CHAPTER 3

OXYGEN EQUIPMENT – GENERAL INFORMATION, SAFETY, AND HANDLING

Section 3-1. Aircraft Oxygen Systems

3-1. GENERAL.

3-2. Aircraft Liquid Oxygen and Gaseous Oxygen Systems provide the aircrewmember with diluted or 100% oxygen for breathing. The Liquid Oxygen System provides facilities to store and convert liquid oxygen (LOX) to gaseous oxygen and to deliver the gaseous oxygen at a breathable temperature and pressure to the aircrewmember. The Gaseous Oxygen System provides facilities to store gaseous oxygen in cylinders at either high or low pressure and to deliver it to the aircrewmember at a reduced pressure for breathing. This chapter also contains safety precautions pertinent to handling and storage of liquid and gaseous oxygen equipment.

3-3. AIRCRAFT OXYGEN SYSTEMS.

3-4. Aircraft Oxygen Systems installed in naval aircraft fall into one of the following categories:

1. Gaseous Oxygen Systems

   a. Low Pressure (0-500 psig)

   b. High Pressure (0-1800 psig)

   c. Reduced High Pressure

2. Liquid Oxygen Systems

3-5. GASEOUS OXYGEN SYSTEMS. Gaseous Oxygen Systems are used primarily in multiplace aircraft where space and weight considerations are less important items. Basically, all Gaseous Oxygen Systems consist of the following:

1. A cylinder (or cylinders) for storing the oxygen supply.

2. Tubing to distribute the oxygen from the main supply to the user(s).

3. Various valves for directing the oxygen through the proper tubing.

4. A regulator (or regulators) to control the flow of oxygen to each user.

5. A gage (or gages) to indicate oxygen pressure.

6. A mask (or masks) to direct the flow of oxygen to each user.

NOTE

The aircraft Illustrated Parts Breakdown (IPB) shall be consulted for usable items and system makeup.

3-6. LIQUID OXYGEN SYSTEMS. Liquid Oxygen Systems are generally used in aircraft where space and weight and mission considerations are paramount. The typical system consists of the following components:

1. A converter (or converters) for storing the liquid oxygen supply.

2. A filler valve for servicing the system.

3. A heat exchanger for warming the oxygen to normal breathing temperatures.

4. A control valve for maintaining desired system operating pressure.

5. A relief valve to relieve excess pressure.

6. Tubing to distribute oxygen to the user(s).

7. Regulator(s), quantity indicator(s), shutoff valve(s) and other essential cockpit (or cabin) equipment.

NOTE

The aircraft Illustrated Parts Breakdown (IPB) shall be consulted for specific items used and make-up of the system for specific aircraft.

3-7. OXYGEN BREATHING REGULATORS.

3-8. DILUTER DEMAND TYPE REGULATORS. Diluter Demand Regulators are currently installed in some naval aircraft. They are used with Gaseous Oxygen Systems. The Diluter Demand Regulator provides the aircrewmember with an air-oxygen mixture, or 100% oxygen, depending on mode of operation selected. By placing the diluter lever (or knob) in the NORMAL position, an air-oxygen mixture is supplied upon demand up to approximately 28,000 to 32,000 feet. The ratio of oxygen-to-air is automatically adjusted to supply increasing oxygen as altitude increases. At approximately 32,000 feet, ambient air is shut off, and the user receives 100% oxygen. By selecting 100% OXYGEN, the regulator supplies 100% oxygen at all altitudes.

3-9. AUTOMATIC POSITIVE PRESSURE DILUTER DEMAND TYPE REGULATORS. Several types of Automatic Positive Pressure Diluter Demand Regulators are currently installed in naval aircraft. These regulators are used with either Gaseous or Liquid Oxygen Systems. Operation of the Automatic Positive Pressure Diluter Demand Regulator at altitudes up to 28,000 to 32,000 feet is basically the same as the Diluter Demand Regulator. Above approximately 30,000 feet, added oxygen at a positive pressure is supplied to the mask. This added pressure increases with altitude. Service ceiling of these regulators is 50,000 feet, but due to human limitations, Automatic Positive Pressure Diluter Demand Regulators shall not be used above 43,000 feet except for very short periods.

3-10. MINIATURE OXYGEN BREATHING REGULATORS. Miniature Oxygen Regulators reduce and regulate supply pressure, and deliver 100% oxygen to the user at a breathable pressure. A safety pressure feature automatically maintains a positive pressure of 0 to 2.5 in H_2O in the mask at all altitudes up to, and including, 34,000 feet. The pressure breathing feature maintains a positive pressure in the mask of up to 20.0 in H_2O at altitudes between 35,000 and 50,000 feet. The positive pressure increases as altitude increases. Miniature Oxygen Regulators can be used routinely up to approximately 43,000 feet, but due to human limitations, Miniature Oxygen Regulators shall not be used above 43,000 feet except for very short periods.

3-11. DILUTER DEMAND TORSO-MOUNTED OXYGEN REGULATORS. These Diluter Demand Regulators are torso-mounted, multi-purpose regulators. They are designed to provide 100% oxygen or an air-oxygen mixture at the correct ratio and pressure to the aircrewmember, depending on altitude and mode selection. The regulators incorporate a selector knob (or lever) for selecting the 100% OXYGEN, or DILUTER mode.

3-12. CONTINUOUS FLOW REGULATORS. Continuous Flow Regulators are used in a limited number of naval aircraft. These regulators do not satisfactorily meet all the oxygen requirements of varying degrees of aircrew activity. Continuous Flow Regulators are not authorized for use by aircrewmembers, but are authorized for passenger use.

Section 3-2. Oxygen Hazards, Safety, and Handling

3-13. GENERAL.

3-14. Personnel safety cannot be guaranteed. However, a high level of safety can be achieved if operating personnel have the proper attitude, understanding, and training. Safety regulations must be conscientiously practiced and rigidly enforced. It is the painful truth that many of these rules have been written because of the death or suffering of those who did not know them or chose to ignore them. The best assurance of personnel safety lies in the safety-education of the people themselves. If they can be made aware of the potential hazards and the means of protecting their own lives,

most of them will respond in a responsible fashion. Responsibility for the safety of one's self and others cannot, however, be obtained solely with a set of written regulations. Responsibility is secured on an individual basis, in varying degrees, and is the framework for all safety-education. There would be little need for safety rules if everyone were extremely responsible and knowledgeable. Unfortunately, this is not always the case. A lack of maturity on the part of an individual, or a new or unfamiliar job assignment, working a manner contrary to the possession of such responsibility and knowledge. Safety rules, then, become a primary tool in securing safety-conscious, well-trained personnel. In many instances, safety-education is conducted on a haphazard basis and only taken seriously when required by top management. It is not uncommon for safety procedures to evolve following a serious accident which has caused injury or death. The safety of personnel can be almost assured only when there is thorough understanding of potential hazards, correct procedures and equipment are used, and the equipment is kept in good working condition.

