MIL-D-19326G
1 October 1985
SUPERSEDING
MIL-D-19326F
18 October 1978

MILITARY SPECIFICATION

DESIGN AND INSTALLATION OF LIQUID OXYGEN SYSTEMS IN AIRCRAFT, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for the design and installation of liquid oxygen (70 and 300 pounds per square inch gauge) (psig) (483 kPa and 2068 kPa) systems in aircraft.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

* 2.1.1 Specification and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

BB-A-1034	-	Air, Compressed, for Breathing Purposes.
BB-N-411	-	Nitrogen, Technical.

MILITARY

MIL-B-5087	-	Bonding, Electrical, and Lighting Protection, For Aerospace Systems.
MIL-W-5088	-	Wiring, Aerospace Vehicle.
MIL-E-5400	-	Electronic Equipment, Airborne, General Specification For.
MIL-V-7908	-	Valve, Aircraft Low-Pressure Oxygen Systems.
MIL-T-8506	-	Tubing, Steel, Corrosion-Resistant, (304), Annealed, Seamless and Welded.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 93) Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 1660

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited

MIL-S-8805/3	-	Switch, Push, 10 Amperes and Low Level, Dusttight.
MIL-V-9050	-	Valves, Oxygen, Pressure Relief, Aircraft.
MIL-C-19328	-	Converter, Liquid Oxygen, 5 Liter, MBA-5A.
MIL-C-19803	-	Converter, Liquid Oxygen, 10 Liter, GCU-24/A.
MIL-H-22343	-	Hose Assemblies, Metal, Liquid Oxygen.
MIL-A-23121	-	Aircrew Environmental, Escape and Survival Cockpit Capsule System, General Specification For
MIL-E-25410	-	Regulators, Oxygen, Diluter-Demand, Automatic Pressure-Breathing.
MIL-V-25513	-	Valve, Check, For 300 PSI Liquid Oxygen Converter System, Type MH-1.
MIL-C-25516	-	Connector, Electrical, Miniature, Environment Resistant Type, General Specification For.
MIL-L-25567	-	Leak Detection Compound, Oxygen Systems.
MIL-I-25645	-	Indicator, Liquid Oxygen Quantity, Capacitance Type, General Specification For.
MIL-C-25666	-	Converter, Liquid Oxygen Capacitance Type Gauging, General Specification For.
MIL-V-25962	-	Valve, Liquid Oxygen Drain.
MIL-C-25969	-	Capsule Emergency Escape Systems, General Specification For.
MIL-T-26069	-	Trailer, Oxygen Cylinder, AF-M32R-3, High and Low Pressure, 2 Wheel 8 Cylinder Capacity.
MIL-D-26392	-	Dummy Converter, Liquid Oxygen Indicator System, 10 Liter, CRU-23/A.
MIL-D-26393	-	Dummy Converter, Liquid Oxygen Indicator System, 25 Liter, CRU-24/A.
MIL-H-26626	-	Hose Assembly, Non-metallic Tetrafluoroethylene, Oxygen.
MIL-O-27210	-	Oxygen, Aviator's Breathing, Liquid and Gas.
MIL-O-27335	-	Oxygen System, Survival Container and Oxygen Kit, General Specification For.
MIL-G-27617	-	Grease, Aircraft and Instrument, Fuel and Oxidizer Resistant.
MIL-T-27730	-	Tape, Antiseize, Tetrafluoroethylene, With Dispenser.
MIL-T-38170	-	Tank, Mobile Storage, Liquid Oxygen, TMU-27/M.
MIL-S-81018	-	Survival Kit Container, Aircraft Seat, With Oxygen, General Specification For.
MIL-C-81302	-	Cleaning Compound, Solvent, Trichlorotri fluoroethane.
MIL-I-81387	-	Indicator, Liquid Oxygen Quantity.
MIL-I-81388	-	Indicator Repeaters, Liquid Oxygen Quantity.
MIL-T-81533	-	1, 1, 1 Trichloroethane (Methyl Chloroform), Inhibited, Vapor Degreasing.
MIL-H-81581/5	-	Hose Assemblies, Breathing Oxygen, Low Pressure, Connector to Regulator.
MIL-R-83178	-	Regulator, Oxygen, Diluter-demand, Automatic-pressure-breathing, General Specification for
MIL-H-87961	-	Hose and Hose Assemblies, Air Duct, Air Breathing, Oxygen Systems, General Specification for

STANDARDS

MILITARY

MIL-STD-143	-	Standards and Specifications, Order of Precedence for the Selection of.
MIL-STD-203	-	Aircrew Station Controls and Displays For Fixed Wing Aircraft.
MIL-STD-889	-	Dissimilar Metals.
MIL-STD-1247	-	Marking, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile and Space Systems.
MS22032	-	Recharger Assembly, Portable Oxygen.
MS22055	-	Hose Assemblies, Oxygen-Breathing Connector to Regulator.
MS22059	-	Oxygen System, Portable, 295 Cu. In.
MS22061	-	Oxygen System, Portable, 96 Cu. In.
MS22068	-	Coupling Assemblies, Quick Disconnect, Aircraft Liquid Oxygen Systems.
MS24548	-	Hose Assembly, Tetrafluoroethylene, Oxygen.
MS27599	-	Regulator, Oxygen, Diluter Demand.
MS33583	-	Tubing End, Double Flare, Standard Dimensions For.
MS33584	-	Tubing End, Standard Dimensions for Flared.
MS33611	-	Tube, Bend Radii.
MS33656	-	Fitting End, Standard Dimensions For Flared Tube Connection and Gasket Seal.
MS33739	-	Aircraft Markings, Servicing, and Precautioning.
MS90341	-	Mounting Bracket, Mating Portion for 5 and 10 Liter Liquid Oxygen Converter.
MS90457	-	Hose Assembly, Metal, Liquid Oxygen.

* 2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

DRAWINGS

AIR FORCE-NAVY AERONAUTICAL

AN929	-	Cap Assembly, Pressure Seal Flared Tube Fitting.
AND10104	-	Tubing, Steel, Corrosion-Resistsant, Round, Standard Dimensions For.

AIR FORCE

44A25450	-	Sleeve, Oxygen Coupling
46A16236	-	Clip, Recharger Low Pressure Oxygen System.
53C3794	-	Cylinder and Regulator, Breathing Oxygen, Portable.

53D3970	-	Mask-Cylinder-Regulator, Oxygen, Portable, Aircraft, Firefighters.
60D3570	-	Cylinder and Regulator, Breathing Oxygen, Portable A/U26S-3, Assembly of

(Copies of specifications, standards, drawings, publications and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

* 2.2 Other publications. The following document form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of solicitation.

SOCIETY OF AUTOMOTIVE ENGINEERS

AMS 4071	-	Aluminum Alloy Tubing, Hydraulic, Seamless, Drawn, Round 2-5Mg-0.25 Cr (5052-0) Annealed

Applications for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

* 2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Selection of specifications and standards. Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.2 Design. The installation of an aircraft liquid oxygen system shall comprise, as required, liquid oxygen converters, tubing, fittings, filler valves, build-up and vent valves, relief valves, check valves, quantity gauges, regulators, portable units, adapters, mask to regulator hoses, brackets, shut-off valves, and all other necessary items specified herein and required for a complete installation. For permanently installed converters, the filler valve shall be located such that filling from a portable servicing trailer can be easily accomplished by servicing personnel standing on the ground outside of the aircraft. Removable converters shall be capable of being removed and replaced in the aircraft within a 5 minute time period. Sufficient access shall also be provided for the removable converters to permit filling of the converter by conventional means when they are installed in the aircraft. Components of the oxygen system shall not be installed where they will be subjected to temperatures in excess of that specified in the individual component specifications, and no part of the system shall be installed in an area which will be subjected to a temperature in excess of 350°F (176.6°C).

3.3 Oxygen systems.

3.3.1 Systems utilizing oxygen mask. Aircraft having flight ceilings over 20,000 feet (6,096 metres), but not over 50,000 feet (15,240 metres) of altitude and the capability of descending within 5 minutes immediately following a decompression to 42,000 feet (12,801 metres) or lower, shall be provided with an installed oxygen system and crew station equipment to support the use of pressure breathing oxygen masks.

3.3.1.1 Fighter and attack aircraft supply. These aircraft shall have an oxygen system of sufficient capacity to supply the entire crew for the total duration of any specified design mission. The oxygen supply system shall be sized to ensure mission completion in the event of loss of cabin pressure enroute to or at the combat zone. If applicable, the oxygen system shall be sized to include range extension due to auxiliary fuel stores and/or aerial refueling.

3.3.1.2 Bomber aircraft supply. Bomber aircraft shall have an oxygen system of sufficient capacity to supply breathing oxygen to the entire crew for 75 percent of the duration of the longest specified design mission, or to the entire crew for the total time the cabin altitude is above 8,000 feet (2,438 metres), whichever condition establishes the larger amount. The oxygen supply system shall be sized to ensure mission completion in the event of loss of cabin pressure enroute to or at the target. If applicable, the oxygen system shall be sized to include range extension due to auxiliary fuel stores and/or aerial refueling.

3.3.1.3 Transport aircraft supply. Transport aircraft shall have an oxygen system of sufficient capacity to supply all of the primary crew members and all of the passengers with breathing oxygen whenever the cabin altitude exceeds 10,000 feet (3,048 metres). In the event of loss of cabin pressure, the oxygen system shall provide the full primary aircrew with breathing oxygen for at least 50 percent of the design mission duration. The passenger oxygen supply shall be dispensed from a continuous flow system and shall have sufficient capacity to provide breathing oxygen to a full passenger load for 50 percent of the design mission duration or for a shorter period if so specified by the acquiring activity, but in no case for less than 15 minutes. When therapeutic oxygen capability is specified, a supplemental quantity shall be included within the passenger oxygen supply. Therapeutic oxygen usage shall be independent from passenger oxygen usage and the quantity shall be adequate for 100 percent of the design mission plus two hours to allow for patient loading and unloading.

3.3.2 High altitude aircraft supply. Aircraft having a sustained flight capability above 50,000 feet (15,240 metres), or the requirement to remain above 42,000 feet (12,801 metres) for a period over 5 minutes, but not equipped with emergency pressurization capsule provisions, shall be provided with an installed oxygen system designed to support high altitude pressure suits and helmets, or pressure breathing masks and counter pressure garmets, as appropriate. The quantity shall be adequate to provide for 100 percent oxygen for the entire mission, including, if appropriate, a period of oxygen breathing at ground level prior to flight. In addition, provisions shall be made for the use of pressure breathing masks during flight operations at lower altitudes.

3.3.3 Systems utilizing capsules. The pressurization requirements and the oxygen requirements shall be as specified in MIL-C-25969 or MIL-A-23121, as applicable. The system to be installed shall be capable of meeting the specified mission profile.

3.3.4 Portable oxygen systems. When crew mobility within the aircraft is required, as is normally the case in bomber and cargo aircraft, portable oxygen systems shall be provided in a ratio not less than one system for two crewmembers. At least one portable oxygen system shall be provided in each compartment of the aircraft including lavatories. Smoke masks suitable for respiratory and eye protection shall be available for use by the pilot and any other critical crewmember and be usable with the crew station oxygen regulator as well as with the portable systems. Portable oxygen systems shall be selected in accordance with 3.6.14.

* 3.3.5 Emergency oxygen. Aircraft equipped with a seat pan or back pack emergency oxygen supply, as specified in MIL-O-27335 or MIL-S-81018, or an equivalent emergency oxygen supply, shall have such system completely independent of the aircraft oxygen supply system. Any emergency oxygen supply system will normally remain with the crewmember during ejection from the aircraft and subsequent descent via parachute. When the emergency oxygen is attached to the seat, separation from the seat shall not occur above an altitude of 15,000 feet (4,571 metres).

