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MILITARY HANDBOOK

OXYACETYLENE AND NITROGEN

AND BREATHING OXYGEN FACILITIES

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ABSTRACT

Basic design guidance for oxyacetylene, breathing oxygen and nitrogen facilities is presented for use by experienced architects and engineers. The contents include characteristics; storage, transfer and generation data; piping systems; and safety clearances for oxyacetylene, nitrogen, and breathing oxygen systems.

FOREWORD

This handbook is one of a series developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command, other Government agencies, and the private sector. This handbook uses, to the maximum extent feasible, national professional society, association, and institute standards in accordance with NAVFACENGCOM policy. Deviations from these criteria should not be made without prior approval of NAVFACENGCOM Headquarters (Code 04A).

Design cannot remain static any more than can the naval functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to Commander, Western Division, Naval Facilities Engineering Command, Code 467.2, P.O. Box 727, San Bruno, CA 94066-0720, Telephone (415) 244-3331.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

SUPPORT FACILITIES CRITERIA MANUALS

Criteria Manual	Title	Preparing Activity
MIL-HDBK-1024/1	Aviation Operational and Support Facilities	SOUTHDIV
MIL-HDBK-1024/3	Oxyacetylene and Nitrogen and Breathing Oxygen Facilities	WESTDIV
MIL-HDBK-1024/4	Ship Support Facilities (Proposed)	PACDIV
MIL-HDBK-1024/5	Logistics Support Facilities (Proposed)	CHESDIV

OXYACETYLENE AND NITROGEN
AND BREATHING OXYGEN FACILITIES

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Section 1: INTRODUCTION

1.1 <u>Scope</u>. Data and criteria in this handbook apply to the design of oxyacetylene and breathing oxygen and nitrogen facilities at Navy and Marine Corps shore activities. Oxyacetylene facilities consist of storage and generating functions. Breathing oxygen and nitrogen facilities consist of storage, generating, vaporizing, or transfer functions.

1.2 <u>Policy</u>. Acetylene, oxygen, and nitrogen generation facilities should only be provided when adequate supplies of the gases cannot be obtained commercially. Obtain approval from Naval Facilities Engineering Command Headquarters (NAVFAC), Code 04A, before designing new acetylene, gaseous oxygen, liquid oxygen and nitrogen generating facilities, or before designing any expansion of existing facilities.

Section 2: DESIGN DATA

2.1 Characteristics. The principal properties of acetylene, oxygen and nitrogen are given in Table 1-A.

TABLE 1-A
Physical Properties of Acetylene, Oxygen, and Nitrogen

Property	Acetylene	Oxygen	Nitrogen
Chemical symbol	C_2H_2	O_2	N_2
Boiling point at atm press, °F(°C)	-118(-83)	-297(-183)	-320(-195)
Flame temperature, °F (oC) (2,632 to 3,482)	4,770 to 6,300	......	......
Latent heat of vaporization, Btu/lb(kJ/kg)	....	91.7(213)	85.8(200)
Gross heat value, Btu/lb(kJ/kg)	21,500 (50,000)	....	....
Density of gas, pcf at 68°F and 14.7 psia (kg/m^3 at 20°2C and 1012 kPa abs)	0.0678(1,087)	0.0833(1.335)	0.0732(1.172)
Density of liquid, pcf (kg/m°	....	71.4 (1146) at -297°F(-183°C)	50.4 (808) at -320°F (-195°C)
Combustion cu ft/cu ft at 70°F(m^3/m^3 at 21.1°C) or	1.0 to 2.5 of O_2 4.76 to 11.94 of Air		
Volumetric expansion of evaporation	....	860 to 1	696 to 1

2.1.1 Acetylene Hazards. See Compressed Gas Association (CGA) G-1.2, Recommendations for Chemical Acetylene Metering. Acetylene is flammable and hazardous when mixed with air, but stable and safe to generate, compress, charge into cylinders, store, use, and dispose of residue when proper safety procedures are followed.

a) The explosive range, when mixed with air (approximately 2.5 to 82 percent acetylene), is the greatest of all industrial gases.

b) The ignition temperature varies, depending on the presence of air and water vapor, initial pressures and temperature conditions, and physical dimensions of a container. For experimentally determined ignition temperatures, see Table 1-B.

c) Never use acetylene gas at pressures above 15 pounds per square inch gage (psig) (103.3 kPa gage) beyond the immediate pressure regulator of supply cylinders. It can be stored and transported at higher pressures only in cylinders approved by Department of Transportation.

TABLE 1-B
Ignition Temperatures of Acetylene Mixtures

Mixture		Ignition Temperatures[1]	
Acetylene (%)	Air (%)	At 14.7 psia (101.3 kPa abs)°F (°C)	At 15.0 psig (103.3 kPa gage)°F (°C)
91	9	1,070 (577)	955 (513)
85	15	644 (340)	617 (325)
70	30	571 (300)	571 (300)
30	70	571 (300)	571 (300)
	Oxygen (%)		
91	9	565 (296)	Not tested
70	30	565 (296)	Not tested

[1]Maximum temperatures applied to outside surfaces of a container before ignition of gas inside, as experimentally determined by US Bureau of Mines. The ignition temperature for pure acetylene at atmospheric pressure is about 1190 degrees F (644 degrees C).

2.1.2 Oxygen Hazards. Both liquid and gaseous oxygen are chemically stable in the pure state. However, oxygen actively supports combustion, and when in contact with certain organic matter will cause spontaneous ignition. Under certain conditions, liquid oxygen mixed with powdered combustible material will detonate.

a) Oxygen vapors, when combined with flammable hydrocarbon vapors in the proper proportion, will explode in the presence of a sufficiently high ignition source. Potentially hazardous concentrations of oxygen can collect in poorly ventilated places.

b) In addition to the danger of chemical activity associated with liquid oxygen, the extremely low temperatures involved and high volumetric expansion also present hazardous conditions.

(1) Physical properties of materials are altered when in

contact with the liquid.

(2) Since the volume of liquid oxygen increases by 860 times when changing into a vapor, all storage containers must be provided with vent and safety relief devices to prevent tank rupture.

c) The following precautions should be taken when handling or working around oxygen:

(1) Under no conditions should organic material or flammable substances of any nature be allowed to come in contact with the liquid or vapors.

(2) Final piping test shall be in accordance with CGA G-4.1, Cleaning Equipment for Oxygen Service and CGA G-4.4, Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems, and inspected by the Naval Air Engineering Center (NAVAIRENGCEN), Code 5223, or the equivalent for the Army and Air Force.

(3) All vessels and piping that carry oxygen must be hydrostatically tested and thoroughly cleaned before use in accordance with CGA G-4.1. Make provisions to prevent organic material contact with the product.

(4) Smoking shall be prohibited in the shop, servicing area, and in any area containing oxygen equipment. Post "NO SMOKING" signs.

(5) Oil shall not be used in any form around oxygen equipment where it might come in contact with the oxygen. If needed, halocarbon oil may be acceptable.

(6) Storage tanks shall not be located in the vicinity of gasoline, oils, or any other combustible material.

(7) All storage vessels and lines in which the liquid oxygen could be trapped between closed valves shall be equipped with pressure relief valves. These safety devices shall be inspected and tested periodically for proper operation.

(8) Because of its low temperature, liquid oxygen should never be allowed to come in contact with the skin.

(9) The physical properties of many metals are seriously altered at low temperatures. All ferrous alloy steels (with the exception of certain stainless steels) lose their ductility and become brittle at low temperatures. These metals are unsuitable for use with liquid oxygen. A number of nonferrous metals (such as copper, bronze, brass, and aluminum) have sufficient ductility at these temperatures and are acceptable for use with liquid oxygen.

(10) Always ensure that hoses and fittings are dry and clean before allowing liquid oxygen to flow through them. Fittings with moisture become frozen in position, and cannot be changed or separated without damage.

2.1.3 Nitrogen Hazards. Both liquid and gaseous nitrogen are chemically inert in the pure state. Nitrogen is nontoxic; however, it can displace oxygen in the atmosphere, creating the danger of asphyxiation to personnel in enclosed spaces. Additional hazards are the extremely low temperature and extremely high vapor pressure of liquid nitrogen. In these aspects, the cautions in the preceding paragraph regarding oxygen are also applicable to nitrogen.

2.1.4 Applications of Oxyacetylene Torch Processes.

a) Gas Welding of Steel. For different plate thickness, see data on torches, welding rods, flame pressures, and gas consumptions in Tables 2-A and 2-B. The table shows equal consumptions of acetylene and oxygen. Actually, 2.5 cubic feet (0.0708 cubic meters) of oxygen are required for each 1.0 cubic feet (0.0283 cubic meters) of acetylene for complete combustion, but the additional 1.5 cubic feet (0.0425 meters) of oxygen is extracted from surrounding air.

b) Gas Cutting of Steel. For different thickness of metal, see recommended cutting speed ranges and gas consumptions in Tables 3-A and 3-B.

c) Oxidizing Flame, Scarfing, and Heavy Cutting. For these services, the ratio of oxygen to acetylene use can run as high as 17 to 1.

2.1.5 Application of Breathing Oxygen. Breathing oxygen is necessary to sustain pilot efficiency during high altitude flights. To take advantage of high volumetric expansion, the oxygen is delivered in liquid form. A storage, transfer, and vaporizing facility at naval air stations is necessary for receiving the liquid oxygen and for transferring it as a liquid or gas to aircraft recharge trailers in a safe and economical manner.

2.1.6 Applications of Nitrogen. Gaseous nitrogen is used for tire inflation and fire extinguishing systems of aircraft. It is also used, normally hot, to purge impurities from piping and equipment such as that used for breathing oxygen. At naval air stations, it is handled in the same way as breathing oxygen.

2.2 Consumption and Supply of Oxyacetylene Systems. Determine the number and location of oxyacetylene consuming stations throughout a naval or marine corps shore activity.

a) Note types of work done at each station, duration, and time when done. From Tables 2-A, 2-B, 3-A and 3-B, estimate acetylene and oxygen consumption at each station. Total the hourly and daily station requirements in each lateral distribution line for acetylene and oxygen, allowing for future extension of both services.

TABLE 2-A
Data for Gas Welding of Steel

Tip size	Diameter of tip-orifice in. (mm)	Plate thickness in. (mm)	Rod diameter in. (mm)	Average length of flame in. (mm)
1	0.037 (0.94)	22-16 gage (0.7-1.6)	1/16 (1.6)	3/16 (4.8)
2	0.042 (1.07)	1/16-(1/8) (1.6-3.2)	3/32 (2.4)	1/4 (6.4)
3	0.055 (1.40)	1/8-3/16 (3.2-4.8)	1/8 (3.2)	5/16 (8.0)
4	0.063 (1.60)	3/16-5/16 (4.8-8.0)	3/16 (4.8)	3/8 (9.5)
5	0.076 (1.93)	5/16-7/16 (8.0-11.1)	3/16 (4.8)	7/16 (11.1)
6	0.086 (2.18)	7/16-5/8 (11.1-15.9)	1/4 (6.4)	1/2 (12.7)
7	0.098 (2.49)	1/2-3/4 (12.7-19.1)	1/4 (6.4)	1/2 (12.7)
8	0.107 (2.72)	5/8-1 (15.9-25.4)	1/4 (6.4)	9/16 (14.3)
9	0.116 (2.95)	1 or over (25.4 or over)	1/4 (6.4)	5/8 (15.9)
10	0.140 (3.56)	Heavy duty	1/4 (6.4)	3/4 (19.1)
11	0.147 (3.73)	Heavy duty	1/4 (6.4)	7/8 (22.3)
12	0.149 (3.78)	Heavy duty	1/4 (6.4)	7/8 (22.3)

TABLE 2-B
Data for Gas Welding of Steel

	Required pressure after regulators psig (kPa gage)		Approximate consumption of gas cu ft/hr (m^3/hr)	
Tip size	Acetylene	Oxygen	Acetylene	Oxygen
1	1 (7)	1 (7)	4.0 (0.112)	4.0 (0.112)
2	2 (14)	2 (14)	5.0 (0.142)	5.0 (0.142)
3	3 (21)	3 (21)	8.0 (0.224)	8.0 (0.224)
4	4 (28)	4 (28)	12.0 (0.340)	12.0 (0.340)
5	5 (34)	5 (34)	19.0 (0.538)	19.0 (0.538)
6	6 (41)	6 (41)	23.0 (0.651)	23.0 (0.651)
7	7 (48)	7 (48)	35.0 (0.991)	35.0 (0.991)
8	8 (55)	8 (55)	48.0 (1.36)	48.0 (1.36)
9	9 (62)	9 (62)	57.0 (1.61)	57.0 (1.61)
10	10 (69)	10 (69)	95.0 (2.69)	95.0 (2.69)
11	10 (69)	10 (69)	100.0 (2.83)	100.0 (2.83)
12	10 (69)	10 (69)	110.0 (3.11)	110.0 (3.11)

TABLE 3-A
Data for Gas Cutting of Steel

	Linear cutting speed[1]	
Thickness of metal in. (mm)	Machine cutting in. (mm/min)	Hand cutting in./min (mm/min)
1/8 (3.2)	22.6 - 32.0 (574-813)	19.9 - 29.8 (505-757)
1/4 (6.4)	20.4 - 28.4 (518-721)	17.6 - 25.8 (447-655)
3/8 (9.5)	18.9 - 26.3 (480-668)	16.0 - 23.7 (406-602)
1/2 (12.7)	17.6 - 24.6 (447-625)	14.8 - 22.2 (376-564)
3/4 (19.1)	15.4 - 21.6 (391-549)	13.1 - 19.8 (333-503)
1 (25.4)	13.6 - 19.4 (345-493)	11.8 - 18.0 (300-457)
2 (50.8)	10.0 - 14.0 (254-356)	8.6 - 13.0 (218-330)
3 (76.2)	7.8 - 10.9 (198-277)	6.6 - 9.8 (168-249)
4 (102)	6.4 - 8.9 (163-226)	5.2 - 7.8 (132-198)
5 (127)	5.4 - 7.4 (137-188)	4.4 - 6.4 (107-163)
6 (152)	4.7 - 6.5 (119-165)	3.5 - 5.4 (89-137)
8 (203)	3.7 - 4.9 (94-124)	2.6 - 4.2 (66-107)
10 (254)	2.9 - 3.8 (74- 97)	1.9 - 3.2 (48- 81)
12 (305)	2.4 - 3.0 (61- 76)	1.4 - 2.6 (36- 66)

[1]Lowest speeds and highest gas consumption per linear foot are for inexperienced operators, short cuts, dirty or poor material. Highest speeds and lowest gas consumption per linear foot are for thoroughly experienced operators, long cuts, clean and good material.