3-15. Safety precautions presented in this Section shall be followed by all personnel responsible for handling liquid and gaseous oxygen. To ensure personal safety and the safe and efficient handling of liquid and gaseous oxygen, all personnel shall be thoroughly familiar with the hazards involved. All operations involving the handling of LOX shall be performed by two or more qualified persons, except the removal and replacement of aircraft LOX converters. The filling of LOX converters removed from the aircraft shall require two qualified persons. (Refer to Glossary for definition of Qualified Personnel.)

WARNING

Use only small amounts of oxygen cleaning compound at a time. Use in a well ventilated open space. Avoid prolonged breathing. Oxygen cleaning compound vapors are hazardous and can cause death if too much is inhaled.

NOTE

Personnel servicing gaseous oxygen systems or LOX converters and operating ground support equipment servicing and transfer units shall be qualified and licensed in accordance with OPNAVINST 4790.2 series.

1. All AIMD oxygen shops, ashore and afloat, shall have oxygen monitors installed to ensure oxygen content in the space is maintained at a safe level (both physiological and over-enriched). Most shops have new oxygen monitor models. However, some AIMD oxygen shops may still have older oxygen monitors installed which can remain in service until receipt of the new monitor. Contact CFA at NAWCAD Lakehurst, NJ for appropriate monitor settings. Refer to NAVAIR 06-30-501 for currently authorized oxygen monitor model numbers.

2. Quality Assurance Division shall audit the oxygen shop to ensure step 1 is complied with.

3-16. SAFETY PRECAUTIONS; OXYGEN CLEANING COMPOUND MIL-C-81302.

3-17. Oxygen cleaning compound may dilute or displace oxygen below levels necessary to sustain life. Low levels are especially susceptible to oxygen displacement. The following warning shall be displayed wherever cleaning compound MIL-C-81302 is used.

WARNING

Inhaling trichlorotrifluoroethane vapor can be fatal.

Vapor concentration, immediately dangerous to life, is almost odorless, colorless, and tasteless. It may cause impairment of manual dexterity and vigilance. Breathing high concentrations may cause death or serious physical harm. In case of spill, warn other personnel and evacuate immediately.

3-18. The following precautions shall be followed by all personnel handling cleaning compound, MIL-C-81302.

1. Avoid breathing vapors. Avoid skin and eye contact.

2. Use the least amount possible to perform the task.

3. Assure good ventilation to maintain vapor levels at an acceptable level.

4. Do not wear contact lenses when using MIL-C-81302 cleaning compound.

5. Wear safety goggles for eye protection.

6. First Aid. If required, perform the following first aid procedures as necessary:

a. In case of direct contact, remove contaminated clothing and wash involved skin with soap and water. Seek medical attention if irritation occurs.

b. In case of eye contact, flush with potable water for at least 5 minutes. Call a physician.

c. If inside, remove to fresh air. If not breathing, give artificial respiration preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician. Do not give epinephrine or similar drugs.

d. If ingested, do not induce vomiting.

NOTE FOR PHYSICIAN:

Trichlorotrifluoroethane has caused cardiac sensitization to epinephrine in experimental animals (dogs). Cardiac arrhythmia, including ventricular fibrillation, could occur if epinephrine or one of its congeners is administered to patients exposed to high concentrations of trichlorotrifluoroethane. Medical use of epinephrine or any of its congeners is contraindicated except for patients with no arterial perfusion.

3-19. GASEOUS OXYGEN HAZARDS.

3-20. Gaseous oxygen is extremely hazardous when used in the presence of readily combustible materials. Do not permit oil, grease, gasoline, kerosene, aviation fuel or any other readily combustible material to come in contact with oxygen.

3-21. GENERAL SAFETY PRECAUTIONS (GASEOUS OXYGEN).

3-22. The following safety precautions shall be followed by all personnel handling gaseous oxygen:

1. Only oxygen conforming to MIL-O-27210, Type I shall be used in aircraft gaseous oxygen systems.

2. Exercise care that compressed oxygen does not become contaminated in anyway with hydrogen, hydrocarbon gases, or oil base liquids as a serious explosion can result.

3. Oil or grease must never be allowed to come into contact with or be used in the presence of open cylinders, valves, regulators, gages or fittings. Fire or explosion may result.

4. Never lubricate oxygen valves, regulators, gages, or fittings with oil or any substance except an approved oxygen compatible lubricant, listed below.

Mil Spec	Description	NIIN
TYPE III	Krytox	
TYPE III	Tribolube	16

Specific lubricants approved for use with oxygen equipment are listed in the appropriate chapter of this manual describing specific oxygen equipment.

NOTE

Krytox and Tribolube shall not be used on aluminum or magnesium fittings in applications where shear stress would be encountered.

MIL-T-27730 Teflon tape shall be used specifically as a thread sealant.

MIL-M-7866 Molybdenum Disulfide shall be used on stainless steel flared fittings and on those applications where Teflon Type MIL-T-27730 cannot be used.

5. Hands should be clean and free from oil before using oxygen equipment; do not wear greasy gloves or clothing.

6. A spark is not necessary to cause a fire or explosion. The chemical reaction of having fuel gases and oils combine with oxygen is sufficient to develop spontaneous combustion, and could cause a fire or explosion.

7. Never permit oxygen cylinders to come into contact with electrical welding circuits or apparatus.

8. Do not allow sparks or flames from welding or cutting torch or any other source to contact cylinders.

9. Never use oxygen from a cylinder without reducing the pressure through a pressure reducing regulator.

10. Never mix other gases or compressed air in an oxygen cylinder.

11. Never test for pipe line leaks or blow-out pipe lines with oxygen unless lines are specifically made and

cleaned for oxygen use. Use water-pumped nitrogen, which does not support combustion, for this purpose. Pipes, pipe threads, and other pressure containers are sometimes greased or oiled. Using compressed oxygen for the general purpose of testing for leaks is extremely dangerous and almost certain to cause a violent explosion.

12. To aid in preventing leakage or material failure due to overtorque of gaseous oxygen system tubing and fittings, strict adherence to torque values listed in table 3-1 is mandatory.

13. Do not confuse air with oxygen. Oxygen is one of several elements contained in air and should always be described by its proper name. Any attempt to use oxygen in place of compressed air may result in an accident. Never use oxygen for pneumatic tools, for starting diesel engines, as a pressure agent in oil reservoirs, for paint spraying, or for any use other than breathing, welding, or cutting.

14. Aviator's breathing oxygen supply cylinders can be readily identified by their green color and 3-inch wide white band around the upper circumference of the cylinder. OXYGEN, AVIATOR'S shall be stenciled in white parallel to the longitudinal axis and on diametrically opposed sides in letters 1 3/4 to 2 inches high.

15. Before connecting oxygen cylinders to oxygen systems, be sure that each cylinder is properly and correctly identified as containing aviator's breathing oxygen.

16. Never pressurize an oxygen system without the proper adapter and safety disc installed on the transfer line.

17. The amount of oxygen in a cylinder is determined by pressure.

18. Under no circumstances shall carbon tetrachloride or similar cleaning fluids be used. Minute quantities of these materials will contaminate the oxygen supply.