3.4 Oxygen quantity determination.

3.4.1 Oxygen flow requirements.

3.4.1.1 Respiratory provisions. The oxygen supply requirement shall be based on an inspiratory minute volume (volume of gas per minute) of 15 litres per minute (lpm) (250 cu.cm/s) per crewmember determined at BTPS conditions; i.e., body temperature 98.6°F (37°C), body pressure (cabin altitude), and saturated with water vapor, 47 mm Hg (6.27 kPa). At normal conditions (NTPD) of sea level altitude, 760 mm Hg (101.3 kPa), 70°F (21.1°C), and dry, the baseline minute volume per crewmember is 13.35 lpm (223 cu.cm/s) (NTPD). For oxygen system design, the baseline oxygen requirements given in Table I shall apply to all aircraft containing 6 or more aircrewmembers. For intermediate altitudes not listed in Table I, the oxygen requirements may be calculated from Figure 8. For aircraft which contain less than 6 aircrewmembers, the design oxygen quantity shall be increased by the multipliers given in Table II, which is estimated to cover the 90th percentile of normal aircrew populations.

3.4.1.2 Flight demand provisions. Where aircrew duties impose more than routine flight demands on the crew, the baseline oxygen quantity, after adjustment for aircrew size, shall be increased by applicable percentages extrapolated from those given in Table III. Some of these situations will not exist throughout the design mission and they shall be applied only to the crewmember or members directly affected and only for that period during which the increased demand is anticipated.

3.4.1.3 Oxygen regulator air dilution. The oxygen added to air ratio depicted in Figure 8 as Curve B is typical of the performance achieved with the CRU-73 oxygen regulator. When significantly different dilution performance is provided by the selected oxygen regulator, as established by cyclic test results approved by the acquiring activity, the applicable oxygen added curve shall be substituted for Curve B and appropriate oxygen usage rates calculated for use in lieu of those given in Table I under "Air Dilution".

3.4.1.4 Design oxygen requirement. The oxygen system supply capacity shall be calculated from the requirements given in Table I with applicable adjustments for crew size and the provisional factors given in Tables II and III. In passenger aircraft, it shall be assumed that, in the event of loss of cabin pressure, the pilot will descend immediately to an altitude not requiring oxygen for passenger stabilization, and then, if necessary for fuel conservation, climb to a more economic cruise altitude which shall not exceed 25,000 feet (7,620 metres). Determine the oxygen quantity required for passengers by using the design flow rates given in Table IV. The oxygen shall be dispensed from constant flow masks selected for their suitability for use up to the maximum cruise altitude expected to occur in the event of a decompressed cabin. Therapeutic oxygen flow is normally adjustable from two to twelve ambient cabin litres per minute (33 cu.cm/s to 200 cu.cm/s). Unless otherwise specified, use an average design flow of 6 NTPD litres per minute (100 cu.cm/s) from three fourths of the outlets, but in no case assume less than four outlets will be in use. Passengers designated to be receiving therapeutic oxygen can be excluded from calculations of required passenger oxygen quantity.

3.4.2 Size and number of converters. Unless otherwise specified, all converters installed in an aircraft shall be of the same size and operating pressure. However, it is acceptable to provide different size converters for crew and passenger systems. The design quantity given in Table V is the amount of oxygen which can be expected to be available from each converter 24 hours after filling and this shall be used for design calculations. In addition, the selected converters shall have design flow rates equal to or larger than the maximum flow expected to be needed in any mission increment.

3.4.2.1 Maximum number of converters. In the event the aircraft performance is such that the number of converters required becomes excessive so that the installation becomes impractical, the acquiring activity shall specify the maximum number of converters (see 6.2.1b).

3.5 System layout. Typical oxygen systems for various types of pressurized or nonpressurized aircraft are shown on Figures 2 through 4, inclusive. These figures represent the general arrangement of the systems; the actual number, location, and application of these items are determined by the aircraft characteristics and the requirements specified herein.

3.5.1 Quantity indicators. A totalizing quantity indicator shall be installed at the pilot's or co-pilot's station of the aircraft in which more than one converter is installed. This will permit monitoring of the total aircraft oxygen supply. Repeater indicators shall be provided in all isolated flight compartments within normal vision of one crewmember. Liquid oxygen quantity indicators shall be in accordance with MIL-I-81387 or MIL-I-25645, as applicable. Liquid oxygen quantity indicator repeaters shall be in accordance with MIL-I-81388 or MIL-I-25645, as applicable.

3.5.2 Single converter, single place aircraft. When only one converter is installed in the aircraft and there is only one crewmember, the system shall be connected in accordance with Figure 2.

3.5.3 Single converter with multiple crew stations. When only one converter is installed in the aircraft and there are two or more permanent crew stations, all stations shall be connected to the same distribution line in accordance with Figure 3.

* 3.5.4 Multiple converters with multiple crew stations. When two or more liquid oxygen converters are installed in an aircraft, all converters shall be of the same size and have the same operating pressure. Converters shall be divided between two distribution lines. Converters shall be divided between each distribution or supply line such that any one converter will provide oxygen supply to all outlets. On aircraft such as transports where it is desired to provide maximum survivability of the oxygen system, the converters shall be separated and check valves provided such that loss of one converter does not result in the loss of the complete oxygen supply. Figure 4 shows an installation with two liquid oxygen converters that when physically separated and provided with the distribution plumbing as shown will maximize survivability.

3.5.5 Single converter, dual regulator. When the performance of the aircraft is such that a pressure suit is required (see 3.3.2), the applicable survival kit shall be used. Figure 5 shows an installation with one liquid oxygen converter and the necessary oxygen control panel and regulators for single place aircraft. Figure 6 shows an installation with one liquid oxygen converter and the necessary oxygen control panels and regulators for multiple crew stations.

3.5.6 Location. The oxygen equipment, tubing and fittings shall be located as remotely as practicable from fuel, oil, hydraulic fluid, water injection, storage battery systems, exhaust stacks and manifolds, electrical, radio and insulating materials. Insofar as practicable, oxygen lines shall not be grouped with lines carrying flammable fluids. Where necessary, deflector plates shall be used to keep flammable fluids away from oxygen lines, fittings and equipment. Converters shall not be in line with the plane of rotation of a turbine or propeller. Components of the oxygen system shall not be installed where they will be subjected to temperatures in excess of that specified in the individual component specifications, and no part of the system shall be installed in an area which will be subjected to a temperature of 350°F (176°C) or greater. In order to minimize loss due to heat, liquid oxygen converters shall not be located near equipment that dissipates a high quantity of heat.

3.6 Major system components.

3.6.1 Converter selection and installation. The liquid oxygen converter, with appropriate indicators, shall be selected from Table V and be based upon the converter capability to support the specified number of crewmembers and based upon the parameters set forth in 3.5.1 for indicators. Space shall be provided in the aircraft based on the maximum converter specification envelope dimensions. If two or more converters are installed in the aircraft, they should be separated as much as practicable to minimize combat vulnerability.

Sufficient space shall be available to replace converters and perform maintenance on all parts. The installation shall also provide for replenishing the liquid oxygen supply by connecting an external filling source directly to the filling valve(s). The filling point(s) shall be located such that the time for gaining access for connecting the external filling source shall not exceed one man minute and shall not create a hazard for servicing personnel.

3.6.1.1 Removable converters. Where removable converters are to be installed in any oxygen system, the converters shall be in accordance with MIL-C-19803 or MIL-C-19328, as applicable. The installation shall provide for simple and rapid replacement. The converter shall be capable of being removed from the aircraft and replaced within five minutes.

3.6.1.2 Permanently installed converters. Where permanently installed converters are to be put in any oxygen system, the converters shall be in accordance with MIL-C-25666.

3.6.1.3 Converter mounting. The converter shall be mounted in such a manner that it is readily accessible to servicing personnel. The converter shall be mounted so that the converter base is within 5 degrees of horizontal when the aircraft is in normal cruise attitude.

3.6.1.3.1 Converter mounting bracket configuration (removable converters). The configuration of the bracket necessary to mount each converter in the aircraft shall be provided in accordance with MS90341.

3.6.1.4 Dummy converter. For aircraft utilizing more than one liquid oxygen converter, a dummy converter (an electrical equivalent to the empty converter) shall be permanently installed adjacent to each converter in the aircraft. The dummy converter shall be used whenever a converter is removed from the aircraft to insure proper operation of the gauging system. The dummy converter shall be in accordance with MIL-D-26392 or MIL-D-26393, as applicable.

3.6.2 Liquid oxygen quantity indicator. Quantity indicators shall be installed using the parameters outlined in 3.5.1. The quantity indicator shall indicate the amount of liquid oxygen in the converter or converters.

3.6.2.1 Indicator location. The quantity indicator shall be connected into the system as shown in Figures 2 through 7. The indicator shall be located in the pilot's or co-pilot's (or other crewmember's) normal field of vision so that he may readily see the indicator when in normal operating or flight position without turning his head and with minimum interference to his flight duties.

3.6.2.2 Press-to-test. A press-to-test switch in accordance with MIL-S-8805/3 shall be located near the liquid oxygen quantity indicator. This switch shall allow the indicator to be functionally checked in accordance with 4.5.6.1.

3.6.2.3 Low pressure, low-level warning system. A low pressure, low-level warning light shall be incorporated into the "Caution" enunciator panel. The low pressure warning shall be activated when the converter system pressure drops to 42 ± 2 psig (290 ± 14 kPa). For each crew station in a 70 psig (483 kPa) oxygen system, the presure sensor shall be located downstream of the on-off valve. If an oxygen regulator in accordance with MIL-R-25410 is used, the pressure sensor shall be located upstream of the regulator. The momentary drop in supply line pressure upon inhalation shall not activate the low pressure warning. The low-level warning shall be actuated below 10 percent of the full scale of the quantity indicator.

3.6.2.4 Gauging system. The gauging system, when installed in the aircraft, shall indicate the amount of liquid oxygen in the converter within an accuracy of ± 2 percent of indication plus ± 4 percent of full scale indication at any of the major dial divisions on the oxygen quantity indicator. The gauging system shall be capable of satisfactory operation using external wiring in accordance with the applicable requirements of MIL-W-5088. The gauging system shall be designed for the use of cables and connectors which shall have equivalent performance to the requirements of MIL-E-5400. The length of the cables shall not affect the accuracy of the systems. The length of the cables shall be adequate to reach the connections of the converter. Adequate clearance shall be provided for the indicator connectors so that they can be readily disconnected by servicing personnel. Provisions shall be made for the storage of the aircraft connectors when they are disconnected.

3.6.3 Regulators.

3.6.3.1 Panel mounted. An automatic diluter demand-pressure breathing regulator, in accordance with MIL-R-25410 or MIL-R-83178 (MS27599), as applicable, shall be installed at each permanent and temporary crew station in the aircraft. The pilot's panel mounted regulator shall be located in accordance with MIL-STD-203. The crewmember's regulator shall be in the crewmember's field of vision so that he can readily read the regulator without more than turning his head and with minimum interference with his flight duties. The regulators shall be located as close to the stations as is required to reach the regultor by normal extension of the crewmember's arm. The regulators shall be located so that they cannot be damaged by movement of personnel around them and may be mounted vertically or horizontally. The regulator shall be installed with flexible hose for both inlet and outlet ports, so that the regulator may be front serviced for both installation or removal.

* 3.6.3.2 Non-panel mounted. Non-panel mounted regulators shall be installed as specified by the acquiring activity (see 6.2.1c). Unless otherwise specified, for installations which utilized regulators without a manual shut-off valve incorporated in the regulator, a manual shut-off valve shall be provided at each crew-member's station. The valve shall be installed in the line upstream of the individual regulator to prevent loss of oxygen when the regulator is not in use and for stopping flow from a defective quick disconnect or a damaged supply hose. Stowage provisions shall be made for chest mounted regulators to prevent damage or contamination during servicing or ingress-egress actions.