TABLE 3-B
Data for Gas Cutting of Steel

Thickness of metal in. (mm)	Gas consumption[1] Oxygen cu ft/hr (m^3/hr)	Acetylene cu ft/hr (m^3/hr)
1/8 (3.2)	45-55 (1.27-1.56)	7.2 - 8.8 (.204-.249)
1/4 (6.4)	77-93 (2.18-2.63)	8.7 - 10.7 (.246-.303)
3/8 (9.5)	95-115 (2.69-3.25)	9.7 - 11.9 (.275-.337)
1/2 (12.7)	105-125 (2.97-3.54)	10.5 - 12.9 (.297-.365)
3/4 (19.1)	117-143 (3.31-4.05)	12.0 - 14.6 (.340-.413)
1 (25.4)	130-160 (3.68-4.53)	13.0 - 16.0 (.368-.453)
2 (50.8)	185-225 (5.24-6.37)	16.2 - 19.8 (.458-.560)
3 (76.2)	240-290 (6.79-8.21)	18.5 - 22.7 (.524-.642)
4 (102)	293-357 (8.29-10.10)	21.1 - 25.9 (.597-.733)
5 (127)	347-423 (9.82-11.97)	23.9 - 29.3 (.676-.829)
6 (152)	400-490 (11.32-13.87)	26.5 - 32.3 (.750-.914)
8 (203)	505-615 (14.29-17.40)	31.5 - 38.5 (.891-1.09)
10 (254)	610-750 (17.26-21.23)	36.9 - 45.1 (1.04-1.28)
12 (305)	720-880 (20.38-24.90)	42.3 - 51.7 (1.20-1.46)

[1] Lowest speeds and highest gas consumption per linear foot are for inexperienced operators, short cuts, dirty or poor material. Highest speeds and lowest gas consumption per linear foot are for thoroughly experienced operators, long cuts, clean and good material.

b) Determine working periods during which operations must proceed without replacing cylinders or recharging generators.

2.2.1 Sources of Supply Obtain acetylene, oxygen, and nitrogen from commercial suppliers. On-site generation of these gases may be provided only with the prior approval from NAVFAC.

a) Acetylene. Determine sources and methods of obtaining acetylene gas at naval shore activities; utilize the following information:

(1) Daily quantity required. See Tables 2-A, 2-B, 3-A, and 3-B.

(2) Location factors. See Table 4.

(3) Reliability of commercially available supplies.

(4) Relative costs of purchasing or generation, including plant costs. See economic studies in paragraph 2.2.3 below.

(5) Operation and risk.

(6) Possibility of generating and supplying cylinder gas to other naval activities within adjacent distribution areas or for shipboard supply.

(7) Current Department of Defense and Navy Department policies. See Section 1, Policy.

b) Oxygen. Factors to determine sources of supply of oxygen are similar to those above for acetylene.

(1) Where oxygen is commercially available, it can be purchased as compressed gas in cylinder lots.

(2) Where large quantities are needed, it is more economical to use trailer-truck tanks or liquid oxygen.

2.2.2 Plant Location Factors. See Table 4.

2.2.3 Economic Studies. Analyze costs of purchasing cylinder oxygen and acetylene gas versus generating (owning plus operating costs) the gases.

a) Distribution piping from an oxyacetylene plant is the same, but plant piping becomes more complicated when oxygen and acetylene are generated, compressed, and charged into cylinders.

b) Generally, gas in cylinders is inexpensive.

TABLE 4
Plant Location Factors

Item	Design procedure
Climate	Determine types of structure and means of ventilation.
Weather data	Obtain maximum and minimum dry bulb temperatures, maximum wet bulb temperatures, maximum and minimum wind velocities, for determining heating and ventilation requirements, prevailing wind.
Topography	Obtain grades and soil conditions for determining architectural layouts floor levels, methods of handling equipment, drainage, and underground piping.
Orientation	Locate plant near load centers and accessible to roads, railroads, and docks.
Industrial areas using oxyacetylene systems systems	Determine available areas for plants or manifolded cylinders, area congestion, types of industries in areas, and space for future expansion.
Local rules and . . . regulations	Obtain permits.
Supplies for acetylene and oxygen	Determine availability of local supplies.
Clearances from LOX facilities	See Section 4, paragraph 4.7. Obtain distances from thoroughfares, parking areas for aircraft and automobiles, hangars, fuel storage and transfer areas, refueling areas, power plants, central heating plants, shops with vapor or gas producing processes, or areas with contaminated atmospheres (such as swamps or dumps).

2.3 Consumption and Supply of Breathing Oxygen. The following example is based on an air squadron consisting of 12 single-seated aircraft and an air group of six squadrons. Of these, 75 percent are assumed operational.

a) At an average consumption of 12 gallons (45 liters (L)) per week per aircraft, a squadron will use 144 gallons (545 L) per week and an air group 864 gallons (3,270 L) per week of liquid oxygen (LOX). For an air group, add approximately 7.5 percent, 65 gallons (246 L) per week for administration and multi-engine aircraft. One gallon (3.79 L) of LOX can be converted to 115 cubic feet (3.25 cubic meters) of breathing oxygen at atmospheric conditions.

b) Provide a total LOX storage for two weeks.

2.3.1 LOX Facility. Generally, if the consumption of breathing oxygen exceeds 435 gallons (1647 L) per week (50,000 cubic feet (1,415 cubic meters) per week), the project should be served by a LOX facility. Where the source of LOX is remote, the limiting consumption should be 174 gallons (659 L) per week (20,000 cubic feet (566 cubic meters) per week). Smaller project consumptions shall be serviced by oxygen trailers, resupplied from commercial sources.

2.3.2 Trailers. Each squadron requiring gaseous oxygen is assigned to one trailer. A trailer can have six standard 300 cubic feet (8.5 cubic meters) gas cylinders (charged to 2,400 pounds per square inch gage (16,550 kPa gage)), or one standard oxygen cylinder with two nitrogen cylinders. Provide regulating manifold and connections to service the bottles for breathing oxygen aboard the aircraft.

a) Each squadron requiring LOX is assigned one 50 gallon (189 L) LOX trailer for each 10 aircraft carrying liquid oxygen flasks (these are usually 5 to 10 liter capacity, with necessary valving and heat exchanger surface to convert LOX to warm gaseous oxygen for breathing).

b) The trailers are towed by ground service equipment (GSE) tow tractors.

2.3.3 Plant Location Factors.

See Table 4. Within safety clearance limits, the facility should be located so that the mobile units can easily serve squadron aircraft. Direct access to the squadron along the apron lines is an important time-and-motion aspect for the handling of GSE. Consideration should be given to the servicing of aircraft by squadron crews from aircraft line shelters located near the apron line. See MIL-HDBK-1028/1, Aircraft Maintenance Facilities.

Section 3: OXYACETYLENE SYSTEM DESIGN

3.1 Supplies of Acetylene and Oxygen Design of generation, storage and distribution systems shall conform with the requirements of National Fire Protection Association (NFPA) 50, Bulk Oxygen Systems at Consumer Sites, NFPA 51, Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes, NFPA 51A, Acetylene Cylinder Charging Plants, and CGA G-4.4.

3.1.1 Capacities. Resources for acetylene and oxygen should be sufficient for continuous supply of the entire diversified demands of all operations during a working period, without any need to replace cylinders or recharge generators. See paragraph 2.2 of this handbook.

3.1.2 Acetylene Gas Generation. The storage of calcium carbide and methods of generating gas are as follows.

3.1.2.1 Calcium Carbide Storage. See NFPA 51. The action of water on calcium carbide is used to produce acetylene gas at naval shore activities.

a) Calcium carbide is generally stored in 100 pound (45.4 kg) airtight metal containers. It becomes a dangerous fire hazard if not dry, and must be kept in these containers until ready for use.

b) Theoretically, one pound (0.454 kg) of calcium carbide produces 0.406 pound (0.184 kg) of acetylene or, volumetrically, 5.92 cubic feet (0.168 cubic meters) of acetylene gas at 60 degrees F (15.6 degrees C) and atmospheric pressure. However, calcium carbide contains silicide of iron, uncombined carbon, and other unconverted raw materials, which reduce the yield of acetylene. Federal Specification O-C-101, Calcium Carbide, stipulates that the minimum acceptable yield per pound of calcium carbide shall be 4.5 cubic feet (1.27 cubic meters) of acetylene at 60 degrees F (15.6 degrees C) and atmospheric pressure. This yield has an average purity of 99.62 percent.

c) The reaction of calcium carbide with water produces acetylene in properly designed acetylene generating equipment. In this process acetylene of highest purity is produced from the carbon (C) of carbide and the hydrogen of water. This process also produces carbon lime or by-product calcium hydrate ($Ca(OH)_2$). Calcium hydrate obtains its calcium from the carbide and its hydroxide radical from the oxygen and the hydrogen in the water. The by-product calcium hydrate from acetylene generation is a good source of calcium lime. Calcium lime is potential top grade hydrated lime, that has commercial value. The by-product and used water are residues. Residues from acetylene generation, consisting of relatively pure calcium hydrate and water, must be disposed of outside the plant. Residues may be hauled to off-site regulated locations by salvage operators in containers conforming to local codes.

3.1.2.2 Gas Generating Methods. See NFPA 51A. There are two methods of generating acetylene gas from calcium carbide. Portable and stationary generators are commercially available for both methods, but only the stationary method is described below. Portable generators are difficult to maintain.

Naval shore activities which produce acetylene gas, and charge the gas into cylinders, are the activities located in Charleston, SC; Norfolk, VA; Portsmouth, NH; and Guam.

a) Medium Pressure Method. This pressure system automatic generator requires building space for a generator, calcium carbide storage, spent carbide settling chamber, and water service. See Figure 1. This method produces gas at a distribution pressure of 15 pounds per square inch gage (psig) (103 kPa gage).

(1) Generators are commercially available in capacities of 300 pounds per hour (136 kg per hour) and 500 pounds per hour (227 kg per hour) of calcium carbide each, corresponding to 1,770 cubic feet per hour (50 cubic meters per hour) and 2,960 cubic feet per hour (84 cubic meters per hour) respectively, of acetylene gas at 60 degrees F (15.6 degrees C) and atmospheric pressure.

(2) Use as many interconnected generators as necessary to meet demands.

b) Low Pressure Method. This method requires more building space and is more complex than the medium pressure method.

(1) The generator, which is generally sheltered, produces gas at 1 psig (6.89 kPa gage).

(2) The necessary gasometer does not ordinarily need housing.

(3) A compressor house is essential, since the gas pressure must be boosted to 15 psig (103 kPa gage) for pipeline distribution and utilization or compressed for cylinder charging.

(4) Housing is needed for cylinder manifold charging, and storage is required for cylinders and calcium carbide.

(5) A piping system consists of low pressure 1 psig (6.89 kPa gage) lines from generator to moisture condenser, gasometer, purifier, and dryer, and then to booster compressor.

(6) The manifold charging lines from compressors to cylinders are designed for 305 psig (2,100 kPa gage) working pressure at 20 degrees F (minus 6.67 degrees C) acetylene temperature. This prevents the liquefaction (condensation) of acetylene.

(7) To restrict compression temperatures to safe operating limits, the compressors are designed for water cooling by flooding the entire cylinder block.

3.1.3 Oxygen Production Methods. The vast majority of oxygen production today is accomplished by the cryogenic process which cools atmospheric air to liquid form (liquefaction) and then distills off fractions of it having

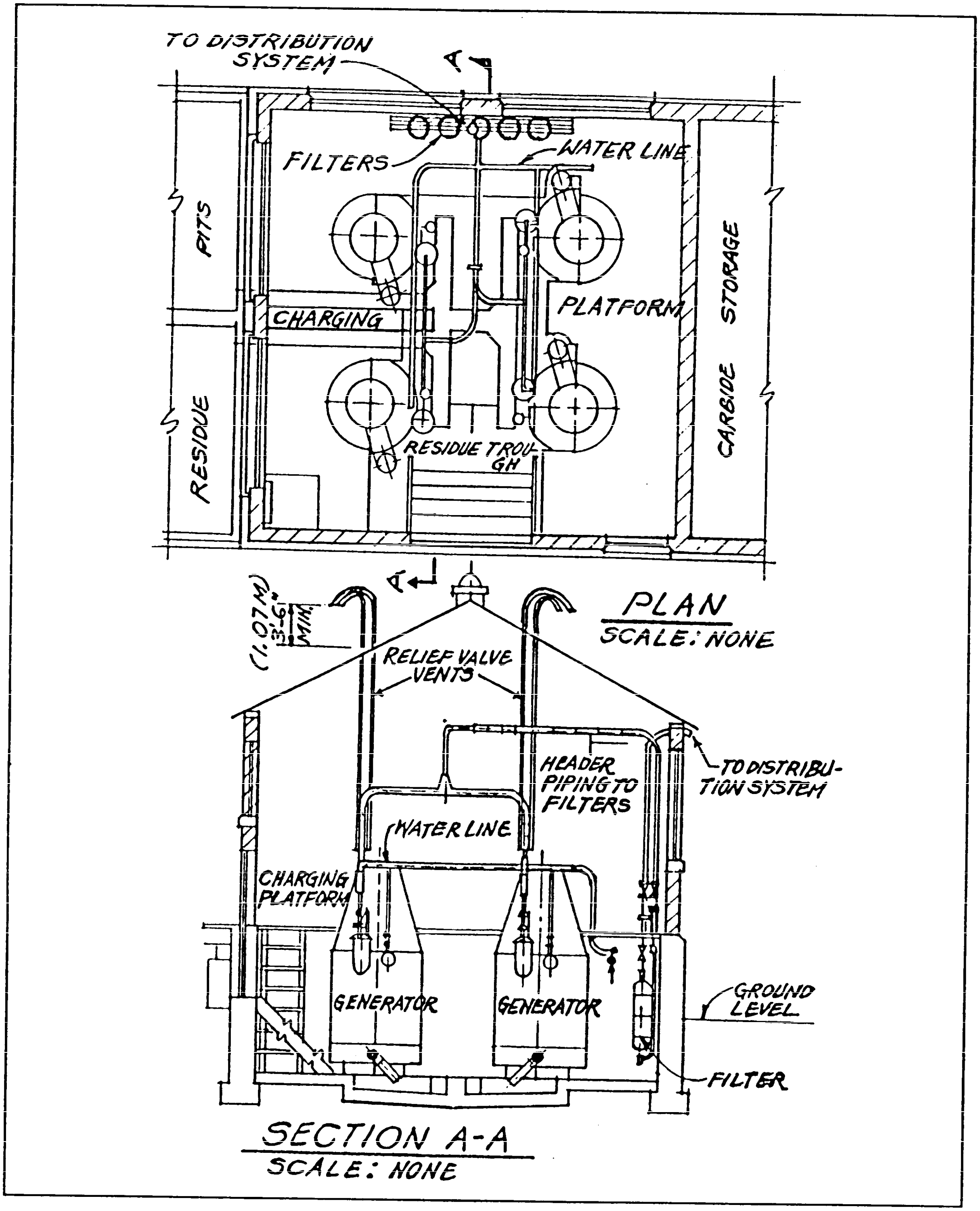


FIGURE 1
Medium Pressure Acetylene Generator Installation

different boiling points (fractional distillation), with production of nitrogen. At stations in continental United States, oxygen is purchased from commercial sources. At stations overseas, oxygen is procured from commercial contractors and may be generated on station with the proper equipment. Cylinders can be charged using a recharger if it is available.

