages for cooling airflow and for Freon 12 refrigerant. The evaporator assembly houses a hydraulically driven fan and a low-temperature cutout switch.

When the vapor cycle system is operating, refrigerant from the expansion valve flows into the Freon passages of the evaporator. At the same time, the hydraulically driven fan is forcing air from the electronic equipment compartment across the coils of the evaporator. The temperature of the air is rather high since it is affected by being circulated through the electronic boxes. This air, in passing through the evaporator, readily gives up its heat to the liquid Freon 12. The Freon is receptive to the heat exchange and, in absorbing the heat, a change of state comes about, changing the Freon from a liquid to a gas at approximately the same temperature that it was changed from a gas to a liquid. Since the Freon compressor is maintaining a constant pressure in the evaporator, the Freon vaporizes at a temperature that causes the air discharging from the evaporator to the electronic compartment to be at approximately 40°F. Vapor leaving the evaporator is also at a temperature of about 40°F.

Attached to the discharge side of the evaporator is a header duct assembly, bolted to the perimeter of the evaporator. This header is used to direct the discharged cooling air to the various distribution ducts. A set of movable louvers in the header is designed to act as a shutoff valve during ground cooling cart operations. During this time an external cart is attached to a receptacle on the right-hand side of the fuselage and feeds to the distribution system for ground operations, if desired. This air, however, would also escape in reverse direction through the evaporator and discharge into the forward compartment, thereby reducing the airflow to the electronic equipment. The louvers are actuated by a single control knob located at the top of the header duct. The knob is a two-position control (open and close) and is placarded to explain operation. To prevent the louvers from being inadvertently left in the closed position with the possibility of starving the avionics gear of cooling air after ground cart operation has been terminated, an overcenter device is incorporated. This device will automatically open the louvers as soon as a pressure is felt on them from the evaporator fan. The header duct also contains a discharge air filter, which filters the recirculated air and also removes the majority of the moisture (if present) in the cooling air on its way to the electronic equipment.

COMPRESSOR ASSEMBLY.— The purpose of the compressor assembly (fig. 3-17) is to evacuate the evaporator, keeping it at a constant pressure, and also to superheat the Freon vapor and feed it to the condenser where it is condensed back into a liquid for reuse. The compressor houses two intermeshing helical rotors that rotate in counterrotating directions. This action causes cool Freon gas to be taken from the evaporator and compressed. This increases its temperature and pressure to a value where it may be fed to the condenser for ambient air to change it back into a liquid. The compressor controls the pressure in the evaporator by varying its speed in response to signals from a suction line pressure switch.

The two intermeshing helical screw-type rotors are enclosed in a close tolerance housing, containing an inlet and an outlet port. Since the rotors mesh, they may be distinguished one from the other by calling one the male and the other the female.

The male rotor is directly coupled to, and driven by, a variable speed hydraulic motor. The

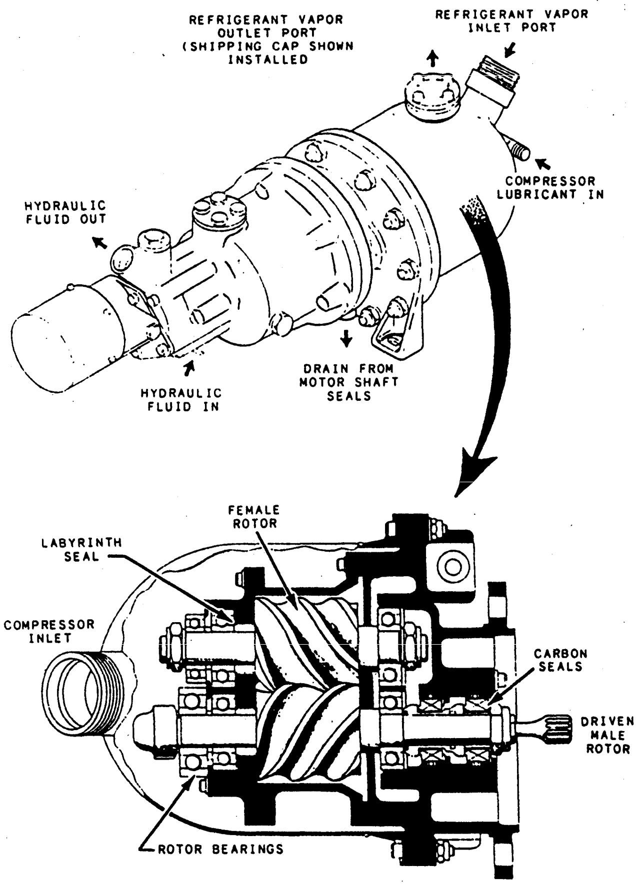


Figure 3-17.—Compressor assembly.

female rotor is driven aerodynamically by the male. There is no physical contact between the two rotors or between the rotors and case. Inter-rotor contact is prevented by the rotors riding on a film of refrigeration oil. Both rotors are suspended by three pairs of ball bearings, one set on the discharge end and two pairs on the inlet end. Bearing lubrication is supplied by the refrigeration oil. Suitable carbon and labyrinth seals are incorporated to provide control of the flow of lubricating oil. Thin ridges are machined on the ends and flutes of the rotors to seal the mechanism against excessive rotor leakage.

The compressor operates on the principle that if a given volume of gas is trapped and the area in which it is contained gradually decreases, the pressure and temperature of the gas will increase. The counterrotating rotors are fed a gas charge from the inlet port. This charge fills the void formed by the rotors. As they rotate, the charge is trapped and forced forward through the housing. The action of the rotors is to decrease the interlobe area in which the charge is contained as they revolve. This increases the pressure and temperature of the refrigerant. As the outlet port is reached, the charge will be contained in the smallest area during its travel through the compressor. Therefore, it is at its highest temperature and pressure and is discharged into the system.

The variable compressor speed is provided by the governor-controlled, hydraulically driven motor, which responds to electronic impulses from the Freon circuit to increase or decrease speed as demanded by the cooling load.

The electrical wiring of the speed-sensing system is such that when the equipment cooling system is shut down, the servomotor will be driven to low speed. This relieves starting loads and also precludes the possibility of an overspeed during startup.

The compressed Freon gas is discharged from the compressor and immediately passes through a check valve, which prevents the high-pressure discharge from motorizing the compressor in reverse at system shutdown.

The compressor section requires lubrication; therefore, an oil is mixed with the Freon during system servicing. This oil is also discharged from the compressor outlet and is reclaimed by the oil separator.

OIL SEPARATOR.— The oil separator is located downstream of the compressor and check valve. It operates on a centrifugal principle; that is, the oil mist refrigerant enters the inlet port of the separator at a tangent to the wall of the cylindrical housing. This imparts a swirling or centrifugal action to the mixture. The centrifugal force has a greater effect on the heavier oil vapors, causing them to collect on the walls and the conical screen. The oil drips from the screen and collects at the bottom of the oil separator.

Oil flows from the bottom of the separator through an oil flow indicator and filter and is injected into the compressor at the shaft seal cavity. The refrigerant vapor rises through the tubular baffle and leaves the separator. A circular sight gauge is provided on the separator to check the level of system oil during operation. Normal oil level is a half full sight gauge.

OIL FLOW INDICATOR.— The oil flow indicator in the oil return line is basically a metal cage with a sight window. It is used to observe the amount of oil returning to the compressor and to prevent compressor failure when no flow is indicated.

OIL FILTER.— Oil returning to the compressor passes through a filter, which ensures a clean oil supply for compressor lubrication. The filter has a replaceable cellulose fiber element. If the filter becomes clogged, a bypass device permits unfiltered oil to circulate through the compressor when the differential pressure across the filter is greater than 18 to 22 psi.

When the differential pressure across the filter is greater than 13.5 to 16.5 psi, the red indicator at the top of the filter will pop up and remain extended to provide an indication that the filter requires replacement prior to becoming completely clogged, and consequently passing contaminant oil to the compressor. The oil filter is designed with an automatic shutoff feature, which permits removal of the filter element and bowl without loss of the refrigerant charge.

CONDENSER EJECTOR AIR SHUTOFF VALVE.— The purpose of the condenser ejector air shutoff valve is to increase airflow across the condenser during ground operation by discharging engine bleed air through the ejector assembly. The valve is pneumatically operated. It is controlled by a piston through a mechanical linkage and is spring loaded to the CLOSED position. A solenoid valve on the actuator chamber side of the piston acts as a bleed off for the air being fed from an upstream tap of the valve housing. This air is fed through the-hollow piston actuator shaft to the top side of the piston where it is bled off as long as the solenoid is de-energized. Energizing the solenoid closes off the actuator chamber bleed, and pressure builds up. This force overcomes spring tension and the valve opens. Any loss of pneumatic or electrical power to the valve will cause it to assume a closed position.

CHARGING VALVES.— There are four backseating charging valves in the vapor cycle system—three in the evaporator group, and one in the condenser group. The valves are used to facilitate servicing of the system as one complete unit or servicing of the evaporator group or condenser group as individual units. The condenser and evaporator group assemblies are equipped with quick-disconnect refrigerant lines to allow their removal from the aircraft without a loss of refrigerant.

PURGE VALVES.— The refrigerant system is equipped with two purge valves—one at the evaporator group assembly high point and the other on the condenser in the top scoop of the aircraft. The valves are similar to the charge valves. They are used to bleed the system, when required, and for attaching test equipment or the vacuum pump for system evacuation.

Maintenance

Maintenance of the vapor cycle ACS, like the air cycle system, will generally require the joint efforts of personnel from the AME and the AE ratings. Malfunctions of the hydraulic motors that drive the compressor and evaporator fan will require the services of an AMH.

Operational checkout of the vapor cycle system can be done in several ways. The AE can perform an operational check of the electrical portion of the system using a Cooling System Test Set, AN/ASM 232 (XN-1), with the engines not running.

Performing an operational check of the complete vapor cycle system without the engines running requires external hydraulic and electrical power and a source of cool air. The cooled air is ducted into the condenser scoop inlet to provide flow through the condenser for condensing the Freon. As was stated earlier, this function is normally done by ram air when sufficient ram airflow is available or by engine bleed air leaving the ejector nozzles and creating a pressure differential that causes sufficient flow for cooling on the ground when the engines are running.

The operational check steps as specified in the applicable MIM should be performed in sequence. If a trouble occurs during a step, it must be corrected before proceeding. Isolation of the trouble can almost always be enhanced by referring to the step of the troubleshooting table that corresponds with the step of the operational checkout where the trouble occurred.

Additional organizational-level maintenance on the vapor cycle system includes servicing (adding refrigerant and lubricating oil), leakage testing and correcting of leaks, and removal and installation of components.

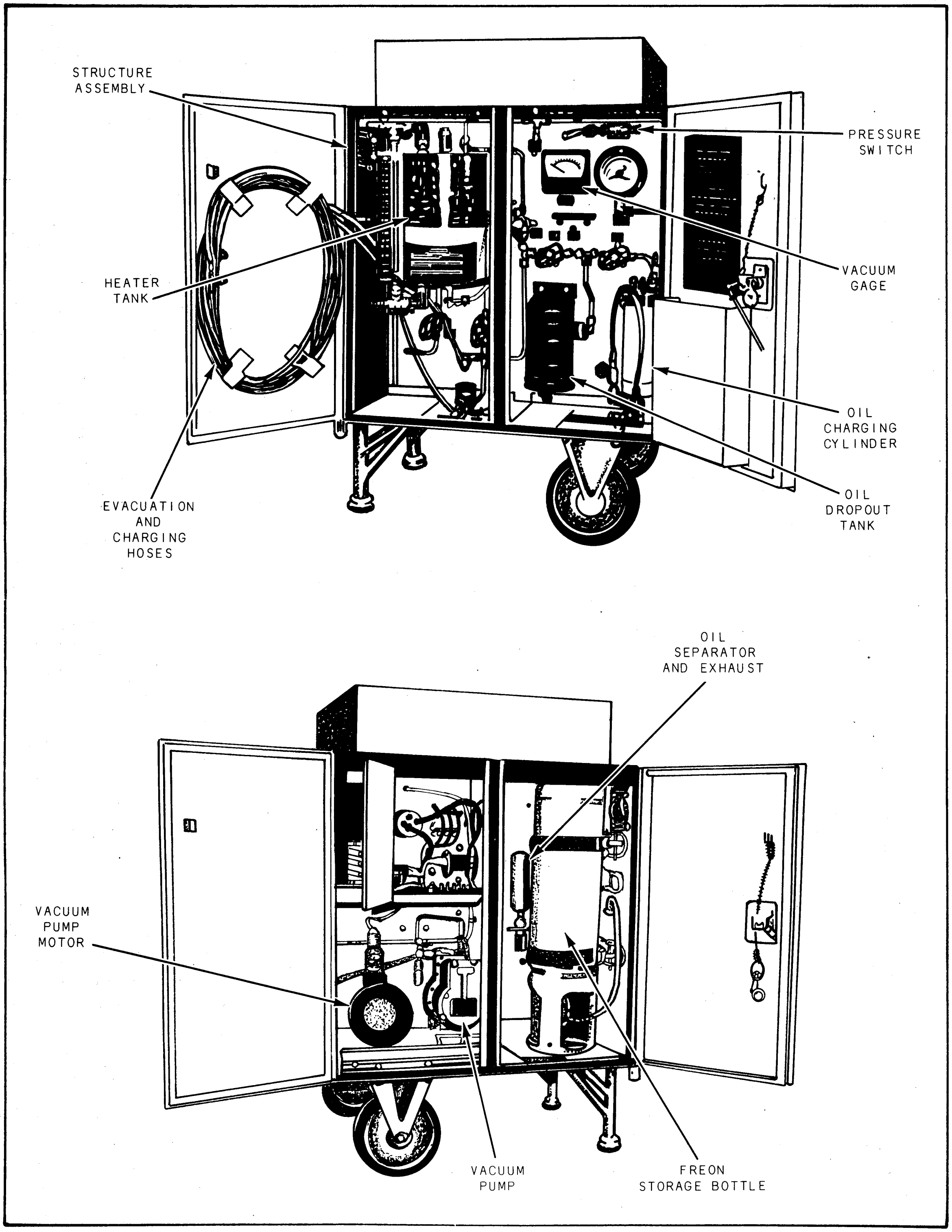
Intermediate-level maintenance of the evaporator assembly, the cindenser group assembly, and the air ejector shutoff valve is restricted to replacement of parts listed in the Spares and Repair Parts Data List provided in the intermediate repair section of the applicable MIM (Part IV). Special test equipment is required to bench test most of the vapor cycle components or assemblies; therefore, not all intermediate-level activities possess the capability to accomplish such maintenance.

Since proper servicing of the vapor cycle system is one of the most important factors affecting operation, equipment used for servicing and servicing procedures are given brief coverage in the following paragraphs.

Servicing Equipment

Servicing of the vapor cycle system involves evacuating and charging the condenser and evaporator group assemblies either separately or preferably together as a system, with refrigerant and/or lubricating oil.

The vapor cycle charging cart (fig. 3-18) is used to replenish the vapor cycle refrigeration system with refrigerant and the compressor with



213.67

Figure 3-18.—Vapor cycle charging cart.

lubricating oil. The major components of the cart are labeled in figure 3-18.

The Freon storage bottle has a capacity of 25 pounds of Freon. The bottle is restrained in the cart by quick-release restraining straps, which permit rapid removal and replacement of depleted bottles.

The electric motor-driven vacuum pump is used to evacuate a refrigerant system prior to recharging it with Freon. Evacuating or pulling a vacuum on the system for a short period of time causes any moisture in the system to be vaporized and withdrawn from the system. Moisture in the system, if of sufficient quantity, can freeze at the expansion valve, thus allowing no Freon into the evaporator and cooling would stop.

The vacuum pump has a displacement of 3 cubic feet per minute (cfm) and is rated for continuous duty.

The heater tank has a capacity of 360 cubic inches and an operating pressure rating of 200 psi at 125°F (52°C). A liquid level sight gauge, mounted vertically on the heater tank, indicates the level of liquid Freon in the tank. A scale, graduated in pounds and ounces, is mounted alongside the sight gauge and ranges from 0 to 17 pounds. The tank is also equipped with a compound pressure gauge, which is graduated from 0 to 30 inches Hg (mercury vacuum) and 0 to 300 psi pressure. A heating blanket surrounds the heater tank and is used to heat the refrigerant for building up tank pressure sufficient for charging a system.

The oil charging cylinder stores Ansul 150 lubricating oil used to replenish the vapor cycle compressor oil supply. The cylinder has a capacity of 68 cubic inches and an operating pressure of 100 psi at 125°F. The cylinder is equipped with an oil level sight gauge and an oil charging pressure gauge. A scale, graduated in centimeters, is mounted beside the sight gauge and ranges from 0 to 800 cc.

The flexible evacuation and charging hoses are both 180 inches long to accommodate hooking the cart to the unit being evacuated or charged without removing the unit from the aircraft.

An aircraft power cable connects primary electrical power from the cart to the aircraft. A deck edge power cable or power cable from electric generating equipment provides power to the cart.

Safety Precautions

To prevent injury to personnel and damage to equipment, you must observe the following safety precautions and handling procedures when working with Freon gas:

1. Protective equipment (apron, gloves, goggles, and face mask) must be worn.
2. If liquid Freon comes in contact with the skin, treat the skin for frostbite.
3. If liquid Freon comes in contact with the eyes, medical attention must be sought immediately. The following first aid treatment should be administered: Do not rub or irritate the eyes; drop sterile mineral oil into the eyes; then wash the eyes with a boric acid solution if the irritation continues.
4. Freon is stored in cylinders that are color-coded orange with appropriate lettering for identification. These cylinders should be handled carefully because the pressure inside the cylinder depends upon the ambient temperature. Refrigerant cylinders should not be exposed to high temperatures or flames. Cylinders that are used for high-pressure liquids should never be thrown around, dropped, or used for anything other than their intended purpose. Refrigerant cylinders should never be filled to more than 85 percent of their capacity.
5. Freon tends to dissolve natural rubber; therefore, only the recommended gaskets, O-rings, and packings should be used in the vapor cycle system.

SH-60B HELICOPTER ENVIRONMENTAL CONTROL SYSTEMS (ECS)

Learning Objective: Identify components and conditions of the ECS for the cockpit, cabin area, and the nose avionics compartment of the SH-60B helicopter.

The SH-60B helicopter cabin cockpit and nose bay environments are controlled by the ECS, which provides both heating and air conditioning in a range of 2°C to 71°C. Supplementary or backup air circulation is provided at all crew stations by manually controlled air inlets for outside air.

The ECS (fig. 3-19) consists of an air-cycle machine (ACM) (fan, turbine, and compressor), bleed-air ducting, necessary controls and valves, water separator, distribution system, air inlet, and heat-exchanger exhaust duct. The bleed-air portion of the ECS functions from two sources

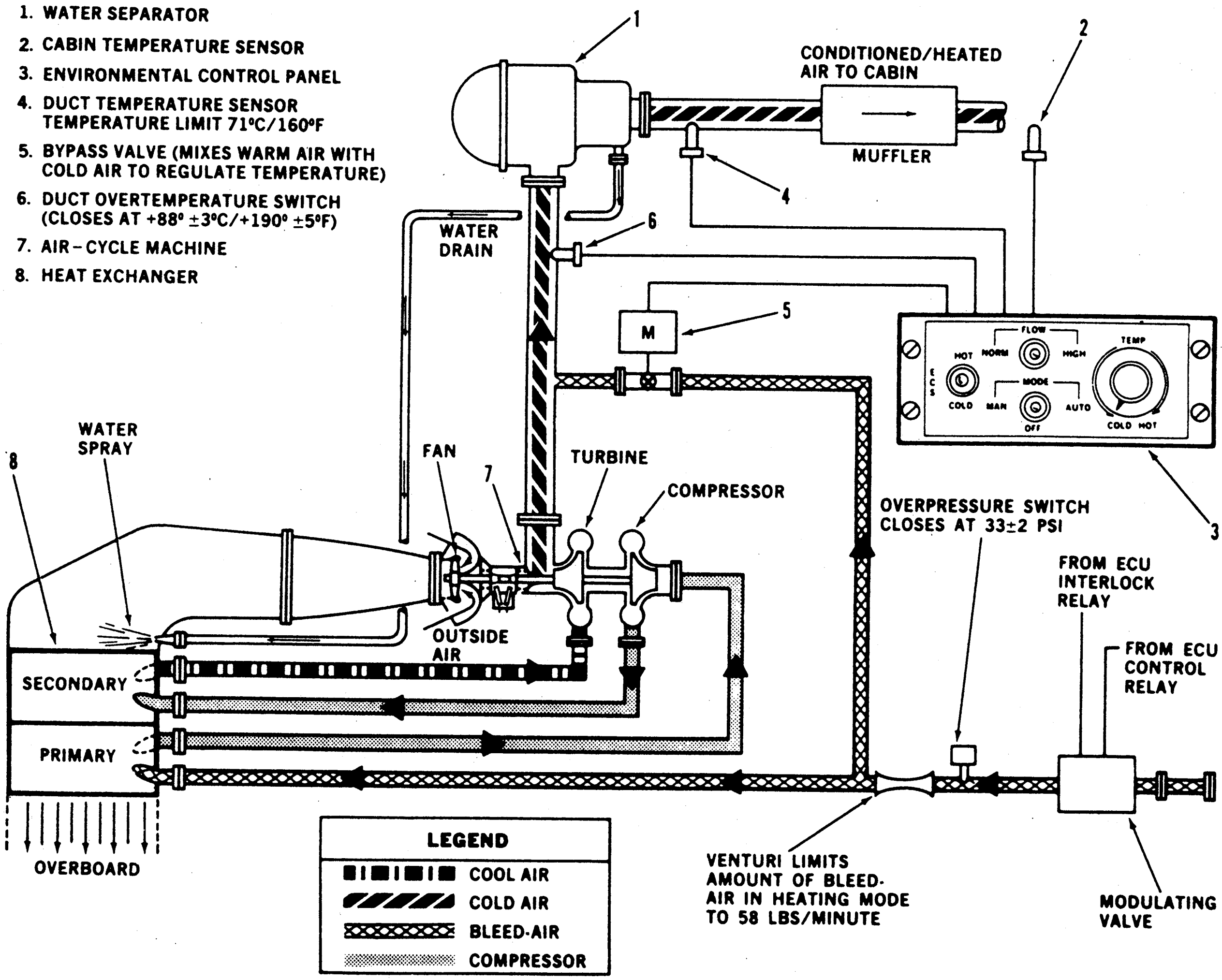


Figure 3-19.—Environmental control system.

of bleed air—engine and auxiliary power unit (APU). The energy extracted from bleed air is used to drive the ACM's cooling fan and compressor. Bleed air is applied to the ACM through a modulating valve, which functions as both an on/off valve and pressure regulator. Air source selection is accomplished by means of the AIR SOURCE ECS/START switch on the overhead control panel. In the ENGINE position, the engine bleed air is selected as a source. In APU position, APU bleed air is used as the air source. With ECS selected ON (from engine source), maximum torque available is reduced by 3.5 percent.

An overpressure switch, located on the ACM side of the modulating valve, senses high air pressure. In an overpressure condition, the over-pressure switch illuminates an advisory panel light to indicate ECS HI PRESS. System shutdown does not occur during an overpressure, since the ACM is capable of withstanding full bleed-air pressure, delivered by the engines or APU. Power is supplied from the No. 2 ac primary bus and the No. 2 dc primary bus, through two circuit breakers, both on the sensor operators (SO) circuit breaker panel, marked ECS PWR and ECS CONTR, respectively. If ECS fails, cooling air must be introduced into the nose avionics compartment by pulling the nose door cooling damper control located on the left-hand side of the console.

ECS CONTROL PANEL

The ECS control panel contains a three-position toggle switch to control the ECS operating modes. At OFF, the switch provides the power to shutoff the system for heating and cooling. At MODE AUTO, the modulating valve is turned on and the cabin temperature is set by the TEMP knob. When at FLOW HIGH, the ECS will operate at high volume from the air-cycle machine. HIGH is used primarily for cooling. Cabin temperature, duct temperature, and the setting of the TEMP knob are all compared in the cabin temperature controller. The MAN position bypasses the cabin and duct control valve by a spring-loaded valve to center HOT-COLD switch. Placing the momentary beep switch to HOT or COLD causes the control valve to move toward open or close as long as the switch is held, allowing manual temperature control.

NOTE: Use of the manual mode of the ECS requires pulsing of the HOT-COLD toggle switch followed by a waiting period to judge the magnitude of temperature change. Excessive manual input may cause ECS shutdown and/or APU failure (if APU is the air source).

The ECS will automatically shut down under the following conditions:

1. Engine contingency power is selected with the contingency-power switch (CNTGY PWR) on either collective stick.
2. In any position of the AIR SOURCE ECS/START switch, when starting either No. 1 or No. 2 engine.

When the AIR SOURCE ECS/START switch is placed to ENGINE, the ECS will also shut down when

1. a turbine gas temperature (TGT) of 856 ± 5°C is reached,
2. either engine ANTI-ICE switch is placed ON, or
3. when the DE-ICE MASTER switch is placed to AUTO and ice is detected.

AVIONICS COOLING

The total aircraft avionics system requires the dissipation of approximately 12 kilowatts of heat. Units cooled by the external air system are maintained at 15° to 27°C. Units cooled by ambient cabin air require an ambient temperature below 29°C.

Two fans provide cooling air for the mission avionics. One fan is located on the right side of the cabin at the base of the mission avionics rack, and the other is located on the left side of the cabin at the base of the sensor operator's (SO's) console. Fan control is provided by the mission power (MSN PWR) switch, located on the lower center console on the MSM SYS (mission systems) panel, and by a 27°C temperature-sensing switch, located at each fan inlet. When the MSN PWR switch is placed in either PRI or SEC position and the fan inlet temperature is above 27°C, the fans run to bring in outside air for circulation through the respective avionics areas. Backup cooling for the avionics is provided by the ECS. If the ECS is operating, the modulating valve will automatically go to the full-open position when the temperature switches at the fan inlets sense a temperature of 54°C or greater. Conditioned cabin air may be circulated through the avionics system by removing the thermal/acoustic panels for backup cooling. Power is supplied from the No. 1 ac primary bus and No. 2 ac primary bus through the (SO) circuit breaker panel by two circuit breakers, marked LH RACT BLOWER and BLOWER, RH RACK.

AIRCRAFT PRESSURIZATION SYSTEMS

Learning Objective: Recognize the purpose and function of aircraft pressurization systems 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 pressuring 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 the use of seals around tubing, ducting, bolts, rivets, and other hardware that pass through or pierce the pressuretight 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 subsystem regulates the outflow of air from the cabin to control the cabin pressure 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 governed by the pressure regulator control, which provides five modes of operation: unpressurized, isobaric, differential cabin-to-ambient pressure, dump, and repressurization.

Below 5,000 feet, the cabin is normally unpressurized. Between 5,000 and 25,000 feet, the cabin altitude will remain at 5,000 feet. Maximum cabin pressure-to-ambient differential is 6.7 ± 0.1 psi. Table 3-1 displays various cabin pressure differentials and cabin altitudes for different flight levels.

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 of operation 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 pressure regulator valve compares this control pressure to cabin pressure, and it positions

Table 3-1.—Cabin Altitude versus 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 ft cabin altitude				

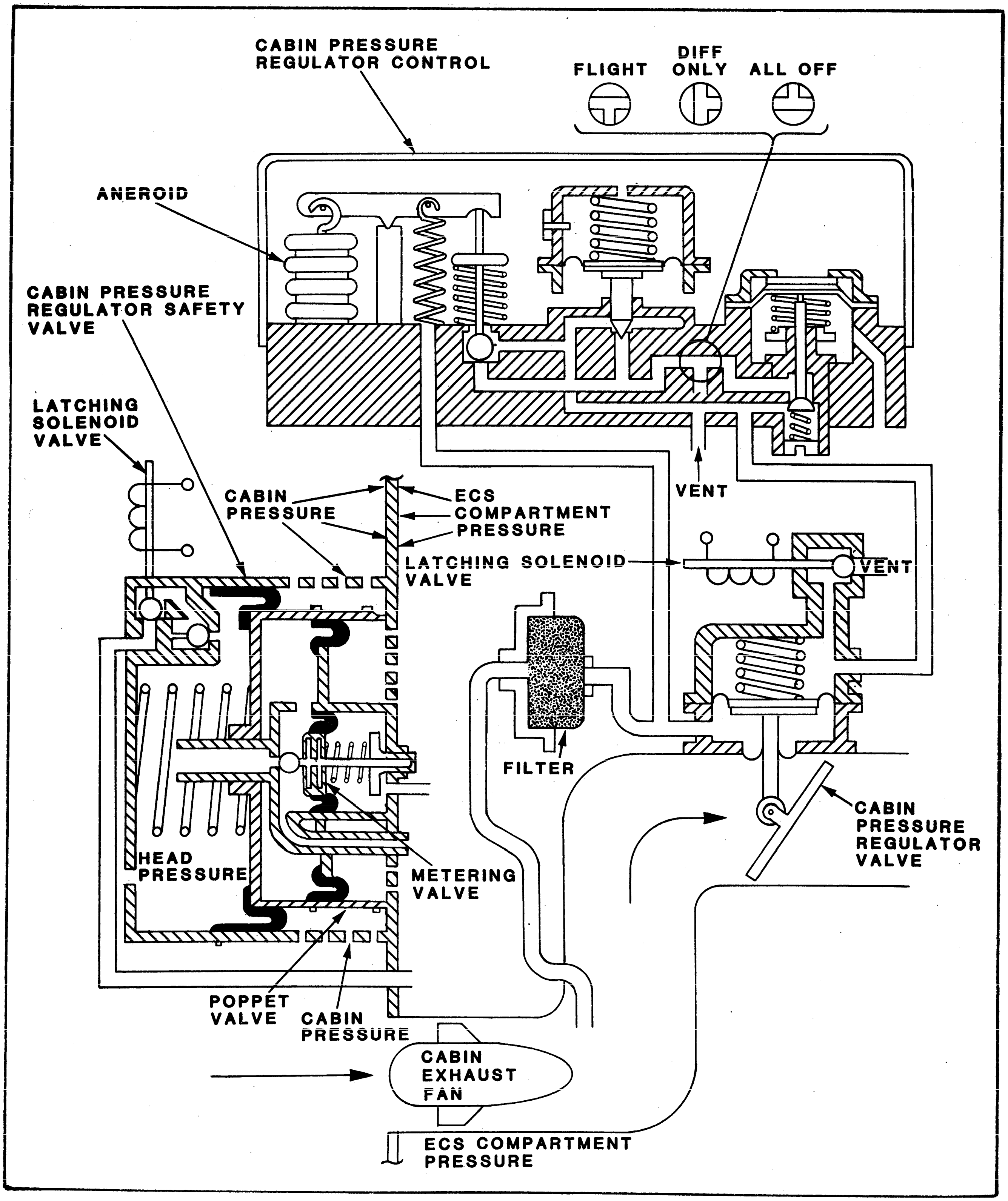


Figure 3-20.—Cabin pressurization subsystem schematic.

the butterfly valve 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 recirculation 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 repressurization 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 repressurization 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, thus allowing the diaphragm to open the pressure regulator valve butterfly. This reduces cabin pressure and the rate of repressurization.

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 repressurization. Therefore, the cabin will be pressurized 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:

1. Keep the cabin pressurized as in flight.
2. Set the cabin pressure switch to DUMP to ensure a full-open pressure regulator valve and a full-open pressure safety valve.
3. If the outside air temperature is below 80°F, turn the auxiliary vent selector to ON and open the cabin entry door.

Component Description

The S-3 cabin pressurization subsystem consists of five primary components. Four of them are shown in figure 3-20. 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 valve 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 and diaphragm operated to the open 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 diaphragm. The solenoid valve is electrically connected to the cabin pressurization switch on the environmental control panel (fig. 3-21).

There are three ports leading into the pressure regulator valve diaphragm chamber (fig. 3-20). 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

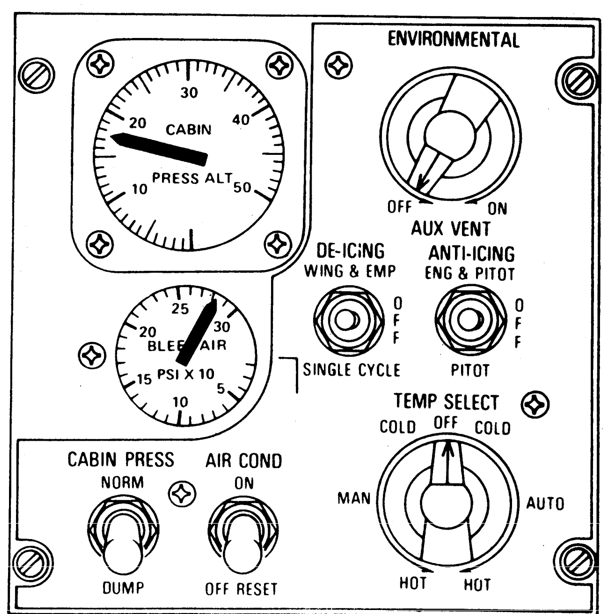


Figure 3-21.—Environmental control panel.

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 the pressure on either side of the diaphragm 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 aground test of the normal delta-P setpoint. The ALL OFF position permits a ground test of the setpoint of the pressure safety valve. These tests are accomplished with pressure supplied by support equipment.

Four pneumatic ports are provided on the pressure regulator control for use 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, use 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 and will decrease relative to 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 repressurization 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 repressurization diaphragm to limit cabin repressurization 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 the cabin absolute pressure. The normally open low-pressure switch closes at 13,000 ± 500 feet and reopens at 11,000±500 feet. The cabin pressurization 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. Many of the components are repairable at the depot level of maintenance rather than at lower levels of maintenance because of the high cost of special equipment required for making adjustments necessary to proper operation.

In most instances, a maladjusted or malfunctioning component must simply be removed and replaced. There are, however, certain components that require periodic servicing, cleaning, and inspection so the component will function properly and efficiently and may be considered reliable for flight. Specific requirements for servicing, cleaning and inspection are listed in the daily, postflight, and special/conditional, Maintenance Requirements Card (MRC) decks as well as the 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 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 3-22 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 handtight.

A continuity check is simply a matter of determining whether or not the circuit to the valve, or other electrically controlled unit, is complete. The check for continuity may be made with a test lamp, which can be drawn from supply.

To perform a continuity check, the connector at the electrically controlled unit is first disconnected. Then, with all necessary switches and circuit breakers closed, the test lamp is connected into the circuit at the electrical connector. The lamp thus indicates whether or not the circuit is complete.

Continuity checks may also be made with the use of a multimeter. A multimeter is an instrument used for measuring resistance, voltage, or amperage.

Troubleshooting

Troubleshooting is the process of locating a malfunctioning component or other unit in a

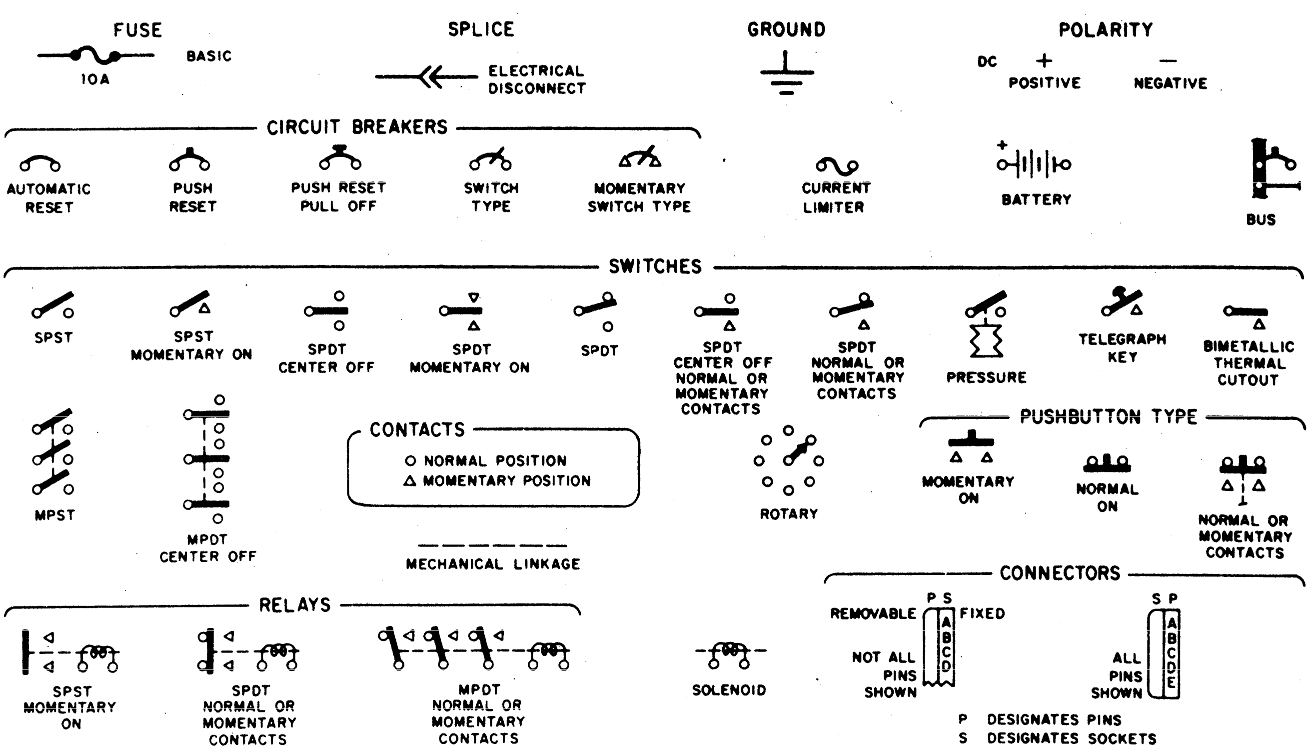


Figure 3-22.—Electrical symbols.

system or mechanism. For the AME, troubleshooting is an important responsibility and one to which he/she will devote a lot of squadron time.

When a malfunction is reported concerning any of the components or systems that are maintained by the AME, he/she must be able to locate the trouble and correct the difficulty.

To troubleshoot intelligently, the AME must be familiar with the system(s) at hand. He/she must know the function of each component in the system and have 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 best achieved by studying the installation and schematic diagrams of the systems 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 all the aircraft system for which he/she is responsible.

Basically, there are seven distinct steps to follow during troubleshooting. These steps are 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 accomplished by using special support equipment such as the environmental control test set or by using aircraft power and equipment with the engines 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 the most probable 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 a 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 the 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 on some of the air-conditioning valves 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 would be a false indication if the shaft was 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 each component and the system should operate. During this step, the AME can make full use of his knowledge and the system schematics to trace system operation and systematically eliminate components. He can then 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, thus 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, 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 that 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.

MULTIMETER TROUBLESHOOTING SKILLS

As previously mentioned, much of the AME's time is spent troubleshooting equipment in the squadron's aircraft. Troubleshooting on the S-3 aircraft environmental control system involves the use of the multimeter to check the resistance of the temperature sensor and to check the voltage to electrical connectors. The material presented in the following paragraphs will increase your knowledge of the multimeter and increase your proficiency as a troubleshooter. If you are not sure of the proper and safe methods for using this equipment, you should request the assistance of an AE.

Multimeter

A multimeter is the most common electrical measuring device used in the Navy. The name multimeter comes from the words MULTIple METER. The multimeter is a direct current (de) ammeter, an alternating current (at) ammeter, a dc voltmeter, an ac voltmeter, and an ohmmeter all in one package. Figure 3-23 is a sketch of a typical multimeter. While it may look complicated, it is very easy to use.

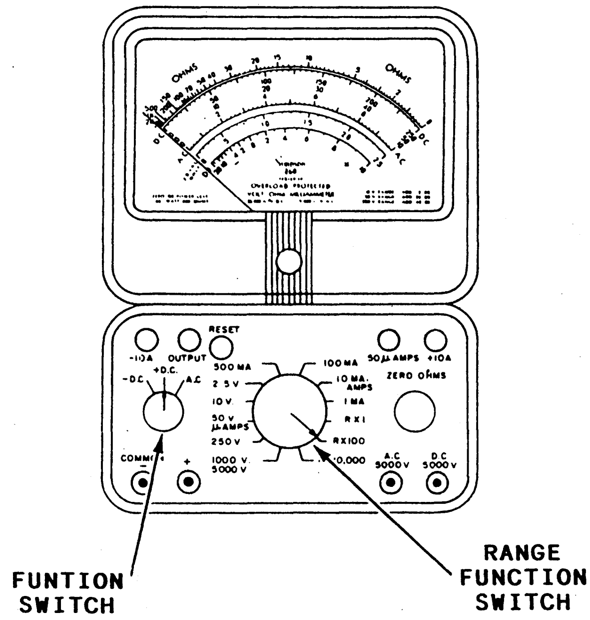


Figure 3-23.—A typical multimeter.

JACKS.— The lower portion of the meter contains the function switches and jacks for the meter leads. The COMMON or (–) jack is used in most functions of the meter. One meter lead is plugged into the common jack. The (+) jack is used for the second meter lead for any of the functions printed beside the range function switch (the large switch in the center). The other jacks have specific functions printed above or below them and are self-explanatory. The output jack is used with the dB scale and will not be explained. To use one of the special function jacks, except the + 10 amps, one lead is plugged into the common jack, and the range function switch is positioned to point to the special function desired.

For example, to measure a very small current (20 microampere), one meter lead is plugged into the common jack, the other meter lead is plugged into the 50 amps jack, and the function switch is placed in the 50V/u amps position. To measure currents above 500 milliamperes, the + 10A and – 10A jacks are used for the meter leads, and the function switch is placed in the 10MA/AMPS position.

FUNCTION SWITCHES.— The function switch is used to select the function desired. The – dc, + dc, ac switch selects director alternating current and changes the polarity of the direct current functions. To measure resistance, this switch should be in the + dc position.

The zero ohms control is a potentiometer for adjusting the 0 reading on ohmmeter functions. The reset is a circuit breaker and is used to protect the meter movement. Not all multimeters have this protection, but most have some sort of protection, such as a fuse.

When the multimeter is not in use, it should have the leads disconnected and be switched to the highest voltage scale and ac. These switch positions are most likely to prevent damage if the next person using the meter plugs in the meter leads and connects them to a circuit without checking the function switch and the dc/ac selector.

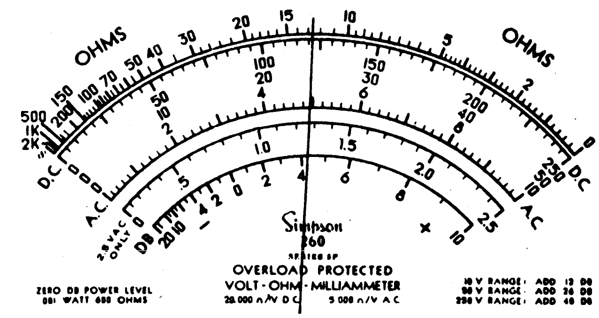
SCALES.— The numbers on the uppermost scale in figure 3-24 are used for resistance measurement. If the multimeter was set to the R x 1 function, the meter reading would be approximately 12.7 ohms.

The numbers below the uppermost scales are used for de voltage and current. These numbers are also used with the scale just below them for ac voltage and current. The fourth scale from the top and the numbers just below the scale are used for the 2.5-volt ac function only. The lowest scale (labeled dB) is not discussed. Figure 3-24 shows how the given needle position should be interpreted with various functions selected.

Multimeter Safety Precautions

As with other meters, the incorrect use of a multimeter could cause injury or damage. The following safety precautions are the minimum for using a multimeter:

1. De-energize and discharge the circuit completely before connecting or disconnecting a multimeter.
2. Never apply power to the circuit while measuring resistance with a multimeter.
3. Connect the multimeter in series with the circuit for current measurements, and in parallel for voltage measurements.
4. Be certain the multimeter is switched to ac before attempting to measure ac circuits.
5. Observe proper dc polarity when measuring dc
6. When you are finished with a multimeter, switch it to the OFF position, if available. If there is no off position, switch the multimeter to the highest ac voltage position.
7. Always start with the highest voltage or current range.



FUNCTION SWITCH	−D.C./+D.C. A.C.	INDICATION
5000 V	+ d.c.	+2420.00Vd.c.
1000 V	− d.c.	− 482.00Vd.c.
250 V	+d.c.	+ 121.00Vd.c.
50 V	a.c.	24.90Va.c.
10 V	a.c.	4.99Va.c.
2.5 V	a.c.	1.28 Va.c.
10 A	+d.c.	4.82 Ad.c.
500mA	a.c.	249.00mAa.c.
100mA	a.c.	49.90mAa.c.
10mA	+d.c.	4.82mAd.c.
50μA	+d.c.	24.20μAd.c.
R x 100	+d.c.	1.27 kΩ

Figure 3-24.—A multimeter scale and readings.

8. Select a final range that allows a reading near the middle of the scale.
9. Adjust the 0 ohms reading after changing resistance ranges and before making a resistance measurement.
10. Be certain to read ac measurements on the ac scale of a multimeter.
11. Observe the general safety precautions for electrical and electronic devices.

All valves are not constructed in the same manner. Therefore, the electrical tests performed on a valve should be accomplished as directed by the appropriate MIM. The voltage and resistance tests described in the following paragraphs are examples and should not be used as references for the performance of tests on aircraft.

VOLTAGE TEST.— To perform a voltage test of the S-3 bleed-air shutoff valve, you must first secure power to the valve. Set the function switch of your multimeter to the + dc position. Set the range select switch to the 50V position. Next, insert the black test lead in the (–) common jack and the red lead in the (+) jack.

Before proceeding, you should review the appropriate MIM for the correct placement of the test lead probes with respect to the connector pins. You should also review the voltage requirements for a successful test. Finally, you should ensure that all circuit breakers and switches are in the correct position.

After applying power to the connector, be sure that you are using the correct meter scale to obtain the voltage reading. In this example, you would use the 50 dc scale. With the test completed, you should return to the MIM for the remainder of the steps in the troubleshooting procedure.

RESISTANCE TEST.— To perform a resistance check on an S-3 cabin temperature sensor you must secure power to it. Then, ground the sensor to remove any voltage that may remain in the circuit. Set the function switch to the + dc position. Set the range select switch to the R x 100 position. Next, insert the black test lead in the(–) common jack and the red lead in the (+) jack.

With the power removed and the meter preset, short the test leads by touching them together. Then place the meter in a horizontal position and rotate the 0 ohms control until the meter indicates zero. It is important to keep the meter in the same position for the entire test to ensure accurate readings.

NOTE: The function switch may have to be reset to keep the resistance reading near the mid-scale point.

Because ambient temperature affects the resistance of the sensor, you should refer to the air temperature versus resistance schedule chart of the MIM to obtain the prescribed resistance readings. The MIM should also be consulted for the proper multimeter probe placement on the sensor. For this example, your resistance readings is read from the top scales (ohms) as shown in figure 3-24.

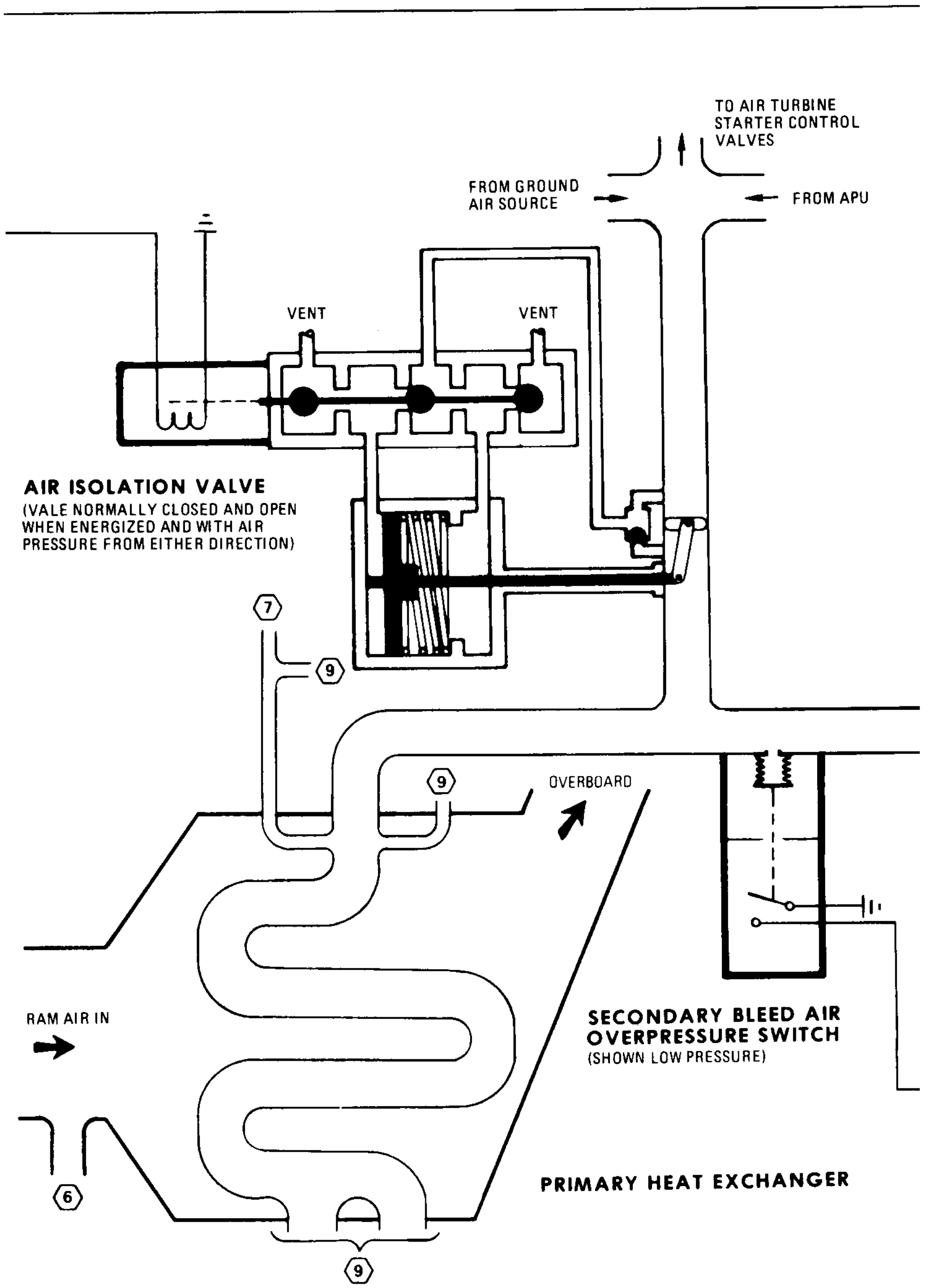


Figure 3-1A.—Bleed-air system.

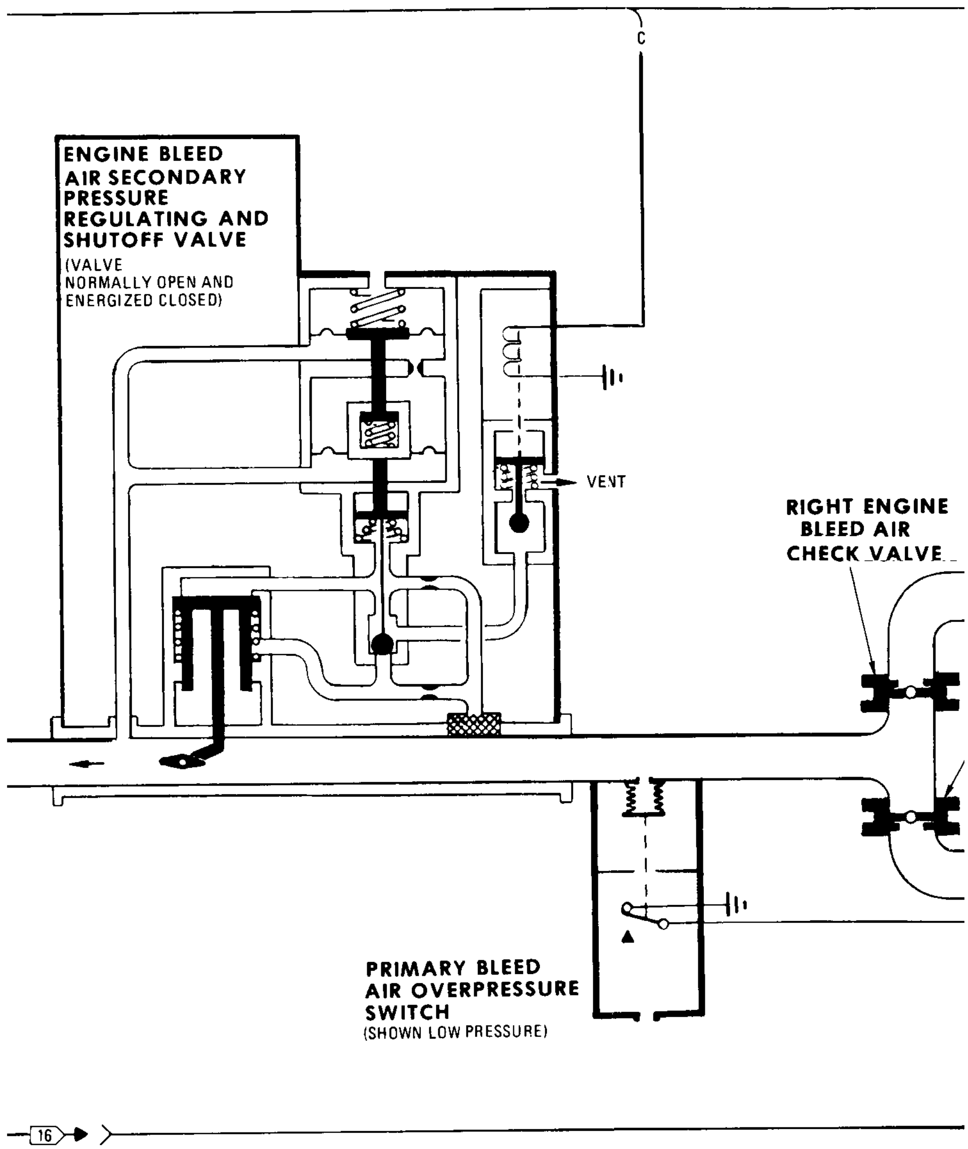


Figure 3-1B.—Bleed-air system-Continued

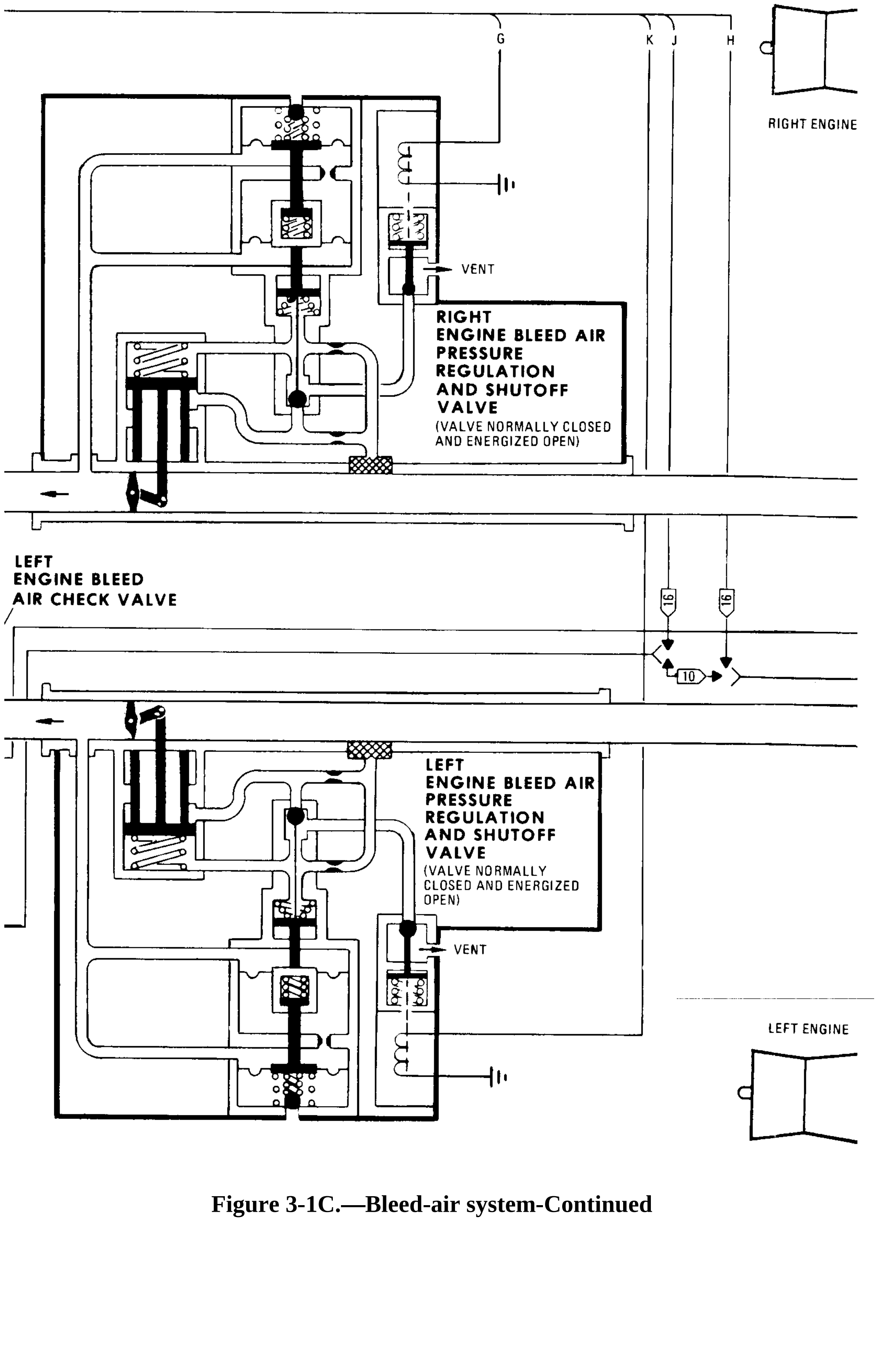


Figure 3-1C.—Bleed-air system-Continued

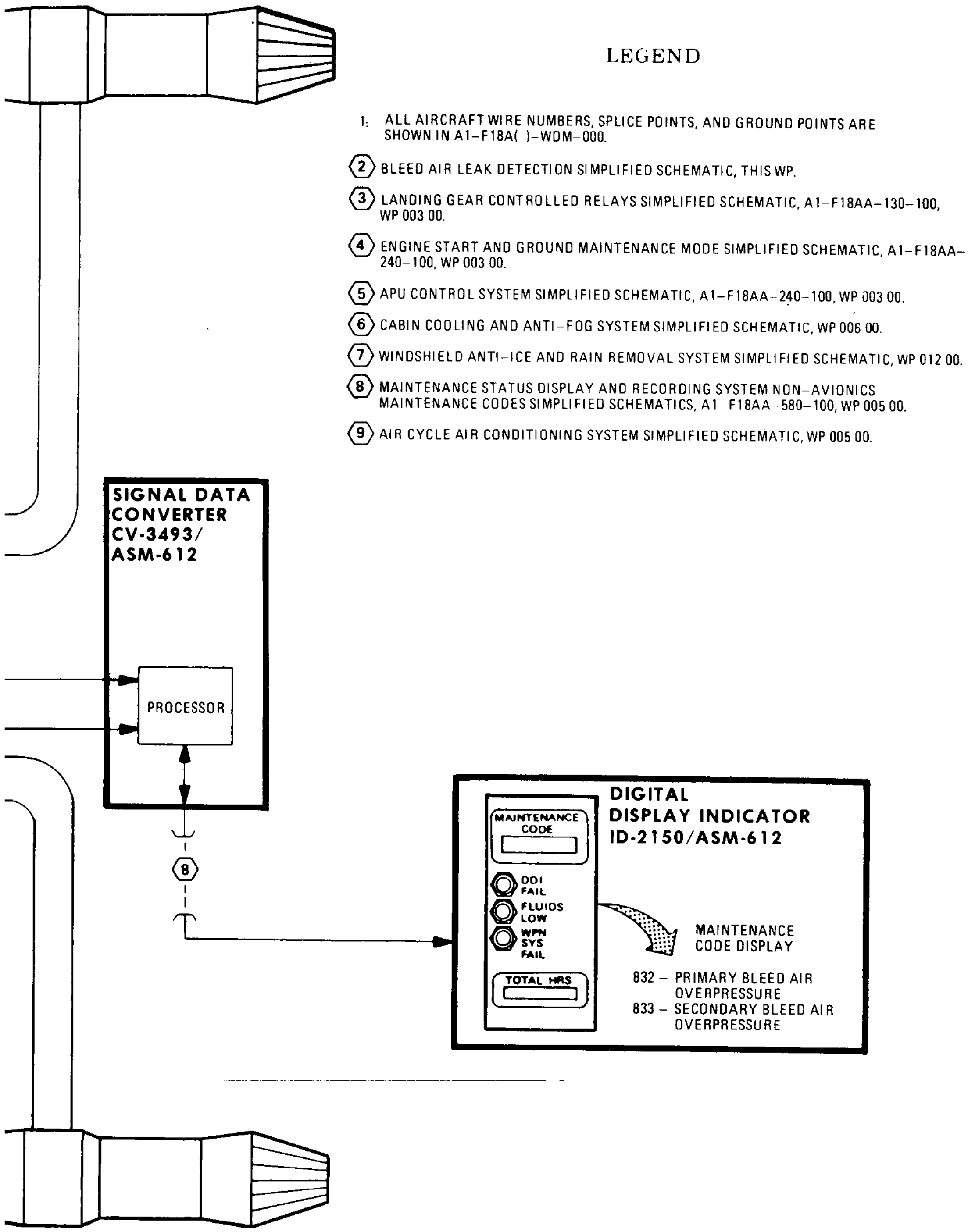


Figure 3-1D.—Bleed-air system-Continued

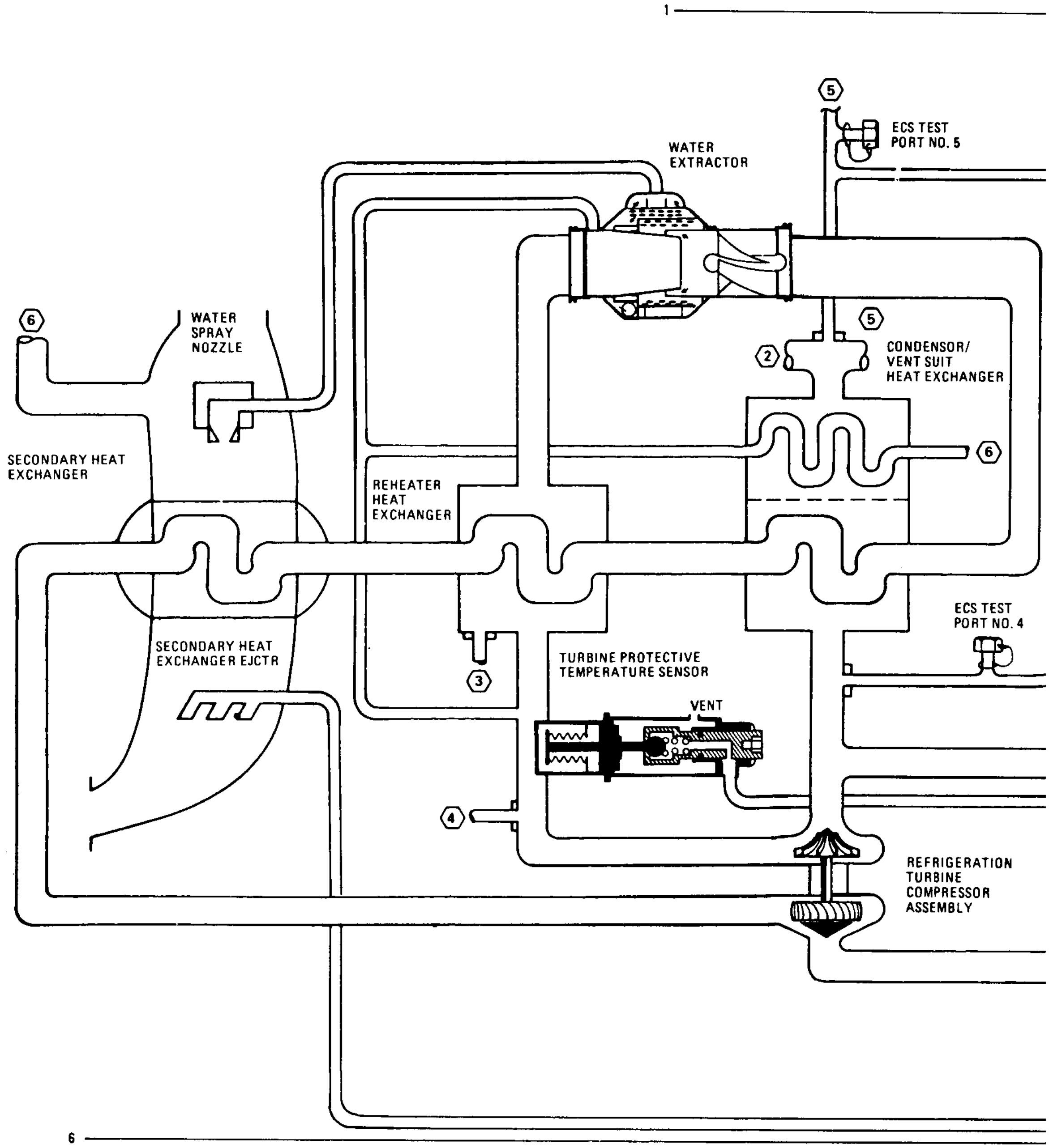


Figure 3-2A.—Air cycle air-conditioning system.

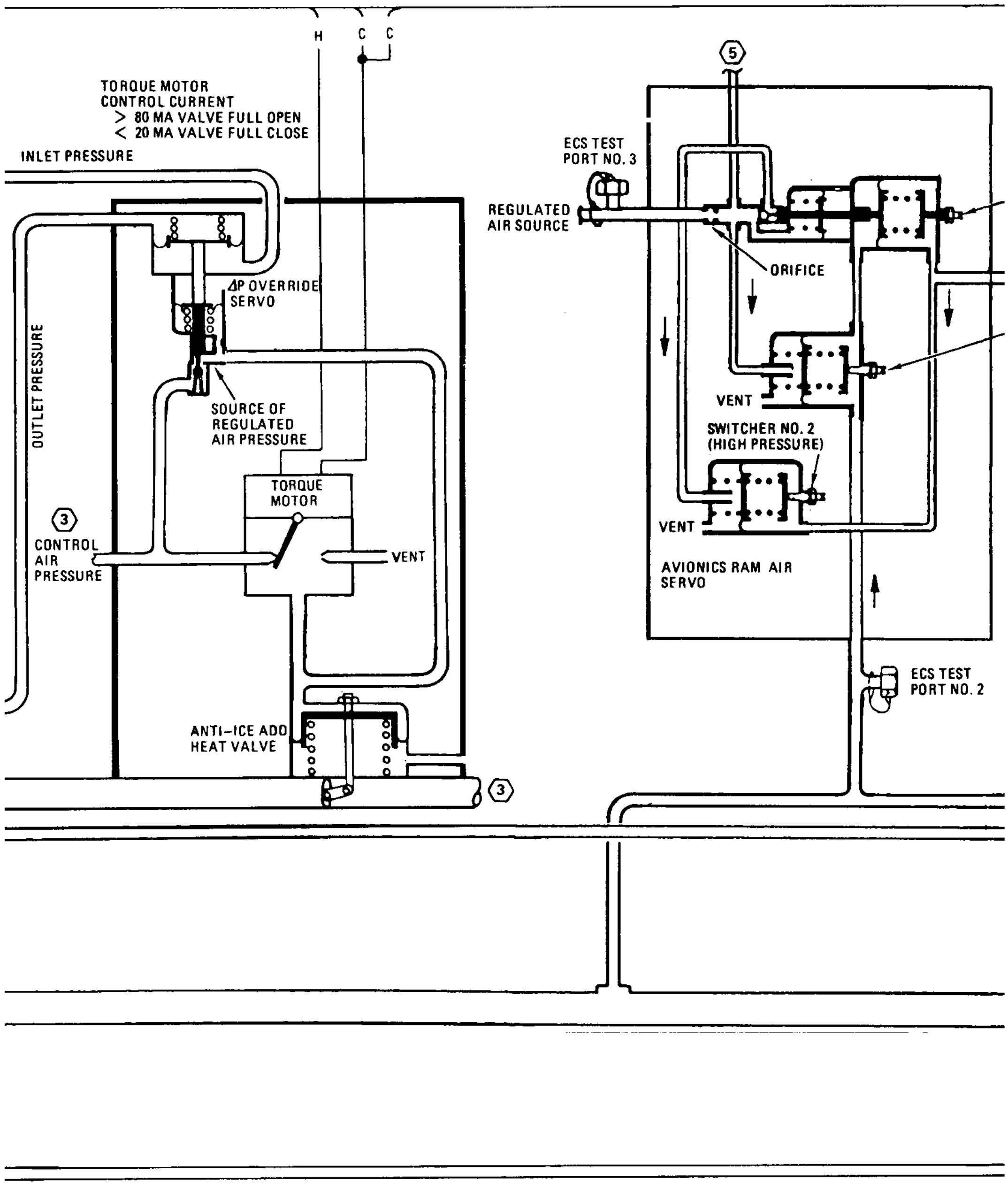


Figure 3-2B.—Air cycle air-conditioning system-Continued

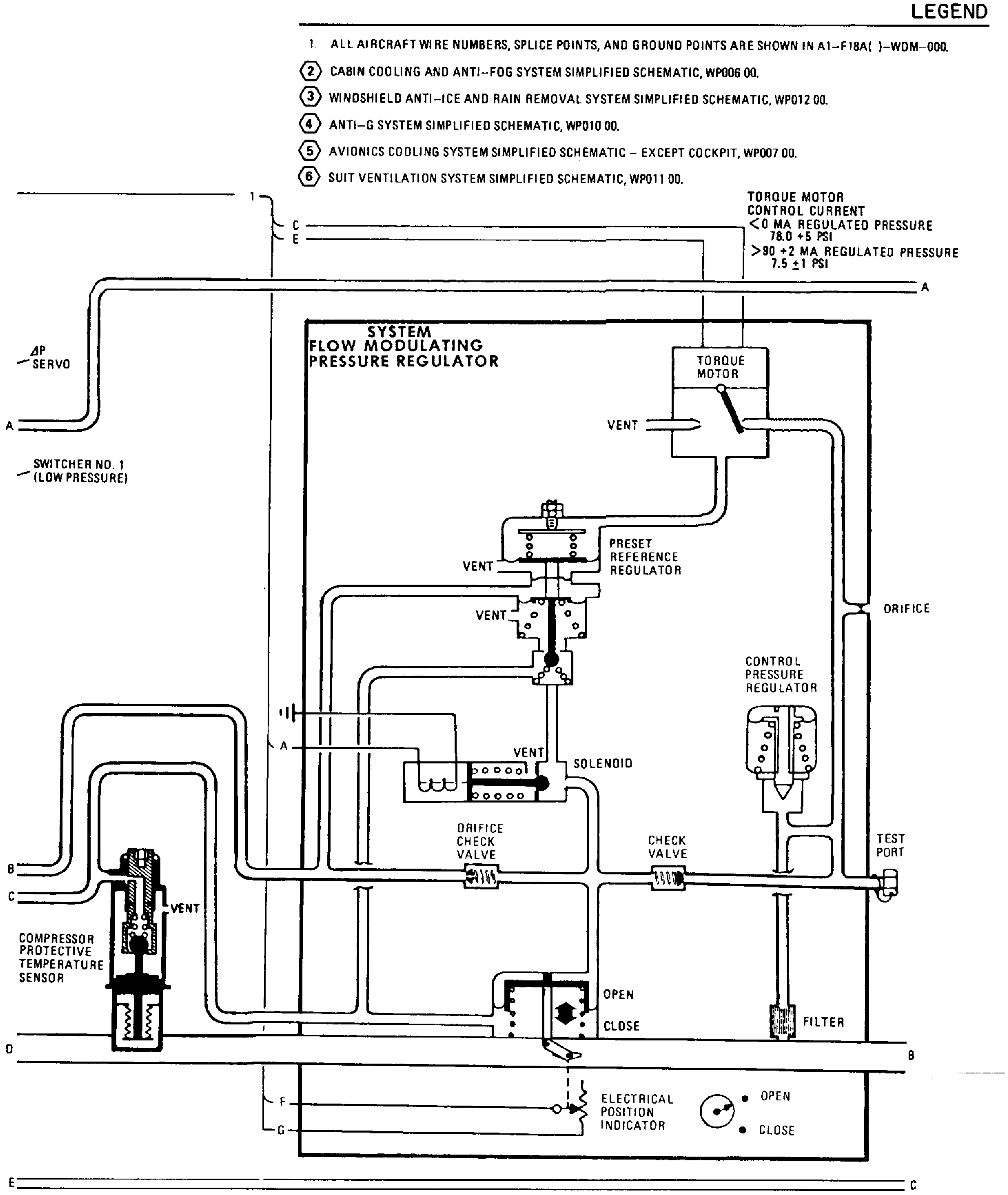


Figure 3-2C.—Air cycle air-conditioning system-Continued

⑦ FUEL PRESSURIZATION AND VENT SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-460-100, WP009 00.

⑧ BLEED AIR SYSTEM SIMPLIFIED SCHEMATIC, WP004 00.

⑨ RADAR LIQUID COOLING SYSTEM SIMPLIFIED SCHEMATIC, WP013 00.

⑩ GROUND POWER SWITCHING SIMPLIFIED SCHEMATIC, A1-F18AA-420-100, WP005 00.

⑪ AIR DATA COMPUTER SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-560-100, WP003 00.

⑫ MAINTENANCE STATUS DISPLAY RECORDING SYSTEM NON-AVIONIC MAINTENANCE CODES SIMPLIFIED SCHEMATIC A1-F18AA-580-100, WP003 00.

⑬ LANDING GEAR CONTROLLED RELAYS SIMPLIFIED SCHEMATIC, A1-F18AA-130-100, WP003 00.

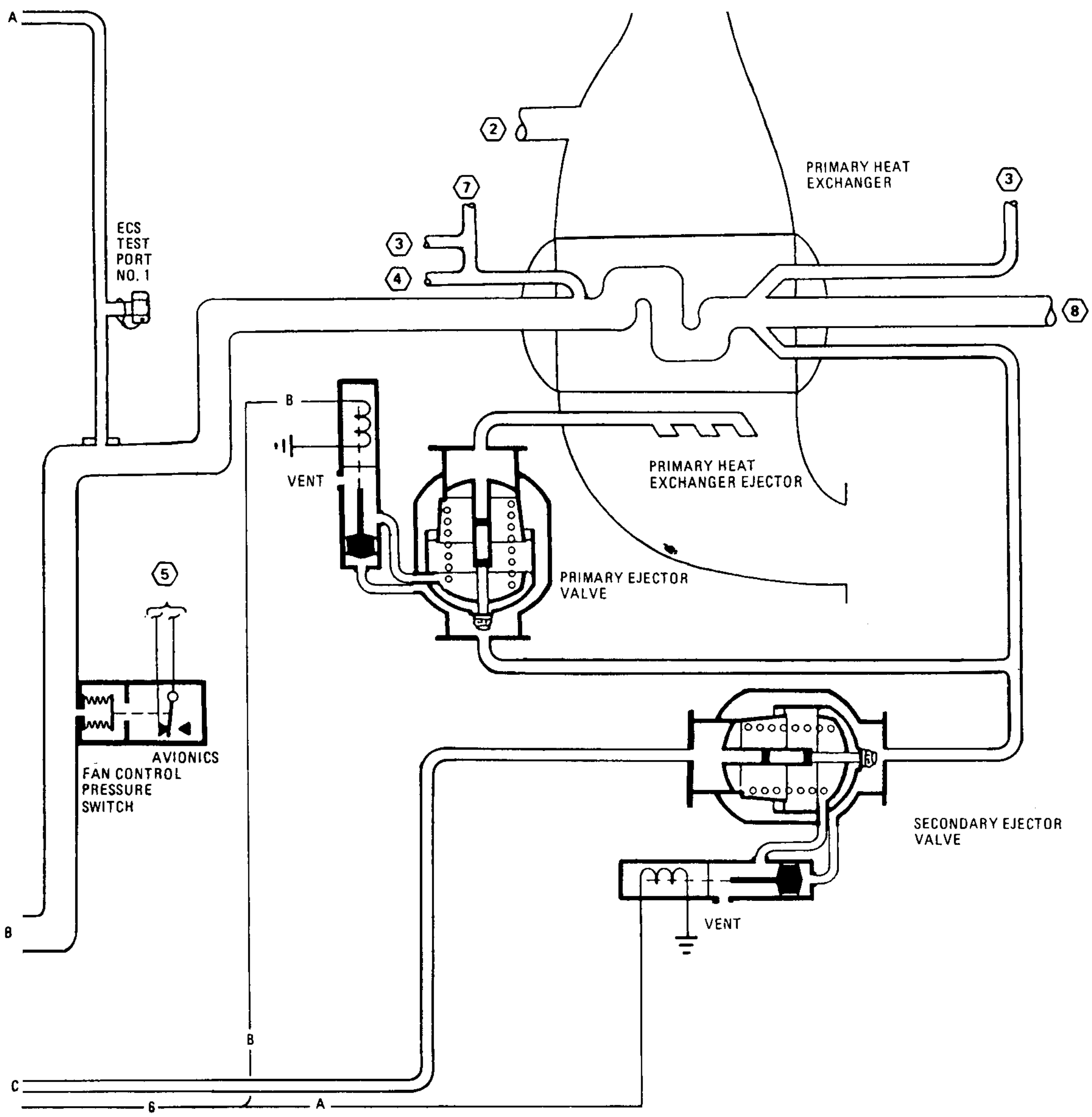


Figure 3-2D.—Air cycle air-conditioning system-Continued

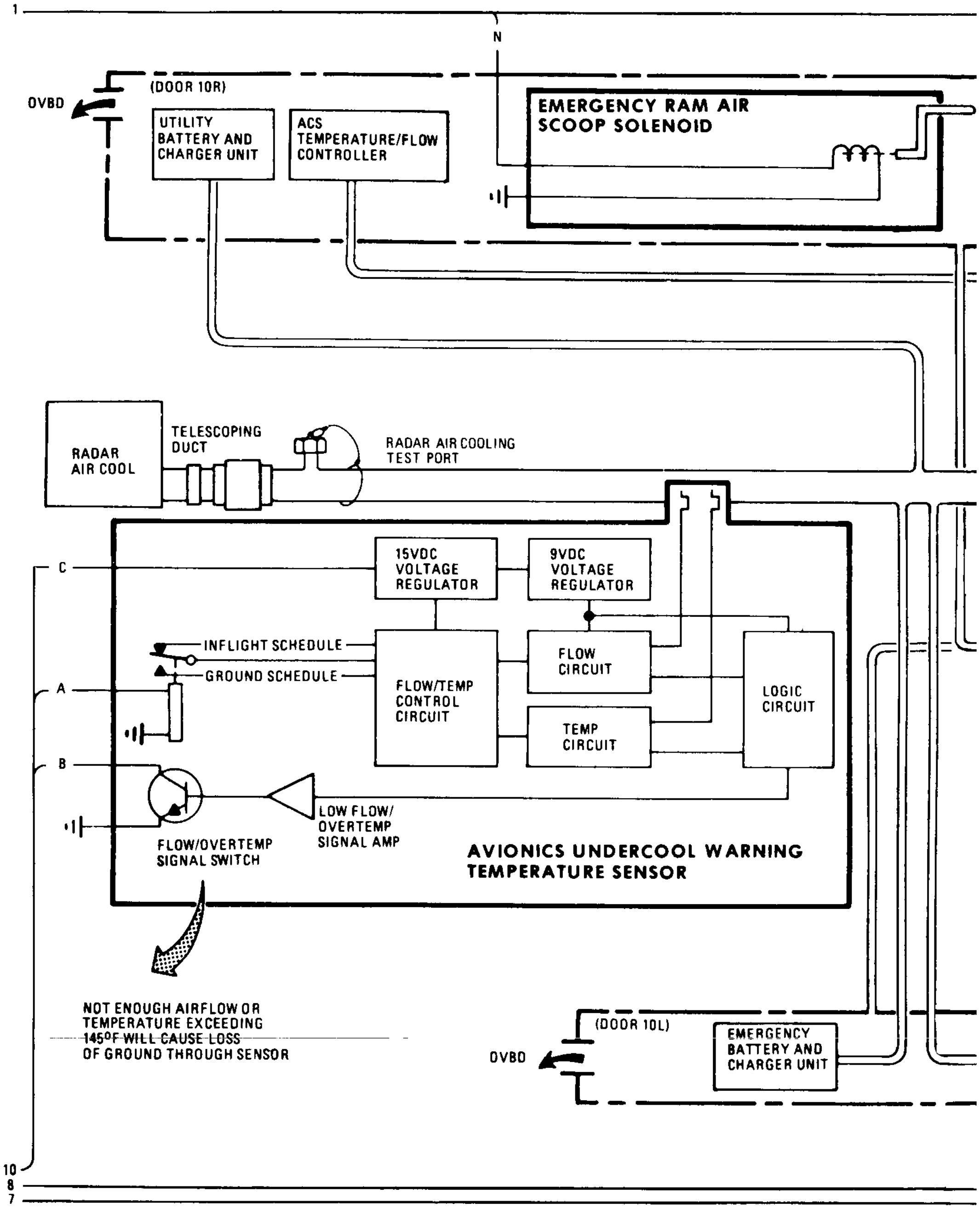


Figure 3-11A.—Avionics cooling system.