3.6.3.3 Preinstallation tests. All regulators shall receive a leakage and flow test in accordance with the applicable specifications prior to installation in aircraft. The test shall be conducted not more than thirty days before installation of the regulator.

3.6.4 Fill-buildup-vent valve. Each permanently installed liquid oxygen converter shall be filled from a separate combination fill-buildup-vent valve. Combination fill-buildup-vent valves used in 70 psig and 300 psig (483 kPa and 2,068 kPa) liquid oxygen system shall be located approximately 5 feet above the ground, where possible, in order to be readily accessible from the ground. Clearance shall be left around the fill-mating section of the combination fill-buildup-vent valve to allow the insertion of the 2 inch (50.8 mm) diameter female section of the ground servicing valve and to permit the ground crew to manually exert an engagement or disengagement torque.

3.6.4.1 Fill line (permanently installed converters). The distance from the fill section of the combination fill-buildup-vent valve to the liquid oxygen conveter shall be kept as short as possible. The fill line shall be not longer than 10 feet (3.048 m). The fill lines shall be insulated to prevent frosting and sweating if they pass over equipment which will be harmed by water dripping from the lines, or drip pans shall be installed under the lines.

3.6.4.2 Vent line. The vent line from the combination fill-buildup-vent valve shall be so located as to drain overboard at the bottom of the aircraft within sight of the filler box and not closer than 24 inches (0.61 m) from it measured along the fuselage. Flow from the overboard vent shall be directed away from the filling valve so as to not create a hazard for servicing personnel and not allow liquid oxygen to impinge on the aircraft. The vent lines shall be insulated to prevent frosting and sweating if they pass over equipment which will be harmed by water dripping from the lines, or drip pans shall be installed under the lines. There shall be no hydrocarbon fills or drains forward or above in proximity to vent outlet.

3.6.4.3 Drain valve (permanently installed converters). For permanently installed converters, a liquid oxygen drain valve, in accordance with MIL-V-25962, shall be connected in the fill line between the combination valve and the converter in order to drain the converter. Plumbing from the outlet of the liquid oxygen drain valve shall terminate in an end fitting conforming to MS33656 and located in the filler box. It shall have a cap in accordance with AN929-5 with a suitable chain permanently attached to the top of the cap.

3.6.5 Pressure relief valve. The pressure relief valve on the liquid oxygen converter shall be vented overboard, using 5/16 inch (7.94 mm) minimum outside diameter tubing. The relief valve overboard vent may be the same as that used for the combination fill-buildup-vent valve. When removale converters are installed, a pressure relief valve in accordance with MIL-V-9050, Type V, shall be connected into the supply line downstream from the MS22068 coupling assembly.

* 3.6.6 Check valves. Except where otherwise specified, check valves shall be installed in accordance with Figure 4. In all multiple converter installations, liquid oxygen check valves shall be installed where they are effective in preventing additional loss of oxygen in the event any one

converter or line is destroyed. When more than one converter is installed in a multiplace aircraft in accordance with Figure 4, a check valve, in accordance with MIL-V-25513 or MIL-V-7908, depending upon the operating pressure, shall be installed in each of the auxiliary distribution lines to each station. Check valves that are designed in accordance with MIL-V-7908 shall be installed along the primary distribution lines to each station. All check valves shall be located downstream from the converter vaporizing and warming heat exchangers such that liquid oxygen will not contact the valves.

3.6.7 Disconnects. The disconnect for the removable converters shall be in accordance with MS22068-7 and MS22068-8. Where the supply line is required to be uncoupled for maintenance purposes, the quick disconnect shall be in accordance with MS22068-1 or MS22068-2.

3.6.8 Hoses. Flexible hoses shall be used for the aircraft system connections to removable converters and to shock mounted converters where movement relative to the aircraft will occur. The flow capacity of the hoses used in lieu of aluminum tubing shall be essentially equivalent to the aluminum tubing size specified for that connection. The bend radii imposed on the hoses during remove and replace actions shall be greater than the minimum established by that hose specification. Hose layouts shall avoid the imposition of torsional forces when being connected to the converter and also avoid the necessity for a particular rotational orientation when the flare nut is torqued. Hoses shall be of sufficient length to provide unstressed connections and be protected against chaffing on surfaces or objects which may damage the wire covering.

3.6.8.1 Metal hose. This wire braid covered hose shall be in accordance with MIL-H-22343 and the applicable part number of MS90457. This hose is flexible at temperatures down to -297°F (-183°C) but since it contains a metal bellows, it is somewhat vulnerable to fatigue failure if subjected to repeated severe flexing.

3.6.8.2 Tetrafluoroethylene hose. This wire braid covered hose shall be in accordance with MIL-H-26626 and the applicable part number of MS24548. This hose is flexible at temperatures down to -65°F (-54°C); therefore, disconnecting and manipulating the hose should be delayed until a few minutes after the flow of LOX has ceased.

3.6.9 Tubing. The tubing shall be of aluminum alloy conforming to AMS 4071, or corrosion resistant annealed steel (304), conforming to MIL-T-8506. The minimum outside diameter of tubing used for oxygen supply lines shall be 5/16 inch (7.94 mm). Tubing for "FILL" and "VENT" lines shall have minimum outside diameters of 3/8 and 1/2 inch (9.53 and 12.7 mm), respectively. All aluminum tubing shall have a wall thickness of 0.035 inch (0.889 mm), while corrosion resistant steel tubing shall conform to AND10104 and have a wall thickness of 0.020, 0.028 or 0.035 inch (0.508, 0.711 or 0.889 mm) as necessary in the application. All tubing shall be electrically bonded in accordance with MIL-B-5087.

3.6.9.1 Evaporation and warming tubing. Where the converter does not include warming coils or a heat exchanger, the aircraft shall include a heat exchanger or a minimum length of tubing, indicated in Table VI, between converter and first crew station for the indicated flow rate. Table VII indicates the approximate length of supply tubing along which frost and condensation can be expected for the indicated flow rate. Where other equipment might be affected by condensation, the supply tubing shall be provided with drip shields or other suitable means of protection. For flows greater than 100 litres per minute (1,666.6 cu.cm/s), pressure losses in 5/16 inch (7.94 mm) tubing may be excessive and necessitate the provision of more than one supply tube or a tube of larger size. The design flow quantity shall be supplied to the oxygen dispensing regulators at a temperature within +10, -20°F (+5.5, -11°C) of the cabin ambient temperature and at a pressure not less than 55 psig (379.2 kPa).

3.6.9.2 Tubing flaring and bending. Aluminum alloy tubing of 5/16 and 3/8 inch (7.94 and 9.53 mm) outside diameters shall be double flared to conform with MS33583. Aluminum alloy tubing of 1/2 inch (12.7 mm) outside diameter and all sizes of corrosion resistant steel tubing may be single flared to conform with MS33584. As an alternative, corrosion resistant steel tubing may be welded, brazed or swaged using methods and quality controls that produce leakproof joints, providing there is no undue degradation of tubing strength, corrosion resistance, or fatigue life. Tubing systems having these permanent type joints shall be designed for ease of fabrication, inspection and installation in the aircraft. The system layout shall provide for rapid in-service repair and component replacement. Tubing bends shall be uniform, without kinks, and fit the span between fittings without tension. The minimum bend radius to tube center lines shall be in accordance with MS33611.

3.6.9.3 Oxygen coupling sleeve. The oxygen coupling sleeve for flared tubing shall be in accordance with Drawing 44A25450.

3.6.9.4 Tubing routing and mounting. In routing the tubing, the general policy shall be to keep total length to a minimum consistent with Table VI. Allow for expansion, contraction, vibration and component replacement. In all installations of two or more converters where check valves are used, there shall be a minimum of tubing lengths in that portion of the system between the regulator and nearest check valve in the distribution line. To further reduce vulnerability to gunfire, the tubing lengths, between this check valve and the converters, shall be separated as much as possible. The separation between these tubing lengths shall be not less than 12 inches (0.305 m). All tubing shall be mounted to prevent vibration and chaffing. This shall be accomplished by the proper use of rubberized or cushion clips installed at no greater than 20 inch (0.508 m) intervals and as close to the bends as possible. Clips shall also be provided near portable recharger connections. The tubing, where passing through or supported by the aircraft structure, shall have adequate protection against chaffing by the use of flexible grommets or clips. The tubing shall not strike against the aircraft structure during vibration and shock encountered during normal use of the aircraft.

3.6.9.5 Tubing marking. All tubing shall be marked in accordance with MIL-STD-1247.

3.6.10 Fittings. All fittings shall be in accordance with applicable standards. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

* 3.6.11 Torque of joints. Tightening of flared tube and pipe connections shall be accomplished in accordance with the best commercial practice. Torque wrenches shall be used, and the torque applied shall be within the limits specified in Tables VIII and IX. The torque limits specified in Table VIII apply to double flared AMS 4071 aluminum tubing or MIL-T-8506 corrosion resistant annealed tubing. Table IX applies only to tapered pipe thread connections with MIL-T-27730 tape applied.

3.6.12 Breathing hose. Unless otherwise specified the breathing hose shall be in accordance with MIL-H-81581/5 and the applicable part number of MS22055.

3.6.12.1 Applicable to the Air Force. The breathing hose shall be in accordance with MIL-H-81581/5 and the applicable part number of MS22055, or MIL-H-87961, (see 6.2.1.d)

3.6.13 Personal services. Crewman's personal services connecting him to the aircraft shall be separated from the aircraft upon ejection by an automatic disconnection system. The disconnection force shall not be applied to the crewman. For disconnection forces, refer to applicable component specification. The installation of the personal services and the lengths chosen shall be such that the user's movements will not be restricted during his normal duties at his station. However, excessive lengths, with resultant bulkiness and resistance to breathing, shall be avoided. Suitable stowage provisions shall be provided in the aircraft for protection of personnel services when not in use.

3.6.13.1 Flow requirement. For panel mounted oxygen regulator installation, the combination of breathing hose, fittings and disconnects between the regulator and the mask connector at the end of the breathing hose shall not exhibit a flow resistance in excess of 2 inches of water (497.6 Pa) with a flow of 80 litres per minute (1,333 cu.cm/s) of oxygen at NTP conditions.

3.6.14 Portable oxygen system.

3.6.14.1 Portable oxygen system (1800 psi) (12.41 MPa). When a portable oxygen breathing system is required but refilling during use is not contemplated, the oxygen assembly shall be selected in accordance with MS22059, MS22061 or Drawing 60D3570. A commercial product may be utilized if the above assemblies are unsuitable for the application, subject to approval of the acquiring activity (see 6.2.1e).

3.6.14.2 Portable oxygen system (300 psi) (2,068 kPa). When a portable oxygen breathing system is required along with refilling during flight, the oxygen assembly shall be in accordance with Drawing 53C3794 for crew use with their pressure breathing oxygen masks, or in accordance with Drawing 53D3970 if the full face pressure breathing smoke mask is to be included. Each assembly shall be secured in a bracket which will retain the assembly under flight conditions and provide for rapid removal for use. The secured assembly shall be convenient to the crew duty stations and to each toilet. Recharging hoses in accordance with MS22032 shall be accessible from crew duty stations and toilets and have the filler valve end secured by a clip conforming to Drawing 46A16236 in a vertical, valve down position.

3.6.15 Emergency oxygen. An emergency oxygen system shall be provided. Provisions shall be made for the automatic opening of the oxygen bail-out supply during ejection seat operation. Position of the emergency oxygen system shall be determined by the type of seat configuration.

3.7 Performance.

3.7.1 Leakage. The oxygen system, when tested as specified in 4.5.2, shall not show any evidence of system leaks.

3.7.2 Pressure decay. The oxygen system, when tested as specified in 4.5.3, shall not exhibit a pressure decay greater than that specified in Table X.