3.1.4 Portable Acetylene Manifold Supply. Where a needed volume of acetylene is relatively small or for infrequent demands, and at stations some distances apart, it is economical and desirable to use portable acetylene cylinders.

3.1.4.1 Cylinder Sizes. There are three sizes of Navy-standard acetylene cylinders: 10 cubic feet (0.283 cubic meters), 70 cubic feet (1.98 cubic meters), and 225 cubic feet (6.37 cubic meters) capacity, respectively, with gas compressed to 250 psig (1,724 kPa gage). The 225 cubic feet (6.37 cubic meters) cylinder is used for general welding and burning. Although other sizes may be used, they are obsolete.

a) The maximum permissible discharge rate per cylinder in cubic feet per hour should be about one-seventh the rated gas capacity of the cylinder in cubic feet or approximately 33 cubic feet (0.93 cubic meters) per hour for a 225 cubic feet (6.37 cubic meters) cylinder.

b) A higher discharge rate frees too much acetone. This acetone interferes with the operation of the pressure regulator, valves, torch, and so forth, and causes poor welds and excessive use of oxygen.

c) If a high discharge rate is maintained for lengthy periods and the cylinder is exposed to cold weather, gas contraction causes a premature pressure drop inside.

d) It is false economy to try to use the last cubic feet of acetylene in a cylinder. When the pressure inside falls below 12 psig (82.7 kPa gage), the acetone flows out readily regardless of the discharge rate, with the undesirable results stated above. Spring loaded discharge valves may be used to avoid acetone discharge below 12 psig (82.7 kPa gage).

3.1.4.2 Portable Manifolds. These cylinder manifolds are necessary when demands for gas exceed the permissible discharge rate of one cylinder. Such manifolds are commercially available for connecting several cylinders, so as to use their combined capacities simultaneously. The gas flow from two to six 225 cubic feet (6.37 cubic meters) cylinders produces a discharge rate up to 200 cubic feet (5.66 cubic meters) per hour for approximately 7 hours of continuous service supply, and proportionately longer with intermittent service.

3.1.5 Permanent Acetylene Manifold Supply. This type of manifold supply is necessary where the daily acetylene gas demand is constant and exceeds the combined capacity of two or three cylinders.

3.1.5.1 Plants. The manifold-cylinder combinations require the simplest form of shelter, including storage rooms for spare supply and empty cylinders or sheds for empty cylinders.

3.1.5.2 Permanent Manifolds. The permanent manifolds are commercially available for connecting cylinder combinations of 4, 6, 8, 10, 12, and 20 cylinders. See Figure 2.

a) Provide one spare cylinder connected manifold with individual shutoff valve control for change over and replacement of empty cylinders.

b) The manifold generally consists of individual cylinder union loop (pigtail) connections (with flashback arresters and cylinder valves), header, header union connections, adjustable pressure reducing regulator (from 250 psig (1724 kPa gage) to utilization pressure under 15 psig (102 kPa gage), and high and low pressure gages.

c) Connect the pressure regulator through a coiled tube, check valve, and hydraulic back pressure valve to the distribution line.

d) A relief valve, with vent and automatic and manual adjustable features, shall be connected to the hydraulic valve. The vent shall terminate in a hood or bend outdoors away from any potential ignition sources.

e) Manifold assemblies shall be electrically grounded.

3.1.6 Oxygen Manifold Supply. See NFPA 51. Oxygen for general welding and cutting use in the Navy is provided in 200 cubic feet (5.66 cubic meters) and 250 cubic feet (7.08 cubic meters) cylinders at 1,800 psig (12,410 kPa gage) and 2,265 psig (15,617 kPa gage), respectively. Manifolds are necessary when the rate of oxygen demand is greater than the rate of flow from one cylinder. Enclose oxygen and acetylene manifolds in separate rooms. Provide fire walls and self-closing, Class B, fire doors of minimum one hour rating.

3.1.6.1 Manifold Usage.

a) Use manifolds or their component parts only for the gas or gases for which they are approved.

b) Although oxygen distribution lines parallel acetylene lines, NFPA 51 requires a 20 feet separation or a 5-foot barrier having a fire resistance rating of 1/2 hour.

c) Oxygen manifolds with cylinders in a combined capacity of more than 6,000 cubic feet (170 cubic meters) should be located preferably outside or in a special building constructed of noncombustible materials.

3.1.6.2 Manifold Types. Use portable or permanent manifolds as required.

a) The manifolds are similar to those used for acetylene, but the pressure gages and regulators must be suitable for reducing higher pressures and controlling the flow at designed line distribution pressures anywhere from 35 psig (241 kPa gage) to 175 psig (1,207 kPa gage).

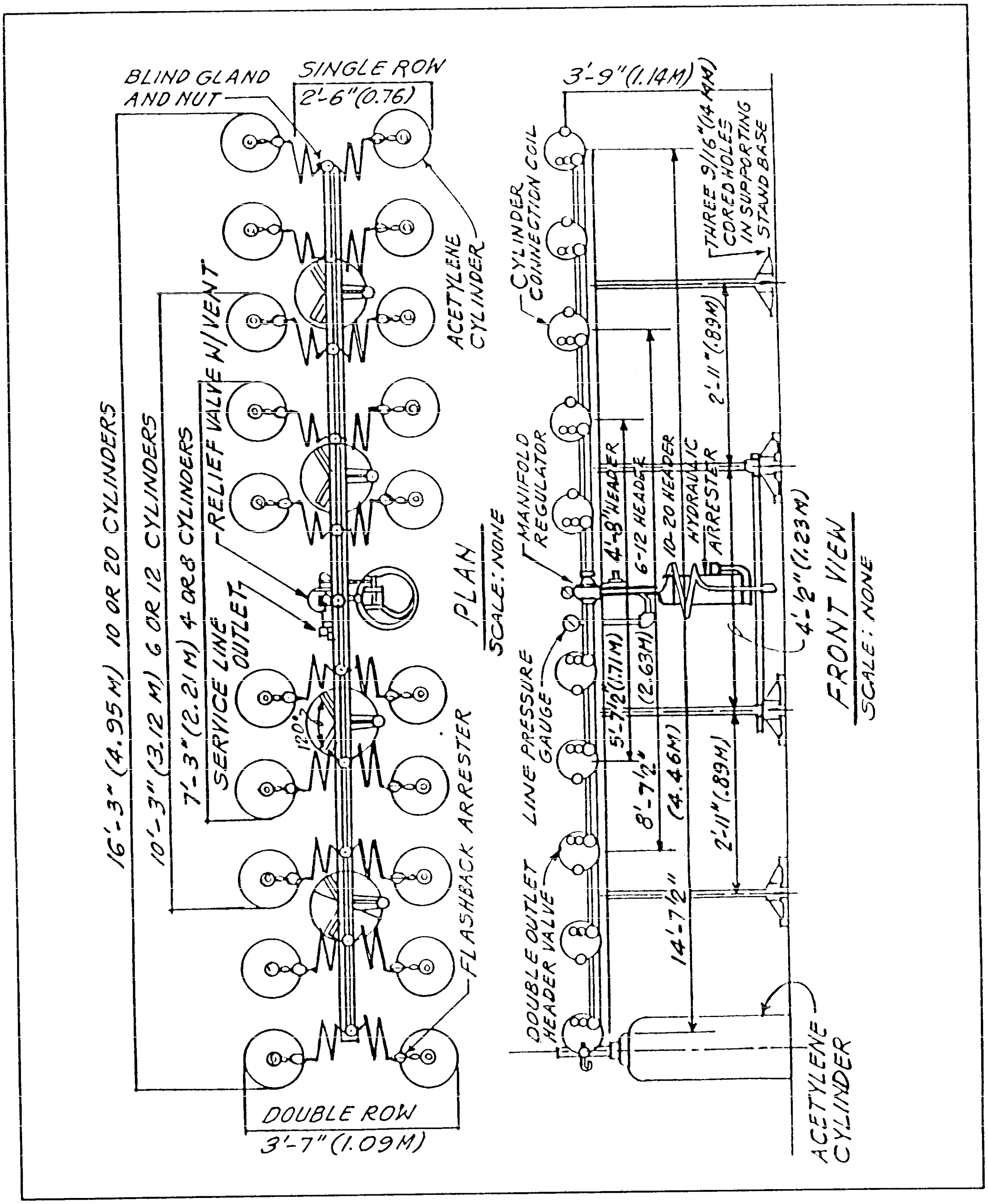


FIGURE 2
Floor Area Dimensions of 4-8, 6-12, and 10-20 Cylinder Acetylene Manifolds

b) Oxygen tank trucks are usually fitted with regulators to reduce pressure and control gas flow, where necessary, to the distribution line.

c) Due to high pressure, regulator sizes, and resistance drops through valves and fittings, it is quite practicable to limit the maximum number of cylinders connected to each manifold to ten.

d) Twenty cylinders can be joined together by manifold if two individual banks of ten cylinders are controlled independently of each other, and cylinder bank changeovers are effected automatically.

e) Standard oxygen manifolds are commercially available for groups of 4, 6, 8, 10, 12, 16, and 20 cylinders. See Figure 3 and CGA G-4.4.

f) Installed cylinder manifold capacity should be based on a system average flow demand.

3.2 Distribution Systems.

3.2.1 Advantages of Distribution Systems. Piping systems for distribution of acetylene and oxygen shall be provided for the following reasons:

a) Reduction in costs of handling cylinders (full or empty).

b) More uniform gas pressure at the torch, resulting in higher grade of work.

c) Less loss of time by an operator changing cylinders, resulting in an uninterrupted supply of gases for production work.

d) Reduction of life and safety hazards since sources of supply are fixed and isolated from ignition sources.

3.2.2 Acetylene and Oxygen Piping Arrangements. Locate each consuming station on a layout drawing for the distribution systems, noting acetylene and oxygen consumption in cubic feet per hour.

3.2.2.1 Aboveground Distribution Lines.

a) Connect acetylene and oxygen service stations to similar and parallel lateral distribution lines, which run to a main distribution line connecting to cylinder manifolds or to generators. See Figures 4 and 5.

(1) Piping details such as cutout, hydraulic back pressure and relief valves, drip points, and rupture discs should be indicated.

(2) Piping can be located overhead or underground, but must be protected against corrosive action, excess heat, and physical damage.

b) Acetylene and oxygen lines shall not run through closed tunnels, drydock service galleries, or trenches unless there is adequate natural or