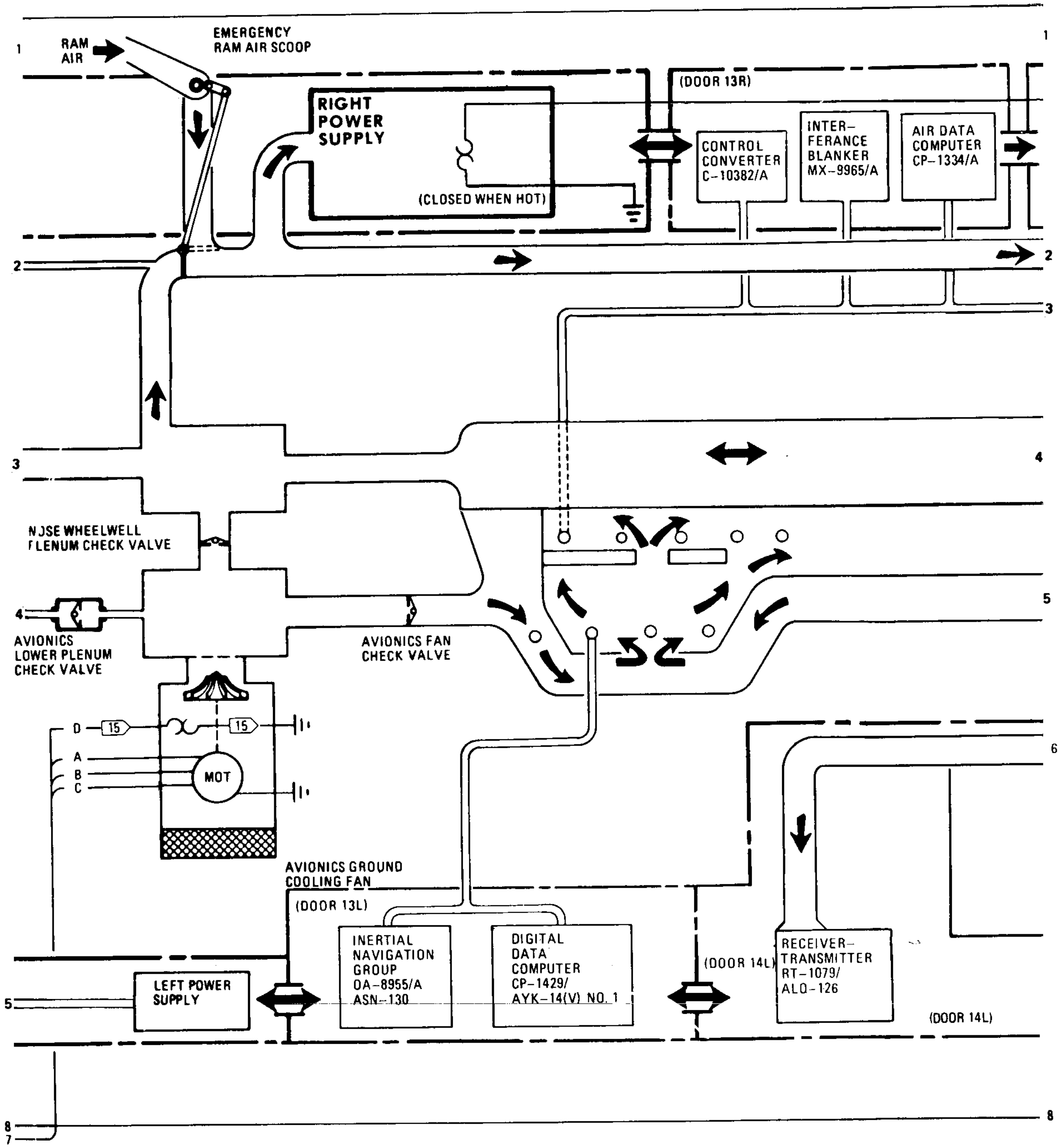


Figure 3-11B.—Avionics cooling system-Continued

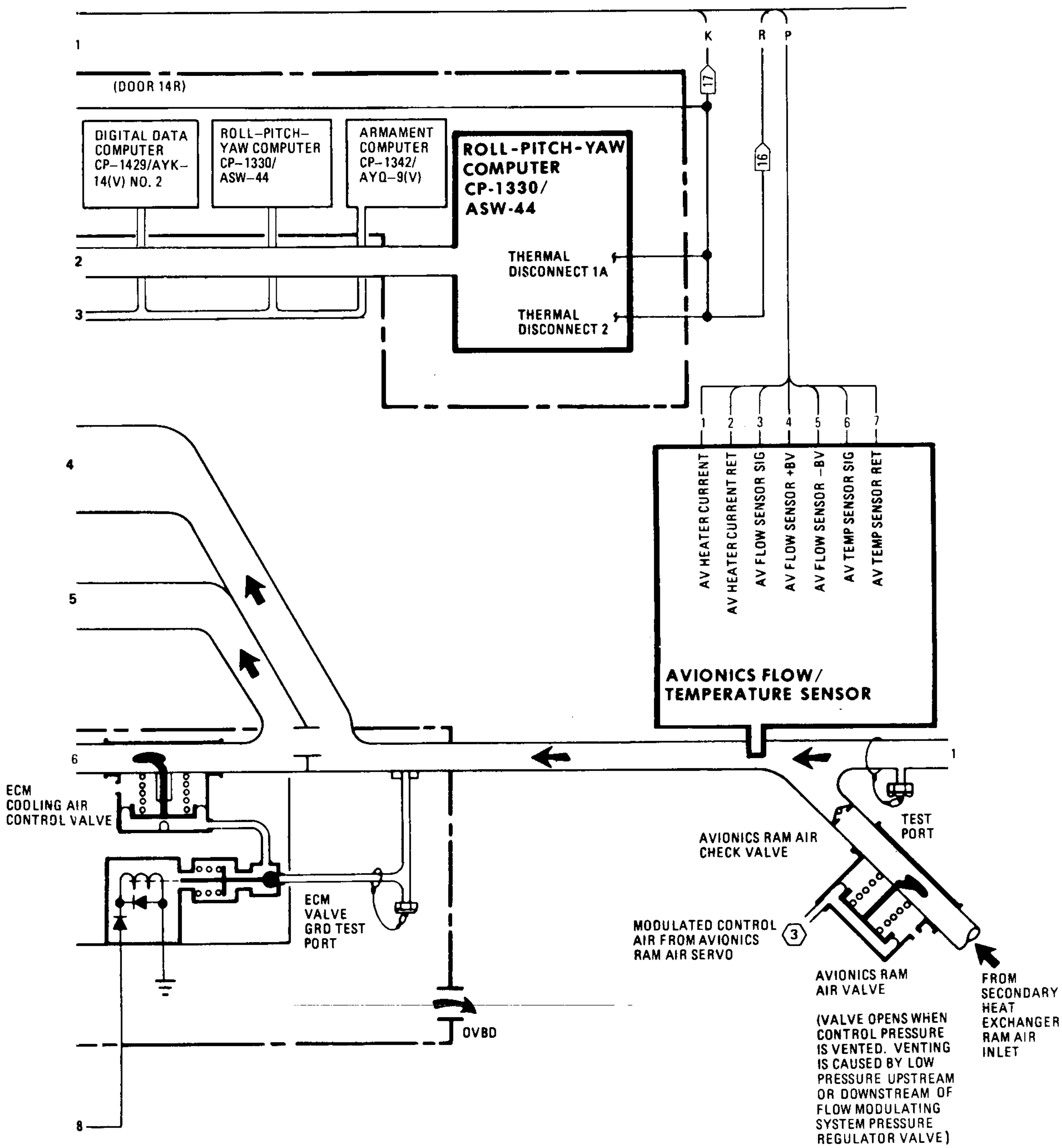
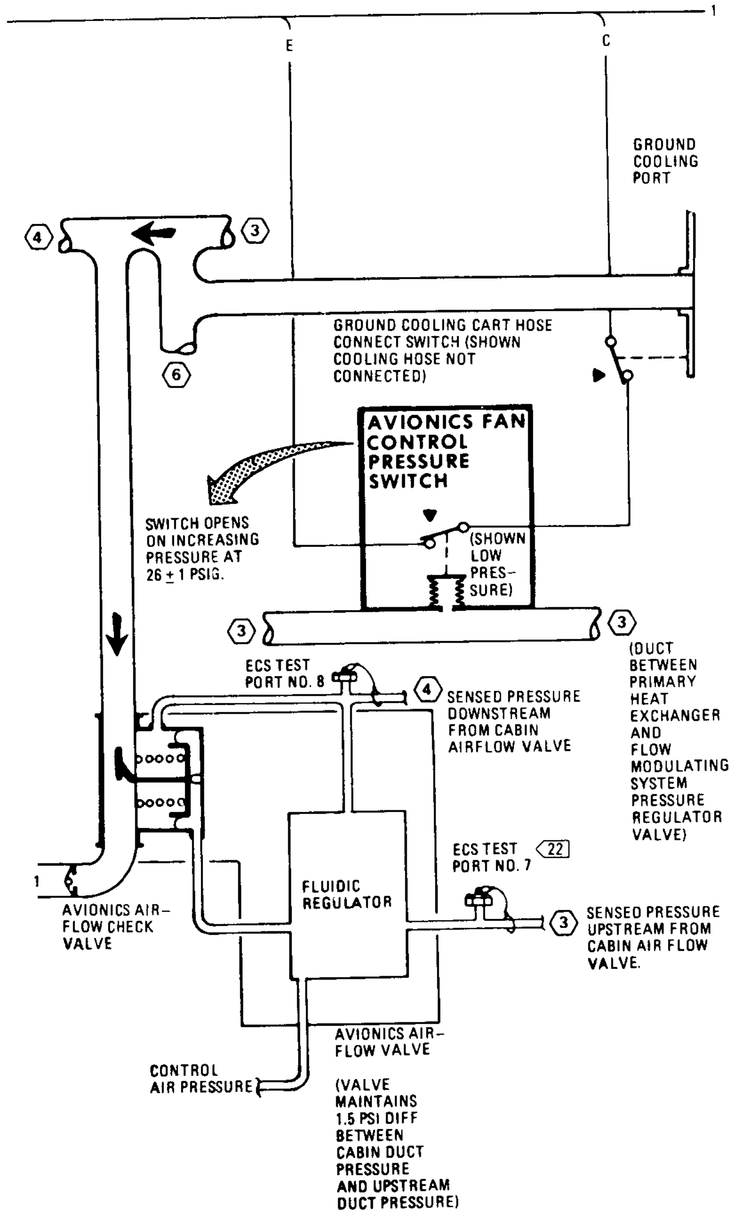


Figure 3-11C.—Avionics cooling system-Continued



LEGEND

1. ALL AIRCRAFT WIRE NUMBERS, SPLICE POINTS, AND GROUND POINTS ARE SHOWN IN A1-F18A( )-WDM-000.

2. GROUND POWER SWITCHING SIMPLIFIED SCHEMATIC, A1-F18AA-420-100, WP005 00.

3. AIR CYCLE AIR CONDITIONING SYSTEM SIMPLIFIED SCHEMATIC, WP005 00.

4. CABIN COOLING AND ANTI-FOG SYSTEM SIMPLIFIED SCHEMATIC, WP006 00.

5. AIR DATA COMPUTER SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-560-100, WP003 00.

6. RADAR LIQUID COOLING SYSTEM SIMPLIFIED SCHEMATIC, 160777 AND UP, WP013 00.

7. COCKPIT WARNING/CAUTION/ADVISORY LIGHTING SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-440-100, WP005 00.

8. MISSION COMPUTER SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-741-100, WP003 00.

9. MAINTENANCE STATUS DISPLAY AND RECORDING SYSTEM SIMPLIFIED SCHEMATIC, A1-F18AA-580-100, WP003 00.

10. LANDING GEAR CONTROLLED RELAYS SIMPLIFIED SCHEMATIC, A1-F18AA-130-100, WP003 00.

11. BLEED AIR SYSTEM SIMPLIFIED SCHEMATIC, WP004 00.

12. CONTROL CONVERTER C-10382/A AND ELECTRONIC EQUIPMENT CONTROL C-10381/ASQ INTERCONNECT SIMPLIFIED SCHEMATIC, A1-F18AA-741-100, WP003 00.

13. AIR CONDITIONING SYSTEM BIT STARTS WHEN ELECTRIC POWER IS APPLIED TO THE ACS TEMPERATURE/FLOW CONTROLLER. INFLIGHT BIT IS A COMPLETE SEQUENCE OF TESTS ON THE ACS TEMPERATURE/FLOW CONTROLLER AND TEN ELECTRICALLY INTERFACING COMPONENTS. NINE SECONDS IS REQUIRED FOR A COMPLETE BIT SEQUENCE, AND THE BIT SEQUENCE IS REPEATED EVERY NINETY SECONDS. IF THE SAME TEST INDICATES A FAILURE ON 2 CONSECUTIVE BIT SEQUENCES, THE BIT PROCESSOR REMOVES A GROUND FROM SIGNAL DATA CONVERTER CV-3493/ASM-612, AND A MAINTENANCE CODE IS RECORDED. AFTER A MAINTENANCE CODE IS RECORDED, BIT IS INHIBITED UNTIL ELECTRICAL POWER IS REMOVED AND REAPPLIED. WHEN THE AIRCRAFT IS ON THE GROUND, BIT OPERATION IS THE SAME AS INFLIGHT BIT EXCEPT THAT ONLY A PARTIAL BIT SEQUENCE IS DONE.

Figure 3-11D.—Avionics cooling system-Continued

CHAPTER 4

OXYGEN SYSTEMS

Terminal Objective: Upon completion of this chapter, you will be able to recognize the importance, characteristics, and uses of oxygen and identify oxygen systems, components, and their functions.

A dependable supply of oxygen is an essential element for the sustainment of 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 very 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 specific aircraft oxygen systems, stressing safety and the use of the applicable Maintenance Instructions Manual (MIM).

IMPORTANCE OF OXYGEN

Learning Objective: Recognize the importance of oxygen to include types, characteristics, and the 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 many days or weeks, living on what is stored in the body. The need for water is more immediate but still will not become critical for several days. The supply of oxygen in the body is limited to a few minutes. When that 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 supercharger or compressor satisfies the engines 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. In like fashion, an aviator's lungs contain less and less air as he/she 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 his/her 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 33,000 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 about 43,000 feet, normal activity is only possible by use of PRESSURE DEMAND equipment. This equipment consists of a "supercharger" 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 (MIL-0-2721OD) 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 breathe.

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 are slowly oxidized, 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 more 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

Most people are not aware of the body's enormous increase in oxygen requirements caused by an increase in physical activity. Strenuous exercise like cross-country running results in a greatly increased 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 sufficient for 24 minutes of quiet breathing maybe 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 accurately predicted. 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 his/her 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 the 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 is appreciable reduced. At 10,000 feet, night operations may be seriously handicapped by poor night vision, which is 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 noticable below 10,000 feet.

BETWEEN 10,000 AND 15,000 FEET.— Although efficiency may be considerably 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 not 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 walkaround equipment. Unusual actions or failure of a crew member 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, unconsciousnes, 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 be functioning correctly and that each breath be taken through a properly fitted oxygen mask. Above a pressure altitude of 35,000 feet, pressure breathing oxygen equipment is required.

GASEOUS OXYGEN SYSTEMS

Learning Objective: Identify safety precautions, components, typical systems, and maintenance procedures for gaseous oxygen systems.

Gaseous oxygen systems are used primarily in large, multiplace aircraft where space and weight limitations are less important items and the systems are used only periodically.

HANDLING/SAFETY PRECAUTIONS

The pressure in gaseous oxygen supply cylinders should not be allowed to fall below 50 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 meticulously 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 conforming to Military Specification MIL-C-8638 or ultra clean solvent cleaning compound (type I, trichlorotrifluoroethane) conforming to Military Specification MIL-C-81302B.

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 technical manual NAVAIROSH Requirements for the Shore Establishment, NAVAIR A1-NAOSH-SAF-000/P-5100; Aviators Breathing Oxygen (ABO) Surveillance Program Laboratory Manual and Field Guide, A6-332A0-GYD-000; Aviation-Crew System, Oxygen Equipment, NAVAIR 13-1-6.4.

SYSTEM COMPONENTS

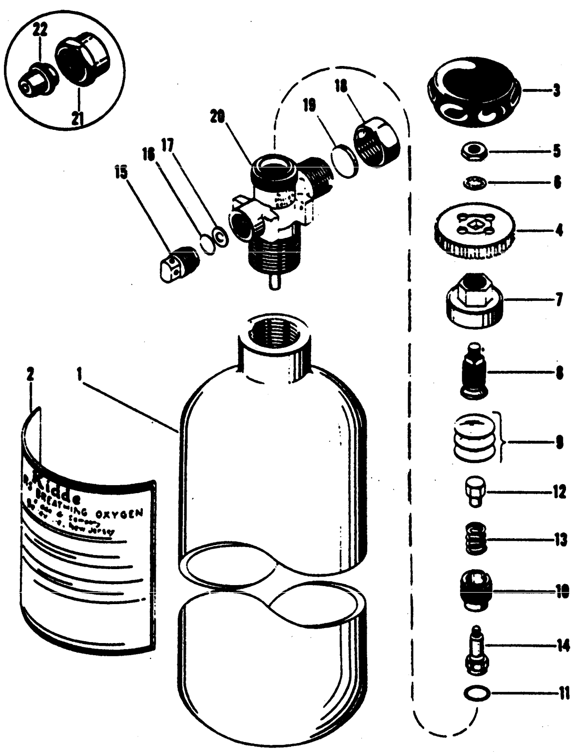
Basically, all gaseous oxygen systems consist of the following:

1. Containers (cylinders) for storing the oxygen supply
2. Tubing to route the oxygen from the main supply to the user(s)
3. Various valves for directing the oxygen through the proper tubing

4. A metering device (regulator) to control the flow of oxygen to the user

5. A gauge(s) for indicating the oxygen pressure

6. A mask to direct the oxygen to each user's respiratory system



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

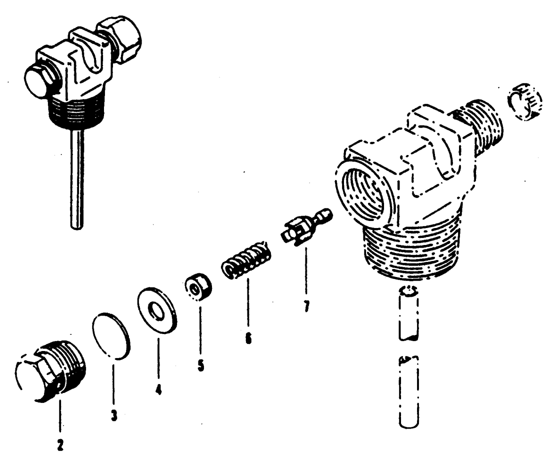
Figure 4-1.—Gaseous oxygen cylinder and handwheel valve assembly.

Cylinders

Gaseous oxygen cylinders used in naval aircraft systems are generally high-pressure, nonshatterable cylinders. The term *shatterproof* or *nonshatterable* indicates 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. 4-1 and 4-2). 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.



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 4-2.—Self-opening oxygen cylinder valve.

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 temperatures. The safety plug is filled with a fusible metal designed to melt at temperatures ranging from 208° to 220°F (97.8° to 104.5°C).

The cylinder and valve assembly is connected to the oxygen tubing by silver 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 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 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 tubing is used in lines carrying pressure above 450 psi.

NOTE: Some of the newer naval aircraft are equipped with high-pressure oxygen lines made of aluminum alloy.

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 temperatures, 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 usually seamless copper tubing, and is manufactured in accordance with strict specifications. It has an outside diameter of 3/16 inch and a wall thickness of 0.035 inch. For application in high-pressure oxygen installations, copper tubing is type N (soft annealed), and is pressure tested at not less than 3,000 psi.

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 fittings and connections. A fitting properly silver soldered to the end of a length of copper tubing will not come loose or leak.

Some of the later models of naval aircraft use aluminum alloy or stainless steel tubing in high--pressure oxygen system installations. Replacement tubing should be manufactured of the same type material as the original tubing or a suitable substitute as specified in the MIM.

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. Check valves are located in the system 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 4-3. The arrow (or arrows) embossed on the valve casting indicates the direction of flow through the valve.

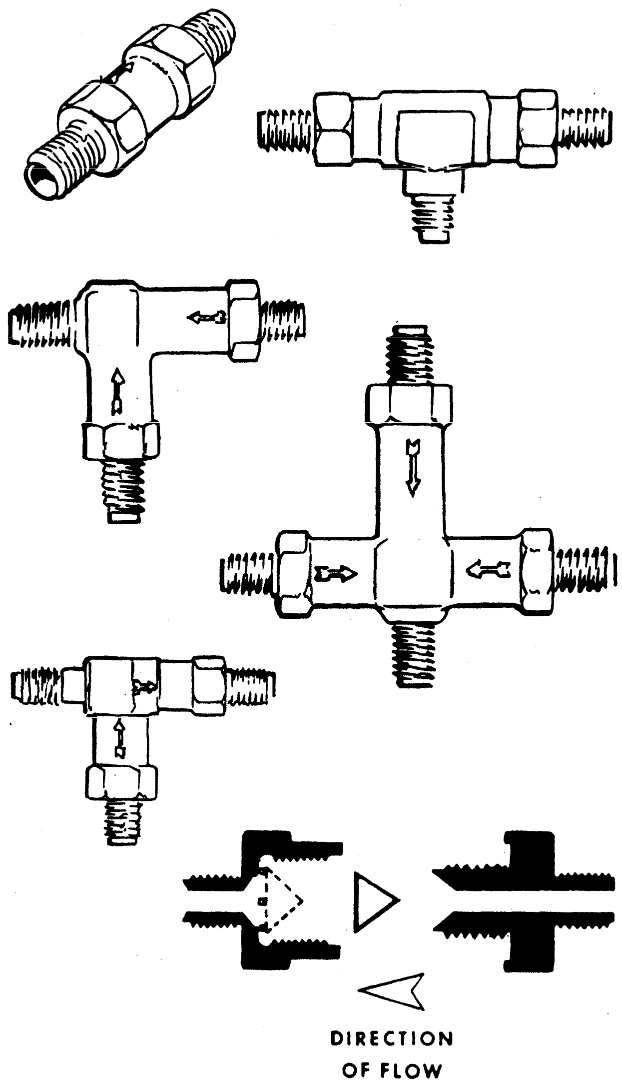


Figure 4-3.—Oxygen system check valves.

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 4-4 illustrates a typical pressure-reducing valve.

FILLER VALVES.— A11 oxygen systems are designed so the entire system can be serviced (refilled) through a common filler valve. The filler valve is generally located so it may be reached by a man 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 (psi). All systems are equipped with at least one gauge that indicates the amount of oxygen in the cylinder(s). The gauge also indicates indirectly how much longer the oxygen will last.

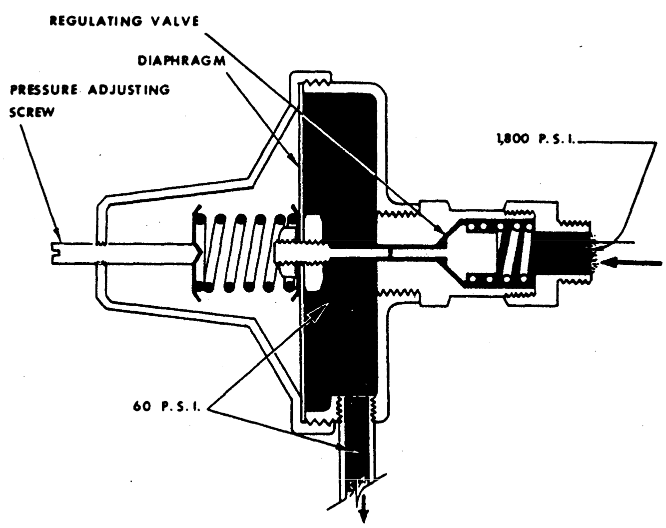


Figure 4-4.—Pressure-reducing valve.

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 an 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, and working pressures reduce to 60 to 70 psi by a reducer or regulator. Systems equipped with pressure reducers are referred to as reduced high-pressure systems. The reduced high-pressure gaseous oxygen system shown in figure 4-5 is typical of such systems. Oxygen is stored in three high-pressure cylinders and supplies three regulators—one each for the pilot, copilot, and flight engineer.

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

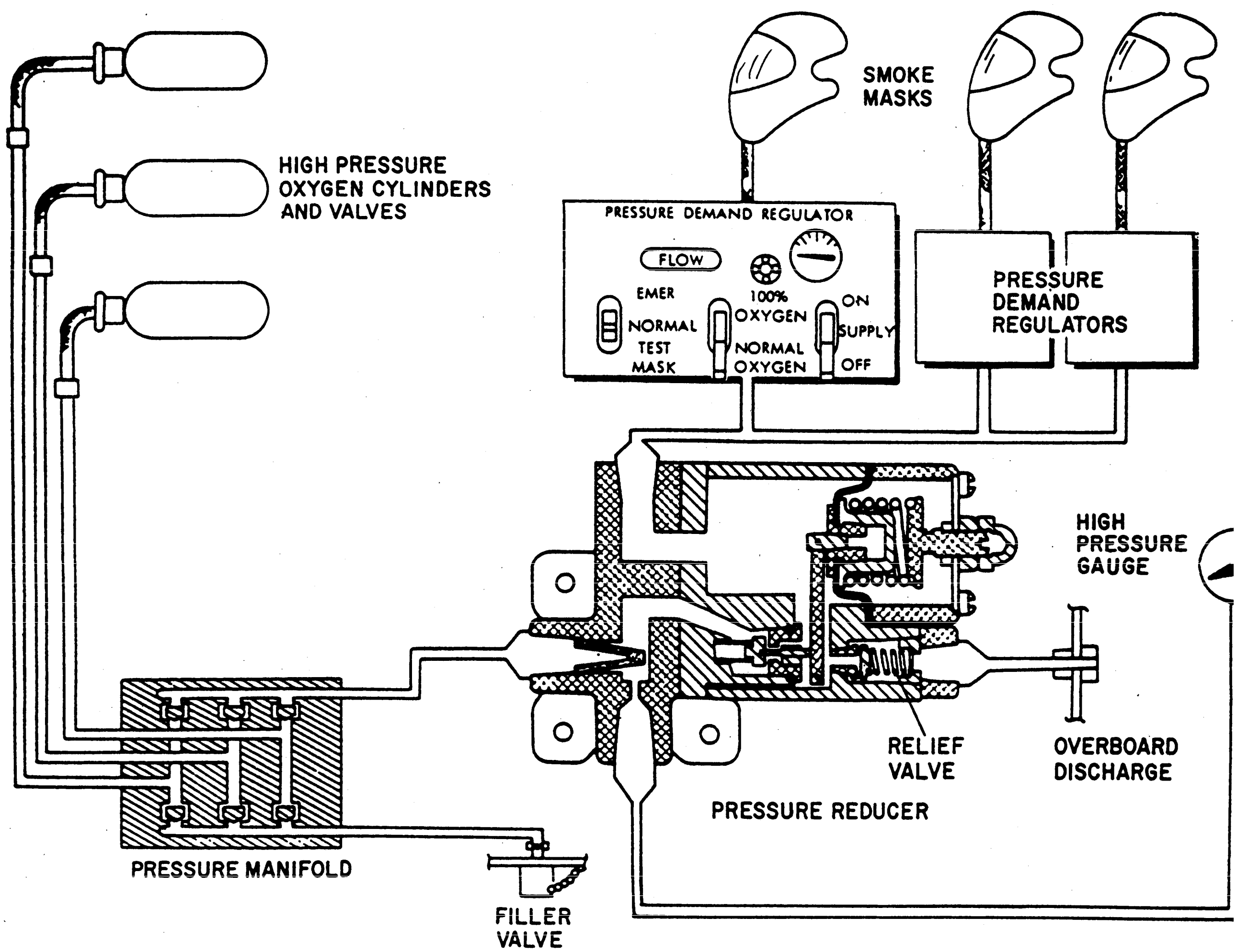


Figure 4-5.—Reduced high-pressure oxygen system schematic,

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.

The oxygen flows from the low-pressure side of the reducer to the three regulators. A flexible hose attached to each regulator is for attachment of the oxygen mask.

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

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 4-6 illustrates a high-pressure walk-around oxygen system. A 295 or 514 cubic inch-capacity, 1,800 psi cylinder is 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 necessary 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

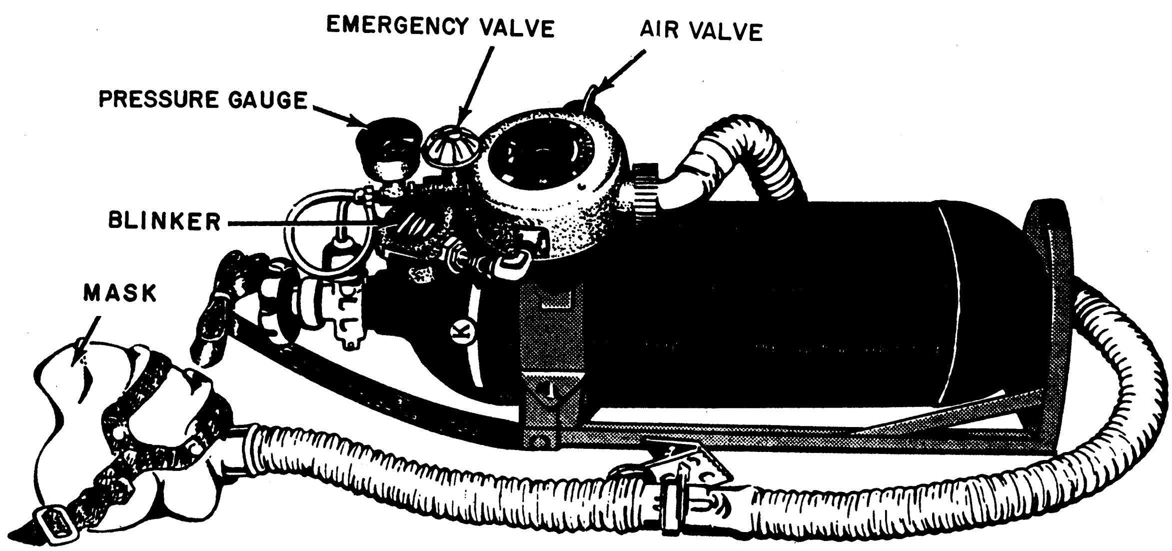


Figure 4-6.—Walkaround oxygen bottle cylinder.

leaks, operationally checking the system, and troubleshooting malfunctions.

Malfunctions may become apparent during inspections, testing, or actual use of the oxygen system. The remedies for some malfunctions will be quite obvious, while others 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 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 4-1 illustrates one type of chart. The discrepancy is listed in the first column with

Table 4-1.—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.

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.

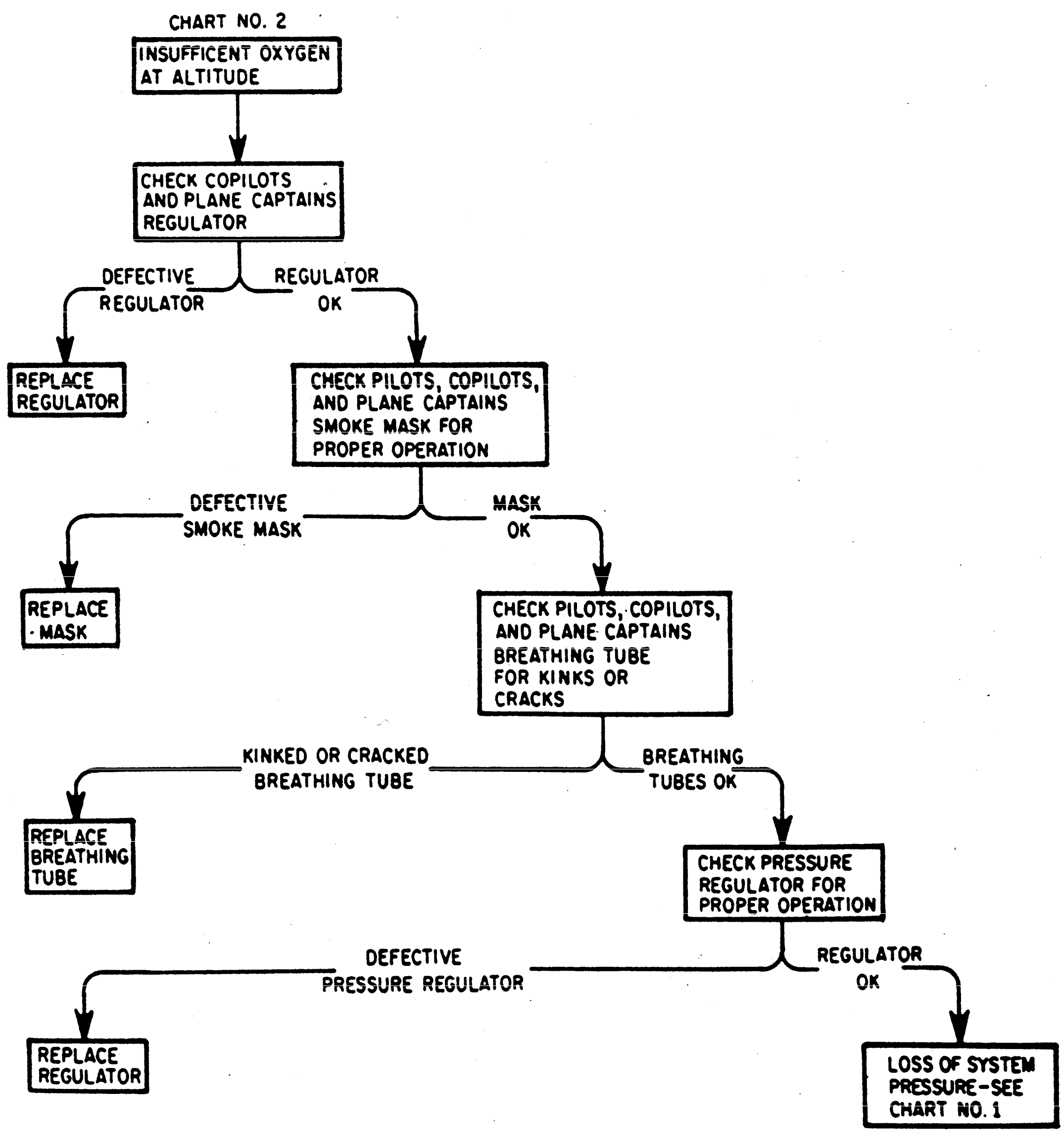
Some manufacturer's troubleshooting charts or aids may include several sheets, similar to the one illustrated in table 4-2, This sheet gives a step-by-step method to correct known malfunctions. Notice how each step progresses through the system. At each step it indicates a correction procedure; however, if the system checks OK at that point, directions are given to proceed with further logical troubleshooting. In almost all cases, the steps of troubleshooting are arranged to correspond with the steps of the operational 'checkout procedures.

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

Table 4-2.—Oxygen System Troubleshooting



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 that 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 in contact with the skin 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 so saturated or subjected to very mild shock or impact.

Extreme care must be taken not to splash or spill LOX on clothing. When LOX come 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 mixed 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 vessels consists of a reseatable relief valve and a 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 the 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 xygen handling area could result in death, serious injury, and property damage.

Smoking, open flames, or sparks are not ermitted 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 drainage 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 clean, dry dressing, and medical aid 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 a drain pan. The AME will also 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 the 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:

1. NAVAIR Al-NAOSH-SAF-000/P5100/l , NAVAIROSH Requirements for the Shore Establishment

2. 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 the precautions and procedures listed in the latest revisions to these publications. They should also 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 crew member using the oxygen system. In addition to the converter(s), most LOX systems contain a heat exchanger, shutoff valves, and quantity indicating units. See figure 4-7 for a schematic diagram of a LOX system.

Container

The LOX converter 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.

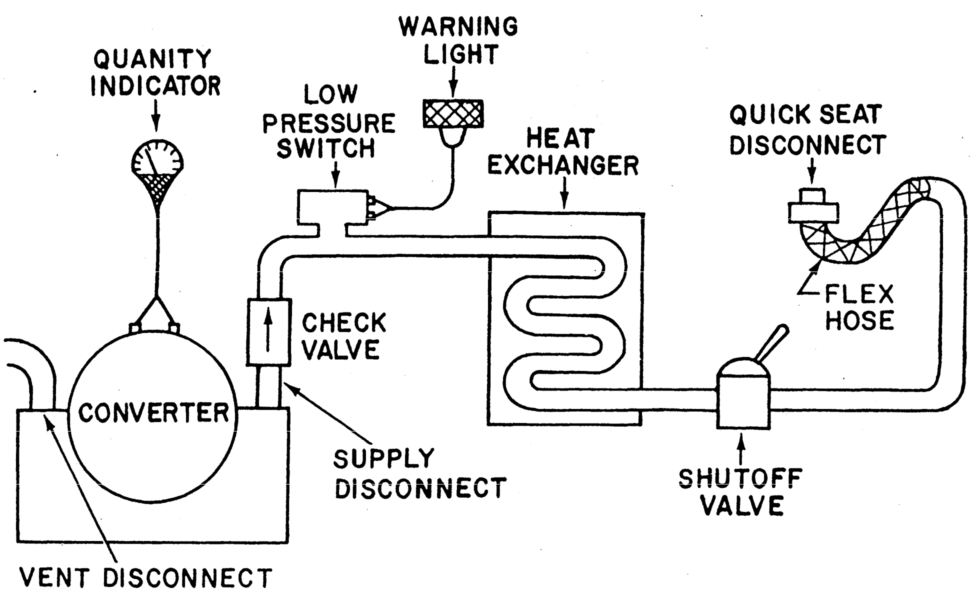


Figure 4-7.—LOX system schematic.

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. 4-8). 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 is also sealed in this position, allowing the gaseous boiloff (from the top of the container) to flow through the gas port to the supply port and into the oxygen system.

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 closing valve maintains operating pressure within the converter. 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 systems capacity every 24 hours. As an example, approximately 1 liter of loss will be experienced from a 10-liter converter.

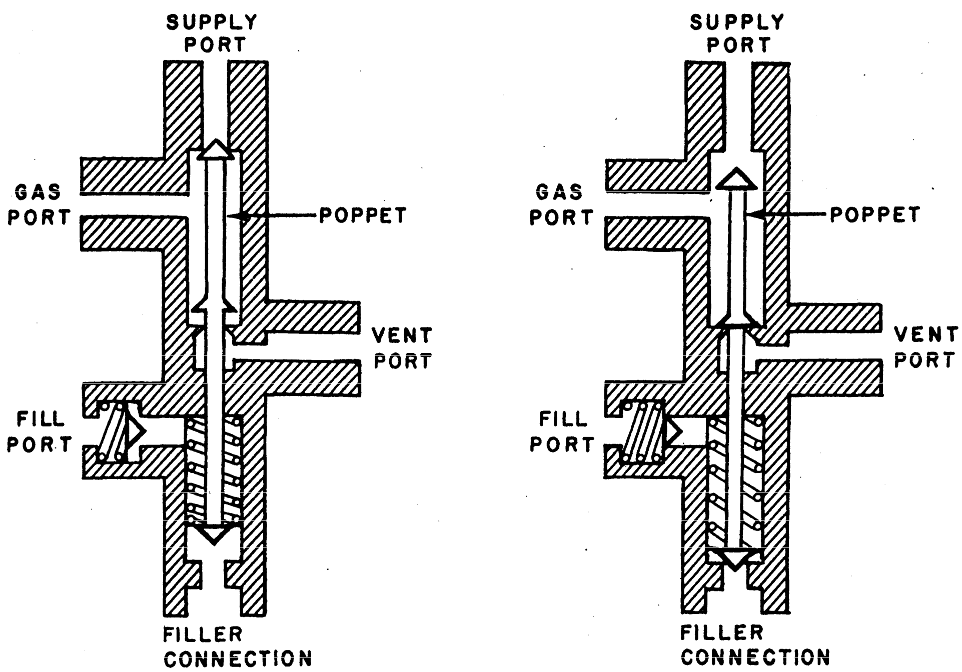


Figure 4-8.—Filler valve.

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. 4-9).

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 in order to expose it to a temperature capable of warming the gaseous oxygen regardless of the altitude of the aircraft. The heat exchanger is constructed of aluminum and has a large interior surface area (fig. 4-10).

Low-Pressure Switch

The low-pressure switch is located in the oxygen system supply line (fig. 4-7). 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. These are located in the cockpit of the aircraft. A quantity probe is also a part of the liquid oxygen converter.

This probe senses the amount (quantity) of liquid contained in the converter. This information is transmitted to the quantity gauge by an

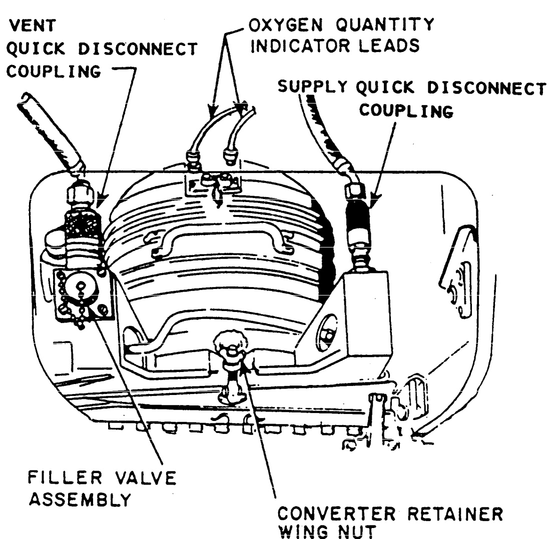


Figure 4-9.—LOX converter installation.

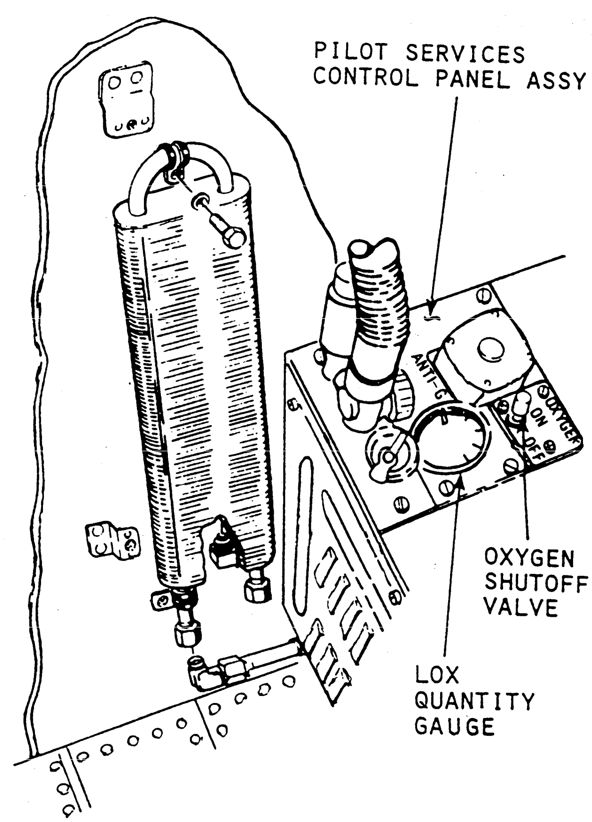


Figure 4-10.—Aircraft air-to-oxygen heat exchanger.

electrical coaxial cable. The quantity gauge is marked in liters from zero to the systems maximum storage capacity (i.e., 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. The maintenance of the quantity indicating and warning light system is the responsibility of the AE rating. You, as an AME, must understand the operation of the electrical portion of the LOX system in order to troubleshoot the indicator and warning systems.

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 4-11 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 crew member from excessive system pressure if there is a malfunction of the liquid oxygen converter. Also, excessive pressure due to thermal expansion of gaseous oxygen trapped within the system when not in use is relieved by this valve. If the oxygen system incorporates a console-mounted regulator, the shutoff valve is a 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 the manufacture and repair of LOX lines. All low-pressure tubing used in LOX systems are aluminum alloy 5052 tubing and is nonheat-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 is also installed from the pressure reducer to the outlets in reduced high-pressure oxygen systems.

Oxygen Regulators

Regulators used with LOX systems are either console-mounted or miniature mask-mounted.

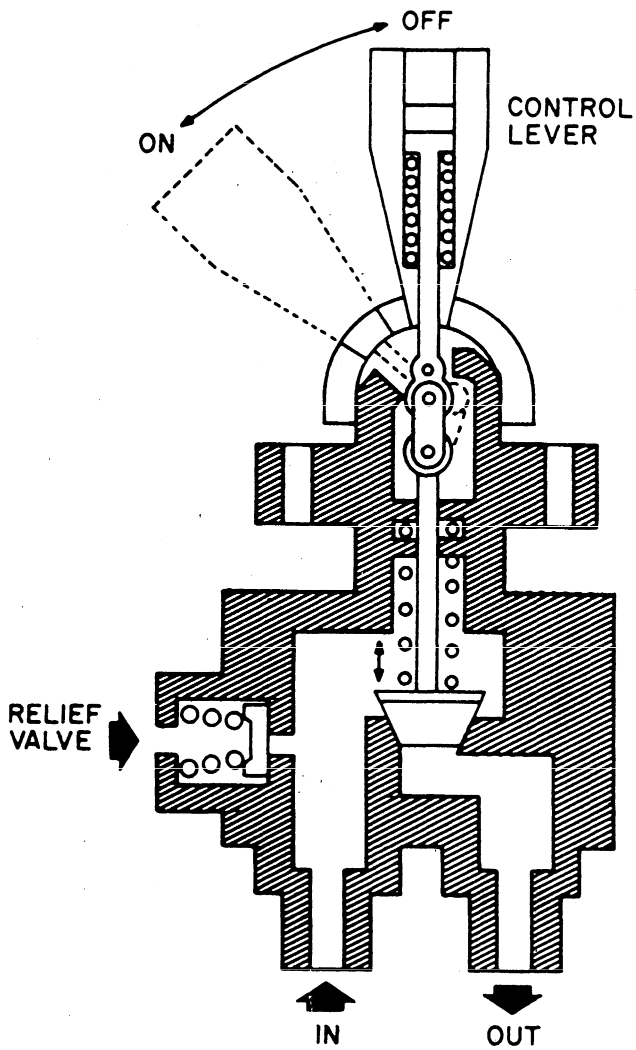


Figure 4-11.—Oxygen shutoff valve.

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 nonelection seat equipped multiplace aircraft such as the E-2 and the P-3.

Miniature Oxygen Breathing Regulator

The miniature mask oxygen regulator, shown in a cutaway view in figure 4-12, 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 weighs 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

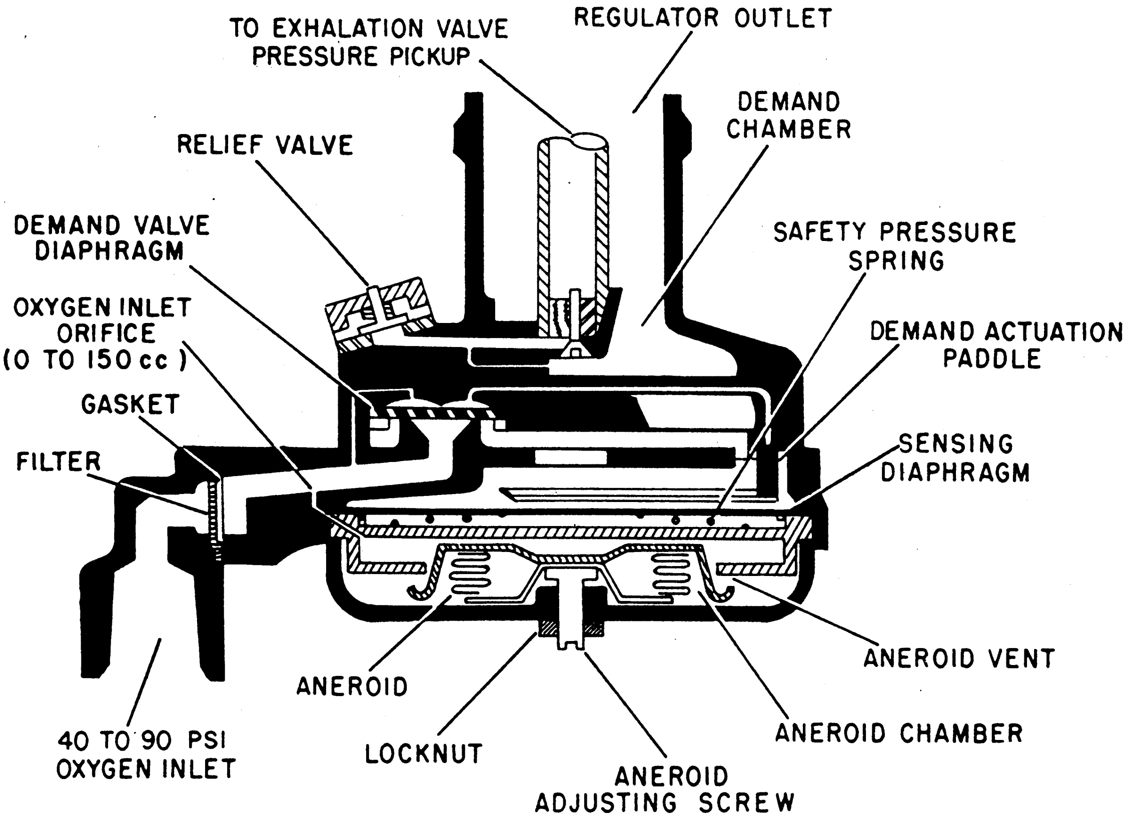


Figure 4-12.—Cutaway view of miniature oxygen regulator.

with an inlet pressure of40 t0 90 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 pressure balanced except for the slight 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 set, 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” (fig. 4-12). 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 the exhalation valve is compensated only by the pressure sent to it by the exhalation valve pickup tube.

Aircraft-Mounted Oxygen Regulators

The MD series regulator is being used in several multiplace naval aircraft. There are two types of regulators in this series—the MD-1 (low-pressure) and MD-2 (high-pressure). 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 (fig. 4-13). 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 found on the upper right of the panel and indicates inlet pressure to the regulator. The regulator has three control levers. A supply valve controller lever, located on the lower right corner, is used to control the supply of oxygen to the regulator; a diluter control lever, located on the lower center of the panel, has two positions—100% OXYGEN and NORMAL OXYGEN; an emergency pressure control lever, located on the lower left of the panel, has three positions—EMERGENCY, NORMAL, and TEST MASK, and with the deluter 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.

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 to assure normal system operation.

Refer to figure 4-14 for the operation of an MD type regulator.

1. Supply oxygen entering through the oxygen inlet (1) is filtered and passes through the manifold

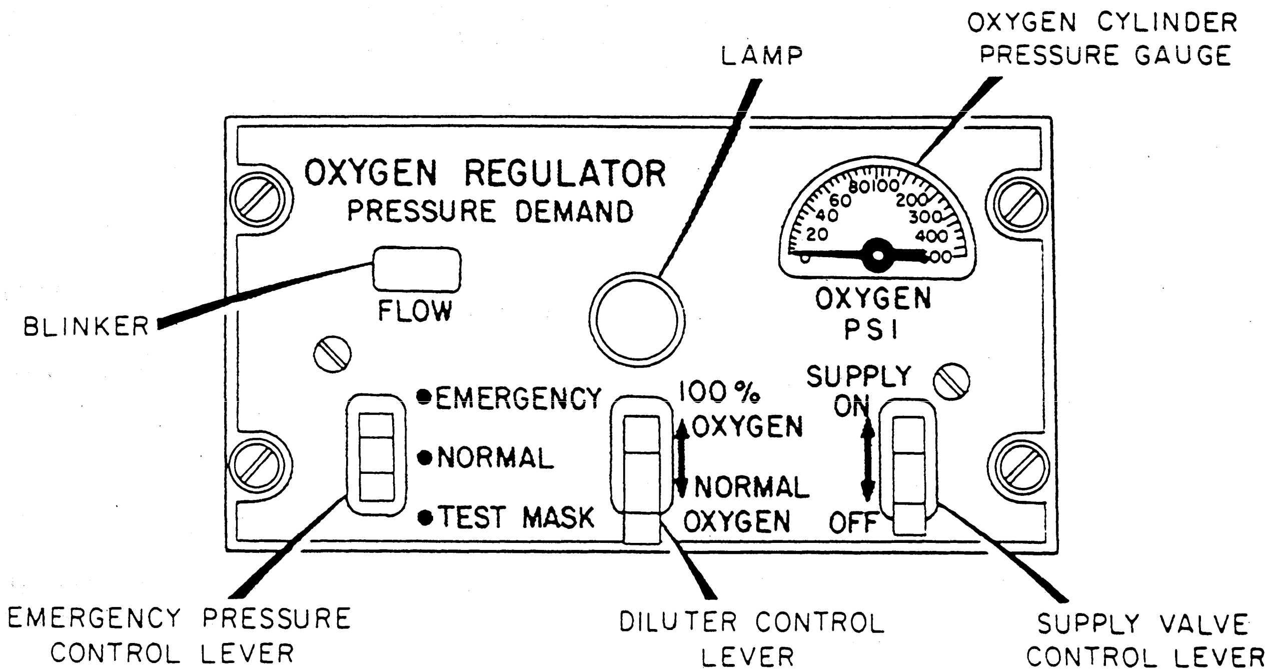
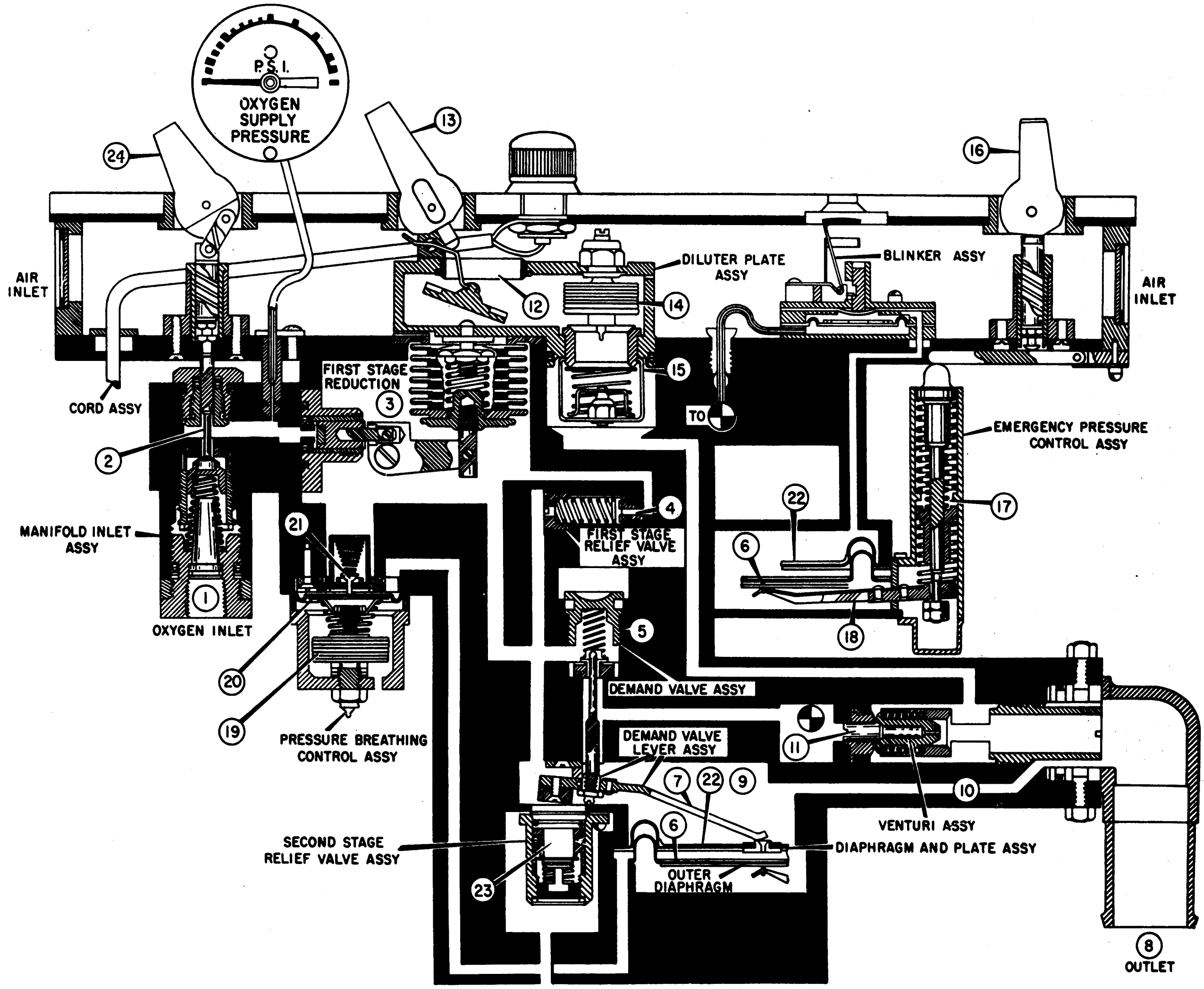


Figure 4-13.—Regulator operating controls and indicators.



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 4-14.—MD regulator operational drawing.

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 regulate; 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).

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 (25) 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 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/POST-FLIGHT/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 4-3 for assistance in trouble-shooting.

Visually inspect the following:

1. Electrical performance of the panel light
2. Legibility of all the markings
3. Plastic lighting plate for cracks and discoloration
4. Low or improper reading on regulator pressure gauge
5. Emergency pressure control lever in NORMAL position
6. Diluter control lever in 100% OXYGEN position
7. Supply valve control lever in OFF position
8. Regulator and surrounding area free of dirt and hydrocarbons
9. 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.

ACCEPTANCE/SPECIAL/DAILY INSPECTIONS.— These inspections are visual inspections followed by a functional test. These inspections and tests are performed in conjunction with the inspection requirements for the aircraft in which the regulators are installed. Refer to table 4-3 for assistance in troubleshooting.

WARNING

Make certain that when working with oxygen, all clothing, tube fittings, and equipment are free of oil, grease, fuel, hydraulic fluid, or any combustible liquid. Fire and/or explosion may result when even slight traces of combustible material come in contact with oxygen under pressure.

To perform the functional test, proceed as follows:

1. Place supply valve control lever in the ON position.

2. Place the diluter control lever in the NORMAL OXYGEN position.

3. Connect the oxygen hose to the quick disconnect, place the mask to the face, and inhale. Proper regulator operation will be indicated by the flow indicator assembly

Table 4-3.—Troubleshooting (Daily, preflight, special, turnaround, transfer and acceptance inspections)

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 control 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 lamp.
	Faulty light assembly	Replace regulator.
	Faulty electrical hookup to power source.	Repair electrical hookup.

showing white during inhalation and black during exhalation.

While at ground level, the regulator will not normally supply oxygen from the supply system to the mask. Therefore, the emergency pressure control lever must be used to check the oxygen supply function of the regulator at low altitudes. The emergency lever is spring loaded at the NORMAL position, and will return to NORMAL when released.

4. Hold the emergency pressure control lever in the TEST MASK position and observe the flow indicator. Flow indicator should be white, indicating a flow through the regulator.

Upon completion of the functional test, secure the regulator as follows:

1. Disconnect the mask from the supply hose.
2. Ensure that the emergency pressure control lever returns to the NORMAL position.
3. Place the diluter control lever in the 100% position.
4. Place the supply valve control lever in the OFF position.

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 RFI regulators. Non-RFI regulators should be forwarded to the nearest maintenance activity having repair capability.

SYSTEM OPERATION

The LOX system shown in figure 4-7 is an example of a typical system. This system converts LOX to gaseous oxygen and delivers it to the crew. The oxygen source of this system is a supply of LOX stored in a 10-liter converter. System pressure is maintained at 75 to 110 psi by a pressure control valve and a pressure relief valve. The converter in this system is installed in an aft equipment compartment.

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 major part of the operation of the LOX system is controlled automatically by the units that make up the converter assembly. The LOX converter has three sequences of operation—fill, buildup, and supply (fig. 4-15). In the supply sequence, the converter alternates between the economy and demand modes of 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. 4-15, 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. 4-15, 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 liquid 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 buildup 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,

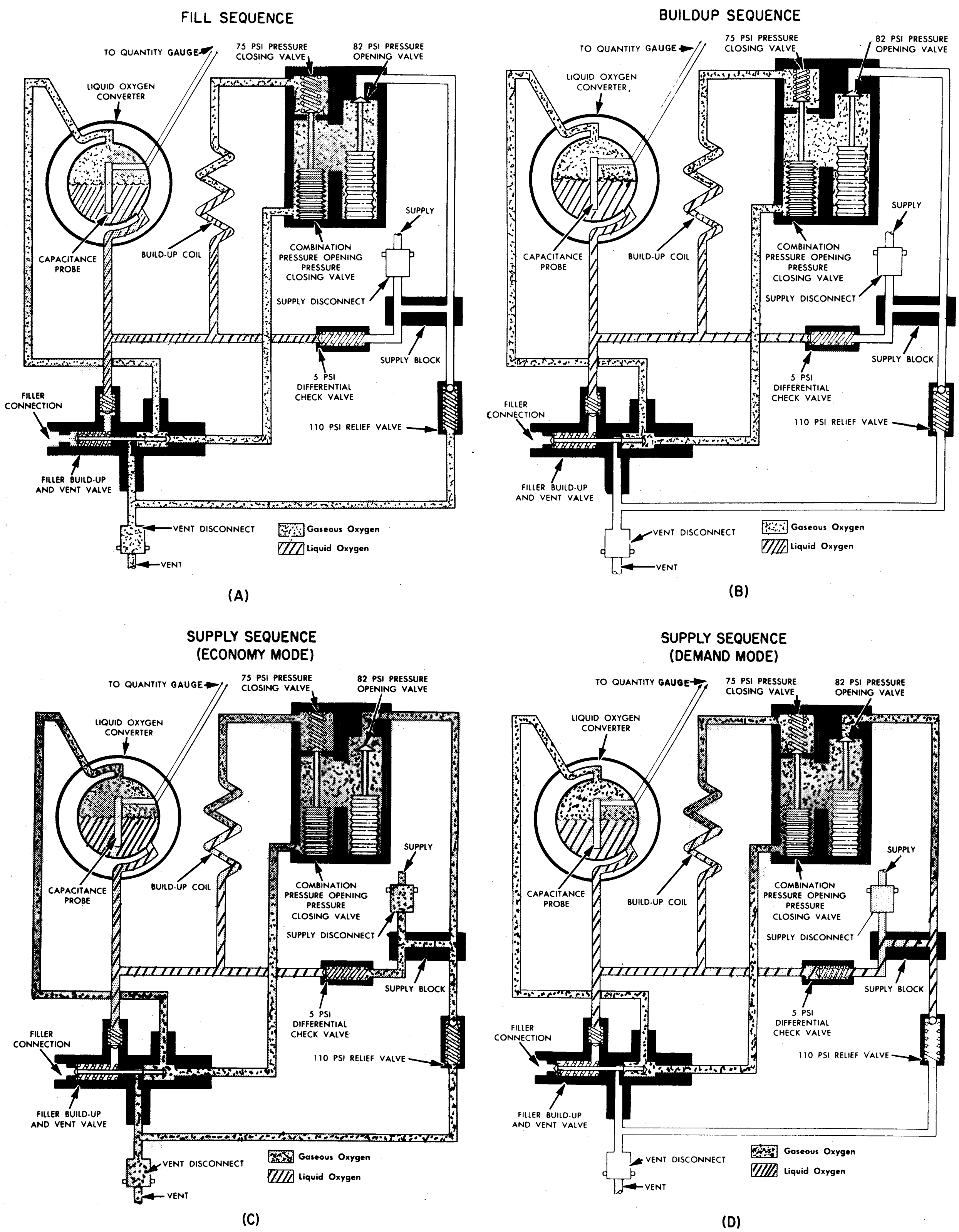


Figure 4-15.—Liquid oxygen converter operation.

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. 4-15, 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 capabilities 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. 4-15, supply sequence, views C and D) and allows liquid oxygen to flow into the supply line, thus 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 LOX system maintenance should also 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 antiseize tape that is approved under specification MIL-T-27730A.
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-25567B. 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-0-27210D 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 tests to ensure that the oxygen is safe for use by the pilot and crew.

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 (LOX). When compared to a LOX system, the OBOGS has several advantages. First, its availability y may be as high as 99 percent. There is no requirement for depot-level maintenance. The OBOGS has no daily service requirements, and scheduled preventive maintenance occurs at 2,000 hours. Incorporation of the OBOGS eliminates the need to store and transport LOX. Additionally, 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 oxygen breathing regulator. The concentrator produces an oxygen-rich gas by processing engine bleed air through two sieve beds. The oxygen monitor senses the partial pressure of the gas and, if necessary, provides a low-pressure warning to the pilot. The oxygen regulator is a positive pressure regulator.

SYSTEM OPERATION

The OBOGS, shown in figure 4-16, 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 bed 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, if necessary, provides a signal to the pilot whenever the pressure exceeds prescribed limits. The oxygen then flows through the regulator to the pilot's mask.

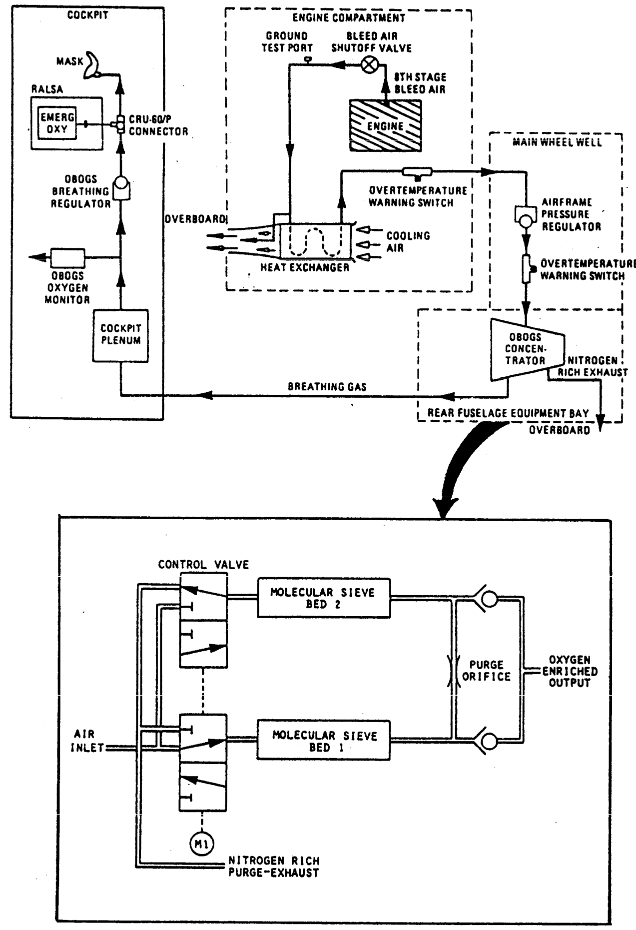


Figure 4-16.—Onboard Oxygen Generating System (OBOGS) schematic.

CHAPTER 5

OXYGEN SUPPORT EQUIPMENT

Terminal Objective: Upon completion of this chapter, you will be able to describe safety precautions and procedures for handling liquid or gaseous oxygen and its support equipment, describe liquid oxygen storage procedures, and recognize contamination control procedures.

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 applicable to this chapter are covered throughout the text. Oxygen safety precautions can also be found in NAVAIR 06-30-501, *Technical Manual of Oxygen/Nitrogen Cryogenic Systems.*

LIQUID OXYGEN STORAGE

Learning Objective: Describe safety precautions and handling procedures for liquid oxygen storage tanks, transfer lines, and valves.

Liquid oxygen (LOX) is centrally stored on naval air stations for issue to users. Few Navy requirements involve containers over 2,000 gallons. The design features and practices described in this chapter apply generally to all sizes of containers. The main emphasis is on tanks of 2,000 gallons and under. Figure 5-1 shows a 2,000-gallon-capacity storage tank.

TANKS

The tank is used for the storage of LOX at low pressure, with low evaporation loss, and for transferring of LOX to smaller containers, as required.

All LOX storage tanks are basically similar, regardless of their size or configuration, whether they are skid mounted, trailer mounted, or permanently installed. They all consist of an

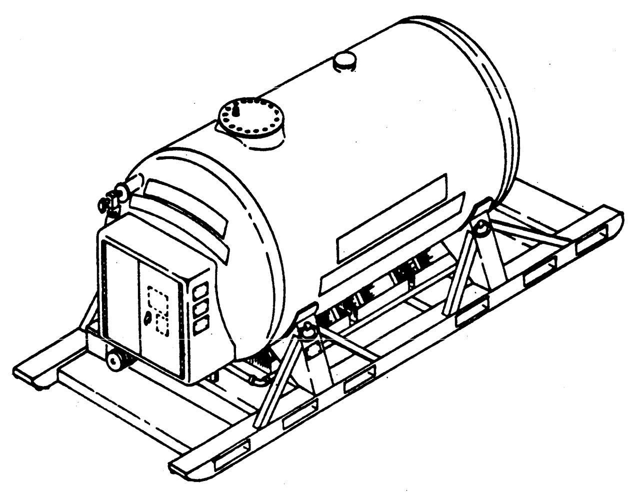


Figure 5-1.—2,000-gallon-capacity liquid oxygen storage tank.

inner and outer container separated by a circular insulated space (the annulus) that is packed with a powder-type insulating material and highly vacuum pressured to minimize heat transfer and evaporation losses.

TRANSFER LINES

Aside from certain large fixed facility piping, most LOX systems are made up of transfer lines—often segmented (in sections) for ease of demountability (reconnecting) so one transfer system can service several pieces of equipment. Generally, what is true for insulation of tanks is applicable to other similar equipment with the exception of transfer lines. Transfer lines are cooled and warmed many times during the course of a day. The liquid oxygen waste due to cooldown losses can be significant. A high vacuum insulated transfer line generally is best for quick, frequent transfers since no insulated cooldown mass is involved. To help reduce LOX waste due to cooldown of transfer lines, several wraps of multilayer insulation adds very little mass to the system, decreases the thermal radiation, and requires less vacuum (if any) in the insulation annulus.

Transfer lines are most commonly constructed of bronze, stainless steel, or aluminum. In the case of vacuum-jacketed lines, annular spaces are necessary to prevent the inner liquid-bearing lines from touching the outer jacket wall. Low thermal conductivity materials are used for this purpose, and schemes are incorporated into the spacer design to provide only a small area contact wherever possible, since the heat influx must be kept low.

Although rigid lines often are used in stationary facility piping installations and for some remountable applications, the predominant type for use in the field is corrugated flexible metal transfer hose (fig. 5-2).

Flexible metal hose is somewhat more vulnerable to abuse than its rigid counterpart; therefore, it usually has a braided metallic covering or tough plastic sheath over the external corrugations. The high working pressure capability of the inner line requires the application of a strengthening braid over it as well. Even though such protection provides a degree of reinforcement to the hose, it should not be subjected to overpressurization in service since a bellowslike action still may be possible if the covering is not securely fastened at the end connections. High pressure expands the hose axially, causing it to grow by lengthening the distance between each corrugation, which makes the line less flexible.

A vital consideration in the construction of all transfer lines is the matter of joints between line segments. Assuming that the transfer lines are vacuum-jacketed to the general region of the joint, the concern with the joint and the closure of the vacuum-jacket in close proximity to the joint is important. The transfer line connector/coupling (bayonet coupling) in figure 5-3 is one of the better designs available today, and the most expensive.

To safely and efficiently use transfer lines, several things must be remembered. NEVER trap liquid in a line between closed valves unless you are absolutely certain that some type of relief device is functionally associated with the inner

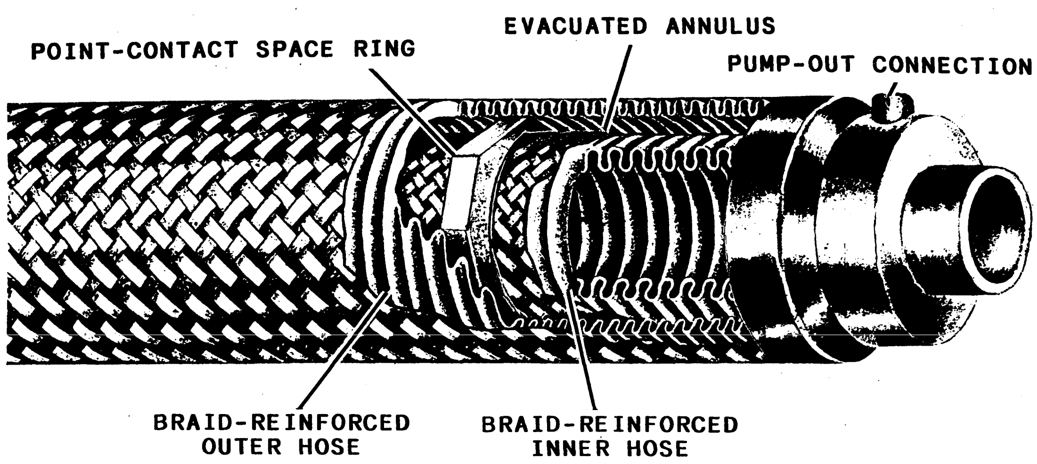


Figure 5-2.—Flexible metal transfer hose.

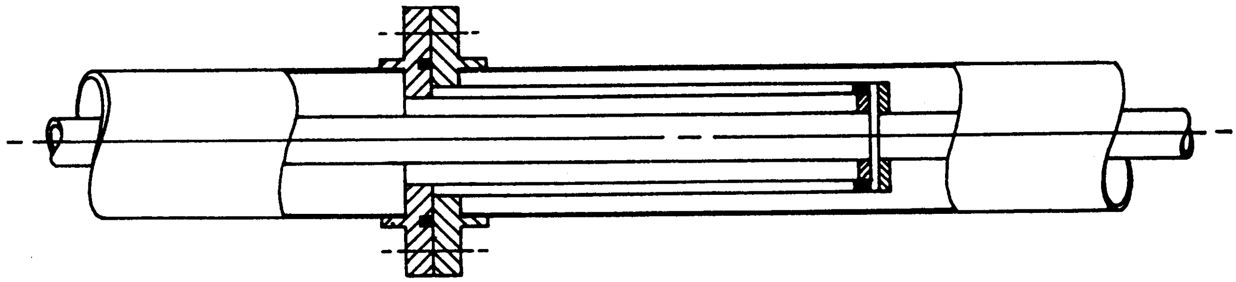


Figure 5-3.—Transfer line connector/coupling.

line. The reason is that as the LOX vaporizes, the vapors will warm, and excessive pressures may develop that can burst the conduit walls.

For transfer efficiency, vacuum-jacketed lines with well-designed, low-heat input couplings are best for most uses. Unthinking use of two or three transfer sections coupled together where one could do the job wastes liquid and time. Several times as much line material has to be cooled down, and several times more heat transferring line surface area is contacted by the LOX. Additional heat influx means additional LOX vaporization; therefore, more liquid is needed to satisfy a given transfer demand.

VALVES

Although valves might appear to be of minor concern in a system, low-temperature valves often cause more trouble than any other element of the system. In addition to the general requirements for any valve, LOX valves must be able to function properly at extremely low temperatures without causing excessive boil-off losses to the liquid flowing through them. Insulation is the best method to meet these thermal requirements. Various materials have been used for insulation, but the best method is to vacuum insulate the valve. The valve illustrated in figure 5-4 is typical of this type. The method of operation will vary by manufacturer.