3.7.3 Functional tests.

3.7.3.1 Panel mounted regulator.

3.7.3.1.1 Flow indicator. The oxygen system, when tested as specified in 4.5.4.1.1, shall permit a free flow of oxygen and the flow indicator of the panel mounted regulator shall function freely with each breath.

3.7.3.1.2 Emergency switch. The oxygen system, when tested as specified in 4.5.4.1.2, shall permit a free continuous flow of oxygen through the mask.

3.7.3.2 Non-panel mounted regulator. The oxygen system, when tested as specified in 4.5.4.2, shall permit a flow of oxygen through the mask without any appreciable resistance to breathing.

3.7.4 Evaporation loss. The oxygen system, when tested as specified in 4.5.5, shall not have liquid oxygen loss greater than that specified in Table XI.

3.7.5 Electrical continuity. The liquid oxygen quantity indicator, when tested as specified in 4.5.6, shall have capacitance inputs within the limits specified in Table XII.

3.7.5.1 Low-level warning. The press-to-test button, when tested as specified in 4.5.6.1, shall actuate the low-level light when the indicator is within the lowest 10 percent of the indicator scale and shall remain actuated until the indicator exceeds 10 percent of full scale indication. When the indicator is moving upscale, the low-level light may remain actuated past 10 percent but not to exceed 20 percent of full scale indication.

3.7.6 Flight test. When specified, flight tests on the oxygen systems shall be conducted to determine the proper functioning of all the oxygen equipment in the aircraft by actual crew use and functional measurements. In addition, a determination may be made of the suitability of the arrangement of the items from the standpoint of accessibility and convenience to all crewmembers during their flight duties.

3.8 Antiseize tape. Antiseize tape shall be used on all male pipe thread fittings. Antiseize tape shall conform to and shall be applied as specified in MIL-T-27730. Antiseize tape shall not be used on flare tube fittings, straight threads, coupling sleeves, or on the outer side of tube flares. None of the tape shall be allowed to enter the inside of a fitting.

3.9 System cleanliness. The completed installation shall be free of oil, grease, fuel, water, dust, dirt, objectionable odors, or any other foreign matters, both internally and externally prior to introducing oxygen into the system.

3.9.1 Filter. A replaceable filter shall be provided in the oxygen system where it will be effective in minimizing the accumulation of contaminants in critical components. Type size and location of the filter shall be determined by the manufacturer.

3.9.2 Closures. If the location of the converter within the aircraft is such that lines are required to be disconnected during aircraft maintenance checks or overhaul, suitable closures shall be provided for each exposed connection to prevent materials which are incompatible with oxygen from entering the system. Caps which introduce moisture and tapes that leave adhesive deposits shall not be used for these purposes. The closures shall remain with the aircraft at all times and shall be stored, when not in use, in close proximity to the connections and in such a manner as not to become contaminated. All openings of lines, fittings, valves, and regulators shall be kept securely capped until closed within the installation.

* 3.9.2 Degreasing. Parts of the oxygen system not covered by cleaning procedures shall be degreased using a cleaning compound, MIL-C-81302, or using vapor phase degreaser in accordance with MIL-T-81533. Ultrasonics may be used for the cleaning of components. When MIL-C-81302 cleaning compound is used, a final rinse in clean, fresh solvent is required. When vapor degreasing is used, the item shall finally be immersed in the cool, clean condensate reservoir and then held in the vapor zone until all condensation has ceased before removal. After completion of the cleaning and when assembled, General Electric Type H Leak Detector, or equivalent Halide testing apparatus, shall be used to determine the absence of the cleaning compound.

3.9.4 Purging. The oxygen system shall be capable of being purged to remove any contaminants. Whenever the oxygen system has been left open to atmospheric conditions for a period of time, or is opened for repairs, the system shall be purged using established industry purging procedures. Hot dry nitrogen conforming to BB-N-411, Type I, Class 1, Grade B or hot dry air conforming to BB-A-1034, Grade A or C may be used to purge the aircraft oxygen system provided the converter assembly has not been installed. The temperature at the inlet to the system shall not exceed 250°F (121.1°C) during purging. The purging procedure shall meet the following requirements.

3.9.4.1 Converter. Table XIII is applicable only when the converter is purged through the vent outlet. Quick change style converters shall be removed from the aircraft and purged away from the flight line.

3.9.4.2 Oxygen distribution system. Purge the aircraft oxygen distribution system separate from the liquid oxygen converter, by establishing a flow from each oxygen station of at least 5 litres per minute (83.5 cu.cm/s) for a period of not less than 30 minutes. In large aircraft, it may be necessary to divide the system, as determined by feeder lines, and purge each separately.

* 3.9.5 Lubricants. Lubricants in accordance with MIL-G-27617 may be used sparingly on seals.

3.10 Maintenance and replacement. All parts of the oxygen system shall be installed to permit ready removal and replacement without the use of special tools. All tubing connections, fittings, regulators, converters and other items shall be readily accessible for leak testing with leak test compound and for tightening of fittings without removal of surrounding parts. Flexible hoses shall be used to connect indicating instruments mounted on shock mounted panels to permit easy maintenance.

3.11 Clearance requirements. Oxygen lines, fittings and equipment shall be installed above and at least six inches away from fuel, oil and hydraulic systems to avoid contamination. Deflector plates shall be used, where necessary, to keep hydraulic fluids away from oxygen lines, fittings and equipment. Open ends of cleaned and dried tubing shall be plugged with impermeable caps at all times, except during attachment or detachment of parts. There shall be at least 2 inches (50.8 mm) of clearance between the oxygen system and flexible moving parts of the aircraft. There shall be at least 1/2 inch (12.7 mm) clearance between the oxygen system and rigid parts of the aircraft, except at clamp areas. The oxygen system tubing, fittings and equipment shall be separated at least 6 inches (152.3 mm) from all electrical wiring, heat conduits and heat emitting equipment in the aircraft. Insulation shall be provided on the hot ducts, conduits or equipment to prevent heating of the oxygen system. To assure adequate glove clearance around valves and disconnects, the following clearances shall be provided. The minimum clearance shall be a 3 inch (76.2 mm) diameter circle around the vent and supply disconnects and a 5 inch (127 mm) diameter circle around the filler valve for permanent installations. The centers of the circular clearance areas coincide with the longitudinal axes of the valves.

3.11.1 Deviations from clearances requirements. When barriers such as ribs, webs, frames, channels, extrusions and stringers exist between oxygen lines and electrical wires in such a manner that there is no danger of such lines contacting each other, the above requirements for separation, mounting and covering shall not be applicable. Shields shall be acceptable to the acquiring activity. Where electrical wires lead into oxygen equipment due to an electrical item being a component of the oxygen equipment, the requirements for separation, mounting and covering are not applicable, except that they shall be secured against chaffing. Deviations other than specified herein must be approved by the acquiring activity.

* 3.12 Aircraft marking requirements. The aircraft shall be permanently and legibly marked in the locations and with the information specified below, using a minimum letter height of 1/4 inch (6.35 mm). Color of the letters are to be black on a white background.

a. Adjacent to the overboard vent opening:

CAUTION
LIQUID OXYGEN VENT

b. On outside surface of filler box cover plate:

LIQUID OXYGEN (BREATHING) ACCESS

c. On underside surface of filler box cover plate:

CAUTION
KEEP CLEAN, DRY AND FREE FROM OILS

d. Adjacent to liquid oxygen drain valve location:

DO NOT OPEN DRAIN VALVE UNTIL DRAIN HOSE AND
DRAIN TANK ARE CONNECTED

e. Adjacent to recharger location:

PORTABLE OXYGEN RECHARGER

f. Adjacent to filling station:

Aircraft shall be marked in accordance with MS33739

3.13 Workmanship. The oxygen system shall be uniform in quality and shall be free from irregularities, defects or foreign matter which could adversely affect safety, performance, reliability or durability.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Quality conformance inspection. Quality conformance inspection consists of examinations and tests performed on individual products or lots to determine conformance of the products or lots with the requirements set forth in this specification(see 4.3).

4.3 Quality conformance inspection. All the examinations and tests of this specification shall be conducted on each liquid oxygen system.

4.4 Test conditions.

4.4.1 Oxygen. Unless otherwise specified, the oxygen used in testing the oxygen system shall conform to MIL-O-27210, Type I and the oxygen employed in filling the oxygen system shall conform to MIL-O-27210, Type II.

4.4.1.1 Transfer equipment. A liquid oxygen storage tank, conforming to MIL-T-38170, or any suitable liquid oxygen servicing trailer, shall be used to service liquid oxygen systems. When gaseous servicing is needed for test purposes, a gaseous oxygen trailer, conforming to MIL-T-26069, shall be used. Transfer equipment shall mate with fittings provided for filling.

4.4.2 Leak test compound. The leak test compound employed in testing the system shall conform to MIL-L-25567.

4.4.3 Temperature and pressure. Unless otherwise specified, tests shall be conducted at local ambient temperature and barometric pressure. Test instruments shall be calibrated or adjusted according to their required usage in conducting individual tests. Temperature and pressure shall be recorded at the time of inspection and shall be available, when required, for correction of test results to normal temperature and pressure (NTP) conditions. NTP conditions are 29.92 inches of mercury (101.2 kPa) and 70°F (21.1°C).

4.5 Inspection methods.

4.5.1 Visual examination. The oxygen system shall be examined visually to determine conformance to this specification and applicable drawings with respect to all the requirements not covered by tests.

4.5.2 Leakage test. The complete oxygen system, excluding the converter, personal mounted regulator, seat pan, mask and hard line relief valve, shall be subjected to a gaseous oxygen pressure equal to its operating pressure. While this test pressure is maintained, all fittings and connections shall be examined for leaks by application of leak test compound conforming to MIL-L-25567. The oxygen system shall pass the requirements specified in 3.7.1. Care shall be taken to remove all traces of compound from the system after this test is performed.

4.5.3 Pressure decay. The complete system shall be charged with gaseous oxygen to the system operating pressure. Removable converters may be removed for this test. After system pressure has been stablized for five (5) minutes, record oxygen pressure, time and distribution line temperature. The oxygen pressure and distribution line temperature shall again be recorded after one-half hour and shall pass the requirements specified in 3.7.2.

4.5.4 Functional test. The following functional tests shall be performed for each station of each aircraft, where applicable, after filling the system with liquid oxygen, and permitting the system to buildup to the designed operating pressure.

4.5.4.1 Panel mounted regulator.

4.5.4.1.1 Flow indicator. Connect a pressure breathing oxygen mask and hose assembly to the oxygen system. Move the diluter lever on the regulator to the "100 - percent oxygen" position. Breathe oxygen normally through the mask for a period of one minute and observe the flow indicator of the regulator. The oxygen system shall pass the requirements specified in 3.7.3.1.1.

4.5.4.1.2 Emergency switch. Connect a pressure breathing oxygen mask and hose assembly to the oxygen system. Move the diluter lever to the "normal" position. Set the regulator emergency switch to the emergency position for a period of 10 to 20 seconds. The oxygen system shall pass the requirements specified in 3.7.3.1.2. After the test, the emergency switch shall be returned to the normal position.

4.5.4.2 Non-panel mounted regulator. Connect an oxygen mask assembly incorporating a pressure breathing regulator and regulator-to-aircraft hose to the oxygen system. Move the oxygen supply valve to the "ON" position. Breathe deeply through the mask several times. The oxygen system shall pass the requirements specified in 3.7.3.2.

4.5.5 Evaporation loss test. The completed aircraft system shall be filled with liquid oxygen, and the mating assembly shall be disconnected from the combination fill-buildup-vent valve. One hour after filling the system, a wax pencil shall be used to mark positions of pointers on glass faces of liquid oxygen quantity-indicators. Twenty-four hours after marking indicators, readings shall be taken on indicators and the evaporation loss shall be within the range specified in 3.7.4.