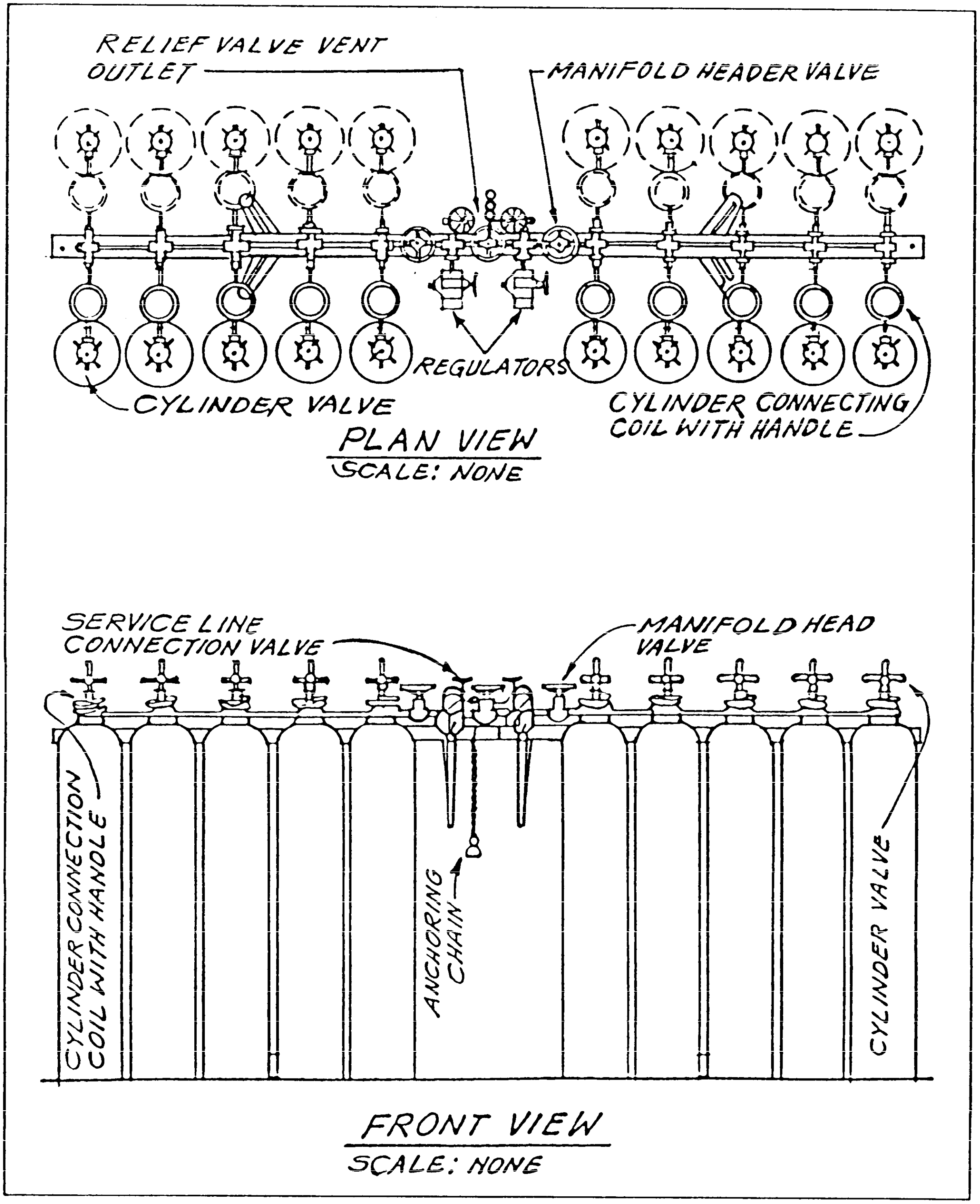


FIGURE 3
Ten-Cylinder Duplex Unit Type Oxygen Manifold

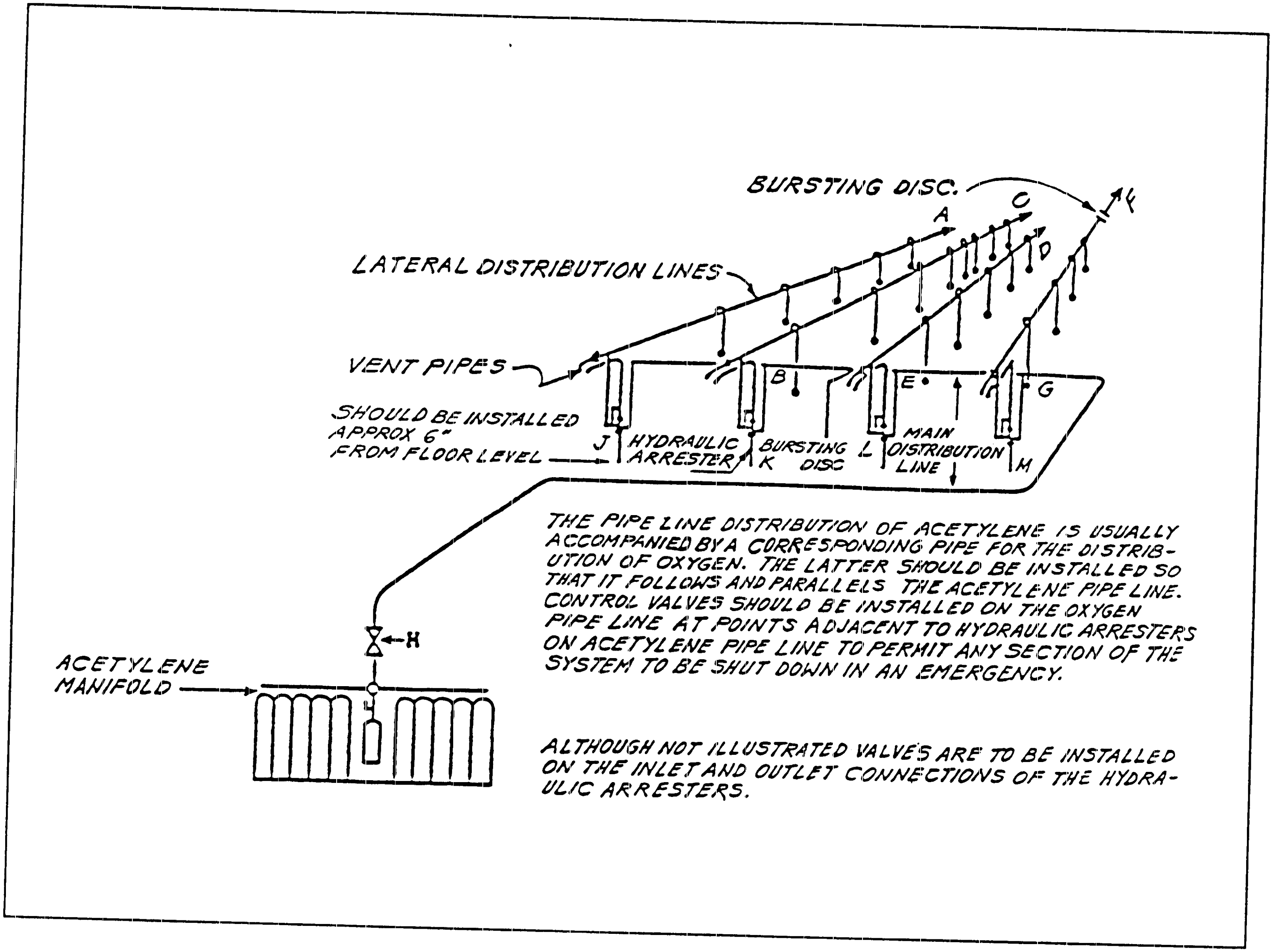


FIGURE 4
Typical Arrangement of a Medium Pressure Acetylene Distribution System

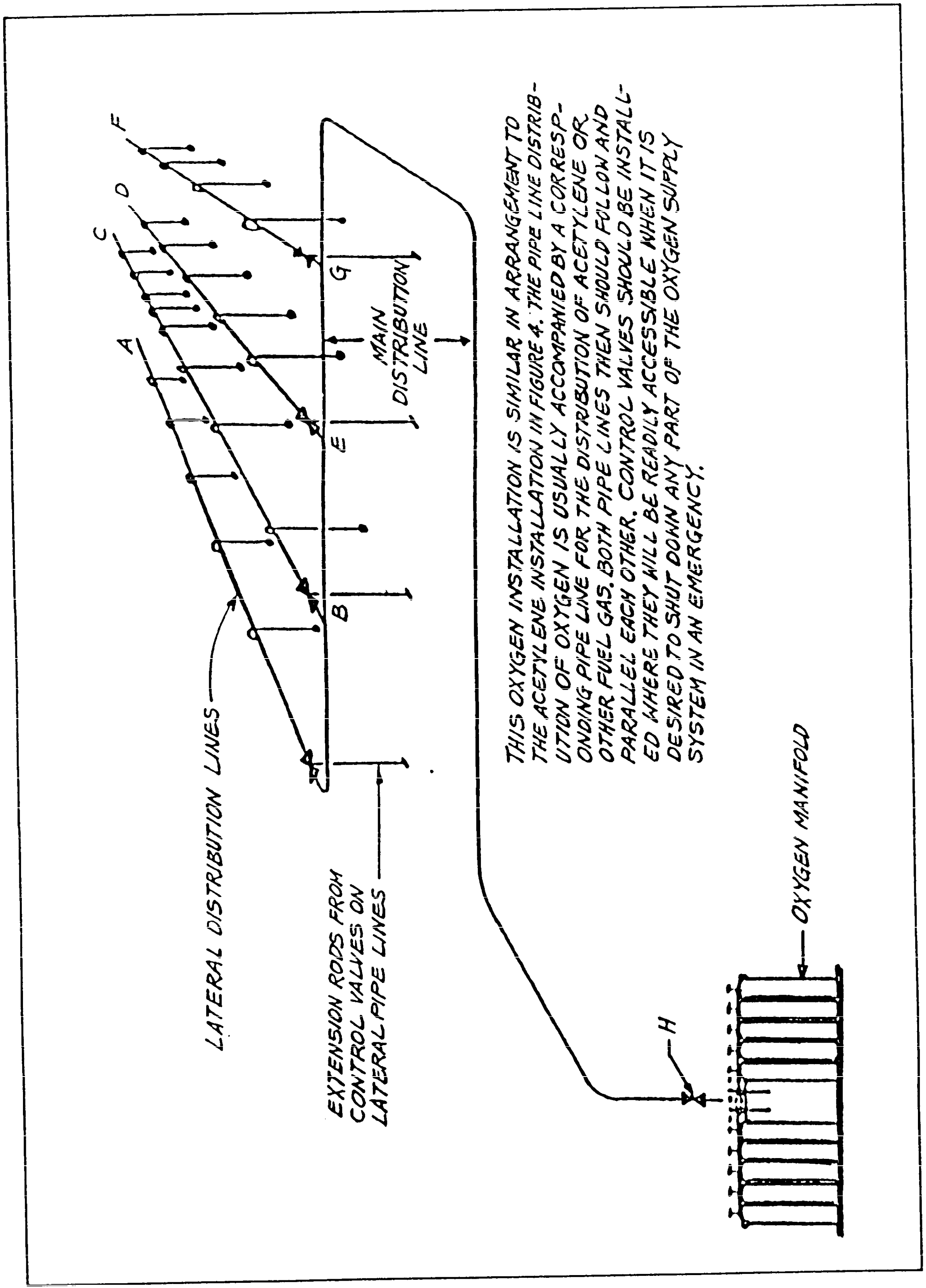


FIGURE 5
Typical Arrangement of an Oxygen Distribution System

mechanical ventilation. Never run an oxygen pipeline in a tunnel, trench, or duct where it can come in contact with oil.

c) Allowance must be made for thermal expansion and support of piping at sufficient intervals to prevent accumulations of condensate in the piping.

d) All appurtenances and entire piping systems shall be in accordance with NFPA 51 and CGA G-4.4.

e) Connections for drop stations shall be made at the top of lateral distribution lines; see Figures 4 and 5.

3.2.2.2 Underground Distribution Lines. In addition to meeting normal requirements for distribution, piping underground lines must have special features.

a) Locate underground lines below the frost line. Piping should be of welded construction. Encase steel piping in steel conduit. Coat and cathodically protect steel conduit. Provide monitoring system to detect leakage of the carrier pipe. Provide detectable aluminum-foil, plastic-backed tape or detectable magnetic plastic tape manufactured specially for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument.

b) Where corrosive soil exists, use well slaked lime, loam, or clay fill around the pipelines.

c) Where lines must pass under railroad tracks, the lines must be sufficiently below the ground surface to avoid mechanical injury. Lines under tracks should be in casings or duct pipes not less than two sizes larger than the pipelines.

3.2.3 Hydraulic Back Pressure Valves. Comply with CGA V-1, Compressed Gas Cylinder Valve Outlet and Inlet Connections. At each station outlet, provide station hydraulic back pressure valve, or pressure regulator combined with shutoff and check valves.

3.2.3.1 Types and Use. Station outlet valves which combine the functions of shutoff and check valves are available commercially. See Figure 6.

a) Where a regulator check valve arrangement exists, the distribution system should be conveniently sectionalized with each section protected by an approved branch line hydraulic back pressure valve of suitable capacity.

b) A well designed distribution system should have acetylene gas passing through only one hydraulic valve, not counting the ones at the generator, gas holder, or cylinder manifold. Explicitly, hydraulic valves should act in parallel, and not in series.

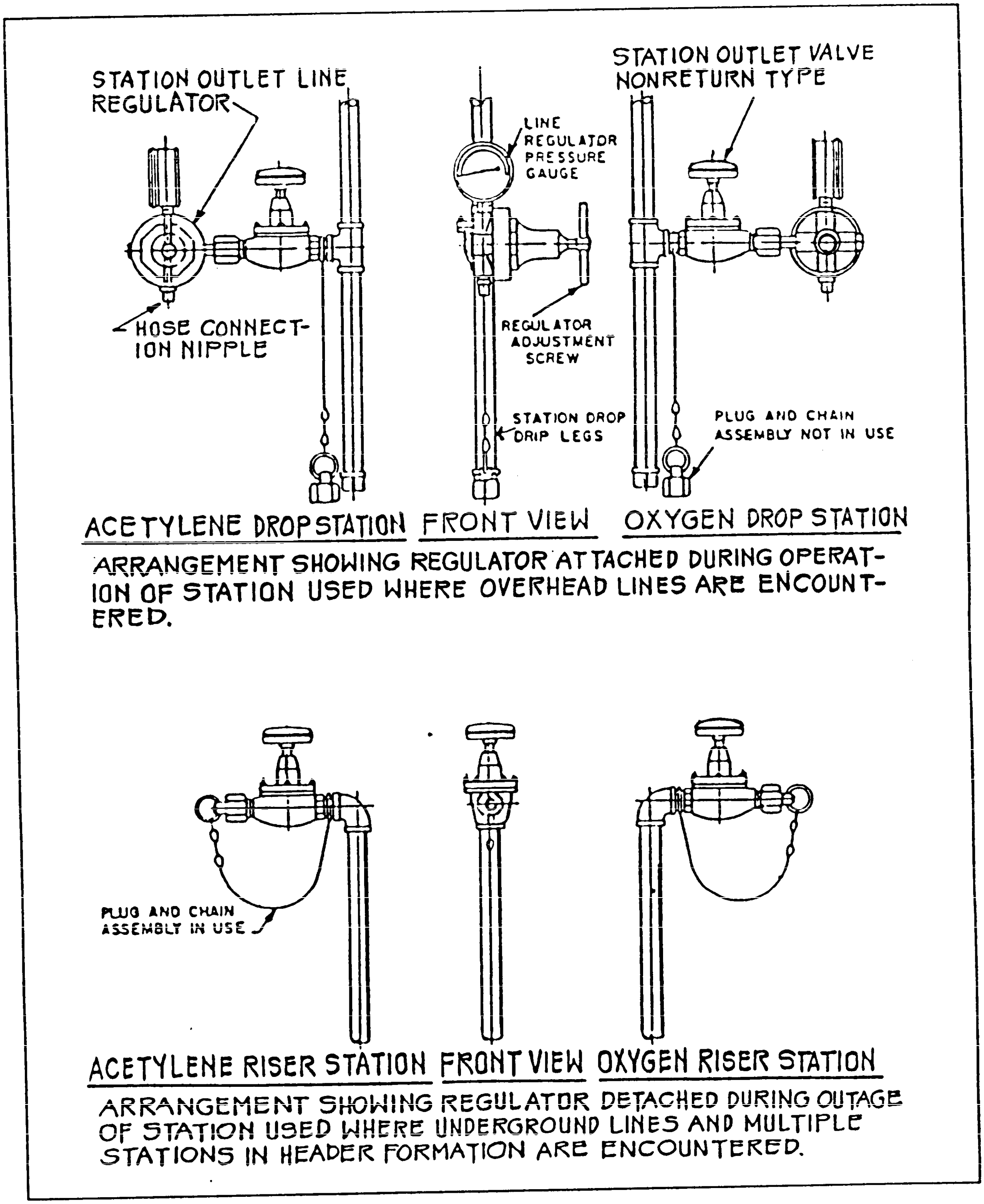


FIGURE 6
Single Outlet Drop and Riser Station

c) When extra hydraulic valves are installed in a line, excessive pressure drops can occur with excess moisture being added to the acetylene, causing unwanted wetness in the torch tip or hazardous condensate in the line.