19. Do not clean any elastomer parts (rubberized) that have become contaminated with oil or grease. All such parts shall be replaced.

20. Prior to using leak detection compound (MIL-L-25567, Type 1), inspect carefully. Compound which is not clear and free from suspended material sediment is considered contaminated and shall be disposed of. Compound exhibiting peculiar odors such as acetone or alcohol is considered contaminated and shall be disposed of.

21. Use leak detection compound (MIL-L-25567, Type 1) sparingly as any solution entering oxygen equipment will contaminate the system. Remove all traces of the compound after test with a clean, damp, lint-free cloth.

22. The pressure in oxygen storage cylinders which service/replenish aircraft oxygen supply cylinders should not fall below 50 psig. Keep valve closed when not in use. Oxygen cylinders depleted to a pressure of approximately 50 psig shall be marked "EMPTY," tagged appropriately, and stored separately from charged oxygen cylinders. All cylinders which have a pressure below 15 psig shall be removed from service for vacuum and heat drying/hot nitrogen gas drying (MIL-STD-1411/MIL-STD-1359).

NOTE

A full oxygen cylinder is a cylinder which is charged to its rated pressure. With respect to a high pressure oxygen cylinder, 1800 psig is considered full.

To refill is to recharge a cylinder, regardless of the residual pressure remaining within the cylinder.

Cylinders that are less than 2 inches in outside diameter and less than 2 feet long do not require a hydrostatic retest.

Hydrostatic test interval for P-3 fixed installed oxygen cylinders (P/N 1084-514), shall not exceed eight years.

Low Pressure Oxygen Cylinders, Type MS21227-1 used on MA-1 Portable Emergency Oxygen System, do not have a Department of Transportation (D.O.T.) ICC number permanently stamped in the neck of the cylinder and therefore do not require hydrostatic testing. These cylinders are painted yellow in accordance with MIL-STD-101.

23. Never refill an oxygen cylinder that has gone beyond its hydrostatic test date (5 years after last test date stamped on cylinder shoulder). As long as the cylinder is full, it may remain in service.

24. Do not confuse aviator's breathing oxygen with welding or hospital oxygen. The latter types of oxygen usually have a moisture content that would freeze and plug the lines and valves of an aircraft oxygen system.

25. Leave cap on cylinder when not in use to protect valve. A broken valve may cause a cylinder to rocket like a torpedo, and could cause serious injury or death.

26. Before opening an oxygen cylinder valve, ensure cylinder is firmly supported. Cylinder valves are to be closed by hand only. If valve cannot be fully closed by hand, it shall be returned with cylinder for repair. A protective cap shall be installed on the valve of any cylinder not in use.

27. Open valves slowly, rapid surges in pressure can damage sensitive equipment and cause extreme temperature rise in small orifices and components.

28. Use existing or formulate charging stages when refilling oxygen cylinders and systems. Rapid pressurization creates heat which can result in fire or explosion.

WARNING

Wire-wrapped cylinders have wire-wrapping removed prior to hydrostatic testing; cylinders passing the hydrostatic test must be rewound prior to placing back in service.

NOTE

Not all cylinders require wire-wrapping. Wire wrapping is not required on 96 cubic inch cylinders manufactured under contracts N00363-78-M-7383 and N00383-77-C-2908.

29. Remove emergency oxygen cylinders or walk around bottles from aircraft for servicing.

30. Never fill aircraft systems without using a pressure reducing regulator. Aircraft have been demolished by failure to observe this precaution.

31. Ensure all oxygen equipment left outdoors is sheltered from the elements.

32. NAVSUPINST 4440.128 series contains instructions for storage, handling and hydrostatic testing intervals for compressed gases and gas cylinders.

3-23. LIQUID OXYGEN HAZARDS.

3-24. The potential hazards associated with the handling of liquid oxygen are due to its extremely cold temperature, rapid expansion upon conversion to gas at ambient (room) temperature, and its reactivity with any organic matter or flammable substance with which it comes in contact.

3-25. FREEZING. Because liquid oxygen has an extremely low temperature, it can freeze or seriously damage skin tissue upon contact. The effect is similar to frostbite or thermal burn. Use extreme caution when filling a warm container because vigorous boiling, splashing and evaporation will occur.

3-26. Metals and similar materials cooled by liquid oxygen may freeze to the skin upon contact. Flesh can be badly burned or torn in an attempt to free it. Always assume that frosted or uninsulated parts of liquid oxygen equipment are approximately -297°F (-182.7°C). Refer to Section 3-3 for protective clothing requirements.

3-27. FIRE AND EXPLOSION. Always handle liquid oxygen in well-ventilated areas. Never dispose of liquid oxygen in confined spaces. If liquid oxygen is spilled on a combustible substance, the substance will burn with great intensity if ignited.

3-28. Do not allow any organic matter or flammable substance to come in contact with liquid oxygen. Some of the materials that may react violently with oxygen under the right conditions of temperature and pressure are oil, grease, dirt containing oil or grease, tar, cotton, lamp black, coal dust, asphalt, gasoline, kerosene, JP fuel, propane, butane, naphtha, alcohol, ether, aniline, benzene, hydrogen, illuminating gas, acetylene, paint, sugar, sulfur, cloth and wood. If exposed to liquid oxygen, organic materials (such as those listed previously) will burn violently when ignited. All combustibles are potential explosion hazards when mixed with liquid oxygen. Mere mixture of liquid oxygen with powdered organic materials under certain conditions may cause explosion. If the vapor from liquid oxygen mixes with fuel vapor in the right proportions, the mixture will explode if ignited. Every fire involving liquid oxygen must therefore be regarded as an explosion hazard.

3-29. PRESSURE EXPLOSION. If liquid oxygen is vaporized and warmed to ambient temperature, one volume of liquid oxygen will expand to 862 volumes of gaseous oxygen. If this evaporation and expansion takes place in a confined space, explosive pressures in excess of 12,000 psig will be created. For this reason, all storage containers must be provided with pressure relief devices, unless the container is so vented that gas cannot be entrapped. All lines and equipment in which liquid may be trapped between closed valves must be equipped with pressure relief valves. All pressure relief valves and rupture discs must be placed and protected so that water cannot splash or condense upon them. Relief valves must be checked periodically to ensure that they are in proper operating condition.

3-30. GENERAL SAFETY PRECAUTIONS (LIQUID OXYGEN).

3-31. The following safety precautions shall be followed by all personnel handling liquid oxygen:

WARNING

Do not service LOX converters in an unsheltered area during inclement weather (rain, snow etc). Moisture can easily enter the vent port of the fill buildup vent valve and supply manifold. Moisture will freeze immediately upon contact with liquid oxygen rendering pressure closing or relief valve or both inoperative. This situation, if undetected, will lead to critical over pressurization and explosion of LOX converter:

LOX converters shall be drained in a well ventilated, clean area with limited access and protection from inclement weather so designated by type commanders or NAVSEA. A drip/drain pan with sides at least 6 inches high and free from dirt, grease, oil, fuel, hydraulic fluid, and other hydrocarbons, shall be used when draining LOX converters. Two qualified persons shall be present when draining LOX converters, one of which will be designated safety observer. A maximum of two LOX converters can be drained at one time.