4.5.6 Electrical continuity test. The liquid oxygen quantity indicator leads shall be disconnected from the converter. A precision variable capacitor, capable of providing stable and precise electrical capacitance equivalents of empty and full liquid oxygen converters, shall be connected to the leads disconnected from the converter. With the capacitor set to provide zero quantity indication, power shall be applied to the indicator, and the capacitance input shall be recorded. The capacitor shall then be set to provide full scale quantity indication, and the capacitance input shall be recorded. The capacitance inputs shall be within the limits specified in 3.7.5. Where two or more converters are installed in an aircraft, the above test shall be conducted at each converter with the capacitor connected to the leads disconnected from one converter, as described above, and all other oxygen quantity indicator leads in the system disconnected from the converters and connected to the dummy converters specified in 3.6.1.4.

4.5.6.1 Low-level warning. The test of the press-to-test button and low-level warning light shall be conducted as specified in 4.5.6, except the variable capacitor shall be set so that the indicator pointer indicates a quantity between 1/2 full and full. The press-to-test button shall then be actuated and the low-level light shall pass the requirements specified in 3.7.5.1.

4.5.7 Flight test. When specified (see 6.2.1f), flight tests shall be conducted and the oxygen system shall pass the requirements specified in 3.7.6. Upon completion of the flight test, the oxygen system shall then be subjected to and pass the tests specified in 4.5.2 and 4.5.4.

5. PACKAGING

5.1 Not applicable.

6. NOTES

6.1 Intended use. The design and installation requirements specified herein are intended for use in designing and installing liquid oxygen systems in aircraft using liquid to gaseous oxygen converters.

6.2 Ordering data.

* 6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Maximum number of converters required (see 3.4.2.1).

c. Installation of non-panel mounted regulators (see 3.6.3.2).

d. Type of breathing hose for Air Force acquisitions (see 3.6.12.1).

e. Whether commercial portable oxygen system is required (see 3.6.14.1).

f. Whether flight tests are required (see 4.5.7).

6.3 Data requirements. For the information of contractors and contracting officers, any of the data specified in (a) subparagraphs below, (b) applicable documents listed in Section 2 of this specification, or (c) referenced lower-tier documents need not be prepared for the Government and shall not be furnished to the Government unless specified in the contract or order. The data to be furnished shall be listed on DD Form 1423 (Contractor Data Requirements List), which shall be attrached to and made a part of the contract or order. NAVAIR Form 4200/25 (Drawings, Lists, and Specifications required) sahll be attached where applicable.

6.3.1 Drawings. Drawings should include the following and shall be in accordance with DOD-STD-100.

6.3.1.1 Pre-engineering information. At least 60 days prior to the preparation of the installation drawings, a schematic diagram of the oxygen system and oxygen duration calculation, for specified mission profiles, shall be submitted to the acquiring activity. The oxygen duration calculations shall include data to show that the number of converters provided is sufficient for the performance of the aircraft. The symbols used on all schematic drawings shall be in accordance with Figure 1.

6.3.1.2 Installation drawings. All installation drawings for oxygen equipment shall be submitted to the acquiring activity for approval. Installation drawings shall show the position of the equipment in the aircraft and the possible stations in the aircraft. Installation drawings shall also show accessibility of replaceable converters and filler valves.

6.3.2 Pilot's flight handbook (for Air Force use).

6.3.2.1 Schematic drawing. A schematic drawing of the oxygen system shall be provided as required in the Pilot's Flight Operating Instruction Handbook in conformance with MIL-M-7700 and MIL-M-38800 Manual, Technical, Organizational Maintenance Instructions. The drawing shall include a plan view of the aircraft and shall include all items for which there is a symbol in MIL-STD-17, Part 2. The drawing shall include the symbol key, where applicable, listing the type number of the items. Each converter on the drawing shall be numbered to correspond with a number placed in a readily visible place by each converter in the aircraft. The symbols used on all schematic drawings shall be in accordance with Figure 1.

6.3.2.2 Pilot's flight operating duration tables. Duration tables as required by the Pilot's Flight Operating Handbook, conforming to MIL-M-7700, shall be provided in the Aircraft Flight Handbook. A conversion factor of 1 litre liquid oxygen equals 860 litres of gaseous oxygen at 70°F (21.1°C) shall be used in oxygen duration tables.

* 6.4 International system of units (SI). The ASTM E 380-74, Metric Practice Guide - A Guide to the Use of SI, the International System of Units, was used for the conversion to the SI units in this document. The following conversion factors are applicable to this specification.

Foot X 0.3048	=	Metre (m)
Litre per hour X 2.77 X 10^{-7}	=	Cubic metre per sec (m^3/s)
Litre pr minute X 16.7 X 10^{-6}	=	Cubic metre per sec (m^3/s)
Pounds per square inch (psi) X 6.894	=	Kilopascals (kPa)
Degrees Fahrenheit (°F)	=	Degrees Celcius (°C) X 1.8 + 32
Inches X 25.4	=	Millimetres (mm)
Inch-pounds X 0.1130	=	Newton-metre (N-m)
Litre per hour X 0.277	=	Cubic centimetre per sec (cm^3/s)
Litres per minute X 16.667	=	Cubic centimetre per sec (cu. cm/s)
Millimetres of mercury X 0.1333	=	Kilopascals (kPa)
Inches of water X 248.18	=	Pascals (Pa)

* 6.5 International standardization. Certain provisions of this specification are the subject of international standardization agreement (ASCC 11/1, ASCC 14/3, ASCC 14/9 and STANAG 3499). When amendment, revision, or cancellation of this specification is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accomodations.

6.6 Marginal notations. The margins of this specification are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the past previous issue.

Custodians:
Army-AV
Navy-AS
Air Force-11

Preparing activity:
Navy - AS
(Project 1660-0491)

TABLE I. Baseline oxygen for each crewmember. 1/

Cabin altitude		Flow rate at 14.7 psia and 70°F (101.3 kPa and 21.1°C)			
		100 Percent oxygen		Air dilution 2/	
X1000 feet	Metres	Litres/hour	cm^3/s	Litres/hour	cm^3/s
0	0	801	222.5	240	66.7
5	1,524	658	182.5	172	47.8
8	2,438	581	161.4	151	41.9
10	3,048	535	148.6	143	39.7
15	4,572	429	119.2	140	38.9
20	6,096	340	94.4	159	44.2
25	7,620	265	73.6	194	53.9
28 and above	8,534 and above	225	62.5	225	62.5

1/ Oxygen values calculated on the basis of 15 lpm (250 cu.cm/s) requirement BTPS.

2/ Based on dilution performance of typical CRU-73 oxygen regulator.

TABLE II. Oxygen requirement adjustment for number in aircrew.

Aircrew number	Multiplier
1	1.20
2	1.10
3	1.06
4	1.03
5	1.02

TABLE III. Oxygen requirement multiplier for specific flight activities.

Specific Flight activity	Multiplier
Breathing safety pressure	1.10
Wearing pressure suit	1.20
Terrain following	1.25
Take off and landing	1.35
Carrier launch and landing	1.50
Aerial combat and threat	1.75

TABLE IV. Oxygen supply requirement for each passenger continuous flow mask.

Cabin altitude		Flow rate at 14.7 psia and 70°F (101.3 kPa and 21.1°C)	
X1000 feet	Metres	Litres/hour	cm^3/s
10	3,048	42	11.7
15	4,572	42	11.7
20	6,096	120	33.3
25	7,620	174	48.3
30	9,144	216	60.0
35	10,668	255	70.8
40	12,192	282	78.3

TABLE V. Liquid oxygen converter characteristics.

Size of converter (litres)	Design flow rate		Theoretical litres of free gas (sea level and 70°F) (21.1°C) immediately after servicing		Design quantity at 70°F, 14.7 psig or 21.1°C, 101.3 kPa	
	Litres/hr	Cu.m/hr	Litres	Cu.m	Litres	Cu.m
5	4,320	4.320	4,300	4.300	3,030	3.030
10 (70 psig)	4,320	4.320	8,600	8.600	6,740	6.740
10 (300 psig)	6,000	6.000	8,600	8.600	6,740	6.740
25	9,000	9.000	21,500	21.500	19,000	19.000
75	24,000	24.000	64,500	64.500	60,900	60.900

TABLE VI. Minimum length of tubing between converter and first station.

Flow rate		Length of 5/16 inch (7.94 mm) tubing, plain		Length of 1/2 inch (12.70 mm) tubing,plain	
Litres/min.	cm^3/s	Feet	Metres	Feet	Metres
20	333.3	20	6.10	11	3.35
40	666.6	40	12.19	22	6.71
60	1,000.0	60	18.29	34	10.36
100	1,666.6	100	30.48	57	17.39
150	2,500.0	150	45.72	85	25.91
200	3,333.3			113	34.44
300	5,000.0			170	51.82
400	6,666.6			227	69.19

TABLE VII. Approximate length of supply tubing to frost line.

Flow rate		Length of 5/16 inch (7,97 mm) tubing, plain		Length of 1/2 inch (1.70 mm) tubing, plain	
Litres/min.	cm^3/s	Feet	Metres	Feet	Metres
20	333.3	12	3.66	6	1.83
40	666.6	24	7.31	12	3.66
60	1,000.0	36	10.97	18	5.49
100	1,666.6	60	18.29	29	8.84
150	2,500.0	90	27.43	43	13.11
200	3,333.0			58	17.68
300	5,000.0			87	26.52
400	6,666.6			116	35.36

*TABLE VIII. Torque requirements for flared tube connections.

Tubing O. D.		Torque			
		Aluminum		Steel	
Inch	mm	In.-lbs.	N-m	In.-lbs.	N-m
5/16	7.94	100-125	11.30-14.12	170-200	19.21-22.60
3/8	9.53	200-250	22.60-28.25	270-300	30.50-33.90
1/2	12.70	300-400	33.90-45.19	450-500	50.84-56.49

TABLE IX. Torque requirements for pipe connections. 1/

Nominal pipe size		Torque			
		Minimum		Maximum	
Inch	mm	In.-lbs.	N-m	In.-lbs.	N-m
1/8	3.18	40	4.52	150	16.95
1/4	6.35	60	6.78	200	22.60
3/8	9.53	100	11.30	400	45.19

1/ Torque to specified minimum value and check for leakage. If additional torque is required to stop leakage, torque may be applied up to specified maximum value.

TABLE X. Liquid oxygen system pressure decay.

Converters capacity (litres)	Maximum allowable pressure decay	
	Psig	kPa
5	12	82.74
10	6	41.37
25	3	20.68
75	2.5	17.24

TABLE XI. Stand-by liquid oxygen loss-buidup condition.

Converters capacity	Maximum allowable loss of liquid oxygen after 24 hours (litres)
5	1.3
10	1.6
25	2.00
75	3.00

TABLE XII. Indicator system capacitance.

Converters capacity (litres)	Converter capacitance (pf)	
	Empty	Full
5	63.5 ± 0.4	92.5 ± 0.4
10	123.5 ± 0.7	181.5 ± 0.7
20	247.5 ± 1.4	363.0 ± 1.4
25	303.5 ± 1.8	448.4 ± 1.8
75	910.5 ± 5.4	1,345.5 ± 5.4

TABLE XIII. Liquid oxygen converter purging requirements.