3.2.3.2 Precautions. In the few instances where gas meters are needed, use flow meters of steel case or orifice type. Protect these meters against damage from flashbacks by hydraulic valves. Use a suitable antifreeze (ethylene glycol) to protect hydraulic valves against freezing, except for those on acetylene generators. Properly located hydraulic valves can serve as drip pots. For safety requirements pertaining to these valves, see NFPA 51.

3.2.4 Pressure Relief.

3.2.4.1 Pressure Relief Valves. Provide relief valves and vents with each hydraulic valve, set to open at not more than 20 psig (138 kPa gage) for acetylene manifolds. Beyond oxygen manifolds, provide self-recovery type relief valves set to release at pressures ranging from 150 psig (1034 kPa gage) to 175 psig (1207 kPa gage).

3.2.4.2 Rupture Relief Disks and Vent Lines. Provide relief rupture disks at both ends and changes in direction of long exposed acetylene lines where piping is 1 inch (25 millimeter) diameter and larger.

a) These disks should be located at intervals not to exceed 200 feet (61 meters) and placed to receive direct impacts from possible backfires. Design disks to rupture at 50 pounds per square inch (psi) (345 kPa).

b) Provide relief vent lines and connect to valves and disk fittings. These relief lines shall discharge outside of buildings.

c) Rupture disks are not necessary for underground lines if these are properly protected by hydraulic valves.

3.2.5 Safety Devices on Cylinders. Gas cylinders shall be fitted with safety devices as safeguards against the development of hazardous pressures within cylinders from exposure to heat, overcharging, or similar causes.

3.2.5.1 Fusible Plugs for Acetylene Cylinders. Comply with CGA C-13, Guidelines for Periodic Visual Inspection and Requalification of Acetylene Cylinders. A fusible plug is a threaded, hex-head plug containing a fusible metal in the center. This safety device is used for acetylene cylinders.

a) When a cylinder is subjected to high temperatures, the fusible metal melts between 208 degrees F (98 degrees C) and 220 degrees F (104 degrees C) and allows gas to escape through a channel previously filled with the fusible metal.

b) A Navy standard 225 cubic feet (6.37 cubic meters) cylinder has two fusible plugs in the cylinder spud and two in the cylinder bottom.

3.2.5.2 Safety Cap with Rupture Disk for Oxygen Cylinders. This cap consists essentially of a frangible safety disk covering a safety port in a valve.

a) The frangible disk is supported by fusible metal in the safety cap, which blocks off the escape port.

b) In practice when a cylinder with a valve and fusible metal is heated above the melting point of the metal between 208 degrees F (98 degrees C) and 220 degrees F (104 degrees C), and the cylinder pressure reaches 2,600 psig (17,926 kPa gage) to 3,000 psig (20,684 kPa gage), the frangible disk ruptures to reduce the pressure.

3.2.6 Portable Headers. Use these in outside locations, such as piers and drydocks, where conditions restrict permanent piping. A portable outlet header is an assembly for valves and connections for acetylene or oxygen consumption service, and is connected to permanent service piping by hose or other non-rigid conduits.

3.3 Piping.

3.3.1 Piping Sizes. Refer to Paragraph 2.2, entitled "Consumption and Supply of Oxyacetylene Torch Systems."

3.3.1.1 Acetylene Piping. Since the maximum allowable pressure beyond a supply source is 15 psig (103 kPa gage), and the desired torch pressure at the most distant station can be as much as 10 psig (69 kPa gage) (see Tables 2-A and 2-B), the total allowable pressure loss in a distribution system is 5 psig (34 kPa gage). Use Tables 5-A, 5-B, and 5-C for sizing piping for various acetylene flows and equivalent lengths at the average line pressure of 12 psig (82.7 kPa gage).

3.3.1.2 Oxygen Piping. Pipe sizes should be selected on the basis of maximum system demands. Flow capacity (see Tables 6-A, 6-B, 7-A, and 7-B) can be used to determine pipe sizes.

3.3.2 Piping Material. Provide the following acetylene, oxygen, and vent piping materials.

3.3.2.1 Acetylene Piping. Use steel piping.

a) Wrought iron, malleable iron, or cast steel fittings can be used. Cast iron fittings are prohibited because of their tendency to shatter under internal explosion pressures.

b) Appurtenances, such as valves, regulators and controls, and manifold connections can be made of brass containing not more than 67 percent copper.

c) Use minimum Schedule 40 piping intended for the distribution system, at the maximum working pressure of 15 psig (103 kPa gage).

d) Use minimum Schedule 80 piping intended for higher working

TABLE 5-A
Flow Capacities for Acetylene in Schedule 40 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe, far end from supply unit, ft (m)	Nominal pipe size in. (mm) 1/2 (13)	3/4 (19)	1 (25)	1-1/4 (32)
25(8)	330 (9.34)	750 (21.2)	1,510 (42.7)	3,300 (93.4)
50(15)	230 (6.51)	530 (15.0)	1,070 (30.3)	2,350 (66.5)
100(31)	165 (4.67)	375 (10.6)	750 (21.2)	1,650 (46.7)
150(46)	135 (3.82)	305 (8.63)	620 (17.5)	1,350 (38.2)
200(61)	115 (3.25)	265 (7.50)	530 (15.0)	1,150 (32.5)
300(91)	... .	215 (6.08)	440 (12.5)	950 (26.9)
400(122)	... .	185 (5.24)	380 (10.8)	850 (24.1)
500(152)	... .	165 (4.67)	340 (9.62)	750 (21.2)
600(183)	... .	155 (4.39)	310 (8.77)	675 (19.1)
800(244)	... .	130 (3.68)	270 (7.64)	600 (17.0)
1,000(305)	... .	120 (3.40)	240 (6.79)	525 (14.9)
1,200(366)	... .	110 (3.11)	220 (6.23)	475 (13.4)
1,500(457)	... .	100 (2.83)	195 (5.52)	425 (12.0)
2,000(610)	... .	... .	170 (4.81)	375 (10.6)
2,500(762)	... .	... .	150 (4.25)	330 (9.34)
3,000(914)	... .	... .	140 (3.96)	300 (8.49)
3,500(1067)	... .	... .	130 (3.68)	280 (7.92)
4,000(1219)	... .	... .	120 (3.40)	260 (7.36)
5,000(1524)	... .	... .	110 (3.11)	235 (6.65)
	Pipe content in cu ft (m^3) per 100 lin ft (31 m).			
	0.21(0.006)	0.37 (0.010)	0.60 (0.017)	1.04 (0.029)

[1] Supply unit delivery pressure 12 psi (82.7 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 5-B

Flow Capacities for Acetylene in Schedule 40 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe, far end from supply unit ft (m)	Nominal pipe size in (mm) 1-1/2 (38)	2 (51)	2-1/2 (64)	3 (76)
25(8)	5,000 (142)	10,400 (294)	....	....
50(15)	3,650 (103)	7,400 (209)	12,200 (345)	....
100(31)	2,560 (72.4)	5,200 (147)	8,600 (243)	....
150(46)	2,100 (59.4)	4,250 (120)	7,000 (198)	12,800 (362)
200(61)	1,800 (50.9)	3,700 (105)	6,100 (173)	11,100 (314)
300(91)	1,500 (42.4)	3,000 (84.9)	5,000 (142)	9,100 (258)
400(122)	1,300 (36.8)	2,600 (73.6)	4,300 (122)	7,850 (222)
500(152)	1,150 (32.5)	2,300 (65.1)	3,850 (109)	7,000 (198)
600(183)	1,050 (29.7)	2,100 (59.4)	3,500 (99.1)	6,400 (181)
800(244)	900 (25.5)	1,850 (52.4)	3,050 (86.3)	5,550 (157)
1,000(305)	800 (22.6)	1,650 (46.7)	2,700 (76.4)	5,000 (142)
1,200(366)	750 (21.2)	1,500 (42.4)	2,500 (70.8)	4,550 (129)
1,500(457)	660 (18.7)	1,350 (38.2)	2,200 (62.3)	4,050 (115)
2,000(610)	575 (16.3)	1,150 (32.5)	1,900 (53.8)	3,500 (99.1)
2,500(762)	510 (14.4)	1,050 (29.7)	1,700 (48.1)	3,150 (89.1)
3,000(914)	470 (13.3)	950 (26.9)	1,570 (44.4)	2,850 (80.7)
3,500(1067)	430 (12.2)	880 (24.9)	1,450 (41.0)	2,650 (75.0)
4,000(1219)	400 (11.3)	820 (23.2)	1,350 (38.2)	2,450 (69.3)
5,000(1524)	360 (10.2)	740 (20.9)	1,220 (34.5)	2,200 (62.3)
	Pipe content in cu ft (m^3) per 100 lin ft (31 m).			
	1.41 (0.040)	2.33 (0.066)	3.32 (0.094)	5.13 (0.145)

[1] Supply unit delivery pressure 12 psi (82.7 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 5-C

Flow Capacities for Acetylene in Schedule 40 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe, far end from supply unit, ft (m)	Nominal pipe size in (mm) 3-1/2 (89)	4 (102)	5 (127)
25(8)	....	....	....
50(15)	....	....	....
100(31)	....	....	....
150(46)	....	....	....
200(61)	....	....	....
300(91)	....	....	....
400(122)	11,700 (331)	....	....
500(152)	10,500 (297)	....	....
600(183)	9,650 (273)	....	....
800(244)	8,350 (236)	11,750 (333)	....
1,000(305)	7,450 (211)	10,500 (297)	....
1,200(366)	7,800 (192)	9,600 (272)	....
1,500(457)	6,100 (173)	8,600 (243)	....
2,000(610)	5,250 (148)	7,450 (211)	....
2,500(762)	4,700 (133)	6,650 (188)	12,300 (348)
3,000(914)	4,300 (122)	6,050 (171)	11,200 (317)
3,500(1067)	4,000 (113)	5,600 (158)	10,400 (294)
4,000(1219)	3,700 (105)	5,200 (147)	9,700 (275)
5,000(1524)	3,300 (93.4)	4,700 (133)	8,700 (246)
Pipe content in cu ft (m^3) per 100 lin ft (31 m).			
	6.87 (0.194)	8.84 (0.250)	13.9 (0.393)

[1] Supply unit delivery pressure 12 psi (82.7 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 6-A

Flow Capacities for Oxygen in Schedule 40 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe far end from supply unit, ft (m)	Nominal pipe size in in (mm) 1/2 (13)	3/4 (19)	1 (25)	1-1/4 (32)
50(15)	1,390 (39.3)	2,760 (78.1)	5,170 (146)	10,200 (289)
100(31)	990 (28.0)	1,950 (55.2)	3,650 (103)	7,200 (204)
150(46)	810 (22.9)	1,590 (45.0)	2,960 (83.8)	5,990 (170)
200(61)	700 (19.8)	1,510 (42.7)	2,570 (72.7)	5,140 (145)
250(76)	630 (17.8)	1,230 (34.8)	2,310 (65.4)	4,500 (127)
300(91)	570 (16.1)	1,130 (32.0)	2,100 (59.4)	4,240 (120)
350(107)	510 (14.4)	1,040 (29.4)	1,960 (55.5)	3,800 (108)
400(122)	490 (13.9)	980 (27.7)	1,820 (51.5)	3,600 (102)
450(137)	470 (13.3)	920 (26.0)	1,720 (48.7)	3,430 (97.1)
500(152)	450 (12.7)	870 (24.6)	1,640 (46.4)	3,270 (92.6)
600(183)	390 (11.0)	790 (22.4)	1,480 (41.9)	2,920 (82.6)
800(244)	350 (9.91)	690 (19.5)	1,280 (36.2)	2,570(72.7)
1,000(305)	310 (8.77)	610 (17.3)	1,140 (32.3)	2,250 (63.7)
1,200(366)	280 (7.92)	560 (15.8)	1,060 (30.0)	2,060 (58.3)
1,500(457)	250 (7.03)	510 (14.4)	950 (26.9)	1,860 (52.6)
2,000(610)	220 (6.23)	440 (12.5)	820 (23.2)	1,600 (45.3)
2,500(762)	190 (5.38)	390 (11.0)	730 (20.7)	1,440 (40.8)
3,000(914)	180 (5.09)	350 (9.91)	670 (19.0)	1,310 (39.1)
3,500(1067)	170 (4.81)	340 (9.62)	620 (17.5)	1,220 (34.5)
4,000(1219)	150 (4.25)	305 (8.63)	580 (16.4)	1,150 (32.5)
4,500(1372)	140 (3.96)	290 (8.21)	540 (15.3)	1,080 (30.6)
5,000(1529)	130 (3.68)	275 (7.78)	520 (14.7)	1,020 (28.9)
Pipe content in cu ft (m^3) per 100 lin ft (31 m).	0.21 (0.006)	0.37 (0.010)	0.60 (0.017)	1.04 (0.029)