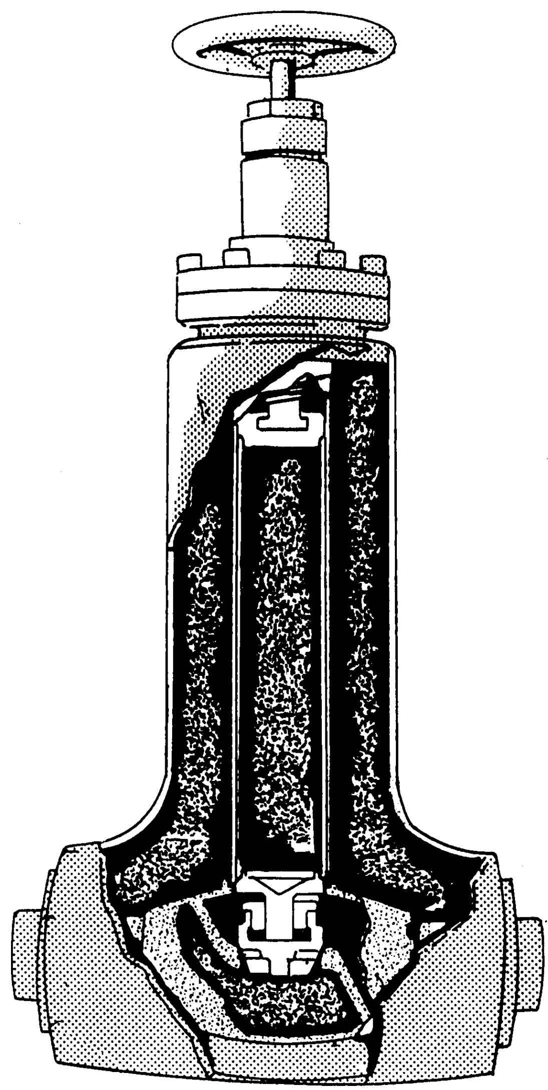


Figure 5-4.—Vacuum-insulated cryogenic valve.

OXYGEN SERVICING EQUIPMENT

Learning Objective: Describe oxygen *servicing equipment to include safety precautions, 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 LOX.

1. Never allow LOX to contact your skin. The extremely low temperature of the liquid quickly freezes skin, and severe frost bite results. If your skin is splashed with LOX, immediately flush the area thoroughly with water, and then obtain first aid.
2. 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.
3. 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.

4. 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.

5. 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.

6. 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.

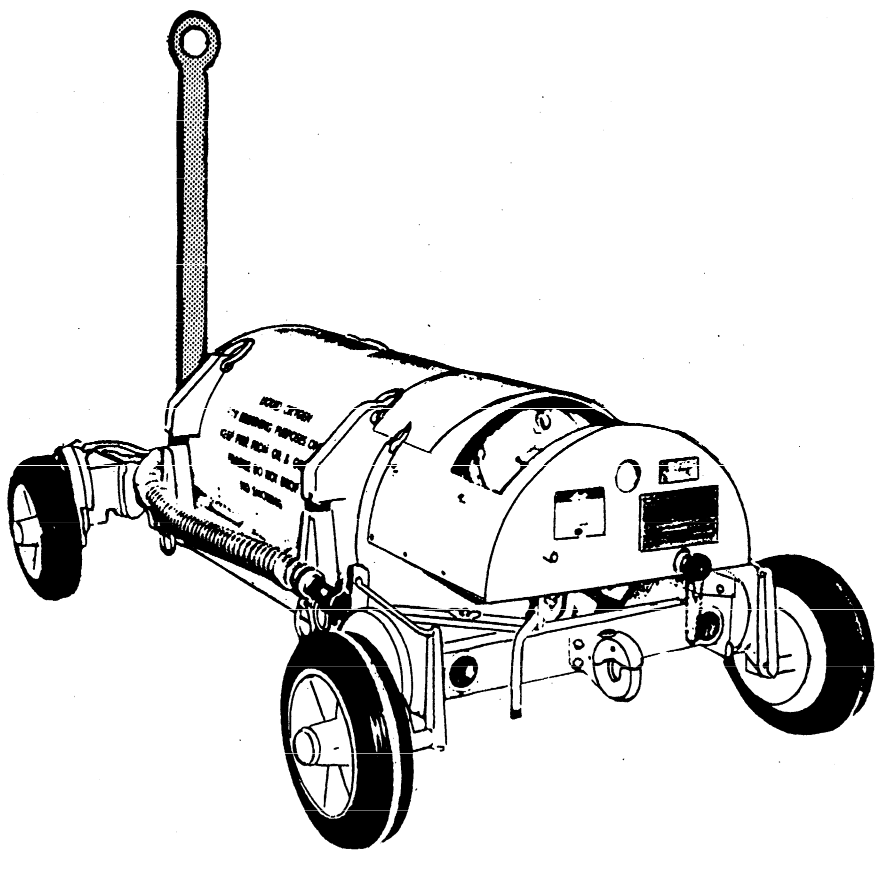


Figure 5-5.—Liquid oxygen servicing trailer, type 7.

LOX SERVICING TRAILERS

The primary purpose of portable transfer equipment is to provide a means of servicing oxygen systems installed in aircraft.

There are currently two types of LOX servicing trailers in use by the Navy—the standard type 7 trailer, which vents gaseous and liquid oxygen overboard through the vent fitting of the LOX converter as it is being filled (fig. 5-5), and the TMU-70/M low loss, closed loop trailer, which recaptures these vented losses (fig. 5-6). The TMU-70/M trailer is manufactured by Cryogenic Engineering Company and has been selected for coverage in this training manual.

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.

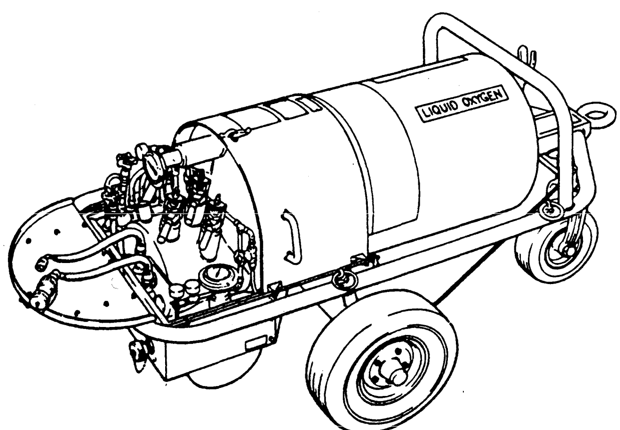


Figure 5-6.—TMU-70/M low loss, closed loop, liquid oxygen servicing trailer.

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.

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 the transfer tank is evacuated down to 5 microns or lower and contains a multilayer, high-vacuum insulation to minimize heat gain and boil-off of the LOX.

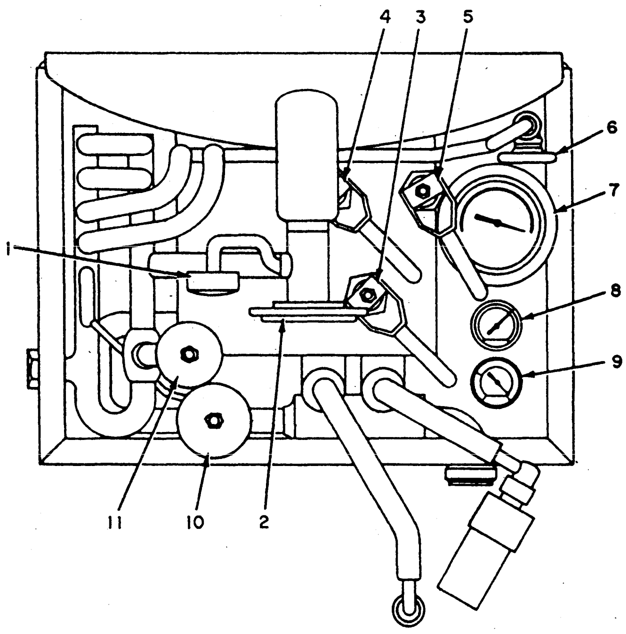
Transfer Tank.— The 15-liter-capacity transfer tank is a double-walled, vacuum-insulated Dewar, permanently attached to the storage tank. It is self-contained and gravity filled from the storage tank. The transfer tank is equipped with a pressure buildup coil, relief valve, rupture disc, and controls. 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 of 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 and identified in figure 5-7. The storage tank pressure gauge (1) indicates the pressure in the inner tank. The storage tank liquid level gauge (2) indicates the level of liquid in the inner tank when the tank is on level ground. The dial is magnetically and mechanically coupled to a float sensor inside the storage tank and is calibrated in gallons. The transfer tank pressure gauge (8) indicates the pressure in the transfer tank. This pressure must be more than that in the storage tank for the liquid to transfer, since the converter is vented into the storage tank during converter filling. The transfer tank liquid level gauge (7), which reads in percent full, is the same type as the storage tank liquid level gauge that reads in gallons. The converter full indicator gauge (9) (marked LIQUID—GAS on the gauge), is a vapor pressure thermometer that monitors the converter vent line temperature. During transfer of liquid to a converter, it indicates "GAS" temperature in the converter vent line. When the converter is full, the vent line is filled with LOX. The converter vent line temperature drops and the gauge indicator moves to the "LIQUID" position that indicates a full converter.



1. Storage tank pressure gauge.
2. Storage tank liquid level gauge.
3. Converter vent line shutoff valve.
4. Transfer tank vent line shutoff valve.
5. Transfer tank fill line shutoff valve.
6. Transfer tank pressure buildup valve.
7. Transfer tank liquid level gauge.
8. Transfer tank pressure gauge.
9. Converter full indicator gauge.
10. Fill-drain line shutoff valve.
11. Storage tank vent line shutoff valve.

Figure 5-7.—TMU-70/M liquid oxygen servicing trailer controls and indicators.

With the exception of the converter full indicator gauge and the transfer tank liquid level gauge, all gauges have a green band to indicate safe operating pressures and a red band to indicate unsafe pressures.

In addition to the indicators covered, there are several valves in the system. The converter vent line shutoff valve (3) controls the flow of oxygen gas vapors from the converter to the storage tank and prevents loss of storage tank gas when the converter is not being filled. The transfer tank vent line shutoff valve (4) controls the flow of oxygen gas vapors from the transfer tank to the vapor space of the storage tank.

The valve used to control the gravity flow of LOX to the transfer tank from the storage tank is the transfer tank fill line shutoff valve (5).

The transfer tank pressure buildup valve (6) controls the flow of LOX from the bottom of the transfer tank to the pressure buildup coil (PBU). The PBU coil is a heat exchanger that exposes the LOX to ambient temperatures, converting the LOX to gas. As this conversion takes place, the gas expands and the output gas from the PBU is fed back to the transfer tank vapor space, providing the pressure to discharge the LOX to the converter.

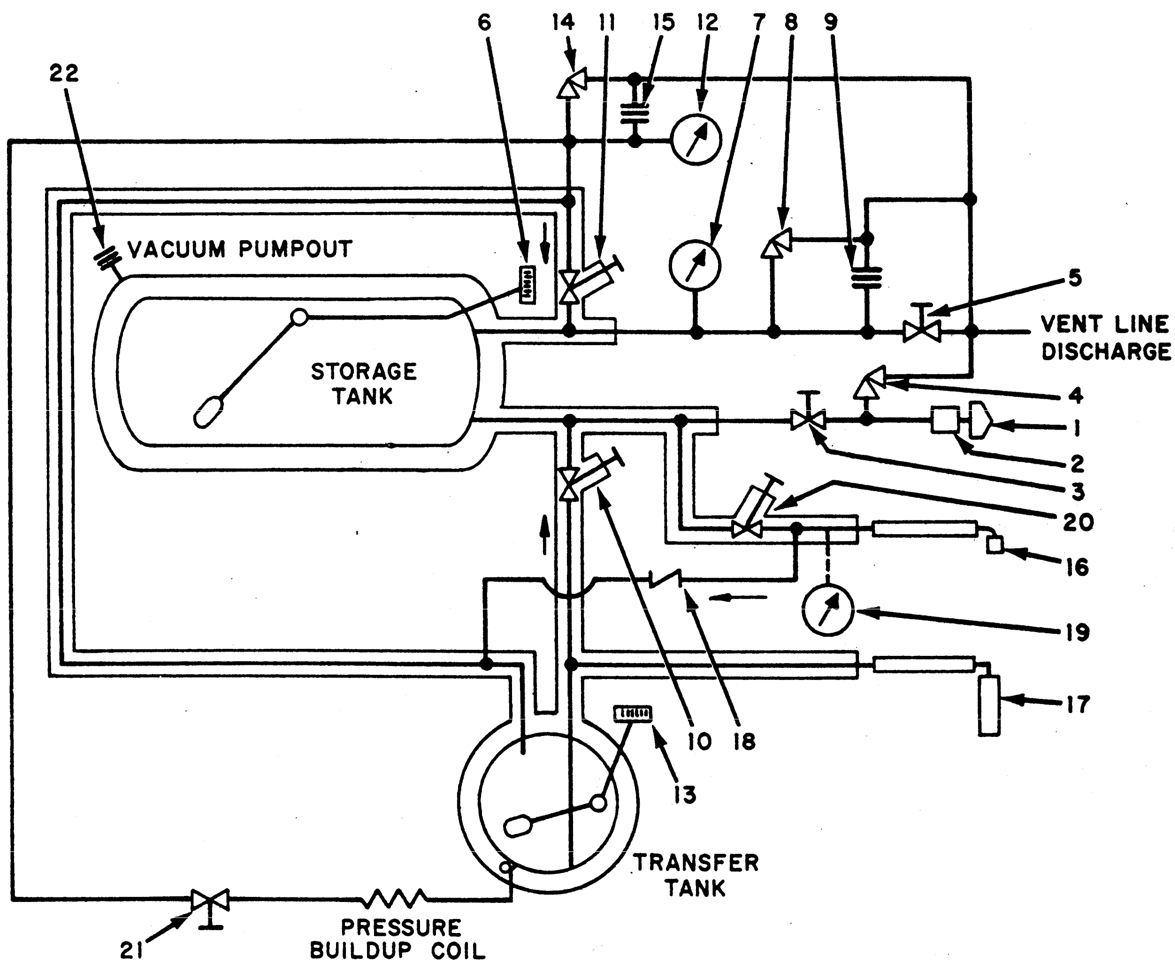
The fill drain line shutoff valve (10) is used during the storage tank filling operation. It permits the flow of LOX from a central supply tank to the storage tank. This valve is to be opened completely during the filling function and closed after the transfer has been completed.

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.

The storage tank vent line shutoff valve (11) is used to control the release of gaseous vapors from the storage tank to the vent piping manifold. This valve is open during filling to vent all pressure from the storage tank. During idle storage, it is left open to vent all vapors generated by normal LOX boil-off. In flight line service, it is left closed to prevent oxygen vapor contact with flammable liquids or vapors, and to prevent unnecessary loss of LOX.

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 5-8.



1. Fill-drain line coupling.
2. Fill-drain line filter.
3. Fill-drain line shutoff valve.
4. Fill-drain line relief valve.
5. Storage tank vent line shutoff valve.
6. Storage tank liquid level gauge.
7. Storage tank pressure gauge.
8. Storage tank inner shell relief valve.
9. Storage tank inner shell rupture disc.
10. Transfer tank fill line shutoff valve.
11. Transfer tank vent line shutoff valve.
12. Transfer tank pressure gauge.
13. Transfer tank liquid level gauge.
14. Transfer tank inner shell relief valve.
15. Transfer tank inner shell rupture disc.
16. Converter vent line connector.
17. Air force filler valve.
18. Converter vent line check valve.
19. Converter full indicator gauge.
20. Converter vent line shutoff valve.
21. Transfer tank pressure buildup valve.
22. Outer shell relief device.

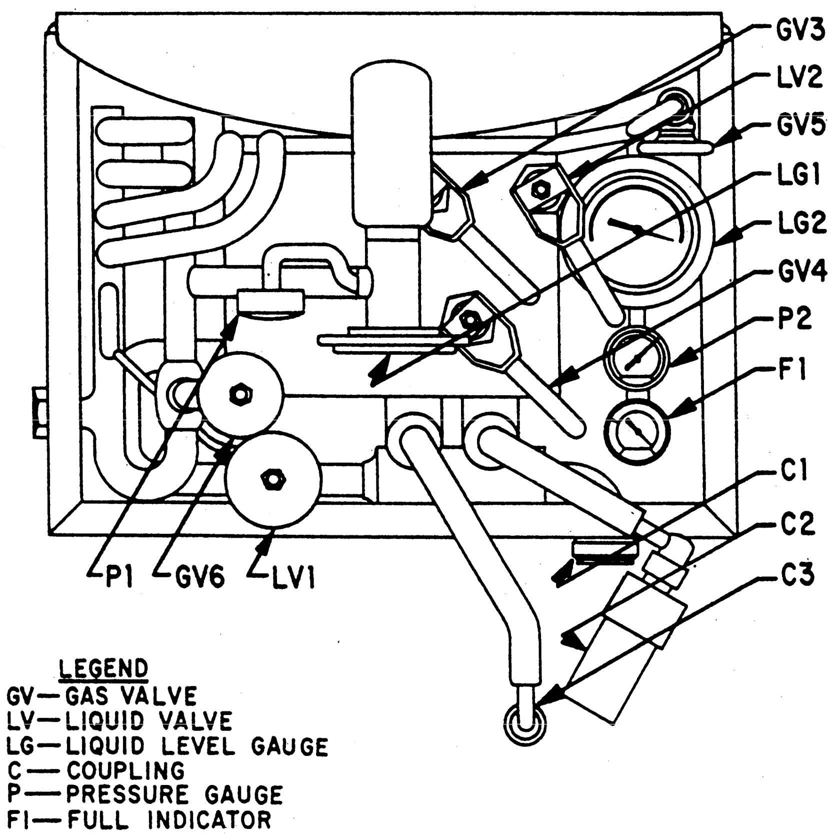
Figure 5-8.—TMU-70/M liquid oxygen servicing trailer storage tank schematic diagram.

Figure 5-9 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 desirable for a warm and empty tank. Prior to filling or pressurizing the tank, perform the inspection procedures indicated in table 5-1.

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



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 5-9.—Operating instructions for TMU-70/M.

Table 5-1.—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.	Daily while in use.
	Inspect with ultraviolet light for presence of hydrocarbons.	Weekly.
Operation	Perform operational checkout.	Monthly or on receipt of new or repaired equipment.

the trailer on a level surface or ensure that the tank has a level attitude. 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. 5-8) to the transfer hose. Open the TMU 70/M's storage tank vent line shutoff valve (5) and fill-drain line shutoff valve (3).

CAUTION

Pressure should not be allowed to rise above 55 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 valve (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 provide. 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 service 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 line system. Under normal conditions and 30 psi transfer pressure, the storage tank should be filled within a period of 5 to 10 minutes. Abnormal 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 shown in figure 5-8). 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 valves (10) and (1 1). Connect the converter vent line connector (16) to the converter vent fitting. Connect the 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 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 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 5-8. 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 pressure buildup coil (PBU) 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. On 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. If observation of the rate of pressure buildup indicates it will 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 until the storage tank is either empty or the maximum operating pressure, as indicated on 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 of maintenance will perform the maintenance.

AMEs are only responsible for the organizational maintenance of LOX trailers, which include those functions normally performed in support of daily operations. Normal operational maintenance functions include inspection and preventive maintenance. Table 5-1 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-0-2710, type II, may be used in aircraft LOX systems. The fire-fighting agents listed below are prohibited from use in conjunction with LOX-enriched fires.

1. Soda-acid extinguishers
2. Mechanical (liquid) foam
3. Methyl bromide
4. Carbon tetrachloride

CONTAMINATION CONTROL

Learning Objective: Recognize 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) Quality Evaluation Program (A6-332AO-GYD-000). For additional information on contamination control, oxygen sampling, and oxygen system purging, refer to that program.

DETECTION

LOX contamination is detected by means of an odor test, sampling, and analysis. Only the odor test will be discussed in this manual 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 200 milliliters (6.8 oz) of the 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 constituents 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 at any time contamination is suspected. Contamination of oxygen used in aircraft can cause many problems, from fire hazards to death of the crew member 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. Physiologically, the effects may be uneasiness, apprehension, or possible panic resulting from detection of odor. Psychologically, 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 be readily triggered 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 contaminates 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 contaminates commonly found in oxygen are water vapor, carbon dioxide, nitrous oxide, and halogenated compounds.

SAMPLING REQUIREMENTS.— Activities that produce LOX from on-base LOX plants must sample generating units for odor and purity after each addition, or if on continuous operation, once each 24 hours. The tank functioning as a receiver must have a sample taken every 90 days or when contamination is suspected and forwarded to a designated test site for analysis.

Base storage tanks are tested for odor each week, and a sample of the contents sent to a designated test site for analysis in accordance with table 5-2.

LOX trailers must be sampled when contamination is suspected and LOX converters must be sampled after any acciclent/incident. Samples must be forwarded to a designated test site for analysis.

Table 5-2.—Liquid Oxygen Storage Tank Sampling Schedule

Boil-Off Rate	Sampling Schedule
1%	Every 30 days
1½%	Every 20 days
2%	Every 13 days

SAMPLE TAKING.— In order to exercise rigid control over the quality of LOX manufactured by the Navy or civilian contractors and to test for suspected contamination, a sample must be taken from the LOX container.

Figure 5-10 illustrates the equipment and setup using the G-276 LOX sampler. Samplers are prepared at depot maintenance activities and shipped to the using activities, as required. Depot preparation includes the separation of valve, adapter, and cylinder; baking and evacuating the cylinder for 1 hour, and flushing once with gaseous oxygen; and finally, while still in the oven and still evacuated, the cylinder is filled to 20 psi with gaseous oxygen. The valve is then closed and the cap installed, and then it is shipped to the using activity.

There are several precautions that should be observed while you are sampling. Observing these precautions will help to ensure a representative sample. Do not sample from a trailer hose. Use only a short connection between the tank and sampler. A few feet of copper tubing, three-eights

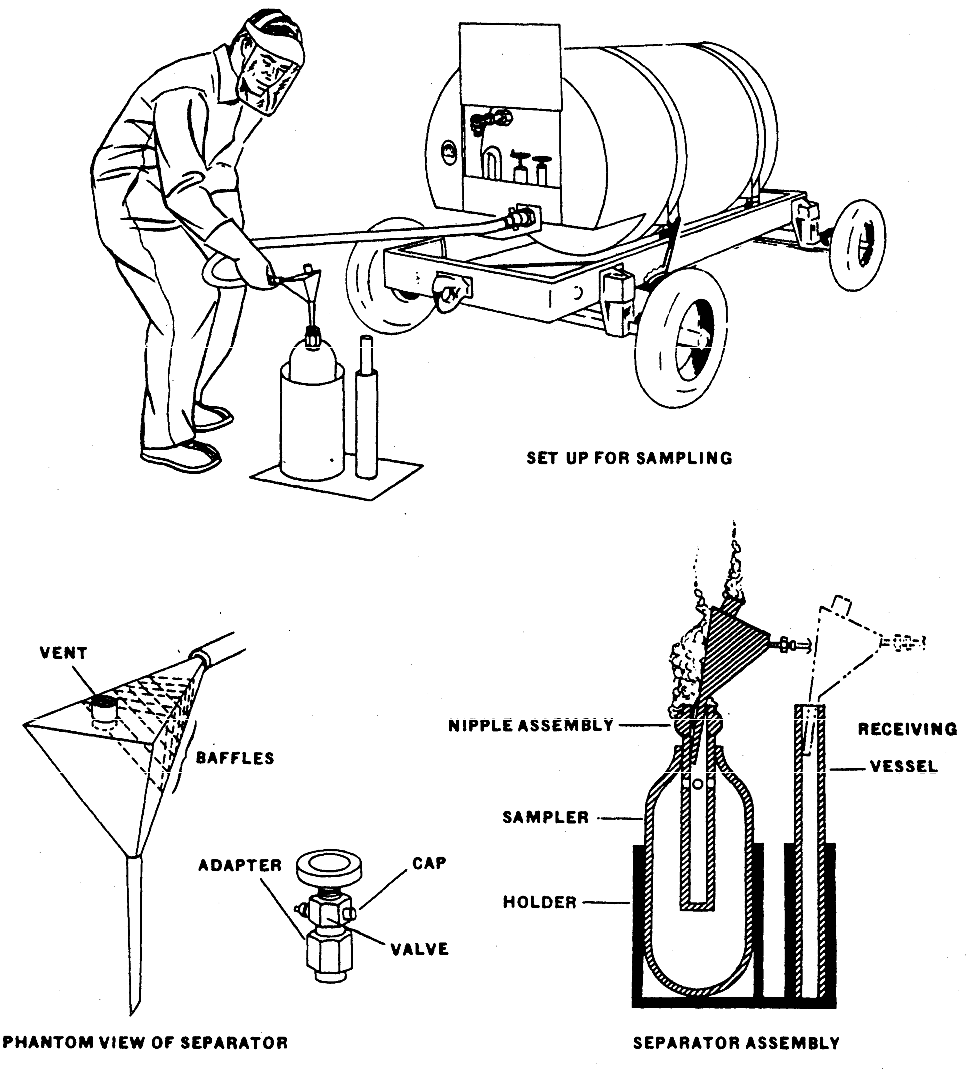


Figure 5-10.—Sampling.

inch in diameter, attached directly to the tank drain outlet, or trailer fill-drain outlet, is recommended by current directives. All flare fittings must be perfect—without dents, scratches, or toolmarks. Do not use any antiseize compound on threads or any cleaning compounds on sampler parts. Contamination will result. A sampler received without residual pressure probably leaks. Such samplers should be rejected and returned.

Just before sampling, remove the cap from the sampler valve; open the valve to release shipping gas pressure, then reclose. Next, remove the valve by disconnecting the adapter from the nipple, and place the cylinder upright in a holder.

Attach the separator and line assembly to the tank drain or fill-drain outlet. Using a trailer pressure of 10 to 20 psi, let the LOX flow into an open container, such as the receiving vessel shown in figure 5-10, for at least 30 seconds to purge the line. Adjust the pressure to obtain a quiet, uniform, full flow from the separator outlet tube.

Wipe the frost from the separator outlet tube, and immediately insert the outlet into the sampler tube and fill it. The filling will take approximately 1 minute. When liquid splashes in droplets over the top, the tube assembly is full. The sampling tube holds about 180 milliliters (6. 12 oz) of LOX, which produces a maximum pressure of 300 psi when vaporized in the closed sampler.

NOTE: During the filling operation, the operator should wear a face shield, hat, gloves, and other protective equipment as excessive pressure will violently throw LOX from the tube assembly.

As soon as the sampler tube is filled, remove the separator from the sampler assembly and install the adapter to the cylinder. Close it tightly with end wrenches, making sure that the valve is fully closed. Turn sampler upside down for a few minutes to allow liquid to flow from the sampler tube into the cylinder. Immerse the valve of the cylinder in water to check for leaks.

PURGING

Purging and other maintenance of LOX trailers is performed by the 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 uncontaminated.

To do this, drain the container using the buildup coil. Do NOT open the vent during this operation. Partially fill the container with uncontaminated LOX and allow the container to stabilize. Build up pressure to 30 to 40 psi and then vent the pressure to 0 psi. Repeat this operation for a total of three cycles. Take a sample and forward it to a designated site for analysis. If the sample is acceptable, the container may be put into service. If the sample is not acceptable, the container must be gas purged using hot water pumped nitrogen.

If allowed to run dry or if odor is detected in the system, aircraft LOX converters must be gas purged before being put into service. Gas purging of aircraft LOX systems must be done if any maintenance is performed on the system that opens it to the atmosphere.

To gas purge a LOX converter, first drain the converter of LOX. If possible, allow the converter to warm to ambient temperature. This saves vast amounts of nitrogen. Attach a purging device to

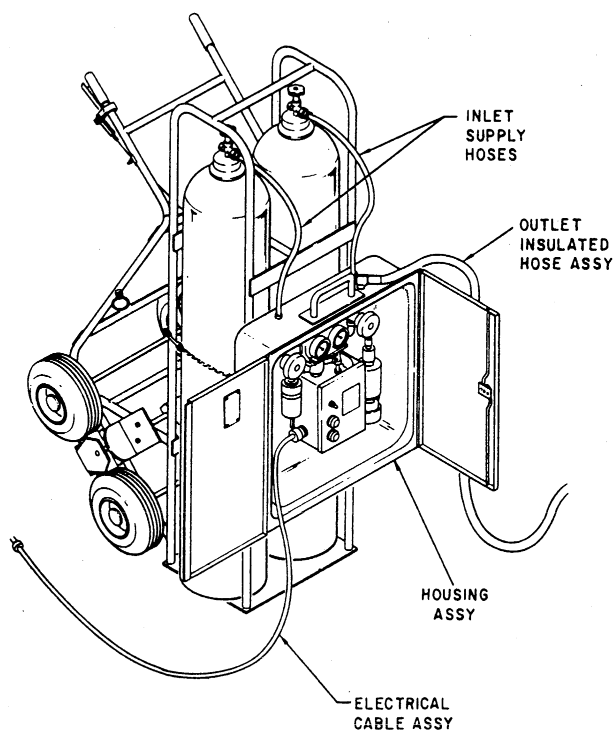


Figure 5-11.—Purging unit ready for use.

the converter and pass hot nitrogen 250°F (122°C) through the converter at 50 psi for at least 2 hours. The gas exiting the converter should exceed 100°F (38°C), or be in accordance with purging equipment instructions.

Next, service the converter and install it in the aircraft. Use an oxygen mask to smell for odors. If odors persist, drain and purge the converter again. Aircraft systems are purged in the same manner as a LOX converter. If an adapter is not supplied with the purging unit, use a supply fitting from a LOX converter.

Different types of purging equipment is used to purge oxygen containers and systems. Only one type unit, the Aircraft Liquid Oxygen System Gas Purging Set, manufactured by Avel Corporation, will be discussed here.

Description

This unit is designed to use water pumped gaseous nitrogen or gaseous oxygen to perform the purging process.

NOTE: Gaseous oxygen is to be used only if gaseous nitrogen is not available. All oxygen safety precautions must be strictly adhered to.

The unit consists of a hand truck and housing assembly, which contain the necessary controls and valves (fig. 5-11). Located within the housing assembly is an electrical enclosure containing a heater block assembly, switches, indicator lamps, and circuit breaker. When not in use, the supply and delivery lines, fittings and filler valve, electrical adapter (for conversion to 400 Hz power), and the electrical power connecting cord are stowed within the housing assembly. The housing assembly may be removed from the hand truck for use as a bench-mounted installation in the oxygen/converter repair shop.

Principles of Operation

As illustrated in figure 5-12, gas flows from the gas cylinders to the hand shutoff valves (HDV-1 and HDV-2), and then to the high--pressure relief valve (RV-1). This valve relieves

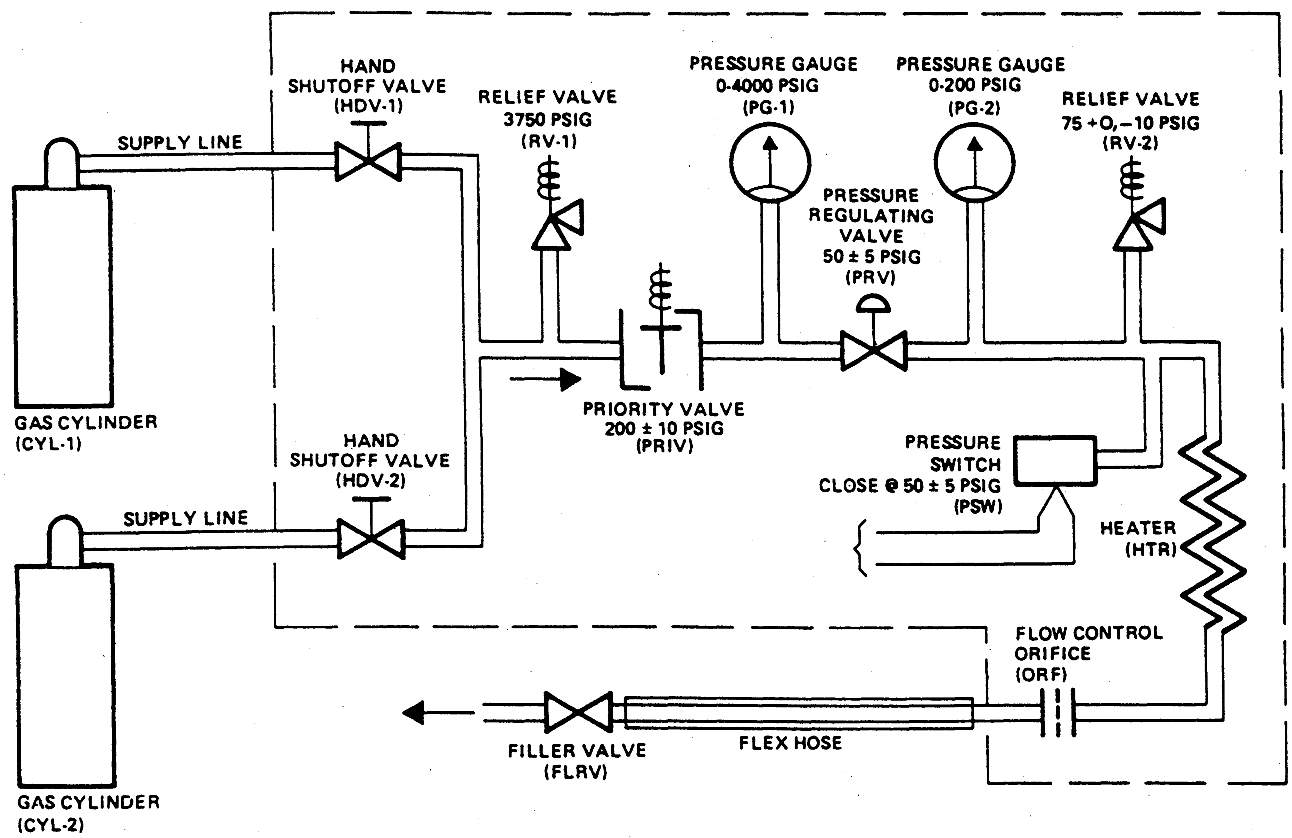


Figure 5-12.—Purging unit functional diagram.

pressures in excess of 3,750 psi. The gas then flows through the priority valve (PRIV). This valve is set to stop the flow of gas from the supply cylinders when cylinder pressure falls below 200 ± 10 psi. From the priority valve, gas flows to the pressure regulating valve (PRV). Pressure indicated on the high-pressure gauge (PG-1) is reduced to 50±5 psi by the pressure regulating valve. The reduced pressure is shown on the low-pressure gauge (PG-2). Gas then flows to the relief valve (RV-2), which is preset to 75+ 0, – 10 psi. From the relief valve, gas passes through the heater assembly (HIR), where the gas is heated to 285°F. The heated gas flow is then directed through the flow control orifice (ORF), which maintains the flow of gas at 0.20±0.017 pounds per minute at the regulated pressure of 50 ± 5 psi. The gas that exists in the filler valve (FLRV) will be at a temperature of 225±25°F.

Electrical power for the heating element in the heater (HTR) is controlled by the pressure switch (PSW) and two temperature switches. When gas pressure of 50±5 psi is reached, the pressure switch energizes the temperature control circuit and allows the heater assembly to warm. The temperature switch breaks contact within the circuit when the heater assembly temperature exceeds 285°F, and re-establishes contact when the heater assembly cools to 270°F, thus maintaining a temperature of 250°F to 260°F at the heater assembly discharge.

The high temperature switch functions as a safety switch. This switch is set to break the heater circuit when heater assembly temperature exceeds 300°F, and re-establish the circuit when temperatures fall below 273°F. For operational use of the purging unit, seethe users manual supplied with the unit or the *Liquid Oxygen, System Gas Purging Set,* NAVAIR 19-25D-27.

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. They are all similar in operation; therefore, only one, the type NO-2, manufactured by Aeroil Products, Incorporated, is described here. The trailer is shown in figure 5-13.

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 shutoff 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 for long-time storage. Always use the handwheel 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 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

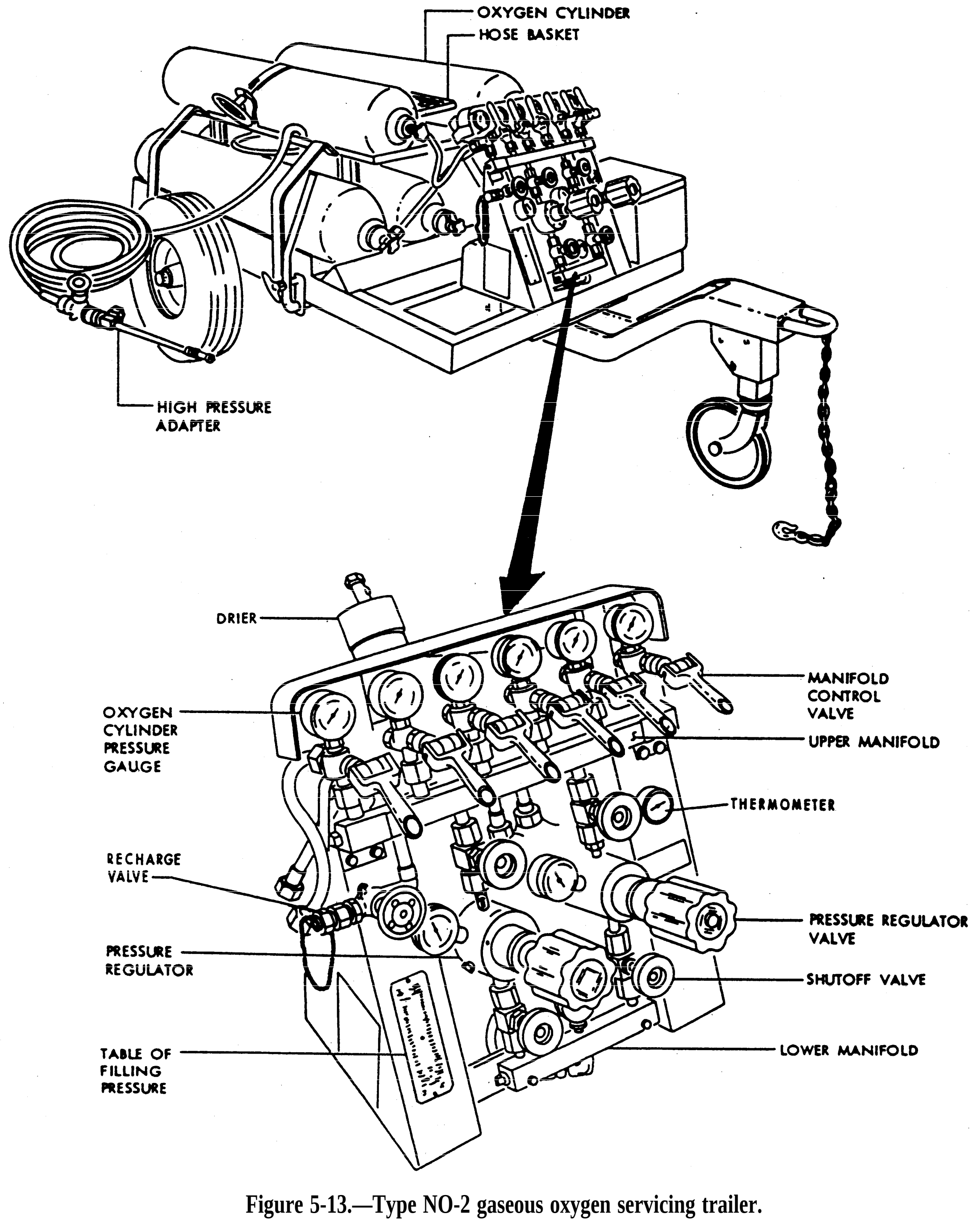


Figure 5-13.—Type NO-2 gaseous oxygen servicing trailer.

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, nonkinking, 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. 5-14). The six control valves are attached to the upper manifold. 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, which 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.

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 be easily 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 of the 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 arrangement should be tightened.

The bottom four cylinders are clamped in pairs by a wheel, and the top cylinders are tightened by a single strap for each one.

After tightening the coupling nuts on the hoses, the hoses should be free of twisting strain. This strain can be prevented by gripping the hose with one hand and twisting slightly in a clockwise direction while tightening the coupling nut. When the nut becomes tight, the hose will twist (counterclockwise) slightly as it seats, and will stop approximately at its neutral position.

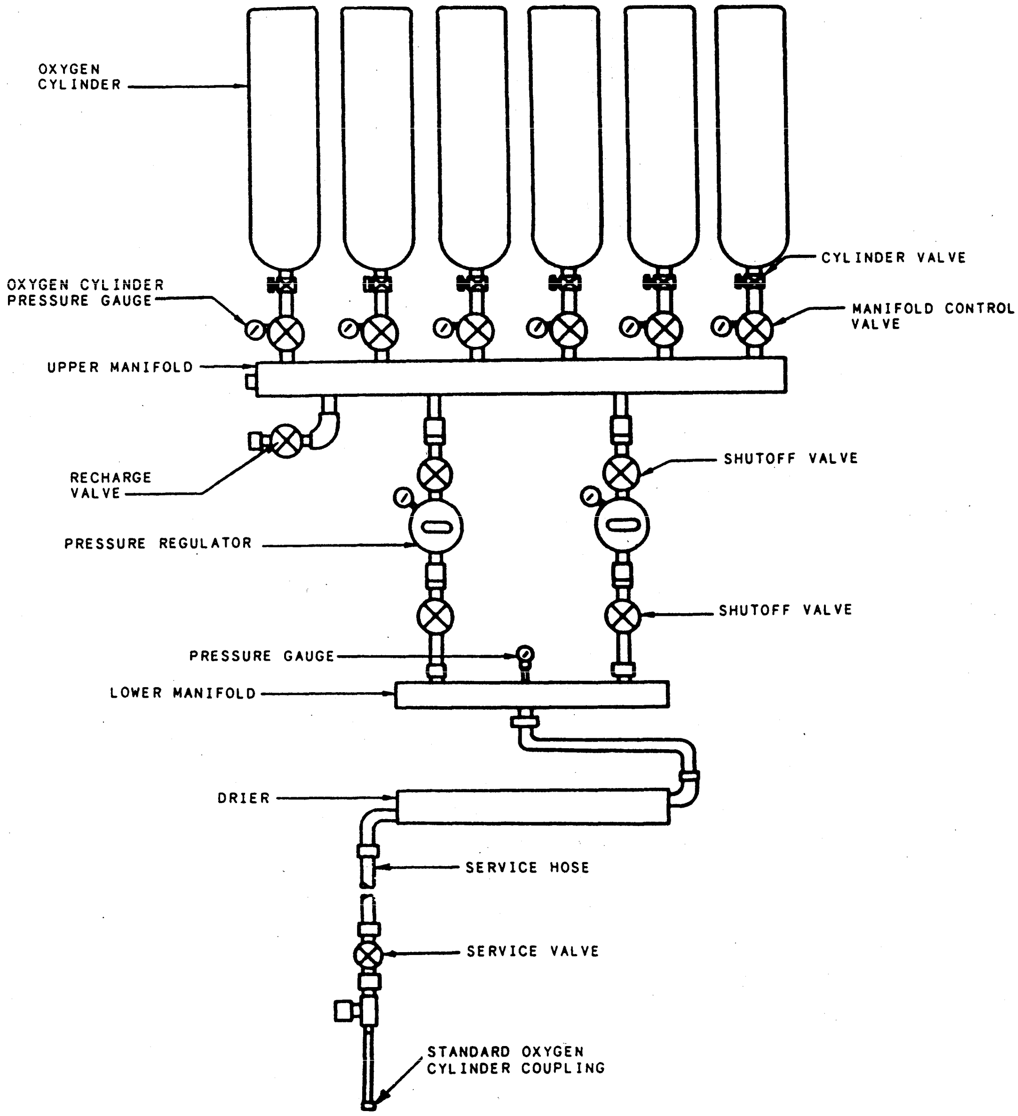


Figure 5-13.—Type NO-2 gaseous oxygen servicing trailer (schematic).

CAUTION

To eliminate the danger of an explosion, do noninterchange parts between oxygen servicing equipment and air/nitrogen equipment.

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.

Replacement of Drying Agent

The chemical drier should reinspected 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/ 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 hose 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 the moisture or humid air does not cause the indicator to change color.

The caps on the drier should be screwed down until they 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, which usually give good service. If leakage occurs, the O-ring should be replaced. Refer to the applicable Operation and Service Instruction Manual (which includes the Illustrated Parts Breakdown) for the part number of the O-ring.

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 Requirements Cards.

Daily/Preoperational Inspections

Maintenance requirements for the gaseous oxygen servicing trailer are provided on daily, preoperational, or periodic maintenance re-requirement cards. These cards provide the minimum requirements necessary to maintain the equipment and ensure that no item is overlooked. They do not contain instructions for repair, adjustment, or means of rectifying defective conditions. The cards are arranged in a work area sequence similar to aircraft maintenance requirements cards so that the inspections can be held in an efficient manner.

The daily requirements should be accomplished prior to the first use of the equipment for that day. It may be necessary to repeat some of the requirements prior to each use of the equipment.

Gaseous Oxygen System Servicing

The danger involved in the transfer of gaseous oxygen as well as its importance to the pilot requires that it be handled with care. The following general safety precautions should be followed for safe operation of the oxygen servicing trailer:

1. Only qualified operators should operate the trailer for recharging aircraft oxygen systems. Complete familiarity with the trailer is a basic prerequisite to safe operating techniques.
2. The aircraft electrical system must be turned off, and no other servicing should be conducted on the aircraft while servicing the oxygen system.
3. Never permit oil, grease, or other readily combustible materials to come in contact with oxygen cylinders, valves, regulators, gauges, or fittings.
4. The servicing hose and aircraft connection fittings must be thoroughly inspected prior to servicing. Any trace of oil, grease, or foreign material must be carefully removed.
5. The servicing hose should always be bled prior to connecting with the aircraft oxygen system.
6. Open all valves slowly.
7. Always know the pressure existing in the aircraft system to be filled and the pressure in all cylinders to be used in the refueling process before starting the recharging operation.
8. Ensure that the line valve on the discharge end of the servicing hose is closed at all times when not actually servicing aircraft.
9. Never have more than one cylinder control valve open during operation.
10. The servicing hose must never be tightly stretched to reach a connection. Position the trailer so that the hose is not under tension.
11. When disconnecting the transfer hose from an aircraft fitting, loosen the connection slowly to prevent rapid bleeding of the trapped oxygen.
12. A malfunctioning pressure regulator should be disconnected from the line by closing its associated shutoff valves. The trailer can then be operated with the remaining pressure regulator.
13. When moving the trailer from place to place, cylinder valves should be closed.

Before servicing an aircraft gaseous oxygen system, you should take care to ensure that the six manifold control valves on the trailer control panel are closed. If these valves are partially opened, the cylinder pressure will equalize from one to the other.

The following are general procedures for servicing a high-pressure oxygen system.

NOTE: Since aircraft oxygen systems vary in design, always check the applicable MIM or maintenance requirements card prior to servicing an aircraft oxygen system.

1. Prior to servicing (recharging) an aircraft gaseous oxygen system, ensure that the following conditions exist on the aircraft and the oxygen servicing trailer.
   a. The trailer and aircraft should be properly grounded.
   b. The line valve on the oxygen servicing hose should be closed.
   c. All six trailer manifold control valves should be closed.
   d. Both pressure regulators and their associated shutoff valves should be closed.
   e. All six individual cylinder valves should be opened and the individual cylinder pressures noted.
2. Open the cylinder valve and then the manifold control valve on the cylinder with the lowest pressure above the aircraft system pressure.
3. Open the two shutoff valves on each side of the pressure regulator valve that is to be used. (The oxygen servicing trailer is equipped with two pressure regulators so that in the event of the failure of one, the other maybe used.)
4. Slowly open the pressure regulator valve (by turning the control knob clockwise) and allow the pressure to buildup to the trailer cylinder pressure. The set pressure of the regulator may be noted on the regulator gauge.

NOTE: A temperature connection charge is given in the applicable MIM or on the side of the servicing trailer. This chart is used to determine the pressure to which the aircraft cylinders should be filled. This pressure depends on the ambient temperature, as maybe noted on the thermometer on the trailer manifold stand.

5. Slowly open the service valve on the servicing hose, and bleed the hose to ensure that all loose foreign matter that might be within the hose is expelled.
6. Close the service valve on the hose, and attach a high-pressure adapter to the coupling nut on the servicing valve.
7. Open the access panel to the aircraft oxygen filler valve. Check the filler valve and the area around the filler valve for any trace of oil, grease, or any other foreign material. Clean the area if necessary. Unscrew the dust cap from the aircraft filler valve.
8. Connect the service hose high-pressure adapter to the aircraft filler valve.
9. Slowly open the service valve on the hose. When there is no longer a flow of gas (lower manifold gauge is within 15 pounds of the supply cylinder gauge), close the cylinder valve and the manifold control valve, and repeat the process with the cylinder with the next higher pressure. Work cylinders in increasing order of their pressure until the aircraft system pressure has reached the desired reading.

NOTE: Oxygen under high pressure will increase in temperature during the servicing procedure. To obtain the desired pressure in the aircraft system, cylinders should be filled slightly above 1,800 psi (+50 to +200 psi), depending upon the ambient temperature.

10. After fully charging the aircraft system, close the service hose valve, shutoff valves, pressure regulator, and associated shutoff valves, manifold control valves, and cylinder control valve, in that order.
11. Disconnect the servicing hose from the aircraft filler valve, and relieve the hose pressure by opening the service valve on the hose.
12. Close the service valve and stow the hose in the trailer hose basket.
13. Replace the aircraft filler valve dust cap and the access plate.

CHAPTER 6

EJECTION SEAT SYSTEMS

Terminal Objective: Upon completion of this chapter, you will be able to recognize the components of and maintenance procedures for the removal, installation, and operational test and check of ejection seat systems.

Today's modern high-performance naval aircraft make extreme demands on emergency escape devices. The most critical time for ejection from aircraft is at low altitudes, especially on takeoffs and landings. The ultimate in seat reliability y is one that safely ejects the occupant at zero airspeed and zero altitude or at low altitudes under high sink rate and/or adverse attitude conditions. Today there are a number of different seats in the inventory of naval aircraft. Each of these seats is produced in various models to fit the escape requirements of many aircraft. As aircraft evolve, new needs and criteria dictate changes to seat systems. You will see many of these equipment changes during the time you spend in the Navy.

As examples of ejection seats, this chapter will cover the following three types of seat systems:

Section 1 - ESCAPAC lE1 ejection seat

Section 2 - MARTIN-BAKER SJU-5/A ejection seat

section 3 - STENCEL SJU-8/A ejection seat

ESCAPAC lE - 1 EJECTION SEAT

Learning Objective: Recognize the components, maintenance requirements, emergency survival equipment, and cartridge-actuated devices (CAD) for the ESCAPAC 1E-1 ejection seat.

The lE-1 ESCAPAC ejection seat is a rocket assisted ejection system that provides a quick and safe means of escape from an aircraft. The ESCAPAC seat provides escape capability from ground level at zero-knots airspeed to all altitudes and airspeeds within the operational limits of the aircraft. The ESCAPAC seat has several variations between models. Seat modifications have been incorporated to give the occupant an improved escape and recovery system that assures directional stability during ejection and positive seat-man separation. A manual backup is provided to allow over-the-side bailout as well as emergency egress from the aircraft. In this section we will discuss the ESCAPAC 1E- 1 ejection seat used in the S-3 aircraft.

SYSTEM DESCRIPTION

Following ejection initiation, the lE-1 ESCAPAC system is fully automatic through rocket thrust and burnout, seat-man separation, and parachute opening. The 1E- 1 ejection seat is a very reliable seat system that is initiated by pulling either the primary (face curtain) or secondary (lower) ejection control handle (fig. 6-1). Two cables attached to the primary ejection control handle, or a single cable attached to the secondary ejection control handle, cause the firing control disconnect assembly to pivot forward. Two attached arms move two firing rods aft to actuate the acutating mechanism, which fires the M99 initiator(s) located between the guide rails. Through the aircraft-attached sequencing system, the power inertia reel hauls back the shoulder harness and stows the tactical air coordinator (TACCO) and sensor operator (SENSO) INCOS trays. Simultaneously, hot gas pressure from the M99 initiators(s) activates an

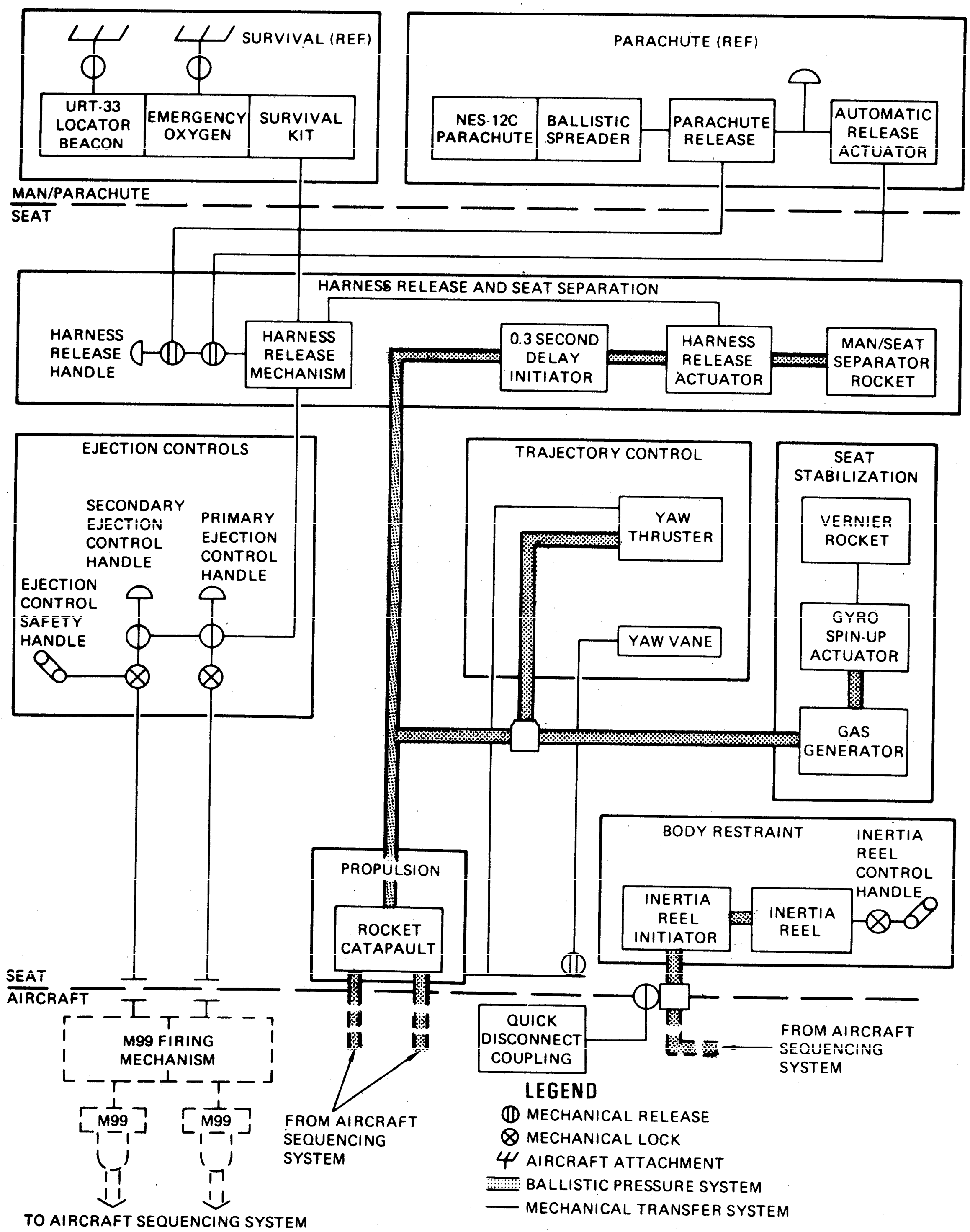


Figure 6-1.—Ejection seat system sequencing schematic.

aircraft-attached 0.3-second delay initiator, which fires the rocket catapult. On the for: ward two seats, an additional 0.5-second delay MK 11 MOD 0 initiator is in series with the 0.3-second delay initiator to delay forward seat ejection sequencing by 0.5 second after the rear seats eject. The eject mode selector handles on the pilot's and copilot's seat provide pilot or copilot control of individual or group ejection of crew members.

The first-phase propulsion of the rocket catapult starts the seat up in the guide rails. When the seat has moved approximately two-thirds the length of the guide rails, the second (or sustainer) phase of the rocket catapult ignites to provide boost for the additional height required during ejection. At sustainer separation, gas pressure from rocket ignition is used to ignite the seat stabilization control system, the yaw thruster, and the seat-attached 0.3-second delay initiator for harness release. Before the seat clears the guide rails, the following five functions occur: crew member services to the aircraft is disconnected; the parachute arming lanyard is pulled, which arms the parachute release actuator; the lanyard connected to the aircraft structure actuates the emergency oxygen bottle in the survival kit to supply the crew member with emergency bailout oxygen; the yaw vane is deployed, and the quick-disconnect coupling on the right side of the seat separates.

Following burnout of the yaw thruster rocket and sustainer rocket, and upon the completion of the pitch stabilization control function, the seat-attached 0.3-second delay initiator fires. Gas pressure from the initiator enters the harness release actuator, which drives the piston upward to rotate the bell crank mounted below the actuator to retract two survival kit retaining pins and shoulder harness pin from two inertia reel straps. Retraction of retaining pins frees the crew member and his survival equipment from the seat. The base of the clevis on the lower end of the actuator piston strikes the firing control disconnect actuating arm. Movement of the arm retracts a spring-loaded retaining pin from the firing control disconnect assembly, and releases the ejection control handle cables from the assembly. A crew member, who may still be holding one of the ejection control handles, is now freed from any restraints that would prevent the final separation from the seat. As the harness release actuator piston completes the stroke, the pressure within the actuator is ported to the man/seat separator rocket, causing the rocket to ignite.

The thrust of the man/seat separator rocket simultaneously rotates and propels the seat away from the crew member with a differential velocity of up to 25 to 30 feet per second. The probability of collison between the seat and a crew member or the parachute after separation is minimized, because no attempt is made to decelerate the seat as the seat travels along a divergent trajectory. As the seat and crew member move into divergent paths, the parachute actuator is armed and the external pilot chute is deployed. After a 0.55-second delay, the main parachute is aerodynamically deployed. Just before the parachute shroud lines stretch, the ballistic spreading gun is fired to forcefully initiate parachute inflation.

If a crew member is above an altitude of 14,000 (± 500) feet, a preset aneroid in the parachute actuator delays parachute deployment until the crew member has descended to the correct altitude. The parachute actuator delay cartridge then fires, causing parachute deployment. The crew member can select parachute deployment at any altitude by pulling the manual ripcord on the parachute.

If the automatic ejection system malfunctions, the crew member can pull the internal jettison handle/initiator(s) in the crew compartment to cut the window/hatches away. Over-the-side bailout is initiated by pulling the harness release mechanism, which disconnects the rigid survival kit and the parachute from the seat structure. The crew member can then stand up and exit the crew compartment. When clear of the aircraft, the crew member pulls the parachute manual ripcord located on the left riser strap immediately above the parachute canopy release fitting. The parachute flaps are thereby released, and the parachute deploys.

COMPONENTS

Figure 6-2 shows the front and rear views of the ESCAPAC 1E-1 ejection seat assembly and its various components.

Ejection Seat

The ejection seat is the basic structure that supports the equipment and mechanisms necessary for crew member comfort and safety while in flight or during the ejection sequence. The seat and associated components are constructed almost entirely of aluminum. The seat is equipped with fixed window/hatch breakers at each top forward corner to permit seat ejection through a 1/4-inch stretched acrylic window or hatch. At the upper center of the seat are headrest cushions that provide cushioning for the safety and comfort of the crew member. On each side of the seat are three seat rollers, which allow for vertical height adjustment during normal conditions and upward travel during ejection. Extended seat bucket sides protect the crew member's knees and legs from flailing during seat ejection. The seat structure supports the parachute assembly and survival kit.

PRIMARY EJECTION CONTROL HAN**DLE.—** The primary ejection control handle (face curtain) gives each crew member the means to manually initiate automatic seat ejection. The primary handle, which is an integral part of the nylon screen assembly, is connected through cables to the firing control disconnect assembly. The pivoted firing control disconnect provides a mechanical interlock between the primary and secondary ejection control handles.

SECONDARY EJECTION CONTROL HANDLE.— The secondary ejection control handle is located on the front frame of the seat structure. A cable connects the handle to a disconnect pulley assembly under the seat bucket. A second cable connects the disconnect pulley assembly to the firing control disconnect assembly at the top of the seat.

EJECTION CONTROL SAFETY HANDLE.— To prevent accidental seat ejection, a safety handle (head knocker), when placed in the down-and-locked position, prevents inadvertent actuation of all component parts of the firing control mechanism. The safety handle is identified by a yellow and black decal that reads PULL OUT TO SAFETY EJECTION CONTROLS. A safety lock, incorporated in the safety handle, automatically locks the handle in the full-out position; the lock must be manually depressed before the safety handle can be moved to the up (recessed) position.

POWER INERTIA REEL INITIATOR.— The inertia reel initiator is located on the rear left side of the seat, below and to the left of the inertia reel. The inertia reel initiator powers the inertia reel for automatic power retraction of the shoulder harness during the seat ejection sequence. The initiator gases discharge into a tubing segment that is filled with high-vacuum grease, and then into the inertia reel.

POWER INERTIA REEL.— The inertia reel is centrally located in the upper part of the seat behind the headrest cushions. In the seat ejection sequence, the inertia reel provides automatic power retraction of the shoulder harness in preparation for seat ejection. The inertia reel facilitates voluntary forward movement of the crew member, and functions as a self-compensating restraint against involuntary forward movement resulting from excessive g-forces or other aircraft stresses. An inertia reel control handle on the left arm of the seat can be manually unlocked or locked to allow or prevent extension of shoulder harness straps. Two prestretched Dacron straps are part of the inertia reel. A flexible inertia reel cable couples the inertia reel to the inertia reel control handle.

GYRO SPIN-UP GAS GENERATOR CARTRIDGE.— The gas generator is attached to the pitch stabilization control (STAPAC), which is located under the seat bucket. The gas generator powers the gyro spin-up actuator, and subsequently powers the sear cam piston. The gas generator is a percussion-ignited device that is fired by ballistic gas pressure ported from the rocket catapult when the rocket portion fires.

VERNIER ROCKET.— The vernier rocket is a mechanically fired rocket motor located across and under the seat bucket; the vernier rocket is part of the pitch stabilization control unit. The gas generator powers the sear cam piston to fire the vernier rocket, whose rotation is controlled by the pitch rate gyro.

PITCH STABILIZATION CONTROL (STAPAC).— A unique but simple STAPAC stabilizes the seat during conditions of large center of gravity (cg) main rocket thrust misalignment, and high aerodynamically induced pitch torque. The STAPAC, located under the seat bucket, operates from the time the seat leaves the guide rails until after rocket sustainer burnout. The STAPAC consists of a mechanically fired vernier

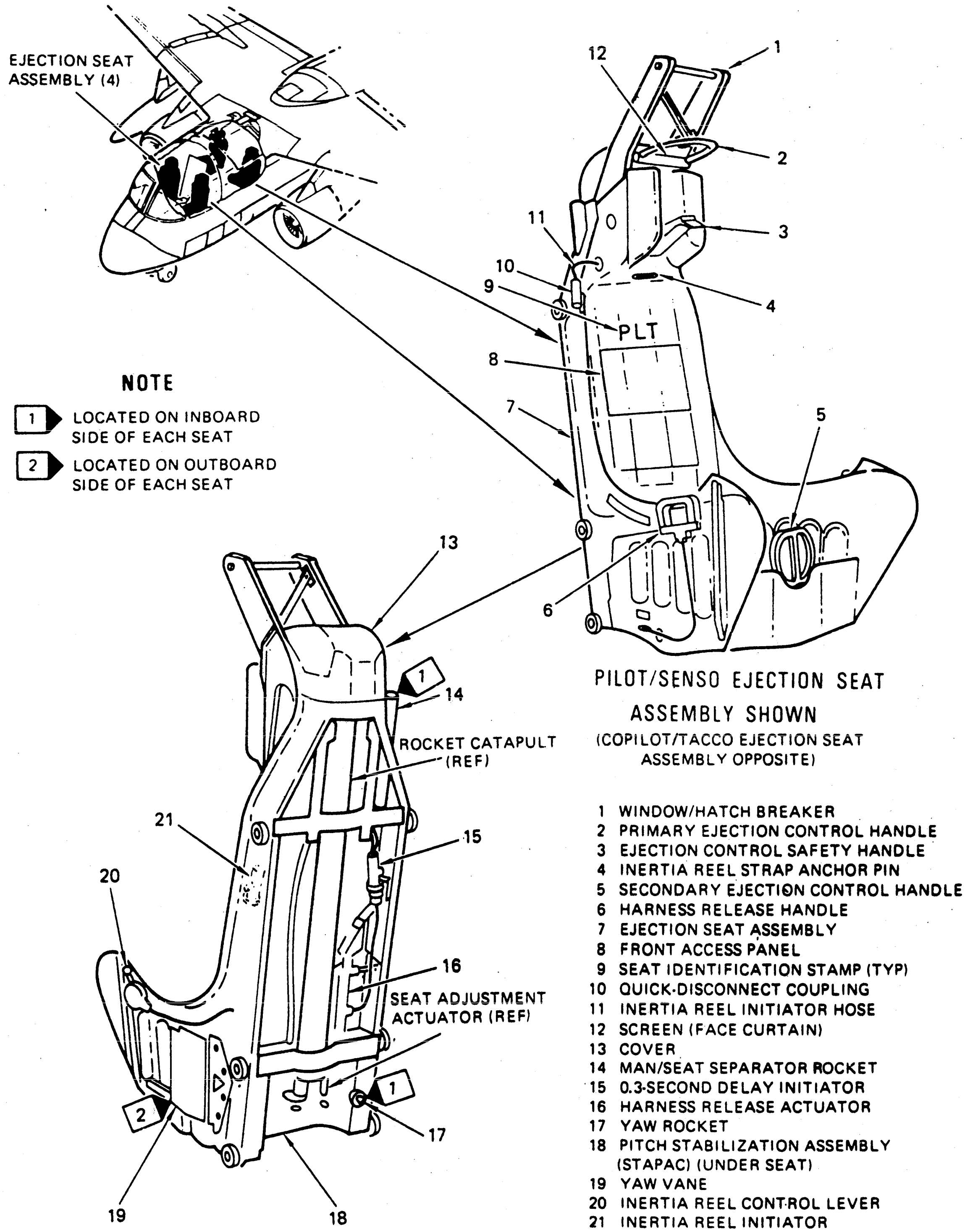


Figure 6-2.—Ejection seat assembly.

rocket, a gyro spin-up gas generator cartridge, and a simple pitch rate gyro located forward of the vernier rocket. The gyro comes up to operating speed by the gas generator-driven gear rack as the gyro is uncaged and the vernier rocket fires. The vernier rocket burns during rocket sustainer stage burning for approximately 0.3 second. Mounting of the vernier rocket in the caged position allows the nozzle thrust vector to be directed up through the nominal cg of the occupied seat. If the seat starts to pitch because of adverse torque of any origin, the gyro precesses and rotates the vernier rocket around the pitch axis, which changes the thrust/cg relationship and applies a correcting moment.

YAW THRUSTER.— To achieve safe separation of multicrew seat trajectories, a yaw thruster is used on each seat to provide a controlled, lateral-angle dispersion from the aircraft's direction of flight. Two types of yaw thrusters are used on the forward and aft seats, with location always on the inboard side of each seat. A low yaw thruster, producing approximately a 10.4 pound-second impulse for 0.1 second, is installed on each forward seat, and a high yaw thruster, producing approximately a 21.0 pound-second impulse for 0.1 second, is installed on each aft seat. The yaw thruster is ignited by high-pressure gas ported from the top of the rocket catapult.

To provide proper yaw rotational impulse for each seat installation, the yaw thruster is mounted to provide a predetermined moment arm about the center of gravity of the seat/crew member system. The mounting bracket for each thruster incorporates a boss that, when combined with a fixed stop permanently mounted on each guide rail, will prevent incorrect installation. The right and left seats are yawed to produce changes in the trajectory paths. Each of the four crew member seats will be separated from the others at parachute full-open condition under nominal lateral center-of-gravity conditions.

YAW VANE.— To assist in providing the proper yaw rotation at higher airspeeds, an aerodynamic yaw vane is installed on the outboard, lower aft side of each seat. The yaw vane deploys just as the seat leaves the guide rails and presents a drag area of 1/2 square foot to yaw the seat approximately 20 degrees. At this position, the vane is blanked by the man/seat structure, and becomes ineffective in creating any further increase in the degree of rotation.

Harness Release and Seat Separation

The harness release system provides automatic release of the shoulder harness and lap belts during the ejection sequence. The survival kit and shoulder harness are locked in the seat by three retaining pins, two through the survival kit lugs and one through the shoulder harness inertia reel strap lugs. Automatic release from the seat during the ejection sequence is accomplished by the harness release actuator, using a pressure-actuated 0.3-second delay initiator. Gas pressure, which exits from the outlet port of the harness release actuator, is used to actuate the man/seat separator rocket in the seat separation subsystem.

PRESSURE-ACTUATED 0.3-SECOND DELAY INITIATOR.— The 0.3-second initiator is located on the rear right side of the seat above the harness release actuator. The 0.3-second initiator is a pressure-actuated device with a conventional firing piston secured in the cocked position by a shear pin. Gas pressure from the rocket catapult actuates the initiator, which fires into the inlet port of the harness release actuator.

HARNESS RELEASE ACTUATOR.— The actuator is mounted on the rear right side of the seat. The actuator contains a piston and rod that are actuated by a 0.3-second delay initiator firing into the inlet port. Gas pressure exits from the outlet port to actuate the man/seat separator rocket. The piston rod, which extends below the actuator, is connected to the harness release bell crank. The bell crank initiates simultaneous automatic actuation of each component of the harness release system to cause man/seat separation during seat ejection. If the lap belts and shoulder harness assemblies fail to release automatically, the crew member can actuate the harness release handle to release the assemblies. The handle is also useful for routine removal and installation of the parachute and survival kit. The following components are connected to the multiple arm bell crank: harness release actuator piston rod, survival kit retaining pins, inertia reel straps retaining pin cable, harness release handle cable, and bell crank return spring. The actuator also actuates the firing control disconnect actuating arm.

MAN/SEAT SEPARATOR ROCKET.— The separator rocket is mounted on the aft inboard side of the headrest area of each seat. The separator rocket is used to separate the crew member from the seat and drive the seat into a divergent trajectory. Pressure from the harness release actuator outlet port is used to initiate the separator rocket. The separator rocket nozzle is oriented to direct the exhaust plume forward, up, and away from the crew member.

Aircraft-Attached Ejection Seat Components

The following ejection seat related components are located on the aircraft structure and remain in the aircraft when the seat is removed for maintenance.

GUIDE RAILS.— Two guide rails are located on each canted bulkhead behind each crew member. Each **set** of guide rails is machined from aluminum extrusions. Each outboard rail has a machined cam at the top to release the aerodynamic yaw vane as the seat travels up the guide rails. Two holes in each inboard guide rail allow installation of two seat servicing pins to support each seat at the 42-inch alternate maintenance position.

SEAT CONTROL SYSTEM.— The seat control system permits vertical height adjustment of each crew member's seat before and during' normal flight. Phase reversal of two phases of a three-phase power source permits raising or lowering each seat according to the selected UP or DOWN position of the switch on the SEAT panel on the side console at each crew member station (fig. 6-3). The seat control system consists of a seat switch and a seat adjustment actuator and motor. Seat adjustment is provided by a

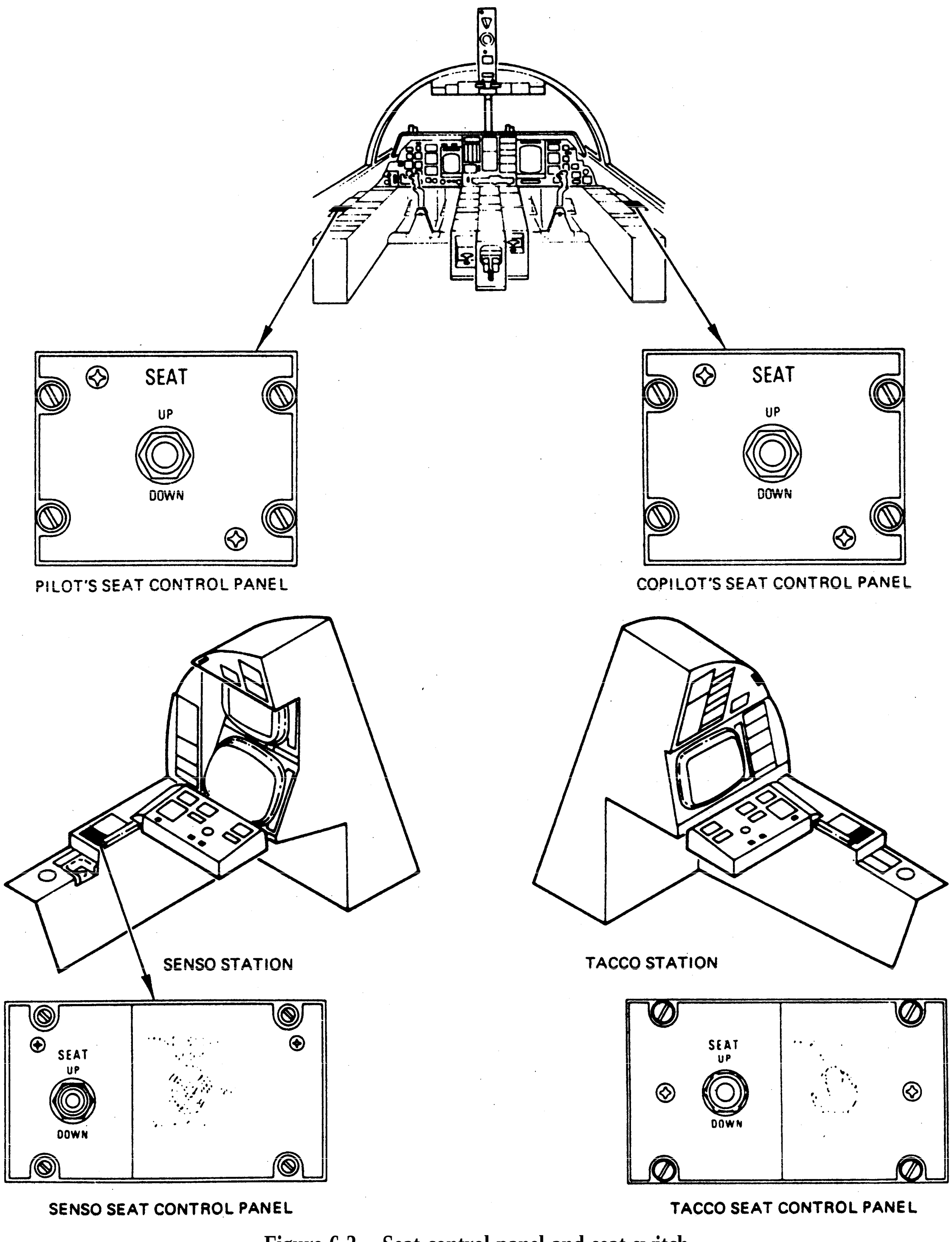


Figure 6-3.—Seat control panel and seat switch.

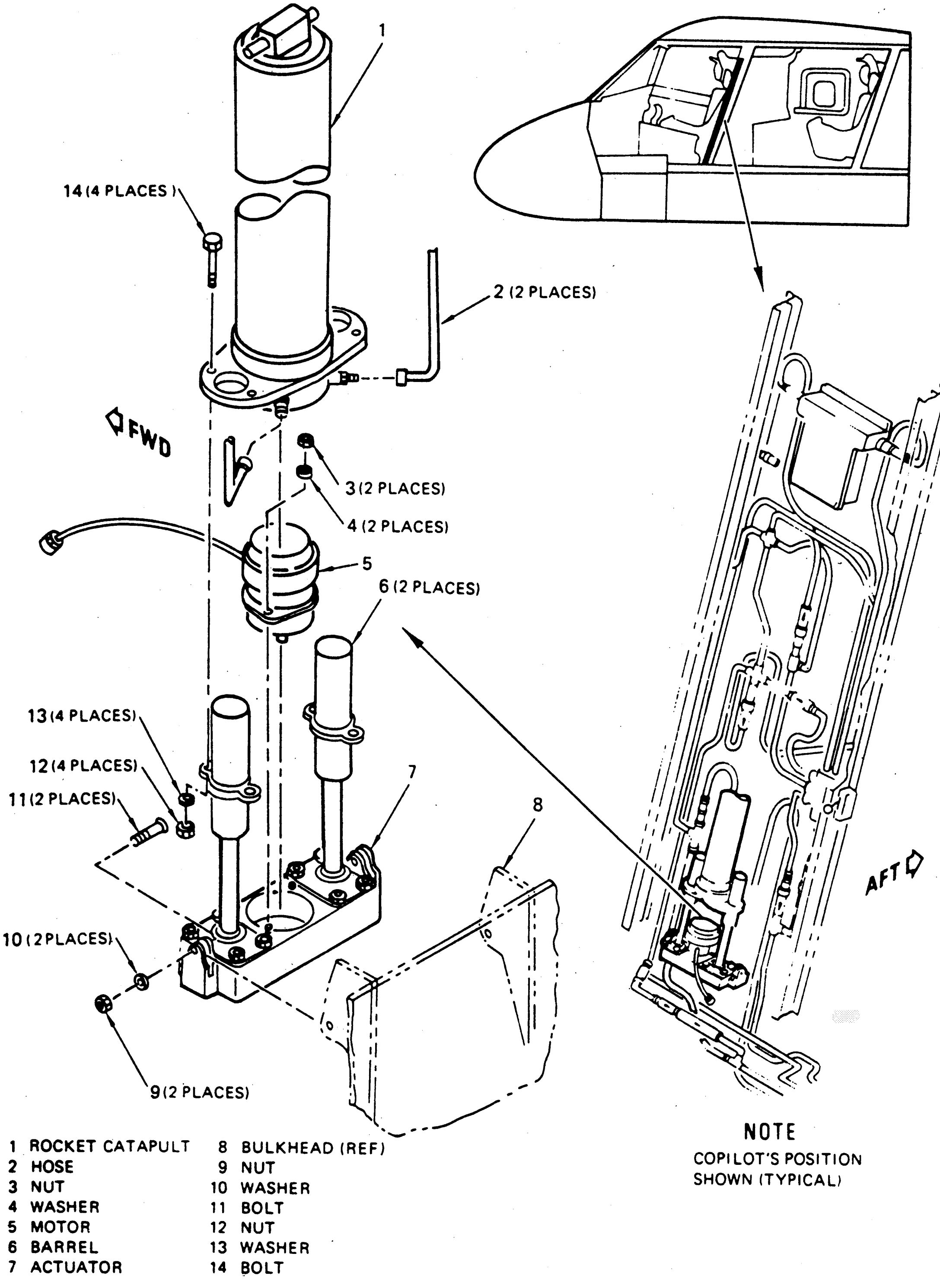


Figure 6-4.—Seat adjustment actuator and motor assembly.

twin-barrel electromechanical actuator (fig. 6-4), which is driven by a 115/200-volt, 400-Hz, three-phase, four-pole induction motor. The motor is geared to a reduction gear train, which drives two screw barrels that are attached to mating flanges on the base of the rocket catapult. The rocket catapult is bolted to the top of the seat structure, which allows a 5.5-inch up and down adjustment of the seat parallel to the guide rails. Six rollers on the seat allow the seat to move up or down the guide rails.