Converters capacity (litres)	Container at ambient temperature	Within 6 hours after draining
	Purging period (minutes)	Purging period (minutes)
5 and 10	70	120
25 and 75	90	120

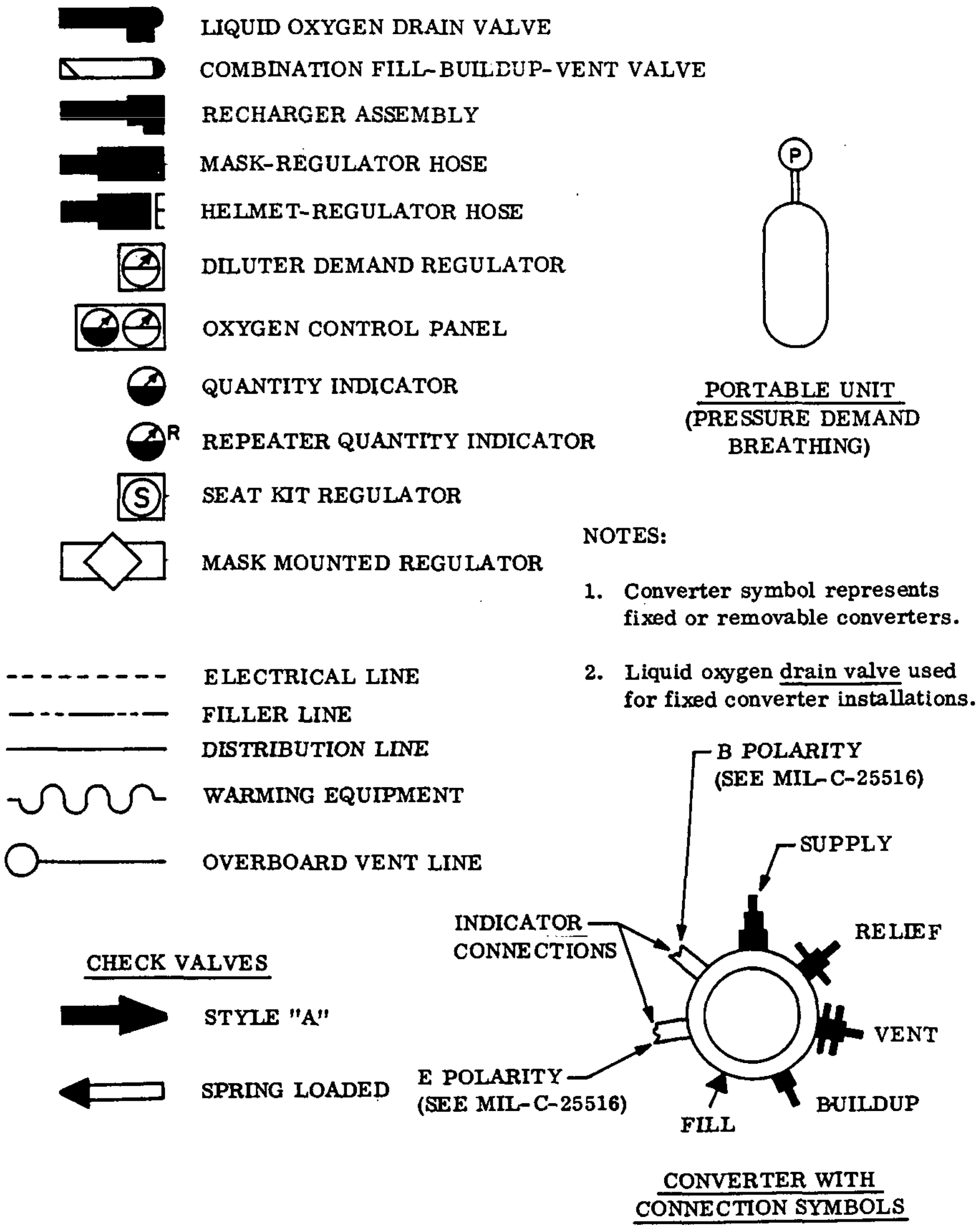

FIGURE 1. Symbols.

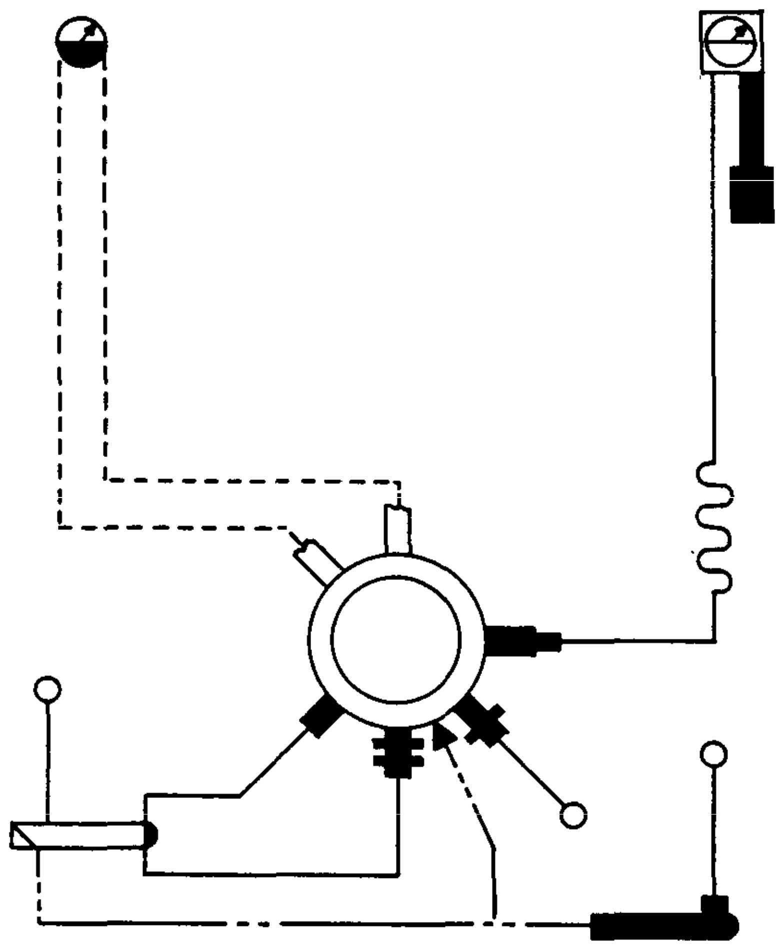

FIGURE 2. Typical installation single converter single place aircraft.

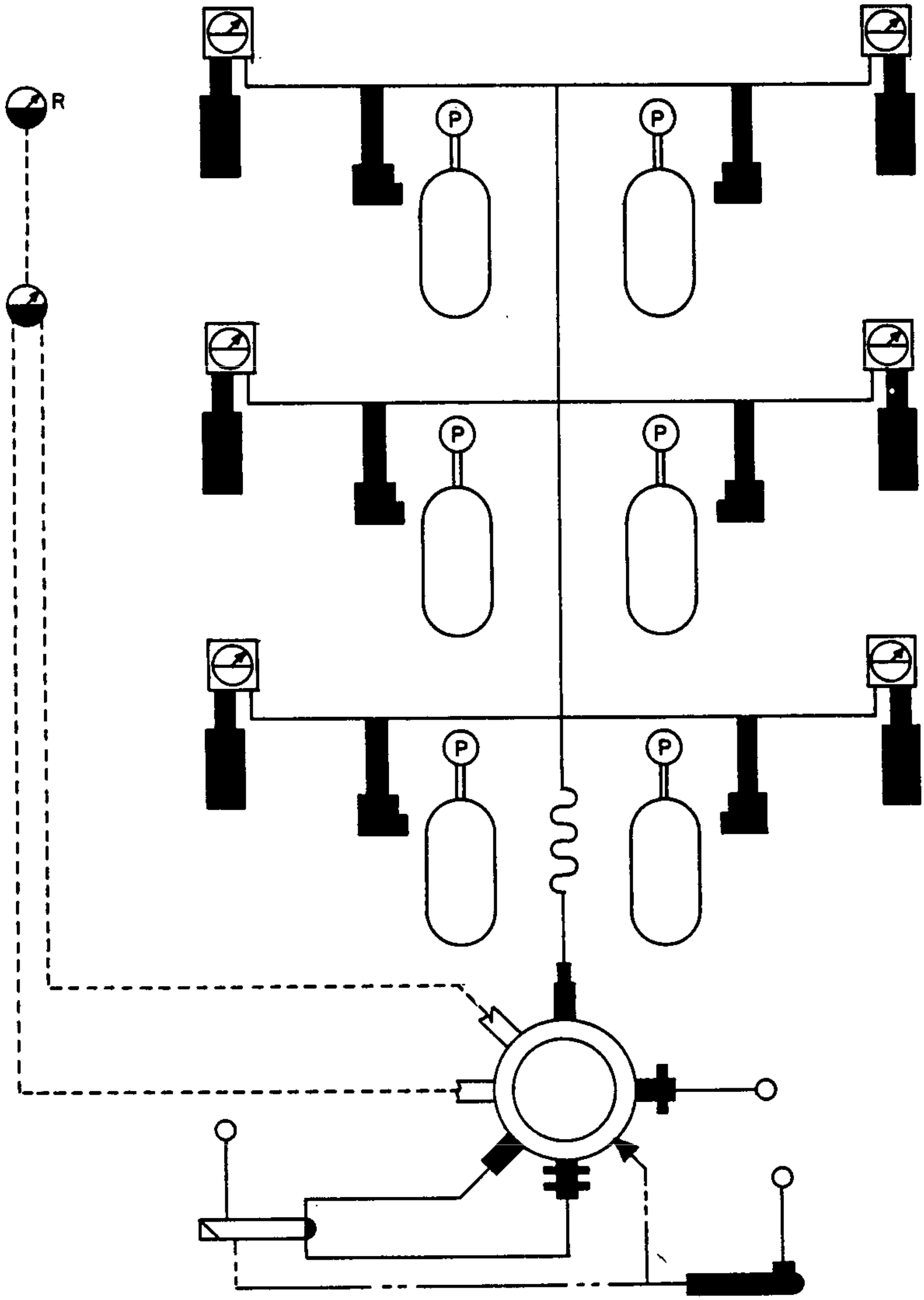

FIGURE 3. Typical installation single converter - multiple crew station.