[1] Supply unit delivery pressure 100 psi (689 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 6-B
Flow Capacities for Oxygen in Schedule 40 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe far end from Supply unit, ft (m)	Nominal pipe size in (mm) 1-1/2 (38)	2 (51)	2-1/2 (64)	3 (76)
50(15)	15,000 (425)	28,100 (795)	43,600 (1234)	75,600 (2139)
100(31)	10,700 (303)	19,900 (563)	31,100 (880)	53,700 (1520)
150(46)	8,900 (252)	16,600 (470)	25,800 (730)	44,700 (1265)
200(61)	7,620 (216)	14,300 (405)	22,200 (628)	38,300 (1084)
250(76)	6,790 (192)	12,500 (354)	19,400 (549)	33,500 (948)
300(91)	6,290 (178)	11,700 (331)	18,200 (515)	31,500 (891)
350(107)	5,620 (159)	10,500 (297)	16,300 (461)	28,300 (801)
400(122)	5,340 (151)	9,960 (282)	15,550 (440)	27,100 (767)
450(137)	5,080 (144)	9,500 (269)	14,790 (419)	25,800 (730)
500(152)	4,850 (137)	9,080 (257)	14,150 (400)	24,300 (688)
600(183)	4,360 (123)	8,140 (230)	12,650 (358)	21,900 (620)
800(244)	3,810 (103)	7,120 (201)	11,500 (325)	19,200 (543)
1,000(305)	3,330 (94.3)	6,230 (176)	9,700 (275)	16,800 (475)
1,200(366)	3,050 (86.3)	5,690 (161)	8,870 (251)	15,400 (436)
1,500(457)	2,740 (77.5)	5,120 (145)	7,960 (225)	13,700 (388)
2,000(610)	2,370 (67.1)	4,440 (126)	6,910 (196)	11,950 (338)
2,500(762)	2,140 (60.6)	3,690 (104)	6,200 (175)	10,700 (303)
3,000(914)	1,940 (54.9)	3,630 (103)	5,630 (159)	9,800 (277)
3,500(1067)	1,810 (51.2)	3,380 (95.7)	5,270 (149)	9,100 (258)
4,000(1219)	1,690 (47.8)	3,170 (89.7)	4,940 (140)	8,540 (242)
4,500(1372)	1,590 (45.0)	2,980 (84.3)	4,630 (131)	8,010 (227)
5,000(1524)	1,500 (42.5)	2,810 (79.5)	4,370 (124)	7,560 (214)
	Pipe content in cu ft (m^3) per 100 lin ft (31 m).			
	1.41 (0.040)	2.33 (0.066)	3.32 (0.094)	5.13 (0.145)

[1] Supply unit delivery pressure 100 psi (689 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 7-A
Flow Capacities for Oxygen in Schedule 80 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe, far end from supply unit, ft (m)	Nominal pipe size in (mm)			
	1/2 (13)	3/4 (19)	1 (25)	1-1/4 (32)
50 (15)	1,000 (28.3)	2,120 (60.0)	4,100 (116)	8,400 (238)
100 (31)	710 (20.1)	1,500 (42.5)	2,890 (81.8)	5,950 (168)
150 (46)	580 (16.4)	1,220 (34.5)	2,360 (66.8)	4,950 (140)
200 (61)	500 (14.2)	1,160 (32.8)	2,040 (57.7)	4,250 (120)
250 (76)	450 (12.7)	950 (26.9)	1,830 (51.8)	3,720 (105)
300 (91)	410 (11.6)	870 (24.6)	1,670 (47.3)	3,500 (99.1)
350 (107)	370 (10.5)	800 (22.6)	1,550 (43.9)	3,140 (88.9)
400 (122)	350 (9.91)	750 (21.2)	1,440 (40.8)	2,980 (84.3)
450 (137)	340 (9.62)	710 (20.1)	1,360 (38.5)	2,840 (80.4)
500 (152)	320 (9.06)	670 (19.0)	1,300 (36.8)	2,700 (76.4)
600 (183)	280 (7.92)	610 (17.3)	1,180 (33.4)	2,410 (68.2)
800 (244)	250 (7.08)	530 (15.0)	1,020 (28.9)	2,120 (60.0)
1,000 (305)	220 (6.23)	470 (13.3)	910 (25.8)	1,860 (52.6)
1,200 (366)	200 (5.66)	430 (12.2)	840 (23.8)	1,700 (48.1)
1,500 (457)	180 (5.09)	390 (11.0)	750 (21.2)	1,530 (43.3)
2,000 (610)	160 (4.53)	340 (9.62)	650 (18.4)	1,320 (39.4)
2,500 (762)	140 (3.96)	300 (8.49)	580 (16.4)	1,190 (33.7)
3,000 (914)	130 (3.68)	270 (7.64)	530 (15.0)	1,080 (30.6)
3,500 (1067)	120 (3.40)	250 (7.08)	490 (13.9)	1,010 (28.6)
4,000 (1219)	110 (3.11)	235 (6.65)	460 (13.0)	950 (26.9)
4,500 (1372)	100 (2.83)	225 (6.37)	430 (12.2)	890 (25.2)
5,000 (1524)	90 (2.55)	210 (5.94)	410 (11.6)	840 (23.8)
Pipe content in cu ft (m^3) per 100 lin ft (31 m)				
	0.163 (0.005)	0.3 (0.008)	0.5 (0.014)	0.89 (0.025)

[1] Supply unit deliver pressure 100 psi (689 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

TABLE 7-B
Flow Capacities for Oxygen in Schedule 80 Steel Pipe[1]
cu ft (m^3) of gas per hr at 14.7 psia (101 kPa abs)
and 70°F (21.1°C)

Distance of pipe, far end from supply unit, ft (m)	Nominal pipe size in (mm) 1-1/2 (38)	2 (51)	2-1/2 (64)	3 (76)
50 (15)	12,500 (354)	23,800 (674)	37,300 (1056)	65,200 (1845)
100 (31)	8,900 (252)	16,900 (478)	26,550 (751)	46,300 (1310)
150 (46)	7,400 (209)	14,100 (399)	22,050 (624)	38,600 (1092)
200 (61)	6,350 (180)	12,100 (342)	18,900 (535)	33,100 (937)
250 (76)	5,560 (157)	10,580 (299)	16,550 (468)	28,900 (818)
300 (91)	5,230 (148)	9,950 (282)	15,560 (440)	27,200 (770)
350 (107)	4,680 (132)	8,900 (252)	13,920 (394)	24,400 (691)
400 (122)	4,450 (126)	8,450 (239)	13,270 (376)	23,150 (655)
450 (137)	4,240 (120)	8,050 (228)	12,620 (357)	22,050 (624)
500 (152)	4,040 (114)	7,680 (217)	12,050 (341)	21,050 (596)
600 (183)	3,630 (103)	6,900 (195)	10,820 (306)	18,900 (535)
800 (244)	3,180 (90.0)	6,030 (171)	9,470 (268)	16,550 (468)
1,000 (305)	2,780 (78.7)	5,280 (149)	8,280 (234)	14,450 (409)
1,200 (366)	2,540 (71.9)	4,830 (137)	7,570 (214)	13,250 (375)
1,500 (457)	2,280 (64.5)	4,340 (123)	6,800 (192)	11,800 (334)
2,000 (610)	1,980 (56.0)	3,760 (106)	5,900 (167)	10,300 (291)
2,500 (762)	1,780 (50.4)	3,380 (95.7)	5,300 (150)	9,260 (262)
3,000 (914)	1,620 (45.8)	3,080 (87.2)	4,820 (136)	8,420 (238)
3,500 (1067)	1,510 (42.7)	2,870 (81.2)	4,500 (127)	7,860 (222)
4,000 (1219)	1,410 (39.9)	2,690 (76.1)	4,210 (119)	7,350 (208)
4,500 (1372)	1,330 (37.6)	2,530 (71.6)	3,960 (112)	6,910 (196)
5,000 (1524)	1,250 (35.4)	2,380 (67.4)	3,730 (106)	6,520 (185)
Pipe content in cu ft (m^3) per 100 lin ft (31 m)				
	1.22 (0.035)	2.05 (0.058)	2.94 (0.083)	4.59 (0.130)

[1] Supply unit deliver pressure 100 psi (689 kPa). Actual cubic feet per hour (cubic meter per hour) of gas converted to cubic feet per hour (cubic meter per hour) measured at 14.7 psia (101 kPa abs) and 70°F (21.1°C).

pressures, where gas is compressed into cylinders at the generating plant.

(1) Seamless steel tubing with welded fittings and joints is desirable.

(2) Seamless steel tubing in sizes 1 inch (25 millimeter) and under, suitable for flared fitting joints, is available commercially.

e) Manifold pipe can consist of standard pipe size of seamless steel tubing with extra strong fittings when made of welded construction.

f) For threaded manifold pipe construction, use double extra-strong piping and extra-strong stop valves, pressure regulators, and fittings.

g) The maximum size of an acetylene manifold header shall not exceed 1-1/4 inch (32 millimeters) diameter (extra-strong pipe size).

3.3.2.2 Oxygen Piping (Gaseous Only)

a) Pipe Material. Piping can be steel, seamless brass, or copper. Generally, Schedule 40 black steel pipe is satisfactory for pressures not exceeding 150 psig (1034 kPa gage), if the line is equipped with CGA V-1 pressure relief devices.

(1) For higher pressures or where corrosive conditions exist, use extra-strong pipe or seamless steel tubing with wall thickness not less than those of standard weight pipe.

(2) Copper or brass tubing could be more desirable for 2-inch (5.08 centimeters) or smaller diameters.

(3) All pipe joints should be welded.

(4) Tube joints and fittings, when not welded, shall be in accordance with the American National Standard Institute (ANSI) B31, Code for Pressure Piping.

(5) Where threaded valves must be used, provide two long nipples, each with one end threaded and well tinned and the other beveled for welding. Screw the nipples into a valve hot, then weld the assembly into a pipeline.

b) Fittings. Cast iron fittings shall not be used in oxygen piping. Rolled, forged, cast steel, or malleable iron fittings can be used.

(1) Generally, fittings should be of the same materials as the pipes, and shall be designed for a maximum line working pressure.

(2) Insert suitable relief valves and pressure gages in oxygen main lines on the low (working) pressure side of high pressure reducing valves, when compressed cylinder gas is the source of supply.

3.3.2.3 Vent Piping. Steel or wrought iron piping for vents shall be galvanized, to avoid rusting on the inside.

3.3.3 Piping Details.

3.3.3.1 Condensate Drip Pots. Where low points occur in acetylene piping systems, install drip pots for removal of condensate. Generally, pipelines should be sloped to drain in the direction of gas flow. It is preferable to use underground pipelines. For suitable arrangements of underground pipeline drip pots, see Figure 7. As an alternative to Figure 7, valve off both sides of the drip pot, and use a gravity drain.

3.3.3.2 Hose Station Connections. See Figure 6 for arrangements of oxygen and acetylene hose station connections, and note use of non-return outlets.

3.4 Miscellaneous Criteria.

3.4.1 Safety Precautions. The use of carbon tetrachloride has been prohibited for any purpose. Use of oxygen and acetylene shall be in strict conformance with NFPA 51.

3.4.2 Shelters. Provide housing for acetylene systems and oxygen cylinders as follows.

3.4.2.1 Housing of Acetylene Systems. For general housing requirements, see paragraph 3.1.2, Acetylene Gas Generation, and paragraph 3.1.5, Permanent Acetylene Manifold Supply.

a) Housing Construction. Follow NFPA 51 for the arrangement of equipment and materials in housing construction.

b) Cylinder Gas. Portable manifold cylinder units, with capacities up to 2,000 cubic feet (56.6 cubic meters) (8 cylinders), for special shop, dock, or pier usage, can be housed within shops, in adjoining shed type buildings, or under the shelter of a pier or dock.

(1) All locations and installation shall be in accordance with MIL-HDBK-1008A, Fire Protection for Facilities Engineering Design and Construction, and NFPA 50.

(2) Locations within a shop are limited to where activities are of nonflammable nature; for example, forge, foundry, ship fitting, machine, and sheet metal processes.

(3) Two or more 2,000 cubic feet (56.6 cubic meters) units can be housed in one room if units are located 50 feet (15 meters) or more apart.

(4) Where the total capacity of manifolded gas exceeds 2,000 cubic feet (56.6 cubic meters) for one location, it shall be housed in a separate building, or in a room or compartment, according to NFPA 51.

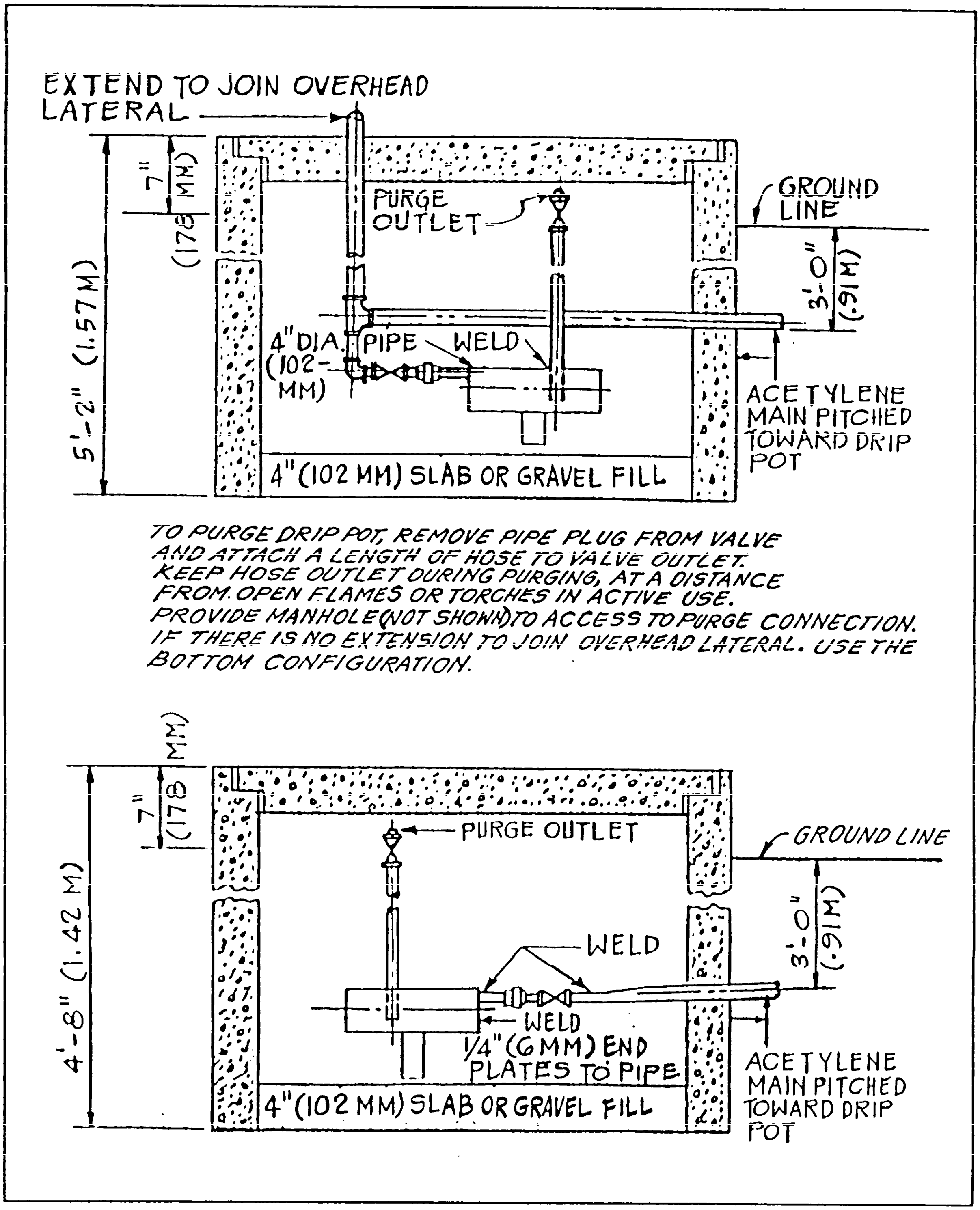


FIGURE 7
Acetylene Pipeline Drip Pots Enclosed in Concrete Boxes

(5) The maximum outside temperature for cylinder gas safety is 130 degrees F (54 degrees C).