1. Only liquid oxygen conforming to MIL-O-27210, Type II shall be used in aircraft liquid oxygen systems.

2. When transferring liquid oxygen or converting liquid oxygen to gaseous oxygen, the safety precautions pertaining to the handling of both liquid oxygen and gaseous oxygen apply.

3. Do not operate liquid oxygen equipment unless you are qualified or are working under the supervision of qualified personnel.

4. Wear goggles or a face shield when handling liquid oxygen.

5. Do not handle with bare hands any tubing or fittings through which liquid oxygen is flowing. Wear clean, dry gloves when handling parts of equipment cooled by liquid oxygen.

6. A rubber coated, cotton duck, impermeable apron shall be worn when working with liquid oxygen. The apron should be tied or secured in a fashion that would make it easy to remove in an emergency.

7. Cuffless coverall shall be worn. The coverall shall be worn over the gloves and the top of shoes, so that in the event of LOX spillage, the LOX will roll off the clothing and not become trapped in the gloves or boots.

8. Approved type liquid oxygen boots shall be worn.

9. In the event of accidental contact with liquid oxygen, quickly thaw the exposed area, preferably by immersion or by bathing area with large amounts of water. After the rapid thaw, wrap the exposed area loosely with clean dry dressing and report to a doctor immediately. Do not apply anything else to the affected area other than the clean dry dressing.

10. Do not permit smoking, open flames, or sparks in the liquid oxygen handling areas.

11. Do not carry matches in liquid oxygen handling areas.

12. Ensure all liquid oxygen equipment left outdoors is sheltered from the elements.

13. Keep work area and equipment free of oil, grease or any other combustible material.

14. Keep tools and clothing free of oil and grease.

15. Avoid spilling liquid oxygen on floor or deck areas. In case of accidental spillage, thoroughly ventilate the area.

16. Always call oxygen by its proper name. Do not confuse it with compressed air. Never use oxygen in place of compressed air for any purpose.

17. Handle converters, storage tanks and transfer hoses with care to avoid damage to the insulating space.

18. (Essex GCU-24/A Only) Prior to filling converter, inspect safety wire and Glyptal dots on relief valve and pressure closing valve for security.

19. When transferring liquid oxygen, do not leave valves open all the way. Open valves wide, and then immediately close them about one quarter turn; otherwise they may freeze in the open position.

20. Disconnect filling or transfer lines as soon as the transfer process is completed.

21. Do not leave liquid oxygen in a closed container, or trapped in a line between two valves; always open a valve on one end to avoid excessive pressure buildup.

22. Use only standard approved equipment in the handling and storage of liquid oxygen.

23. Do not introduce moisture into the system. Exercise care to ensure that no moisture is present on filler valve nozzles when they are connected or disconnected.

24. Purge piping and equipment with oil-free nitrogen, Type I, Class 1, Grade B, (Fed Spec BB-N-411).

25. To aid in preventing leakage or material failure due to over-torquing of liquid oxygen system tubing and fittings, strict adherence to torque values listed in table 3-1 is mandatory.

26. For additional precautions and information, refer to Technical Manual of Oxygen/Nitrogen Cryogenic Systems (NAVAIR 06-30-501).

3-32. (Converters Permanently Installed in Aircraft) Before recharging an aircraft liquid oxygen system with the converter installed, take the following precautions in addition to those already indicated. Ensure that:

1. The aircraft is in an open ventilated area.

2. The aircraft is not being fueled.

3. The aircraft is static grounded.

4. The aircraft electrical system is OFF.

5. No APUs or starting units are connected to the aircraft or are operating in the vicinity.

6. A CO_2 fire extinguisher is immediately available.

7. Personnel are kept clear of the aircraft overboard vent.

8. The deck under and in the immediate vicinity of the overboard vent is free from grease, oil, or any other combustible material.

9. A stainless steel, aluminum or copper drip pan is placed beneath the aircraft overboard vent.

3-33. (Converters Incorporating a Quick-Disconnect Mounting Plate) Converters shall be removed from aircraft prior to any servicing.

3-34. SAFETY PRECAUTIONS ABOARD SHIP. In addition to the general safety precautions, all personnel aboard ship shall follow these additional safety precautions:

Table 3-1. Torque Values for Tubing and Fittings

Torque Requirements for Flared Tube Connections (Aluminum)		
Tubing O.D. (inches)	Minimum Torque (pound-inches)	Maximum Torque (pound-inches)
5/16 3/8 1/2	100 200 300	125 250 400
Notes: Standard straight tapered pipe thread fittings have no torque values. Tape the pipe threads with two turns of teflon tape and install the fitting finger tight. Then attach wrench and tighten one to two turns maximum.		

WARNING

LOX converters shall be drained in a well ventilated, clean area with limited access and protection from inclement weather so designated by type commanders or NAVSEA. A drip/drain pan with sides at least 6 inches high and free from dirt, grease, oil, fuel, hydraulic fluid, and other hydrocarbons, shall be used when draining LOX converters. Two qualified persons shall be present when draining LOX converters, one of which will be designated safety observer. A maximum of two LOX converters can be drained at one time.

1. When smoking or when carrying an open or unshielded light or any potential spark-producing apparatus, do not enter an oxygen storage compartment. Do not approach any point where oxygen is being discharged or where there is a suspected leak in piping.

2. Exercise care in handling ammunition near oxygen.

3. Keep open flames at last 100 feet away from oxygen storage tanks or oxygen equipment.

4. Oxygen storage and handling compartments shall be sprayed with one coat of fire-resistant paint before being used. However, first remove any other existing paint from plant and equipment and thoroughly clean them to bare metal.

5. Do not permit painting when liquid oxygen is contained in the compartment.

6. During transfer operations, position the transfer trailer so that it will not shift with the pitch and roll of the ship. Lock the brakes and tie down the trailer.

7. Do not drain or vent oxygen in a closed compartment.

8. During transfer operations keep work area, equipment, tools, and clothing free from oil, grease of other hydrocarbon points.

9. Post LIQUID OXYGEN signs in a conspicuous place on all storage tanks, compartments, and handling rooms. Post CAUTION and NO SMOKING signs at entrances and hazardous points.

10. When liquid oxygen piping is not enclosed in a double wall or flame tight casing, post NO SMOKING signs in the compartments containing the piping.

3-35. STORAGE.

3-36. Liquid oxygen storage containers must be protected from excessive heat and direct rays of the sun. Liquid oxygen containers must be stored apart from containers of other gases or liquids and must not be stored within 50 feet of flammable material of any kind. Never transfer liquid oxygen in or around areas in which odors of any type may be absorbed by the liquid.

3-37. All storage containers must be provided with pressure-relief devices. These pressure-relief devices shall be checked periodically to ensure that they are in proper operating condition.