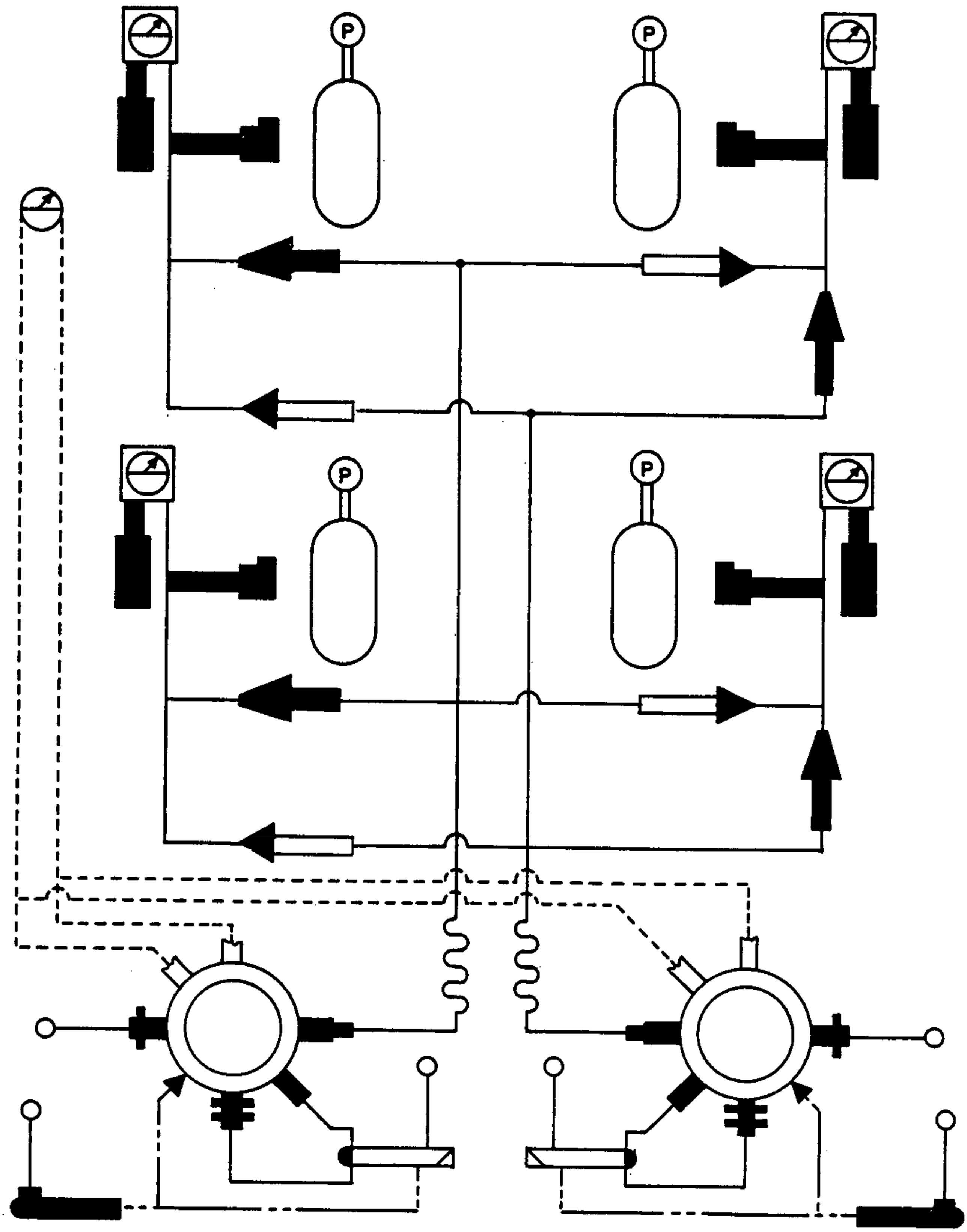

FIGURE 4. Typical installation multiple converters - multiple crew stations.

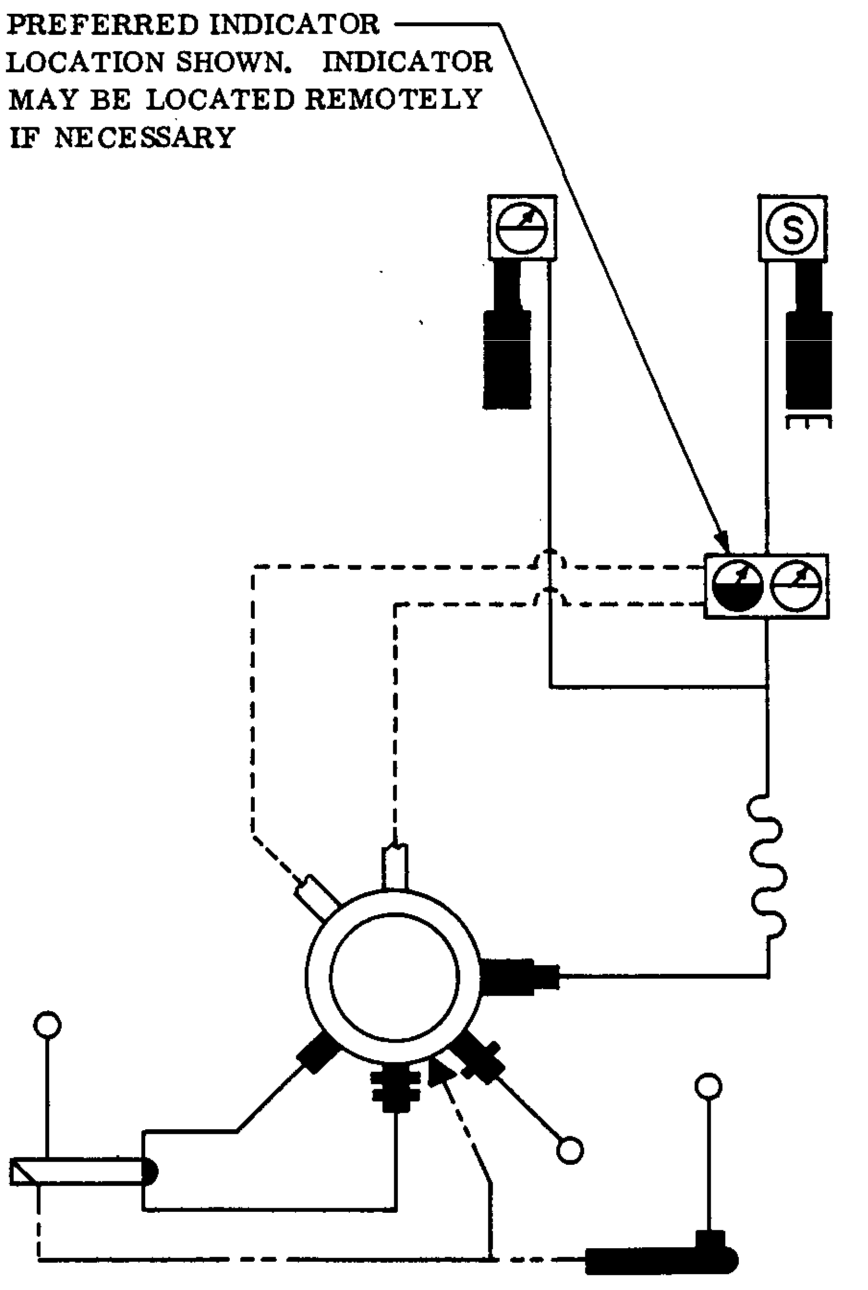

FIGURE 5. Single converter - dual regulator.

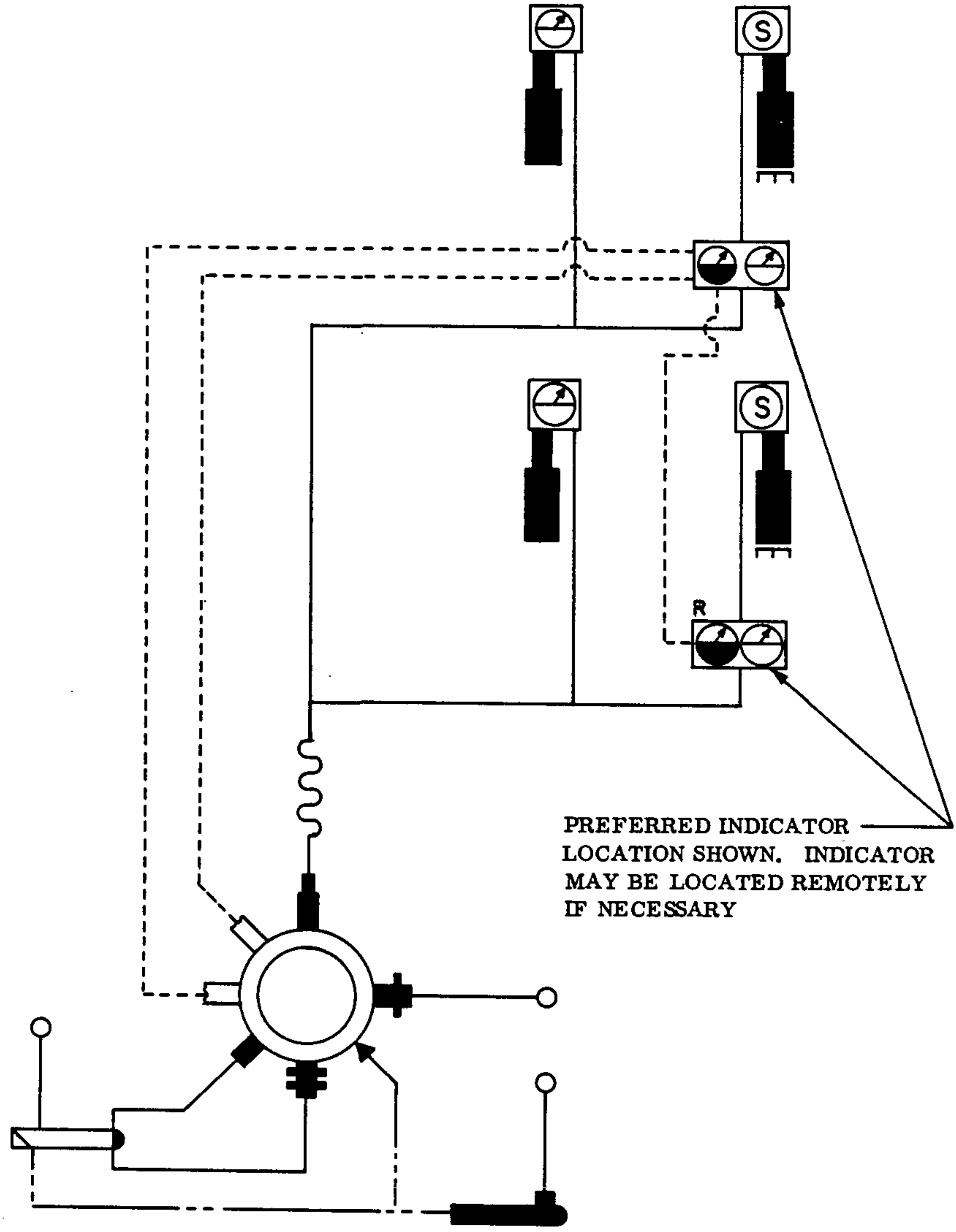

FIGURE 6. Single converter - dual regulator multiple crew station.

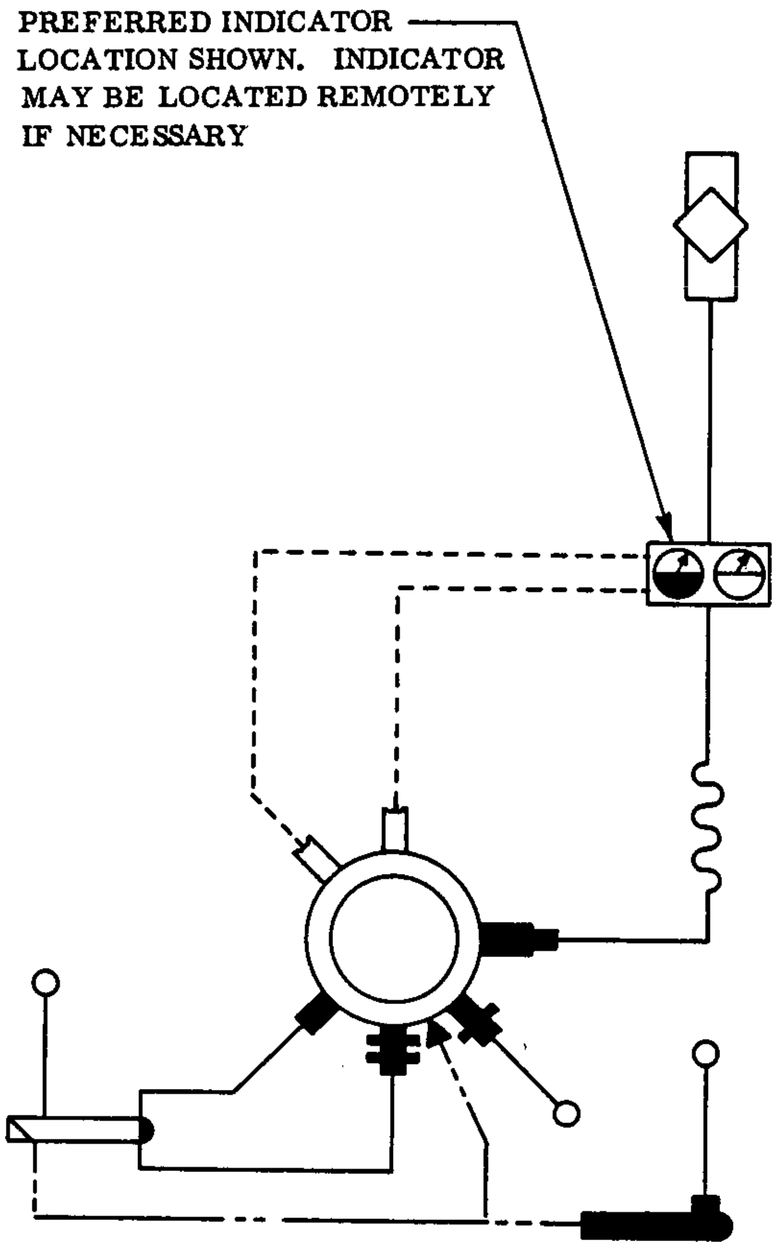

FIGURE 7. Single converter - mask mounted regulator.