ROCKET CATAPULT.— The rocket catapult provides the necessary propulsion to eject the seat and crew member from the aircraft during the ejection sequence. The performance capability of the rocket catapult at zero altitude and zero airspeed reduces the effects of high sink rate and nosedown attitudes encountered during critical approach and landing operations. The rocket catapult is secured at the top center of the seat back, and is supported at the base by twin barrels of the seat adjustment actuator. Two attachments on the actuator secure the actuator to the aircraft bulkhead.

M99 INITIATORS.— Two M99 initiators are installed on the M99 initiator actuating mechanism (fig. 6-5) near the top of each canted bulkhead behind the pilot's and copilot's seats, and one M99 initiator is installed at each tactical air coordinator (TACCO) and sensor operator (SENSO) seat location. The M99 initiator is a mechanically fired, pressure-developing source. Each M99 initiator, consisting of a constant-volume cylinder with a tube connection at one end, contains a mechanically fired mechanism and cartridge. The M99 initiator firing mechanism can be secured in a safe position by a safety pin that passes through the cap and a groove on the side of the M99 initiator pin. Pulling either the primary or secondary ejection control handle initiates the ejection sequence, which, in turn, rotates the firing control disconnect, moves two firing rods

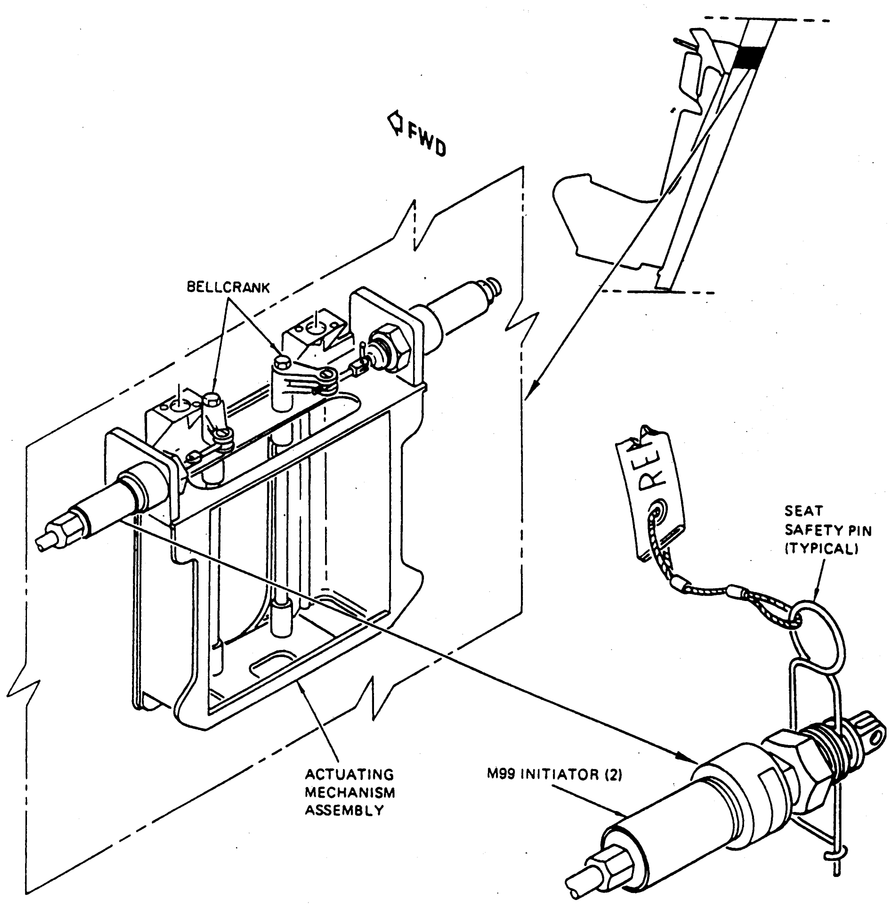


Figure 6-5.—M99 initiator location.

aft to rotate the actuating mechanism bell crank(s) that fires the initiator(s).

M99 INITIATOR ACTUATING MECHANISM.— The actuating mechanism is located between the guide rails, and is attached to the upper section of each canted bulkhead, behind each crew member's seat. The actuating mechanism for the forward seats have dual bell cranks (striker plates) and clevises to actuate the two M99 initiators installed on each side of the actuating mechanism. Since each aft seat requires one M99 initiator for the ejection sequence, the actuating mechanism is a single bell crank and clevis arrangement. During the seat ejection sequence, the seat-mounted firing rods are moved aft to rotate the actuating mechanism bell crank(s) and clevis(es) to fire the M99 initiator(s).

Refer to figure 6-6 while reading the following text.

M53 INITIATOR.— There are thirteen M53 initiators installed in aircraft-attached ejection seat plumbing. Eleven of the M53 initiators are installed between the guide rails, and two initiators are installed at flight station (FS) 263 (one each at the INCOS tray thruster location). Each pilot and copilot location has four M53 initiators; the TACCO location has one; and the SENSO station has two. The M53 initiator is a cartridge-actuated, gas-producing device triggered by gas pressure from a remote source. The M53 initiator consists of a constant-volume cylinder with a tube connection at one end and a gas-operated firing mechanism and cartridge. In the ejection seat sequence, gas pressure from the M99 initiator(s) actuates the M53 initiators. M53 initiators characteristically serve as line-boosters in the ejection seat system to counteract rapid pressure decay caused by tubing length.

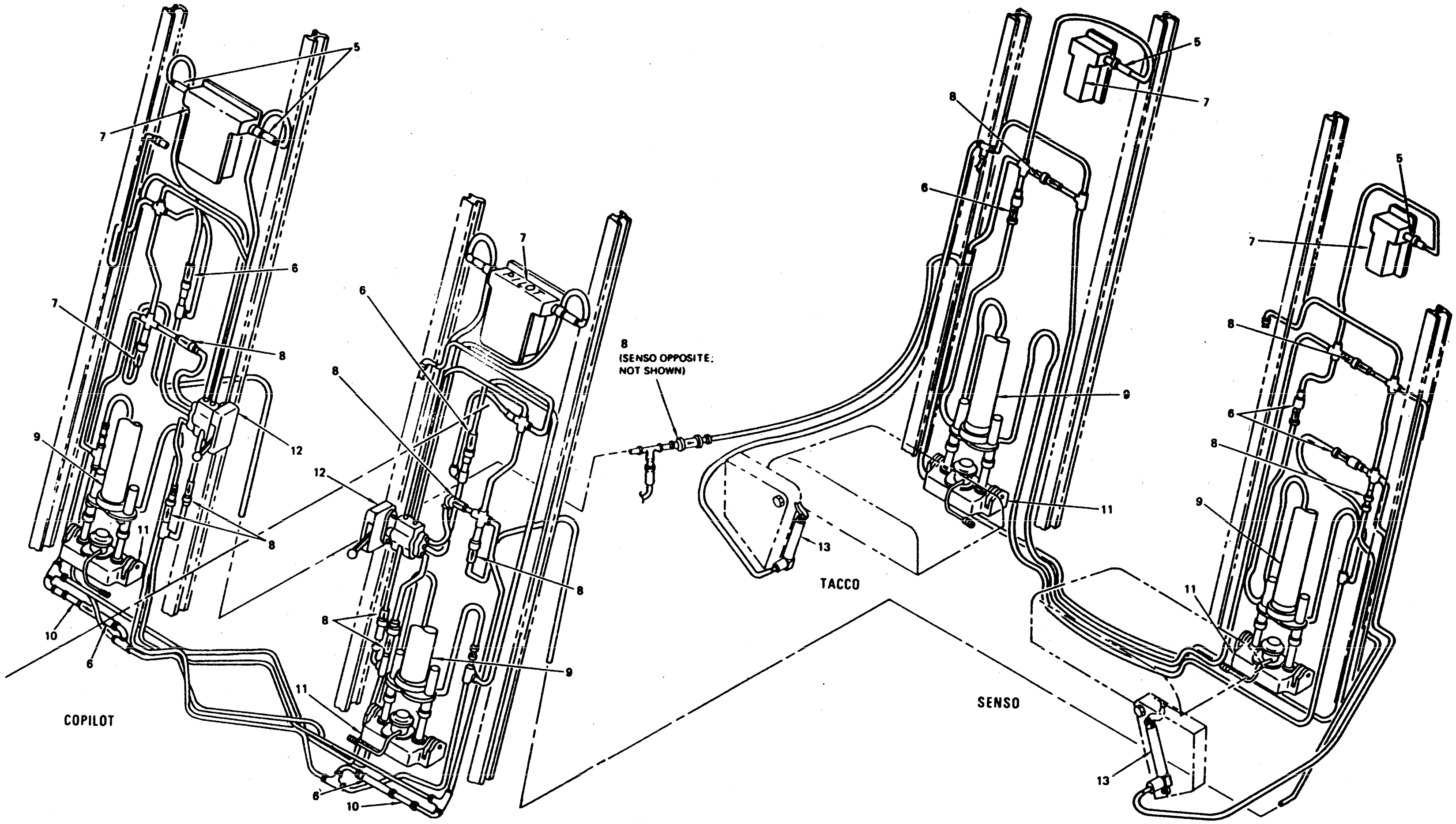
PRESSURE-ACTUATED 0.3-SECOND DELAY INITIATOR.— Seven 0.3-second delay initiators are installed between the guide rails. Two 0.3-second delay initiators are installed at the pilot's, the copilot's, and the SENSO station; and one is installed at the TACCO station. At the pilot's and copilot's stations, an Mk 11 MOD 0 initiator is installed on the 0.3-second delay initiator. The 0.3-second delay initiator is a pressure-actuated device with a conventional firing piston secured in the cocked position by a shear pin. In the ejection sequence, the 0.3-second delay initiators are used as time delays in the inertia reel shoulder harness retraction, in the INCOS trays retraction, and in the group or solo ejection sequencing of crew members in the firing of the rocket catapult(s).

MK 11 MOD 0 INITIATOR.— A MK 11 MOD 0 initiator is installed below the floor line directly under the rocket catapult at the pilot and copilot seat locations. Each MK 11 MOD 0 initiator is installed on the 0.3-second delay initiator, and both fire into the rocket catapult. The MK 11 MOD 0 initiator is a cartridge-actuated device triggered by gas pressure from a remote source. In the ejection sequence, the MK 11 MOD 0 initiators are used as time delays in the group-ejection (all seats) mode to allow the two aft seats to eject 0.5 second before the front seats to permit proper spacing of personnel for safe parachute deployment and landing.

PLUMBING AND CHECK VALVES.— Most plumbing for the aircraft-attached ejection seat components is flexible hose-type plumbing located between the guide rails. There are a minimum of lines between the forward and aft seats and the INCOS tray thrusters. There are twenty check valves installed in aircraft-attached ejection seat components; all are located between the guide rails. In the ejection sequence, the check valves allow the correct group or solo-ejection selection to occur.

INCOS TRAY THRUSTER.— At both the TACCO and SENSO locations, a thruster is installed to retract the respective INCOS trays during the seat ejection sequence. The thruster is a pressure/percussion device that employs sear pins, firing pins, and primers to ignite the main charge. In the ejection sequence, the INCOS tray is retracted at the same time that the inertia reel shoulder harness retraction occurs.

EJECT MODE SELECTOR VALVE.— A selector valve is installed on each inboard guide rail in the flight station. The selector valve consists of a beam assembly with a switch and handle and the valve body. The selector valve routes high-pressure gas from the M99 initiators to the aircraft sequencing system, depending on the selected position (GROUP EJECT or SELF EJECT) of the selector valve. When the pilot's or copilot's selector valve handle is in the down or GROUP EJECT position, an electrical ground is completed, which causes the GROUP EJECT indicators to come on at the SENSO and TACCO instrument panels. When either selector valve handle is in the up or SELF EJECT position and the aircraft altitude is less than 15,000 feet, the altitude sensor switch cause the indicator



1 THROUGH 4 NOT SHOWN
ON THIS PART
5 M99 INITIATOR
6 PRESSURER-ACTUATED 0.3- SECOND
DELAY INITIATOR
7 ACTUATING MECHANISM
8 M53 INITIATOR
9 ROCKET CATAPULT
10 MK11 MOD 0 INITIATOR
11 SEAT ADJUSTMENT ACTUATOR
12 EJECT MODE SELECTOR VALVE
13 NOT SHOWN ON THIS PART

1 THROUGH 4, 10, AND 12 NOT
SHOWN ON THIS PART
5 M99 INITIATOR
6 PRESSURE-ACTUATED 0.3-SECOND
DELAY INITIATOR
7 ACTUATING MECHANISM
8 M53 INITIATOR
9 ROCKET CATAPULT
11 SEAT ADJUSTMENT ACTUATOR
13 INCOS TRAY THRUSTER

Figure 6-6.Aircraft mounted CAD's.

on the annunicator panel (located on the center instrument panel) to come on.

ALTITUDE SENSOR SWITCH.— An altitude sensor switch is located on the forward bulkhead of the camera compartment. The sensor switch monitors the aircraft altitude. When the eject mode selector valve handle is in the up or SELF-EJECT position and the aircraft altitude is less than 15,000 feet, the sensor switch causes the seat select indicator on the annunciator panel (located on the center instrument panel) to come on. When the aircraft altitude reaches or exceeds 15,000 feet, the seat select indicator goes off.

GROUP EJECT INDICATORS.— A group eject indicator is installed on the SENSO and TACCO instrument panels. When the pilot's or copilot's selector valve handle is in the down or GROUP EJECT position, a switch in the selector valve completes an electrical ground, and causes both group eject indicators to come on. When both selector valve handles are in the up or SELF EJECT position, the group eject indicators go off.

EJECTION WARNING SYSTEM.— The ejection warning system is used to warn the TACCO and SENSO that an emergency is occurring, and that seat ejection is about to be initiated. The system uses an eject switch on the eyebrow panel, an emergency power unit, a flasher, and eject indicators on the TACCO and SENSO instrument panels. The pilot or copilot sets the eject switch to EJECT, which turns on flashing eject indicators on the TACCO and SENSO instrument panels.

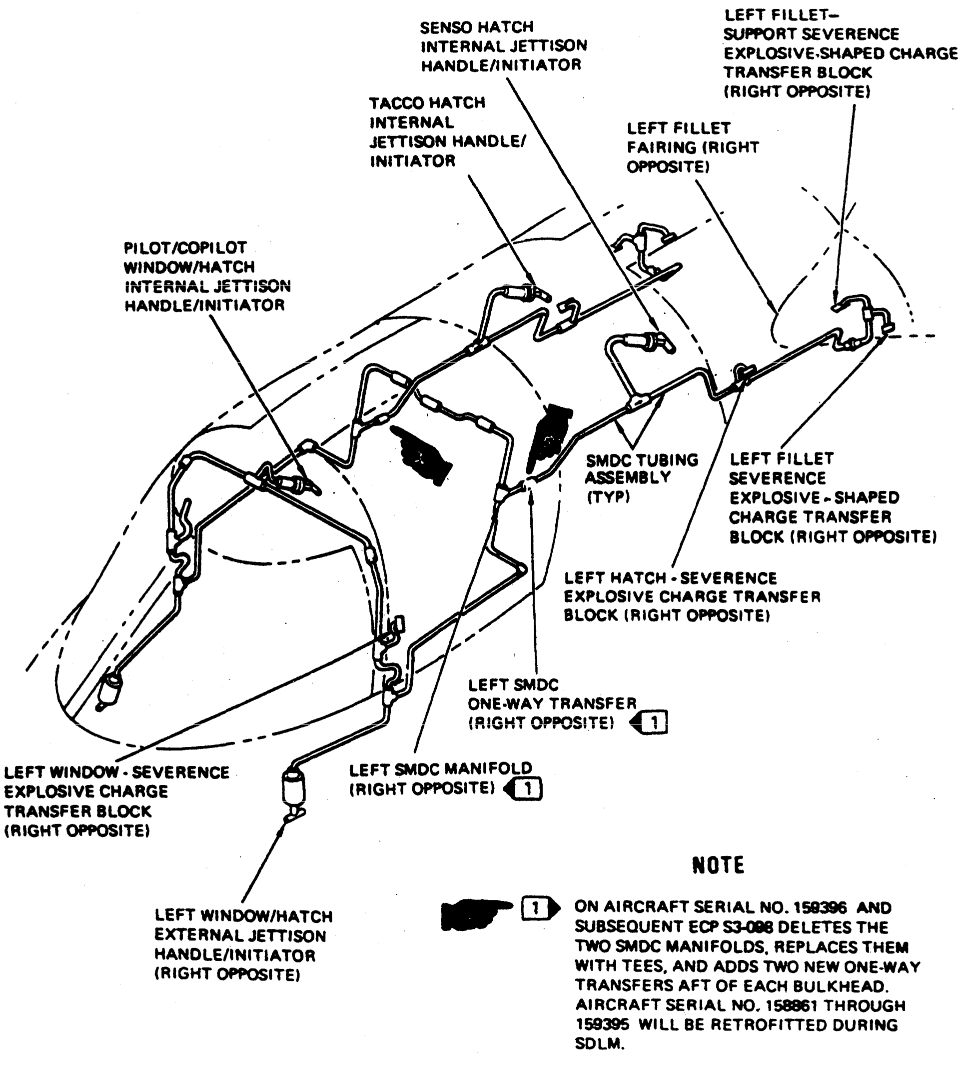


Figure 6-7.—Emergency egress system components and plumbing.

Window/Hatch Severance System

The emergency egress system provides a means of escape from the aircraft for crew members after ditching or after a wheels-up landing by initiation of explosive charges to blow out windows and hatches. The S-3 emergency egress system is distinguished from hot gas and actuator systems by its use of shielded mild-detonating cord (SMDC) instead of hot gas and explosive charges instead of actuators. The S-3 system is much less susceptible to inadvertent actuation than hot gas systems, and more convenient and safer for maintenance personnel.

The S-3 emergency egress system (fig. 6-7) consists of two window-hatch external jettison handle/initiators, three window/hatch internal jettison handle/initiators, window and hatch-severance explosive charges, fillet-severance and fillet-support severance explosive-shaped charges, SMDC's, and SMDC manifolds or one-way transfers.

FUNCTIONAL DESCRIPTION.— The S-3 emergency egress system is initiated from any one of 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 exterior window/hatch external jettison handle/initiator, and by the pilot's,/copilot's interior window/hatch internal jettison handle/initiator. The TACCO and SENSO window/hatch internal jettison handle/initiators cut only the respective panel next to the crew member, The system is used primarily for ground and water rescues. The handle/initiators have a trigger action. Once the system is actuated, the system will respond to completion without further action by crew members. The functional sequence is from the handle/initiator (any one) 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 crew member actuates the handle/iniator, the opposite hatch and the two flight station windows will not be cut, since an SMDC manifold (check tee) or one-way transfer restricts transfer of pyrotechnic energy flow to one direction.

The emergency egress system is entirely self-sufficient and completely independent. The system does not depend on any other aircraft system, nor does the system aid, assist, or sequence with another system. The SMDC system is more reliable and much faster than a comparable hot gas system. The 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 system initiation by ordinary sawing, filing, drilling, or hammering. With quick-release safety pins properly installed, the system is virtually inert.

COMPONENTS.— The following items are components of the window/hatch severance system.

Window/Hatch External Jettison Handle/ Initiator.— Two external jettison initiators are installed inside access doors on each exterior side of the aircraft just below and forward of the windshield aft posts, The external cartridge-activated initiator (fig. 6-8) is a mechanically fired device,

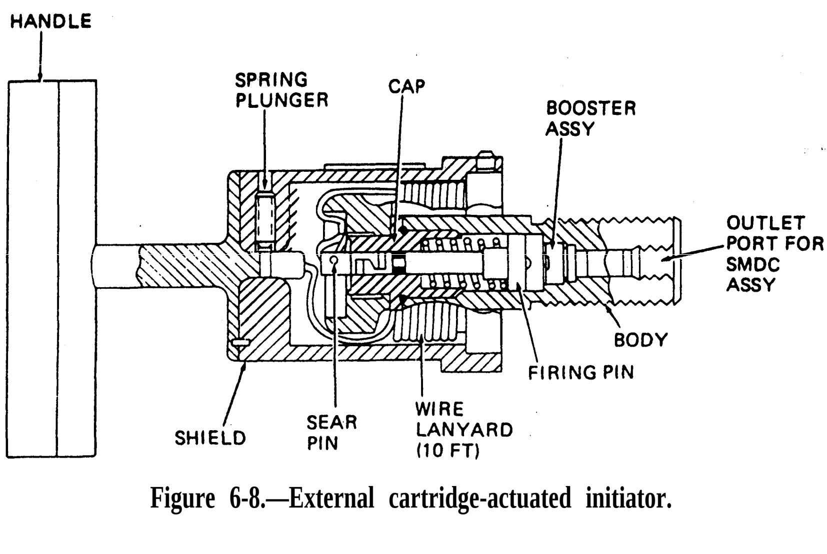


Figure 6-8.—External cartridge-actuated initiator.

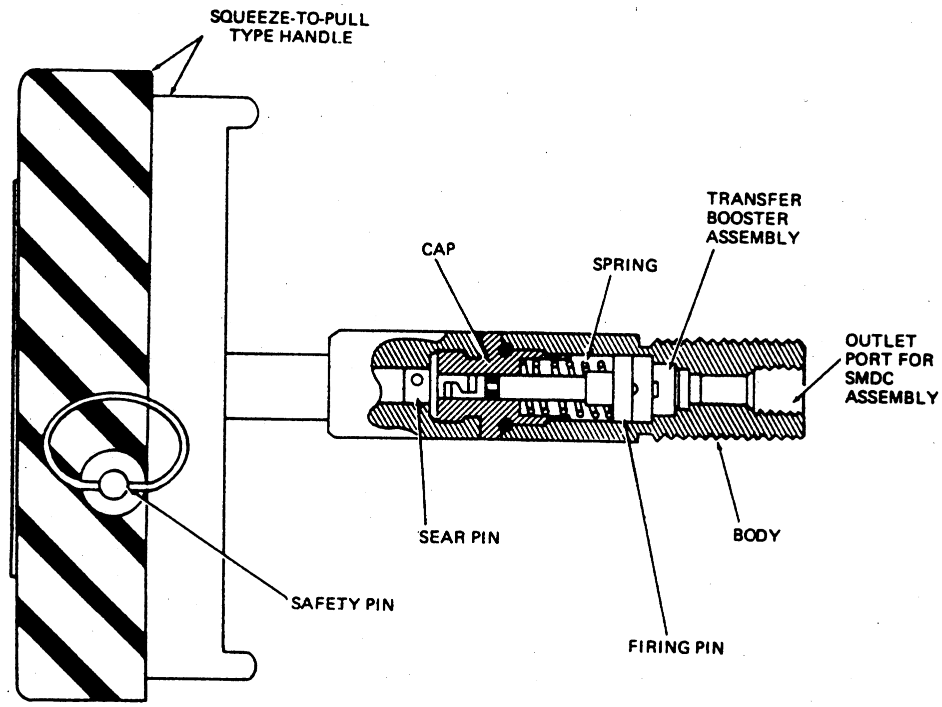


Figure 6-9.—Internal canopy/hatch severance initiator.

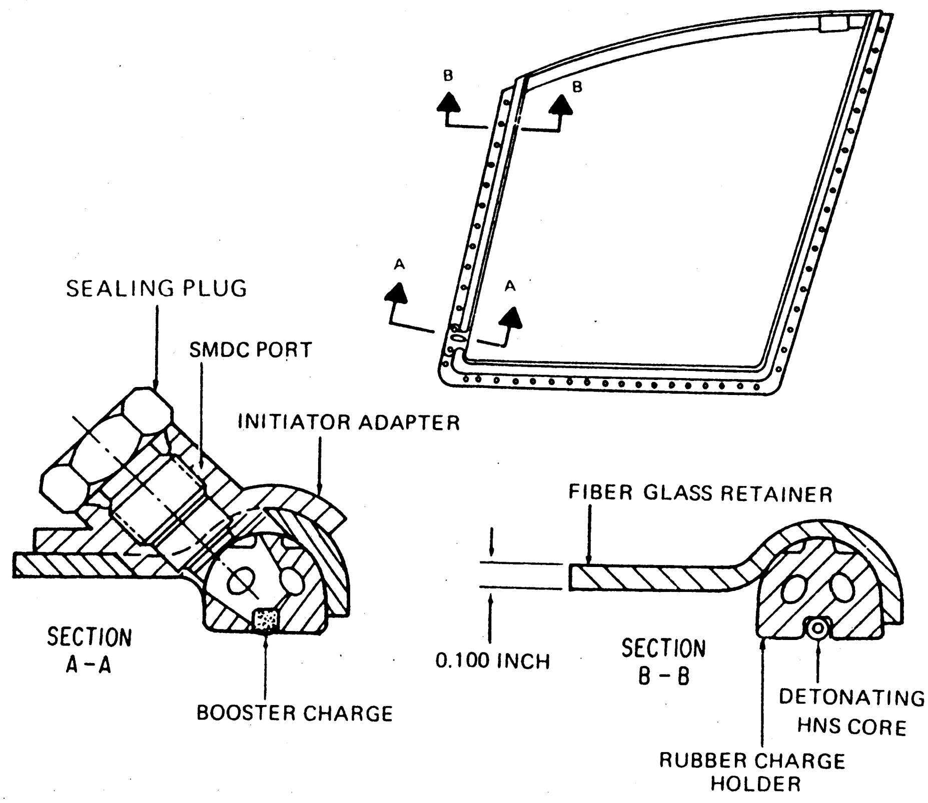


Figure6-10.—Pilot/NFO window-severance linear shaped charge.

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 azide 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. 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 window/hatch internal jettison handle/initiators (internal jettison initiators) are located in the crew compartment: one at the eyebrow panel and one each at the TACCO and SENSO instrument panels. The internal canopy/ hatch severance initiators (fig. 6-9) are the squeeze-to-pull type, which have a quick-release safety pin in the squeeze segment of the operation for safetying. The pilot's/copilot's handle will blow all windows and hatches, whereas the TACCO and SENSO handles will blow only the hatch above the crew member. The basic internal jettison handle initiators are similar to the external jettison handle initiators except for the handle and the absence of the lanyard feature.

Pilot/NFO Window Severance Linear Shaped Charge.— A window severance explosive charge (fig. 6-10) is attached to the inside periphery of the pilot's and copilot's windows. An SMDC connects to a transfer block at the lower front corner of the explosive charge. The window explosive charge is actuated by the pilot's/ copilot's internal jettison handle/initiator or by either external jettison handle/initiators through the SMDC segments. The explosive charge acts as the cutting device for the window glass.

Hatch Severance Explosive Charge.— The hatch severance explosive charge is similar to the window severance explosive charge. The explosive charges of the hatches can be actuated by the external jettison handle/initiators or by the pilot's/copilot's handle/initiator. The TACCO or SENSO hatch explosive charge can be actuated individually by the respective TACCO or SENSO handle/initiator.

Fillet and Fillet Support Explosive Shaped Charge.— Each right and left upper wing-to-fuselage fillet has a fillet-severance, explosive shaped charge attached near the outer and rear fillet attachments (fig. 6-11). The shape charge cuts the attached fillet from the aircraft to allow complete egress of the respective hatch. A fillet

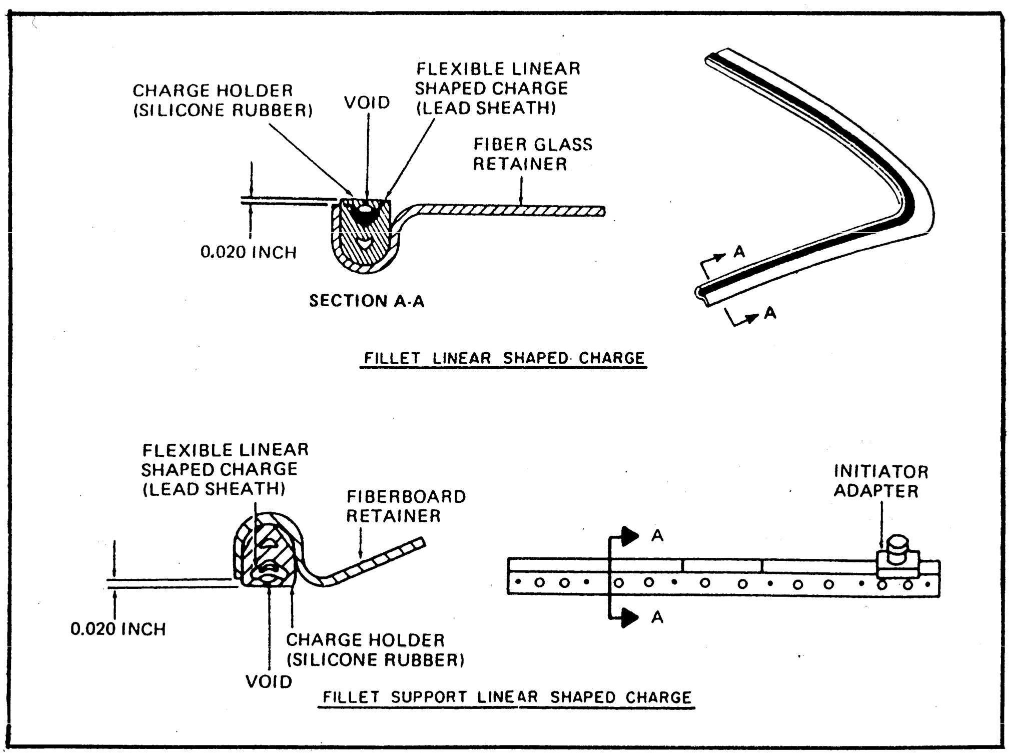


Figure 6-11.—Fillet and fillet support explosive shaped charge.

support is cut by a second shaped charge attached at the bottom.

Fillet Support Severance Explosive Shaped Charge.— A shaped charge is attached at the bottom of the internal fillet support to cut the support to allow the-fillet to separate from the aircraft during the emergency egress system operation (fig. 6-11).

Shielded Mild Detonating Cord (SMDC).— The 31 SMDC segments (fig. 6-12) act as the plumbing for the emergency egress system. The SMDC connects all external and internal jettison handle/initiators; all connectors, tees, and manifolds or one-way transfers; all explosive charges; and all explosive shaped charges. Each SMDC segment is loaded with 1 to 2 grains per foot of hexanitrostilben I (HNS I). 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 an acceptor charge.

Shielded Mild Detonating Cord (SMDC) Manifold.— Two SMDC manifolds are located on the pilot's and copilot's bulkhead. The SMDC manifold acts as a check tee or one-way detonating transfer device. The SMDC manifold is a self-contained unit housing a sealed receptacle for dual-shaped charges. Any detonation entering the side ports from either direction will transfer to the aft port. Any detonation originating from the aft port (TACCO or SENSO) segment of the SMDC manifold will not transfer back into the side portions. 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.

MAINTENANCE REQUIREMENTS

Maintenance on ejection seats is primarily performed during aircraft inspections. The ejection system could be called a dormant system, as it is only operated in an emergency situation. A true functional test of the complete system cannot be performed because of the destructive functions of some of the components. For this reason it is of the utmost importance that you thoroughly know all aspects of the ejection system that you perform maintenance on and follow all the steps for testing components as outlined in the maintenance instructions manual (MIM).

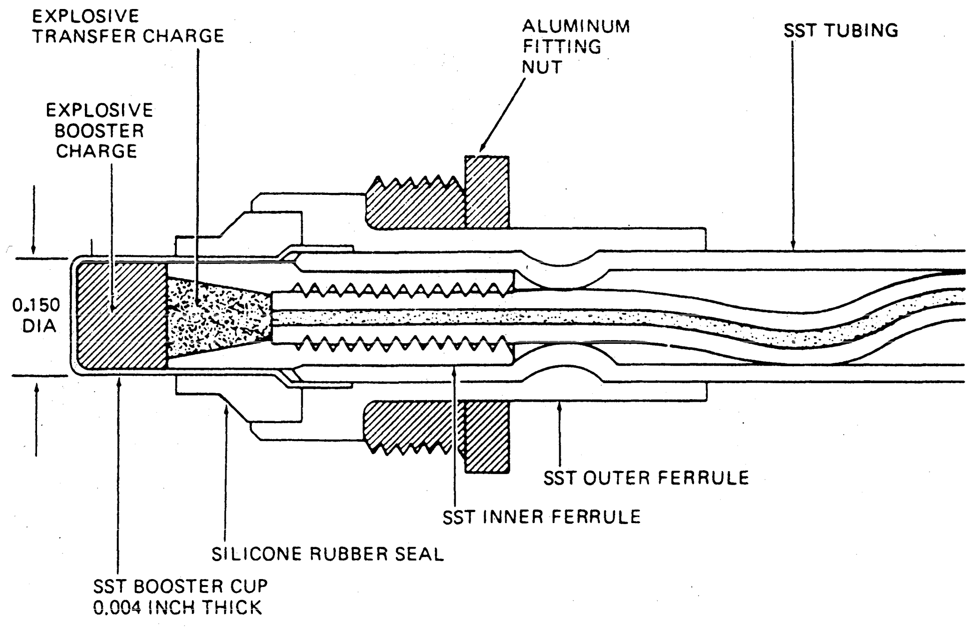


Figure 6-12.—Shielded mild detonating cord tip (typical).

WARNING

Do not perform maintenance on equipment with installed cartridges except in the presence of personnel capable of rendering aid if necessary.

Seat Removal and Installation

Before entering the cockpit, ensure that all seat and canopy safety pins and devices are properly installed. Check that the ejection control safety handle (fig. 6-13) (head knocker) is in the down and locked position. Ensure that the pilot's and copilot's eject mode selector handles are set to the SELF EJECT position.

Remove the parachute and survival kit by disconnecting the oxygen and communications quick-disconnect. Disconnect the emergency oxygen and emergency radio beacon quick-release lanyard attached to the aircraft's structure. Squeeze the harness release handle and disengage from holder. Remove the parachute actuator arming cable from the handle, and pull upward on the handle until the harness release actuator locks in the MANUAL DETENT position. Reseat the handle into the holder.

Withdraw the inertia reel straps from the chute roller fittings. Rotate the aft end of the survival kit up and forward to release the forward mounting hooks from the seat mounting brackets. Remove the parachute and survival kit from the aircraft and deliver to the aviators equipment work center.

If the seat is not in the full down position, apply electrical power and lower the seat to the full down position. Do not hold the seat adjust switch in the UP or DOWN position for more than 15 seconds to prevent damage to the seat height actuator.

Remove the M99 initiator actuating cover and install safety pins in the initiators (fig. 6-5). The pilot and copilot seats require two safety pins, and the TACCO and SENSO seats require one safety pin. Remove, as required, overhead window or hatch assembly. Remove cover from top of the

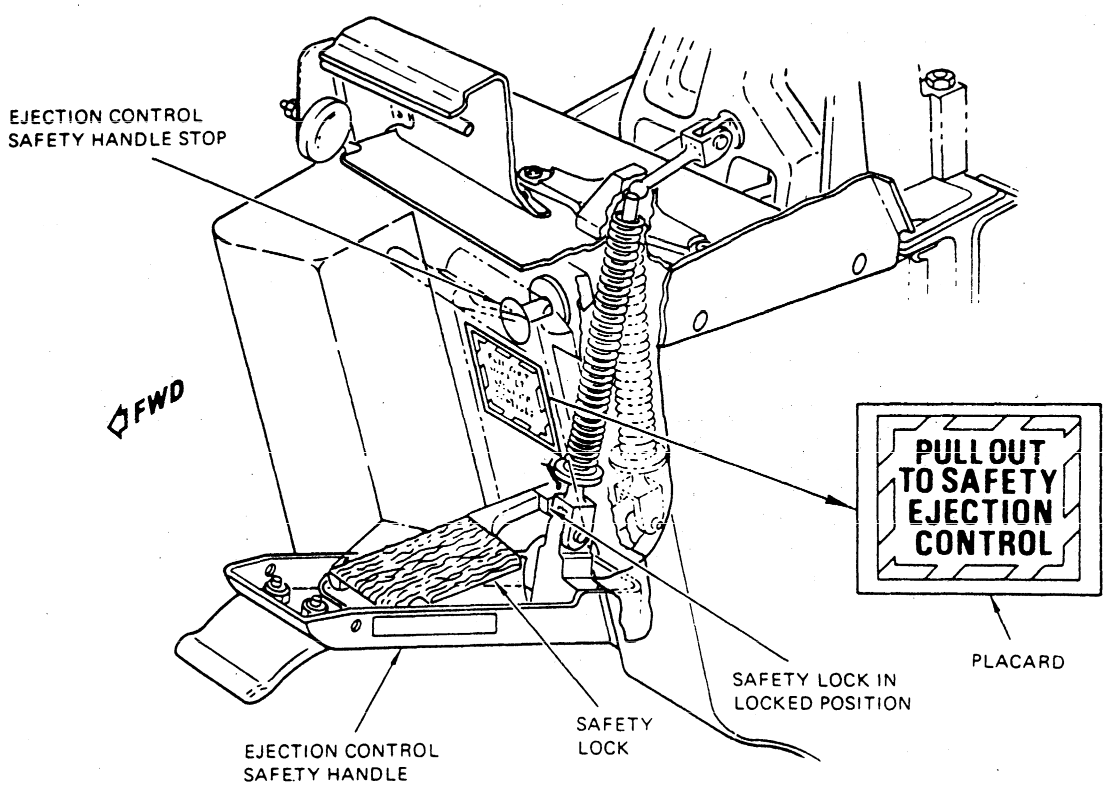


Figure 6-13.—Ejection control safety handle.

rocket catapult (fig. 6-14). Disconnect the inertia reel ballistic hose quick disconnect using the special key and flag assembly.

Attach the hoisting sling to the seat and overhead hoist. Using the hoist, apply upward pressure on the seat to prevent damage to the seat/rocket during removal of the trunnion bolt. Remove the trunnion bolt and ensure that all seat connections have been disconnected. Raise the seat with the hoist. As the seat reaches the top of the guide rails, prevent the yaw vane from deploying. Caution must be taken to prevent injury to maintenance personnel as the yaw vane is deployed by a 40-pound spring force. Continue raising the seat until the lower rollers on the seat clear the guide rails. After the yaw vane trip lever has passed the cam on the outboard guide rail, reset the yaw vane latch. Lower the seat and secure it to the ejection seat cradle.

CAUTION

Do not rest the seat on the STAPAC cover on the bottom of the seat.

The seat installation is essentiality a reversal of the removal procedures.

NOTE: The following text provides information for in-shop maintenance of the ESCAPAC lE-1 ejection seat.

Primary Ejection Control

Pull forward and down on the primary ejection control handle (face curtain handle) to

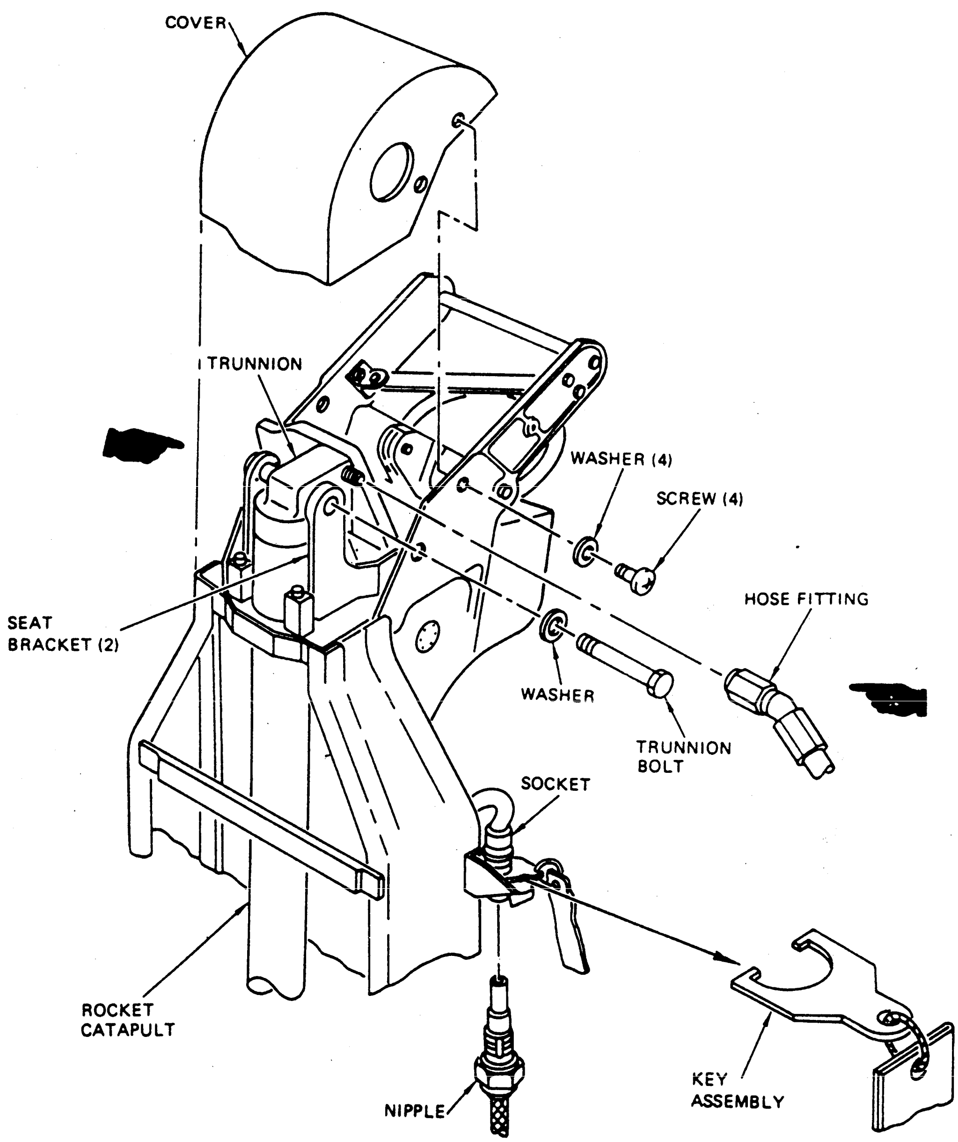


Figure 6-14.—Rocket catapult to seat connections.

disengage the handle plungers from their detent retainers. Reach behind the seat and move the firing control disconnect cable (fig. 6-15, callout A) sideways to unlock the firing control disconnect fitting. Continue to slowly pull on the face curtain until the cable ball ends pull free.

Inspect the screen assembly for damage or deterioration and that it has a valid expiration date, if applicable. Reinstall the face curtain.

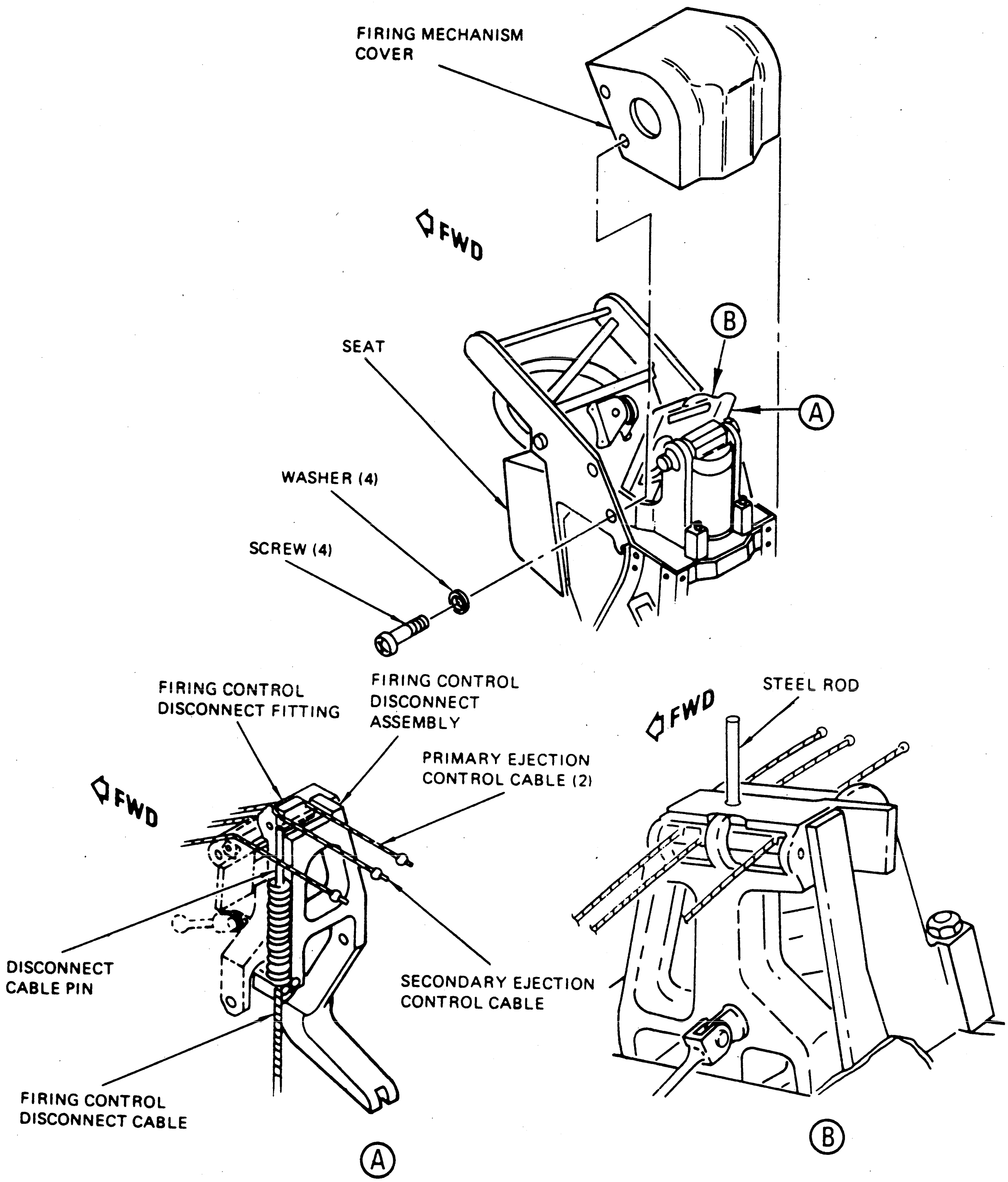


Figure 6-15.—Firing control disconnect fitting and pin.

Ensure that the face curtain screens convex surface is facing upward. Feed the two screen cables through their respective grommets in the back wall of the curtain stowage compartment. Fold the curtain into accordian pleats and stow in the compartment. Snap the screen handle plungers into their retainer detents, ensuring that there is no fabric lodged between the plungers and detents. Insert the screen cable ball ends into their respective slots in the firing control disconnect fitting. Ensure that the secondary ejection control cable ball end (center one) is installed in the disconnect fitting also. Rotate the top of the fitting aft until the fitting is reset. With the screen assembly pull test adapter and push-pull spring scale in place, perform the ejection controls pull test (fig. 6-16) on the face curtain by pulling forward and downward on the face curtain handle observing the force required to unseat the plungers from their retainers detents. The force must be 30 ± 10 pounds. Fold and restow the face curtain.

Secondary Ejection Control

Attach push-pull spring scale to the secondary ejection control handle and pull upward on the scale. A force of 25 ± 2 pounds is required to unseat the handle from the stowed detent position.

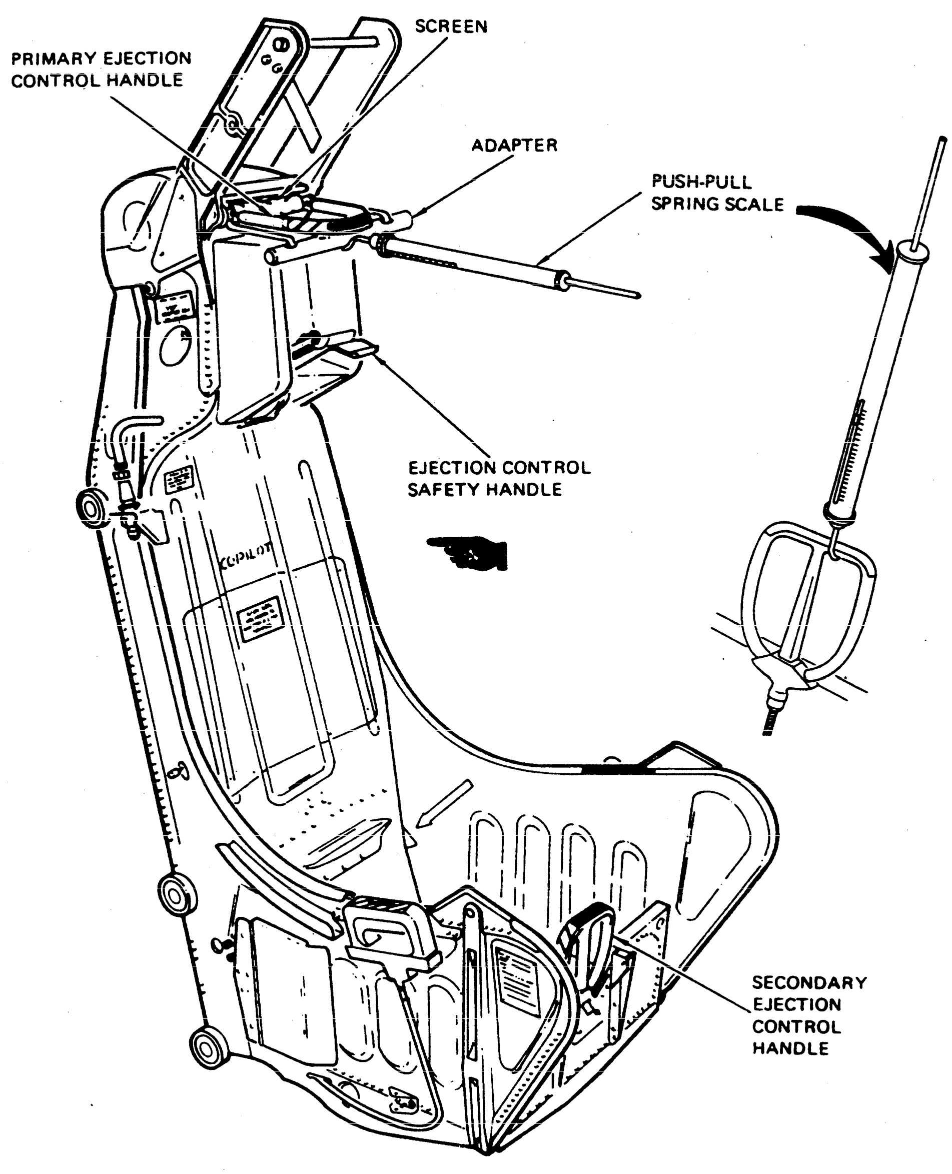


Figure 6-16.—Ejection control pull test.

Verify that the handle will extend not less than 0.75 inch from the handle stowed position. Remove the spring scale and restow the handle in the holder.

Power Inertia Reel

Place the inertia reel control lever in the unlocked position. Extend the inertia reel straps, ensuring that they extend and retract freely and that the inertia reel action is smooth. Inspect the straps for deterioration and fraying and replace as required. With the inertia reel control handle in the unlocked position, while extending the straps, accelerate the motion sharply to simulate 3 g's. If the inertia reel does not lock, it must be replaced.

Place the control lever in the locked position and allow the straps to retract into the reel. ensure that random pull checks during rewind allow no more than 2 inches of extension at any check.

Harness Release Actuator

With the blast shield removed from the rear of the seat, inspect the harness release actuator and attaching hardware for corrosion or damage. With the harness release piston in the fully extended position (fig. 6-17), measure from the bottom of the actuator housing to the clevis

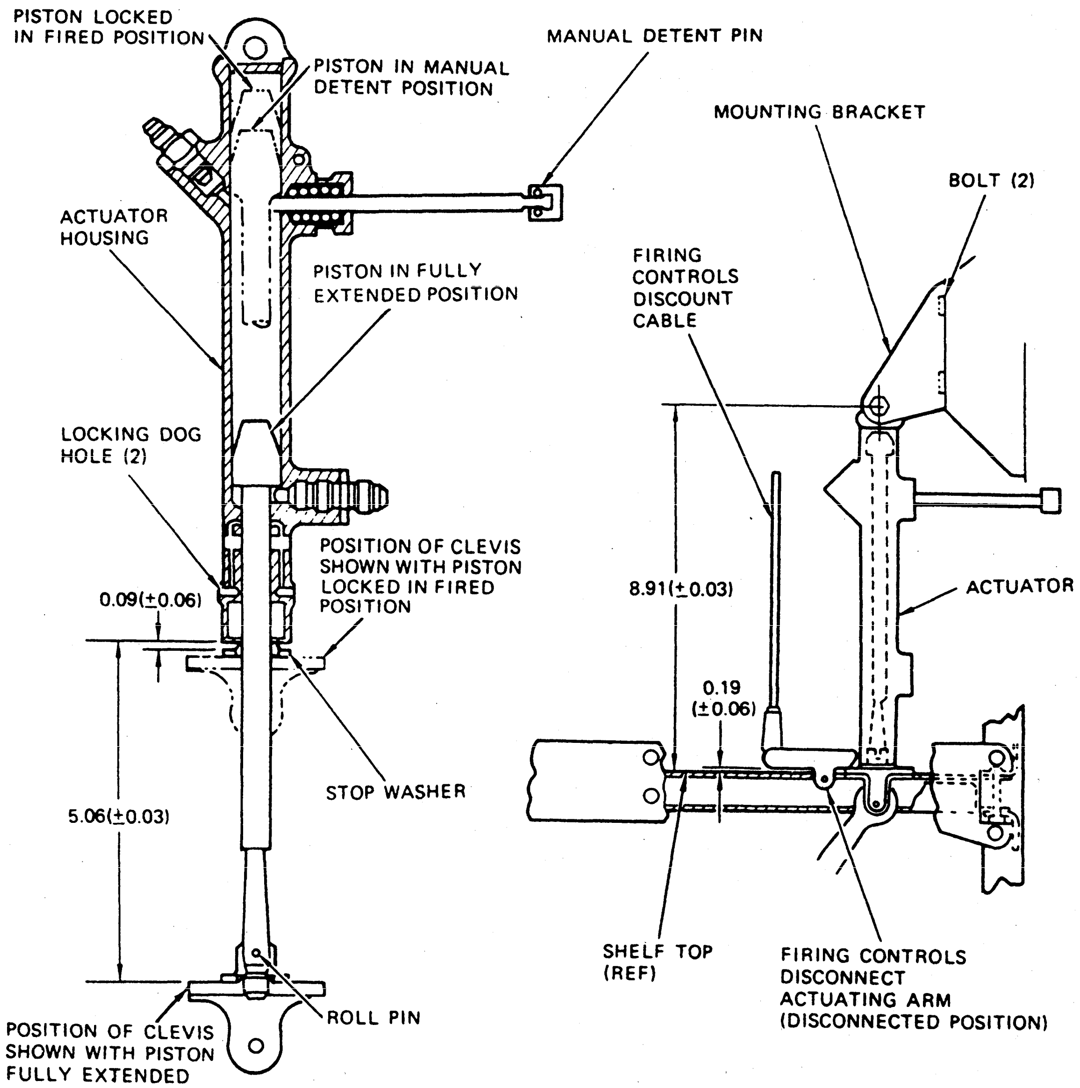


Figure 6-17.—Harness release actuator adjustment.

shoulder; it should be 5.06±0.03 inches. If not, remove the roll pin and adjust the clevis as required. With the piston in the fired position, verify the clearance between the bottom of the actuator housing and stop washer on top of the clevis is 0.09±0.06 inches. To release the piston from its fired position, with two 1/8-inch rods inserted into the locking dog holes, pry down on the two rods to spread the locking dogs and pull the piston out of the fired detent position.

Move the piston to the full down position by pulling out on the manual detent pin, and continue pulling downward on the piston. Ensure that there is a clearence of 0.19 ± 0.06 inch between the firing controls disconnect actuating arm and the shelf top with the harness release disconnect actuating arm in the disconnect position.

With a push-pull spring scale, pull slowly upward on the harness release handle until the manual detent pin engages the harness release acutator piston. The force required to lock the piston should not exceed 40 pounds. Remove the spring scale and continue pulling upward on the harness release handle, ensuring that the handle has a minimum of 0.125 inch of over travel from the manual detent position.

To check the firing control disconnect pin travel (fig. 6-15, callout B), insert a 1/8-inch diameter rod in the hole at the top of the firing control disconnect assembly. Mark an index line on the rod at the exact top of the hole in the firing control disconnect assembly. Pull upon the harness release handle (in overtravel position) and ensure that the rod does not exceed 3/16 inch of downward travel from its original up position. If travel exceeds 3/16 inch, adjust the lock pin to this tolerance. This test simulates firing control disconnect pin travel, and excessive travel could prevent seat ejection as a result of overtravel movement of the harness release handle. This causes unseating of the firing control disconnect fitting and release of the ejection control cables.

Reset the harness release handle into the holder and pull the manual detent pin to reset the harness actuator. Verify that the lap belt and shoulder harness retaining pins protrude through the seat structure a minimum of 0.06 inch, not including the tapered end of the pin.

EMERGENCY SURVIVAL EQUIPMENT

The emergency survival equipment (fig. 6-18) accompanies the crewman during ejection or ditching. It can sustain life, aid rescue during emergency conditions, and provide support and comfort to the crewmen during normal operation. The survival equipment consists of all equipment used after seat/man separation from the ejection seat.

Parachute NES-12E

The parachute is designed for use in rocket catapult ejection seats. The parachute is a backpack-type assembly that normally opens automatically, but it can be deployed manually by pulling the conventional rip cord D-ring. The parachute is connected to the RSSK-8A-1 survival kit by two nylon harness straps running from the bottom of the parachute to the back portion of the survival kit.

Survival Kit RSSK-8A-1

The survival kit is connected to the ejection seat by lugs on the back of the survival kit, which engage detents in the survival kit lug retaining pins. The retaining pins are integral parts of the harness-release bell crank assembly.

The survival kit is a two-piece fiber glass container with top and bottom sections. A foam pad cushion is positioned on top of the kit to provide comfort for the crew member. A manual kit-release handle on the right side of the kit provides for separation of the two survival kit halves and release of the survival gear. The top half contains the emergency oxygen bottle, which is automatically actuated by a cable attached to the aircraft structure as the ejection seat moves up the guide rails during the ejection sequence. The oxygen bottle is normally used for high-altitude ejections, but it can be manually actuated, if the normal oxygen supply fails, by pulling the emergency oxygen lanyard located on the inboard side of the front thigh support of the survival kit. The bottom half of the kit contains a life raft, a radio transmitter (if installed), and a survival kit bag. The life raft is folded and stowed in the front section of the kit. A self-contained pneumatic bottle automatically inflates the raft upon separation from the kit. A battery-operated radio transmitter is automatically switched on during the ejection sequence by an aircraft-attached lanyard. The survival kit bag is a zippered bag stowed next to the life raft. The bag contains dye markers, seawater desalter, sponge, two escape and evasion kits, rations, sunburn ointment, signal distress flares, signal mirror,

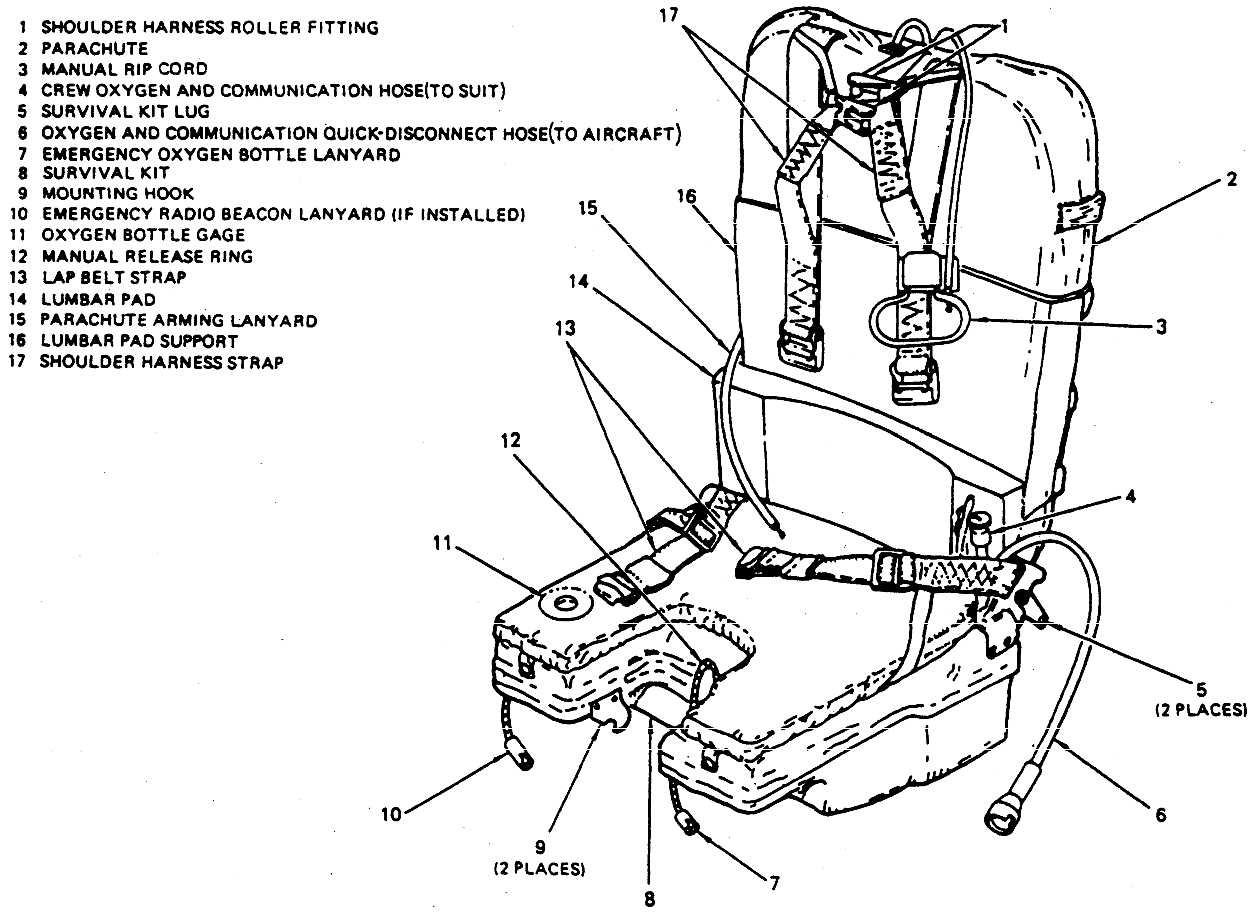


Figure 6-18.—Survival kit and parachute removed.

emergency code card, water storage bag, a 50-foot nylon cord, and shark repellent.

Operation

As the seat moves up the guide rails during seat ejection, the aircraft-attached emergency oxygen lanyard is pulled automatically to actuate a supply of emergency oxygen. In the event of high-altitude ejection, the emergency oxygen provides protection against blackout while the crew member is descending to a safe altitude. By pulling the manual kit-release handle on the right side of the kit, the crew member may deploy the kit during parachute descent. Upon deployment of the kit, the top and bottom halves separate; both halves are still connected to the crew member by a retaining lanyard. The survival kit gear remains with the bottom half of the container (stowed in a zippered bag), while the life raft separates from the container. A self-contained pneumatic bottle automatically inflates the life raft, which remains attached to the crew member by means of the retaining lanyard.

Parachute deployment occurs following the crew member/seat separation phase of normal seat ejection. If the crew member is above a preset pressure altitude of 14,000 (± 500) feet, an aneroid in the parachute barometric actuator delays parachute deployment until the crew member has descended to the correct pressure altitude. The parachute actuator delay cartridge then fires, causing parachute deployment. The parachute also can be deployed manually by pulling a conventional D-ring rip cord.

CARTRIDGES AND CARTRIDGE-ACTUATED DEVICES (CADs)

The types of explosive devices incorporated in egress systems are varied. The AME working with these devices must know how they function, their characteristics, how to identify them, their service-life limitations, and all safety precautions. The AME who understands the importance of all of these factors and who correctly uses the maintenance manuals is better equipped to supervise and train others. Always refer to the manual, *Cartridges and Cartridge-Activated Devices* (NAVAIR 11-100-1). The manual contains cartridge information and safety precautions for handling explosives.

Initiators

As previously discussed, initiators, such as the M99, start an action. Initiators are explosive devices, and no maintenance is allowed on explosive devices. When installing explosive devices or during aircraft inspections, initiators will be verified for expiration, and if newly installed they will be marked with an approved marking medium with all the information required by the cartridge manual, NAVAIR 11-100-1.

Delay initiators serve the same function as initiators, but they have a built-in delay charge to allow another function to be performed before they fire. An example would be a 0.5-second delay initiator installed in the line to the rocket motor of the forward seat in a two-place aircraft. This would allow the rear seat to clear the aircraft first by delaying the firing of the forward seat ejection rocket for 0.5 second.

Detonating Cord

Detonating cord is installed between different components of an ejection system, taking the place of pneumatic gas lines. The detonating cord is a stainless steel tubing filled with an explosive, and is more reliable and much faster than comparable pneumatic gas systems. The system is also safer from the standpoint of inadvertent actuation due to the extremely high initiating velocities, and pressures, as previously discussed.

Rocket Catapult

The rocket catapult, MK 16 MOD 1, used in the S-3 aircraft is rated as a class B explosive. The MK 16 MOD 1 is a self-contained, gas-initiated, two-phase, solid-propellant booster and rocket. The rocket catapult consists of two gas-initiated firing mechanisms, a solid-propellant booster assembly, a rocket launching tube, a gas-initiated rocket igniter, a solid-propellant rocket motor, and an output cartridge for actuation of other gas initiated escape devices.

Each firing mechanism consists of one firing pin (shear pinned in place) mounted inside a special fitting that combines the inlet port and firing mechanism housing. Two inlet port/firing mechanism housings are threaded into each base cartridge assembly.

The catapult tube assembly consists, primarily, of a cartridge assembly, lock, unlock sleeve, unlock piston, unlock spring, outer housing, motor lock disk, mounting bracket, and front body housing.

The rocket motor assembly consists, primarily, of a steel motor tube with canted nozzle assembly and a tungsten insert, a solid-propellant grain, an ignition charge, an output cartridge assembly, and a seat mounting lug to facilitate attachment to the aircraft ejection seat.

FUNCTION.— When the aircrewman pulls the face-curtain ejection handle or the alternate ejection handle or when the sequential ejection system is actuated, an external initiator begins the catapult operation by forcing gas through the inlet fitting(s) into the cartridge assembly of the rocket catapult. This gas pressure provides the force necessary to shear the pins that hold the rocket catapult firing pins in place. The firing pins then develop the energy necessary to fire the percussion primers in the cartridge assembly. The percussion primer then fires the ignition material within the cartridge assembly, which, in turn, ignites the booster cartridge. The piston unlock ring then moves downward, compressing the unlock spring and releases the lower tangs of the lock assembly.

After the lower tangs of the lock assembly have been released, movement of the rocket motor assembly begins. As gas from the main cartridge charge expands and drives the assembly up the catapult tube, the nozzle is kept sealed by the motor lock disk. Near the end of the catapult stroke, the motion of the unlock sleeve is stopped by interference with the front body housing, and the shear pins between the unlock sleeve and the rocket motor assembly are sheared. At this point, the rocket motor has achieved a velocity of approximately 50 feet. per second. When the rocket motor has traveled another

0.9 inch (approximately), the shoulder on the lock strikes the immobilized unlock sleeve and stops. This action releases the upper tangs of the lock and unseals the rocket motor nozzle by severing the nozzle plug and retaining the motor lock disk.

The hot, pressurized gases from the cartridge then pass into the rocket motor assembly through the nozzle. These gases energize the rocket motor firing mechanism, which ignites the rocket ignition material. The rocket ignition material and/or the hot gases from the booster cartridge ignite the rocket motor solid-propellant grain. The rocket motor then provides additional thrust to the aircrewman seat after separation of the booster and rocket sections.

The rocket motor internal pressure energizes two output cartridge firing mechanisms that fire the output cartridge. The output cartridge then actuates other escape devices, which are attached to the output fitting.

INSPECTION OF THE ROCKET CATAPULT.— The rocket catapult must be inspected whenever it is removed from the shipping container for use and prior to returning it to stowage. If the rocket catapult is found in a hazardous condition, explosive ordinance disposal (EOD) personnel must be immediately notified. After the rocket catapult is rendered safe, or if it is rejected for any other reason, it must be disposed of in accordance with NAVAIR 11-85-1.

Inspect the rocket catapult for damage, such as dents and corrosion; reject the unit if it has any visible defects. Inspect the head end cap for tightness by grasping the cross-shaped head end trunnion (word AFT stamped on face) with one hand and attempt to tighten the head end cap with the other. If any cap motion is detected, do not reject the unit but repair it in the following manner.

Back off head end cap until the U-shaped slot in the rocket motor tube is exposed. Inspect to see if the head end trunnion pin is completely contained within the U-shaped slot. If the entire pin is not visible within the slot, reject the unit.

NOTE: Pin is not necessarily bottomed in the slot.

If unit passes inspection, apply Locktite (grade N) to exposed thread area, hand tighten cap, and then tighten with strap wrench. Inspect the adjustment ring for tightness by grasping the cross-shaped head end trunnion (word AFT stamped on face) with one hand and attempt to tighten the adjustment ring with the other. If more than a few degrees of side-to-side play is evident in adjustment rings with six holes (two configurations of adjustment rings are in service—one with six holes and one without holes), reject the unit. If the adjustment ring without holes is found to be loose, do not reject the unit but repair it in the following manner.

Back off the adjustment ring until it contacts the head end cap, and apply Locktite sealant (grade N) to the exposed, degreased thread area. Ensure that the front body housing is tightened down against the catapult tube prior to hand tightening the adjustment ring against the front body housing. Allow Loctite sealant to set. Reinspect prior to use.

MARTIN-BAKER SJU-5/A EJECTION SEAT

Learning Objective: Recognize the components, seat system/subsystems, support components, system operations, component test and test equipment, and corrosion control procedures for the Martin-Baker SJU-5/A ejection seat.

The SJU-5/A ejection seat is a ballistic catapult and rocket system that gives the pilot a quick and safe means of escape from an aircraft. The seat system includes an initiation system that jettisons the canopy, positions the pilot for ejection, and fires the seat catapult. Canopy breakers on the top of the seat allow the seat capability to eject through the canopy should it fail to jettison.

As the seat ejects from the aircraft, a rocket motor on the bottom of the seat is fired. Then a drogue gun is fired to deploy two drogue parachutes. These parachutes either remain attached to the top of the seat or they are released to deploy the main parachute, depending upon the altitude and the number of g's applied to the seat. An automatic time-release mechanism opens the main parachute container and releases the drogue parachutes that deploy the main parachute.

SYSTEM OPERATION

Before flight, the ejection seat safe/arm handle is kept in the SAFE position. In this position, the visible portion of the handle is colored white and placarded as SAFE. When the aircraft is ready for flight, the pilot sets the safe and arm handle to the ARMED position. In this position, the visible portion of the handle is colored with yellow and black markings and placarded as ARMED.

The ejection sequence (fig. 6-19) starts when the pilot pulls the ejection control handle. The upward movement of the handle removes two sears from the seat initiator and fires two cartridges with the seat initiator.

Firing Sequence

Ballistic gas generated by the right cartridge within the seat initiator actuates the pin puller. The gas also activates the shielded mild detonating cord (SMDC) initiator. The SMDC then activates the aircraft identification friend or foe unit (IFF) and the canopy jettison system. Additionally, it activates the inertia reel cartridge and the 0.3-second delay initiator. Ballistic gas generated by the left cartridge within the seat initiator starts the 0.3-second delay initiator. Ballistic gas pressure from either 0.3-second delay initiators ignites the primary cartridge within the catapult.

Catapult Firing and Initial Seat Movement

Ballistic gas pressure developed by the catapult primary cartridge causes the inner and intermediate barrels within the catapult to rise and release the top latch mechanism. The secondary cartridges within the catapult fire progressively as the rising barrels are exposed to the heat and pressure of the primary cartridge gas. Progressive firing of the catapult secondary cartridges provides a relatively even gas pressure during catapult extension. This eliminates excessive g-forces during ejection.

As the seat moves upward, the emergency oxygen system is activated. A trip rod withdraws the firing link from the drogue gun and starts a 0.5-second internal timer. Another trip rod withdraws the firing link from the time-release mechanism. Aircraft electrical power and personal services (oxygen and communication) between the seat and the aircraft are disconnected.

At this point in the sequence, the leg restraint lines are drawn through the snubbing units to restrain the pilot's legs to the seat bucket. When the leg restraint lines become taut, the upper portion of the leg restraint line shears from the lower portion, which is attached to the floor bracket. Forward movement of the lines is prevented by the snubbing units.

After 72 inches of catapult extension, the rocket motor initiator is fired by a cable that is attached to the drogue gun trip rod. Ballistic gas pressure generated by the cartridge within the rocket motor initiator is routed to a pressure actuated firing mechanism located on the rocket motor. Flame and pressure ignite the rocket motor propellant grain. The thrust of the motor is approximately 4,500 pounds and lasts for 0.25 second.

Aircraft and Seat Separation

Separation of the seat from the aircraft occurs at approximately 76 inches of catapult extension. At this point, the inner barrel separates from the intermediate barrel. The seat is now clear of the aircraft.

The drogue gun primary cartridge fires after a 0.5-second delay to propel the piston from the drogue gun barrel. The inertia of the piston extracts the parachute flap closure pin and deploys the 22-inch controller drogue. The controller drogue, in turn, deploys the 60-inch stabilization and retardation drogue. The 0.5-second time delay allows the seat to reach its maximum altitude before the drogues are fully developed. The seat will stabilize and decelerate because of the drogues, which are held to the seat by the scissor mechanism.

If the drogue gun primary cartridge fails to fire, ballistic gas pressure will pass to the drogue gun when the time-release mechanism (TRM) fires. This gas shears the firing pin retaining pin. The firing pin then strikes the secondary drogue gun cartridge, which results in drogue deployment. Should both the drogue gun primary and time-release mechanism cartridges fail to fire, operation of the manual override handle will fire

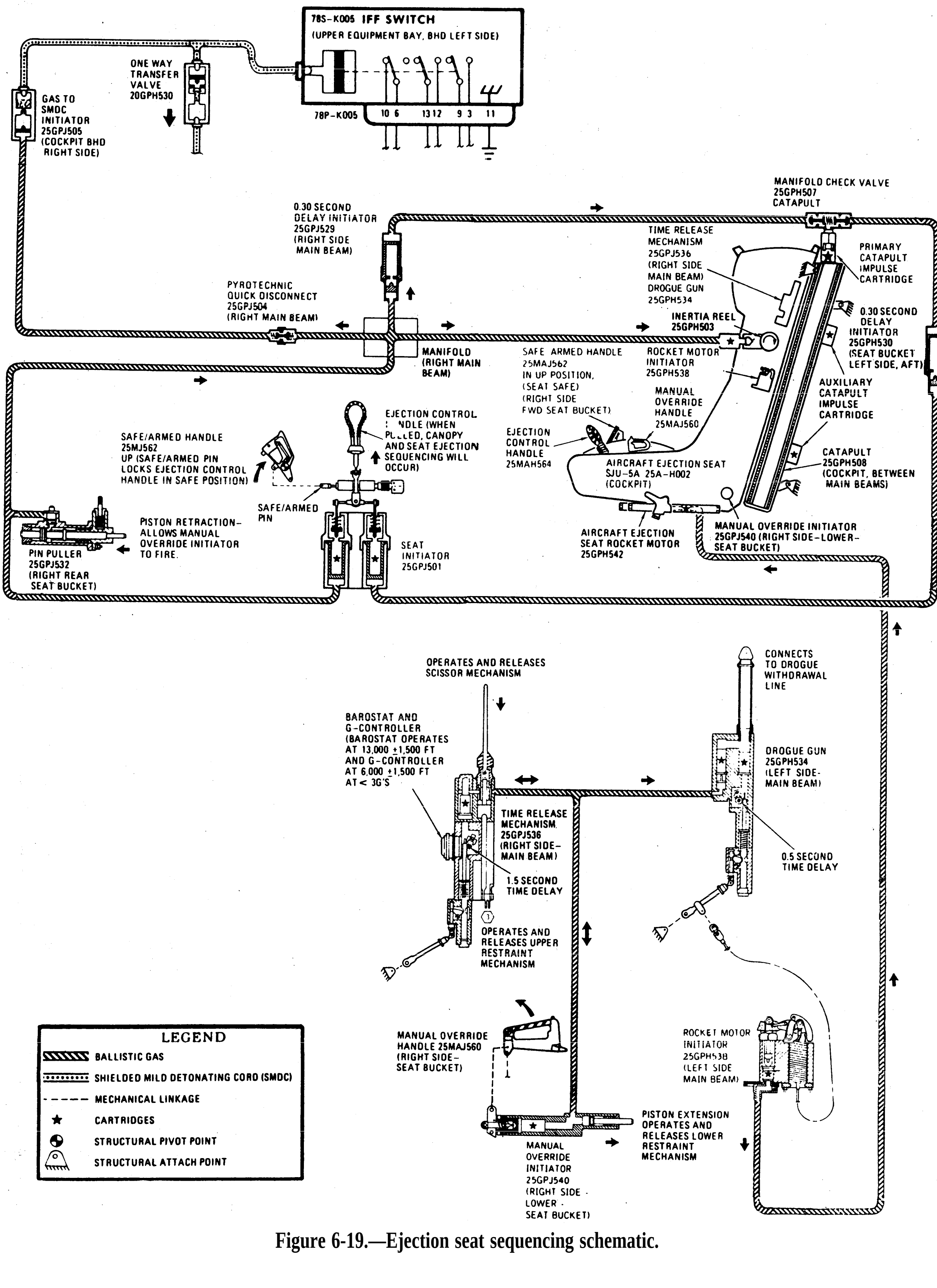


Figure 6-19.—Ejection seat sequencing schematic.

the manual override initiator cartridge. This duplicates the function of the TRM and fires the drogue gun secondary cartridge. The drogue gun then deploys the drogue parachutes and personnel parachute concurrently.