3-38. Oxygen must not be stored or used near flammable material or any substance likely to start or accelerate fire. Oxygen is not flammable, but supports combustion intensively. Store at least 50 feet from combustible materials.

3-39. Oxygen cylinders must not be stored with hydrogen or other combustible gas cylinders in an unventilated place. If stored inside, they shall be separated by a fire-resistant wall.

3-40. Do not store oxygen cylinders, LOX converters and apparatus under moving machinery, cranes, belts, or where exposed to residue from stack gasses. Oil and grease may drop and cause explosion, fire or contamination.

3-41. Gaseous and liquid oxygen servicing trailers can be stowed or parked inside enclosed buildings or hangars provided those spaces are constructed of concrete or steel and meet minimum ventilation requirements. Gaseous or liquid oxygen servicing trailers shall not be stowed or parked in enclosed wooden buildings. If approved stowage or parking facilities are not available, servicing trailers must be stowed or parked in a covered lean-to enclosed on three sides only. The lean-to should be positioned a minimum of 50 feet from traveled roadways, parking areas, and wooden structures.

3-42. LOX CONVERTER STORAGE. Liquid oxygen converters stored outdoors must be sheltered from the elements (e.g., direct rays of the sun, rain, snow, etc.), as moisture can easily enter vent or supply couplings. The moisture when frozen can render the presure closing valve or relief valve inoperative; this can lead to overpressurization and explosion of the LOX converter.

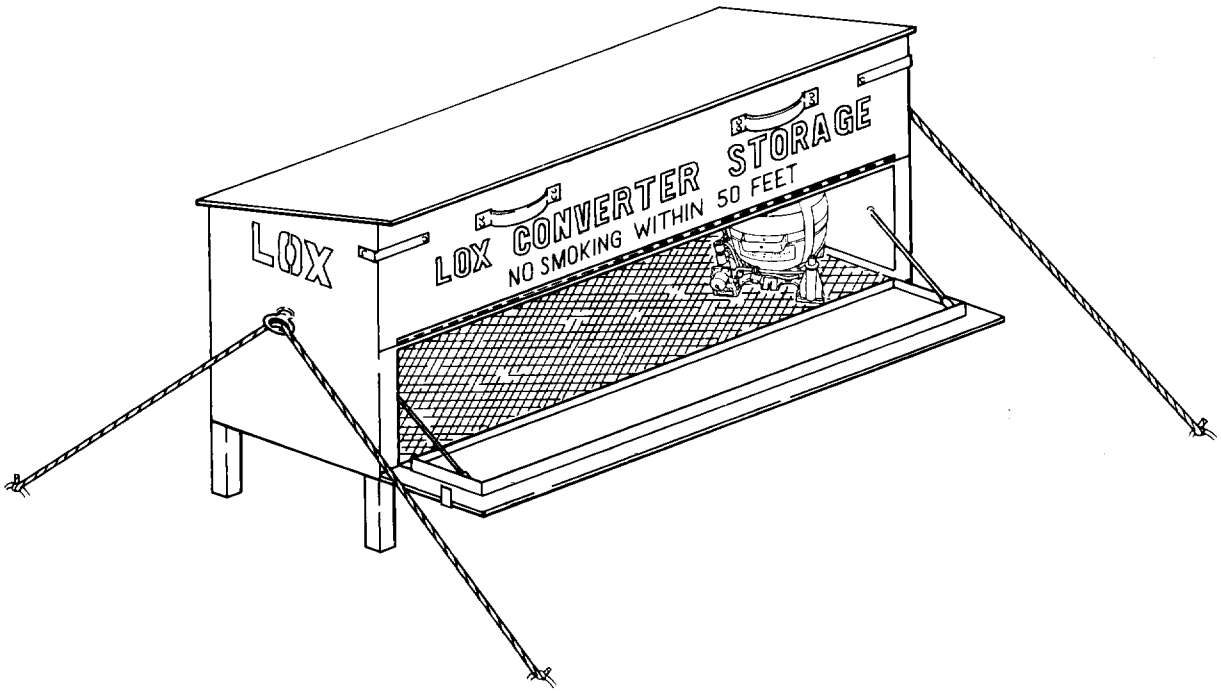

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Figure 3-1. Liquid Oxygen converter Storage Shelter

3-43. Protective shelters shall be provided for LOX converters which are stored outdoors (figure 3-1). Protective shelters may be locally manufactured to suit individual activity requirements. Protective shelters shall be manufactured according to these requirements:

1. Shelters must be well ventilated to prevent the buildup of potentially dangerous concentrations of oxygen.

2. Shelters must be constructed of noncombustible materials.

3. All shelves must be constructed of expanded stainless steel wire mesh or other perforated material to provide adequate ventilation.

4. Shelves shall be no less than 17 inches high. The shelf depth shall be no less than 18 inches. The length shall be determined by the number of converters to be stored, leaving 18 inches or more for each converter. The bottom shelf must be a minimum of 10 inches above the ground.

5. Shelters shall be painted white and marked “LOX CONVERTER STORAGE” using green reflective tape L-S-300B. Letters shall be no less than 4 inches high. In addition the warning “NO SMOKING WITHIN 50 FEET” shall be marked on the shelter using red reflective tape L-S-300B. Letters shall be no less than 2 inches high.

6. The shelter shall be provided with eyebolts or handles to provide a four-point tiedown.

Section 3-3. Protective Clothing

3-44. GENERAL.

3-45. Because of the hazards associated with handling liquid oxygen, it is imperative that all personnel working with liquid oxygen wear protective clothing.

3-46. The following is a list of approved protective clothing and authorized allowance that can be used when working with liquid oxygen:

Support Equipment Required

Quantity	Description	Reference Number
1 ea per individual	Apron, Impermeable, Cotton Duck, Rubber Coated	MIL-A-41829 (CAGE 81349) NIIN 00-082-6108
1 ea per individual	Face Shield, Industrial, Style B	L-F-36 (CAGE 81348) NIIN 00-202-9473
2 ea per individual	Coveralls, Explosive Handlers	MIL-C-14610 (CAGE 81349)
	X Small (32-34)	NIIN 00-279-2455
	Small (36-38)	NIIN 00-279-8719
	Medium (40-42)	NIIN 00-279-8720
	Large (44-46)	NIIN 00-279-8721
	X Large (48-50)	NIIN 00-279-8722
1 ea per individual	Shoe, Molders	MIL-S-82245 (CAGE 81349)
	7D	NIIN 00-926-9965
	7EE	NIIN 00-926-9966
	8D	NIIN 00-926-9967
	8EE	NIIN 00-926-9968
	9D	NIIN 00-926-9969
	9EE	NIIN 00-926-9970
	10D	NIIN 00-926-9971
	10EE	NIIN 00-926-9972
	11D	NIIN 00-926-9973
	11EE	NIIN 00-926-9974

Support Equipment Required (Cont)

Quantity	Description	Reference Number
1 pr per individual	Gloves, LOX Servicing (Note 1)	(CAGE 65370)
	Medium	LOX-MIL-M
	Large	LOX-MIL-L
	X-Large	LOX-MIL-XL

Notes: 1. LOX Servicing Gloves are not currently stocked in the Navy Supply System and must be ordered Open Purchased from the following vendor:
Tempshield Inc.
23 Industrial Way
Trenton Business Park
Trenton, Maine 04605
TEL: (800) 680-2796

1. Face Shield/Safety Goggles. Eye protection shall be worn at all times when working with liquid oxygen. When working in confined areas or overhead, wear face shield or safety goggles to protect the eyes. Safety glasses with side shields may also be used.