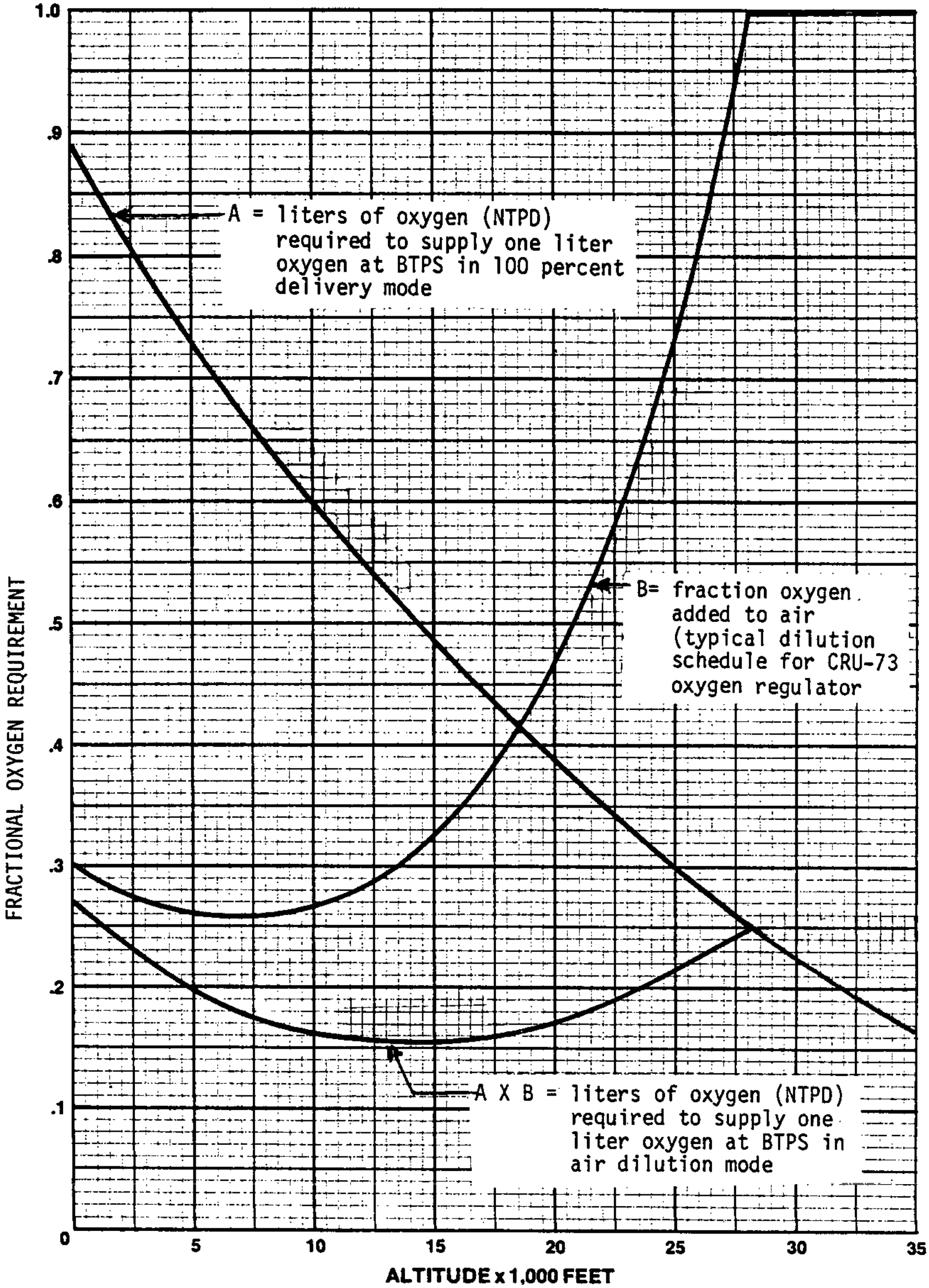

FIGURE 8. Fractional oxygen requirement versus cabin altitude.

INDEX

Page		Para.
17	Aircraft marking requirements	3.12
15	Antisize tape	3.8
1	APPLICABLE DOCUMENTS	2
17	Clearance requirements	3.11
17	Deviations from clearance	3.11.1
18	CLASSIFICATION OF INSPECTION	4.2
18	Quality conformance inspection	4.2a
21	DATA	6.3
21	Drawings	6.3.1
21	Installation drawings	6.3.1.2
21	Pre-engineering information	6.3.1.1
21	Pilot's flight handbook (for Air Force use)	6.3.2
22	Pilots flight operating duration tables	6.3.2.2
21	Schematic drawings	6.3.2.1
4	DESIGN	3.2
6	EMERGENCY OXYGEN	3.3.5
27	FIGURES (1 to 8)	
19	Inspection methods	4.5
20	Electrical continuity test	4.5.6
20	Low-level warning	4.5.6.1
20	Evaporation loss test	4.5.5
20	Flight test	4.5.7
19	Functional test	4.5.4
20	Non-panel mounted regulator	4.5.4.2
19	Panel mounted regulator	4.5.4.1
19	Emergency switch	4.5.4.1.2
19	Flow indicator	4.5.4.1.1
19	Leakage test	4.5.2
19	Pressure decay	4.5.3
19	Visual examination	4.5.1
21	INTENDED USE	6.1
22	INTERNATIONAL STANDARDIZATIONS	6.5
22	INTERNATIONAL SYSTEM OF UNITS (SI)	6.4
17	MAINTENANCE AND REPLACEMENT	3.10
8	MAJOR SYSTEMS COMPONENT	3.6

INDEX -Continued

Page		Para.
14	Breathing hose	3.6.12
14	Applicable to the Air Force	3.6.12.1
11	Check valves	3.6.6
8	Converter selection and installation	3.6.1
9	Permanently installed converters	3.6.1.2
9	Converter mounting	3.6.1.3
9	Converter mounting bracket	3.6.1.3.1
9	Dummy converter	3.6.1.4
9	Removable converter	3.6.1.1
12	Disconnects	3.6.7
15	Emergency oxygen	3.6.15
11	Fill-built-up vent valve	3.6.4
11	Drain valve (permanently installed converters)	3.6.4.3
11	Fill line (permanently installed converters)	3.6.4.1
11	Vent line	3.6.4.2
13	Fittings	3.6.10
12	Hose	3.6.8
12	Metal hose	3.6.8.1
12	Tetrafluoroethylene hose	3.6.8.2
9	Liquid oxygen quantity indicator	3.6.2
10	Gauging System	3.6.2.4
9	Indicator location	3.6.2.1
10	Low-pressure, low-level warning system	3.6.2.3
9	Press-to-test	3.6.2.2
14	Personal services	3.6.13
14	Flow requirement	3.6.13.1
11	Pressure relief valve	3.6.5
14	Portable oxygen system	3.6.14
14	Portable oxygen system (1800 psi) (12.41 MPa)	3.6.14.1
14	Portable oxygen system (300 psi) (1068 kPa)	3.6.14.2
10	Regulators	3.6.3
10	Non-panel mounted	3.6.3.2
10	Panel mounted	3.6.3.1
11	Preinstallation test	3.6.3.3
14	Torque of joints	3.6.11
25	Torque requirements for flared tube connedctions	Table VIII
25	Torque requirements for pipe connections	Table IX
12	Tubing	3.6.9
12	Evaporation and warming tubing	3.6.9.1
24	Minimum length of tubing between converter and first station	Table VI
25	Approximate length of supply tubing to frost line	Table VII
13	Tubing flaring and bending	3.6.9.2
13	Oxygen coupling sleeve	3.6.9.3
13	Tubing marking	3.6.9.5
13	Tubing routing and mounting	3.6.9.4

INDEX -Continued

Page		Para.
22	MARGINAL NOTATIONS	6.6
21	ORDERING DATA	6.2
21	Acquisition requirements	6.2.1
6	OXYGEN QUANTITY DETERMINATION	3.4
6	Oxygen flow requirements	3.4.1
23	Baseline oxygen for each crewmember	Table I
7	Design oxygen requirement	3.4.1.4
24	Oxygen supply requirement for each passenger continous flow mask	Table IV
6	Flight demand provisions	3.4.1.2
24	Liquid oxygen converter characteristics	Table V
23	Oxygen requirement adjustment for number in aircrew	Table II
7	Oxygen regulator air dilution	3.4.1.3
23	Oxygen requirement multiplier for specific flight activities	Table III
6	Respiratory provisions	3.4.1.1
7	Size and number of converters	3.4.2
7	Maximum number of converters	3.4.2.1
5	OXYGEN SYSTEMS	3.3
5	Emergency oxygen	3.3.5
5	Systems utilizing oxygen masks	3.3.1
5	Bomber aircraft supply	3.3.1.2
5	Fighter and attack aircraft supply	3.3.1.1
5	Transport aircraft supply	3.3.1.3
5	High altitude aircraft supply	3.3.2
6	Portable oxygen systems	3.3.4
6	Systems utilizing capsules	3.3.3
15	PERFORMANCE	3.7
15	Electrical continuity	3.7.5
26	Indicator system capacitance	Table XIII
15	Low-level warning	3.7.5.1
15	Evaporation loss	3.7.4
26	Stand by liquid oxygen loss - buildup condition	Table XI
15	Flight test	3.7.6
15	Functional tests	3.7.3
15	Non-panel mounted regulator	3.7.3.2
15	Panel mounted regulator	3.7.3.1
15	Emergency switch	3.7.3.1.2
15	Flow indicator	3.7.3.1.1
15	Leakage	3.7.1

INDEX -Continued

Page		Para.
15	Pressure decay	3.7.2
26	Liquid oxygen system pressure decay	Table X
18	QUALITY CONFORMANCE INSPECTION	4.3
18	RESPONSIBILITYFOR INSPECTION	4.1
18	Responsibility for compliance	4.1.1
1	SCOPE	1.
4	SELECTION OF SPECIFICATION AND STANDARDS	3.1
16	SYSTEM CLEANLINESS	3.9
16	Filter	3.9.1
16	Closures	3.9.2
16	Degreasing	3.9.3
16	Purging	3.9.4
16	Converter	3.9.4.1
16	Oxygen distribution system	3.9.4.2
17	Lubricants	3.9.5
26	Liquid Oxygen converter purging requirements	Table XIII
7	SYSTEM LAYOUT	3.5
8	Location	3.5.6
8	Multiple converters with multiple crew stations	3.5.4
7	Quantity indicators	3.5.1
8	Single converter, dual regulator	3.5.5
8	Single converter, single place aircraft	3.5.2
8	Single converter with multiple crew stations	3.5.3
19	TEST CONDITIONS	4.4
19	Leak test compound	4.4.2
19	Oxygen	4.4.1
19	Transfer equipment	4.4.1.1
19	Temperature and pressure	4.4.3
18	WORKMANSHIP	3.13

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