The TRM altitude-sensing barostatic time release prevents the 1.5-second timer from starting at altitudes above 11,500 feet. The barostatic time release ensures that the pilot descends rapidly through the upper atmosphere to a more survivable altitude. At altitudes between 7,500 and 11,500 feet, the time delay for deployment of the personnel parachute is controlled by an internal g-limiter, which interrupts the timing sequence until the deceleration force is less than 1.5 g's. This results in lower parachute opening loads. At altitudes below 7,500 feet, the 1.5-second timer starts without interruption.

After the 1.5-second timer delay, the TRM cartridge fires. This releases the upper restraint mechanism, lower restraint mechanism, parachute mechanical lock, and drogue shackle. When the drogue is free from the scissor mechanism, it deploys the personnel parachute. The personnel parachute lifts the pilot and the survival kit from the seat and pulls the sticker-clip strap lugs from their clips. This is necessary to ensure that collision between the seat and the pilot is avoided. The radio beacon activates when pilot and seat separation occurs. Then a normal parachute descent begins.

While descending in the parachute, the pilot can pull the survival kit handle to separate the kit halves. This allows deployment and automatic inflation of the life raft. The life raft and survival kit items are connected by a lanyard to the survival kit lid, which is attached to the pilot.

SYSTEM COMPONENTS

The SJU-5/A ejection seat system (fig. 6-20) provides support for the pilot during normal flight conditions and a method of escape from the aircraft during emergency conditions. Selected seat system components are discussed in the following paragraphs and keyed to figure 6-20.

Catapult

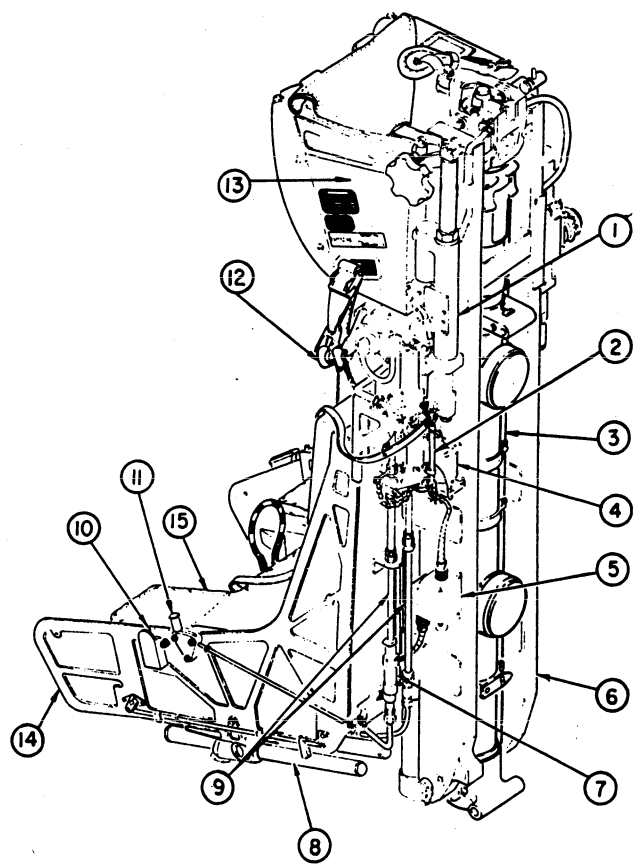
The catapult (3) is a cartridge-actuated device that provides the initial force required to eject the seat from the aircraft. The catapult is located within the main beam assembly (6) and is attached to the bulkhead of the cockpit by two mounting lugs. The ejection seat is installed on the catapult with three pairs of slippers located on the inboard side of the main beam assembly. The main beam assembly fits into catapult guide rails located on the outboard sides of the catapult's outer barrel. The ejection seat is locked to the catapult by the top latch mechanism. The catapult consists of three major parts: the inner barrel, the intermediate barrel, and the outer barrel.

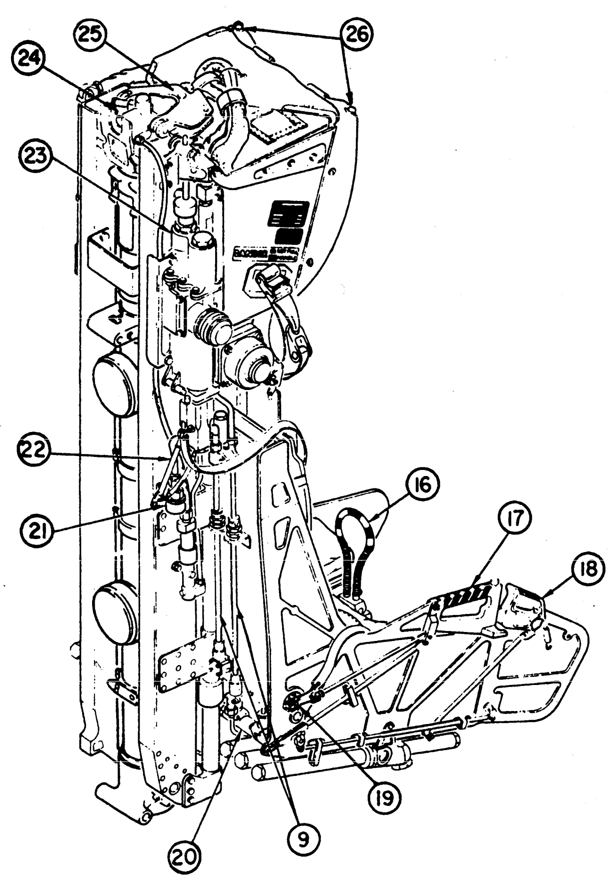
INNER BARREL.— A neck-shaped piston head, fitted with a set of expander and piston rings, is attached to the lower end of the inner barrel to provide a gas seal with the intermediate barrel. A breech is located at the upper end of the inner barrel for the primary firing mechanism and cartridge. The breech has a groove on the outside edge into which the plunger of the top latch mechanism of the ejection seat is engaged.

INTERMEDIATE BARREL.— The intermediate barrel is located between the inner barrel and the outer barrel. The intermediate barrel increases the length of catapult extension. It also restrains bending loads incurred during ejection. A piston head fitted with two sets of six expander and piston rings is attached to the lower end. The piston head serves as a gas seal between the intermediate barrel and the outer barrel. A guide bushing is riveted to the upper end of the intermediate barrel to keep the inner barrel steady during extension. The guide bushing rivets are sheared by the neck-shaped piston head of the inner barrel during ejection. This allows separation of the inner and intermediate barrels. Twelve pressure rings are installed on the intermediate barrel to absorb the inertia forces encountered during barrel separation.

OUTER BARREL.— The outer barrel houses the intermediate and inner barrel assemblies. Two breeches are located on the aft side to accept the auxiliary cartridges. Two guide rails are bolted on the outboard sides of the outer barrel. The lower end is used to attach the catapult to the aircraft. The upper end has a square aperture to engage the plunger of the top latch mechanism. The upper fitting is threaded for the guide bushing that retains the intermediate barrel. The guide bushing is locked in place by a dowel screw.

1. Drogue gun
2. Drogue gun trip rod
3. Catapult
4. Rocket motor initiator
5. Electrical connector housing
6. Main beam assembly
7. 0.30-second delay initiator
8. Rocket motor
9. Trombone fittings
10. Seat height adjustment switch
11. Shoulder harness control handle
12. Inertia reel assembly
13. Parachute container
14. Seat bucket
15. SKU-3/A seat kit





16. Ejection control handle
17. Manual override handle
18. Safe/Arm handle
19. Manual override initiator
20. Pin puller
21. Pyrotechnic quick disconnect
22. Time-release mechanism trip rod
23. Time-release mechanism
24. Manifold check valve
25. Scissor mechanism
26. Canopy breakers

Figure 6-20.—Martin-Baker SJU-5/A ejection seat.

Manifold Check Valve

The manifold check valve (24) (figs. 6-20 and 6-21) provides an interface between the ejection seat and the catapult. The manifold check valve is mounted to the top of the catapult. The valve is held against the primary firing mechanism by a spring-loaded plunger and a retaining pin. The valve contains two inlet ports, which connect the hoses from the 0.30- and 0.30/0.75-second delay initiators. Internal check valves ensure that 400 to 600 psi gas pressure is maintained at the catapult primary firing mechanism.

Main Beam Assembly

The main beam assembly (6) (fig. 6-20) is the main structure of the ejection seat. The main beam assembly consists of left and right vertical beams bridged by three cross members. The assembly supports the major components of the ejection seat. Three slippers are bolted to the inboard side of each beam to engage the guide rails on the catapult outer barrel. The upper cross member is used to hold and correctly position the top of the catapult. This member withstands the full thrust of the catapult during the ejection sequence. The bolts that attach the upper cross member to the main beam assembly also attach the top latch mechanism to the left beam. The inertia reel (12) and the upper attachment for the seat height actuator are mounted to the center cross member. Two tabular tubes are secured to the center and lower cross members. The tubes have two sliding runners that attach to the seat

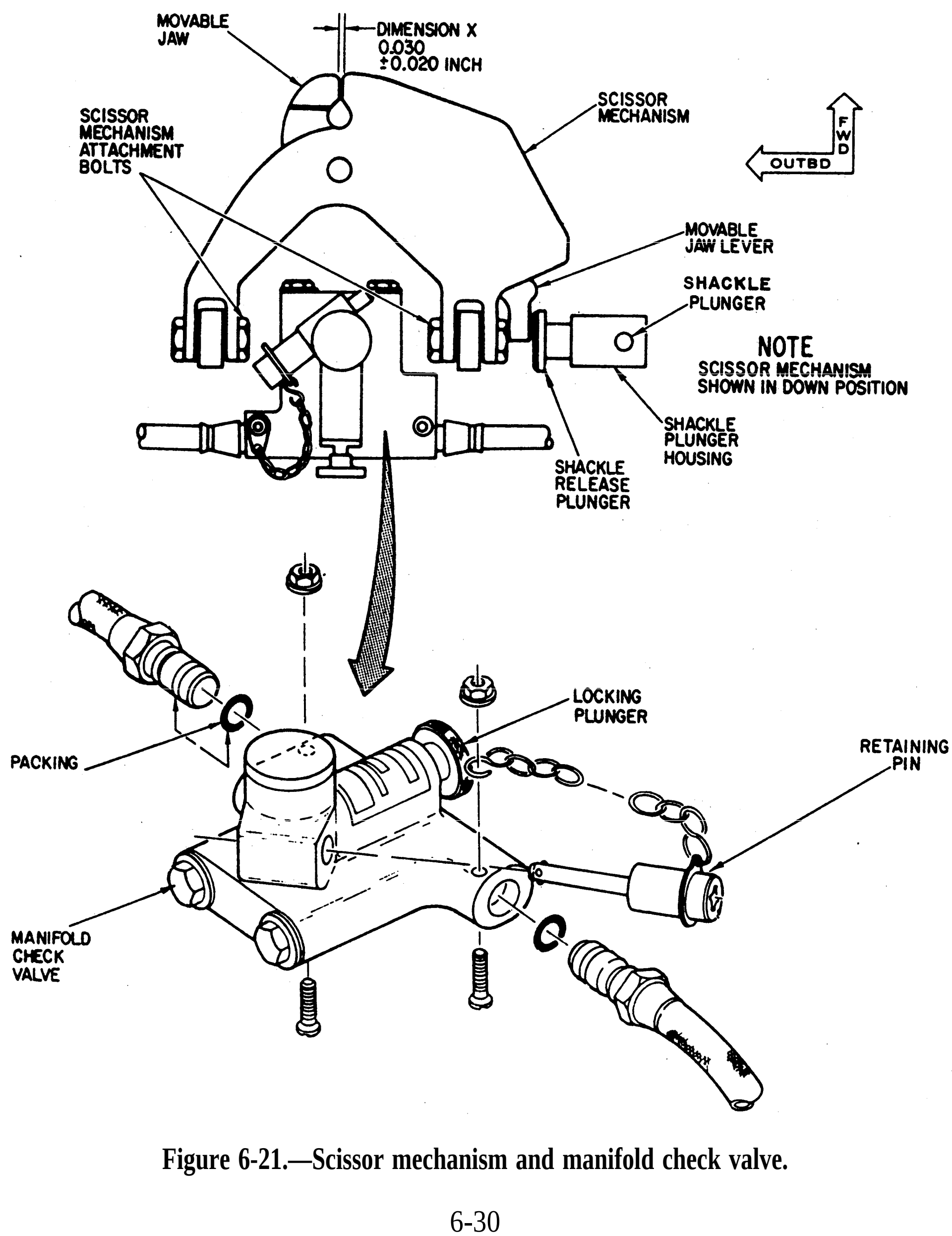


Figure 6-21.—Scissor mechanism and manifold check valve.

bucket. The seat height actuator rod is attached to the lower sliding runner. The components attached to the main beam assembly are discussed in the following paragraphs.

TOP LATCH MECHANISM.— The main beam assembly is secured to the catapult by the top latch mechanism, which is located on the upper end of the left beam. The mechanism consists of a housing with a spring-loaded plunger. The inboard end of the plunger is shaped to engage the catapult inner barrel. The outboard end is threaded to accept the top latch handwheel. When the handwheel is installed, it permits removal of the ejection seat from the catapult.

SCISSOR MECHANISM.— The scissor mechanism (25) (fig. 6-20) (also shown in fig. 6-21) is located on top of the main beam assembly upper cross member. It retains the drogue parachutes after they are deployed and prevents deployment of the personnel parachute until a safe altitude and g-force is reached. The scissor mechanism has a moveable jaw, which is held in the closed position by the shackle plunger of the upper body of the time-release mechanism.

TIME-RELEASE MECHANISM.— The time-release mechanism (TRM) (23) (fig. 6-20) (also shown in fig. 6-22) is mounted on the outboard side of the right beam. The TRM automatically releases the drogue parachutes, deploys the personnel parachute, and releases the pilot from the ejection seat at the proper time in the ejection sequence.

The TRM consists of a time-delay mechanism, barostat assembly, barostatic g-controller, spring-loaded firing mechanism, connecting rod,

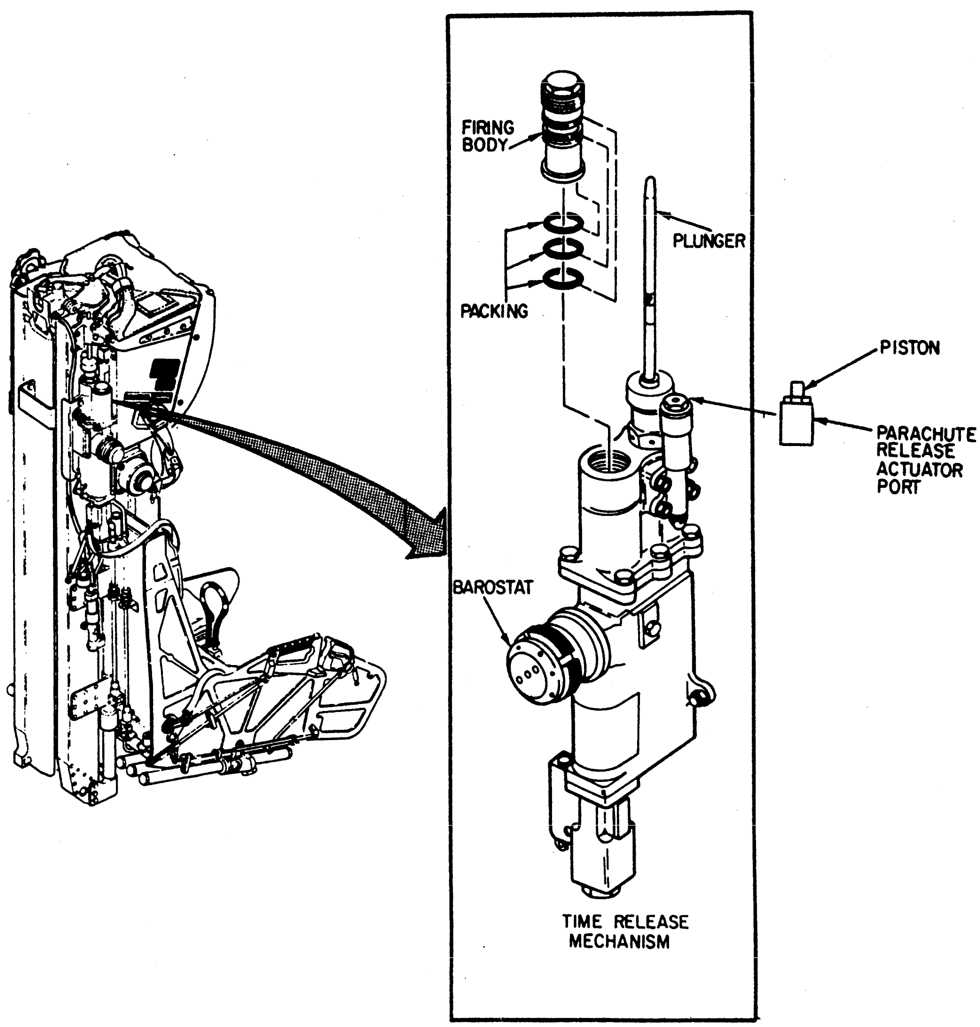


Figure 6-22.—Time-release mechanism.

cartridge, and a shackle plunger assembly. The shackle plunger is secured in the scissor shackle plunger housing to lock the scissor mechanism in the closed position, as shown in figure 6-21. In this position, the drogue shackle is secured to the ejection seat. Gas lines connect the TRM to the manual override initiator and to the secondarys cartridge of the drogue gun. A piston located on top of the upper body engages the parachute mechanical lock to secure the personnel parachute.

The TRM 1.5-second time-delay mechanism delays seat/man separation and deployment of the personnel parachute until the drogue parachutes stabilize and decelerate the ejection seat. The barostat assembly delays the deployment of the personnel parachute until the pilot and the ejection seat descend to 14,500 feet. This delay prevents prolonged descent in the upper atmosphere. When ejection occurs above 7,500 feet, a barostat g-controller delays the deployment of the personnel parachute until deceleration loads are less than 3 g's.

DROGUE GUN.— The drogue gun (1) (fig. 6-20) (also shown in fig. 6-26) is mounted on the outboard side of the left beam. The drogue gun deploys the drogue parachutes during the ejection sequence. The drogue gun incorporates a 0.5-second delay to ensure that the ejection seat has cleared the cockpit prior to deploying the drogue parachutes. The gun consists of a body and a barrel assembly.

The drogue gun body contains a time-delay mechanism, a spring-loaded firing pin, and two cartridges (primary and secondary). The barrel assembly contains a piston that is held in place by a shear pin. The barrel holds the primary cartridge and water seal. The primary cartridge is mechanically fired by a trip rod attached to the cockpit bulkhead.

A chamber connected by a gas passage to the barrel holds the secondary cartridge and a gas-operated firing mechanism. This chamber ensures that actuation of either cartridge will fire the piston from the barrel.

INERTIA REEL ASSEMBLY.— The inertia reel (12) (fig. 6-20) is mounted on the center cross member of the main beam assembly. During normal operation in the UNLOCK position, the inertia reel is free to extend or retract as required by the pilot's movements, but an automatic lock feature will prevent rapid forward movement. When the rapid movement ceases, the inertia reel returns to normal operation. When the inertia reel is in the LOCKED position, it will retract the straps but will not allow them to extend. When the ejection sequence is initiated, a pyrotechnic cartridge is used to activate the inertia reel. This retracts and locks the pilot into the correct position for ejection.

ROCKET MOTOR INITIATOR.— The rocket motor initiator (4) (fig. 6-20) is mounted on the outboard side of the left beam. The rocket motor initiator consists of a cartridge chamber, a firing mechanism, and a coiled static line. The chamber is attached to the trombone fittings (9) by an outlet connector. The static line is coiled into a plastic container. The upper end of the line is attached to the quadrant lever and the lower. end is attached to the drogue gun trip rod.

SEAT HEIGHT ACTUATOR.— The seat height actuator is mounted in the main beam assembly forward of the catapult gun. The actuator permits adjustment of the seat bucket within a vertical travel of approximately 5 inches. The seat height actuator consists of an electric motor and housing, gearbox, bearing housing, and jackscrew assembly.

AIRCRAFT SEAT PARACHUTE.— The aircraft seat parachute container (13) (fig. 6-20) is located near the top of the main beam assembly. The parachute consists of a 22-inch controller drogue, a 5-foot stabilizing main drogue, and a 17-foot personnel parachute. The controller drogue deploys the -stabilizing drogue that decelerates and stabilizes the ejection seat during the initial phase of the ejection sequence. The personnel parachute provides the pilot with a safe means of descent. The parachute container provides support for the pilot's head during forward acceleration or wind blast.

The personnel parachute is packed in the container first. It is secured by flaps and a closure pin that is attached to the personnel parachute withdrawal line. The withdrawal line attaches the main drogue to the apex of the personnel parachute. Then the main and controller drogues are packed. They are secured by four flaps and a closure pin, which is attached to the drogue withdrawal line. The drogue shackle secures the parachute withdrawal line and extender strap. Then the drogue shackle is secured in the scissor mechanism.

Seat Bucket

The seat bucket (14) (fig. 6-20) is mounted on the lower forward side of the main beam assembly. It is attached to studs on the seat bucket runners. The components described in the following paragraphs are related to the seat bucket.

EJECTION CONTROL HANDLE.— The ejection control handle (16) is located on the front of the seat pan. It is the only means by which ejection can be initiated. The handle is molded in the shape of a loop and is connected to the sears of the ejection seat initiators. The seat initiators have two rigid lines that connect to the trombone fittings. An upward pull of the loop removes both sears from the dual initiators to initiate ejection. Either initiator can fire the seat. After ejection, the handle remains attached to the seat. The ejection control handle is safetied by using the ejection seat safe/arm handle and safety pin.

EJECTION SEAT SAFE/ARM HANDLE.— To prevent inadvertent seat ejection, an ejection seat safe/arm handle (18) is installed. To safety the seat, you must rotate the handle up and forward. To arm the seat, you rotate the handle down and aft. When in the ARMED position, the portion of the handle that is visible to the pilot is colored yellow and black with the word ARMED showing. In the SAFE position, the visible portion of the handle is colored white with the word SAFE showing. By placing the handle to the SAFE position, it causes a pinto be inserted into the ejection firing mechanism. This prevents withdrawal of the sears from the dual seat initiators.

SHOULDER HARNESS CONTROL HANDLE.— The shoulder harness control handle (11) and seat height adjustment switch (10) are mounted on the left side of the seat bucket. The shoulder harness control handle is connected to the inertia reel. The seat height adjustment switch controls electrical power to the seat height actuator motor.

MANUAL OVERRIDE HANDLE.— The manual override handle (17) is located on the right side of the seat bucket. The handle is connected to the lower restraint mechanism. It is also connected to the manual override initiator.

MANUAL OVERRIDE INITIATOR.— The manual override initiator (19) is mounted in a covered compartment in the lower aft right side of the seat bucket. A linkage connects the sear to the manual override handle. Pulling the handle releases the lower restraints. Full upward movement of the handle is prevented by the pin puller. However, during ejection, the pin puller is automatically retracted. This allows the manual override handle to pull the sear from the manual override initiator, which will override the automatic sequencing. This is accomplished by routing gas pressure to the time-release mechanism and the secondary cartridge of the drogue gun.

PIN PULLER.— The pin puller (20) (fig. 6-20) (also shown in fig. 6-23) is located on the aft right side of the seat bucket. Full aft rotation of the manual override handle is prevented by the pin puller. A pin extended from the pin puller engages a slot in the manual override linkage. During the ejection sequence, gas pressure from the right seat initiator cartridge retracts the pin.

ROCKET MOTOR.— The rocket motor (8) is attached to the bottom of the seat bucket. A rigid line from the rocket motor firing mechanism is connected to the inboard trombone fitting on the aft left side of the seat bucket. The trombone fitting interfaces with the rocket motor initiator, which is located on the main beam assembly.

The rocket motor consists of a firing mechanism, igniter cartridge., manifold, four nozzles, and 17 propellant tubes. Gas pressure from the rocket motor initiator forces the firing mechanism into the igniter cartridge. The rocket motor ignites as the catapult nears the end of its extension and raises the ejection seat to a height sufficient for a safe ejection, even if the aircraft has zero speed and zero altitude. The rocket motor produces approximately 4,500 pounds of thrust for 0.25 second. The nozzles on the seat are positioned forward and outward. This positioning allows the thrust to pass close to the center of gravity of the ejection seat and pilot.

SEAT SURVIVAL KIT.— The SKU-3/A seat survival kit (fig. 6-24) consists of a two-piece bonded fiber glass container and a seat cushion. The kit is located in the seat bucket and functions as a seating platform for the pilot. The survival kit contains the torso harness attachments, locking system, retaining lanyard, survival equipment, radio beacon, and emergency oxygen. A bracket for insertion of the negative-g strap is mounted

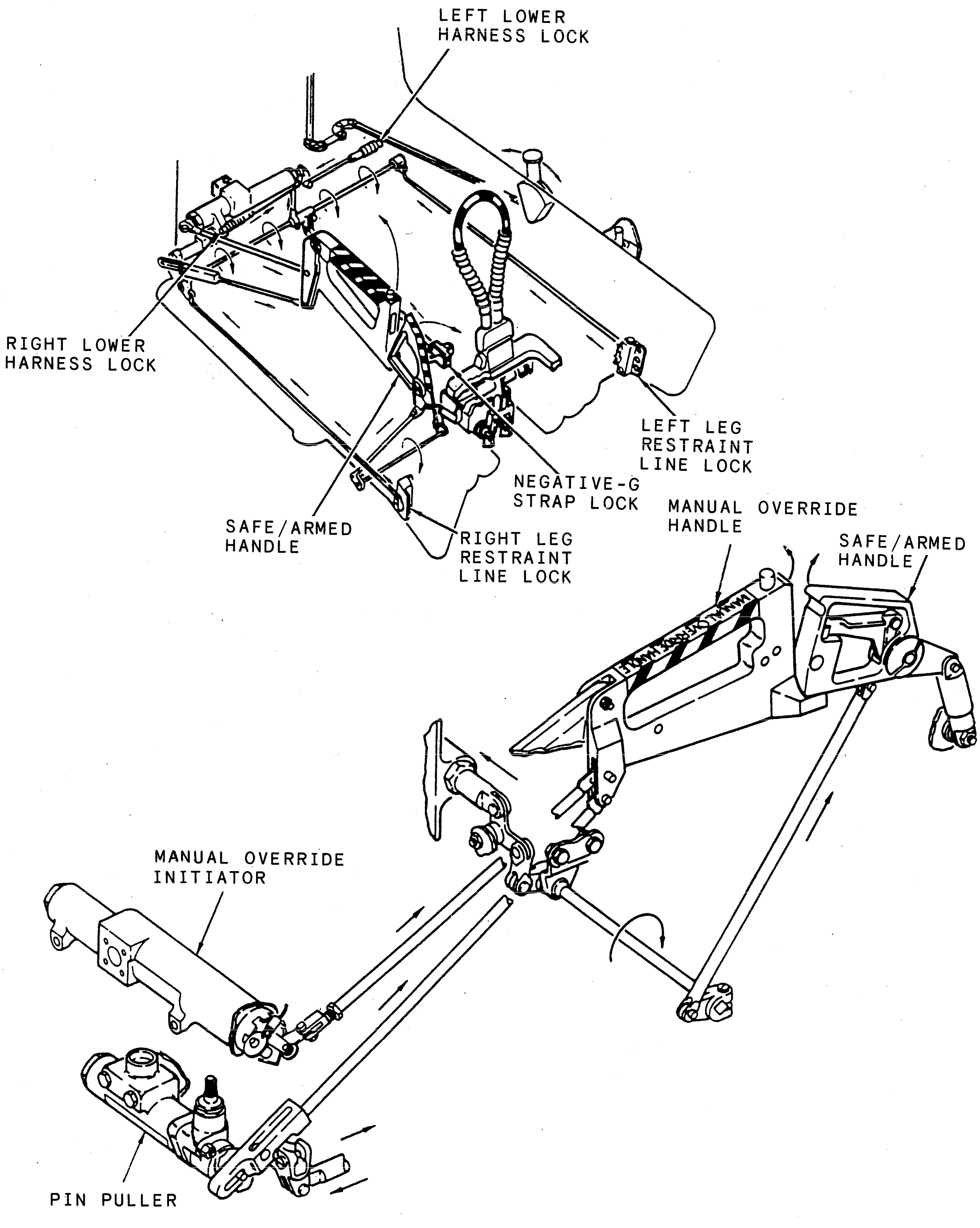


Figure 6-23.—Manual override system.

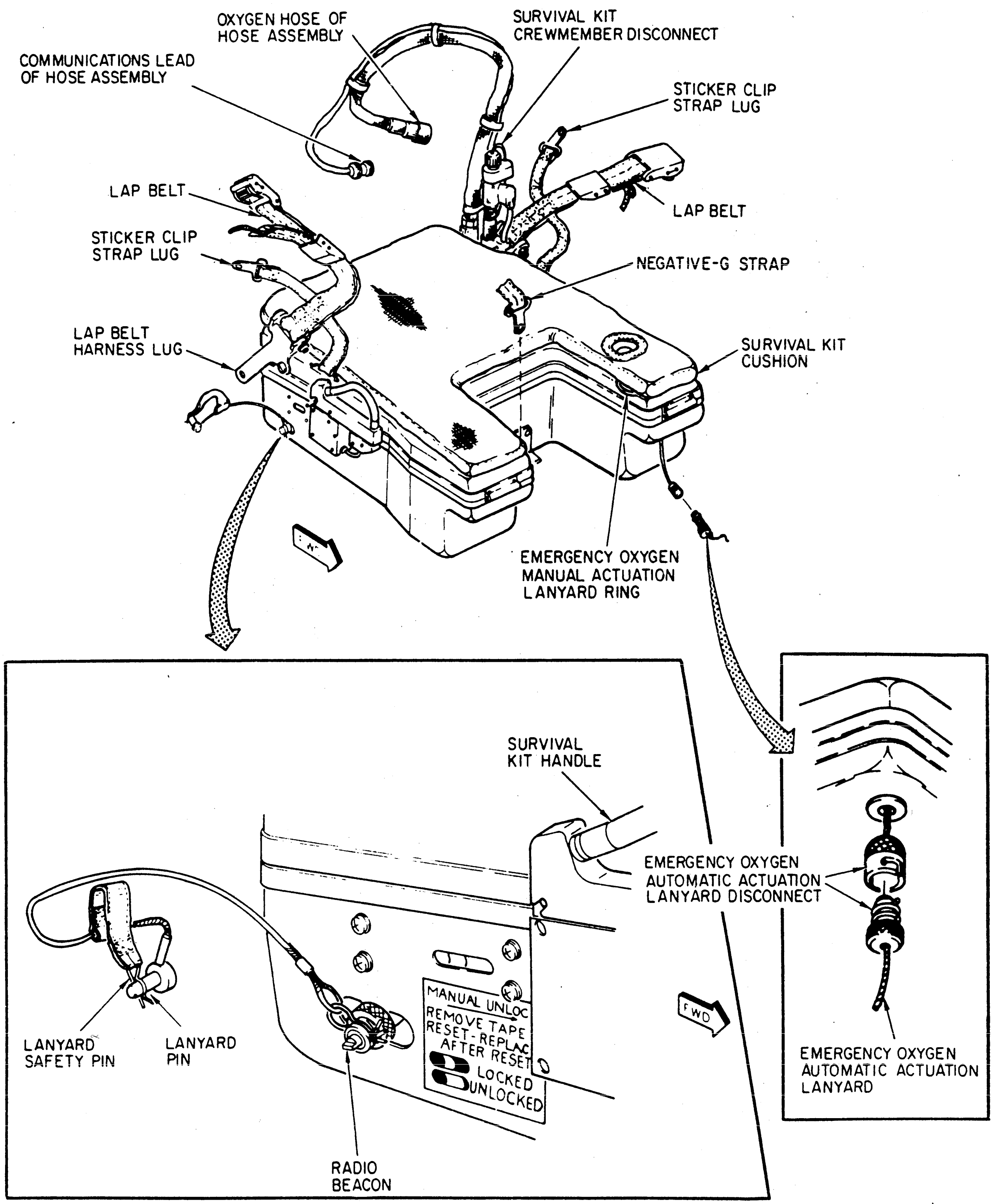


Figure 6-24.—SKU-3/A survival kit.

on the forward lower half of the survival kit. The emergency oxygen system, located in the lid of the survival kit, consists of an emergency oxygen cylinder, reducer assembly, actuation assembly, and manifold assembly. A lanyard and quick-disconnect fitting provide automatic actuation of the emergency oxygen system during ejection. If the aircraft oxygen system fails, emergency oxygen is available by actuating the emergency oxygen manual release. The release is a green ring located on the forward left side of the survival kit. A mounting is provided for the radio locator beacon and lanyard. The lanyard actuates the beacon upon ejection.

LEG RESTRAINTS.— Two leg restraint line snubbing units and lines are mounted to the forward structure of the seat bucket. The leg restraint lines are secured in locks located on the inboard sides of the seat bucket.

The leg restraints secure the pilot's legs to the seat during ejection. They consist of two adjustable leg garters, a restraint line, and a snubber unit for each leg. One garter is worn on the thigh and one on the lower leg. The restraint lines are routed through the garter rings and the snubber unit. One end of each restraint line is secured to the cockpit floor and the other is secured to the seat by a releasable pin. During ejection, the slack in each line is taken up and the leg lines separate at the tension rings. When the pilot and seat separate, the pins are normally released by the time-release mechanism. They may also be released by pulling the manual override handle. Both the lower garter and thigh garter contain a quick-release buckle. The leg restraint line runs through a ring that is disconnected by the buckle. This permits the pilot to exit the aircraft while wearing both the upper and lower garters.

The lower restraint mechanism locks are located in the lower aft portion of the seat bucket. These locks are connected by a cross shaft and linkage to the leg restraint line locks and the negative-g strap lock.

COMPONENT OPERATION

The operation of SJU-5/A system components and subsystems is discussed in the following paragraphs.

Catapult

A firing pin in the catapult firing mechanism is actuated by ballistic gas from the 0.3-second delay initiator. The firing pin then strikes the catapult primary cartridge. The ballistic gas from the primary cartridge starts the inner and intermediate barrels to extend upward. The upward movement of the inner barrel releases the spring-loaded top latch plunger from the retaining groove on the inner barrel.

As the inner barrel continues to extend upward, the ports of the inner and intermediate barrels expose the secondary cartridges. The secondary cartridges are ignited by the pressure and heat of the primary cartridge. The secondary cartridges assist in propelling both barrels and seat upward. After approximately 37 inches of travel, the piston head on the intermediate barrel contacts the pressure rings. These rings absorb the inertia force. The inner barrel continues to extend until it contacts the inner guide bushing. The inner barrel shears the rivet connecting the inner guide bushing to the intermediate barrel. This shearing separates the inner and intermediate barrels. The intermediate and outer barrels remain with the aircraft. The inner barrel remains with the ejection seat.

Manifold Check Valve

Gas from the delay initiators enters the manifold check valve and causes two internal check valves to be depressed. Then gas pressure passes to the catapult primary firing mechanism and severs the shear pin holding the firing pin.

Main Beam Assembly

The main beam assembly supports the major components of the ejection seat. The operation of the components supported by the main beam assembly is discussed in the following paragraphs.

TOP LATCH MECHANISM.— When the ejection seat is installed on the catapult, the top latch handwheel is removed. The top latch mechanism plunger passes through a hole in the outer barrel of the catapult and engages the locking groove. A locked indication is given by the position of the plunger and the indicator within the top latch mechanism housing. When the locking indicator spring-loaded plunger and mechanism housing are flush with each other, the top latch mechanism is locked. To remove the seat, you must install the top latch handwheel on the top latch plunger. This releases the seat from the catapult gun.

DROGUE GUN.— As the ejection seat rises, the trip rod withdraws the firing link from the drogue gun firing mechanism. This releases the spring-loaded firing pin. Firing pin movement is slowed for 0.5 second by an escapement mechanism to allow the ejection seat to clear the aircraft. After a 0.5-second delay, the firing pin activates the primary cartridge. Heat and pressure from the primary cartridge cause the secondary cartridge to fire. The gas produced by both cartridges shears the shear pin and expels the piston from the drogue gun barrel.

The drogue withdrawal line is attached to the piston. When expelled, the piston withdraws the pin from the closure flaps of the parachute container and deploys the drogue parachutes. The secondary cartridge serves as a backup system to the mechanically fired primary system. The cartridges in the time-release mechanism and manual override initiator provide gas pressure to the gas-operated secondary firing mechanism of the drogue gun. If the drogue gun primary firing mechanism fails, the gas-operated secondary firing mechanism cartridge will be fired by the secondary cartridge and the combined gas pressure will expel the piston from the drogue gun barrel to deploy the drogue parachutes.

TIME-RELEASE MECHANISM.— As the ejection seat rises, the trip rod also withdraws the firing link from the TRM and releases a spring-loaded firing pin. Firing pin movement is prevented for 1.5 seconds by a barostat and g-controller. When the altitude of the seat is less than 14,500 feet and acceleration forces are less than 3 g's, the barostat and g-controller release the firing mechanism. After the 1.5-second delay, the firing pin activates the cartridge. The gas produced by the cartridge passes to the upper body chamber and forces the shackle plunger down. This allows the scissor mechanism to open. At the same time, the gas actuates the connecting rod in the lower body and opens the inertia reel locks. Gas pressure is also provided to operate the piston to release the personnel parachute, manual override initiator, and the drogue gun secondary cartridge.

SCISSOR MECHANISM.— When the TRM cartridge fires, the shackle plunger retracts into the upper body of the TRM. This action allows the movable jaw of the scissor mechanism to open and release the personnel parachute from the container.

INERTIA REEL ASSEMBLY.— During the ejection sequence, gas pressure is used to fire the inertia reel cartridge. The gas pressure forces the head of the piston along the cylinder. The horizontal movement of the piston is transmitted by a threaded drive screw to rotate the ratchet wheel. The rotation of the ratchet wheel retracts the inertia reel straps and restrains the pilot in the seat. Then the locking pawl locks the spools in the retracted position.

Extension of the inertia reel straps at excessive speed causes the governor pawls to rotate outward because of centrifugal force. They engage the rack on the housing, which prevents any additional extension of the straps. When the shoulder harness control handle is in the rear position, the system restrains the pilot from moving forward. With no tension applied to the inertia reel straps, the pawl will reset itself and disengage from the rack. This will allow free extension of the straps.

ROCKET MOTOR INITIATOR.— During the ejection sequence, the static line connected to the drogue gun trip rod and to the rocket motor initiator is withdrawn from the aft initiator housing. When the static line is extended to approximately 72 inches, a spring-loaded plunger is unlocked. The plunger rotates the quadrant lever and removes the sear from the firing mechanism. Removal of the sear fires the cartridge in the breech. The gas produced is routed to the rocket motor firing mechanism, which ignites the rocket motor.

AIRCRAFT SEAT PARACHUTE.— The drogue shackle, which contains the parachute withdrawal line and extender strap, allows the drogues to be deployed without extraction of the personnel parachute. A mechanical lock secures the parachute withdrawal line to prevent premature deployment until pilot and seat separation has occurred. The lock is released by a piston in the upper body of the time-release, mechanism.

The parachute risers are routed down the forward side of the parachute container. Quick-release fittings are located on the end of the risers and connect to the pilot's torso harness. The inertia reel straps are routed from the inertia reel, through the parachute riser roller fittings, and are secured in the inertia reel locks.

SEAT BUCKET SUPPORTED COMPONENTS

The seat bucket supports several components on the lower portion of the ejection seat. The operation of these components is discussed in the following paragraphs.

Ejection Seat Initiator

With the safe and arm handle in the down or ARMED position, an upward pull on the ejection control handle removes the two sears from the firing mechanisms and causes the two cartridges within the initiator to fire. Gas pressure from either cartridge will initiate seat ejection.

Manual Override Initiator

Aft rotation of the manual override handle positions the safe and arm handle up to the SAFE position and releases the lower restraint. In this position, the pin puller engages a slot in the manual override handle linkage and prevents actuation of the manual override initiator. During the ejection sequence, the pin puller is retracted inboard. This allows the manual override initiator to be actuated and override the automatic sequencing. Gas pressure from the manual override initiator is piped to the time-release mechanism and the secondary cartridge in the drogue gun.

Pin Puller

During the ejection sequence, gas pressure from the right seat initiator cartridge enters the pin puller and operates a spring-loaded ball lock. This allows the pressure to retract the pin and disengage it from the manual override linkage.

Seat Survival Kit

The seat survival kit is opened by operating the release handle located on the right forward side of the kit. During the ejection sequence, the oxygen hose and communication lead disconnect from the aircraft. The emergency oxygen and radio beacon are automatically actuated. During parachute descent, the pilot may operate the release handle to open the survival kit. This allows deployment and inflation of the life raft. The life raft and survival equipment are connected by a lanyard to the survival kit lid, which is attached to the pilot.

Manual Override System

Operation of the manual override handle will rotate the cross shaft of the lower harness locks, leg restraint line locks, and the negative-g strap lock. This is necessary for emergency ground egress from the aircraft. Full aft rotation of the handle is prevented by engagement of the pin puller piston in a slot of the manual override handle linkage. This prevents firing of the manual override initiator.

During the ejection sequence, gas pressure from the right seat initiator cartridge operates the pin puller to withdraw the pin puller piston from the slot in the manual override handle linkage. In the event of a time-release mechanism failure or drogue gun failure above barostatic altitude, aft rotation of the manual override handle will fire the manual override initiator. Gas pressure from the manual override initiator cartridge operates the lower harness release system. It will also pass up the trombone fitting and fire the time-release mechanism cartridge. This cartridge operates the upper harness release mechanism, scissor mechanism release plunger, and parachute lock. Additionally, the gas pressure passes to the drogue gun and fires the secondary cartridge.

Leg Restraint System

As the seat travels up the guide rails during the ejection sequence, the leg restraint lines are drawn through the snubbing units. This action pulls the pilot's legs aft against the seat bucket. As the seat continues to rise, the leg restraint lines become taut. When the force on the bottom fittings reaches approximately 900 pounds, the shear ring will shear. The shearing releases the lower portion of the leg restraint lines.

Automatic Harness Release System

Firing of the time-release mechanism cartridge moves the piston and connecting rod down and rotates the cross shaft. Rotation of the cross shaft releases the inertia reel locking plungers and releases the inertia reel straps. Simultaneously, gas pressure is routed down the trombone fitting to fire the cartridge in the manual override initiator. Gas pressure from the manual override initiator cartridge presses against the head of the piston. Movement of the piston rotates the bell crank lever and releases the spring-loaded locking plungers of the lower harness locks. This releases the lap belt lugs and rotates the cross shaft. Rotation of the cross shaft releases the looking plungers in the leg restraint line and negative-g strap locks.

COMPONENT TEST AND TEST EQUIPMENT

Ejection seats and associated components are carefully designated, manufactured, and tested to ensure dependable operation. Such equipment must function perfectly the first time it is used. Malfunction or failure to operate usually results in severe injury or death to crew members. You must use the utmost care in maintaining escape system equipment. Proper handling and strict compliance with the maintenance procedures presented in the maintenance instructions manuals (MIMs) and the maintenance requirements cards (MRCs) are mandatory and cannot be overemphasized.

NOTE: The information presented in this chapter must not be used in place of information provided in the MIM.

The SJU-5/A ejection seat undergoes a variety of functional checks during the 364-day special inspection. In-depth testing of the firing unit mechanisms, catapult gun, time-release mechanism, drogue gun, and a complete mechanical operational check is required. The time-release mechanism and drogue gun checks are discussed in the following paragraphs.

Drogue Gun Check-out

The drogue gun must be removed from the ejection seat to accomplish the check-out. You should make sure the drogue gun is disarmed before performing any maintenance on it. Then, you should remove the drogue gun barrel and piston and inspect them for damage and corrosion. The three tests used in the check-out are the time-delay test, the firing pin protrusion test, and the firing pin cocking test. These tests must be done with the barrel and piston removed. These tests are discussed in the following paragraphs.

TIME-DELAY TEST.— To complete the time-delay test, you should perform the following steps in sequence.

1. Install the drogue gun adapter on the time-delay test base. Connect the adapter electrical cables to the time-delay test set timer. Then connect the test set to a 110-volt ac 60-Hz power supply. An air source regulated to 80 psi is also required. Figure 6-25 reflects the correct mounting of the drogue gun to the test set.

2. Extend the ram connecting plunger by pressing the reset button on the test set. The reset

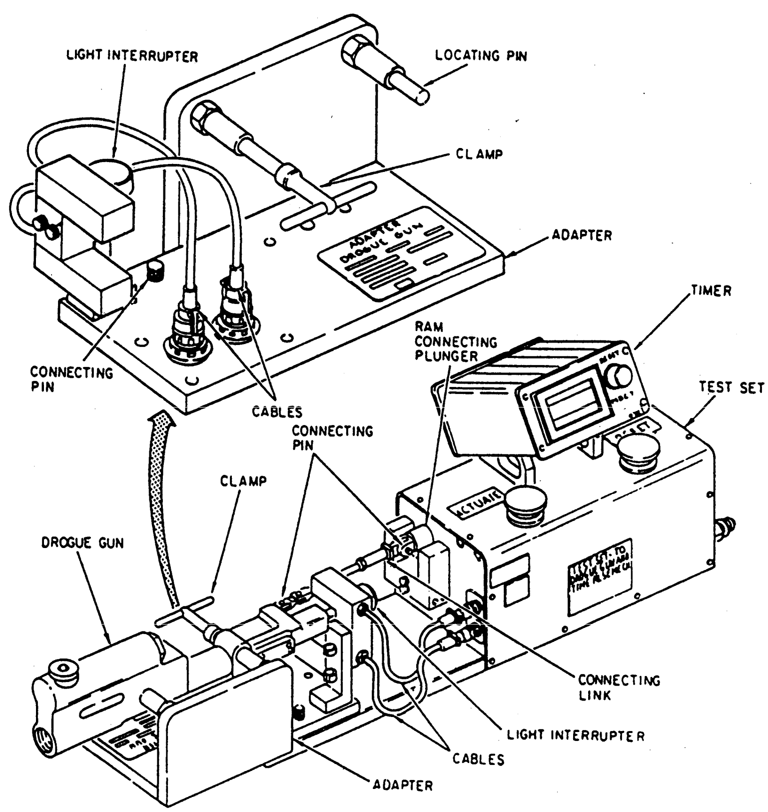


Figure 6-25.—Drogue gun time-delay check-out.

button also sets the timer to zero. Remove the lockwire from the drogue gun firing link and remove the hex head plug from the base of the drogue gun. Ensure the drogue gun is secured to the test set with the clamp. Next, attach the drogue gun firing link to the test set connecting ram plunger with the connecting link and connecting pins. Install the light interrupter into the base of the drogue gun.

NOTE: Before proceeding any further with the test, ensure quality assurance (QA) personnel are present to witness the results.

3. Press the time-delay test set actuate button and record the time required to pull the firing link from the drogue gun. The elapsed time should not exceed 0.5 ± 0.1 second. If the testis unsuccessful, the drogue gun must be replaced.
4. Remove the light interrupter and drogue gun from the test set and secure the equipment.

FIRING PIN PROTRUSION TEST.— To complete the firing pin protrusion test, you should perform the following steps in sequence.

1. Place the protrusion gauge over the firing pin.
2. Check the position of the inner center shaft of the gauge. It must be flush or slightly above the gauge outer case, as shown in figure 6-26.
3. If the firing pin fails this test, the drogue gun must be replaced.

FIRING PIN COCKING TEST.— To complete the firing pin cocking test, you should perform the following steps in sequence.

1. Place the drogue gun clamp into a vise and position the drogue gun on the clamp. Screw the cocking handle into the base of the drogue gun.
2. Pull the handle until the firing mechanism is fully extended. With the mechanism fully extended, install the firing link into the drogue gun.
3. Release the tension on the cocking handle. If the mechanism is cocked, the firing link will be held firmly in place.
4. Remove the handle and install the hex head plug and washer.
5. Lockwire the firing link to the drogue gun housing by inserting the lockwire through the housing and roll pin, which is attached to the firing link.

NOTE: At this point in the procedure, request QA to inspect the engagement and lockwiring of the sear.

Time-Release Mechanism Check-out

The time-release mechanism must be removed from the ejection seat to perform

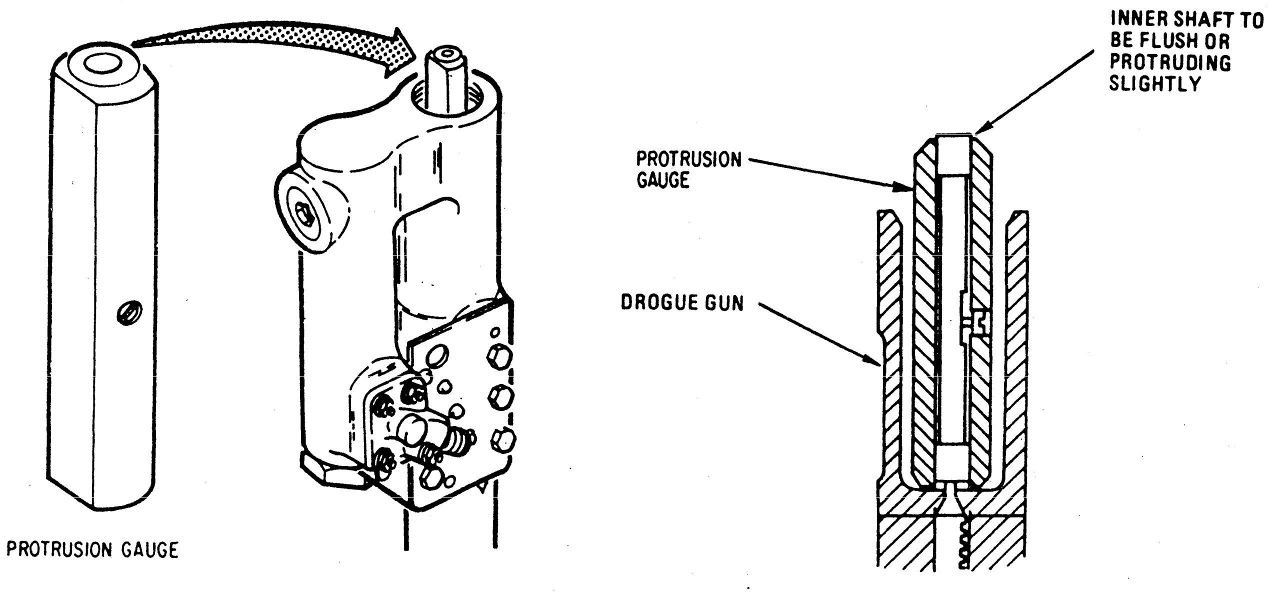


Figure 6-26.—Drogue gun firing pin protrusion check-out.

this check-out. You should ensure the TRM is disarmed before performing maintenance on it. Then, remove the firing body from the time-delay g-sensing release mechanism. Remove the lockwire from the firing link and remove the hex head plug and washer from the base of the unit. Inspect the TRM for damage and/or corrosion. If damaged or corroded, check the MIM for corrective action to be taken.

Time Delay Check-Out

To complete the time delay check-out, you should perform the following steps in sequence.

1. Remove the light interrupter from the test set and screw it into the base of the time-delay g-sensing release mechanism, as shown in figure 6-27. Install the TRM adapter on the time-delay test set base. Connect the adapter

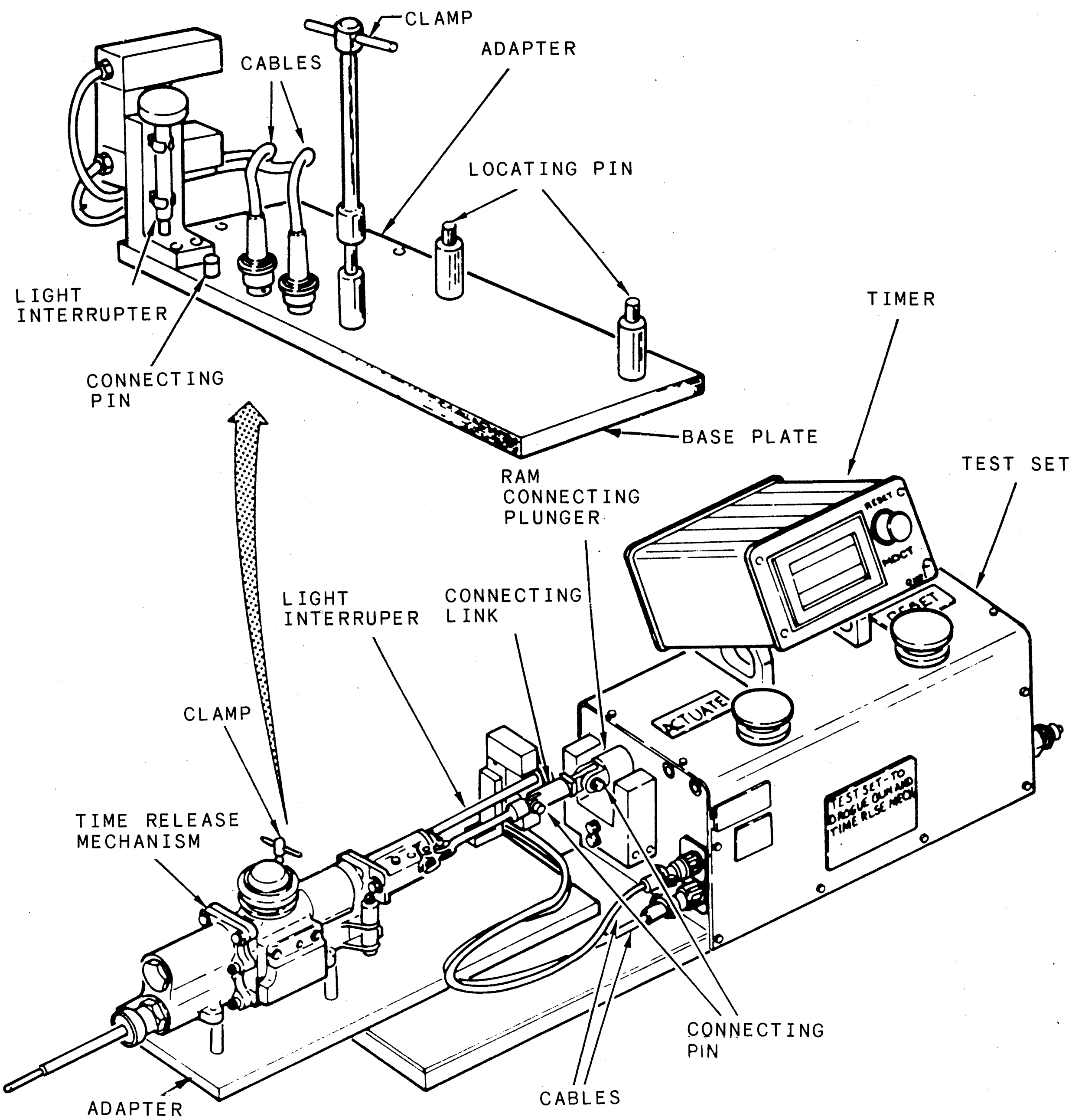


Figure 6-27.—Time-release mechanism time delay check-out.

electrical cables to the time-delay set timer. Then connect the test set to a 110-volt ac 60-Hz power supply. Again, you will need an air source regulated to 80 psi.

2. Extend the ram connecting plunger on the test set by pressing the reset button. Position the TRM on the test set and secure it with a test set clamp. Attach the time-delay g-sensing release mechanism firing link to the test set ram connecting plunger, connecting link, and connecting pins.

NOTE: At this point, you should ensure QA personnel are present to witness the elapsed time function.

3. Press the time-delay test set actuate button and record the time required to pull the firing link from the time-release g-sensing release mechanism. The elapsed time should not exceed 1.5 ± 0.1 seconds. If the time is greater than 1.5 ± 0.1 seconds, the unit must be replaced.

FIRING PIN PROTRUSION CHECK.— To complete the firing pin protrusion check, you should perform the following steps in sequence.

1. With the cartridge body removed from the TRM, place the TRM protrusion gauge over the firing pin.
2. Check the position of the inner center shaft of the gauge. It must be flush or slightly above the outer case of the gauge.
3. If the firing pin fails this test, it must be replaced.

FIRING MECHANISM COCKING TEST.— To complete the firing mechanism cocking test, you should perform the following steps in sequence.

1. Place the TRM clamp in a vise and position the TRM on the clamp. Screw the TRM cocking handle into the base of the TRM. Pull the cocking handle until the firing mechanism is fully extended.
2. In this position, install the test firing pin into the time-delay g-sensing release mechanism. The test firing pin is furnished as part of the TRM test set.
3. Release the tension on the cocking handle. Ensure the mechanism is cocked by pulling on the test firing pin. If the firing mechanism is cocked, it will be held firmly in place.
4. Remove the cocking handle from the TRM. Then remove the TRM from the clamp. The TRM is now cocked and ready for the barostat test check out.

Barostat Check-Out

To complete the barostat check-out, you should perform the following steps in sequence.

1. Connect the TRM test box to a 110-volt ac 60-Hz power supply. Ensure all protective plugs and parts of the test set are installed in the test box holes labeled “cocking control and altitude.”
2. Position the TRM in the test set and secure it with a clamp screw, as shown in figure 6-28.
3. Insert the operating handle through the hole in the test set labeled “firing control.” Screw the handle into the test firing pin.
4. Set the test box altimeter to 1013 millibars. With this setting, the altimeter will show a reading, in feet, above sea level and the altitude test will be relative to sea level.
5. Ensure the test set cover and seal are clean before closing the cover. A light application of pressure might be required to seal the cover.
6. Turn the vacuum release valve clockwise to the CLOSED position.

NOTE: Before you continue with the test, QA personnel should be present to witness the results.

7. Set the test set switch to the ON position. Make sure the vacuum pump starts and the red indicator light is illuminated.
8. While you monitor the test set altimeter, set the on/off switch to OFF when the altimeter reaches 30,000 feet.
9. Pull the operating handle to remove the test set firing pin from the TRM. The TRM should not operate at this time.
10. Monitor the test set altimeter while you slowly open the vacuum release valve. Open it until the altimeter indicates a steady descent rate, but not exceeding 200 feet per second.
11. Record the reading on the altimeter at which the TRM actuates. The actuation must occur at $13{,}000 \pm 1{,}500$ feet. If the TRM fails the test, it must be replaced.
12. After actuation, open the test set vacuum release valve. When the altimeter indicates zero, carefully open the test set cover.
13. Remove the clamp and disconnect the test firing pin from the TRM. Then remove the TRM from the test set.

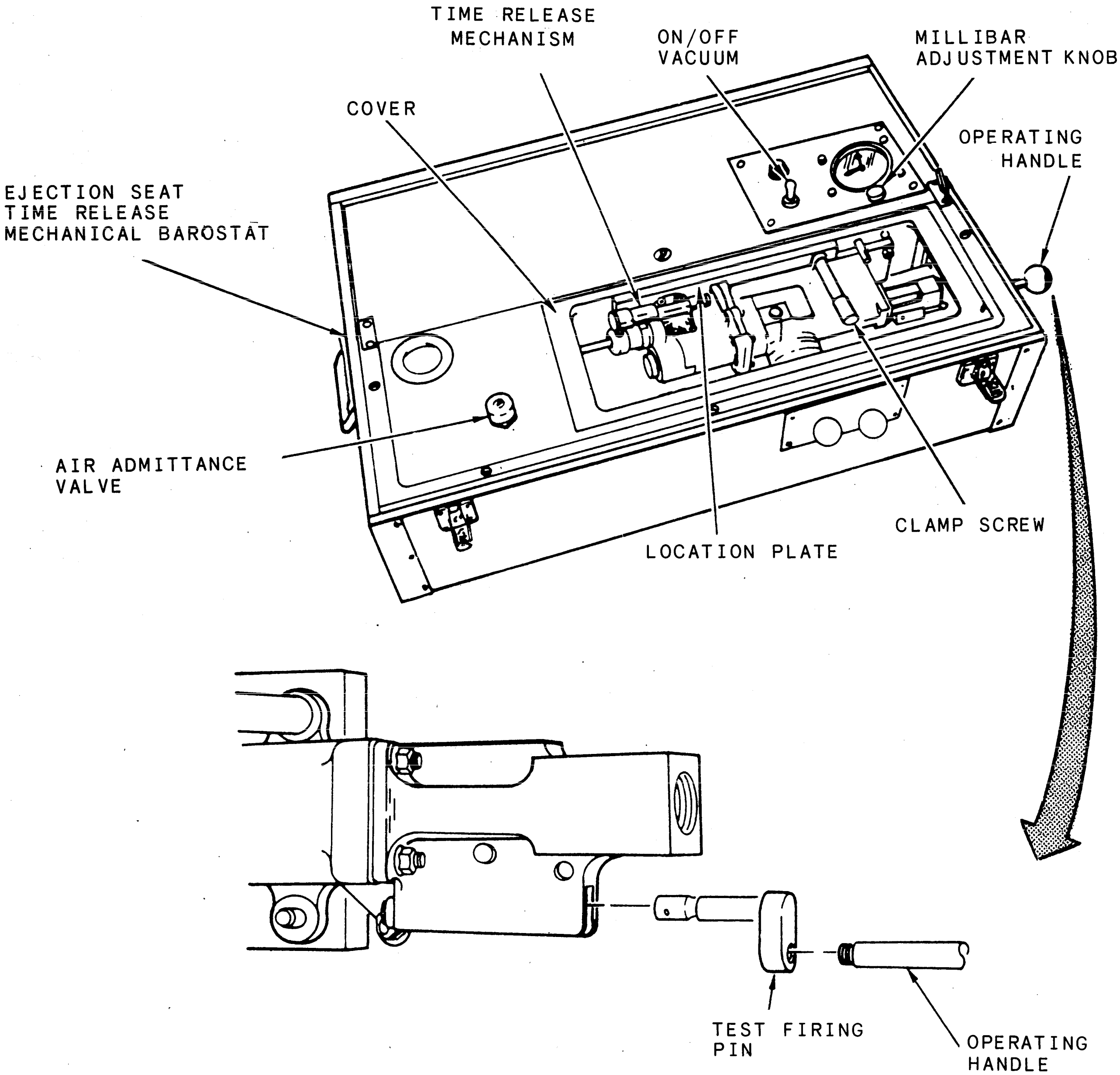


Figure 6-28.—Time-release mechanism barostat check-out.

14. Secure the test set and recock the TRM. Lockwire the firing link to the TRM and install the hex head plug and washer in the base of the TRM.

NOTE: QA should inspect the sear installa-tionand lockwire.

Other Tests

Other tests are required for this ejection seat. These tests are performed in strict compliance with the MRCs and MIMs. The steps requiring QA action are also very important.

All ejection seat parts and components received from supply must be checked or tested before being put into service. It is also recommended that ejection seats reinstalled on their mated ejection catapult guns.

Cannibalization of ejection system com-ponents must beheld to an absolute minimum. The swapping of components increases the possibility of maintenance error. Minimizing cannibalization should also decrease the possibility of logbook record error.

STENCEL SJU-8/A EJECTION SEAT

Learning Objective: Recognize the components, parachute and seat separation operations, seat subsystems, component maintenance, corrosion control, and lubrication and emergency cleaning procedures for the Stencil SJU-8/A ejection seat.

The Stencel SJU-8/A ejection seat is used in the A-7E aircraft. It uses thrust from a ballistic catapult and two seat-back rockets to propel it from the aircraft. (See figures 6-29, 6-30, and 6-31.) The seat provides escape capabilities during takeoff and landing emergencies from zero speed and zero altitude to speeds and altitudes of 600 knots and 50,000 feet. The system incorporates a seat-mounted, environmentally protected parachute, survival package with raft, emergency oxygen supply, and emergency locator beacon. The parachute is stored in a non-adjustable headrest. The front surface of the seat bucket provides a buffer for the calves of the legs, which are automatically restrained by straps to prevent flailing during ejection. The sides of the bucket extend upward and forward from the seat to protect the legs during canopy penetration.

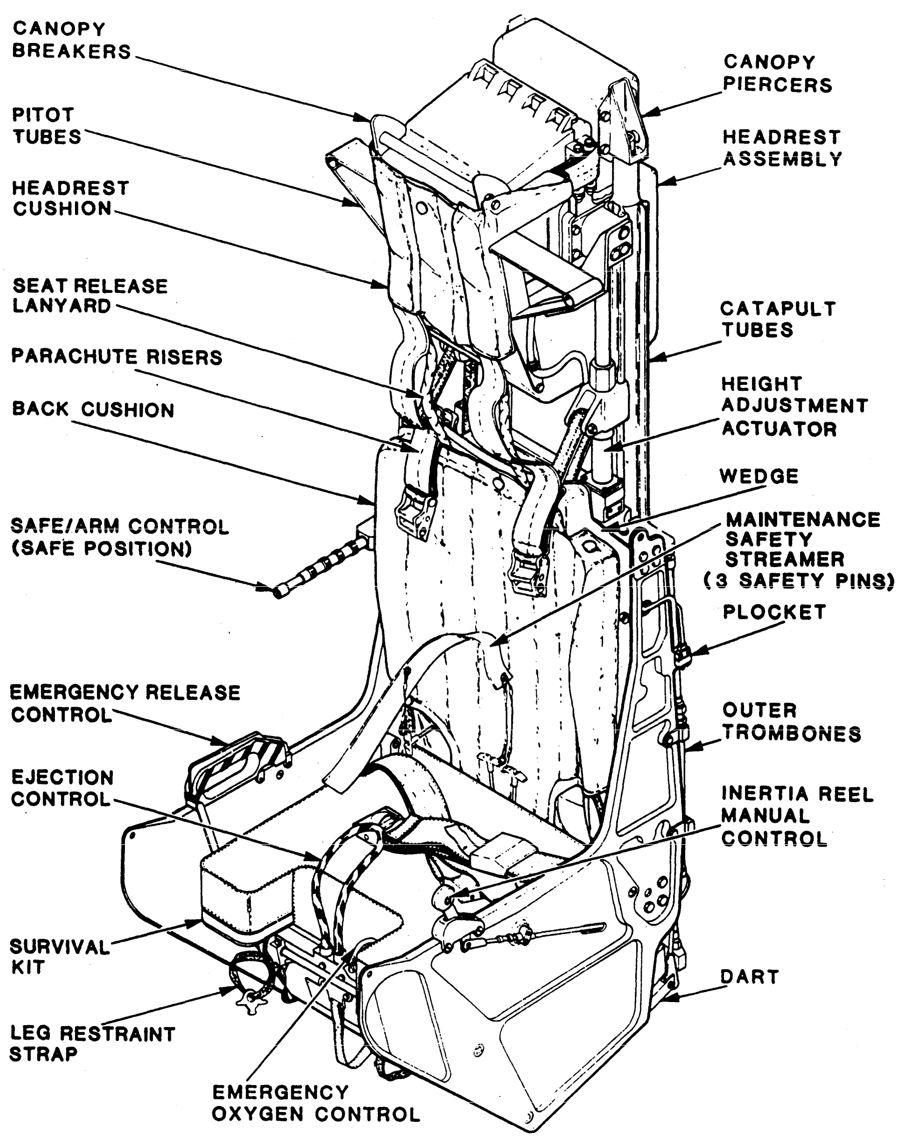


Figure 6-29.—SJU-8/A ejection seat assembly.

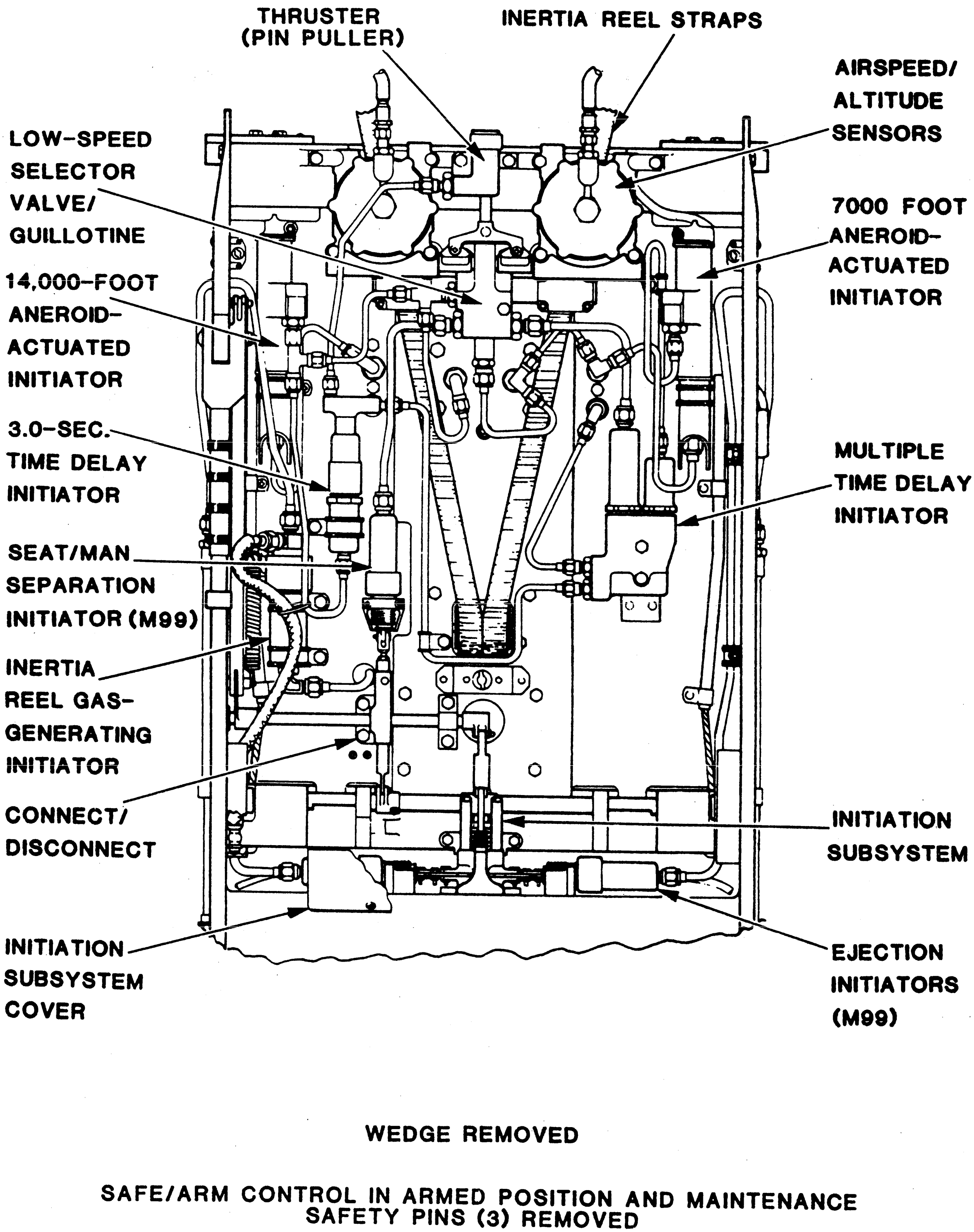


Figure 6-30.—SJU-8/A ejection seat assembly (front view).

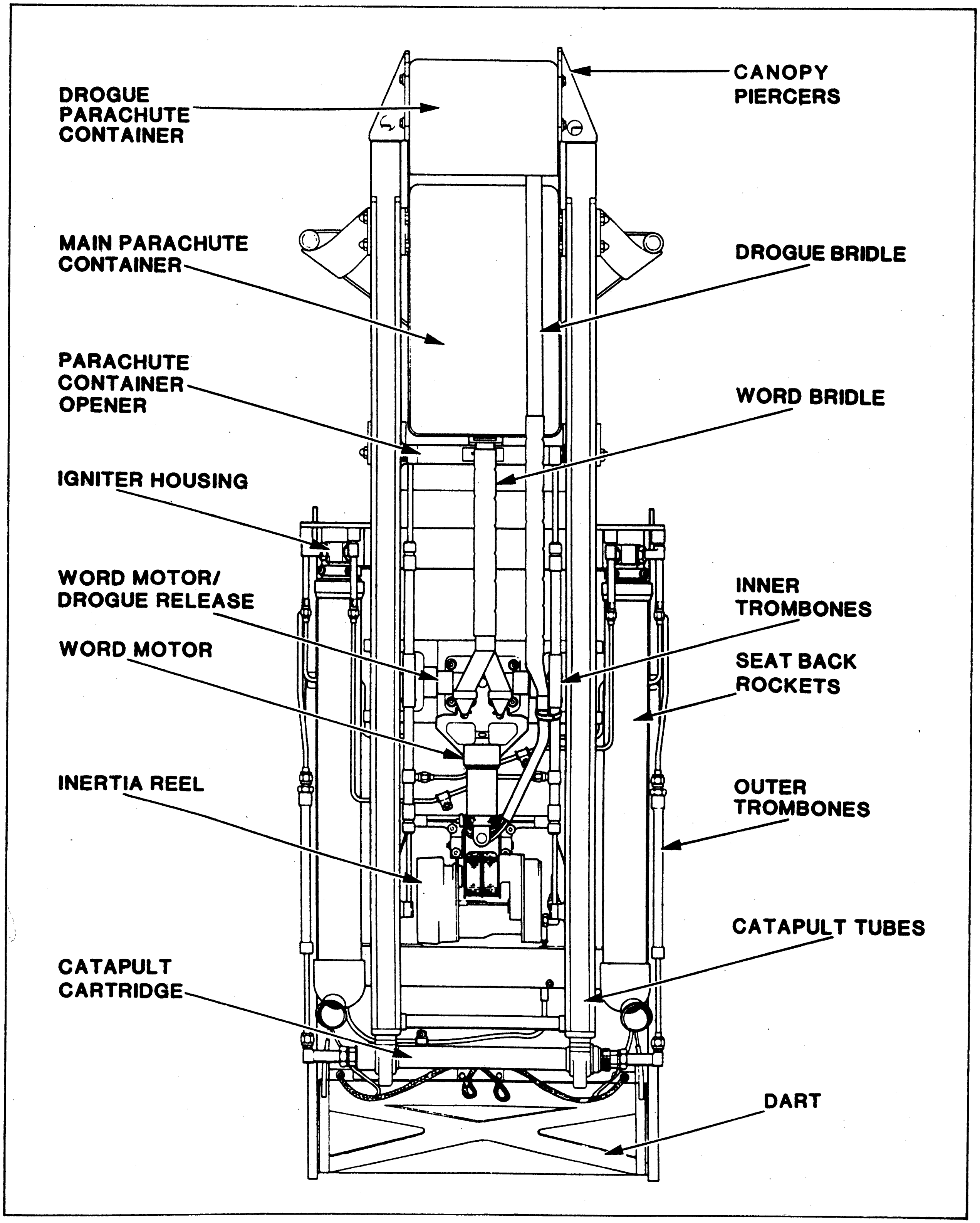


Figure 6-31..—SJU-8/A ejection seat assembly (back view).

The Stencel system has four modes of operation. As you read the material in the following paragraphs, carefully note the differences between these modes. The material describing the subsystems and components will amplify the modes of operation by explaining how and when each mode is activated. The remainder of this section will address the test equipment and test procedures used in the maintenance of the system.

SYSTEM OPERATION

The ejection sequence is initiated by pulling upward on the ejection control handle, which is located on the front panel of the seat bucket. Pulling the ejection control handle requires a force of 15 to 25 pounds through a distance of less than 4 inches. Pulling the control handle fires two M99 ejection initiators, which release hot, high-pressure gas to the ballistic signal transmission system (BSTS). Figure 6-32 is a schematic of the BSTS. The right M99 ejection initiator supplies gas pressure to the right side of the catapult cartridge igniter and the inertia reel gas-generating initiator. The left M99 ejection initiator supplies gas pressure to the left side of the catapult cartridge igniter, thereby

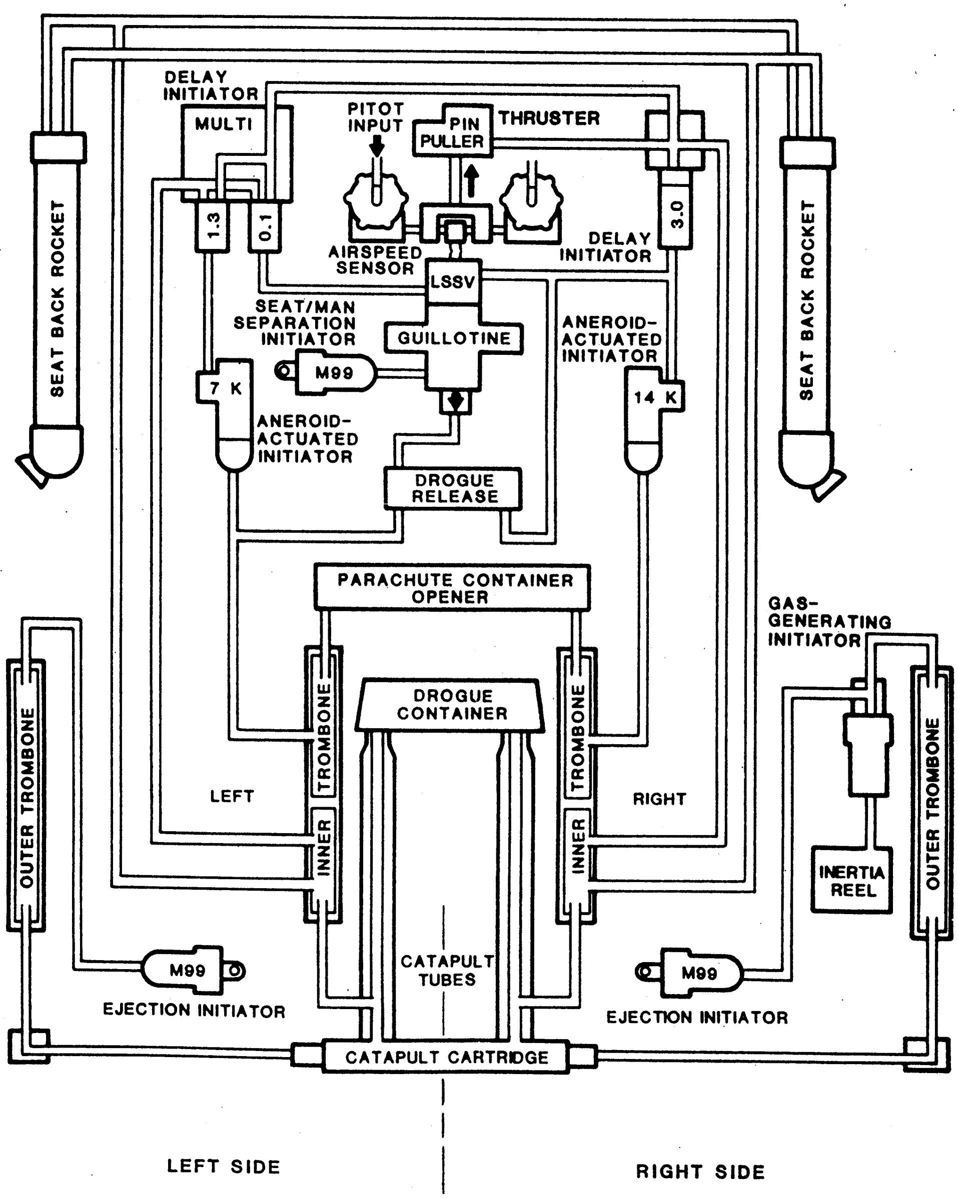


Figure 6-32.—SJU-8/A ballistic signal transmission system.

providing redundant ignition to the catapult cartridge.