2. Always wear LOX servicing gloves when handling any equipment that is or may have been in recent contact with liquid oxygen. Gloves shall be loose fitting so that they can be quickly removed if LOX gets into them. In addition use protective gloves when handling purging units.

3. Coverall, explosive ordnance handlers, cotton sateen, fire resistant shall be used by liquid oxygen handlers. Cuffless sleeves and trouser legs shall be worn over the top of gloves and shoes.

4. Apron, impermeable, cotton duck, rubber coated, shall be worn when working with liquid oxygen. The apron shall be tied or secured in a fashion that would make it easy to remove in case of an emergency.

5. Shoes, LOX boots (shoes, safety, molders, congress style, black) a type that can be easily removed, shall be worn when working with liquid oxygen.

6. Clothing that is splashed by liquid oxygen shall be removed immediately and thoroughly aired for at least 1 hour.

Section 3-4. Aircraft Oxygen System Requirements

3-47. GENERAL.

3-48. Aircraft oxygen systems shall be purged when the system is left open to the atmosphere, when empty, or whenever contamination is suspected.

3-49. When maintenance action involves the removal and reinstallation of connecting hardware without a change in adjustment or alignment to the system, a thorough ground functional check shall be conducted prior to the aircraft being released for flight. (Refer to OPNAVINST 4790.2 series.)

WARNING

Only clean plastic caps or plugs (MIL-C-5501) shall be used to close oxygen system openings. Under no circumstances will tape, rags, or paper be used to close openings created by removal of components.

3-50. When an aircraft oxygen system is opened for the removal/replacement of any component, all openings created shall be immediately plugged or capped to prevent entrance of moisture or contaminants.

3-51. PURGING OXYGEN SYSTEMS.

3-52. The following Materials Required, Support Equipment and procedures shall be followed when purging oxygen systems:

Materials Required

Quantity	Description	Reference Number
As Required	Nitrogen, Oil-free, Water Pumped, Type I, Class I, Grade B	Fed Spec BB-N-411 NIIN 00-985-7275

Support Equipment Required

Quantity	Description	Reference Number
1	Gas/LOX Purging Unit, Model A/M26M-3	3447AS100-1

3-53. PURGING LOW-PRESSURE OXYGEN SYSTEMS. Low-pressure gaseous oxygen systems shall be purged by one of the following methods:

1. Aircraft having filler and distribution lines connected to the same end of the cylinder shall be purged by charging the system with gaseous oxygen; then by depleting. Perform this procedure a minimum of three times.

WARNING

Use only oil-free nitrogen, Type I, Class 1, Grade B for purging oxygen systems. The use of aircraft nitrogen servicing trailers for purging oxygen systems is strictly prohibited. For oxygen test stands and purging equipment, use only nitrogen from gray cylinders marked NITROGEN OIL FREE in white letters. Two 3-inch wide black bands mark the tops of these cylinders.

2. Aircraft having the filler valve connected to one end of the cylinder and distribution lines to the opposite end (i.e., continuous flow system) shall be purged as follows:

a. Connect purging unit (P/N 3447AS100-1) to aircraft filler valve.

b. Disconnect regulator distribution line(s) at regulator(s) to permit a flow.

c. Pass heated oil-free nitrogen through system at maximum pressure of 120 psig and a minimum temperature of 90°F for 30 minutes. Create a flow through the system. This can be accomplished by various methods, depending on the type of aircraft system. Consult the applicable aircraft MIM for detailed instructions. If moisture or contaminants are still present, repeat purge as required.

d. Disconnect purging unit. Reconnect regulator(s) and recharge system with oxygen.

e. Drain system through regulator(s) to remove any residual nitrogen.

f. To complete purge, recharge system with oxygen.

3-54. PURGING HIGH-PRESSURE OXYGEN SYSTEMS. Two factors must be considered when purging high-pressure oxygen systems: purging for the removal of contamination or purging for the removal of moisture.

3-55. To purge a high-pressure oxygen system of contamination, proceed as follows:

NOTE

It can never by certain that moisture is not present. Therefore, the following purge procedures should only be used in emergency situations where the procedures outlined in paragraph 3-56 can not be accomplished.

1. Charge system with gaseous oxygen; then drain system through regulator(s).

2. Repeat step 1 a minimum of two times.

3. To complete purge, recharge system with oxygen.

3-56. To purge a high-pressure oxygen system of moisture, proceed as follows:

WARNING

Cylinders which have been open to the atmosphere and voided of oxygen (to less than 15 psig) shall be removed from service for vacuum and heat drying/hot nitrogen gas drying (MIL-STD-1411 and MIL-STD-1359A) before recharging.

Use only oil-free nitrogen, Type I, Class 1, Grade B (Fed Spec BB-N-411) for purging oxygen systems. The use of aircraft nitrogen servicing trailers for purging oxygen systems is strictly prohibited. For oxygen test stands and purging equipment, use only nitrogen from gray cylinders marked NITROGEN OIL FREE in white letters. Two 3-inch wide black bands mark the tops of these cylinders.

1. (Manually Operated Cylinder Valve) Close cylinder valve; disconnect supply line at cylinder.

2. (Automatic Opening Cylinder Valve) Disconnect supply line at cylinder.

3. Disconnect regulator distribution line(s) at regulator(s) to permit a flow.

4. Connect purging unit (P/N 3447AS100-1) to aircraft filler valve and pass a flow of heated oil-free nitrogen (Fed Spec BB-N-411) through system at maximum pressure of 120 psig and a minimum temperature of 90 °F for 30 minutes. Create a flow through the system. This can be accomplished by various methods, depending on the type of aircraft system. Consult applicable aircraft MIM for detailed instructions. If moisture or contaminants are still present, repeat purge as required.

5. When purging is completed, disconnect purging unit, reconnect all lines, and open cylinder valve (if applicable).

6. Functionally test system in accordance with applicable Maintenance Instruction Manuals (MIMs).

3-57. PURGING AIRCRAFT LIQUID OXYGEN SYSTEMS. To purge aircraft liquid oxygen systems, proceed as follows:

WARNING

Use only oil-free nitrogen, Type I, Class 1, Grade B (Fed Spec BB-N-411) for purging oxygen systems. The use of aircraft nitrogen servicing trailers for purging oxygen systems is strictly prohibited. For oxygen test stands and purging equipment, use only nitrogen from gray cylinders marked NITROGEN OIL FREE in white letters. Two 3-inch wide black bands mark the tops of these cylinders.