3.4.2.2 Housing for Oxygen Cylinders.

a) Bulk Storage. Bulk storage of oxygen shall conform with the requirements of NFPA 50, defined as storage capacity of (1) more than 13,000 cubic feet (368 cubic meters) of oxygen at normal atmospheric temperature and pressure (NTP) connected in service or ready for service or (2) a capacity of more than 25,000 cubic feet (708 cubic meters) at NTP including unconnected reserves.

b) Multiple Storage. In a building where three or more oxygen cylinders are stored or connected to a manifold, the following shall apply:

(1) The cylinders shall be separated from other occupancies and operations by fire walls, with access only from the outside.

(2) Areas so used shall be constructed of fully noncombustible materials.

(3) Furniture, cabinets, shelves, and similar items shall be held to an absolute minimum, and shall be constructed of fully non-combustible materials.

3.4.3 Ventilation. All spaces or enclosures used for storage, generation, distribution, or utilization of acetylene shall be continuously ventilated. Use natural or mechanical method to provide continuous ventilation, regardless of operating equipment. Consider standby equipment for ventilation. Do not use electric power driven, induced draft fan systems unless specifically approved by NAVFAC. Provide ventilation at a rate of not less than 1 cubic foot (0.03 cubic meters) per minute per square foot (0.09 cubic meters) of ceiling area. Exhaust air to a safe location outside of the building. Locate inlet openings near the floor. Locate outlet openings at the high point or ceiling levels of the room.

3.4.4 Electrical Equipment. Provide motors, lighting, and appurtenances as follows.

3.4.4.1 Motors. Electric motors shall not be used in acetylene generating, compressor, storing, or manifold distribution rooms, or in carbide storage rooms.

a) Locate drive motors for compressors or pumps outside rooms, with drive shafts fitted with gas-tight stuffing boxes passing through walls.

b) Compressor reduction gearing shall be totally enclosed.

c) Belt drives shall not be allowed.

3.4.4.2 Lighting. Acetylene generator rooms shall have natural lighting during daylight hours.

a) Artificial Lighting. Where artificial lighting is needed in a generator, compressor, manifold distribution, or storage room, it shall be supplied by electrical fixtures labeled by Underwriters' Laboratories, Inc., as suitable for Class I, Division, 1, Group A hazardous atmospheres as defined in NFPA 70, National Electrical Code.

b) Wiring Circuits. Wiring circuits for lighting units shall be the rigid metal or intermediate metal conduit type with threaded connections, and shall be properly sealed off in an approved method whenever entering a room.

3.4.4.3 Appurtenances. Switches, portable lights, telephones, receptacles, or any other electrical apparatus shall not be located in any of these rooms. These items can be located in adjacent rooms if the separating walls are gas-tight and rooms are adequately ventilated.

3.5 Fire Protection. Installation shall be in accordance with MIL-HDBK-1008A.

Section 4: NITROGEN AND BREATHING OXYGEN FACILITIES

4.1 Liquid Oxygen and Nitrogen Storage and Generation. Liquid oxygen and nitrogen (LOX/LN_2) generation facilities should not be provided for naval air stations located in the continental United States. See policy statement relative to generation facilities included in paragraph 1.2. Generation facilities may be provided for naval air stations located outside the continental United States if the required quantities of product cannot be obtained commercially. Design information for a LOX/LN_2 storage, transfer, and vaporizing facility contained in this handbook also applies to a generating facility except as noted otherwise. Information on the installation, maintenance, and operation of LOX/LN_2 generators is included with the equipment which is provided as government furnished equipment by the Naval Air Engineering Center, Lake Hurst, New Jersey for the Navy or the equivalent for the Army and the Air Force.

4.2 Storage Facilities. Vertical, packaged LOX/LN_2 units which include a pumping and vaporizing system along with a storage container are recommended for facilities which use commercially procured products. At generation facilities, the product may be stored in stationary tanks (500 gallons (1,893 L), 1,000 gallons (3,786 L), or 2,000 gallons (7,571 L)) or in mobile tanks (400 gallons (1,516 L) or 500 gallons (1,893 L)), depending on the operational concept. The packaged storage units, mobile tanks, and stationary storage tanks are provided as government furnished equipment (GFE) by the Naval Air Systems Command.

4.2.1 Tanks. Characteristics of LOX/LN_2 tanks are as follows.

a) Construction. The storage tanks are constructed on the principle of the Dewar Vessel. These thermos type tanks are insulated by a double-walled annular vacuum space containing insulating material. The inner shell is constructed of stainless steel; the outer shell of carbon steel, aluminum, or stainless steel.

b) Evaporation Loss. Estimated evaporation loss of a warm 500-gallon (1,893 L) storage tank is 25 gallons (95 L) (5 percent) each time it is filled; for a 2,000 gallon (7,571 L) storage tank, the loss is 50 gallons (189 L) (2-1/2 percent). The daily evaporation loss of a 500 gallon (1,893 L) tank is 5 gallons (19 L) (1 percent); for a 2,000 gallon (7,571 L) tank, the loss is 10 gallons (38 L) (1/2 percent). The evaporation loss is practically constant, regardless of the amount of liquid in the tank.

4.2.2 Schematic Diagram. A typical diagram of a vertical, packaged unit for LOX/LN_2 is shown on Figure 8.

4.2.3 Vacuum Assembly. The vacuum assembly on the tanks consists of a filter, shutoff valve of the packless diaphragm type, coupling for attaching a portable vacuum pump, and a valved probe for the vacuum gage.

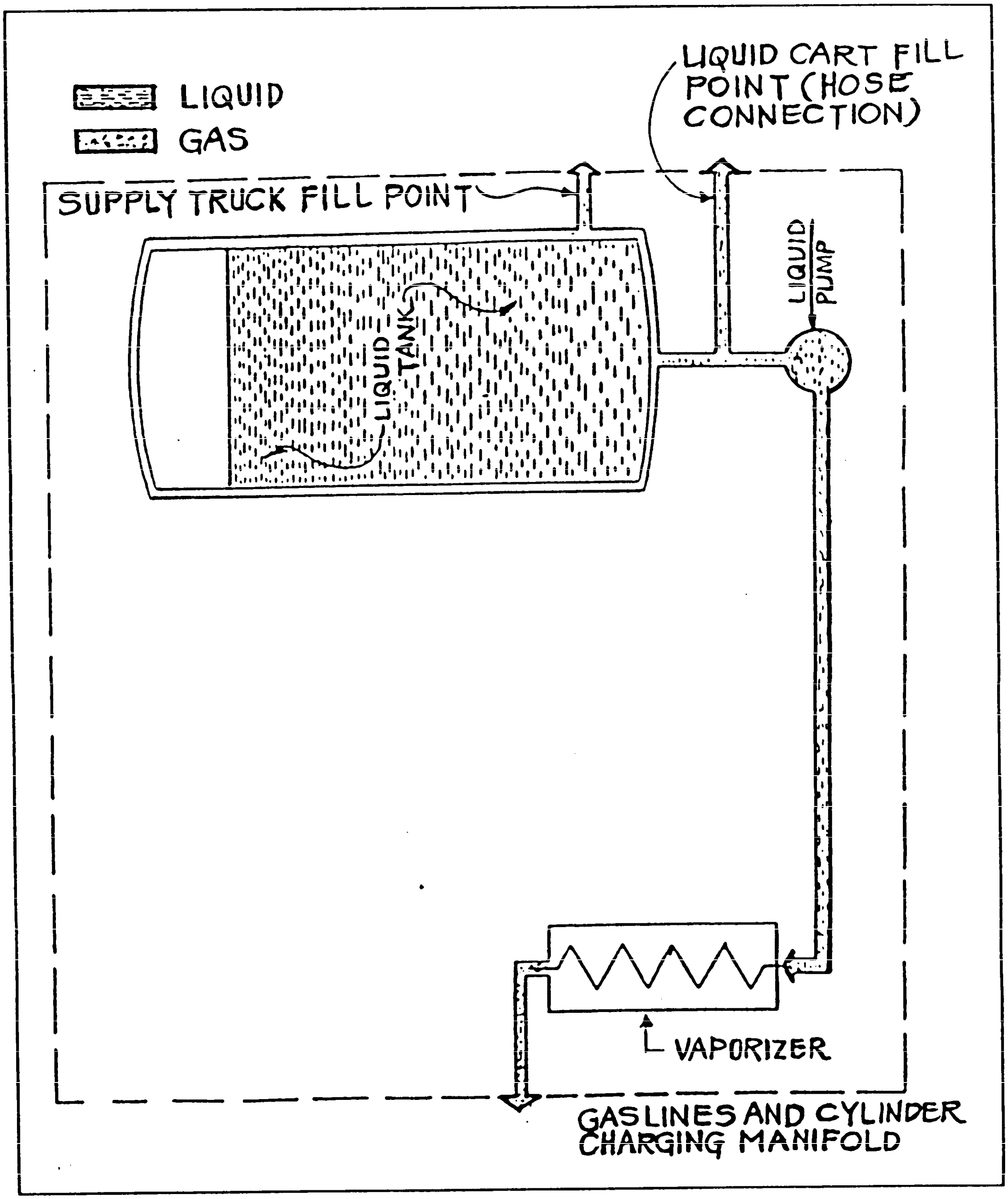


FIGURE 8
Schematic Flow Diagram (Typical) of
LOX/LN_2 Packaged Storage, Pump, and Vaporizing Unit

4.2.4 Service Equipment. Tanks are mounted outdoors and are normally replenished by commercial suppliers by way of tank truck. The supply tank trucks contain pumping equipment to discharge the liquid nitrogen or oxygen directly to the storage tanks.

4.3 Vaporizing System. The vaporizing system includes a liquid pump and a vaporizer. The liquid oxygen or nitrogen is pressurized by the pump for delivery to the vaporizer where it is evaporated in heat exchanger coils and then flows to either the oxygen-gas storage cylinders or to the mobile gas cylinder cart.

4.3.1 Transfer and Storage Facilities. At transfer and storage facilities, the vaporizing system is a part of the vertical, packaged unit used for LOX and LN_2. For a schematic flow diagram of the packaged unit, see Figure 8.

4.3.2 Generation Facilities. At LOX/LN_2 generation facilities separate vaporizer-pump units are used. The cryogenic fluid is transferred to these units by insulated hose. These vaporizer-pump units are provided as GFE by the Naval Air Systems Command.

4.4 Transfer System. The transfer system consists of the piping, connections, hoses, and manifolds necessary to transfer oxygen and nitrogen from the storage tanks to the cart fill point and the cylinder charge rack. For details of arrangement, see Facility Plate Nos. 141-87, Sheets 4A, 4B, and 5A. A flexible, insulated transfer hose, with quick couplings, is provided for LOX/LN_2 transfer. Hoses are provided as GFE by the Naval Air Systems Command.

4.5 Nitrogen and Oxygen Piping Systems.

4.5.1 LOX and LN_2 Piping. Handle LOX/LN_2 with extreme care because of the extremely low temperatures and high pressures. Oxygen reacts with fuels and certain other hydrocarbons to form a potentially explosive mixture. Nitrogen is inert, but in an enclosed space it can replace the oxygen in the air and cause suffocation. See Facility Plate No. 141-87, Sheets 1, 2, 3, 4A, 4B, 5A, 5B, and 5C, for LOX/LN_2 transfer and storage facility.

a) LOX/LN_2 Generation Facility. While actual requirements must be calculated for specific projects, the following guide may be used for planning purposes (based on the design concept for cryogenic fluid transfer which provides for the filling of 500-gallon liquid mobile tanks directly from the cryogenerator and the charging of gas servicing trailers and cylinders in the recharging area).