As the seat catapult fires, the gas pressure forces locking pistons in the catapult tubes to disengage the locking balls, which unlock the inner and outer catapult tubes. As the seat and outer catapult tubes move upward, the pilot's legs are drawn against the front of the seat by the leg restraint mechanism. Simultaneously, the quick-disconnect fittings for pilot services are separated, and a lanyard on the catapult manifold activates the emergency oxygen bottle, IFF, and AN/URT-33 emergency radio beacon.

After approximately 16 inches of seat travel, gas pressure is applied to the drogue gun pistons housed in the catapult tubes. These pistons forcibly expel the drogue parachute container for quick drogue parachute deployment. The drogue parachute provides seat stability and aids in withdrawing the main parachute.

After approximately 31 inches of seat travel, gas pressure is ported to a thruster (pin puller), a 3-second time-delay initiator, a multiple time-delay (0.1- and 1.3-seconds) initiator, and the igniters of the two seat-back rocket (SBR) motors. The SBRs produce the thrust necessary for the seat and pilot to attain sufficient terrain and aircraft tail clearance to permit parachute deployment. The necessary thrust is available even at zero airspeed and zero altitude.

Upon ejection, the seat is stabilized by a Directional Automatic Realignment of Trajectory (DART) system. Two lanyards, attached to the aircraft and feeding through tension brake assemblies beneath the seat, counteract excessive pitch and roll.

The post-ejection sequencing system for deploying the Wind Oriented Rocket Deployment (WORD) motor and drogue release mechanism follows one of four automatic ejection modes, depending on the aircraft's airspeed and altitude. These modes of operation will be discussed later in this chapter. Depending on the mode of operation, the time-delay initiators fire, directing gas pressure to actuate the WORD motor and drogue release mechanism, and arm the aneroid-actuated initiator.

Upon actuation, the WORD motor/drogue release disconnects the WORD rocket motor. This allows the wind resistance on the drogue chute to withdraw the WORD motor from the seat. When the WORD rocket motor arming cable is withdrawn, it releases the firing pin and ignites the rocket. Depending on the mode of operation, the aneroid-actuated initiator fires. This activates the personnel parachute container opener, releasing the personnel parachute. The parachute will be withdrawn by either the WORD rocket motor, drogue parachute, or internal pilot chute.

When the personnel parachute suspension lines and risers become taut, a firing lanyard attached to a ballistic spreading gun extracts the spreading gun firing pin sear. The released firing pin strikes and activates a spreading-gun ballistic charge, which expels metal slugs in a 360-degree pattern. The slugs, attached to parachute suspension lines, rapidly inflate the canopy during very low-speed ejection. During high-speed ejection, the airstream energy far exceeds that of the spreading gun. Therefore, the gun has little effect on parachute inflation time.

As wind resistance acts on the personnel parachute, tension on the seat and man release lanyards actuates the seat and man separation initiator to produce gas pressure directed to the guillotine. The guillotine severs both inertia reel straps and releases the pilot's upper torso. Simultaneous actuation of seat and man separation mechanical linkage by the lanyards releases the survival kit assembly and pilot from the ejection seat.

The pilot may release the survival package in the survival kit by pulling a handle located near his right hip. After the package drops 12 feet, a snubbing lanyard initiates inflation of the life raft. The remainder of the survival package drops an additional 13 feet and hangs below the life raft to stabilize it during descent.

Ejection Mode Sequences

The Stencel seat is equipped with a mode sequencing system that controls four automatic ejection modes. The system includes a parachute container opener that is activated by gas pressure from the 7,000- or 14,000-foot aneroid initiators, or the seat and man separation initiator. The WORD rocket is also part of the system. The WORD rocket, mounted on the back of the seat, is connected to the drogue bridle assembly on one end and to the parachute WORD bridle on the other end. The WORD rocket motor is released from the seat and fired by a lanyard as it falls away from the seat during low-speed ejections or by the pull of the drogue during high-speed ejections.

The ejection sequence follows one of four modes, depending on aircraft airspeed and altitude. Mode 1 includes ejections where the aircraft is operating below 7,000 feet and at a speed less than 225 knots. Mode 2 includes an altitude below 7,000 feet, but at a speed greater than 225 knots. Mode 3 occurs above 7,000 feet, but below 14,000 feet, at any airspeed. Mode 4 occurs above 14,000 feet at any airspeed. Figure 6-33 presents a comparison of the various modes.

MODE I.— Mode 1 (fig. 6-34) is for a low-speed, low-altitude ejection. After the catapult outer tube assemblies have traveled upward a distance of approximately 31 inches, ballistic gases are ported through the inner trombone assemblies to actuate the 0.1- and 1.3-second time delays in the multiple delay initiator and the 3-second delay initiator. Gases from the 0.1-second delay actuate the drogue and WORD release and arm the 14,000-foot aneroid initiator. Below 14,000 feet, the initiator immediately actuates and gases pass through the right trombone to actuate the parachute container opener. Upon actuation of the WORD motor and drogue release assembly, the aerodynamic drag of the drogue parachute

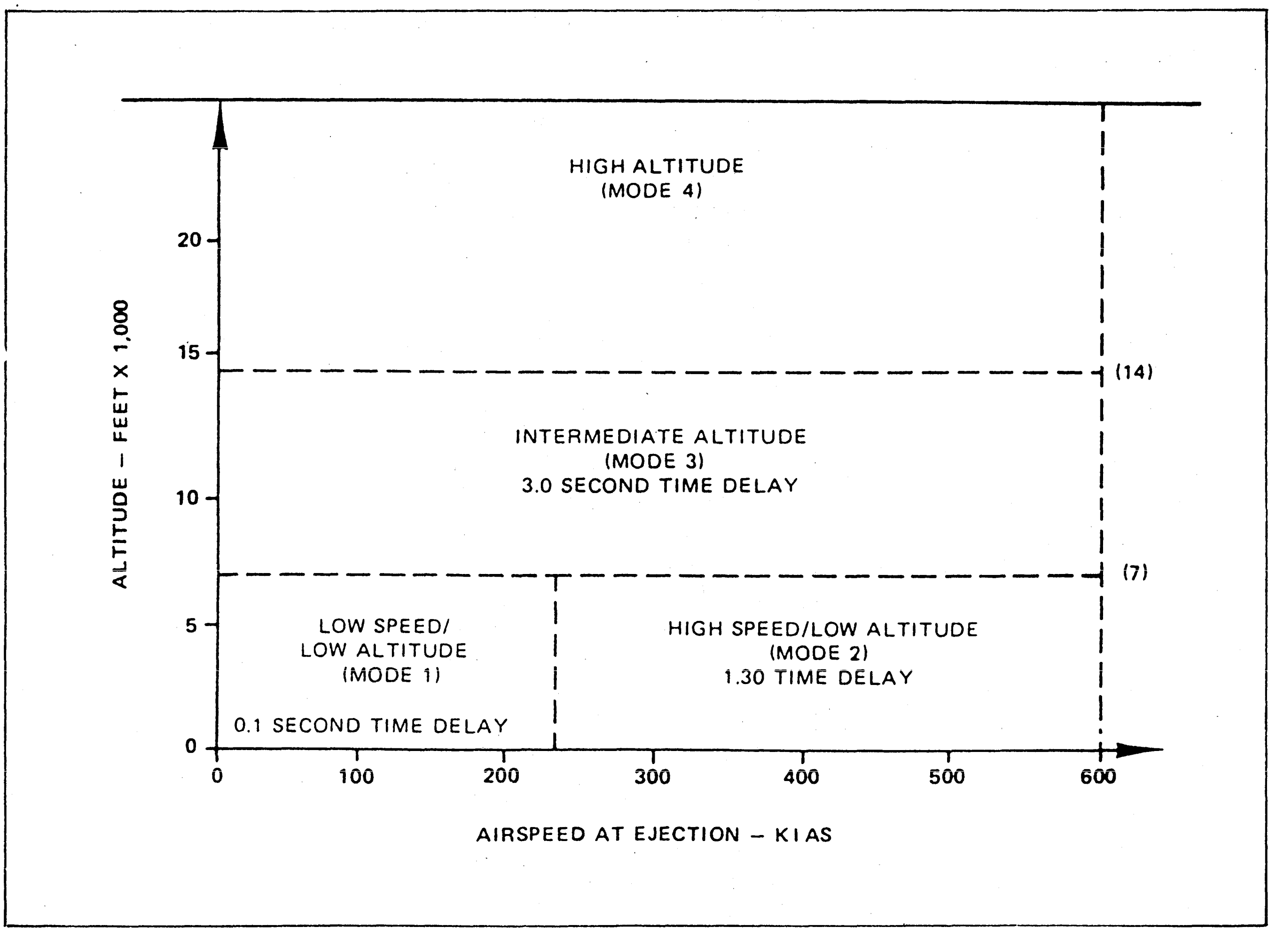


Figure 6-33.—SJU-8/A mode of operation.

pulls the WORD motor away from the seat back. This action extracts the firing lanyard from the motor and ignites the WORD motor.

When the WORD rocket is fired, it extracts the parachute from its container. The parachute drag pulls a lanyard that fires the ballistic spreading gun. The gun expels metal slugs, which are attached to alternate suspension lines on the parachute canopy skirt in a 360-degree pattern. This opens the parachute and allows the canopy to fill quickly. If the spreading gun fails to fire, a fail-safe collar releases the slugs and allows normal parachute inflation. If mode 1 fails, mode 2 will automatically provide the ejection sequence.

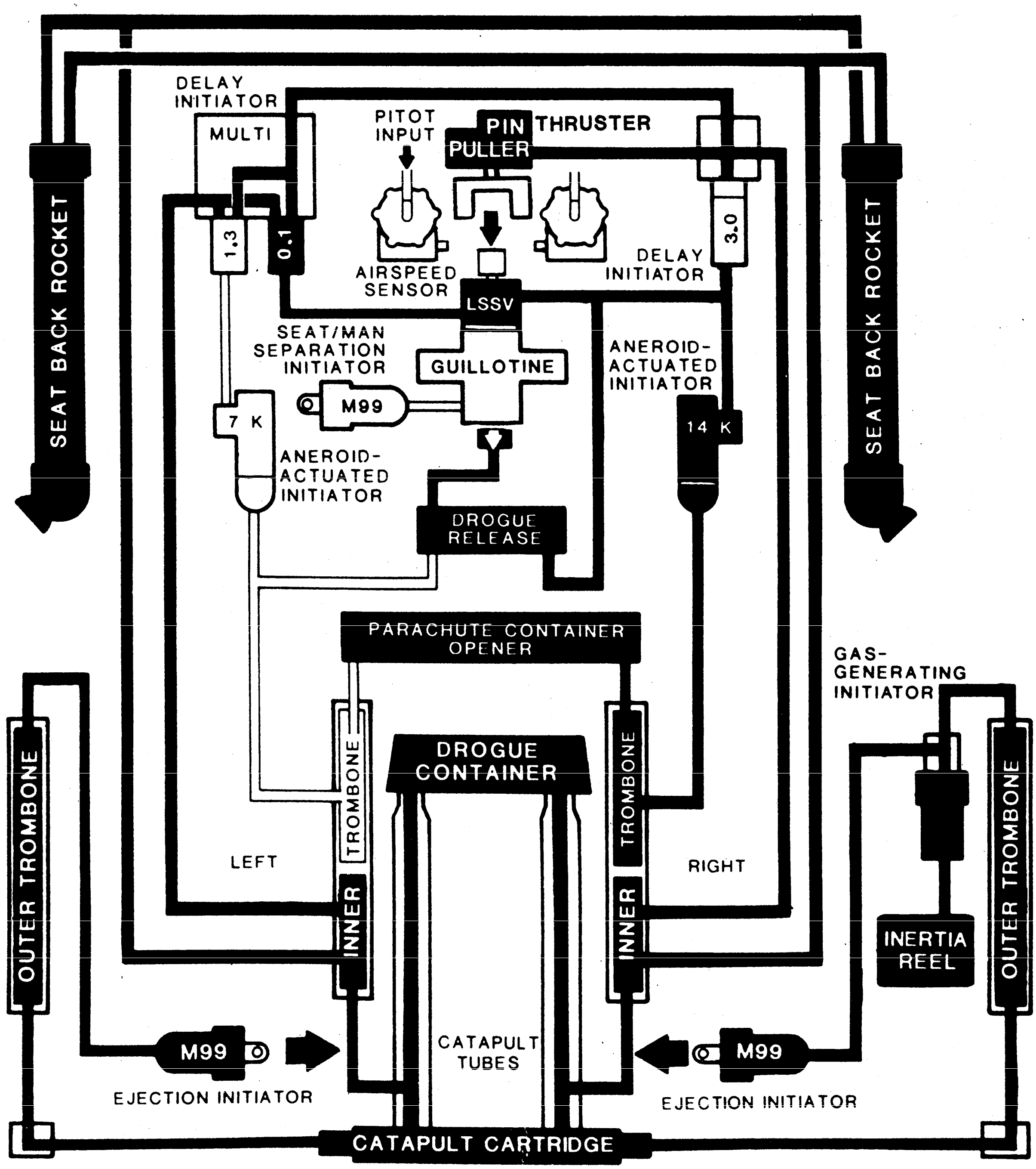


Figure 6-34.—Mode 1: low speed/low altitude.

MODE 2.— Mode 2 (fig. 6-35) is for a high-speed, low-altitude ejection. The primary initiation of the mode 2 sequence is identical to that of mode 1. To reduce parachute opening loads, the drogue decelerates and stabilizes the seat before the parachute opens. In mode 2, the output of the 0.1-second initiator is blocked by the low-speed selector valve (LSSV) because airspeed is above 225 knots. The flow of gases is delayed until the 1.3-second delay initiator fires. This delay reduces the parachute's opening shock. When the 1.3-second delay initiator fires, the ballistic gases are directed to the 7,000-foot aneroid-actuated initiator. Since the altitude is below 7,000 feet, the initiator fires. This actuates the WORD motor and drogue release assembly

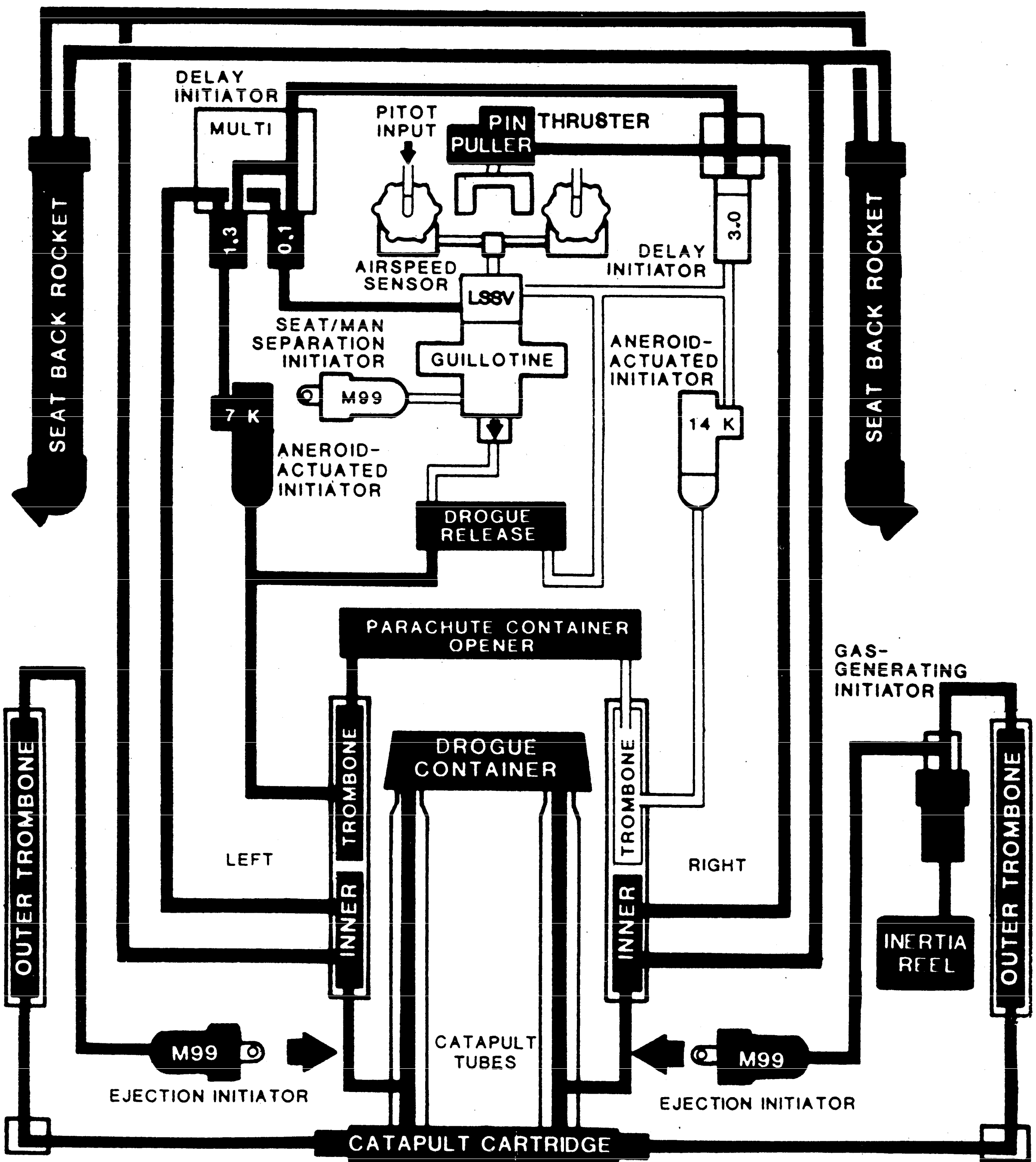


Figure 6-35.—Mode 2: high speed/low altitude.

and operates the parachute container opener assembly. The remainder of the mode 2 sequence is identical to the mode 1 sequence. If the mode 2 sequence should fail, then the mode 3 sequence automatically provides the ejection sequence.

MODE 3.— Mode 3 (fig. 6-36) is an intermediate altitude (above 7,000 feet and below 14,000 feet) ejection, which may occur at any airspeed. The primary initiation of the mode 3 sequence is identical to that of mode 1. At ejection, the airspeed and altitude sensors and low-speed selector valve (LSSV) block the gases from the 0.l-second delay initiator. The 1.3-second delay initiator fires and arms the 7,000-foot aneroid initiator, which is delayed

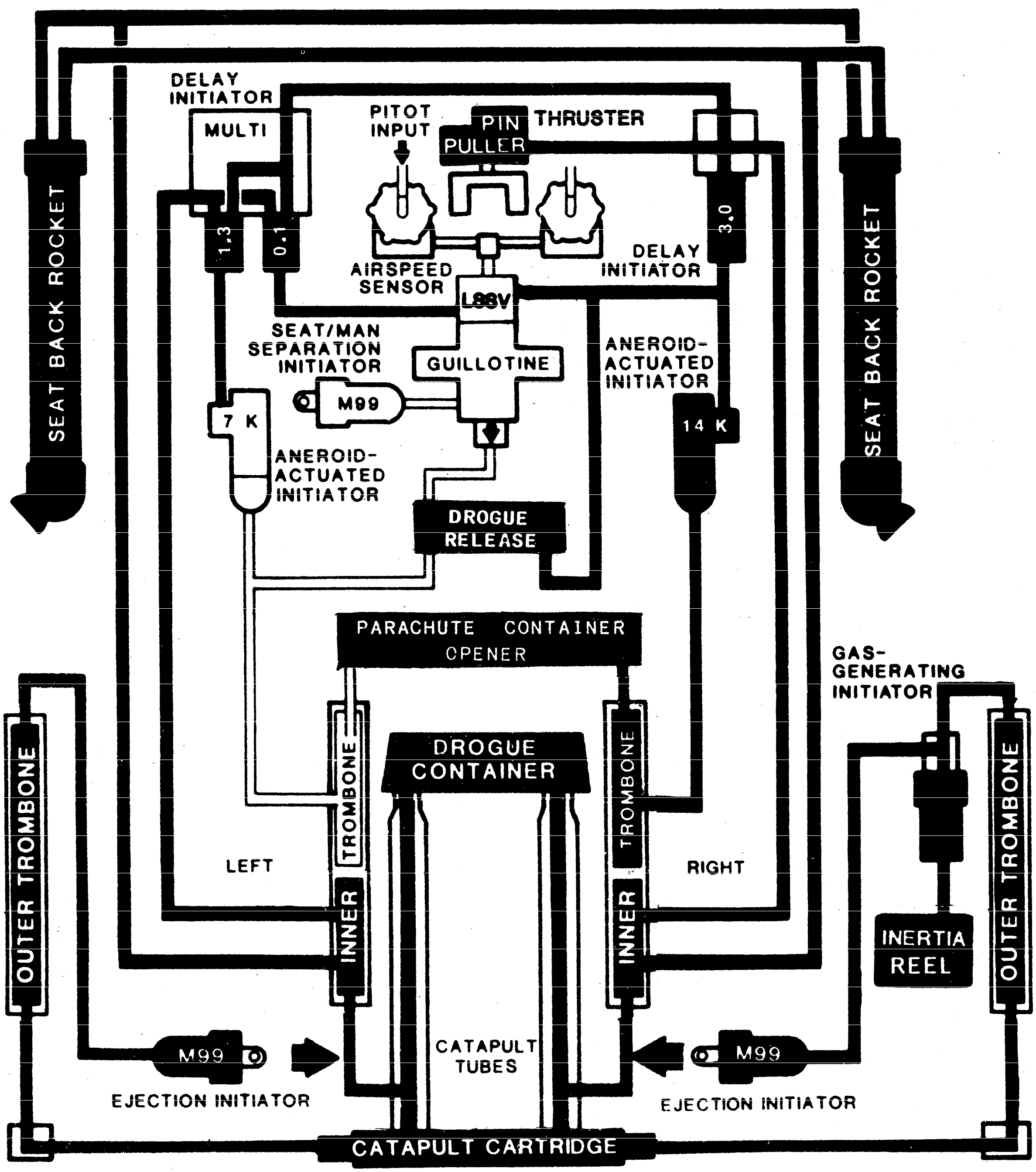


Figure 6-36.—Mode 3: intermediate altitude.

because ejection occurs above 7,000 feet. When the 3-second delay initiator fires, its gases actuate the drogue and WORD release and arm the 14,000-foot aneroid initiator. Since ejection occurs below 14,000 feet, the initiator fires immediately through the right trombone to operate the parachute container opener. The remainder of mode 3 is identical to mode 1. If mode 3 fails, then mode 4 automatically provides the ejection sequence.

MODE 4.— Mode 4 (fig. 6-37) is an ejection above 14,000 feet at any airspeed. The primary initiation of the mode 4 sequence is identical to that of mode 1. At ejection, the ballistic gases from the 3-second delay initiator actuate the

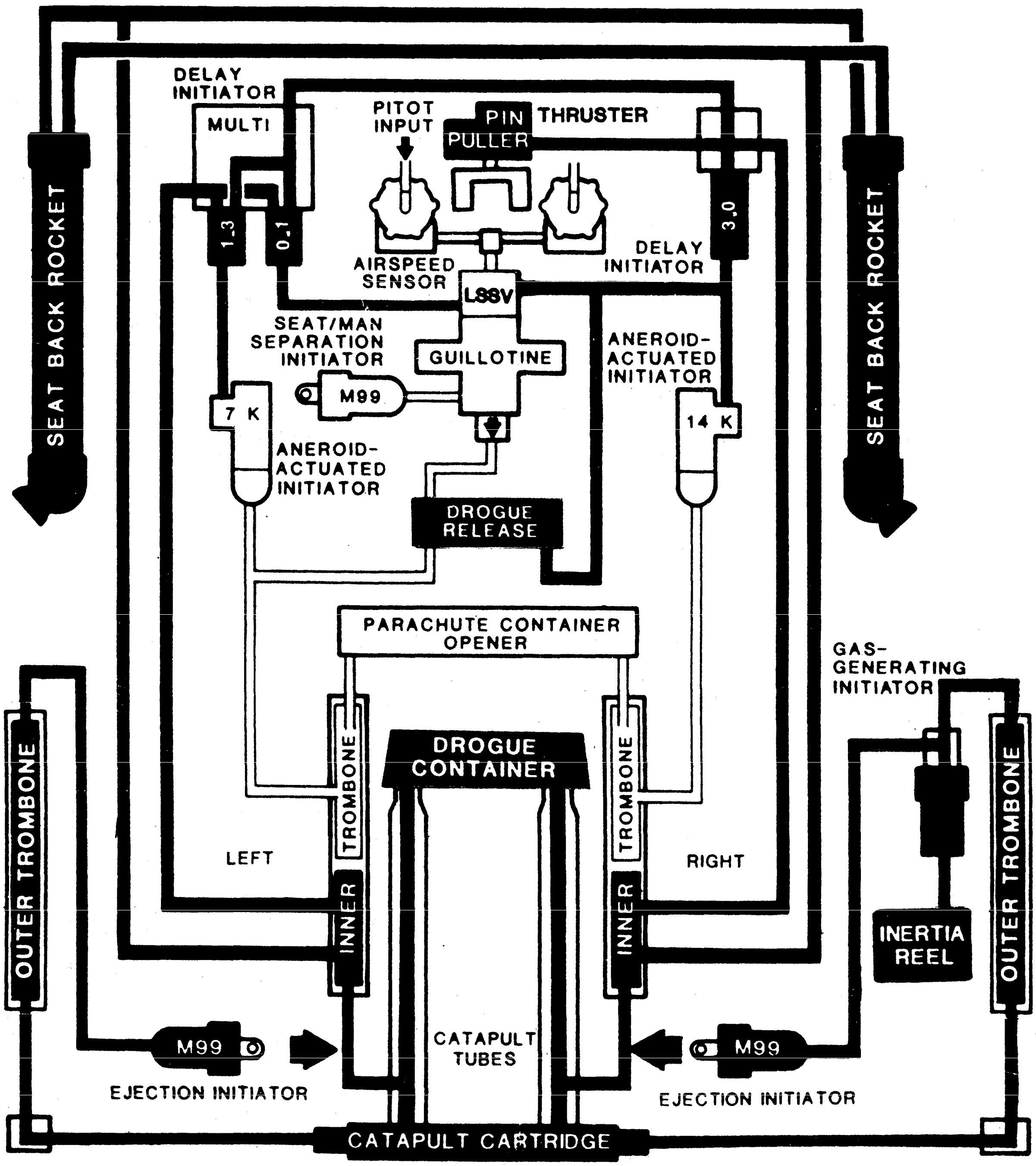


Figure 6-37.—Mode 4: high speed/high altitude.

WORD motor and drogue release assembly and arm the 14,000-foot aneroid-actuated initiator. Meanwhile, the 1.3-second delay initiator arms the 7,000-foot aneroid-actuated initiator, which acts as a backup. The seat and pilot, which are stabilized by the drogue parachute, descend to 14,000 feet pressure altitude. At that point, the 14,000-foot aneroid-actuated initiator fires, actuating the personnel parachute container opener assembly. The personnel parachute assembly is then deployed by the aerodynamic forces acting on the drogue parachute assembly.

Should either the 3-second delay initiator or the 14,000-foot aneroid-actuated initiator fail, the sequence would proceed as described above, except that free fall would continue to 7,000 feet pressure altitude. There, the 7,000-foot aneroid-actuated initiator would actuate the personnel parachute container opener assembly. The personnel parachute assembly would then be deployed by the drogue parachute assembly.

Emergency Parachute Operation and Seat Separation

If all automatic modes fail after the seat is ejected, the emergency release handle may be used for parachute deployment or seat and pilot separation. Operation of the emergency release handle overrides all automatic modes, but it should not normally be used above 14,000 feet.

Upon actuation, mechanical linkage fires the seat and man separation initiator directing ballistic gas to the inertia reel strap guillotine. The guillotine severs two straps and releases the pilot's upper torso restraint. Ballistic gas also actuates both the WORD motor and drogue release assembly and the parachute container opener assembly. The personnel parachute assembly is

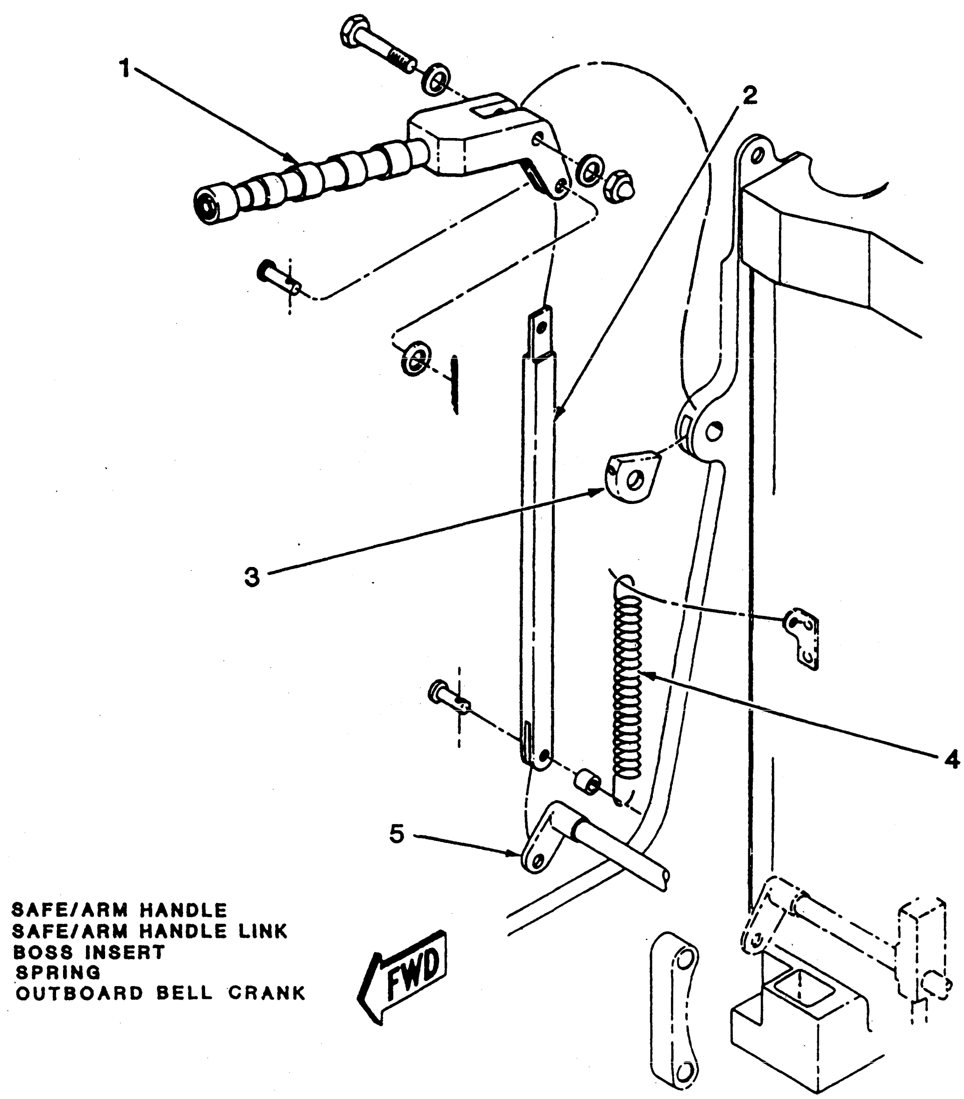


Figure 6-38.—Safe/arm control assembly and link.

then deployed by the drogue and the WORD motor, depending upon airspeed at the time of manual override initiation.

SUBSYSTEMS

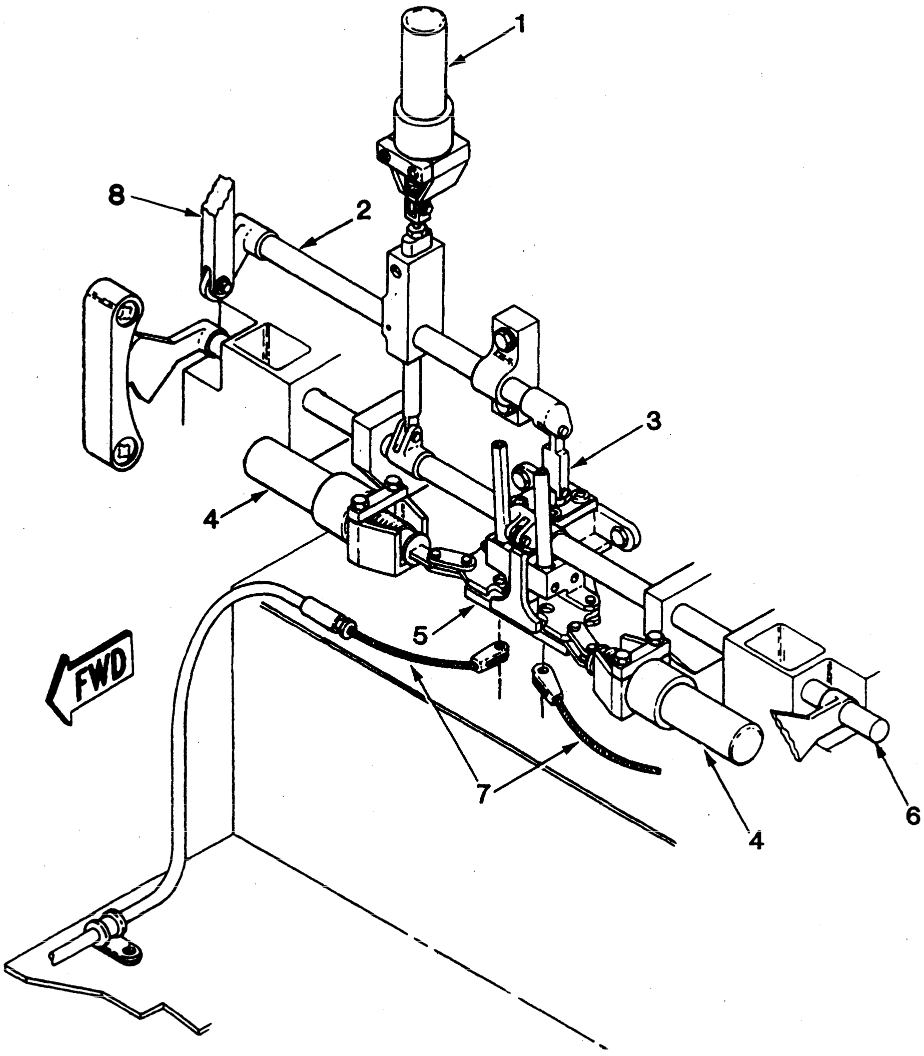
There are several functional subsystems of the Stencel SJU-8/A ejection seat. The subsystems are described in the approximate order in which they operate in the ejection sequence.

Safe/Arm Control Assembly and Link Subsystem

The safe/arm control assembly and link subsystem (fig. 6-38) places the seat in either a safe or an armed condition. The subsystem safeties three mechanically actuated M99 initiators when the seat is not occupied or when it needs to be kept in the safe condition. For the safe position, you should pull the knob on the handle to disengage the lock. Then move the handle to the full UP position. The seat is safetied by mechanically positioning a link and plunger, which prevents rotation of the initiation subsystem rotors. It also safeties the linkage that actuates the seat/man separation initiator. For the armed position, you should pull the knob on the handle and move the handle to the full DOWN position.

Ejection Initiation Subsystem

The ejection initiation subsystem (fig. 6-39) consists of an ejection control handle, mechanical



1. Seat/Man separation initiator
2. Connect/Disconnect assembly
3. Safety plunger
4. Ejection initiators
5. Initiator subsystem assembly
6. Seat release shaft
7. Ejection control handle cables
8. Safe/Arm handle link

Figure 6-39.—Ejection initiation system.

linkage, and two ejection initiators. Actuation of the ejection control handle, located on the front panel of the seat bucket, mechanically pulls the firing cable, rotating the initiation subsystem rotors, which, in turn, extract a firing pin from each of the two M99 ejection initiators. The output gas pressure from either or both of the initiators is transmitted to two igniters, one on each side of the catapult cartridge, the inertia reel gas-generating initiator, the multiple time-delay initiator, and the thruster. The two catapult cartridge igniters provide catapult ignition redundancy.

Catapult Subsystem

The catapult subsystem (fig. 6-40) provides seat propulsion throughout the catapult stroke and applies pressure to the drogue pistons that project the drogue parachute and its container upward into the airstream. It also provides ballistic gas to initiate seat-back rocket ignition and post-election sequencing operations. This subsystem may be divided into five major parts. These parts are described in the following paragraphs.

CATAPULT CARTRIDGE.— The catapult cartridge provides ballistic gas pressure to boost

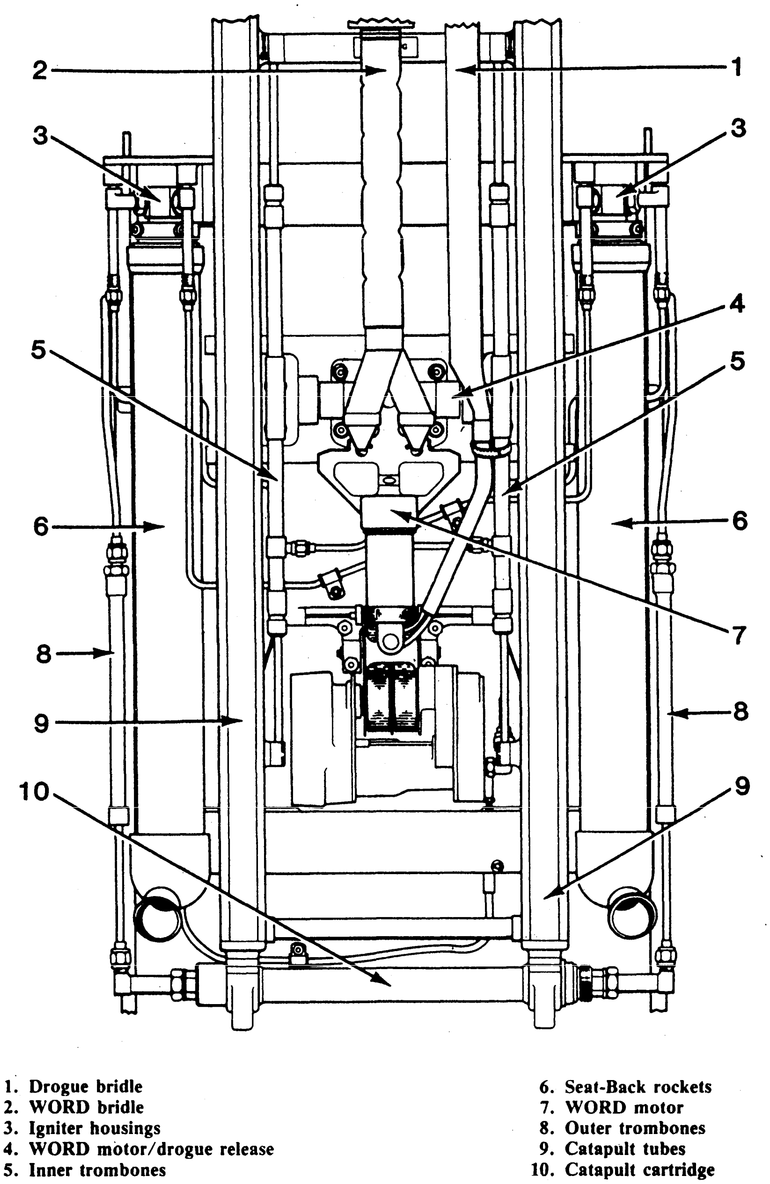


Figure 6-40.—Catapult system.

the seat and pilot out of the cockpit and to expel the drogue container and chute from the seat. The catapult cartridge also initiates ignition of two SBR motors and initiates the post-ejection sequencing subsystem (fig. 6-41).

CATAPULT TUBE ASSEMBLIES.— The catapult tube assemblies house the catapult lock and unlock mechanism, provide physical support for the seat bucket via the seat height adjustment actuator and slipper assemblies, and support the trombone assemblies. They also support a headrest and personnel parachute container assembly, drogue parachute and container assemblies, and associated interconnecting hardware.

The catapult tube assemblies also provide several other functions. First, they provide the energy and movement for the canopy piercers and breakers to penetrate the aircraft canopy. They also route and apply ballistic gas pressure to eject the drogue container and parachute. They route and apply ballistic gas pressure to initiate the seat-back rocket motors. Finally, they route and apply ballistic gas pressure to initiate the

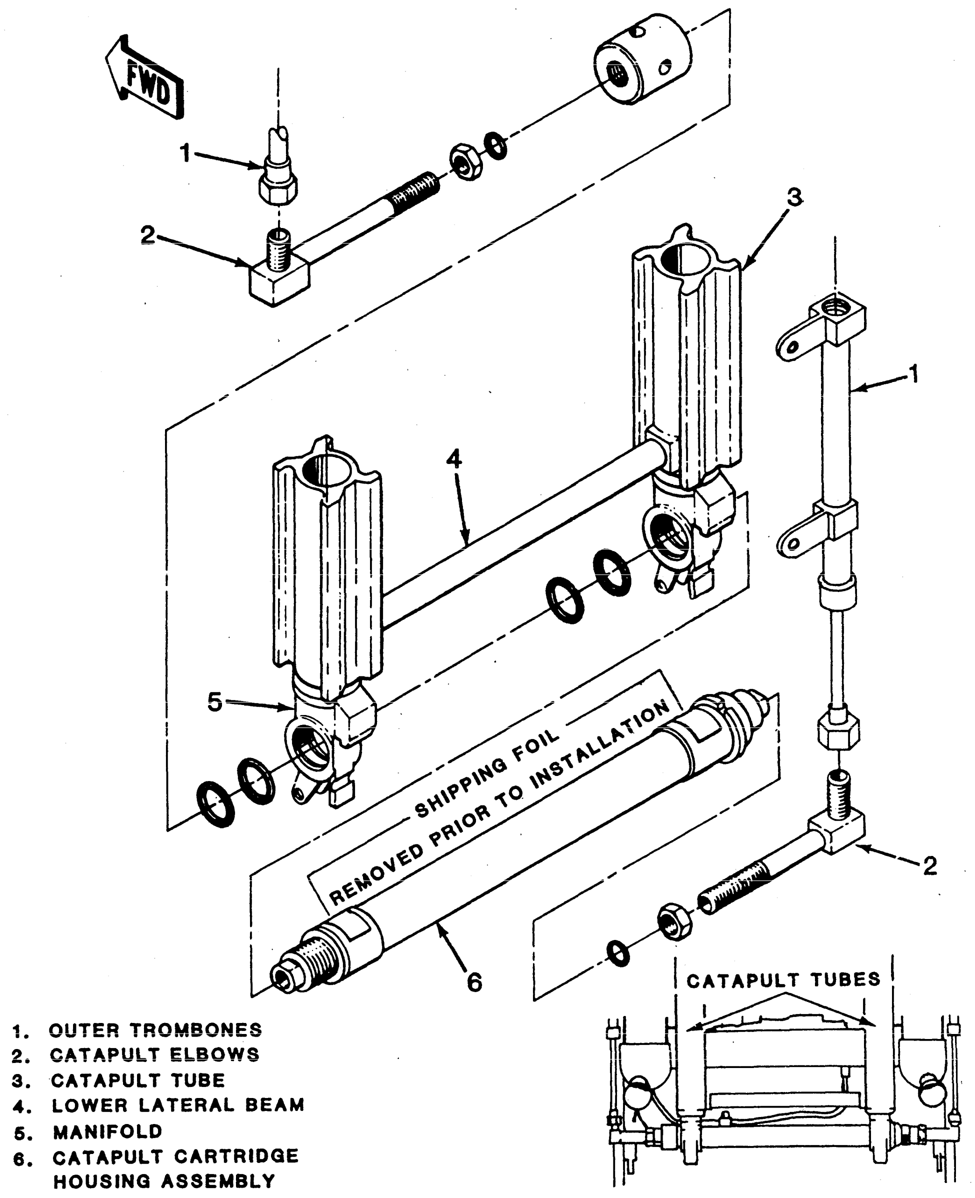


Figure 6-41.—Catapult cartridge and tube assemblies.

gas-operated components of the post-ejection sequencing subsystem (fig. 6-41).

CATAPULT LOCK AND UNLOCK MECHANISM.— The catapult lock consists of a locking piston and six locking balls set between the inner and outer catapult tubes. The catapult lock retains the seat in the cockpit during inverted flight. Upon seat ejection, the lock is released by gas pressure from the catapult cartridge. Catapult cartridge gases move the locking piston upward and permit the locking balls to disengage from the groove in the outer catapult tube. This action removes all connection between the inner and outer catapult tubes.

DROGUE CHUTE AND CONTAINER PROJECTION.— When the outer catapult tubes have moved upward approximately 16 inches on the inner tubes, gas pressure is applied to the pistons attached to the drogue container. There is one piston in each outer tube. When the pistons exit the top of the outer catapult tubes, the drogue container and parachute move up and aft of the seat. Then, aerodynamic pressure is applied to the container. This causes stretching of the drogue bridle and loosening of the drogue container flaps. The drogue suspension lines and canopy then emerge while the container and associated hardware are jettisoned (fig. 6-42).

TROMBONE ASSEMBLIES.— Two pairs of trombone assemblies are associated with the catapult. The outer trombone assemblies route ballistic gas from two M99 ejection initiators to the catapult cartridge igniters.

The inner trombone assemblies route ballistic gas pressure from the catapult tube assemblies to components of the post-ejection sequencing subsystems and to both seat-back rockets (SBR). They also route ballistic gas pressure from the 7,000- and 14,000-foot aneroid-actuated initiators to the parachute container opener (fig. 6-40).

Sustainer Thrust Subsystem

During either mode 1 or mode 2 operation, two SBR motors provide the thrust necessary to propel the seat and pilot to an altitude sufficient to attain terrain and aircraft tail clearance and to allow personnel parachute deployment and inflation. Each SBR has dual-ignition inlet ports. Ballistic gas pressure from both catapult tube assemblies is ported into both SBRs to provide redundant ignition. This pressure fires internal SBR igniters, which ignite the propellant grain for a burn time of approximately 0.25 second (fig. 6-40).

DART Stabilization Subsystem

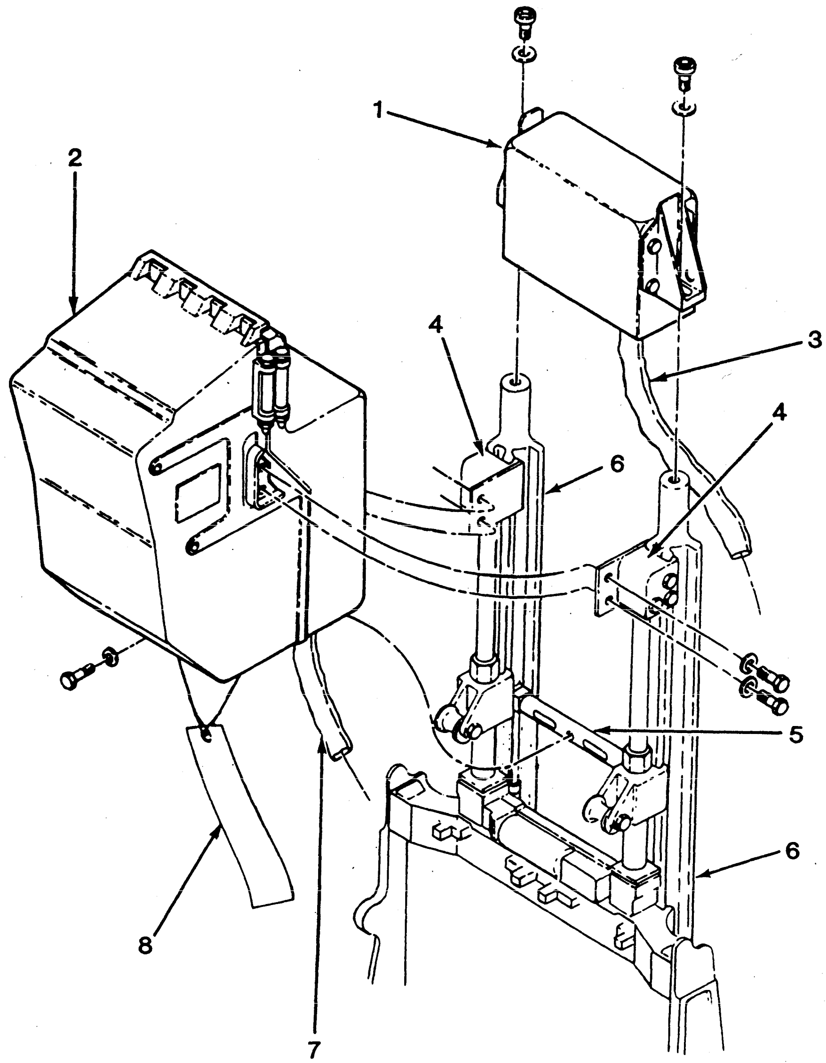
The directional automatic realignment of trajectory (DART) stabilization subsystem, composed of a bridle, a brake assembly, and two nylon slip lines, provides stabilization for the seat and pilot during low-speed ejections. Stabilization is accomplished by correcting any misalignment of the seat and pilot center of gravity relative to the SBR thrust center line. One end of the bridle is permanently attached to the under side of the seat bucket. It acts as a hinge during DART operation. Cables attached to the other end of the bridle restrict the arc of the bridle to a predetermined angle. This ensures optimum operation. Part of each slip line is stowed in a protective fabric housing routed through the brake assembly. The remainder of the two slip lines is stowed in a second protective fabric housing after being routed through fairleads on the bridle aft side. Free ends of the slip lines are attached to the catapult cartridge manifolds of the ejection seat. Slack in the slip line permits the seat to travel through seat tip-off and initial rotation, which results from center of gravity and thrust center line misalignment. Tension developed in the slip lines by the brake assembly imparts a correcting moment to the seat and pilot. This is necessary to counteract excessive seat and pilot pitch rotation and also to provide trajectory control.

Post-ejection Sequencing Subsystem

The post-ejection sequencing subsystem includes all gas-operated and cartridge-actuated devices required to initiate operational mode sequencing functions. It also includes the WORD rocket motor, the primary means for personnel parachute deployment in the inertia-WORD (I-WORD) rocket motor deployment sequence of mode 1, and the backup means for the drogue-WORD deployment sequence of modes 2, 3, and 4 .

Personnel Parachute Subsystem

The personnel parachute subsystem includes a WORD bridle assembly, riser assemblies with lanyards, spring-loaded internal pilot parachute assembly, main canopy assembly, ballistic spreading-gun assembly, and an override and



1. Drogue container assembly
2. Headrest assembly
3. Drogue bridle
4. Supports
5. Parachute container opener
6. Catapult tubes
7. WORD bridle
8. Headrest safety pin assembly

Figure 6-42.—Headrest and drogue container assemblies.

disconnect assembly. The riser assemblies with lanyards initiate the spreading gun and the seat and man separation.

When the parachute container opener is actuated, either one of the two locking clips will disengage and release a ball fitting on the end of a restraining cable. This action allows the container to open and the main canopy assembly to deploy. The canopy assembly is propelled by the WORD bridle, which is acted upon by the force of the drogue and WORD motor. Should the WORD bridle fail, the internal pilot parachute functions as a backup system.

When the main canopy and suspension lines are fully deployed, the spreading-gun firing lanyard exerts tension on a spring-loaded firing pin in the ballistic spreading-gun assembly. This pin is withdrawn until the pin-locking balls slip into a groove in the gun housing. Then, the firing pin, driven by spring force, releases, strikes, and fires dual primers that ignite the spreading gun cartridge. Cartridge energy drives 14 pistons (attached to alternate suspension lines), which expel 14 slugs in a 360-degree pattern and spread the main canopy. Should the spreading gun cartridge fail to fire, continued tension on the firing lanyard removes a piston-retaining band. This frees the slugs from the spreading-gun housing to allow conventional canopy inflation.

During main canopy deployment, tension is exerted on the pilot chute and main canopy by the WORD bridle. Also, during this time, the override and disconnect will secure the WORD bridle to the parachute. If there is no tension on the WORD bridle and the chute has over 10 pounds of drag, the override and disconnect will function to jettison the drogue chute, drogue bridle, WORD motor, and WORD bridle.

Seat/Man and Survival Kit Release Sequencing Subsystem

The seat/man and survival kit release sequencing subsystem has four functions. These functions are described in the following paragraphs.

AUTOMATIC RELEASE.— As the personnel parachute inflates during the ejection sequence, the parachute risers pull on the seat/man release lanyards. The lanyards rotate the seat pan release rod and fire the seat/man separation initiator. Gas pressure from the initiator then actuates the inertia reel strap guillotine. Gas is also transmitted to the WORD motor and drogue release assembly and parachute container opener, but these devices will have previously operated. Rotation of the seat release shaft releases the seat pan with the attached survival kit.

MANUAL OVERRIDE RELEASE.— The pilot can override any of the post-ejection sequences by actuating the emergency release control. When it is actuated, a mechanical linkage fires the seat and man separation initiator. This directs ballistic gas to the inertia reel strap guillotine, which severs the two straps. With the straps severed, the pilot's upper torso restraint is released. Ballistic gas also shuttles the WORD motor, drogue release assembly, and the parachute container opener assembly. The personnel parachute assembly is then deployed by the drogue or the WORD motor, depending upon the airspeed at the time of manual override initiation.

GROUND EMERGENCY EGRESS.— When the emergency release control is pulled, it rotates the seat release shaft and releases the seat pan with attached survival gear from the seat. The control also operates the linkage that fires the seat and man separation initiator. Initiator gases actuate the inertia reel strap guillotine, which severs the straps that are sewn to the personnel parachute risers. The pilot can then remove the shoulder harness, stand, and exit from the aircraft without parachute hang-up. As the pilot stands, the seat pan moves unrestrained and personnel service leads pull free from their connections. Also, activation of the seat/man separation initiator ballistically releases the WORD and drogue release and parachute container opener.

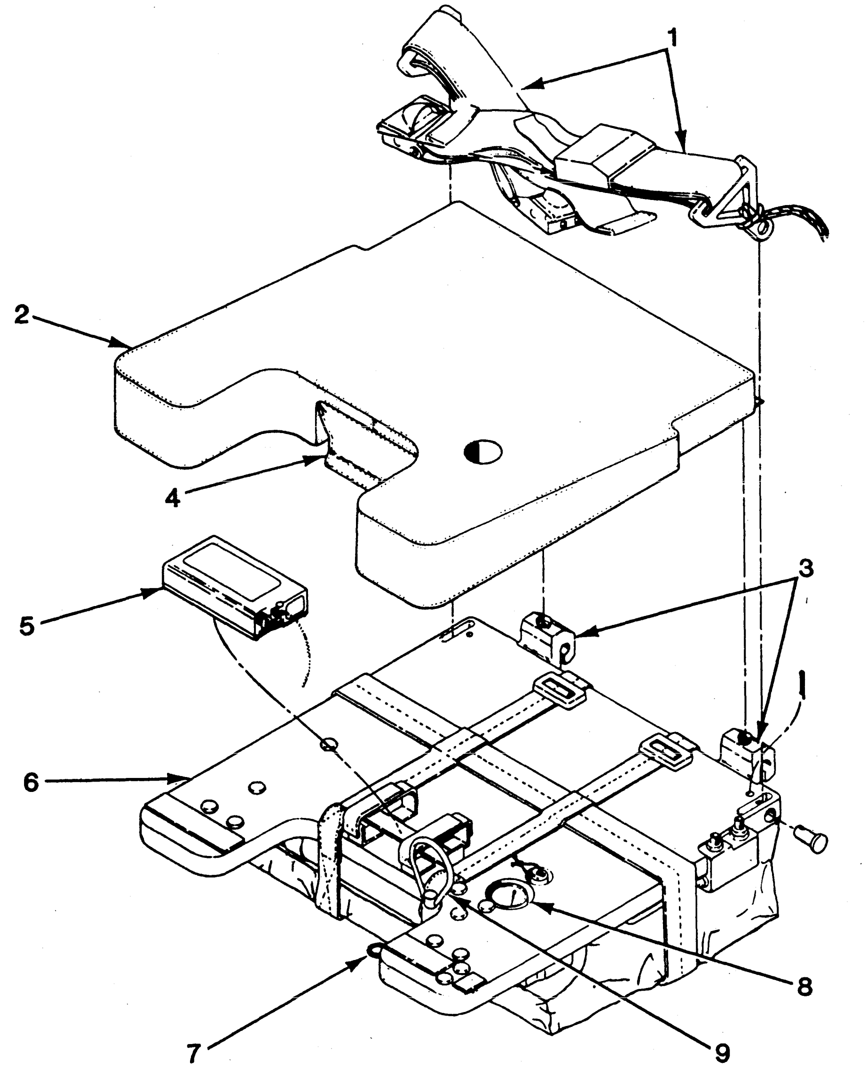
ROUTINE MAINTENANCE.— With the safe and arm control in the UP position and maintenance safety streamer safety pins installed, you must pull the emergency release control to remove the survival kit from the seat for replacement or maintenance.

Survival Kit

The survival kit (fig. 6-43) is a post-ejection life support unit that also serves as a structural portion of the ejection seat. There are three distinct components in the kit: the seat pan, survival package, and emergency oxygen supply.

The seat pan, constructed of a honeycomb core with aluminum alloy face sheets, performs a dual function. First, it provides a base for attaching post-ejection life support equipment. Secondly, as the pilots seat in the aircraft, it provides a structurally secure attachment for the pilot's lower torso restraint belts.

The survival package is attached to the seat pan through a lanyard system. This allows the package to fall free of the seat pan and still remain near the pilot. Upon manual release, the survival package falls approximately 12 feet. It is then snubbbed by a lanyard, which inflates the life raft. The package then falls 13 feet below the raft. This stabilizes the raft during parachute descent. The survival package contains a life raft,



1. Lap belt assembly
2. Bottom cushion assembly
3. Aft hooks
4. FOD flap
5. Radio beacon assembly
6. Survival package assembly
7. Emergency oxygen and personnel locator beacon lanyard
8. Emergency oxygen pressure gauge
9. Manual emergency oxygen control handle

Figure 6-43.—Survival kit assembly.

signal devices, medical aids, and miscellaneous survival aids.

The emergency oxygen supply, attached to the seat pan bottom, is a self-contained unit that can provide 50 cubic inches of breathing oxygen. It can be operated either automatically (during ejection) or manually. Automatic emergency oxygen control is provided by a lanyard assembly located on the underside of the seat pan left thigh support and is connected to the catapult cartridge manifold. During ejection, upward movement of the seat provides automatic actuation. Manual emergency oxygen control is provided by a handle and pull ring located on the inboard side of the seat pan left thigh support. An upward pull on the handle provides emergency oxygen to the pilot should the aircraft's main oxygen system fail. A pressure gauge, visible through a cutout on the forward left-hand side of the survival kit assembly, should indicate 1,800 psi (needle in the black area) with a full bottle. The emergency oxygen supply should last approximately 15 minutes, depending upon altitude and pilot demand. The higher the altitude, the shorter the duration, because oxygen is delivered by the mask regulator under pressure upon demand.

NOTE: Automatic actuation of the emergency oxygen supply also provides automatic actuation of the emergency locator beacon.

COMPONENT MAINTENANCE

Since the seat assembly is designed for "one-shot" operation, it cannot be operationally checked as a unit. However, various components that contribute to the successful functioning of the seat assembly must be operationally checked and tested.

It is your responsibility to check, test, and adjust ejection seat components as well as remove and replace cartridges. By using the applicable MIMs that contain the procedures for testing, adjusting, and checking components, along with diagrams, drawings, and trouble-shooting charts, you will be able to maintain the ejection seat properly and safely.

NOTE: The following material contains only typical maintenance practices and must not be used during actual component repair and tests. Use only the information contained in the applicable MIM.

There are several procedural checks that may be performed on the Stencel ejection seat. For each of these checks, you should ensure that the safe/arm control is in the SAFE (up and locked) position and that all three maintenance safety streamer safety pins are installed prior to beginning the tests. Most of the checks require that you remove the survival kit and wedge assemblies prior to starting the test and reinstall them at the completion of the test. This is not required for the height adjustment actuator check-out. When you are performing several checks in succession, you do not need to remove and reinstall the survival kit and wedge assemblies between each test.

Safe/Arm Control Assembly Check-out

The individual actions required to check-out the safe/arm control assembly may be grouped' into 11 major steps.

1. Install the initiator pull test tool set, as shown in figure 6-44.

2. Manually release the safe/arm control assembly release. You should ensure that spring tension is evident in the release knob. Then, you should lower the safe/arm control to the full DOWN position.

3. Attach a push-pull gauge to the safe/arm control assembly and then pull upward. The handle should move upward and lock in the SAFE (full up) position with a maximum force of 10 pounds with no evidence of binding. You should observe the outboard bell crank rotate downward, disengaging the upper and lower connect and disconnect sears. Also observe that the inboard bell crank rotates upward to fully engage, the safety plunger between the initiator rotors.

4. Raise the emergency release handle to the UP and LOCKED position. You should not see movement of the upper connect and disconnect sear; however, the lower connect and disconnect sear should move down. You should check to see that the T-bar blocks the initiation rotors.

5. Lower the emergency release handle to the full DOWN position: You should see the bell crank connected to the lower sear rotating upward, the initiation subsystem rotors not moving, and the T-bar moving, down.

6. Observe that the initiation rotors do not move when you pull on the ejection control handle.

7. Lower the safe/arm control assembly to the full DOWN position. You should ensure the safe/arm control moves to the DOWN position with no evidence of binding, and the inboard bell crank moves downward and completely disengages the safety plunger from the rotors.

8. Raise the safe/arm control assembly to the full UP position. You should ensure that the safe/arm control is locked into position.

9. Lower the safe/arm control assembly to the full DOWN position. The emergency release handle is raised to the UP and LOCKED position. You should observe that the upper sear moves down and the pull-test tool extends to the RELAXED position.

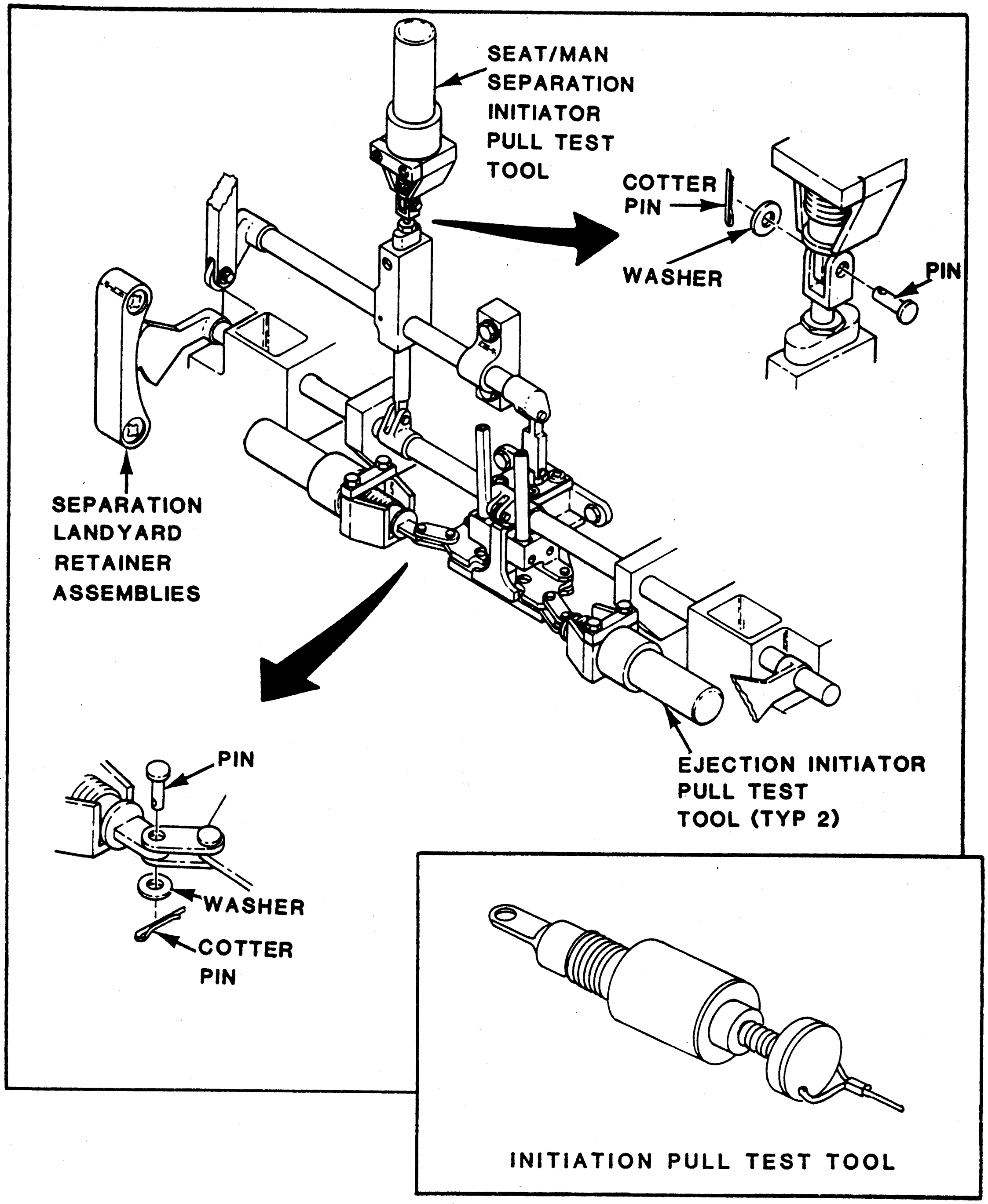


Figure 6-44.—Initiation pull-test tools installation.

10. Lower the emergency release handle to the DOWN and LOCKED position. When you pull up on the ejection control handle, you can observe that the initiation rotors move and the pull-test tool extends to the relaxed position.

11. Stow the ejection control and reset the pull-test tools. You should raise the safe/arm control to the full UP position. Then, you remove the initiation pull-test tool set.

Emergency Release Handle Assembly Check-Out

The emergency release handle assembly check-out may be divided into nine major steps.

Portions of the test are shown in figures 6-45 and 6-46.

1. Install the initiation pull-test tool set. Lower the emergency release handle and the safe/arm control to the DOWN and LOCKED position. Position the push-pull gauge against the top of the emergency release handle and press down on the latch. You should be able to retract the latch with a maximum of 15 pounds of force.

2. Depress the locking latch and raise the emergency release handle one-fourth inch. Attach a push-pull gauge and lanyard to the emergency release handle and pull up and aft. The handle should rotate fully with a maximum force of 40 pounds. You should also notice that seat release shaft rotation actuates the seat and man separation sear, and the pull-test tool extends to the relaxed position. Check to see that the T-bar blocks the firing control rotors, and the emergency release handle is locked in the UP position.

3. Lower the emergency release handle to the full DOWN and LOCKED position. Watch the seat and man separation sear return to the ARM position and the T-bar disengage from the firing control rotors.

4. Raise the safe/arm control to the full UP and LOCKED position. Squeeze the emergency release handle and slowly pull up and aft. Notice that the connect and disconnect upper sear does not move. Lower the emergency release handle to the full DOWN and LOCKED position.

5. Grasp the emergency release handle and, without squeezing the handle or releasing the locking latch, pull up on the handle. The handle should not move.

6. Remove the clevis from the fork at the connect and disconnect sear. Remove the top screws and loosen the bottom screws on the lanyard retainer assemblies. Rotate the retainers forward.

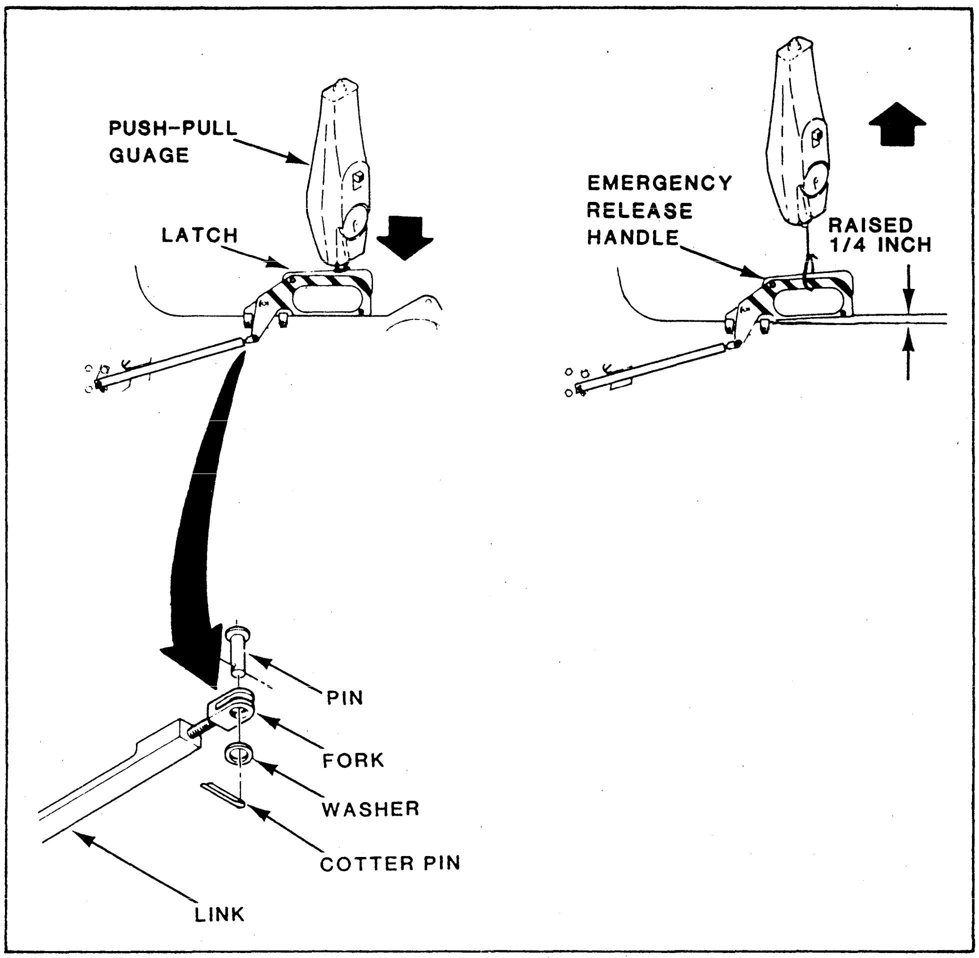


Figure 6-45.—Emergency release handle assembly check-out.

7. Lower the safe/arm control to the DOWN and LOCKED position. Simulate a seat/man separation by unlocking the emergency release handle. Pull upon both the seat and man separation lanyards. Observe that the seat release shaft rotates to the released position and the seat/man separation upper sear moves downward. You should also notice that the seat/man separation lanyards release from the bell cranks.

8. Attach the seat release lanyards to the seat release lanyard bell cranks. At this point, make sure that the seat release lanyards are not pinched between the seat release lanyard bell cranks and the slots in the lanyard retainer assemblies. Rotate the seat release lanyard bell cranks down below the shear pins in the lanyard retainer assemblies. You should ensure that the lanyards remain attached to the bell cranks. Rotate the lanyard retainer assemblies up and aft and install the top screws and washers. Tighten the bottom screws in the lanyard assemblies. When you apply light hand pressure, you should observe freedom of movement in the bell cranks.

9. Lower the emergency release handle to the DOWN and LOCKED position. Remove the initiation pull-test tool set.

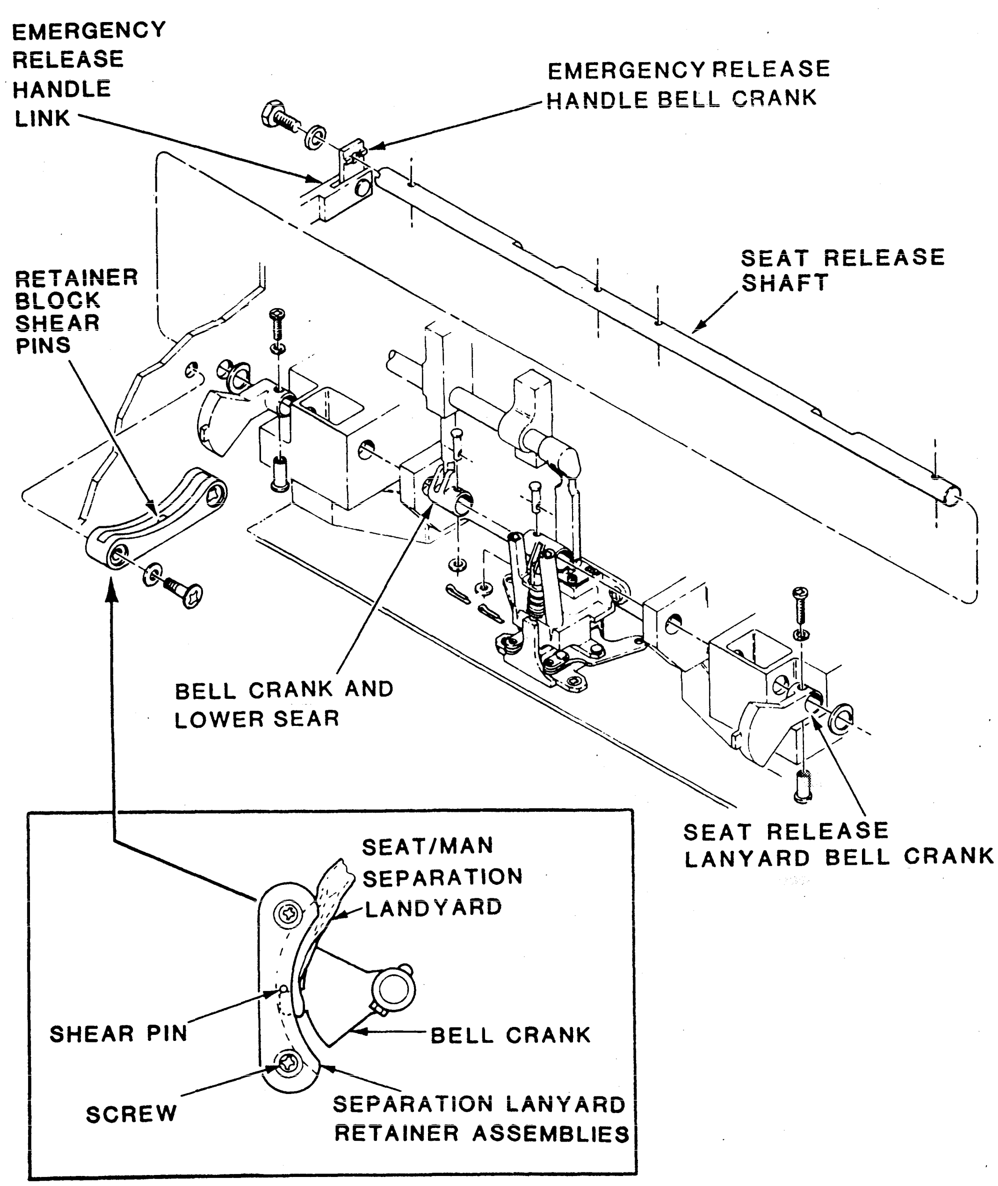


Figure 6-46.—Separation lanyard retainer assemblies.

Ejection Control Assembly Check-out

Checking the ejection control assembly is a four part procedure. The first part of the procedures shown in figure 6-47.

1. Install the initiation pull-test tool set. Ensure the ejection initiator pull-test tools are not preloaded. Position the safe/arm control to the full UP position. Attach a push-pull gauge to the ejection control assembly. Pull upward and record the breakout force. The breakout force should be 15 to 25 pounds.
2. Lower the safe/arm control to the full DOWN position. Continue pulling upward on the ejection control assembly until the pull-test tools extend to the relaxed position. The force required to accomplish this task should be 15 to 40 pounds. You should ensure that the ejection control assembly does not separate from the seat. You should also observe the initiation rotors rotating past the safety plunger.
3. Stow the ejection control assembly while manually returning the initiation subsystem rotors to the ARMED position. Then install the initiation pull-test tool to the upper connect and disconnect sear. At this point you can simulate automatic seat/man separation by rotating the emergency release handle to the full UP position. Notice that the upper connect and disconnect sear moves down, and the pull-test tool extends to the relaxed position. Check to see that the T-bar is in the full UP position, and that it is blocking the initiation rotors.
4. Raise the safe/arm control to the UP and LOCKED position. Lower the emergency release handle to the DOWN and LOCKED position. Remove the initiation pull-test tool set.

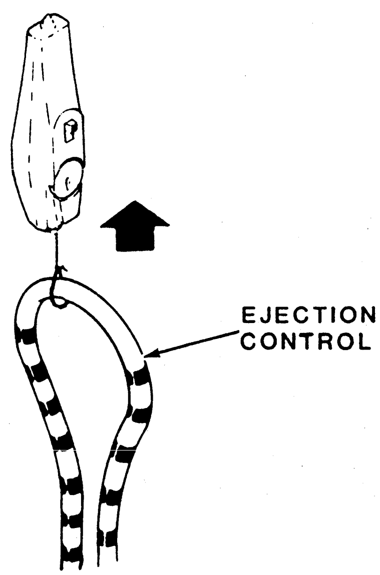


Figure 6-47.—Ejection control assembly check-out.

Inertia Reel Assembly Check-out

The inertia reel check-out may be grouped into seven steps. The test is shown in figure 6-48.