1. Disconnect and, if necessary, remove LOX converter.

2. Connect purging unit (P/N 3447AS100-1) to aircraft system supply quick-disconnect.

3. Create a flow at user end of system. This can be accomplished by various methods, depending on type of aircraft system. Consult applicable MIM for detailed instructions.

4. Pass heated oil-free nitrogen (Fed Spec BB-N-411) through system at maximum pressure of 120 psig and a minimum temperature of 90°F for 30 minutes. If contaminants are still present, repeat purge as required.

5. When purging is completed, disconnect purge unit. Reconnect aircraft system supply quick-disconnect to LOX converter.

6. Fill aircraft system if applicable. Functionally test system in accordance with applicable MIM.

3-58. LOX CONVERTER MAINTENANCE.

3-59. QUICK-DISCONNECT CONVERTERS. A Calendar Inspection, consisting of a Visual Inspection followed by a Bench Test, shall be performed on all LOX converters incorporating a quick-disconnect mounting plate prior to being placed in service, and at intervals not exceeding 231 days thereafter. The Calendar Inspection shall be performed in accordance with the chapter in this manual, or the technical manual pertaining to the specific type and part number LOX converter to be serviced. These converters shall be removed from aircraft prior to servicing.

3-60. PERMANENTLY INSTALLED CONVERTERS. A Calendar Inspection shall be performed on all permanently installed LOX converters in accordance with the technical manual pertaining to the specific type and part number LOX converter to be serviced. These converters shall undergo bench testing during the Standard Depot Level Maintenance (SDLM) of the aircraft in which it is installed.

3-61. PURGING LOX CONVERTERS. LOX converters shall be purged when they have been emptied, or whenever moisture or contamination is suspected. Purging shall also be performed upon completion of any maintenance action which causes the system to be open to the atmosphere. In no case shall purge interval exceed 231 days. Purging of LOX converters shall be performed in accordance with the applicable chapter of this manual. To purge LOX converters not included in this manual, proceed as follows:

Materials Required

Quantity	Description	Reference Number
As Required	Nitrogen, Oil-free, Water Pumped, Type I, Class I, Grade B	Fed Spec BB-N-411 NIIN 00-985-7275

Support Equipment Required

Quantity	Description	Reference Number
1	Adapter Assembly	59A120-D5-46
1	Gas/LOX Purging Unit, Model A/M26M-3	3447AS100-1

WARNING

Liquid oxygen converters shall be emptied of LOX and allowed to warm to ambient temperature prior to purging.

1. Connect purging unit to vent port of fill, buildup, and vent valve.

2. Attach adapter assembly to fill port of fill, buildup, and vent valve. Turn knurl knob clockwise until it seats and then back out counterclockwise two complete turns.

3. Attach converter drain line to converter supply quick-disconnect coupling.

NOTE

For ARO Corporation converter P/N 21170-10/-13 remove relief valve tubing and cap the two fittings that tubing was removed from.

4. Pass heated oil-free nitrogen through the converter at a pressure of 120 psig and a minimum discharge temperature of 90°F. Duration of purge is dependent on converter type. Purge duration is as follows:

NOTE

For converters that indicate internal probe shortage it may be necessary to purge the converter for a longer period of time.

a. Essex Industries Inc. converters P/N 10C-0016-10A and 10C-0016-16 and Bendix Corporation P/N 29073-D2, 3263004-0201, and 3263006-0101 which are at ambient temperature shall be purged for a period of 30 minutes.

b. ARO Corporation converters P/N 21170-10/-13 which are at ambient temperature shall be purged for a period of 60 minutes.

5. When purging is completed, disconnect purging unit and bench test the converter.

Section 3-5. Oxygen System Components Maintenance Shop

3-62. GENERAL.

3-63. During the evolution of cleanliness requirements for oxygen systems, additional requirements have been generated. This has occurred partly because applications vary in scope from industrial use with the least stringent requirements, to manned space vehicles with the most demanding requirements. The major difference between aerospace cleanliness and industrial cleanliness is that the former eliminates airborne contaminants. Therefore, the aerospace industry requires particle count, white rooms and deionized water. These tiny particles are not considered significant contaminants by the oxygen industry. The exclusion of airborne particles is an extremely costly process requiring pressurized rooms, expensive filtration equipment and elaborate procedures. The AIMD/depot level cleanliness standards need not be of clean room quality, but an enclosed, air-conditioned clean area, segregated from contaminant-producing operations shall be considered adequate.

3-64. Shore-based operational facilities shop design criteria are presented is the Naval Facilities Engineering Command Design Manual (NAVFAC DM-24). Deviations from NAVFAC DM-24 shall not be made without prior approval of Naval Facilities Engineering Command Headquarters (NAVFAC HQ). See figure 3-2 for typical shore-based facility.

3-65. The climate control system must be able to maintain a temperature of 65° to 75°F. Oxygen facilities without LOX generating equipment may be heated by unit heaters (steam), or direct-fuel heaters employing an air distribution duct system, providing the heating unit is not located in the transfer shop. Oxygen facilities with Lox generating equipment may be heated by a central heating plant, or by electric heat. Open-fired heaters shall not be used.

3-66. VENTILATION.

3-67. All air supplied to a shop where gaseous or liquid oxygen/nitrogen is transferred from one unit to another shall be exhausted directly to the atmosphere. Under no circumstance shall the exhaust air be returned to the oxygen/nitrogen transfer area.

3-68. Ventilation shall be provided in LOX converter and oxygen components shop, to prevent accumulation of potentially dangerous concentrations of oxygen or nitrogen. Mechanical exhaust fans capable of providing a minimum of 3 air changes per hour shall be used as a positive means of exhausting the air. Although oxygen is about 10 percent denser than air, it is not necessary to evacuate the air near the floor because oxygen rapidly diffuses into air.

3-69. Ventilation requirements for oxygen shops aboard ship that support OBOGS systems only, require only 2.0 air changes per hour. However those spaces must meet required safety standards when working with hazardous materials such as oxygen cleaning compound (MIL-C-81302), toluene, acetone and other materials associated with the repair and cleaning of OBOGS components.

3-70. ELECTRICAL.

3-71. All electrical wiring and electrical equipment shall be in accordance with NAVFAC Specification 9Y (latest revision). The following information has been extracted from this specification:

1. Rigid conduit shall be used in wiring installations.

2. Electrical receptacles on the outside of buildings shall be weatherproof, 250V ac, 20 ampere (minimum), 3-wire grounding-type, and shall be furnished with plugs. Receptacles shall be connected to 220V ac, single phase service.

3. Lighting fixtures may be standard type, except that where exposed to mechanical damage, a suitable guard or cover shall be provided.

4. Switches and motor starting shall be enclosed and of the general use type.

5. Motors shall be of a type that do not have arcing or contact making parts. Three-phase motors of squirrel cage type shall be used wherever possible.