1. Insert the bridle rod through both the parachute riser loops. Position the inertia reel manual control to UNLOCK. Then grasp the center of the bridle rod and extend the risers to mid position. Hold the risers extended and position the inertia reel manual control lever to LOCK. When you pull firmly on the center of the bridle rod, the risers should not extend.
2. Slowly allow the risers to retract. The risers retracting and ratcheting action should be audible during retraction. The inertia reel control lever should not snap into position, or the test results will not be valid.
3. Slowly position the inertia reel manual control lever to UNLOCK. Grasp the center of the bridle rod and extend both risers to the mid position. Exert a sharp pull on the bridle rod. The inertia reel should lock and the risers should not extend when a firm pull is applied. Slowly allow the risers to fully retract, and then pull the risers again. You should not be able to extend the risers.
4. Position the lever to LOCK, and then UNLOCK and extend and retract the risers. The risers should extend and retract freely.
5. Attach a push-pull gauge to the bridle rod. Pull the gauge straight and extend the risers. You should record the force required to extend them. Repeat the step three to five times. The risers should extend with a force of 5 to 15 pounds. Allow the riser to retract slowly.
6. Position a 24-inch steel rule against the forward edge of the yoke and perpendicular to the catapult tubes. Without extending the inertia reel straps, lift the bridle rod and measure the normal extension of the risers. You should record this measurement. Pull on the bridle rod and measure the full extension of the risers. Again, record the measurement. Allow the risers to retract slowly. At full extension, you should observe a minimum of 18 inches. Then, subtract the normal measurement from the extended measurement. The difference between the

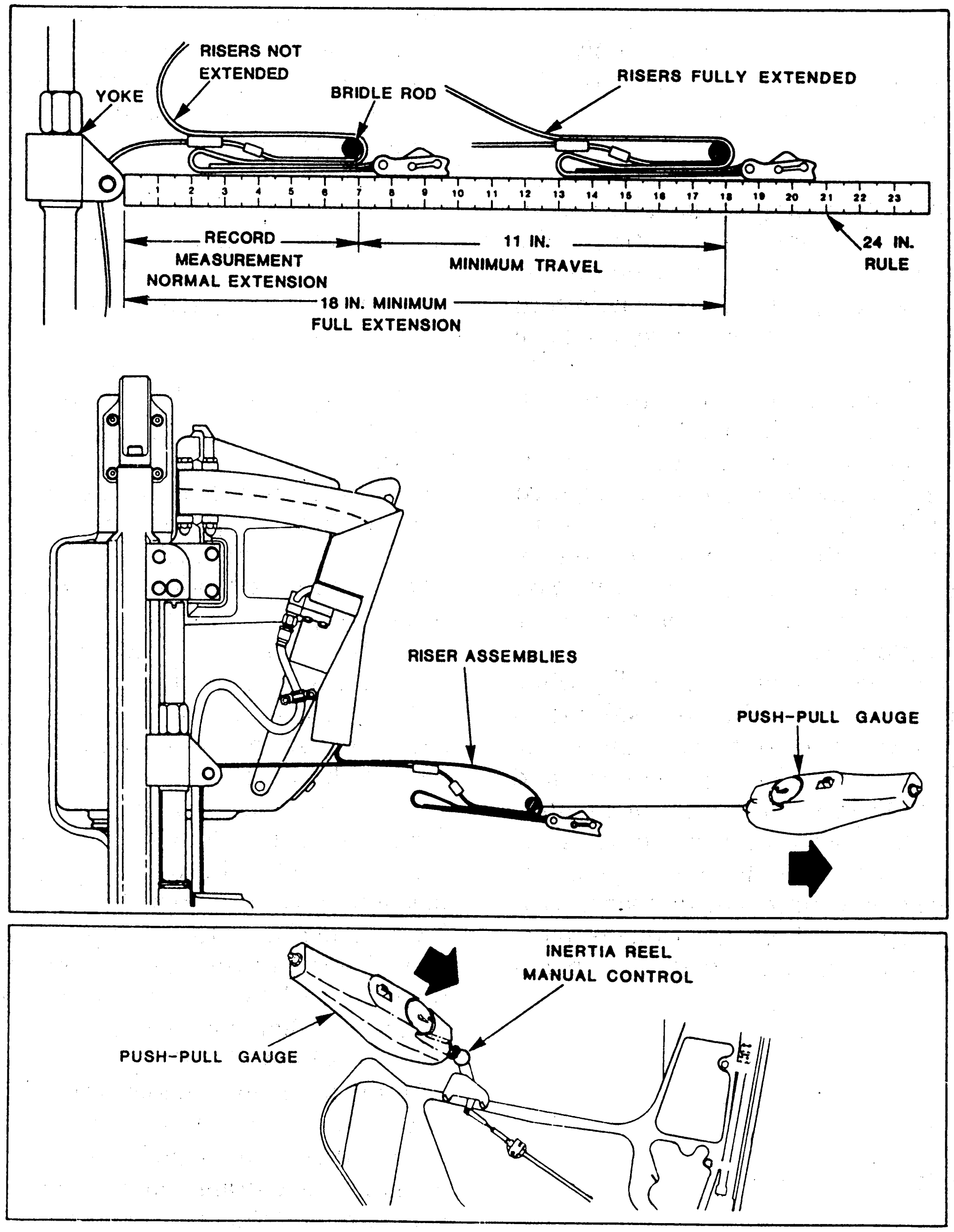


Figure 6-48.—Inertia reel assembly check-out.

measurements should be a minimum of 11 inches of total riser travel.

7. Position the inertia reel control to LOCK. Attach a spring scale to the center of the bridle rod. Position a push-pull gauge against the forward edge of the control knob parallel to the seat side panel. Apply a 50-pound pull to the bridle rod and maintain this tension while applying a push force to the control knob. The control knob should move, without binding, to the aft position with a maximum of 25 pounds of force. Allow the risers to completely retract and remove the spring scale and bridle rod.

Seat Height Adjustment Actuator Check-out

Removal of the wedge and survival kit assemblies is. not required to complete the five steps of the seat' height adjustment actuator

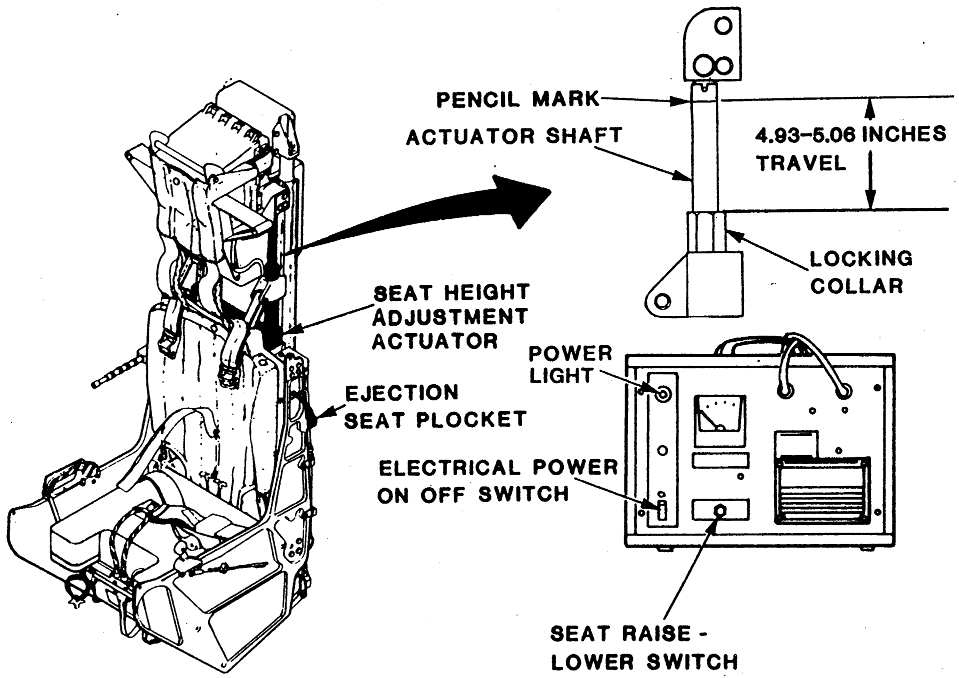


Figure 6-49.—Seat height adjustment actuator check-out.

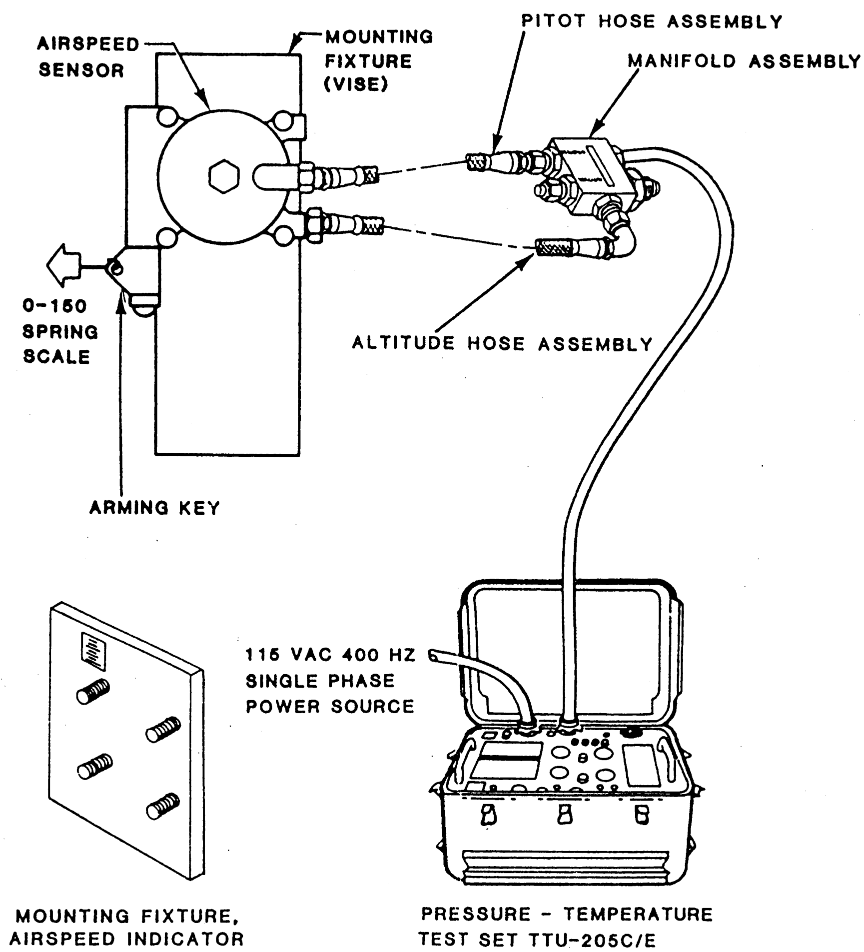


Figure 6-50.—Airspeed/altitude sensor functional check setup.

check-out. Portions of this test are shown in figure 6-49.

1. Attach a control tester to the plocket on the left side of the seat. You should ensure that the tester power switch is OFF and the raise-lower switch is in the mid position. Connect the tester electrical plug to a 115-volt ac, 60 Hz, single-phase power source and position the power switch to ON.

CAUTION

> To prevent damage to the height adjustment actuator motor because of overheating, the operating time limit of 30 seconds on and 1 minute off must be observed.

2. Position the raise-lower switch to RAISE and hold it in that position. You should observe the current indicated on the control tester ammeter while the seat travels to the full UP position. The maximum start current should be 15 amps and the maximum run current should be 5 amps.

3. Release the raise-lower switch and place a pencil mark on the actuator shaft at the locking collar. Now, move the raise-lower switch to LOWER and hold it in that position. Again, you should observe the current indicated on the control tester ammeter while the seat travels to the full DOWN position. You should notice no binding while the seat is traveling. The start and run current requirements are the same as in the previous step.

4. Release the raise-lower switch. At this time, you should measure and record the distance from the pencil mark on the actuator shaft to the upper edge of the locking collar. For the test results to be acceptable, the difference between the measurements should be 4.93 to 5.06 inches of total actuator shaft travel.

5. Raise the seat bucket to the mid-travel position. Position the power switch to OFF. Disconnect the tester electrical plug from the power source and disconnect the tester electrical plocket from the seat.

Airspeed/Altitude Sensor Check-out

The airspeed/altitude sensor (A/AS) must be removed from the aircraft to perform the check-out procedure. The following paragraphs describe the steps of the test procedure. Figures 6-50 and 6-51 show portions of the test.

1. Place the A/AS in the mounting fixture and secure it to the workbench. Screw the pitot

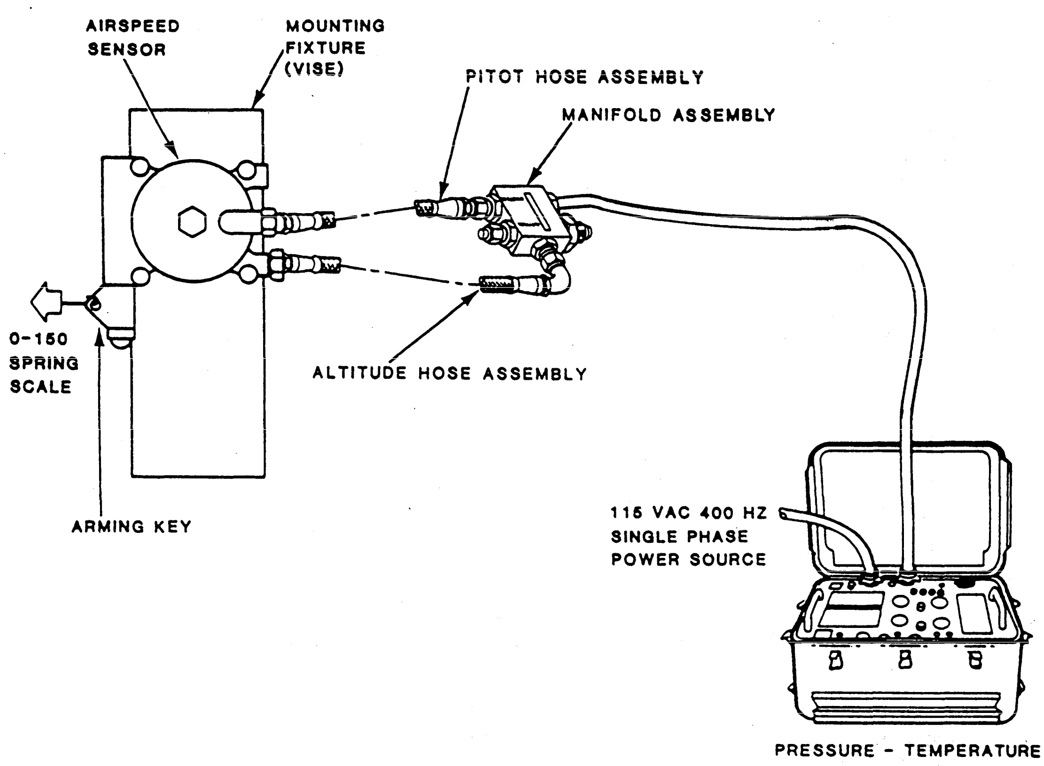


Figure 6-51.—Airspeed/altitude sensor function check.

hose from the manifold assembly onto the pressure port of the A/AS. After you remove the static port filter, screw the altitude hose from the manifold assembly into the static port of the A/AS. Then connect the pitot pressure hose of the test set to the airspeed port of the manifold assembly. Set the pressure temperature test set controls to the positions listed in table 6-1.

WARNING

The TTU-205-C/E test set must be properly grounded to prevent injury to personnel.

2. Connect the test set electrical plug to a 115-volt ac, 400 Hz, single-phase power source. Set the test set power switch to ON. When the pressure stabilizes, the static pressure ready light and the pitot pressure ready light will illuminate. Rotate the static pressure vent and pitot pressure vent controls full clockwise. Position the airspeed knots control to 500. Vary the airspeed trim control as necessary to obtain 500 on the airspeed knots indicator. It will take a few minutes for the airspeed knots indication to increase to 500.

3. Position the airspeed leak test switch to ON. Allow the pitot pressure to stabilize. At this point, you should ensure that the pitot pressure light goes out and that the leak rate is not more than 15 knots in 5 minutes. Position the airspeed leak test switch to OFF. The pitot pressure light should illuminate and the airspeed knots should return to 500. Position the airspeed knots control to 280. Vary the airspeed trim control to obtain 280 on the airspeed knots indicator.

WARNING

To prevent injury, make sure personnel are clear of the A/AS plunger during actuation.

4. Attach a 0- to 150-pound spring scale to the arming key. Apply a straight pull on the scale and remove the sensor arming key. The arming key should release between 6 to 16 pounds of force and the sensor plunger should remain extended.

5. Extend the plunger with the pull tool and reinstall the arming key. Position the airspeed knots control to 250 and vary the airspeed trim control to obtain 250 on the airspeed knots indicator. Remove the A/AS arming key and observe the A/AS plunger retract. Again, use the pull tool to extend the plunger and reinstall the arming key.

6. Position the airspeed knots control to 50. After the airspeed knots indication decreases to the set value, position the test set power switch to OFF. Rotate the static pressure vent and pitot pressure vent controls full counterclockwise. Disconnect the test set pitot hose from the manifold and test set. Remove the pitot hose assembly from the airspeed port of the manifold and connect it to the altitude port of the manifold assembly. Plug the airspeed port of the manifold.

7. Rotate the static pressure vent and pitot pressure vent controls full clockwise. Position the

Table 6-1.—TTU-205-C/E Tester Control Settings

CONTROL	SETTING
POWER	OFF
MODULATION FREQ. HZ	OFF
MODULATION AMPLITUDE	0
MACH LIMIT DISABLE/NORMAL	NORMAL
MACH LIMIT SET	1.5
ALT LEAK TEST	OFF
A/S LEAK TEST	OFF
AIRSPEED KNOTS	50
AIRSPEED RATE/KNOTS/MINUTE	0
AIRSPEED TRIM	CENTERED
ALTITUDE X 1000 FEET	0
ALTITUDE RATE X 1000 FEET/MINUTE	0
ALTITUDE TRIM	CENTERED
ALTITUDE HOLD/NORMAL	NORMAL
TOTAL TEMP: SIMULATE	50.0 OHMS
STATIS PRESSURE VENT	FULL COUNTERCLOCKWISE
PITOT PRESSURE VENT	FULL COUNTERCLOCKWISE
NORMAL/READ EXT.	NORMAL

test set power switch to ON. Position the ALTITUDE x 1000 FEET control between 7 and 8. The altitude feet indication should increase to approximately 7750. You may have to vary the altitude trim control to obtain 7750 on the altitude feet indicator. Remove the A/AS arming key. The A/AS plunger should remain extended.

8. Use the pull tool to extend the plunger and install the arming key. Set the ALTITUDE x 1000 FEET control between 6 and 7. Vary the altitude trim control to obtain 6250 on the altitude feet indicator. The arming key should release with a pull of 6 to 16 pounds of force and the A/AS plunger should retract.

9. Again, you should use the pull tool to extend the plunger and reinstall the arming key. Position the altitude control to zero. After the altitude feet indication decreases to the set value, position the test set power switch to OFF. Rotate the static pressure vent and pitot pressure vent controls full counterclockwise.

10. Remove the manifold assembly from the A/AS and disconnect it from the test set. Disconnect the static pressure hose from the test set. Disconnect the power source and remove the test set.

If the A/AS passes the functional check, you may install it on the seat. If the A/AS is faulty, you should forward it to depot-level maintenance for repair.

CORROSION CONTROL

The manufacturers of the Stencel ejection seat have stated that the seat is corrosion resistant. Therefore, on the special 40-day corrosion inspection, the SJU-8/A ejection seat has no inspection requirements. But we know that during shipboard operation, the seat will come in contact with salt spray, jet exhausts, stack gases, and various other debris. Although the seat is not addressed in the 40-day MRCs, it should be maintained in accordance with the NA 01- lA-509 and local squadron instructions. The NA 01-l A-509 states that ejection seats should have a 7-day inspection performed while at sea and a 14-day inspection when ashore.

LUBRICATING PROCEDURES

You should ensure that oils, greases, preservatives, cleaning solutions, and solvents do not enter enclosed mechanisms, cartridge chambers, and ballistic hose and tube assemblies or come in contact with cartridges or initiators. You should cap all open ports during corrosion maintenance. All lubricants must be applied sparingly, and you must exercise care to protect nylon and cotton fabrics from contamination. Indiscriminant use of paint and preservatives that dry and build up with repeated or excessive application will often result in restricted movement of parts. This can easily render affected seats useless for ejection purposes.

The following lubricants and procedures should be used on the Stencel ejection seat as stated in the NA 01- lA-509.

1. Lubricating oil, VV-L-800, should be applied to all parts that rotate, such as bell cranks, levers, pins, rollers, and similar components.

2. Grease, MIL-G-81322 or MIL-G-23827, should be applied to all parts that slide and should also be used as a corrosion preventive for all bright metal parts.

3. Apply MIL-C-85054 by brush or swab to all unpainted, nonmoving parts, such as nuts and bolts, that do not require lubrication.

4. Cleaning solvent and lubricants may be applied with brush or cloth providing adequate care is taken to prevent entry into closed mechanisms.

5. Surface contaminants such as dried lubricants, dirt, grit, or corrosion products can be removed from intricate bell cranks and levers by scrubbing with a small nylon bristle brush using P-D-680, Type II, cleaning solvent. Follow the cleaning solvent with a light coat of VV-L-800 oil to the entire component or assembly.

EMERGENCY CLEANING

The following emergency cleaning procedures should be used for cleaning ejection seats exposed to gross amounts of salt water or fire-extinguishing agents. The procedures described are normally used only to prevent further damage and will usually require further treatment at a higher level of maintenance.

WARNING

Disarm ejection seat mechanisms before cleaning. Only authorized personnel should disarm seats and perform cleaning operations.

1. Remove parachutes, drogue parachutes where applicable, and seat pans. These items

should be returned to local work centers for cleaning or replacement.

2. Remove ejection seats according to the applicable MIM.

3. Remove the CADs, rockets, and inertia reels from the seats. Cap all gas lines and ports. Then, wipe down these components with fresh water.

4. Rinse the seat thoroughly with fresh water. Continue washing while directing the water into crevices and close fitting parts until the contaminants are removed.

5. Blow as much water as possible from equipment with low pressure, clean, dry air.

6. Dry excess water deposits with a clean cloth, clean paper towels, or remnant cloths.

7. Apply the water displacing preservative MIL-C-81309, Type II, by spray or brush to critical metal surfaces and to recess areas that may not be completely dry. Water displacing preservative protects equipment during necessary inspection or inquiry, and during transfer to the repair custodian.

8. Wash all survival gear and pilot safety equipment with fresh water and dry thoroughly. You should refer to NAVAIR 13-l-6-X for detailed preservation procedures. Lubricate and control corrosion in accordance with maintenance requirements cards.

9. You should comply with all special inspection requirements before reinstallation. Reassemble ejection seats in accordance with the MIMs.

10. If necessary, send the ejection seat to the next higher level of maintenance.

11. Aircraft-mounted escape system components (mechanically activated CADs) should be wiped with fresh water, a cloth, and dried. If external contamination is suspected, these components should be removed and replaced.

CORROSION CONTROL

The existing MIMs and MRCs for most ejection seat systems do not provide sufficient or explicit instruction for corrosion control and lubrication. The *Aircraft Weapons System Cleaning and Corrosion Control Manual*, NA 01-lA-509, and COMNAVAIRPAC/COMNAVAIRLANT INSTRUCTION 4750.2 (series) contain more information on corrosion control. These publications should be on your required reading list. The *Aviation Maintenance Ratings (AMR) Fundamentals*, NAVEDTRA 10342-3, and *Aviation Maintenance Ratings (AMR) Supervisor*, NAVEDTRA 10343-A1, also contain information regarding corrosion control. If needed, commands may develop local MRCs or local maintenance instructions to help eliminate corrosion of ejection seats.

The following general information pertains to most ejection seats. Steps must be taken to prevent corrosion before it occurs. Correct procedures for repair of components and systems after corrosion has been treated must be used to ensure that corrosion does not return. The performance of the 210- and 364-day inspections, the 7-day inspections while at sea, and the 14-day inspections while ashore should be conducted according to the applicable MIMs and MRCs. Preventive maintenance on seat components, including procedures for cleaning and lubrication, is discussed in the following paragraphs.

Seat Structure and Components

Command philosophy varies regarding the painted parts of a seat structure. Some squadrons strip and paint at each 210- and 364-day inspection. Some leave the original anodized finish unpainted. Some touch-up chipped paint. Some do nothing. Each of these philosophies has some merit depending upon local conditions. The seat bucket and beam structure should be wiped with VV-L-800 general-purpose oil. You should allow the oil to soak into crevices, around rivets, and then wipe dry.

Clean metal components with P-D-680, Type II, dry-cleaning solvent, and then inspect them for surface damage and corrosion. Do not attempt to remove light corrosion or discoloration of the cadmium-plated parts. Parts showing rust or pitting of the base metal or more than one area of plating loss should be replaced. Remove light corrosion, except for cadmium plated parts, by using a fine Scotchbrite abrasive mat or 500/600 aluminum oxide abrasive cloth. Lubricate moving parts, such as springs, linkage, and pivot areas, with MIL-G-81322 general-purpose grease. Lubricate firing pins and rollers with VV-L-800 oil. When using VV-L-800 oil, you should apply it with a clean, lint-free cloth such as MIL-C-85043.

Indiscriminate use of paint, preservatives, or other materials that dry and buildup following application can prevent or restrict proper motion of movable parts. These materials must only be used where specified on nonmoving parts. Paint touch-ups of seats installed on the aircraft should be done with a brush.

Metal Removal

The following paragraphs provide guidelines for removal of corrosion products without damaging the structure. Removal of corrosion that has propagated beyond these limits requires replacement of the part.

CADMIUM-PLATED PARTS.— On cadmium-plated parts, corrosion will be evident as mottling of the plated surface with color ranging from light gray to black. This is a function of the cadmium plating to protect the underlying base metal, and no attempt should be made to remove the discoloration. The presence of exposed base metal in a localized area is acceptable and should be protected. The appearance of red rust is cause for part replacement.

CHROMIUM AND NICKEL-PLATED PARTS.— You should polish bright plated parts with a fine Scotchbrite abrasive mat or 500/600 aluminum oxide abrasive cloth. Do not penetrate to the base material. If base material is exposed, it is cause to remove and replace the affected part.

ALUMINUM FORGINGS AND CASTINGS.— Metal removal should not exceed 0.005 inch in depth. You should apply chemical conversion coating (alodine) to bare surfaces and repaint them as required.

RESTORATION OF FINISH

Abrasions and isolated damage areas may be restored using the following procedures: First, mask the area to be treated. You should feather sand the area around the damage with abrasive paper or Scotchbrite mat. Next, apply paint remover or methyl ethyl ketone and wipe the area dry with cheesecloth before the solvent evaporates. At this point, if bare metal is showing, you should apply alodine and allow it to dry. Finally, apply one coat of primer and two coats of paint.

Special attention should be paid to the use of primers, polyurethane paints, paint removers, and methyl ethyl ketone. They are all flammable and toxic. Do not use them near open flames or sparks. Do not allow them to come in contact with your skin or eyes. Their use should be restricted to a well-ventilated area.

SAFETY PRECAUTIONS

Safety precautions must be strictly observed when working around aircraft equipped with an ejection seat. These safety precautions cannot be overemphasized. Each ejection seat has several ground safety pins. These safety pins are provided on red-flagged lanyards for use at every point of potential 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:

1. Ejection seats must be treated with the same respect as a loaded gun.
2. Always consider an ejection seat system as loaded and armed.
3. Before you enter a cockpit, know where the ejection seat safety pins are located and make certain of their installation.
4. 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 adequate supervision. Unless proper maintenance procedures are followed explicitly, even the most routine ejection seat maintenance tasks can grow drastically out of proportion and bring about an accident or injury. Education of the workers involved is the best assurance for personnel safety. The workers should be made aware of potential hazards and the proper means of protecting themselves. Workers should be assigned according to their capabilities.

APPENDIX I

GLOSSARY

ABO—Aviators breathing oxygen.

ACM—Air-cycle machine.

ACS—Air-conditioning system.

ADC—Air data computer.

AFC—Airframes change.

AIMD—Aircraft intermediate maintenance department.

ALLOY—A metal that is a mixture of two or more metals.

AMBIENT—Surrounding; adjacent to; next to. For example, ambient conditions are physical conditions of the immediate area such as ambient temperature, ambient humidity, ambient pressure, etc.

AN—Air Force—Navy (standard or specification).

ANOXIA—A complete lack of oxygen in the blood stream.

APU—Auxiliary power unit.

BIT—Built in tester.

BLEED AIR—Hot, high-pressure air, taken from the compressor section of a jet engine.

CAD—Cartridge and cartridge-actuated devices.

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. This scale was formerly known as the centigrade scale, but it was renamed in recognition of Anders Celsius, the Swedish astronomer who devised the scale.

CF_3Br—The chemical symbol for trifluorobromomethane.

CNO—Chief of Naval Operations.

CONTAMINANT—An impurity such as harmful foreign matter in a fluid.

EI—Engineering investigation.

FCDC—Flexible confined detonating cord.

FLSC—Flexible linear shaped charge.

GPM—gallons per minute.

Hg—Mercury.

IMA—Intermediate maintenance activity.

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, 3030 indicates the 30th day of 1983.

KINKED—A twist or curl, as in cable, wire, or tubing, caused by its doubling or bending upon itself.

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.

MRC—Maintenance Requirements Card.

MULTIMETER—An instrument used for measuring resistance, voltage, or amperage.

NADEP—Naval Aviation Depot.

NATOPS—Naval Air Training and Operating Procedures Standardization.

NAVAIRSYSCOM—NAVAIR; NA (Naval Air Systems Command).

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.

OPNAV—Office of the Chief of Naval Operations.

OXIDATION—That process by which oxygen unites with some other substance, causing rust or corrosion.

PSI—Pounds per square inch.

PSIA—Pounds per square inch absolute.

PSIG—Pounds per square inch gauge.

PRESSURE—The amount of force distributed over each unit of area. Pressure is expressed in pounds per square inch (psi).

RAC—Rapid Action Change.

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. Formerly ground support equipment (GSE).

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.

SOLVENT—A liquid that dissolves other substances.

TENSION—A force or pressure exerting a pull or resistance.

TORQUE—A turning or twisting force.

TOXIC—Harmful, destructive, deadly; poisonous.

VOLATILE LIQUIDS—Liquids that are readily vaporizable at relatively low temperatures. Explosive liquids.

WARNING—An operating procedure, practice, etc., that if not followed correctly could result in personal injury or loss or life.

WORK—The transference of energy from one body or system to another. That which is accomplished by a force acting through a distance.

APPENDIX II

REFERENCES

CHAPTER 1

Environmental Control Systems, NAVAIR 01-85, ADF-2-2.5.1, Naval Air Systems Command, Washington, DC, August 1988

Escape and Survival Systems, NAVAIR 01-85, ADF-2-2.4, Naval Air Systems Command, Washington, DC, May 1987.

Utility, Environmental and Personnel Survival Equipment, NAVAIR 01-85WBA-2-2.4, Section II, Naval Air Systems Command, Washington, DC, April 1981.

Principles of Operation Environmental Control System, NAVAIR 01-S3AAA-2-2.7, Work Packages 00900, 01100, and 01300, Naval Air Systems Command, Washington, DC, September 1985.

Principles of Operation Propulsion System, NAVAIR 01-S3AAA-2-2.6, Work Package 004 08, Naval Air Systems Command, Washington, DC, April 1980.

Principles of Operation Environmental Control System, A1-F18AA-410-100, Work Packages 00800, 01200, and 01300, Naval Air Systems command, Washington, DC, March 1980.

Airborne Weapons/Stores Loading Manual, NAVAIR 01-F14AAA-75, Chapter 2, Naval Air Systems Command, Washington, DC, July 1984.

Maintenance Environmental Control System, NAVAIR 01-F1AAA-2-4-2, Work Package 05500, Naval Air Systems Command, Washington, DC, September 1983.

Principles of Operation Environmental Control System, NAVAIR 01-F14AAA-2-2-2, Work Package 01000, Naval Air Systems Command, Washington, DC, January 1984.

Ground Support Equipment, NAVAIR 01-F14AAA-4-15, Work Package 01400, Naval Air Systems Command, Washington, DC, March 1982.

Principles of Operation Airframe Group Systems, NAVAIR 01-S3AAA-2-2.2, Work Packages 00307, 00308, 00309, and 013 13, Naval Air Systems Command, Washington, DC, July 1977.

Description and Principles of Operation Escape and Survival System, NAVAIR 01-45AAE-2-2.3, Work Package 00500, Naval Air Systems Command, Washington, DC, October 1985.

T2 B/C Personal Survival, NAVAIR 01-60GAB-2-2.2, Chapter 2, Naval Air Systems Command, Washington, DC, December 1987.

CHAPTER 2

Principles of Operation Environmental Control System, NAVAIR 01-F14AAA-2-2-2, Work Packages 01400 and 02000, Naval Air Systems Command, Washington, DC, January 1984.

Principles of Operation Escape System, NAVAIR 01-F14AAA-2-2-3, Work Package 006 00, Naval Air Systems Command, Washington, DC, January 1984.

Escape and Survival Systems, NAVAIR 01-85ADF2-2.4, Naval Air Systems Command, Washington, DC, May 1987.

T2 B/C Utility System, NAVAIR 01-60GAB-2-2.3, Chapter 2, Naval Air Systems Command, Washington, DC, December 1987.

Escape and Survival Systems, NAVAIR 01-S3AAA-4-8, Page 1, Naval Air Systems Command, Washington, DC, November 1984.

General Use Cartridges and Cartridge-Actuated Devices for Aircraft and Associated Equipment, NAVAIR 11-100-1.1, Chapter 1, Naval Air Systems Command, Washington, DC, September 1984.

CHAPTER 3

Environmental Control Systems, A1-F18AC-410-100, Work Packages 00500, 00700, 00800, and 00900, Naval Air Systems Command, Washington, DC, August 1988.

Utility, Environmental and Personnel Survival Equipment, NAVAIR 01-85WBA-2-2.4, Section II, Naval Air Systems Command, Washington, DC, April 1981.

Navy Electricity and Electronics Training Series, NAVEDTRA 172-03-00-85, Module 3, Chapter 1, Naval Education and Training Program Development Center, Pensacola, FL, 1985.

Principles of Operation Environmental Control System, NAVAIR 01-S3AAA-2-2.7, Naval Air Systems Command, Washington, DC, September 1985.

Vapor Cycle Charging Cart Assembly, NAVAIR 17-15BH-14, Naval Air Systems Command, Washington, DC, June 1966.

Principles of Operation Environmental Control System, Al-H60BB-410-100, Work Package 00300, Naval Air Systems Command, Washington, DC, March 1983.

CHAPTER 4

NAVAIROSH Requirements for the Shore Establishment, NAVAIR A1-NASOH-SAF-0001P-5100-1, Naval Air Systems Command, Washington, DC, February 1986.

Aviators Breathing Oxygen (ABO) Surveillance Program and Field Guide, A6-332A0-GYD-000, Naval Air Systems Command, Washington, DC, October 1985.

Escape and Survival Systems, NAVAIR 01-85ADF-2-2.4, Naval Air Systems Command, Washington, DC, May 1987.

Clifton Precision Instrument and Life Support Division, Publication NO. 7596L, Davenport, Iowa, January 1983.

Clifton Precision Instrument and Life Support Division, Publication NO. 7974A, Davenport, Iowa, January 1983.

Technical Report NO. SY-136R-81, Naval Air Test Center, Patuxent River, Maryland, December 1981.

CHAPTER 5

Servicing Trailer, Liquid Oxygen Low Loss, Closed Loop, NAVAIR 19-25D-26, Naval Air Systems Command, Washington, DC, October 1987.

Gaseous Oxygen Servicing Trailer, NAVAIR 19-25D-1, Naval Air Systems Command, Washington, DC, October 1985.

Tank Storage, Liquid Oxygen, 2,000 Gallon Capacity, NAVAIR 19-5-29, Naval Air Systems Command, Washington, DC, August 1967.

Liquid Oxygen System Gas Purging Set, NAVAIR 19-25D-27, AVEL Corporation, Naval Air Systems Command, Washington, DC, July 1978.

Aviators Breathing Oxygen (ABO) Surveillance Program and Field Guide, A6-332AO-GYD-000, Naval Air Systems Command, Washington, DC, October 1985.

NAVAIROSH Requirements for the Shore Establishment, NAVAIR A1-NAOSH-SAF-0001P-5100-1, Naval Air Systems Command, Washington, DC, February 1986.

CHAPTER 6

Daily/Special/Preservation Maintenance Requirements Cards, Al-F18AA-MRC-200, Cards 66-69, Naval Air Systems Command, Washington, DC, January 1987.

FA-18/A Organizational Maintenance Principles of Operation, A1-F18AC-120-100, Work Packages 00500, 00502, and 00503, Naval Air Systems Command, Washington, DC, May 1985.

Ejection Seat Assembly, AS-730CA-MMO-000, Work Packages 00300, 004 00, 00500, 00700, 00800, and 01000, Naval Air Systems Command, Washington, DC, October 1982.

Principles of Operation Escape and Survival Systems, NAVAIR 01-S3AAA-2-2.8, Naval Air Systems Command, Washington, DC, October 1978.

Testing and Troubleshooting Escape and Survival Systems, NAVAIR 01-S3AAA-2-3.8, Work Packages 00303 and 00304, Naval Air Systems Command, Washington, DC, February 1976.

Weapon System Maintenance Escape and Survival Systems, NAVAIR 01-S3AAA-2-4.8, Naval Air Systems Command, Washington, DC, September 1987.

Aircrew Escape Propulsion System (AEPS) Devices, NAVAIR 11-85-1, Naval Air Systems Command, Washington, DC, June 1985.

General Use Cartridges and Cartridge-Actuated Devices (CADs) for Aircraft and Associated Equipment, NAVAIR 11-100-1.1, Naval Air Systems Command, Washington, DC, September 1984.

Cartridges and Cartridge-Actuated Devices (CADs) for Unique Aircraft Systems, NAVAIR 11-100-1.2, Naval Air Systems Command, Washington, DC, September 1984.

INDEX

D

E

F

G

H

I

L

M

O

P

V

W

Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

COMMANDING OFFICER
NETPMSA
6490 SAUFLEY FIELD RD
PENSACOLA FL 32509-5237

Errata No. 2

3 February 1993

Specific Instructions and Errata for
Nonresident Training Course

Aviation Structural Mechanic E 2

1. TO OBTAIN CREDIT FOR DELETED QUESTIONS, SHOW THIS ERRATA TO YOUR LOCAL COURSE ADMINISTRATOR (ESO/SCORER). THE LOCAL COURSE ADMINISTRATOR (ESO/SCORER) IS DIRECTED TO CORRECT THE ANSWER KEY FOR THIS COURSE BY INDICATING THE QUESTIONS DELETED.

2. This errata supersedes all previous errata. No attempt has been made to issue corrections for errors in typing, punctuation, and so forth, which do not affect your ability to answer the questions.

3. Assignment Booklet

Delete the following questions and leave the corresponding spaces blank on the answer sheets.

Questions

4-61
5-41
7-50
7-51

Make the following changes:

Question	Change
1-25	In the question, line 3, change the word “compressurization” to “overpressurization.”
1-51	In choice 4, change “chamber A” to “chamber C.”
1-65	In choices 2 and 4, change “psi” to “psia.”

Question	Change
2-50	In column A, under "Functions" change to read "Operates on nitrogen pressure received from the canopy pneumatic control module and canopy pneumatic timer."
3-6	In choice 4, change "The vent bleeder valve" to read "The vent bleeder check valve."
3-10	In choice 4, add "above pressure regulator" after "psi."
4-34 to 4-38, Instructions for	For questions 4-34 through 4-38, refer to "FIGURE 3-2" instead of "FIGURE 4-2."
5-48	In choice 2, "change the word "slack" to read "black."
7-7	In choice 4, change the word "ON" to read "Test mask."
8-31	In choice 3, change "115/120" to "115/200."

Assignment 1

Textbook Assignment: "Utility Systems." Pages 1-1 through 1-23.

Learning Objective: *Recognize the operating principles and functions of auxiliary bleed-air utility Systems.*

1-1. In addition to furnishing air for air-conditioning and pressurization system, auxiliary bleed air also supplies air for which of the following actions or systems?

1. Electronic equipment cooling
2. Windshield washing, anti-icing
3. Anti-g system
4. Each of the above

1-2. Auxiliary system bleed air can range up to what maximum temperature and pressure?

1. 100°F and 50 psi
2. 200°F and 90 psi
3. 400°F and 125 psi
4. 600°F and 150 psi

1-3. The windshield anti-ice/rain removal system is designed to provide a means of maintaining visibility from the aircraft.

1. True
2. False

1-4. What are the three modes of operation controlled by the windshield anti-ice/rain removal switch?

1. Normal, rain, anti-ice
2. Off, rain, anti-ice
3. On, anti-ice, rai n
4. Off, on, automatic

1-5. The supply air temperature is controlled to a lower limit of 290°F by which of the following?

1. Cooling as it passes through the ducting
2. Warm air temperature control valve
3. Warm air temperature sensor
4. Both 2 and 3 above

1-6. The warm air overtemperature sensor actuates when supply air temperature reaches which of the following ranges?

1. 275° ± 50°F
2. 300° ± 50°F
3. 375° ± 25°F
4. 400° ± 75° F

1-7. The anti-ice/rain removal air control regulating valve completes the final pressure regulation and flow control before airflow reaches what item?

1. The anti-ice/rain removal nozzle
2. The anti-ice modulating valve
3. The windshield
4. The air temperature control valve

1-8. The windshield overheat temperature sensor closes when airflow temperature drops to what minimum level?

1. 290° ± 5°F
2. 300° ± 10°F
3. 280° ± 5°F
4. 250° ± 25°F

1-9. Anti-g systems are used to prevent which of the following effects on the pilot?

1. Excessive fatigue
2. Decreased alertness
3. Both 1 and 2 above
4. Air sickness

1-10. What is the source of air pressure for the operation of an anti-g system?

1. The emergency survival kit cylinder
2. The air-conditioning ducting
3. The engine compressor bleed-air ducting
4. Either 2 or 3 above, depending on type of aircraft

1-11. How many types of anti-g valves are used in naval aircraft?

1. One
2. Two
3. Three
4. Four

1-12. What is the maximum pressure provided to the anti-g suit?

1. 1.5 psi
2. 5.0 psi
3. 10.0 psi
4. 11.0 psi

1-13. What are the positions of the demand and exhaust valves after the g-farces applied to an aircraft, have stabilized and become constant?

1. Demand valve closed, exhaust valve open
2. Demand valve closed, exhaust valve closed
3. Demand valve open, exhaust valve open
4. Demand valve open exhaust valve closed

1-14. In what location in an anti-g system is the filter unit installed?

1. In the outlet port of the anti-g valve
2. In the supply line to the anti-g valve
3. In the inlet port of the anti-g valve
4. Either 2 or 3 above depending on the type of aircraft

1-15. A composite quick disconnect may include which of the following service lines?

1. Oxygen and ventilating air
2. Anti-g system and communications
3. Both 1 and 2 above
4. Defog and anti-icing system

1-16. What prevents foreign material from entering the anti-g system quick-disconnect hose when it is not in use?

1. A ball check valve
2. A spring-loaded cover
3. It is stored in an inverted position
4. A plastic cap

1-17. If the required test equipment is available, dual range anti-g valves may be repaired by AIMDs. Repair of single stage anti-g valves is not recommend.

1. True
2. False

1-18. Which of the following actions should you take after removing and replacing an anti-g filter?

1. Make a logbook entry
2. Check for free piston movement
3. Test the relief valve
4. Check for air leaks

1-19. In what range should an operational check be performed on dual range anti-g valves?

1. High range
2. Low range
3. Both 1 and 2 above

1-20. The vent-air system provides a measure of personal comfort by offsetting discomfort caused by which of the following circumstances?

1. Wearing the antiexposure suit
2. Heat created by cockpit equipment
3. High-temperature ambient air
4. All the above

1.21 Temperature control of the vent-air system is regulated between which of the following ranges?

1. 40°F and 80°F
2. 50°F and 100°F
3. 70°F ± 15° F

1-22. The vent air controller responds to signals from which of the following devices?

1. The vent suit temperature control valve
2. The temperature sensor
3. The temperature selector
4. Both 2 and 3 above

1-23. The range of numbers on the temperature selector thumbwheel is 1-14.

1. True
2. False

1-24. When an aircraft is changing altitude, the temperature is maintained within what tolerance level?

1. A ± 2°F
2. A ± 5°F
3. A ± 10°F
4. A ± 12°

1-25. Which of the following valves protects the vent-air system from accidental compressurizatiom?

1. Check
2. Bypass
3. Restrictor
4. Relief

1-26. Which of the following conditions could occur from the formation of ice on aircraft surface?

1. Decreased lift
2. Additional weight
3. Difficulty in controlling aircraft
4. Each of the above

1-27. How many methods are used on naval aircraft to eliminate or prevent ice formation?

1. One
2. Two
3. Three
4. Four

1-28. Which of the following groups of deicer boots starts to inflate after 30 seconds of an inflation cycle have elapsed?

1. Inbaard wing
2. Outboard wing
3. Outboard stabilizer and vertical fin
4. Inboard stabilizer and fin

IN ITEMS 1-29 THROUGH 1-32, SELECT FROM COLUMN B THE DEICING SYSTEM COMPONENT THAT PERFORMS EACH FUNCTION IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions	B. Components
1-29.	Allows suction to be applied to the deicer boots to hold them down during flight	1. Pressure regulator and relief valve
1-30.	Causes the inlet to the boots to change from suction to pressure when energized	2. Distributor valve
1-31.	Maintains the pressure of the bleed air in the deicer system at approximately 18 psi	3. Ejector
1-32.	Provides the necessary suction to deflate the deicer boots	4. Suction relief valve

---

1-33. When suction in the manifold lines becomes excessive, the suction relief valve will open and stay open until suction pressure is reduced to approximately what pressure?

1. 5 in Hg
2. 2 in Hg
3. 6 in Hg
4. 4 in Hh

1-34. What indicates normal system operation of the deicer system?

1. Steady gauge readings of 18 psi and 6 in Hg, respectively
2. A slight fluctuation of the pointers on the gauges
3. Steady gauge readings of 1.0 psi and 2 in Hg, respectively
4. A fluctuation of 10 to 20 psi of the pointers on the gauges

1-35. Maintenance of the deice boot system is normally preformed by what ratings?

1. AE
2. AME
3. AMS
4. Each of the above

1-36. Which of the following surfaces is not protected by the deice and anti-icing system for the S-3 aircraft?

1. Vertical stabilizer leading edge
2. Engine nacelle
3. Ram air inlet
4. Parts of the engine

1-37. What is the purpose for sequencing the bleed–air deicing and anti–icing systems?

1. To control temperature
2. To control pressure
3. To minimize bleed air consumption
4. To prevent air duct overheat

1-38. After being used, what happens to anti–icing air?

1. It is returned to the system to be reheated
2. It is vented overboard
3. It is routed to the cabin air system
4. It is returned to the engine

1-39. To ensure the flow of bleed air is directed to the appropriate points regardless of the position of movable surfaces, which of the following components are used?

1. Extension ducts
2. Leakproof rotary joints
3. Both 1 and 2 above
4. Special wing fold seals

1-40. Which of the following areas should follow the right center wing in proper sequencing of the anti-icing system?

1. Left inboard wing
2. Left center wing
3. Right outboard wing
4" Right horizontal stabilizer

1-41. The cyclic valve will remain in the open position for 30 seconds or until the aircraft skin temperature reaches what maximum level?

1. 35° ± 2°F
2. 50° ± 4°F
3. 60° ± 3°F
4. 100° ± 5°F

1-42. The DEICE-HOT indicator light will come on if aircraft skin temperature exceeds what maximum level?

1. 75° ± 3°F
2. 100° ± 4°F
3. 200° ± 5°F
4. 300° ± 10°F

1–43. Normal deicing is available in which of the following circumstances?

1. Both engines operating
2. Single engine operation
3. Both 1 and 2 above
4. Engine-start cycle

1-44. The deicing system cannot be operated until the anti-ice switch is set to which of the following positions?

1. Deice Hot
2. Wing – Emp
3. Eng - pitot
4. Reset

IN ITEMS 1-43 THROUGH 1-49, SELECT FROM COLUMN A THE FUNCTION PERFORMED BY THE UNIT LISTED IN COLUMN B. UNITS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions	B. Units
1-45.	Regulates deicing air pressure when energized	1. Deice pressure regulator Valve
1-46.	Maintains a constant reference pressure when the deice system is operating	2. Wing and empennage deice timing controller
1-47.	Interrupts the operating sequence if the leading edge skin temperature exceeds 60° ± 3°F	3. Control air pressure regulator
1-48.	Shuts off deicing air when de-energized	4. Probe sensor temperature transmitter
1-49.	Provides 30-second sequential control signals to each cyclic valve	

1-50. When the deice pressure regulator is activated, spring pressure is overcome by control air pressurizing which of the following chambers?

1. Chamber A
2. Chamber B
3. Both 1 and 2 above
4. Chamber C

1-51. When the solenoid valve mounted on the cyclic valve is de-energized, it performs which of the following functions?

1. Vents chamber A air to ambient
2. Vents inlet air to ambient
3. Vents downstream air to ambient
4. Vents inlet air to chamber A

1-52. When a deicing thermostatic switch senses an overheating conditions, it causes which, if any, of the following actions to take place?

1. Deice warning light comes on
2. Deice system shuts down
3. Cold air is added to lower the deice air temp
4. None

1–53. Malfunction of the S-3 aircraft engine anti-icing system primary pressure regulating element is indicated by what system response?

1. A light on the control panel comes on
2. The system automatically shuts clown
3. Extension of a pop-out button on the Valve
4. The formation of ice

1-54. In the event of electrical power failure, the engine anti-icing valve will take what position?

1. Remains in the open position, if open
2. Moves to the “anti-icing ON” position, if closed
3. Either 1 or 2 above depending on positiom of the valve
4. Moves to the closed position, if open

1-55. The sensing element of the S-3 bleed-air leak detection system will respond to which of the following conditions?

1. Pressure loss
2. Heat
3. Airflow
4. Each of the above

1-56. The test circuit of the bleed-air leak detection system is powered by what voltage level?

1. 400Hz, 115 Vdc
2. 28 Vdc
3. 60 Hz, 115 Vdc
4. 115 Vdc only

1-57. In normal operation, the chemical in the bleed-air leak detectian element conducts electrical current to activate the indicator light when temperature exceeds what maximum level?

1. 100°F
2. 225°F
3. 255°F
4. 375°F

1-50. The bleed air leak detector control contains what number of modules and electrical circuits?

1. 1 module with 2 electrical circuits
2. 2 modules with 4 electrical circuits
3. 1 electrical circuit with 2 modules
4. 2 electrical circuits with 4 modules

1-59. The S-3 aircraft air for internal stores heating is provided by what source?

1. Crew compartment exhaust air
2. Eked-air deicing and anti-icing supply
3. Windshield defog supply
4. Engine 14th stage bleed-air

1-60. Cooling air for the F–18 aircraft radar liquid cooling system heat exchanger comes from which of the following sources?

1. Ram air
2. Air cycle air conditioning system
3. A cooling fan
4. Each of the above

1-61. Radar liquid coolant fluid for the transmitter is maintained within which of the following temperature ranges?

1. 40°F to 55°F
2. 60°F to 75°F
3. 80°F to 90°F
4. 100°F to 110°F

1-62. An electrical ground is provided to the closed side of the liquid cooling ram air valve through which of the following components?

1. Weight on wheels relay
2. Air data cumputer, when ram air is hot
3. Either 1 or 2 above
4. Low fluid level switch

1-62. Excessive contaminatian of the radar liquid cooling system filter will cause which of the following actions?

1. Bypass valve to open
2. Extension of a manual reset indicator
3. Ram air valve to go fully open
4. System to automatically shutdown

1-64. Contamination of the F-18 aircraft waveguide pressuri- zation filter will cause which of the following actions?

1. A relief valve to open and bypass air around the filter
2. Extension of a manual reset indicator
3. Ram air valve to go fully open
4. System to automaticdlly shutdown

1–65. Waveguide cavities are pressurized to what maximum pressure?

1. 14 psi
2. 14 psi
3. 19 psi
4. 19 psi

1–66. The waveguide pressurization system contains what number of ground test ports?

1. Zero
2. Two
3. Three
4. Four

Assignment 2

Textbook Assignment: "Utility Systems"; "Canopy Systems." Pages 1-23 through 2-8.

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

2-1. What type of coolant is used in the F-14 aircraft missile cooling system?

1. Freon
2. Hydraulic fluid
3. Dielectric fluid
4. Methyl alcohol

2-2. What component houses the coolant pump and the air-moisture-contaminant remover?

1. Right wing fillet
2. Right Phoenix missile fairing
3. Left Phoenix missile fairing
4. Left wing fillet

2-3. The missile coolant pump circulates coolant at what prescribed rate?

1. 8 gallons per minute
2. 8 gallons per second
3. 18 gallons per second
4. 18 gallons per minute

2-4. When the missile cooling system is in the warm-up mode, in what positions are the (a) cold air and (b) hot air modulating valves?

1. (a) Open (b) open
2. (a) Open (b) closed
3. (a) Closed (b) closed
4. (a) Closed (b) open

2-5. What material is used to cool the missile caolant pump?

1. Refrigerated air
2. Ram air
3. System coolant
4. Freon

2-6. The pneumatic pressure indicator is marked in what units of measure?

1. Degrees Fahrenheit
2. Pounds per square inch
3. Pounds per square foot

2-7. Which of the following contaminants will the air-moisture-contaminant remover NOT filter from the coolant?

1. Air
2. Moisture
3. Foreign particles
4. Standing water

2-8. If the remover filter is clogged, what color but-tan extends as a warning?

1. White
2. Red
3. Yellow
4. Green

2-9. Which of the following coolant's should NOT be used in the missile cooling system?

1. Coolanol 25
2. Coolanol 25R
3. Flo-cool 108
4. Flo-cool 180

2-10. What is the minimum number of minutes that coolant should be circulated by the aircraft pumps before a sample is taken?

1. Five minutes
2. Six minutes
3. Seven minutes
4. Eight minutes

Learning Objectives:
Identify components of the windshield wiper and washer systems and their functions. Recognize components of the aircraft rain repellent system.

2-11. The oscillating motion of the windshield wiper system is converted from rotary motion by which of the following parts?

1. Cam assembly
2. Bell crank assembly
3. Motion converter
4. Hydraulic slide valve

2-12. Windshield washer solution consists of 20 percent distilled water and what percent additional material?

1. 80 percent soap solution
2. 80 percent isopropyl alcohol
3. 80 percent aliphatic naphtha
4. 70 percent isopropyl alcohol and 10 percent soap solution

2-13. The motor/pump assembly for the S-3 aircraft windshield washer is mounted in what location?

1. In the reservoir
2. Between the reservoir and the filter
3. In the nosewheel well
4. Behind the cockpit switch panel

2-14. The windshield wiper switch must be in which of the following positions before the rain repellent system will function?

1. Low
2. Off
3. Either 1 or 2 above
4. High

2-15. Approximately how many applications of rain repellent fluid are available from a full container?

1. 10
2. 30
3. 60
4. 100

2-16. The nitrogen pressure in a fully charged rain repellent container will read what psi?

1. 50 psi
2. 75 psi
3. 100 psi
4. 150 psi

Learning Objective:
Identify operating principles, components, and maintenance procedures for fire-extinguishing utility systems.

2-17. Aircraft fire-extinguishing utility systems are designed primarily to protect what aircraft components?

1. Heaters
2. Engines
3. Fuel systems
4. Electronic equipment

2-18. The inspection and maintenance of aircraft fire-extinguishting systems is an important responsibility of the AME.

1. True
2. False

2-19. CF_3Br is a desirable fire-extinguishing agent for which of the following reasons?

1. It is noncorrosive and leaves no residue
2. It is an electrical insulator
3. It goes farther than CO_2, and does not deteriorate
4. Each of the above

2-20. The CF_3Br agent discharged from the distributing assembly as a spray extinguishes an engine fire by what action?

1. It lowers the temperature to a point at which combustion will not take place
2. It forces the fire away from the engine
3. It vaporizes in the heat and smothers the fire by reducing the oxygen content of the area
4. It acts in all of the above ways

2-21. What retains the nitrogen charge and CF_3Br agent in the container?

1. A bonnet and a cartridge
2. A bonnet and a frangible disc
3. A frangible disc and a cartridge
4. A frangible disc and a fusible plug

2-22. The fusible plug in the CF_3Br system melts at temperatures within what range?

1. 100° to 120°F
2. 166° to 180°F
3. 208° to 220°F
4. 225° to 240°F

2-23. Which of the following statements concerning CF_3Br fire extinguishing systems is false?

1. Some systems are equipped with a relief valve instead of a fusible plug
2. Some larger aircraft use more than one fire-extinguishing agent container to direct the agent to several points
3. Some system containers are equipped with two valve assemblies that provide a secondary means of discharging the agent from the container
4. Some systems are equipped with pneumatically operated valves as a secondary means of discharging the agent from the container

2-24. When performing a leakage test on a fire-extinguishing system, what should you use to pressurize the system?

1. CO_2
2. CF_3Br
3. Nitrogen
4. Compressed air

Learning Objective: *Recognize the purpose of the thermal radiation protection system.*

2-25. What type radiation shields are on the A-6 aircraft?

1. Fiber glass panels
2. Fabric curtains
3. Metal panels
4. Aluminized cloth

2-26. The sliding panels of the canopy radiation enclosures on the A-6 aircraft are moved to the open, half open, and closed positions by what means?

1. Manually only
2. Electrically only
3. Manually or electrically
4. Pneumatically

2-27. When the thermal closure switch is placed in the CLOSE position for manual operation of the A-7 radiation protection system, which of the following actions occurs first?

1. The seat position switch is actuated
2. The closure selector valve is energized
3. The ejection seat is lowered to within 1/4 inch of full down position
4. The extend lines to the closure actuators are vented

2-28. What component in the A-7 radiation system initiates the automatic made of operation?

1. Nuclear flash sensor
2. Thermal closure switch
3. Closure selector valve
4. Switching, demodulator unit

2-29. When flying special weapons missions, the pilot's helmet is equipped with which of the following devices?

1. Polarized lens
2. ELF lens
3. Voice powered mike
4. Special insulated line

Learning Objective: *Identify the types of canopy systems and their purpose. Recognize the function, operation, and purpose of the components in the F-14 aircraft canopy system.*

2-30. The canopy of modern high–performance sit-craft serves which of the following purposes?

1. Protection
2. Visibility
3. Avenue of escape
4. Each of the above

2-31. What are the two types of canopies commonly used on naval aircraft?

1. Hinged and actuating
2. Sliging and clamshell
3. Actuating and sliding
4. Split and clamshell

2-32. The F-14 canopy contains how many acrylic panels?

1. One
2. Two
3. Three
4. Four

ITEMS 2-33 THROUGH 2-41 PERTAIN TO THE F-14 AIRCRAFT CANOPY SYSTEM.

2-33. What is the indicator that the canopy is closed and locked?

1. The reference mark are aligned
2. The marker indicates closed
3. The pressure indicator goes to zero
4. The control handle indicates closed

2-34. How many control handles are there for opening and closing the F–14 canopy?

1. One
2. Two
3. Three
4. Four

REFER TO FIGURE 2-2 IN THE TEXT TO ANSWER ITEMS 2-35 THROUGH 2–41.

2-35. When the canopy control handle is positioned to OPEN, what component in the system prevents nitrogen pressure from escaping from the No. 6 valve through the overboard vent?

1. The number 1 valve
2. The number 2 valve
3. A solenoid valve
4. A check valve

2-36. When the canopy control handle is in position ti OPEN, nitrogen pressure is routed through what valves?

1. Number 1 valve to he unlock part of the canopy-lock pnuematic actuator
2. Number 2 and 6 valves to the unlock part of the canopy-lock pnuematic actuator
3. Number 1 and 6 valves to the unlock part os the canopy-lock pnuematic actuator
4. Number 1 and 2 valves to the unlock part of the canopy-lock pnuematic actuator

2-37. When the canopy handle is pulled to the open position, the number 1, 2, and 6 valves are positioned by which of the following methods?

1. 2 and 2 electrically, 6 pneumatically
2. 1 and 2 mechanically, 6 pneumatically
3. 1 and 2 pneumatically, 6 mechanically
4. 1 and 2 hydraulically, 6 electrically

2-38. What operating nitrotgen pressure is used to open the canopy?

1. 115 psi
2. 195 psi
3. 245 psi
4. 325 psi

2-39. What cnmponent(s) within the canopy hydraulic actuator converts nitrogen pressure to hydraulic pressure for operating the actuator?

1. Open transfer cylinder
2. Close transfer cylinder
3. Flow regulator and bypass valve
4. Open and close transfer cylinders

2–40. Nitrogen pressure passing through the timer check valve is used to operate the canopy actuator to the open position. Which of the following components makes the nitrogen available at the timer check valve?

1. Shuttle valve
2. Number 1 valve
3. Open transfer cylinder
4. Canopy pneumatic timer

2-41. When the canopy hydraulic actuator opens the canopy, the displaced hydraulic fluid on the close side of the actuator returns to what device?

1. Number 4 valve in the control module
2. Open side of the canopy hydraulic actuator
3. Close transfer cylinder
4. Overboard vent through the C2 port

2-42. What canopy control handle position stops the canopy motion in any desired positions?

1. Hold
2. Normal close
3. Normal open
4. Stop

2–43. Which of the following forces normally classes the canopy?

1. Pneumatic power
2. Canopy weight
3. Electrical power
4. Each of the above

2–44. (Refer to figure 2–2 in the text.) When the canopy is closing, what happens to the nitrogen in the open transfer cylinder that is displaced by the hydraulic fluid from the open side of the hydraulic actuator?

1. It is returned to the auxiliary pneumatic reservoir
2. It is returned to the canopy pneumatic reservoir
4. It is vented overboard through the number 1 valve in the control module
4. It is vented overboard through the number 3 valve in the control module

2-45. When the canopy caution lights on the advisory panels go out, this indicates the canopy is in which of the following positions?

1. Full down
2. Full forward
3. Locked
4. Full up and locked position

2-46. The boost closing mode is used to close the canopy under what of the following circumstances?

1. When the wind prevents normal closing
2. When AFC 95 has been installed
3. When valve NO. 4 is inoperative
4. When nitrogen pressure is low

2-47. (Refer to figure 2-2 in the text.) The pressure for boosted closing of the canopy comes from which of the following components?

1. The 790 psi pressure reducer
2. The 1250 psi relief valve
3. The 325 psi pressure reducer
4. The reservoir relief valve

2-48. Under which of the following circumstances should the auxiliary opening made be used?

1. When the port fails to open
2. When the control handle will not move
3. When nitrogen pressure drops below 225 psi
4. When not modified by AFC 95

2–49. What is the purpose of the auxiliary pneumatic reservoir?

1. To operate the canopy hydraulic cylinder when normal reservoir pressure is low
2. To open the emergency cylinder when normal reservoir pressure is low
3. To supply boosted pressure to the system when normal reservoir pressure is low
4. To unlock the canopy when normal reservoir pressure is low

(REFER TO FIGURE 2-2 IN THE TEXT TO ANSWER ITEMS 2-50 THROUGH 2-54.) IN ITEMS 2-50 THROUGH 2-54, SELECT FROM COLUMN B THE COMPONENT IN THE CANOPY SYSTEM THAT PERFORMS THE FUNCTION(S) LISTED IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions	B. Components
2-50.	Operates on nitrogen pressure received from the canopy pneumatic control on the module canopy pneumatic timer	1. Flow regulators
2-51.	Vents pneumatic pressure from the canopy hydraulic actuator to the canopy pneumatic control module for canopy closing	2. Timer check valve
2-52.	Vents/pressurizes the canopy hydraulic actuator shutoff valves	3. canopy-lock pneumatic actuator
2-53.	Controls the operational speed of the canopy hydraulic actuator	4. Canopy pneumatic timer
2-54.	Moves the canopy forward to the locked position or aft to the unlocked position	

2-55. {Refer to figure 2-2 in the text.) What valve prevents the canopy pneumatic reservoir from going to zero pressure when a leak develops in the system's servicing charging module?

1. Restrictor
2. Relief
3. Shutoff
4. Check

2-56. (Refer to figure 2-2 in the text.) When auxiliary mode is selected to unlock the canopy, nitrogen is directed to the unlocking side of the canopy-lock pneumatic actuator at what pressure?

1. 225 psi
2. 325 psi
3. 3,000 psi
4. 4,100 psi

IN ITEMS 2-57 THROUGH 2-61, SELECT FROM COLUMN B THE COMPONENT IN THE CANOPY SYSTEM THAT PERFORMS THE FUNCTION(S) LISTED IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions	B. Components
2-57.	Allows normal pneumatic pressure or auxiliary pneumatic pressure to enter the canopy lock pneumatic actuator	1. Low pressure Sensor
2-58.	Causes the module valves to lock pressure in the canopy hydraulic actuator for canopy counter-balance	2. 325 psi pressure reducer
2-59.	Permits auxiliary pneumatic reservoir pressure to be applied to the shuttle valve	3. Shuttle Valve
2-60.	Provides the normal operating pneumatic pressure for the system	4. Auxiliary Unlock pneumatic release valve
2-61.	Operates the No. 5 and No. 6 valves in the pneumatic control module	

2-62. Which of the following valves will prevent aver-pressurization of the canopy pneumatic system?

1. Reservoir relief
2. 1250 psi relief
3. 500 psi relief
4. Restrictor

2-63. Concerning servicing a canopy system's normal and auxiliary reservoirs to maximum pressure and capacity, which of the following statements is correct?

1. The auxiliary reservoir has a larger capacity and lower pressure than the canopy reservoir
2. The auxiliary reservoir has a higher pressure and lower capacity than the canopy reservoir
3. The auxiliary reservoir has a smaller capacity but the same pressure as the canopy reservoir
4. The auxiliary reservoirs capacity and pressure are the same as the canopy reservoirs'

2–64. After the auxiliary unlocking made has been used to open the canopy, which of the following actions must be accomplished to return the system to normal?

1. Auxiliary pneumatic reservoir must be reserviced
2. The unlock shuttle valve must be manually reset
3. The canopy–lock pneumatic actuation must be repositioned
4. The auxiliary unlock pneumatic release valve cam must be manually reset

2-65. The position of the unlock shuttle in the canopy system is controlled by what action or device(s)?

1. Pneumatic pressure
2. Mechanical linkage from the canopy central handle
3. A cable and pulley assembly and an electric cam
4. Mechanical linkage from the canopy-lock pneumatic actuator

2-66. When ejection is initiated, the upward movement of the canopy by the hydraulic actuator is accomplished by what means?

1. Hydraulic pressure and mechanical linkages
2. Pneumatic pressure and mechanical linkages
3. High-pressure gas
4. Mechanical linkages only

2-67. (Refer to figure 2-4/2-5 in the text.) What is the total number of emergency canopy initiator handles in the system?

1. Six
2. Two
3. Three
4. Four

2-68. The backup initiator is located on what part of the canopy area?

1. The back of the forward ejection seat
2. The canopy actuator
3. The cockpit turtle deck
4. The safe–and-arm module

Assignment 3

Textbook Assignment: "Canopy System"; "Pressurization and Air-conditioning Systems." 2-8 through 3-2.

Learning Objective: *Recognize the operation, emergency jettison procedures, and components of the sliding canopy system.*

3-1. What type of canopy is used on the A-6A aircraft, and which of the following methods is normally used to open and close it?

1. Clamshell, manual
2. Sliding, electrical
3. Sliding, hydraulic
4. Clamshell, pneumatic

3-2. When the canopy will not open by its normal system, it can be opened by what other method?

1. Pneurnatically with the emergency switch
2. Electrically with the emergency switch
3. Mechanically through linkages
4. Hydraulically with the hand pump system

3-3. When the canopy is emergency jettisoned, what method is used to fire the jettison cartridge?

1. Electrical
2. Pneumatic
3. Hydraulic
4. Manual

3-4. From how many positions on the aircraft can the canopy jettison cartridge be fired?

1. One
2. Two
3. Three
4. Four

3-5. (Refer to figure 2-7 in the text.) What valve prevents air battle pressure from escaping overboard if a leak develops in the air filler valve?

1. Check
2. Relief
3. Air release
4. Vent bleeder check

3-6. Should leakage occur in any one of the air release valves, what prevents inadvertent firing of the jettison cartridge?

1. The check valve
2. The relief valve
3. The flow regulator
4. The vent bleeder valve

3-7. What is the purpose of the manual override feature on the vent bleeder valve in the jettison system?

1. To bleed off pressure after testing the system
2. To bleed off excessive, pressure that builds up after servicing the system
3. To bleed off excessive pressure that builds up from thermal expansion in the system
4. To vent excess pressure overboard during servicing of the svstem

Learning Objective: *Recognize the purpose and operation of the canopy seal system.*

3-8. A canopy seal system provides an airtight seal between the canopy assembly and the aircraft structure to maintain cockpit pressurization.

1. True
2. False

3-9. The canopy seal regulator performs which of the following functions?

1. Provides 80 psi pressure in the canopy seal when the canopy is unlocked
2. Provides 80 psi pressure in the canopy seal when the canopy is locked
3. Provides 25 to 30 psi above ambient when the canopy is unlocked
4. Provides 25±5 psi pressure above ambient when the canopy is closed and locked

3-10. The venting of pressure through the relief/vent port of the canopy seal regulator will occur when which of the following events happen?

1. When the service air heat exchanger has supplied approximately 80 psi pressure to the canapy seal regulator
2. When the service air heat exchanger has supplied approximately 25 to 30 psi pressure to the canopy seal regulator
3. When the canopy is unlocked
4. When the pressure downstream of the regulator is between 6 t0 8 psi

3-11. What valve in the electrically actuated canopy seal prevents pressure from becoming excessive during rapid altitude changes?

1. Dump
2. Relief
3. Outflow
4. Shutoff

3-12. Electrical failure of the canopy seal system will cause which of the following actions to occur?

1. The relief valve will close
2. The dump switch solenoid will energize
3. The solenoid valve will energize
4. The regulator vavle will dump

3-13. (Refer to table 2-1 in the text.) During a ground test on an electrically actuated canopy seal system you find that the seal will not inflate. If you determine that all controls pertinent to the proper operation of the seal have been activated, which of the following conditions could cause the trouble?

1. A ruptured seal
2. A defective canopy seal regulator or check valve
3. A defective power supply circuit to the seal regulator
4. Each of the above

Learning Objective: *Recognize the purpose and operation of a frangible escape system.*

3-14. A frangible escape system is used to jettison the canopy on the S-3A aircraft?

1. True
2. False

3-15. The S-3A canopy glass is removed during ejection by what device(s)?

1. Glass cutters
2. Glass crashers
3. Breaker plates
4. Both 2 and 3 above

3-16. What is the approximate length of the external jettison initiator cable on the S3 aircraft?

1. 6 feet
2. 8 feet
3. 10 feet
4. 12 feet

3-17. Which of the following parts will be blown away from the aircraft when either of the external handles is pulled?

1. Hatches
2. Fillets
3. Supports
4. All of the above

3-18. What total number of internal initiators are in the canopy and hatch jettison system?

1. Five
2. Two
3. Three
4. Four

3-19. What device prevents the internal jettison handle from being squeezed and pulled?

1. Shear pin
2. Safety pin
3. Shear wire
4. Safety guard

3-20. What is the total number of SMDC initiator handles in the S-3A aircraft?

1. Five
2. Six
3. Three
4. Four

3-21. Which, if any, of the following actions will initiate the SMDC when safety pins are installed?

1. Drilling
2. Filing
3. Hammering
4. None

Learning Objective:
Recognize the service life and expiration dates of cartridges and cartridge-activated devices (CAD).

(A)	Description, Preparatian For Use, and Handling Instructions, Aircrew Escape Propulsion System (AEFS) Devices
(B)	General Use Cartridges and Cartridge-Actuated Devices for Aircraft and Associated Equipment
(C)	Ammunition Afloat
(D)	Ammunition and Explosives Ashore

Figure 3-1

IN ANSWERING QUESTIONS 3-22 THROUGH 3-25, SELECT THE PUBLICATION NAME FROM FIGURE 3-1 ABOVE, WHICH RELATES TO THE PUBLICATION NUMBER USED AS THE QUESTION.

3-22. NAVAIR 11-85-1.

1. A
2. B
3. C
4. D

3-23. OP 4.

1. A
2. B
3. C
4. D

3-24. OP 5

1. A
2. B
3. C
4. D

3-25. NAVAIR 11-100-1.

1. A
2. B
3. C
4. D

3-26. The specific period of time that a CAD is allowed to be used is called its

1. shelf life
2. service life
4. installed life
5. removed life

3-27. What date must be checked prior to installing a CAD into any system?

1. Open
2. Service life expiration
3. Installed
4. Manufacture

3-28. To determine the service-life expiration date of a CAD, what date(s) must be computed?

1. Aircraft life
2. Shelf life
3. Installed life
4. Both 2 and 3 above

3-29. If the date of manufacture of a CAD is 0981 and the shelf life is 6 years, what is its shelf life expiration date?

1. 0985
2. 0986
3. 0987
4. 0988

3-30. To which of the following manuals should you refer to determine the instalkd-life expiration date of a CAD?

1. NAVAIR 11-100-1
2. NAVAIR 11-85-1
3. OP 4
4. OP 5

3-31. To determine the installed–life expiration date, the installed-life date is added to the date the container was subjected to what action?

1. Opened
2. Received from supply
3. Received from the manufacturer
4. Sealed by the manufacturer

3-32. If the installed life is 66 month, what is the installed-life expiration date of a CAD whose container was opened during 1183?

1. 0588
2. 0688
3. 0589
4. 0689

3-33. After the shelf life and installed life dates have been computer, the earlier date will be used for CAD service-life expiration date.

1. True
2. False

3-34. A hermetically sealed container was opened on 15 March. Which of the following dates is used to compute the expiration date?

1. 1 January
2. 1 March
3. 15 March
4. 31 March

3-35. Scribing is an approved method for marking expiration dates on CADs

1. True
2. False

3-36. Which of the following dates must be marked on a CAD that is being installed in an aircraft?

1. Installed
2. Shelf life
3. Container opened
4. Installed life

3-37. A logbook entry for a CAD must be made-when which of the following events occurs?

1. Actuation
2. Replacement
3. Reinstallation
4. Refurbishment

3-38. A contingency service-life extension for a CAD granted by the commanding officer may not exceed what maximum number of days?

1. 15
2. 30
3. 45
4. 60

3-39. An additional service-life extension beyond the contingency extension may be requested by message from which of the following activities?

1. NAVORDSTA
2. NAVAIRLANT
3. NAVAIRSYSCOM
4. NAVORDSYSCOM

3-40. A change to NAVAIR 11-100-1 may change the permanent service life of CADs. Which of the following methods is used to change NAVAIR 11-100-1.

1. Rapid action change
2. Interim rapid action change
3. Formal change
4. Each of the above

Learning Objective: *Identify CAD Maintenance policy to include SMDC and FCDC maintenance and inspection requirements and safety precautions.*

3-41. The service life of wire-braid, Teflon®-hoses is the same as the service life of what associated item?

1. The initiator to which it is attached
2. The aircraft in which it is installed
3. The CAD to which it leads
4. The rocket motor to which it leads

3-42. Hoses in an escape system should be inspected how often?

1. At every phased inspection
2. Upon removal of the seat
3. After the bases are disconnected
4. Each of the above

3-43. For safety reasons, which of the following devices will be installed in CADs when CADs are removed from an aircraft?

1. Caps
2. Plugs
3. Safety pins
4. Each of the above

A.	0.10 inch
B.	0.25 inch
C.	0.75 inch
D.	1.00 inch

Figure 3-2

IN ANSWERING QUESTIONS 3–44 THROUGH 3-48, SELECT THE CLEARANCE FROM FIGURE 3-2 ABOVE, WHICH SHOULD BE USED FOR THE STRUCTURAL DESCRIPTION PROVIDED IN THE QUESTION. CLEARANCES USED IN FIGURE 3-22 MAY BE USED MORE THAN ONCE.

3-44. A supported section of SMDC and the adjacent structure.

1. A
2. B
3. C
4. D

3-45. Straight unsupported sections of SMDC and the adjacent structure.

1. A
2. B
3. C
4. D

3-46. Two parallel SMDCs.

1. A
2. B
3. C
4. D

3-47. Unsupported sections of SMDC and any operating mechanism.

1. A
2. B
3. C
4. D

3-48. A supported section of SMDC and an electrical wire bundle.

1. A
2. B
3. C
4. D

3-49. When using the detonating card inspection gauge set to check the booster tip, what action, if any, should you take if the bar does not touch both sides of the gauge?

1. Replace the tip
2. File the tip
3. Replace the booster
4. None

3-50. When using one CAD from a two-CAD set, what information should you mark on the unused CAD?

1. Shelf life
2. Expiration date
3. Container open date
4. Both 2 and 3 above

3-51. Which of the following actions causes CADs to stick?

1. Overtorquing during installation
2. Using incorrect tools
3. Using incorrect lubricants
4. Each of the above

Learning Objective: Identify the *reason for the ordnance certification program.*

3-52. What manual provides the guidelines for an ordnance certification program?

1. OPNAVINST 8023.2
2. OPNAVINST 8024.2
3. OPNAVINST 8324.3
4. OPNAVINST 8024.9

3-53. All personnel handling live ammunition must be qualified and certified in accordance with OPNAVINST 8023.2?

1. True
2. False

3-54. All ordnance certified personnel must be frequently instructed in which of the following areas?

1. Safety precautions
2. Methods of handling
3. Storage and uses of the ammunition or explosives
4. Each of the above

3-55. New or inexperienced personnel must be under the direct and constant supervision of skilled, experienced, and certified personnel.

1. True
2. False

3-56. Personnel who supervise or perform work in connection with handling, inspection, installation, and care of cartridges must observe which of the following restrictions?

1. Ensure that all applicable regulatioms are rigidly observed
2. Carefully supervise the activities of all subordinate personnel
3. Inform all personnel of the constant need for using the utmost vigilance in the performance of their work
4. Each of the above

Learning Objective: *Recognize the affect high altitude flight could have on flight personnel because of decreased atmospheric pressure.*

2-57. Without the use of pressurized aircraft cabins, crew members would not get enough oxygen at higher altitudes. Which of the following factors is responsible for this?

1. As altitude increases the content of inert gases in the air increases, therefore, less oxygen is taken into the body during the breathing process
2. As altitude increases oxygen content increases along with atmospheric pressure, but not in proportion; therefore, less oxygen is taken into the body during the breathing process
3. As altitude increases, atmospheric pressure and oxygen content of the air decreases, resulting in less oxygen being taken into the body during the breathing process
4. As altitude increases air density increases resulting in less oxygen being taken into the body during the breathing process

3-58. The lowest outside air temperature encountered by an aircraft will occur at a altitude of about

1. 1 mile
2. 5 miles
3. 3 miles
4. 7 miles

3-59. Various sections of an aircraft are pressurized for which of the following reasons?

1. To provide for the proper operation of all aircraft electrical components
2. To provide for the proper operation of specific aircraft components only
3. To provide for the survival of personnel in a high altitude environment only
4. To provide for personnel survival at high altitudes and the proper operation of specific aircraft components

3-60. In addition to aerodynamic heating, other factors affecting cabin/cockpit temperatures are engine heat, solar heat, heat from electrical units, and heat from the body.

1. True
3. False

3-61. What is the maximum temperature a person can withstand for extended periods while still maintaining efficiency?

1. 85°F
2. 80°F
3. 75°F
4. 70°F

Assignment 4

Textbook Assignment: "Pressurization and Air-Conditioning Systems." Pages 3-2 through 3-16.