6. All equipment shall be static-grounded.

7. Transformer banks shall be located a minimum of 50 feet from transfer shop or LOX storage tank areas.

3-72. INTERIOR FINISHING AND FIXTURES.

3-73. FLOORS. In shops where gaseous oxygen transfer operations are conducted, a concrete floor or vinyl-type floor covering is considered adequate. In shops where LOX transfer operations are conducted, the floor shall be concrete. Non-glazed, or rough-glazed ceramic tile is also a suitable floor finish.

3-74. WALLS. The walls shall be finished with a smooth, impact-resistant, non-chipping, non-flaking material.

3-75. CEILINGS. The ceilings shall be easily cleanable, non-dust accumulating acoustical-type material.

3-76. WORK BENCHES, TABLES AND STORAGE BINS. Work benches and table tops shall be of seamless, non-porous material free of hydrocarbon finishes. Color shall be in contrast to walls and ceilings to minimize eye fatigue. Storage bins shall not contain more than the required parts to maintain an orderly production rate. Work benches, tables and storage bins shall be maintained free of grease, oil and other combustible materials.

3-77. TOOLS.

3-78. All tools and equipment shall be maintained free of grease, oil and other combustible materials. Tools used on oxygen equipment shall not be used for any other purpose. Tools shall be marked OXYGEN USE ONLY, or other suitable methods of identification may be used.

3-79. WORK AREA CLEANLINESS.

3-80. Work areas shall be kept clean at all times. Dust and dirt removal shall be accomplished by a vacuum system at any time that dust is evident at any location in the work area. Damp mopping will be used to follow up the vacuum cleaning for dirt and dust removal. Heel and chair marks or other discolorations of the floors shall be removed by scrubbing. All spare parts shall be removed from the work benches or covered with a lint free covering at the end of the last work shift each day. Work benches and test equipment will be wiped clean prior to the start of each work day. Smoking, refreshments, or lunch containers of any kind shall not be permitted in the work area. Only ball type pens are permitted for use in the shop (no lead or erasures).

3-81. PERSONAL CLEANLINESS.

3-82. Solvent contact with the skin should be avoided where possible. Finger nail polish shall be removed prior to entering shop. Cosmetics and medication which may produce contamination shall not be worn by any personnel. In particular, eye makeup, rouge, face powder and hair spray shall be avoided. Under no conditions will makeup be applied in the shop area. Personnel with skin and/or upper respiratory diseases shall not be allowed to work in the overhaul shop area. Personnel with colds, temporary coughing, sneezing and severe sunburn shall be assigned temporary jobs outside the shop until they are sufficiently recovered.

3-83. QUALITY ASSURANCE.

3-84. Long, trouble-free service can only be expected when cleanliness in the shop is maintained. Frequent Quality Assurance inspections are required to ensure proficiency in work performed by shop personnel, and that cleanliness is maintained.

3-85. TRAINING.

3-86. Shop supervisors shall be responsible for conducting a continuing training program stressing the significance of oxygen system cleanliness, personal cleanliness and the oxygen safety program. Conscientious adherence to all cleanliness requirements and safety regulations shall be observed at all times.

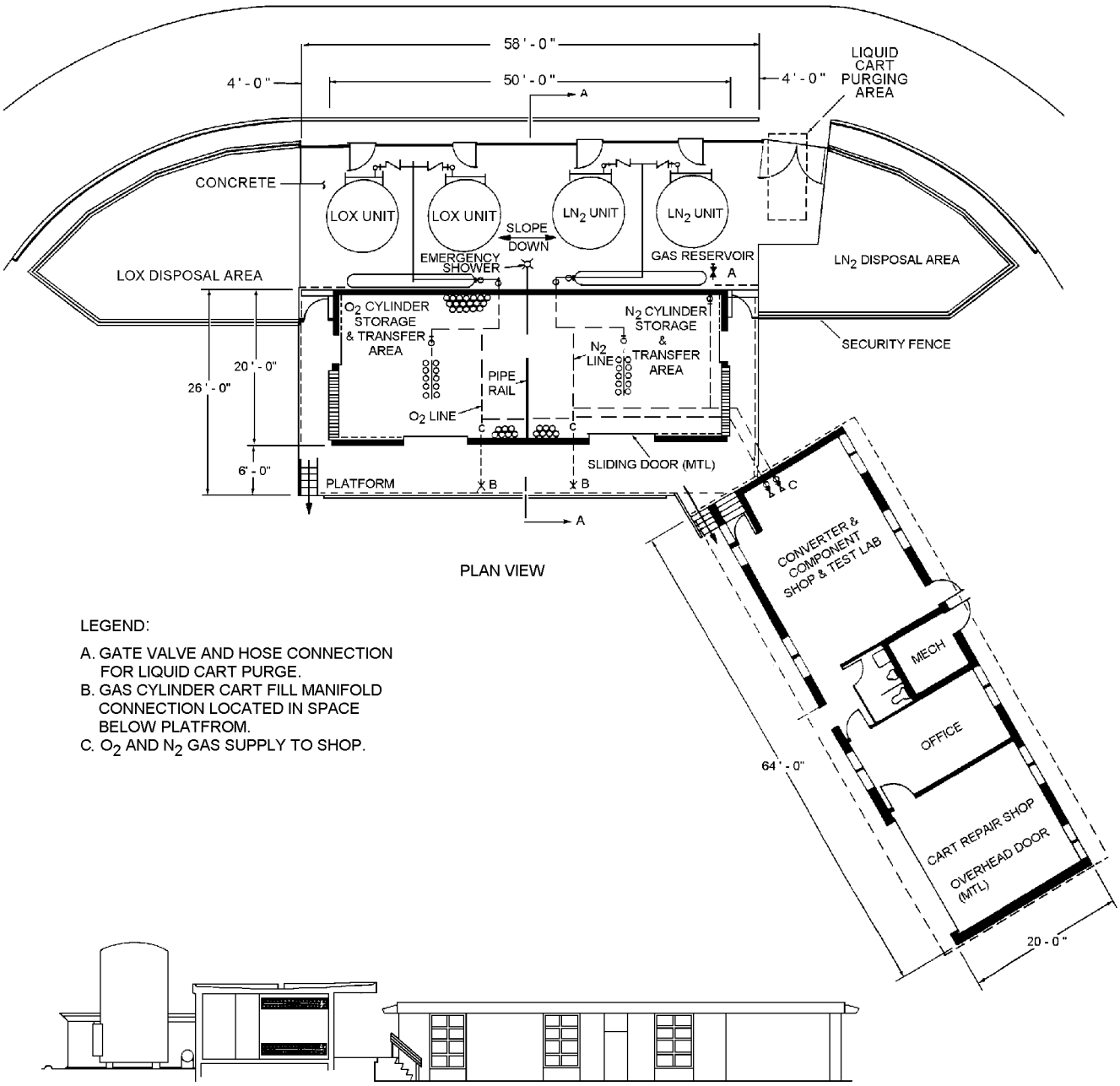

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Figure 3-2. Typical Oxygen Transfer and Components Maintenance Facility

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