Learning Objective: *Recognize the need for environmental Control systems.*

4-1. Which of the following factors is of primary importance to the manufacture of pressurized aircraft cabins?

1. The cabin area must be large enough to accommodate the pressurized components
2. The cabin area must be limited in size in order to adequately pressurize it
3. The cabin must be designed to withstand the necessary pressure differential
4. All pressurizing components must be strategically located for ease of maintenance

4-2. Which of the following components protects the cabin from excessive pressures?

1. Cabin pressure valve
2. Cabin safety valve
3. Cabin pressure regulator
4. Cabin air check valve

4-3. On jet aircraft, air for pressurizing the cabin is supplied by which of the following engine sections?

1. Air inlet
2. Accessory
3. Turbine
4. Compressor

4-4. Which of the following statements best explains the method for controlling cabin pressure?

1. A bleed valve is installed in the cabin air line
2. A regulator is installed to limit the air exiting the cabin
3. A regulator is installed to limit the air entering the cabin
4. A controlled orifice is installed in the cabin inlet air line

4-5. Which of the following aircraft systems are classified as environmental systems?

1. Deicing, defagging, rain removal, and pressurization systems
2. Anti–icing, air-conditioning equipment cooling, and windshield washing systems
3. Deicing, anti-icing, air-conditioning, and defogging systems
4. Defogging, rain removal, pressurization, and air-conditioning systems

ITEMS 4-6 THROUGH 4-15 PERTAIN TO THE SYSTEM USED ON THE F-18 AIRCRAFT.

4–6. When the environmental system on the aircraft is in operation with one engine shut down, what component prevents bleed air from the operating engine from being lost when the engine is shut down?

1. Air pressure regulation valve
2. Engine bleed–air check valve
3. Reverse flow valve
4. Spring-loaded shutoff valve

4-7. What is the purpose of the two overpressure switches in the bleed-air system?

1. To protect the system components from damage due to excessive pressure
2. To prevent excessive pressure buildup in the engine compressor section
3. To maintain the desired pressure in the cabin during cabin pressurization
4. To vent pressure overboard when excessive pressure exists in the air-conditioning system

4-8. When electrical failure occurs in an operating air-conditioning system, what action is taken by the spring-loaded engine bleed-air pressure regulation valve?

1. It remains in the position it was in at the time of electrical failure
2. It is powered to the open position by the spring tension
3. It is powered to the closed position by spring tension
4. It requires manual operation to the desired position

4-9. What component) in the bleed-air system maintain bleed-air pressure from the engines within 75±15 psi?

1. Engine bleed check valves
2. Primary bleed-air over-pressure switch
3. Engine bleed-air pressure regulation and shutoff valves
4. Engine bleed-air secondary pressure regulating and shutoff valves

4-10. In the event bleed-air pressure becomes higher than normal due to a malfunction, what component in the system will take over and regulate air pressure?

1. Engine bleed-air secondary pressure regulating and shutoff valve
2. Engine bleed check valve
3. Primary bleed-air over-pressure switch
4. Secondary bleed-air over-pressure switch

4-11. Which of the following statements is correct regarding the purpose/function of the primary bleed-air overpressure switch?

1. The switch will activate at 250 psi maintaining the system at that pressure when normal regulation fails
2. Activation of the switch will give maintenance personnel data for determining malfunctions in the bleed-air system
3. The switch will activate a digital display indicator on the instrument panel warning the pilot of a bleed-air system failure
4. Activation of the switch will close three pressure regulator shutoff valves, shutting down the bleed-air system

4-12. Which of the following circumstances will cause the secondary bleed-air overpressure switch to activate?

1. Right engine bleed-air pressure-regulator and shutoff valve failure only
2. Left engine bleed-air pressure regulator and shutoff valve failure only
3. Failure of both right, and left engine bleed-air pressure regulation and shutoff valves
4. Bleed-air pressure downstream of the secondary bleed-air regulator exceeds 150±10 psi

4-13. What valve(s) in the bleed-air system provide(s) bleed air from the operating engine to start the second engine?

1. Engine bleed-air check valve
2. Air isolation valve
3. Engine bleed-air secondary pressure valve
4. Engine bleed-air pressure valve

4-14. Aircraft APU air can be used to augment engine bleed air for operating the aircraft air-conditioning system. What valve(s) in the bleed-air system provide(s) air for this feature?

1. Air isolation valve
2. Engine bleed-air check valve
3. Engine bleed-air secondary pressure valve
4. Engine bleed-air pressure valves

4-15. What is the function of the control unit in the bleed-air “ leak detection system?

1. To close the bleed-air pressure regulator when an overheat condition occurs in the system only
2. To operate a warning light on the advisory panel when an overheat condition occurs in the system only
3. To close the bleed-air pressure regulator and light a warning light on the advisory panel when overheat occurs in the system
4. To provide a means for selecting a nonleaking system for backup

---

Learning Objective: *Recognize the operating principles and components of the air cycle air-conditioning system.*

4-16. Air cycle air-conditioning systems are used in most naval aircraft for which of the following reasons?

1. The overall costs for installation and operation of air cycle systems are lower
2. Refrigerant systems do not function well at high altitudes
3. Refrigerant systems are more difficult to maintain
4. Air cycle systems are efficient for their weight and the space required and are relatively trouble free

ITEMS 4-17 THROUGH 4-54 PERTAIN TO THE AIR-CONDITIONING SYSTEM IN THE F-18 AIRCRAFT.

4-17. What is the source of the cooling air used to cool bleed air in the primary and secondary heat exchangers?

1. RAM air/outside air flowing across the heat exchangers
2. AFU air being ejected across the heat exchangers
3. Bleed air modulated by a system pressure regulator valve ejected across the heat exchanger
4. Bleed air forced through the heat exchanger by the turbine compressor

4-18. What is the purpose of the secondary heat exchanger?

1. To cool the bleed air after it leaves the engine compressor section
2. To cool the bleed air before it is ejected into the primary heat exchanger
3. To cool the bleed air coming from the compressor end of the refrigeration turbine/compressor
4. To increase the temperature of the bleed air before it enters the refrigeration turbine/compressor

4-19. What system component cools bleed air by the rapid expansion method?

1. Refrigeration compressor
2. Primary heat exchanger
3. Secondary heat exchanger
4. Refrigeration turbine

IN ITEMS 4-20 THROUGH 4-26, SELECT FROM COLUMN B THE COMPONENT THAT IS RESPONSIBLE FOR THE FUNCTION LISTED IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

A. Functioms	B. Components
	1. Primary ejector valve
	2. Primary heat exchanger
	3. Avionics RAM air servo
	4. Flow modulating system pressure regulator valve

4-20. Cools hot engine bleed air

4-21. Cools air on the same principle that a car radiator cools water

4-22. Controls flow of bleed air to primary heat exchanger ejectors

4-23. Uses the electrical signals from the avionics temperature flow sensor

4-24. Protects the refrigeration turbine from heat damage during overtemperature conditions

4-25. Monitors the differential pressure of the bleeder air up and downstream of the flow modulating system pressure regulator valve

4-26. Ensures that a sufficient amount of cooling air goes to the avionics systems

4-27. When an overtemperature exists in the turbine or compressor section of the refrigeration turbine/compressor assembly, the protective temperature sensors will cause which of the following conditions to occur?

1. The sensor sensing the overtemperature will close the flow maculating system pressure regulator and cause turbine speed to decrease
2. The sensor sensing the overtemperature will close the engine bleed-air pressure regulation and shutoff valve on the engine producing the overtemperature
3. The sensor sensing the overtemperature will close the engine bleed-air check valve on the engine producing the overtemperature
4. The compressor temperature sensor closes the flow modulating system pressure regulator and the turbine temperature sensor closes the affected engine bleed-air check-valve

IN ITEMS 4-28 THROUGH 4-33, SELECT FROM COLUMN B THE COMPONENT THAT IS RESPONSIBLE FOR THE FUNCTION LISTED IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

A. Functions	B. Components
4-28. Receives the air from the compressor section of the refrigeration turbine/ compressor assembly	1. Secondary ejector valve
4-29. Controlled by an electrical signal from the air data computer	2. Secondary heat exchanger
	3. Reheater heat exchanger
	4. Water spray nozzle

4-30. Controls the flow of bleed air to the secondary heat exchanger ejector

4-31. Aids in cooling the inlet air entering the secondary heat exchange

4-32. Uses the water that is extracted from the conditioned air

4-33. Cools air before moisture removal and heats air after moisture removal

REFER TO FIGURE 4-2 AND SUPPORTING MATERIAL IN THE TEXT TO ANSWER ITEMS 4-34 THROUGH 4-33.

4-34. The air used for cooling in the condenser/vent suit heat exchanger comes directly from which of the following components?

1. The reheater heat exchanger
2. The secondary heat exchanger
3. The water extractor
4. The turbine/compressor assembly

4-35. The air to be cooled in the condenser/vent suit heat exchanger comes directly from which of the following component?

1. The turbine/compressor assembly
2. The hot side of the reheater
3. The secondary heat exchanger
4. The primary heat exchanger

4-36. The purpose of the water extractor to extract water from the air coming directly from which of the following components?

1. The reheater heat exchanger
2. The secondary heat exchanger
3. The condenser/vent suit heat exchanger
4. The turbine compressor assembly

4-37. The water removed by the water extractor is used for which of the following purposes?

1. Suit ventilation
2. Augment ram air cooling in the secondary heat exchanger
3. Supply ram air to the secondary heat exchanger
4. Supply dry air to the reheater heat exchanger

4-38. Air exiting the turbine end of the turbine compressor assembly is used for which of the following purposes?

1. To operate the flow modulating system pressure regulator
2. To provide air to the secondary heat exchanger
3. To provide air for environmental control
4. To provide air to the avionics ram air servo

4-39. What component prevents icing in the condensor/vent suit heat exchanger?

1. Turbine compressor assembly
2. Anti-ice add heat valve
3. Avionics ram air servo
4. Reheater heat exchanger

ITEMS 4-40 THROUGH 4-45 PERTAIN TO COMMON AIR-CONDITIONING COMPONENTS.

4-40. Which of the following components is used in bleed air ducting to compensate for duct expansion due to high temperatures?

1. Flexible line connectors
2. Marmon clamps
3. Thermal compensators
4. Flexible mounting brackets

4-41. Which of the following statements is correct concerning the materials bleed air and air-conditioning distribution lines are made of?

1. Air-conditioning lines are made of stainless steel and bleed-air lines of aluminum alloy
2. Air-conditioning and bleed-air lines are both made of stainless steel
3. Bleed-air lines and air-conditioning lines are both made of aluminum alloy
4. Bleed-air lines are made of stainless steel and air-conditioning distribution lines of aluminum alloy

4-42. Excessive torquing of clamps used in bleed-air air-conditioning systems will cause which of the following results?

1. Sructural loads on the ducting
2. Structural loads on support brackets
3. Structural loads on the clamping devices
4. Ruptures in the system ducting

4-43. When installing a base between two duct sections, what is the minimum and maximum distance allowed between the duct ends?

1. 1/8 inch minimum, 1/4 inch maximum
2. 1/8 inch minimum, 3/4 inch maximum
3. 1/4 inch minimum, 1/2 inch maximum
4. 1/4 inch minimum, 3/4 inch maximum

4-44. When installing a hose between two ducts, what is the maximum misalignment allowed between the two duct ends?

1. 1/8 inch
2. 1/4 inch
3. 3/8 inch
4. 1/2 inch

4-45. When installing rigid couplings on ducting, which of the following methods is used to assure proper alignment of the flanges in the couplings?

1. Tighten coupling until gap is completely closed, then back off 1/4 turn on the nut
2. Torque coupling to prescribed torque, tap around coupling with a plastic mallet and retorque to an additional 10 percent of prescribed torque
3. Tighten coupling firmly, tap around outer surface of coupling with a plastic mallet, then tighten coupling to prescribed torque valve
4. Torque coupling to torque valve, check clamp for proper position, then retorque to an additional 10 percent of original torque valve

---

Learning Objective: *Recognize the components and functions of the cabin cooling and antifog system.*

ITEMS 4-46 THROUGH 4-52 PERTAIN TO THE CABIN COOLING AND ANTIFOG SYSTEM ON THE F-18 AIRCRAFT.

4-46. When an increase in air temperature is desired in the cabin, air is routed through which of the following components?

1. Cabin/defog ram air control valve
2. Cabin add heat valve
3. Cabin flow valve
4. Anti-ice add heat valve

4-47. Distribution of conditioned air to the cabin can be divided between air used for the cabin and air used for defogging the windshield. This distribution is accomplished by what action?

1. Selecting the appropriate position on the suit/cabin temperature control valve
2. Selecting the appropriate position on the air-conditioning system temperature/flow controller
3. Selecting the appropriate position on the windshield defogging switch
4. Selecting the appropriate position on the cabin defog plenum distribution valve with a control handle

4-48. Which of the following components provides the electrical signal that determines the position of the cabin add heat valve?

1. Cabin air overtemperature sensor
2. Cabin airflow\temperature sensor
3. Cabin/defog plenum distribution valve
4. Suit/cabin temperature control

4-49. Which of the following actions explains how air pressure and spring tension operate the cabin add heat valve?

1. Venting air pressure from the valve allows the valve to close against spring tension
2. Venting air pressure from the valve allows the valve to open under spring tension
3. Regulated air pressure to the valve and spring tension aid in opening the valve
4. Regulated air pressure to the valve overcomes spring tension opening the valve

4-50. When an overtemperature occurs in the cabin cooling system, the cabin air overtemperature sensor allows which of the following actions?

1. The cabin flow valve to open
2. The cabin/defog plenum distribution valve to close
3. The cabin add heat valve to close
4. The cabin ram air check valve to open

4-51. What component(s) in the cabin cooling and antifog system provide(s) for the automatic operation of the cabin flow valve?

1. Cabin/defog ram air solenoid only
2. Cabin/defog ram air solenoid and the cabin overtemperature sensor
3. Cabin airflow/temperature sensor only
4. Cabin airflow/temperature sensor and the air-conditioning system temperature/flow controller

4-52. Which of the following statements is correct regarding the automatic drain valve in the cabin cooling and antifog system?

1. It relieves excessive pressure
2. It regulates pressure in the system
3. It is open to drain moisture from the supply duct, it closes when pressure is applied
4. It drains the system of moisture when the switch on the air-conditioning system temperature/flow controller is turned on, and it closes automatically when pressure is applied to the system

---

Learning Objective:
Recognize the source for avionics cooling air and identify the components of the avionic cooling system and the function of each component.

ITEMS 4-53 THROUGH 4-62 PERTAIN TO THE F-18 AVIONICS COOLING SYSTEM.

4-53. The air taken from the aircraft air-conditioning system to cool avionic equipment is controlled by which of the following components?

1. ECM cooling air control valve only
2. Avionics RAM air valve only
3. ECM cooling air control valve and avionics ram air valve
4. Avionics flow/temperature sensor and temperature/flow controller

4-54. A pressure differential of 1.5 psi between the avionics cooling system and the air cycle air-conditioning system is maintained by which of the following components?

1. Avionics flow/temperature sensor
2. Avionics flow valve
3. ECM cooling air control valve
4. Avionics ram air valve

4-55. Air that comes through the avionics ram air valve to augment avionics cooling comes from which of the following sources?

1. Secondary heat exchanger ram air inlet
2. Liquid cooling system
3. Emergency ram air scoop
4. Air cycle air-conditioning system

4-56. What component in the avionics cooling system operates the avionics ram air valve?

1. Avionics flow/temperature sensor
2. Pressure switch and the secondary heat exchanger
3. ECM cooling air central valve
4. Avionics ram air servo

4-57. Which of the following components controls the amount of airflow that will be directed to the ECM equipment for cooling purposes?

1. Avionics ram air valve
2. Emergency ram air scoop
3. ECM cooling air control valve
4. Avionics fan control pressure switch

4-58. What component controls the position of the ECM cooling air control valve?

1. ECM made switch
2. ECM cooling air control valve switch
3. Avionics fan control pressure switch
4. Avionics airflow control valve switch

4-59. Under which of the following conditions does the aircrafts avionics ground cooling fan cool avionics equipment?

1. During ground operation only
2. During ground operation and taxi only
3. During takeoffs only
4. During ground operation, taxi, takeoffs, and landings

4-60. (Refer to figure 3-11 and supporting material in the text.) What prevents cooling air in the avionics system from escaping through the ground cooling duct during flight?

1. Avionics ram air check valve
2. Nose wheel well plenum check valve
3. Avionics fan check valve
4. Avionics airflow check valve

4-61. (Refer to figure 3-11 and supporting material in the text.) The avionics fan control pressure switch will operate the avionics ground cooling fan when which of the following conditions exist?

1. During low airspeed flight operation
2. During all flight and ground operation
3. When the avionics ram air valve fails
4. When the air cycle air-conditioning system's pressure is below 26±1 psig

4-62. The emergency ram air scoop provides-ram air cooling for essential conditions. The air scoop is activated by which of the following components?

1. Air-conditioning system temperature/flow controller
2. Avionics temperature/flow sensor
3. FCS cool switch
4. Ram air pressure control switch

Assignment 5

Textbook Assignment: "Pressurization and Air-Conditioning Systems"; and "Oxygen Systems." Pages 3-17 through 4-3.

Learning Objective: *Recognize the operating principle of a vapor cycle air conditioning system and identify system components and their functions.*

ITEMS 5-1 THROUGH 5-2 PERTAIN TO THE VAPOR CYCLE AIR-CONDITIONING SYSTEM USED ON THE E-2 AIRCRAFT.

5-1. In what system component is the pressure of the refrigerant increased to the point that its condensing temperature is above the temperature of the water or air used for condensing purposes?

1. Expansion valve
2. Evaporator
3. Compressor
4. Condenser

5-2. (Refer to figure 3-12 and supporting material in the text.) Which of the following is the flow sequence for refrigerant through the system?

1. Receiver → subcooler → expansion valve → evaparator → subcooler → compressor → condenser → receiver
2. Receiver → subcooler → evaparator → subcooler → expansion valve → compressor → condenser → receiver
3. Receiver → condenser → subcooler → compressor → evaporator → subcooler → expansion valve → receiver
4. Receiver → expansion valve → compressor → subcooler → condenser → evaparator → subcooler → receiver

5-3. The air delivered to the aircraft avionics compartment is controlled within which of the following temperature ranges?

1. 33° ±5°C
2. 38° ±5°C
3. 38° ±5°F
4. 43° ±5°F

5-4. What is the source of power for the compressor and the evaporator fan mounted on the evaporator assembly?

1. Ram air driven motor
2. Hydraulically driven motor
3. Electrically driven ac motor
4. Electrically driven dc motor

5-5. During ground operation with engines running and insufficient ram air across the condenser for cooling, what component allows engine bleed air to be used to increase airflow across the condenser?

1. Thermostatic expansion valve
2. Ram air scoop actuator
3. Ejector air shutoff valve
4. Condenser pressure transducer

5-6. With the equipment cooling switch set to ON, what valve is energized to direct hydraulic pressure to the compressor drive motor and evaporator assembly fan motor?

1. Service
2. Shutoff
3. Lower charge
4. Thermostatic expansion

5-7. From an operational standpoint, what happens to the compressor motor and evaporator fan motor when the aircraft is in flight with the landing gear down, either engine in autofeather position, and the equipment cooling switch in the ON position?

1. Compressor motor and fan motor will continue to operate
2. Compressor motor and fan motor will stop operating
3. Compressor motor will continue to operate and fan motor will stop operating
4. Compressor motor will stop operating and the fan motor will continue to operate

5-8. The high-speed cutout switch will cause the equipment cooling caution light in the cockpit to come on if the refrigerant pressure exceeds what pressures?

1. 225 ±10 psi
2. 225 ±5 psi
3. 250 ±10 psi
4. 250 ±5 psi

5-9. If the high-pressure cutout switch fails to function properly, at what pressure will the relief valve in the compressor discharge line open?

1. 323 psi
2. 324 psi
3. 325 psi
4. 326 psi

5-10. What component of the condenser assembly provides a signal to control the position of the condenser flap to regulate pressure?

1. Actuator
2. Expansion valve
3. Pressure transducer
4. High side controller

5-11. What component prevents surges in the refrigerant flow rate of the vapor cycle system?

1. Receiver
2. Evaporator
3. Check valve
4. Thermostatic expansion valve

5-12. The refrigerant temperature in the vapor cycle system is maintained between 29.8° and 32.9° ±0.6°F. This will produce approximately what temperature in the equipment compartments?

1. 36°F
2. 38°F
3. 40°F
4. 42°F

5-13. At what fan inlet temperature will the low temperature cutoff switch de-energize the compressor power relay?

1. 28°F
2. 29°F
3. 30°F
4. 31°F

IN ITEMS 5-14 THROUGH 5-16, SELECT FROM COLUMN B THE FUNCTION OF EACH COMPONENT LISTED IN COLUMN A.

A. Components	B. Functions
5-14. Subcooler	1. Removes moisture and other contaminants that may be in the liquid Freon 12
5-15. Receiver	2. Ensures that the liquid Freom 12 will not vaporize prematurely after passage through the thermostatic expansion valve
5-16. Filter-drier	3. Aids in determining whether servicing of the refrigerant unit is required
	4. Ensures that the thermostatic expansion valve receives an adequate supply of liquid Freon 12 during peal load conditions

3-17. The flow of refrigerant to the outlet parts of the expansion valve is controlled by positioning a metering valve pin. The position of this pin is determined by what factor?

1. Superheat spring setting only
2. Evaporator discharge pressure only
3. Pressure created by the remote sensing bulb only
4. The pressure created by the remote sensing bulb, superheat spring setting, and evaporator discharge pressure

5-18. What part of the expansion valve is designed to ensure that the Freon 12 is in a gaseous state when it returns to the compressor?

1. The metering valve
2. The superheat spring
3. The inlet port
4. The equalizer port

5-19. An overcenter device installed in the evaporator header duct assembly--opens the louvers automatically and supplies cooling air to the avionics gear when which of the following conditions exist?

1. When the aircraft is on the ground and equipment cooling is required
2. When the aircraft is airborne and equipment cooling is required
3. When the aircraft is on the ground and a ground cooling cart is plugged into the aircraft for equipment cooling
4. When the aircraft is on the ground and equipment cooling is being changed from ground cart to aircraft cooling system

5-20. In which of the following system components does Freon 12 changes state occur?

1. The compressor and the receiver
2. The condenser and the compressor
3. The evaporator and the condenser
4. The receiver and the evaporator

5-21. The compressor operates in accordance with which of the following principles?

1. The pressure and temperature of a given volume of confined gas will increase if its volume increases
2. If a given volume of gas is trapped and the area in which it is contained gradually decreases, the pressure and temperature will increase
3. The pressure of a given volume of confined gas will increase and its temperature will decrease if its volume decreases
4. The pressure of a given volume of confined gas will decrease and its temperature will increase if its volume decreases

5-22. The highest temperature and pressure of the refrigeration cycle begins at what device or location?

1. Receiver
2. Condenser
3. Discharge side of the compressor
4. Discharge side of the ther– mostatic expansion valve

5-23. When the system is shut down, what prevents high-pressure discharge from the compressor from motorizing the compressor in reverse?

1. The check valve
2. The relief valve
3. The charge valve
4. The high-pressure cutout switch

5-24. At what differential pressure range across the filter will the bypass device open and permit unfiltered oil to circulate through the compressor?

1. 13.5 to 16.5 psi
2. 16.5 to 18.5 psi
3. 16 to 20 psi
4. 18 to 22 psi

IN ITEMS 5-25 AND 5-26, SELECT FROM COLUMN B THE COMPONENT USED FOR THE FUNCTION GIVEN IN COLUMN A.

	A. Functions	B. Components
5-25.	To facilitate. individual group servicing or servicing the system as one complete unit	1. Condenser ejector shutoff valve
		2. Purge valve
5-26.	To bleed the system and to attach test equipment or the vacuum pump	3. Charging valves

Learning Objective: *Recognize vapor cycle charging cart heater tank capacity and the oil chargínq cylinder’s temperature/pressure relation.*

5-27. What is the capacity of the Freon storage bottle in the vapor cycle charging cart shown in fig. 3-18 in the text?

1. 20 pounds
2. 25 pounds
3. 20 gallons
4. 25 gallons

5-28. The vacuum pump has a displacement of 3 cubic feet per minute (cfm) and is rated for continuous duty.

1. True
2. False

5-29. What is the capacity in cubic inches of the heater tank on the vapor cycle charging cart?

1. 280 cubic in
2. 299 cubic in
3. 330 cubic in
4. 360 cubic in

5-30. The oil charging cylinder of the vapor charging cart has a capacity of 68 cubic inches and an operating pressure of 100 psi at which of the following temperatures?

1. 120°F
2. 125°F
3. 130°F
4. 135°F

5-31. Refrigerant cylinders should never be filled to more than what percent of their capacity?

1. 65 percent
2. 75 percent
3. 85 percent
4. 95 percent

Learning Objective: *Indentify components and conditions pf the ECS for the cockpit, cabin area, and the nose avionics compartment of the SH-60B helicopter.*

5-32. The SH-60B helicopter cabin cockpit and nose bay environments are controlled by the ECS, which provides both heating and air conditioning within what temperature range?

1. 2° to 71°C
2. 2° to 73°C
3. 3° to 72°C
4. 5° to 70°C

5-33. Bleed air is applied to the air-cycle machine (ACM) through a modulating valve which functions in what capacity?

1. As an on/off valve and pressure relief valve
2. As an on/off valve and temperature control valve
3. As a pressure regulator and relief valve
4. As an on/off valve and pressure regulator

5-34. With ECS selected ON (from engine source), maximum torque available is reduced by what percent?

1. 1.5
2. 2.5
3. 3.5
4. 4.5

5-35. In an overpressure condition, the overpressure switch will cause which of the following actions?

1. The ECS HI PRESS advisory panel light to come on
2. The modulating valve to close
3. System shutdown only
4. None of the above

5-36. (Refer to figure 3-19 and supporting material in the text.) The ECS control panel contains a three-position toggle switch to control the ECS operating modes. What are the three settings for this toggle switch?

1. OFF, ON, and MAN
2. OFF, AUTO, and MAN
3. OFF, ON, and RAM AIR
4. OFF, AUTO, and RAM AIR

5-37. The ECS will automatically shut down under which of the following conditions?

1. Engine contingency power is selected with the contingency-power switch (CNTGY PWR) on either collective stick
2. In any position of the AIR SOURCE ECS/START switch, when starting either No. 1 or No. 2 engine
3. Both 1 and 2 above
4. None of the above

5-38. Fan control is provided by the mission power (MSU PWR) switch, and by what other switch?

1. A 27°C temperature-sensing switch
2. A 27°C temperature-sensing switch located at each fan outlet
3. A 25°C temperature-sensing switch
4. A 27°C temperature-sensing switch located at each fan inlet

---

Learning Objective: *Recognize the purpose and function of the aircraft pressurization system to include maintenance and troubleshooting operations.*

5-39. What is the total number of cabin pressurization modes of operation provided by the S-3 aircraft pressure regulator control?

1. Five
2. Two
3. Three
4. Four

5-40. (Refer to table 3-1 and supporting material in the text.) During flight operations between 5,000 and 24,000 feet, the isobaric mode maintains the cabin altitude within what pressurization range?

1. 3,500 and 4,000 feet
2. 4,350 and 5,000 feet
3. 4,500 and 5,000 feet
4. 5,000 and 5,380 feet

5-41. The pressure regulator safety valve is an independent pneumatically operated, balanced poppet valve that limits cabin-to-ambient pressure differential to what pressure range?

1. 7+0.5 and -0.5 psi
2. 7+0.2 and -0.2 psi
3. 7+0.2 and -0.1 psi
4. 7+0.2 and -0.0 psi

5-42. The normally open low-pressure switch closes at 13,000 ±500 feet and reopens at what altitude?

1. 5,000 ±500 feet
2. 8,000 ±500 feet
3. 9,000 ±500 feet
4. 11,000 ±500 feet

5-43. Although an AE generally locates and corrects electrical troubles, the AME should be able to check circuits for lease connections and perform continuity checks.

1. True
2. False

5-44. There are how many distinct steps to follow during troubleshooting?

1. Five
2. Six
3. Seven
4. Eight

Learning Objective: *Recognize operating procedures for a multimeter.*

5-45. Which of the following instruments is used to measure direct current, alternating current, and resistance?

1. Direct current meter
2. Alternating current meter
3. Ohmmeter
4. Multimeter

5-46. When measuring resistance, in what position should you place the -dc/+dc/ac switch.

1. -dc
2. +dc
3. +ac
4. Resistance

5-47. When the multimeter is not in use, in what position should you place the range function switch?

1. Lowest resistance setting
2. Highest resistance setting
3. Lowest voltage setting
4. Highest voltage setting

5-48. Which of the following actions should be taken to read the resistance of a component after setting the meter to zero?

1. Keep the meter in the same position
2. Insert the slack test lead in the (+) jack
3. Keep the reading on the left of the second scale
4. All of the above

5-49. Ambient temperature affects the resistance of sensors.

1. True
2. False

Learning Objective: *Recognize the importance of oxygen to include types, characteristic, and the effects of a lack of oxygen.*

5-50. What is the most urgently needed substance to sustain human life?

1. Food
2. Oxygen
3. Water
4. Clothing

5-51. Sea level air pressure is how much greater than air pressure at 18,000 feet?

1. One and one-half times
2. Twice
3. Three times
4. Three and one-half times

5-52. What type of oxygen equipment is required on aircraft capable of flying in the 35,000 to 43,000 feet altitude ranges?

1. Demand type
2. Pressure type
3. Pressure demand type
4. Demand pressure type

5-53. What kind of oxygen is type 1?

1. Liquid oxygen for technical uses
2. Gaseous oxygen for technical uses
3. Gaseous oxygen for aviator's breathing purposes
4. Liquid oxygen for aviator's breathing purposes

5-54. What type of oxygen is type II oxygen, Spec. MIL-O-2720D?

1. Liquid oxygen for technical purposes
2. Liquid oxygen for aviator's breathing purposes
3. Gaseous oxygen for technical purposes
4. Gaseous oxygen for aviator's breathing purposes

5-55. Water vapor content is specified for breathing oxygen in order to prevent which of the following problems?

1. Clogging of the oxygen system with ice
2. Rust from forming in the oxygen system
3. Excessive humidity in the lungs
4. Physical injury to the body

5-56. What is the natural state of oxygen?

1. Solid
2. Liquid
3. Gel
4. Gas

5-57. Oxygen forms what percent by volume of the total composition of the atmosphere?

1. 12%
2. 21%
3. 52%
4. 78%

5-58. What is the most plentiful element in our environment?

1. Chlorine
2. Argon
3. Nitrogen
4. Oxygen

5-59. Which of the following are characteristics of oxygen?

1. Weightless, colorless, and tasteless
2. Tasteless, valueless, and odorless
3. Colorless, odorless, and tasteless
4. Volumeless, weightless, and colorless

5-60. The most rapid oxidation is found in which of the following processes?

1. Rust
2. Combustion
3. Evaporation
4. Liquefaction

5-61. Oxygen is found in which of the following chemical states?

1. Gas or solid only
2. Gas or liquid only
3. Liquid or solid only
4. Gas, liquid, or solid

6-62. One gallon of liquid oxygen weighs how many pounds?

1. 6.00 pounds
2. 8.49 pounds
3. 9.52 pounds
4. 16.00 pounds

5-63. A complete lack of oxygen, which causes death, is called anoxia,

1. True
2. False

5-64. Which of the following statements concerning hypoxia is NOT true?

1. Individuals vary in their reactions to hypoxia
2. The same sensations experienced in suffocation are present in hypoxia
3. The effects of a certain degree of hypoxia on a person cannot be accurately predicted
4. A person may be highly susceptible to hypoxia one day and relatively resistant to it the next

5-65. In order to determine when supplemental oxygen is needed, the aviator must depend on what factor or device?

1. His judgement
2. The altimeter
3. His sensations
4. The flow indicator

5-66. Generally, what parts of the body are first affected by hypoxia?

1. Ears
2. Eyes
3. Lungs
4. Muscles

5-67. At what minimum altitude will hypoxia appreciably impair night vision?

1. 5,000 feet
2. 7,500 feet
3. 10,000 feet
4. 12,000 feet

5-68. At altitudes between 10,000 and 15,000 feet, what is the greatest danger from hypoxia?

1. Headache
2. Drowsiness
3. Poor vision
4. Error in judgement

3-69. Most of the anoxia deaths during World War II occurred in which of the following altitude ranges?

1. 10,000 to 15,000 feet
2. 15,000 to 20,000 feet
3. 20,000 to 25,000 feet
4. 25,000 to 30,000 feet

Assignment 6

Textbook Assignment: "Oxygen Systems." Pages 4-4 through 4-18.

Learning Objective: Identify safety precautions, components, typical systems, and maintenance procedures for gaseous oxygen systems.

6-1. A minimum of 50 psi must be maintained in a gaseous oxygen supply cylinder. What could be the result of not maintaining this minimum pressure?

1. The oxygen regulators would not function properly
2. The crew member's masks 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

6-2. Pressurized oxygen is potentially very dangerous, therefore; personnel must be very knowledgeable and extremely cautious when handling oxygen or servicing and maintaining oxygen systems.

1. True
2. False

6-3. Personnel servicing or maintaining oxygen systems and components must be meticulously careful to protect systems from which of the following substances?

1. Grease and oil
2. Hydraulic fluid
3. Both 1 and 2 above
4. Type 1 trichlorotrifloroethane

6-4. When oxygen cylinders are handled or transported, the valve protection cap must be in place and, prior to removing the cap and opening the valve, the cylinders must be firmly held in place.

1. True
2. False

6-5. Anyone familiar with the established color codes provided in MIL-STD-101A can identify the contents of a cylinder as oxygen because it is painted what color?

1. Gray
2. Blue
3. Green
4. Yellow

6-6. Oxygen cylinder valves are equipped with a fusible metal safety plug filled with a fusible metal designed to melt within what temperature range?

1. 190° to 207°F
2. 208° to 220°F
3. 221° to 245°F
4. 246° to 268°F

6-7. 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

6-8. Which of the following regulator maintenance tasks are NOT performed by AMEs?

1. Removal
2. Installation
3. Repairs
4. Operational checks

6-9. The tubing used in aircraft high-pressure oxygen systems is made from which of the following types of metal?

1. Copper
2. Steel
3. Bronze
4. Aluminum

6-10. What lines run from the oxygen cylinders to the regulators?

1. Filler
2. Cylinder
3. Regulator
4. Distribution

6-11. Oxygen lines are identified by strips of what color paint and/or tape?

1. White paint
2. Blue and white tape
3. Green and white tape
4. Green paint

6-12. At what minimum pressure is type N tubing pressure tested?

1. 300 psi
2. 450 psi
3. 1,800 psi
4. 3,000 psi

6-13. 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 reducer 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 bath high and low-pressure systems

6-14. Adapters and fittings are connected to the ends of copper tubing in high-pressure oxygen systems in what manner?

1. Flared
2. Electric arc welded
3. Silver soldered
4. Tin and lead soldered

6-15. Some later models of naval aircraft with high-pressure oxygen will have which of the following types of tubing in the oxygen system?

1. Aluminum-alloy
2. Stainless steel
3. Both 1 and 2 above
4. Aluminum

6-16. 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. Check
2. Filler
3. Shutoff
4. Pressure-reducing

6-17. Check valve castings have arrows embossed on them to provide what information?

1. The direction of the master oxygen supply
2. The direction of 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

6-18. 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

6-19. Pressure reducers are always in what locations?

1. Oxygen distribution lines
2. Cylinder outlet caps
3. Filler valve inlets
4. Regulator outlets

6-20. What valve, located within the common filler valve, opens during the oxygen system filling operation and closes when filling is complete?

1. Check
2. Shutoff
3. Regulator
4. Pressure-reducing

6-21. 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

6-22. High-pressure gaseous oxygen system pressure gauges mounted at each flight statiom 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

6-23. What type of oxygen system usually uses pressure reducers in the distribution lines?

1. Law-pressure system
2. High-pressure system
3. Reduced high-pressure system
4. Reduced low-pressure system

6-24. 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 above
4. Rupture of the green disc in the discharge indicator

6-25. 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

6-26. An AME can intelligently locate a malfunctioning component in a gaseous oxygen system without being familiar with the system or knowing the function of each component within the system.

1. True
2. False

Learning Objective: *Identify safety precausions, components, installation and testing of components, and operating procedures for liquid oxygen (LOX) systems.*

6-27. Liquid oxygen will remain a liquid under normal atmospheric pressure at what temperature?

1. -320°F
2. -297°F
3. -220°F
4. -182°F

6-28. What is the expansion ratio of liquid oxygen to gaseous oxygen?

1. 962-1
2. 862-1
3. 782-1
4. 692-1

6-29. Personnel that could be exposed to accidental spillage of LOX must wear which of the following equipment?

1. Face shield
2. Gloves and oxygen safety shoes
3. Coveralls
4. Each of the above

6-30. The combustion supporting potential of oxygen is a greater danger than freezing.

1. True
2. False

6-31. 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. Four slowly to allow the receiving receptacle to cool sufficiently without thermal breakage
3. Both 1 and 2 above
4. Minimize LOX from venting into the atmosphere by pouring as rapidly as possible

6-32. 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
2. 12,000
3. 14,000
4. 16,000

6-33. The pressure relief assembly in LOX system storage vessels consists of which of the following items?

1. A ruptured disc
2. A reseatable relief valve
3. Both 1 and 2 above in series
4. Both 1 and 2 above in parallel

6-34. 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

6-35. 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 down 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

6-36. 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

6-37. 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

6-38. What is the advantage of using liquid oxygen systems over gaseous oxygen systems on aircraft?

1. Liquid systems are 1ess dangerous
2. One LOX converter replaces several cylinders of gaseous oxygen
3. Liquid systems are more efficient
4. Liquid oxygen is more economical to manufacture

6-39. A LOX converter consists of a steel inner and outer shell. If a leak should develop in the inner shell an explosion could occur. Which of the following components prevents an explosion from occurring?

1. Pressure relief valve
2. Blowout disc
3. Pressure regulator
4. Each of the above

6-40. When servicing an aircraft LOX system, what prevents liquid from flowing into the oxygen system supply port?

1. One-way check valve
2. Isolation valve
3. Filler valve
4. Two-way check valve

6-41. During servicing of an aircraft LOX system, a means for venting is needed. What valve in the oxygen system provides this venting?

1. Spring-loaded check valve
2. Pressure relief valve
3. Vent valve
4. Filler valve

6-42. If for some reason the spring fails to tightly hold the poppet in the filler port on its seat after the LOX cart has been disconnected from the aircraft, oxygen from an aircraft's converter will not escape into the atmosphere because of what valve or poppet?

1. Check valve in the filler port
2. Check valve in the converter supply line
3. Finer valve supply poppet
4. Converter pressure control valve

IN ITEMS 6-43 THROUGH 6-48, SELECT FROM COLUMN B THE LOX SYSTEM COMPONENT THAT PERFORMS THE FUNCTION LISTED IN COLUMN A. COMPONENTS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions	B. Components
6-43.	Operates when the pressure control valve malfunctions	1. Pressure opening valve
6-44.	Controls the flow of gaseous oxygen into the supply line	2. Pressure closing valve
6-45.	Prevents system contamination when the converter is removed	3. Relief valve
6-46.	Prevents excess pressure from building up in the system when not in use	4. Quick-disconnect coupling
6-47.	Allows easy removal of the LOX converter from the aircraft	
6-48.	Maintains operating pressure within the converter	

6-49. 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 crew member breathing the oxygen
4. To convert the LOX to gaseous oxygen

6-50. 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

6-51. How does a crew member know when the LOX(system is in a low state?

1. By dchecking the quantity indicator
2. By the illumination of a low quantity light
3. By both 1 and 2 above
4. By checking the oxygen pressure gauge

6-52. What is incorporated in the LOX system to protect the pressure regulator and crew member 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

6-53. 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

IN ITEMS 6-54 THROUGH 6-58, SELECT FROM COLUMN B THE ACTION THAT RESULTS FROM THE MINIATURE OXYGEN BREATHING REGULATOR FUNCTIONS LISTED IN COLUMN A. ACTIONS IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Functions.	B. Action
6-54.	Oxygen flow from the paddle base area produces a pressure drop behind the demand valve diaphragm	1. Oxygen flow
6–55.	The sensing diaphragm returns to the balanced position	2. Safety pressure obtained
6-56.	The small volume bleed vent closes the aneroid vent and builds up pressure on the sensing diaphragm	3. Automatic pressure breathing
6-57.	The sensing diaphragm force is equal to the aneroid chamber force	4. Opens the mask exhalation valve
6-58.	The relief valve acts as a pivot device	

6-59. Which of the following are low pressure oxygen regulators?

1. Miniature and MD-2
2. Miniature and MD-1
3. MD-1 and MD-2
4. Miniature only

THE MD TYPE OXYGEN REGUATORS HAVE THREE TOGGLES. IN ITEMS 6-60 THROUGH 6-65, MATCH THE SPECIFIC TOGGLE LISTED IN COLUMN B WITH THE ACTION STATEMENT LISTED IN COLUMN A. THE TOGGLE IN COLUMN B MAY BE USED MORE THAN ONCE.

	A. Action	B. Toggles
6-60.	Used to cutoff the oxygen supply to the regulator	1. supply toggle
6-61.	Used to obtain 100% oxygen at 10,000 ft	2. Diluter toggle
		3. Emergency toggle

6-62. Used to deliver positive pressure to the mask at crew member demand

6-63. Used for checking the fit of the mask

6-64. Has a position labeled normal oxygen

6-65. Can be placed in one of three positions

Assignment 7

Textbook Assignment: "Oxygen System"; and "Oxygen Support Equipment." Pages 4-19 through 5-16.

Learning Objective: *Identify safety precautions, components, installation and testing of components, and operating procedures for liquid oxygen (LOX) systems. (This objective is continued from assignment 6.)*

7-1. What component in the MD type regulator protects it from overpressure?

1. Second stage relief valve
2. First stage relief valve
3. Venturi assembly
4. Aneroid check valve

7-2. Ambient air for mixing with oxygen passes through what component in an MD type regulator?

1. Demand valve assembly
2. Demand diaphragm chamber
3. Venturi assembly
4. Diluter aneroid assembly

7-3. What component in the MD type regulator prevents oxygen from flowing out through the inlet ports?

1. Demand valve assembly
2. Diluter aneroid assembly
3. Venturi assembly
4. Aneroid check valve

7-4. Pressure breathing above 30,000 feet is a feature of MD type pressure regulators. Which of the following is one of the components in the regulator that provides this feature?

1. Aneroid assembly
2. Demand valve assembly
3. Diluter aneroid assembly
4. Aneroid check valve assembly

7-5. Fire and/or explosion may result when even slight traces of combustible material come in contact with oxygen under pressure.

1. True
2. False

7-6. In making a functional check of the MD type regulator, a properly operating regulating will be indicated on the flow indicator in which of the following ways?

1. The indicator will show movement from the zero position-when inhaling
2. The indicator will show movement from the zero positiom when exhaling
3. The indicator will show white when inhaling and black exhaling
4. The indicator will show white when exhaling and black inhaling

7-7. When making a functional check of an oxygen system that uses the MD type regulator, what position must the emergency lever be in to check for oxygen supply through the regulator at ground level?

1. Emergency
2. 100-percent oxygen
3. Normal
4. ON

7-8. When making a functional check of an oxygen regulator, holding the emergency pressure control lever in the TEST MASK position produces which of the following results on the oxygen regulator panel?

1. The lamp will light
2. An increase in pressure on the pressure gauge
3. The flow indicator will go to the white position
4. Each of the above

7-9. What are the LOX converter's three sequences of operation?

1. Service, supply, and reservice
2. Fill, buildup, and supply
3. Reservice, supply, and buildup
4. Buildup, supply, and standby

IN ITEMS 7-10 THROUGH 7-14, SELECT FROM COLUMN B THE SEQUENCE OF LOX SYSTEM OPERATION THAT IS AUTOMATICALLY STARTED BY EACH ACTION/VALVE OPERATION LISTED IN COLUMN A. SEQUENCES OF OPERATION IN COLUMN B B MAY BE USED MORE THAN ONCE.

	A. Actions/ Valves Operations	B. Sequence of Operations
7-10.	The differential check valve opens	1. Fill
		2. Buildup
7-11.	The trailer hose nozzle is removed from the converter	3. Demand mode
		4. Supply-economy mode

7-12. The pressure opening valve unseats

7-13. The trailer hose nozzle is connected to the filler port

7-14. When oxygen becomes available at the supply outlet

7-15. When installing a section of tubing in an aircraft's oxygen system, which of the following items is permitted for use on the threads of the tubing connectioms prior to tightening?

1. Locktite
2. Waterproof grease
3. Antiseize tape
4. Thread compound

Learning Objective: *Identify the system components and operation of the onboard oxygen generating system (OBOGS).*

7-16. Which of the following is an advantage of the OBOGS as compared to the LOX system?

1. An OBOGS requires no extensive depot-level maintenance
2. An OBOGS eliminates the need for daily servicing
3. An OBOGS requires no special transportation and storage equipment
4. Each of the above

7-17. Scheduled preventive maintenance occurs at what number of hours on the OBOGS?

1. 1,000 hours
2. 2,000 hours
3. 3,000 hours
4. 4,000 hours

7–18. Through which of the following components does the OB0GS receive engine bleed air?

1. Engine turbine
2. Heat exchanger
3. Cooling turbine
4. Ram air outlet

7-19. Which, if any, of the following elements is retained in the molecular sleeve beds as the airflow passes through them?

1. Oxygen
2. Nitrogen
3. Argon
4. None of the above

7-20. What component acts as a surge tank and an accumulator for the OBOGS?

1. Plenum
2. Reservoir
3. Heat exchanger
4. Oxygen monitor

Learning Objective: *Describe safety precautions and handling procedures for liquid oxygen (Lox) storage tanks, transfer lines, and valves.*

7-21. LOX storage tanks consist of what components?

1. Single containers
2. High density containers
3. Outer and inner containers
4. Low density containers

7-22. The annular insulated space between containers of LOX storage tanks is vacuum pressurized.

1. True
2. False

7-23. Significant waste of LOX by the transfer hose/line is due to what factor?

1. Leaks
2. Cooldown
3. Improper connection
4. O-ring failure

7-24. Flexible metal hose under high pressure reacts in what manner?

1. It expands in length only
2. It expands in diameter only
3. It expands in length and diameter
4. It does not expand

7-25. LOX should never be trapped in a line between closed valves because of what occurrence?

1. The valves will freeze
2. The line will freeze
3. Excessive pressure can develop in the line
4. Pressure in the tank will bleed off

7-26. Which of the following components of a LOX storage system causes the most trouble?

1. Relief valve
2. Low temperature valve
3. Servicing hose
4. Rupture disc

7-27. Which of the following methods is most effective in insulating LOX valves?

1. Vacuum jacketing
2. Fiber glass insulation
3. Polyethylene foam insulation
4. Heater jacketing

Learning Objective: *Describe oxygen servicing equipment to include safety precautions, service trailers, and system servicing.*

7-28. What should be the first aid provided if LOX is splashed on the skin?

1. Coat the area with petroleum jelly
2. Wrap the area with dry cloth
3. Wrap the area with damp cloth
4. Flush the area with water

7-29. Which of the following valves must be in the open position when a LOX oxygen trailer is not in use?

1. Buildup
2. Supply
3. Fill drain
4. Vent

7-30. In the LOX handling area, what is the safe distance permitted for smoking or open flames?

1. 25 feet
2. 50 feet
3. 75 feet
4. 100 feet

7-31. What is the major difference between the standard and the closed loop LOX trailers?

1. The closed loop trailer operates on a higher pressure
2. The closed loop trailer recaptures vented LOX losses
3. The standard trailer operates faster
4. The standard trailer is more economical

7-32. Which of the following safety hazards is eliminated by use of the closed loop LOX cart?

1. Venting oxygen
2. Trapped liquid in the lines
3. Static discharge
4. Overpressurization

7-33. The transfer tank of the closed loop LOX trailer has what capacity?

1. 15 liters
2. 25 liters
3. 50 liters
4. 65 liters

7-34. To what minimum number of microns is the 30-gallon storage tank of the closed loop LOX trailer evacuated?

1. 5
2. 7
3. 9
4. 11

7-35. What is the primary function of the 15-liter transfer tank?

1. To maintain system pressure
2. To hold small volumes of LOX for transfer
3. To maintain system temperature
4. To pressurize the 50 gallon storage tank

7-36. To transfer LOX to the converter, the transfer tank pressure must be in what relationship with the storage tank pressure?

1. Less than storage tank pressure
2. Greater than storage tank pressure only
3. Equal to storage tank pressure only
4. Greater than or equal to storage tank pressure

7-37. When using the closed loop LOX trailer, when the converter is full, the converter full indicator gauge displays what reading?

1. 5 liters
2. 10 liters
3. Full
4. Liquid

7-33. Which of the following gauges does not have green and red indicating bands?

1. The transfer tank pressure gauge
2. The storage tank pressure gauge
3. The storage tank liquid level gauge
4. The transfer tank liquid level gauge

7-39. Pressure in the storage tank of the closed loop LOX trailer must not exceed what pressure?

1. 55 psi
2. 65 psi
3. 75 psi
4. 85 psi

7-40. Under normal conditions, using a 30 psig transfer pressure, the TMU 70/M LOX trailer should fill in what maximum length of time?

1. 1 to 2 minutes
2. 5 to 10 minutes
3. 12 to 15 minutes
4. 20 to 30 minutes

7-41. You should never let the transfer tank pressure of the closed loop LOX trailer exceed what maximum pressure?

1. 30 psi
2. 50 psi
3. 70 psi
4. 90 psi

7-42. At what maintenance level are AMEs allowed to perform maintenance on LOX trailers?

1. Organizational
2. Intermediate
3. Depot
4. Both 2 and 3 above

7-43. Which, if any, of the following fire-fighting agents is authorized for use on LOX enriched fires?

1. Soda acid
2. Methyl bromide
3. Carbon tetrachloride
4. None of the above

Learning Objectives: *Recognize contamination control procedures for oxygen equipment to include detection, purging, and purging equipment.*

7-44. How often must an odor test be performed on a LOX trailer when it is not in use?

1. Every day
2. Every 3 days
3. Every 6 days
4. Every 9 days

7-45. How often must an odor test be performed on an aircraft oxygen system?

1. When painting has been performed on the aircraft
2. When odors are reported by the pilot or aircrew
3. When the aircraft oxygen system is found to have a leak
4. When a phase inspection is performed

7-46. How many milliliters of LOX is used to perform an odor test?

1. 100
2. 200
3. 300
4. 400

7-47. During an odor test, odors will be most prevalent under which of the following conditions?

1. While liquid is in the beaker
2. Fifteen to twenty minutes after the liquid has evaporated
3. Both 1 and 2 above
4. When the beaker has warmed to nearly room temperature

7-40. If odors are discovered during an odor test, what procedure must be performed on the converter or LOX system?

1. It must be refilled and retested.
2. It must be sampled and tested by NADEF
3. It must be purged in accordance with existing directives
4. It must be wet cleaned and refilled

7-49. What is the most dangerous contaminant of LOX?

1. Water vapor
2. Nitrogen
3. Hydrocarbons
4. Inert solids

7-50. Which of the following is NOT a psychological effect of hydro-carbon contamination in LOX?

1. Uneasiness
2. Apprehension
3. Panic
4. Asphyxia

7-51. Which of the following is NOT a physiological effect of hydro-carbon contamination in LOX?

1. Panic
2. Nausea
3. Illness
4. Intoxication

7-52. Acetylene is the most hazardous hydrocarbon contaminant in LOX because of its ability to cause which of the following conditions?

1. Freezing of the lines
2. Internal corrosion of oxygen regulators
3. Both 1 and 2 above
4. It becomes its own source of ignition

7-53. Which of the following LOX contaminants will cause mechanical malfunctions of LOX system components?

1. Water vapor
2. Fibers
3. Nitrous oxide
4. Halogenated compounds

7-54. Base LOX storage tanks will be tested for odor a minimum of how often?

1. Every 7 days
2. Every 14 days
3. Every 21 days
4. Every 28 days

7-55. LOX samples are prepared for use by what organization?

1. The AME shop
2. The AIMD paraloft
3. The ground support equipment work center
4. The depot maintenance activity

7-56. The sampler, as received by the using activity, is sealed and contains gaseous oxygen at what pressure?

1. 5 psi
2. 10 psi
3. 15 psi
4. 20 psi

7-57. A LOX sampler received without a residual gaseous oxygen pressure should be given what treatment?

1. Purged before use
2. Wet cleaned and purged before use
3. Rejected and returned
4. Dried in an oven before use

7-58. What is the maximum number of ways to purge oxygen containers?

1. One
2. Two
3. Three
4. Four

7-59. What is the purpose of the LOX wash method of purging?

1. To purge LOX lines
2. To lower the contamination of LOX trailers
3. To purge gaseous oxygen cylinders
4. To lower the contamination of LOX converters

7-60. Aircraft LOX converters must, be purged under which of the following conditions?

1. Before putting them into service
2. If allowed to run dry
3. If odor is detected
4. Each of the above

7-61. The hot nitrogen gas used in purging LOX converters must be at what minimum temperature?

1. 100°F
2. 150°F
3. 200°F
4. 250°F

7-62. The hot nitrogen gas used in purging a LOX converter is regulated to what minimum pressure?

1. 30 psi
2. 40 psi
3. 50 psi
4. 60 psi

7-63. What is the minimum amount of time a converter should be purged?

1. One hour
2. Two hours
3. Three hours
4. Four hours

7–64. What should be the minimum temperature of the hot nitrogen exiting a converter being purged?

1. 50°F
2. 100°F
3. 150°F
4. 200°F

7-65. After a LOX converter has been purged and serviced, an odor test is performed. If odors persist, the converter must be subjected to what action?

1. Repurging
2. Turn into supply
3. Routing to NADEP
4. Wet cleaning

7-66. The gas purging set is designed to be used with which of the following gases?

1. Hydrogen
2. Nitrogen
3. Helium
4. Argon

7-67. Which of the following gases can be used with the gas purging set if water pumped gaseous nitrogen is not available?

1. Helium
2. Hydrogen
3. Oxygen
4. Argon

7-68. On the gas purging set, the high pressure relief valve relieves pressure in excess of what maximum pressure?

1. 3,550 psi
2. 3,600 psi
3. 3,675 psi
4. 3,750 psi

7-69. The high pressure gas from the gas supply cylinders is reduced to what pressure range?

1. 40 ±5 psi
2. 50 ±5 psi
3. 60 ±5 psi
4. 70 ±5 psi

7-70. Gas passing through the heater assembly is heated to what maximum temperature?

1. 165°F
2. 205°F
3. 255°F
4. 285°F

7-71. The gas exiting the filler valve of the gas purging set will be within what maximum temperature range?

1. 125 ±25°F
2. 225 ±25°F
3. 285 ±50°F
4. 325 ±50°F

7-72. A high temperature safety switch in incorporated in the system. It will break the electrical circuit to the heater assembly when heater assembly temperature exceeds what maximum temperature?

1. 175°F
2. 200°F
3. 250°F
4. 300°F

Assignment 8

Textbook Assignment: "Oxygen Support Equipment"; and "Canopy Systems."
Pages 5-16 through 6-25."

Learning Objective; *Identify components and operating procedures for gaseous oxygen servicing trailers.*

8-1. What maximum number of manifold control valves are located on the No-2 oxygen trailer?

1. 1
2. 5
3. 6
4. 8

8-2. The No-2 oxygen trailer has two pressure regulators to ensure uninterrupted operation should one fail.

1. True
2. False

8-3. The recharge valve on the No–2 oxygen trailer is provided for recharging the trailer cylinders directly through what device(s)?

1. The lower manifold
2. The upper manifold
3. One of the two pressure regulators
4. The servicing hose and line valve

8-4. Where are the four shutoff valves located on the No-2 oxygen trailer?

1. On the upper manifold
2. On the lower manifold
3. One onthe inlet and outlet side of each pressure regulator
4. On the drier assembly

8-5. The lower manifold is connected to the drier assembly by what hose or line?

1. Flexible hose
2. Steel line
3. Aluminum line
4. Copper line

8-6. The oxygen flows through the top of the dryer, passes down through the drying agent, and out through the servicing hose.

1. True
2. False

8-7. Because gaseous oxygen cylinders must never be completely drained. residual pressure in O_2 cylinders should never be allowed to fall below what minimum pressure?

1. 10 psi
2. 50 psi
3. 90 psi
4. 100 psi

8-8. Prior to removal or installation of oxygen cylinders on the No-2 oxygen trailer, cylinder safety caps will be installed.

1. True
2. False

8-9. After 12 cylinders of oxygen have been used, the drying agent should be subjected to what action?

1. Inspection
2. Changing
3. Drying
4. Destruction

8-10. What is the color of the drying agent in the dryer?

1. Blue
2. White
3. Red
4. Green

8-11. When moisture is present in the oxygen system, the color of the indicating agent will change to what color?

1. White
2. Black
3. Green
4. Pink

8-12. The indicating agent is well mixed with the drying agent.

1. True
2. False

8-13. How should the caps on the dryer be tightened?

1. By hand only
2. To specified torque
3. With a strap wrench
4. With a pipe wrench

8-14. If leakage occurs around the dryer caps, what is the most probable cause of the leak?

1. A cross-threaded cap
2. A crack in the dryer
3. A bad O-ring
4. A weak marmon clamp

8-15. What information do the daily, preoperational, or periodic maintenance requirement cards for the No-2 oxygen trailer provide?

1. Instructions for repair
2. Instructions for adjustments
3. A means of rectifying defective conditions
4. The minimum requirements necessary to maintain the equipment and ensure that no item is overlooked

8-16. The daily requirements should be accomplished prior to the first use of the equipment for that day.

1. True
2. False

8-17. A temperature correction chart to determine the pressure to which aircraft cylinders should be filled may be found in what location(s)?

1. In the oxygen trailer daily requirement cards
2. In the oxygen trailer maintenance requirement cards
3. On the aircraft oxygen cylinders
4. In the applicable MIM or on the side of the No-2 oxygen servicing trailer

8-18. Oxygen under high pressure will increase in temperature during the servicing procedure.

1. True
2. False

Learning Objective:
Identify the components, operation, maintenance requirements, emergency survival equipment, and cartridge-actuated devices (CAD) for the ESCAPAC 1E-1 ejection seat.

8-19. The ESCAPAC 1E-1 seat provides escape capabilities within what ejection parameters?

1. Ground level and O-knots
2. All altitudes and airspeeds
3. Both 1 and 2 above
4. A minimum altitude of 50 feet and 100 knots

8-20. The rocket catapult is fired by what initiator?

1. M99
2. 0.5-second delay
3. Mk 86
4. 0.3-second delay

8-21. Which of the following components prevent the forward seat from firing before the rear seat?

1. An in-line restrictor
2. Mk 11 Mod 0 initiator
3. Selector valve
4. Diverter manifold

8-22. Which of the following actions is caused by rotation of the bell crank attached to the harness release actuator?

1. Survival kit and shoulder harness pins are released
2. Retaining pin is retracted from the firing disconnect
3. Seat/man separator racket is ignited
4. Each of the above

8-23. Upon seat/man separation, the main parachute will deploy after a delay of what minimum number of seconds?

1. 0.10 second
2. 0.25 second
3. 0.55 second
4. 1.25 seconds

8-24. An aneroid prevents deployment of the main parachute if ejection is above what minimum altitude?

1. 12,500 ft
2. 13,000 ft
3. 14,000 ±500 ft
4. 15,500 ±500 ft

8-25. Which of the following components is used to prevent accidental seat ejection?

1. Initiator safety pin
2. Safety disconnect
3. Head knocker
4. Face curtain safety pin

8-26. Which of the following components is NOT located under the seat bucket?

1. Gyro spin-up cartridge
2. Vernier rocket
3. Pitch stabilization control
4. Yaw thruster

8-27. What prevents incorrect installation of the yaw thruster?

1. Tapered bolts
2. Boss and fixed stop
3. Flat–sided clevis pin
4. Mechanical guide groove

8-28. The yaw vane provides enough drag to yaw the seat what minimum number of degrees?

1. 10
2. 20
3. 30
4. 40)

8-29. The delay cartridge in the harness release actuator is fired by what means?

1. A spring action
2. A trip rod
3. Hydraulic pressure
4. Gas pressure

8-30. After ejection, the aircrewman is separated from the seat by what action?

1. A rocket
2. Pushing down and back on the seat
3. Air blast
4. A drague chute

8-31. The seat height actuator is driven by what motor or pressure?

1. A 2B-volt electric motor
2. Hydraulic pressure
3. A 115/120-volt electric motor
4. Pneumatic pressure

8-32. How many M99 initiators are installed in the four seat positions of the S-3 aircraft?

1. 4
2. 6
3. 8
4. 12

8-33. Which of the foallowing component is mounted on the ejection seat?

1. Guide rails
2. Seat height control
3. M99 initiator
4. Firing rods

8-34. How many M53 initiators are installed in the ejection seat plumbing?

1. 9
2. 11
3. 13
4. 15

8-35. How many 0.3-second delay initiators are installed in the s-3 seat ejection system?

1. 5
2. 7
3. 3
4. 10

8-36. How many check valves are installed in the ejection seat plumbing?

1. 17
2. 20
3. 29
4. 32

8-37. Group ejection is controlled by what individual(s)?

1. Pilot only
2. Copilot only
3. Pilot/copilot
4. None of the above

8-38. Which of the following components routes gas pressure to the ejection sequencing system?

1. Selector valve
2. Delay initiator
3. Sequencing valve
4. Gas manifold

8-39. The altitude sensor switch provides which of the following functions?

1. On ejection, it prevents seat separation above 15,000 feet
2. Monitors aircraft altitude
3. Locks the parachute spreader gun below 14,500 feet
4. Monitors ,cabin pressure

8-40. Which of the following signals warn the TACCO and SENSO that group ejection is going to take place?

1. Bell
2. Buzzer
3. Eject warning flag
4. Flashing indicator lights

8-41. When the aircraft is on the ground, crew members conduct an emergency exit by what means?

1. Manually jettisoning the canopy
2. A window/hatch severance system
3. Ejecting through the canopy
4. Manually cutting through the canopy

8-42. The emergency egress system can be initiated from any one of how many positions?

1. Five
2. Two
3. Three
4. Four

8-43. Which of the following statements regarding the emergency egress system is NOT true?

1. It is more reliable than a hot gas system
2. It is slower than a hot gas system
3. It is safer than other like systems
4. It is an inert system when properly safetied

8-44. The window/hatch jettison system is actuated by which of the following methods/components?

1. Electrical switch
2. Hydraulic pressure
3. Initiator gas pressure
4. Pneumatic bypass valve

8-45. The wing-to-fuselage fillet is cut during emergency hatch jettison by which of the following components?

1. Initiator fired cutter
2. Shaped charge
3. Explosive bolts
4. Pneumatic severance cable

8-46. Which of the following components in the S-3 egress system replaces pneumatic lines in older egress systems?

1. SMDC segments
2. Electronic relays
3. LED arrays
4. CPUs

8-47. Before starting the removal of the ejection seat, which of the following checks should be made?

1. Seat and canopy safety pins are installed
2. Head knocker in the down position
3. Pilot and copilot eject mode selector handles in self-eject position
4. Each of the above

8-48. When adjusting the height of the ejection seat, the actuator switch should not be held in the up or down position for more than how many seconds?

1. 10
2. 15
3. 20
4. 25

8-49. Which of the following tools is used to disconnect the inertia reel base?

1. Box-end wrench
2. Open-end wrench
3. Spanner wrench
4. Key and flag assembly

8-50. When removing the seat, what must be done to prevent injury to maintenance personnel as the seat reaches the top of the guide rails?

1. Disconnect rocket firing lanyard
2. Safety the M95 initiators
3. Prevent the yaw vane from deploying
4. Install the seat balance beam

8-51. When performing the face curtain pull test, how many pounds of force is required to unseat the plungers from their retainers?

1. 20 ±10 pounds
2. 30 ±10 pounds
3. 40 ±10 pounds
4. 50 ±10 pounds

8-52. During ejection seat testing, a force of how many pounds is required to unseat the secondary ejection control from the stowed detent position?

1. 12 ±5 pounds
2. 20 ±5 pounds
3. 25 ±2 pounds
4. 30 ±2 pounds

8-53. When the secondary ejection control is pulled, it must extend at least how many inches from the stowed position?

1. 0.50 in
2. 0.75 in
3. 1.00 in
4. 1.25 in

8-54. If the inertia reel fails the simulated g test, it must be replaced. What is the simulated g force required for this test?

1. 1 g
2. 2 g
3. 3 g
4. 4 g

8-55. With the harness release piston in the fully extended position, what should the measurement be between the bottom of the actuator housing and the clevis shoulder?

1. 5.06 ±0.03 in
2. 5.35 ±0.05 in
3. 6.00 ±0.50 in
4. 6.09 ±0.07 in

8-56. To release the piston from its fired position, what tool(s) is/are used to spread the locking dogs?

1. Spanner wrench
2. Two 1/4-inch drive extensions
3. Drift punch
4. Two 1/8-inch rods

8-57. What is the maximum force required to lack the piston in the harness release actuator?

1. 10 pounds
2. 20 pounds
3. 30 pounds
4. 40 pounds

8-58. The lap belt and shoulder harness retaining pins should protrude through the seat structure a minimum of how many inches?

1. 0.06 in
2. 0.19 in
3. 0.25 in
4. 0.47 in

8-59. Which of the following items is NOT contained in the bottom half of the RSSK-8A-1 survival kit?

1. Life raft
2. Radio transmitter
3. Emergency oxygen bottle
4. Survival kit bag

8-60. The seat survival kit oxygen bottle may be actuated by what process?

1. Automatically only
2. Manually only
3. Automatically or manually
4. Pneumatically or electrically

8-61. Information for marking initiators is found in which of the following manuals?

1. NAVAIR 01-1A-509
2. NAVAIR 01-1A-l7
3. NAVAIR 11-85-1
4. NAVAIR 11-100-1

8-62. Egress system pneumatic gas lines have been replaced in later aircraft by which of the following components?

1. Detonating cords
2. Electrical circuits
3. Booster initiators
4. Gallium arsenide connectors

8-63. Which of the following components fires the booster cartridge in the rocket catapult?

1. Firing control initiator
2. Detonating card booster
3. Ejection delay initiator
4. Rocket catapult cartridge assembly

8-64. Information on disposing of damaged rocket catapults is found in which of the following manuals?

1. NAVAIR 01–1A-17
2. NAVAIR 01-1A-509
3. NAVAIR 11-85-1
4. NAVAIR 11-100-1

Assignment 9

Textbook Assignment: "Canopy Systems." Pages 6-26 through 6-73.

Learnong Objective: *Recognize the components, seat system/subsystems, support components, system operations, component test and test equipment, and corrosion control procedures for the Martin-Baker SJU-5/A ejection seat.*

9–1. When the safe/arm handle is in the safe position, the pilot sees the handle as what color?

1. Yellow
2. Black
3. White
3. Red

9-2. What initiator provides the gas pressure required to activate the IFF?

1. Right seat initiator
2. SMDC initiator
3. Left seat initiator
4. 0.3-second delay initiator

9–3. What force is used to fire the inertia reel cartridge during the ejection sequence?

1. Sear withdrawal
2. Electrical current
3. Gas pressure
4. Heat

9-4. What force ignites the primary cartridge within the, catapult?

1. Ballistic gas
2. Sear removal
3. Electrical current
4. Pneumatic pressure

9-5. Forward movement of the leg restraints is prevented by what component?

1. Seat bucket
2. Deck mounts
3. Locking lugs
4. Snubbing unit

9-4. If the drogue gun primary cartridge fails, what component(s) will fire the secondary cartridge?

1. Rocket motor initiator
2. Time-release mechanism
3. Manual override initiator
4. Both 2 and 3 above

9-7. Below what altitude will the 1.5-second timer in the TRM start to operate without interruption?

1. 7,500 feet
2. 8,000 feet
3. 8,500 feet
4. 9,000 feet

9-8. When the ejection seat is installed in the aircraft? what component locks it to the catapult?

1. Time-release mechanism
2. Top latch mechanism
3. Left main beam
4. Right main beam

9-9. What components absorb the inertia forces encountered during barrel separation?

1. Pressure rings
2. Guide bushings
3. Piston rings
4. Expander bushings

9-10. What component locks the guide bushing to the outer barrel?

1. Retaining pin
2. Dowel screw
3. Locking plunger
4. Guide bushing rivet

9-11. The seat height actuator rod is attached to what component?

1. Lower cross member
2. Center cross member
3. Upper sliding runner
4. Lower sliding runner

9-12. What component holds the moveable jaw of the scissor mechanism in the closed position?

1. Trombone fitting
2. Drogue gun
3. Rocket motor
4. Time-release mechanism

9-13. The parachute container houses which of the following parachutes?

1. Controller drogue
2. Main drogue
3. Personnel
4. All of the above

9-14. What handle is the only means by which ejection can be initiated?

1. Safe/arm
2. Face curtain
3. Ejection central
4. Manual override

9-15. What handle is located on the left side of the seat bucket?

1. Safe/arm
2. Ejection control
3. Manual override
4. Shoulder harness control

9-16. During the ejection sequence, gas pressure from what cartridge retracts the pin?

1. Right seat initiator
2. Left seat initiator
3. Manual override initiator
4. Time-release initiator

9-17. What barrel(s) of the catapult will remain with the seat during ejection?

1. Inner
2. Intermediate
3. Outer
4. Both 2 and 3 above

9-18. By what method is the primary cartridge of the drogue gun fired?

1. Electrically
2. Mechanically
3. Pneumatically
4. Ballistically

9-19. What component prevents full upward movement of the manual override handle?

1. Pin puller
2. Shear rivet
3. Safety pin
4. Bell crank assembly

9-20. What initiator actuates the pin puller?

1. Right seat
2. SMDC
3. Left seat
4. 0.3-second delay

9-21. Gas pressure from the TRM travels through what fitting to fire the cartridge in the manual override initiator?

1. Quick-disconnect
2. Trombone
3. Delay
4. Venturi

9-22. During the time-delay test of, the drogue gun. the firing link is pulled from the drogue gun in 0.7 second. Based upon the result, what action, if any, should be taken?

1. Lubricate the firing link
2. Repeat the test
3. Replace the drogue gun
4. None

9-23. Before you perform checks on the time-release mechanism, which of the following actions should you take?

1. Disarm the TRM
2. Remove the TRM from the seat
3. Inspect the TRM for damage
4. All of the above

9-24. To obtain satisfactory results in the time delay check-out of the time-release mechanism, the firing link must be pulled from the time-release g-sensing mechanism within what maximum number of seconds?

1. 1.5 ±0.1
2. 1.7 ±0.1
3. 1.8 ±0.1
4. 1.8 ±0.2

9-25. To do a barostat check-out, the test box altimeter must be set to what prescribed millibar value?

1. 1000
2. 1013
3. 1026
4. 1039

Learning Objective: *Recognize the components, parachute and seat separation operations, seat sunsystems, component maintenance, corrosion control, and lubrication and emergency cleaning procedures for the Stencil SJU-8/A ejection seat.*

9-26. The SJU-8/A seat provides escape capabilities at which of the following ejection parameters?

1. All altitudes and airspeeds
2. Zero altitude and zero airspeed
3. Maximum airspeeds and altitudes of 600 knots and 50,000 feet
4. Both 2 and 3 above

9-27. What total number of operating modes are incorporated in the SJU-8/A ejection seat?

1. One
2. Two
3. Three
4. Four

9-28. What initiator supplies gas pressure to the inertial reel gas-generating initiator?

1. 3.0-second time delay
2. Left M99 ejection
3. Right M99 ejection
4. Seat/man separation

9-29. The catapult cartridge is fired by gas pressure from what device?

1. Inner trombone
2. Multi-time delay
3. Low-speed selector valve
4. Left and right ejection initiators

9-30. Gas pressure is applied to the drogue gun pistons after approximately how many inches of seat travel?

1. 8 in
2. 12 in
3. 16 in
4. 20 in

IN ITEM 9-31 THROUGH 9-34, SELECT FROM COLUMN B THE AIRSPEED AND ALTITUDE INFORMATION THAT APPLIES TO THE WIDE IN COLUMN A.

	A. Mode	B. Airspeed and Altitude
9-31.	Mode 1	1. Altitude above 14,000 feet
9-32.	Mode 2	2. Airspeed above 225 knots and altitude below 7,000 feet
9-33.	Mode 3	3. Altitude between 7,000 and 14,000 feet
9-34.	Mode 4	4. Airspeed below 225 knots and altitude below 7,000 feet

---

9-35. (Refer to fig. 6-32 and supporting material in the text.) The 0.1-second time delay receives gas pressure from what device?

1. Gas-generating initiator
2. Left--hand inner trombone
3. Right-hand outer trombone
4. Low-speed selector valve

9-35. Under mode 1 conditions, what initiator arms the 14,000-foot aneroid initiator?

1. 0.1-second delay
2. 1.3-second delay
3. 3.0-second delay
4. Left-hand M99 ejection

9-37. Under mode 2 conditions, the output of the 0.1-second delay initiation is blocked by what component?

1. Pin puller
2. Guillotine
3. Drogue release
4. Low-speed selector valve

9-38. What mode(s) would operate as a backup in the event of mode 2 failure?

1. Mode 1 only
2. Mode 3 only
3. Mode 4
4. Modes 1 and 3

9-39. What is the purpose of the 3.0-second time-delay initiator?

1. To arm the 7,000-foot aneroid in mode 2
2. To arm the 14,000-foot aneroid in mode 3
3. To fire the guillotine mechanism
4. To position the low-speed selector valve

9-40. The safe and arm control handle safeties what initiator(s)?

1. Left-hand M99 ejection
2. Right-hand M99 ejection
3. Seat/man separation
4. All of the above

9-41. What is the total number of ejection control handles incorporated in the SJU-8/A ejection seat?

1. One
2. Two
3. Three
4. Four

9-42. The output gas pressure from the two M99 ejection initiators is routed to igniters contained in what device?

1. Word motor
2. Drogue container
3. Catapult cartridge
4. Seat back rocket

9-43. Which of the following statements describes the catapult tube assemblies?

1. They provide support for the seat bucket
2. They house the catapult lock and unlock mechanism
3. They provide support for the headrest and personnel parachute
4. All of the above

9-44. The catapult lock mechanism consists of a locking piston and what other items?

1. Top latch mechanism
2. Two retainer rings
3. Three guide bushings
4. Six locking balls

9-45. The outer trombone assemblies route ballistic gas from the two M99 ejection initiators to the catapult cartridge igniters.

1. True
2. False

9-46. What is the approximate burn time of the seat back rackets?

1. .15 second
2. .25 second
3. .35 second
4. .45 second

9-47. Actuation of what component allows the main parachute canopy assembly to deploy?

1. Word bridle
2. Drogue bridle
3. Parachute container opener
4. Word motor

9-48. What total number of slugs are contained in the spreader gun assembly?

1. 10
2. 14
3. 18
4. 22

9-49. Rotation of the seat pan release rod fires what initiator?

1. Left M99 ejection
2. Multiple time-delay
3. 3-second time-delay
4. Seat/man separation

9-50. Gas pressure from the seat/man separation initiator is transmitted to what device(s)?

1. Inertia reel strap guillotine
2. Drogue release assembly
2. Parachute container opener
4. All of the above

9-51. When the emergency release handle is pulled, which of the following actions takes place?

1. The seat release shaft rotates
2. The harness release actuator retracts
3. The firing central disconnect fitting unseats
4. The time-release mechanism arms

9-52. A full emergency oxygen bottle contains a total of how many cubic inches of oxygen?

1. 30
2. 40
3. 50
4. 60

9-53. The emergency oxygen supply lanyard is attached to the bottom of the seat pan and to what other item?

1. Cockpit deck
2. Safe and arm control handle
3. Catapult cartridge manifold
4. Seat release shaft

9-54. A properly serviced emergency oxygen system should have what prescribed pressure when the bottle is full?

1. 1200 psi
2. 1500 psi
3. 1800 psi
4. 2100 psi

9-55. Automatic actuation of the emergency oxygen supply also provides automatic actuation of the emergency locator beacon.

1. True
2. False

9-56. When performing the safe and arm control assembly check-out, what should be the maximum amount of force required to move the handle to the full up position?

1. 5 pounds
2. 10 pounds
3. 15 pounds
4. 20 pounds

9-57. What is the name of the component that block the movement of the initiation rotors?

1. T-bar
2. Interlock block
3. Arming key
4. Trip rod

9-58. During the emergency release handle check, the handle should move up with a maximum force of

1. 20 pounds
2. 30 pounds
3. 40 pounds
4. 50 pounds

9-59. (Refer to fig. 6-46 and supporting material in the text.) What devices are installed in the separation lanyard retainer assemblies to hold the seat release lanyard bell cranks in place?

1. Trip rods
2. Shear pins
3. Cotter pins
4. Setscrews

9-60. The initial breakout force for the ejection control assembly check should be between what maximum number of pounds?

1. 5 and 15 pounds
2. 15 and 25 pounds
3. 25 andf 35 pounds
4. 35 and 45 pounds

9-61. When performing the inertial reel check, the force required to extend the risers should be between what maximum number of pounds?

1. 5 and 15 pounds
2. 15 and 25 pounds
3. 25 and 35 pounds
4. 35 and 45 pounds

9-62. How many steps are used to complete the seat height adjustment actuator check-out?

1. Five
2. Two
3. Three
4. Four

9-63. To prevent heat damage to the height adjustment actuator motor, what are the operating time limits that must be observed?

1. 15 seconds on and 30 seconds off
2. 30 seconds on and 1 minute off
3. 30 seconds on and 45 seconds off
4. 1 minute on and 1 minute off

9-64. The airspeed/altitude sensor must be removed to perform the check-out procedure.

1. True
2. False

9-65. Recording to the NA 01-1A-509, ejection seats should be inspected for corrosion control at what minimum interval while at sea?

1. Every day
2. Every other day
3. Every 7 days
4. Every 14 days

9-66. VV-L-800 lubricating oil should be applied to all points that slide and used as a corrosion preventive for all bright metal parts.

1. True
2. False

9-67. During emergency cleaning of the ejection seat, what should you use to rinse the seat?

1. Lubricating oil
2. Fresh water
3. Safety solvent
4. Water emulsion cleaner

9-68. The MIMs and MRCs for most ejection seat systems provide explicit instructions for corrosion control.

1. True
2. False

9-69. Indiscriminate use of paint, preservatives, or other materials that dry and buildup following application can prevent or restrict proper motion of movable parts.

1. True
2. False

9-70. What color flags are used on ejection seat ground safety pins?

1. Red
2. Orange
3. Yellow
4. Black and white