(1) Mechanical Requirements

Plumbing

Cold water	Maximum 36 gallons per minute (2.27 L per second) (Do not include fire protection requirements in this flow rate)

Hot water	30 gallon (113.6 L) Storage and 15 gallons per hour (56.8 L per hour) recovery
Indoor design	68^{o} F (20^{o} C)
Heating (1,000 Btu per hour (70 gram-calories per second))	347 for minus 5^{o} F (minus 19.45^{o} C); 300 for 5^{o} F (minus 15^{o} C); 251 for 15^{o} F (minus 9.44^{o} C); and 204 for 25^{o} F (minus 3.89^{o} C)
Outdoor design	Refer to NAVFAC P-89, Engineering Weather Data, for temperatures

(2) Electrical Requirements

Equipment power	585 kilowatts (kw) (8389 kilogram-calories per minute (kg-cal per min)) connected load; 526 kw (7543 kg-cal per min) demand load
Lighting	12 kw (172 Kg-cal per min) connected load; 11 kw (158 kg-cal per min) demand load
120 volt receptacles	10 kw (143.4 kg-cal per min) for connected load; 4 kw (57.4 kg-cal per min) for demand load
Total load	607 kw (8704.4 kg-cal per min) connected load; 541 kw (7758.4 kg-cal per min) demand load

(3) Area

Gross area without mechanical room	2195 squared feet (sq ft) (203.9 square meters (sq m)
Mechanical room	175 sq ft (16.3 sq m)
Gross area	2370 sq ft (220.2 sq m)

(4) Government-Furnished Equipment. Naval Air System Command (NAVAIRSYSCOM) will furnish the following equipment: LOX storage tanks, mobile 500 gallon (1,893 L); LN_2 storage tanks, mobile 500 gallon (1,893 L); LOX/LN_2 generator plant with installation drawings; LOX recharger; LN_2 recharger; and cryogenic piping, hoses, and fittings as required.

b) LOX/LN_2 Transfer and Storage Facility (Facility Plate 141-87). Bulk liquid tanks are a part of vertical packaged units used for storage, pumping, and vaporizing oxygen and nitrogen. The LOX and LN_2 cryogenic units shall be mounted on concrete foundations. These cryogenic units are 2,000 gallon (7,571 L) or less in capacity and contain cryogenic tank, vaporizer, pumps, valves, and safety devices. Facility plates show a tank transfer area for 150 O_2 and 150 N_2 high pressure cylinders. Modify storage area when gas transfer operations require the handling of significantly different number of gas cylinders. The actual automatic control level and piping arrangement in a given system depend on the specific needs of the facility. Wall anchors and chains shall be provided to prevent filled cylinders from being accidentally knocked over. Provide 25 cubic feet (0.708 cubic meters) gas reservoirs in accordance with Military Specification MIL-F-22606, Flask, Compressed Gas, and End Plugs; for Air, Oxygen, and Nitrogen, Class 5000, Service B. Provide reinforced masonry exterior walls, noncombustible roofs, structural steel framework, and minimum 50 feet (15.24 meters) practical turning radius for a semitrailer tank truck. While actual requirements must be calculated for specific projects, the following guide may be used for planning purposes.

(1) Disposal Area. In the disposal area detail of Facility Plate 141-87, Sheet 5B of 8, provide 12 inch (30.48 centimeters) deep sandbed for disposal area for contaminated products or accidental spills. Use washed concrete sand approximately 1/8-inch (0.3175-centimeter) diameter. Minimum volume of disposal pit shall be 200 cubic feet (5.664 cubic meters). Provide minimum 1 percent slope for surface drainage for the deck under the tank towards disposal pit.

(2) Deluge Shower and Eyewash Station. A deluge shower and eyewash station shall be provided adjacent to the bulk storage area, and shall be a nonfreeze type where required by climatic conditions. Ceiling type radiant electric heat may be provided in the transfer areas when the outdoor temperatures so dictate. Bulk oxygen installation locations are not hazardous per NFPA 70, Article 500, Hazardous (Classified) Locations. Therefore, general purpose or weatherproof types of electrical wiring and equipment are acceptable; however, all equipment shall be static grounded. The distance between oil filled transformers and bulk oxygen storage shall be a minimum of 25 feet. Provide exterior flood lighting for night operations when required.

(3) Mechanical Requirements

Plumbing

Cold water	Maximum 40 gallons per minute (151 L per min) (Do not include fire protection requirements in this flow rate)
Hot water	10 gallon (37.85 L) storage capacity electric water heater
Safety shower eyewash station	minimum available waterflow of 30 gpm (1.89 L per sec) at an inlet supply of 30 psi (21,093 kgs/m^2)

Heating

Indoor design	65° F (18.33° C) for shop area and test Lab; 25° F (minus 16.67° C) for transfer area
Outdoor design	Refer to NAVFAC P-89 for temperatures

(4) Electrical Requirements (Kilowatts)

Lighting	12 kw (172 kg-cal per min) connected load; 11 kw (157.7 kg-cal per min) demand load
Power	34 kw (487.56 kg-cal per min) connected load; 31 (444.54 kg-cal per min) demand load
Total load	46 kw (659.64 kg-cal per min) connected load; 42 kw (602.28 kg-cal per min) demand load

(5) Area

LOX/LN_2 disposal	1010 sq ft (93.83 sq m)
LOX/LN_2 bulk storage	1850 sq ft (171.87 sq m)
Cylinder storage and transfer	1160 sq ft (107.76 sq m)
Office, shops, and test laboratory	1280 sq ft (118.91 sq m)
Overhanging covered dock	580 sq ft (53.88 sq m)
Canopy covered walkway	260 sq ft (24.15 sq m)
Gross area	6140 sq ft (570.41 sq m)

(6) Cylinder Systems. A cylinder manifold shall have two banks of cylinders that alternately supply the piping system. Provide a pressure regulator for each bank. Connect cylinders to a common header. Each bank shall contain a minimum of an average day's supply unless normal delivery schedules require a greater supply. When the content of primary bank is unable to supply the system, the secondary bank shall automatically operate to supply the system. Cylinder systems may be provided with reserve supply to operate

automatically in the event that both primary and secondary supplies are unable to supply the system. Provide a check valve between each cylinder lead (pigtail) and the manifold header to prevent the loss of gas from the manifold cylinders in the event the pressure relief device on an individual cylinder functions or a cylinder lead fails.

b) Design Considerations. For facilities structural requirements, see MIL-HDBK-1190, Facility Planning and Design Guide; MIL-HDBK-1002/9, Masonry Structural Design for Buildings; and MIL-HDBK-1032/2, Covered Storage. For fire protection, see MIL-HDBK-1008A, Fire Protection for Facilities Engineering Design and Construction. For mechanical ventilation and air conditioning, see MIL-HDBK-1003/3, Heating, Ventilating, Air Conditioning, and Dehumidifying Systems.

4.5.2 Gaseous Oxygen and Nitrogen Piping. Piping for high pressure gaseous oxygen and nitrogen shall be as follows:

a) Material. Brass or copper piping is suitable for 3,000 psig (20,684 kPa gage) gaseous oxygen lines. Piping for all gaseous nitrogen shall be hydrostatically tested, seamless, austenitic stainless steel tube in accordance with American Society for Testing and Materials (ASTM) A269, Seamless and Welded Austenitic Stainless Steel Tubing for General Service. Brass and copper piping are of insufficient strength for the 5,000 psig (34,474 kPa gage) required for nitrogen. At new facilities, annealed austenitic stainless steel tubing is recommended for both the gaseous nitrogen and oxygen lines where economy is attainable in the purchase and installation of a single piping material. Mild steel is susceptible to corrosion in pure oxygen, whereas stainless steel, brass, and copper are resistant to corrosion.

b) Wall Thickness. The wall thickness of pipe or tubing should generally be adequate for a minimum working pressure of 3,000 psig (20,684 kPa gage) for oxygen and 5,000 psig (34,474 kPa gage) for nitrogen. Minimum standard wall thickness for seamless 304, 304L, 316, 317, 321, 347, and 348 austenitic stainless steel tube at 5,000 psi (34,474 kPa) working pressure are as follows:

Nominal tube OD in (mm)	Wall thickness in (mm)
3/8 (9.6)	0.058 (1.47)
1/2 (12.7)	0.083 (2.11)
5/8 (15.9)	0.095 (2.41)
3/4 (19.1)	0.120 (3.05)

CAUTION: To prevent accidental use of underrated stainless steel tubing at new or rehabilitated facilities, all tubing of the same nominal diameter shall have the same pressure rating. This pressure rating shall be for the highest pressure which a given size tube will encounter on the project.

c) Piping Connections. Piping connections for stainless steel tubing to valves, equipment, and other devices shall be flared tube fittings, and other connections for stainless steel tubing shall be either welded or flared tube fittings.

(1) Grip type fittings shall not be used on oxygen systems because of the explosion danger due to the possibility of an oxygen contact with an improper lubricant on the fitting. Also, grip type fittings shall not be used for nitrogen systems where the nitrogen is used for cleaning or purging oxygen equipment.

(2) All flared tube fittings shall be austenitic stainless steel in accordance with either MIL-F-5509, Fittings, Flared Tube, Fluid Connections, or MIL-F-18866, Fittings, Hydraulic Tube, Flared, 37-Degree and Flareless, Steel. These specifications shall be qualified so that the fittings shall have a minimum burst strength of 20,000 psig (1,378.96 kPa gage). To prevent interchanging these two types of fittings, all of the fittings for a single contract shall be of the same type.

(3) Whenever practical, fittings used for a modification to an existing system should be of the same type as in the rest of the system.

(4) Connections to copper and brass pipe shall be threaded connections with seal-welded threads, threaded connections made with polytetrofluoroethelene (PTFE) tape, or welded connections. Welded connections shall be in accordance with ANSI B31.

d) Valves. Valves on the high pressure gas lines shall be suitable for the system pressure, and shall be of the globe body type in order to minimize shock waves downstream of the valve when opened. Quick opening valves shall not be used.

e) Pressure Reducing and Relief Devices. A pressure relief valve or other safety device shall be located as close as practicable to the low pressure side of the pressure reducing valve. The safety device shall be in accordance with ANSI B31.

f) Cleaning. Comply with CGA G-4.1. All piping, valves, accessories, connections, and fittings contacting oxygen shall be thoroughly cleaned free of dirt, scale, flux, chips, grease, and other foreign materials before assembly. Wash in suitable solvents or detergent solution, rinse, and dry. (Do not use carbon tetrachloride for any cleaning operation. It is hazardous to health and also induces corrosion of metals.)

g) Installation Tests. After installation, hydrostatically test both oxygen and nitrogen piping systems (excluding tanks, pumps, vaporizer, cylinder charging manifold, gages, piping insulation, or other equipment which could be damaged) with oil-free water in accordance with applicable sections of ANSI B31. The only deviation from this specification is that the test pressure must be 150 psig (1,034 kPa gage) for the liquid lines and 1-1/2 times the maximum operating pressure for the gaseous lines.

(1) After the hydrostatic test, the system shall be thoroughly

cleaned as described previously, and then retested with dried water-pumped nitrogen pressurized to the design working pressure of the system. A solution of grease-free soap shall be applied to all joints, and any leaks shall be corrected.

(2) The compressed nitrogen shall then be allowed to stand in the system, and when the temperature has been equalized the pressure drop shall not exceed 1 percent in 24 hours for the high pressure gaslines and 5 percent in 6 hours for the liquid lines.

4.6 Building. Liquid oxygen and nitrogen facilities shall be permanent or semipermanent construction. A roof shall be provided over the transfer and cylinder storage areas and the loading platform. These areas shall be separated from the bulk tanks by a fire wall, but the other three sides shall be as open as possible to permit maximum natural ventilation. To accommodate an accidental spill of liquid oxygen or nitrogen, the pavement beneath the bulk tanks shall be sloped to drain into the liquid disposal areas. The driveways adjacent to storage and transfer areas and loading platform shall be portland cement concrete. Asphaltic concrete or other bituminous surfacing may be used for other paving so long as it is not within 50 feet of the bulk oxygen tanks. Floors in the storage transfer areas and in the generator building shall be concrete, and those in the shop and test laboratory shall have a dust-free surface such as vinyl tile. The development shall adhere to this military handbook, and to the Facility Plates of the prototype facilities as shown in Facility Plates Nos. 141-87, Sheets 1, 5A, 5B, and 5C.

4.6.1 Concrete. Concrete paving and floor slabs shall be as follows:

a) Except for joints, concrete pavement shall be constructed in accordance with NAVFAC Guide Specification (NFGS)-02520, Portland Cement Concrete for Roads and Airfields, for roads and vehicle parking. Concrete floor slabs shall be constucted in accordance with NFGS-03300, Cast in Place Concrete. Joints in concrete pavement and floor slabs shall be installed in accordance with NFGS-02561, Joints, Reinforcement, and Mooring Eyes in Concrete Pavements, except as follows: use ASTM D1752, Preformed Rubber and Cork Expansion Joint fillers for Concrete Paving and Structural Construction, joint filler containing no oils or bituminous materials. Joint filler shall be non-flammable.

b) Vapor barriers installed beneath concrete floor slabs shall be fabricated from polyethylene sheeting minimum 0.004 inch (0.10 millimeter) thick. Maintenance procedures shall keep cracks in concrete floors repaired with LOX compatible sealant.

c) Water stops when used below, at, or a foot above the level of the slab of the facility shall be of copper.

4.6.2 Fire Protection. Inside protection of the building shall be accomplished by portable fire extinguishers. A sprinkler system is not required. See MIL-HDBK-1008A.

a) One fire extinguisher of either carbon dioxide type 15 pound (7 kg) capacity or dry chemical type 20 pound (9 kg) capacity shall be provided in the work shop area.

b) Two 2-1/2 gallon (9.5 L) water pressurized extinguishers shall be provided for the transfer area.

c) At least two fire hydrants shall be provided and placed so that they are located at least 50 feet (15 meters) from any wall of the building, but not exceeding 250 feet (76 meters).

4.6.3 Generating Facilities. Facilities which include LOX/LN_2 generating equipment have the following additional requirements.

a) Heating. Use heat from a central heating plant or electric heaters. Do not use open-fired heaters that emit products of combustion.

b) Ventilation. Provide ventilation in the storage facilities and enclosed spaces of generating plants to prevent the accumulation of potentially dangerous oxygen or nitrogen concentrations. Use mechanical exhaust fans to give a positive means of exhausting the air. Although oxygen gas is about 10 percent heavier than air, it is not necessary to evacuate the air near the floor because oxygen rapidly diffuses into air. Provide a minimum of 10 air changes per hour.

4.7 Safety Clearances. The required clearances at storage, transfer, vaporizing, and generating facilities are as follows.

4.7.1 Storage, Transfer, and Vaporizing Facilities. The minimum clearance between the LOX/LN_2 facility and aircraft parking areas, fuel storage and transfer areas, and refueling areas shall be 100 feet (30 meters). The minimum clearance between LOX/LN_2 facilities shall be 50 feet (15.24 meters) for combustible buildings and 25 feet (7.5 meters) for noncombustible buildings. Enclosed the facility by a six feet (1.83 meters) high fence topped by 3 strands of barbed wire.

a) The minimum safety clearance between the LOX/LN_2 facility and automobile parking areas and thoroughfares shall be 25 feet (7.5 meters).

b) In the event that these external clearances cannot be obtained at existing air stations, a specific waiver can be granted by NAVFAC to reduce these clearances. Depending on the particular conditions involved, alternate protective measures will normally be required.

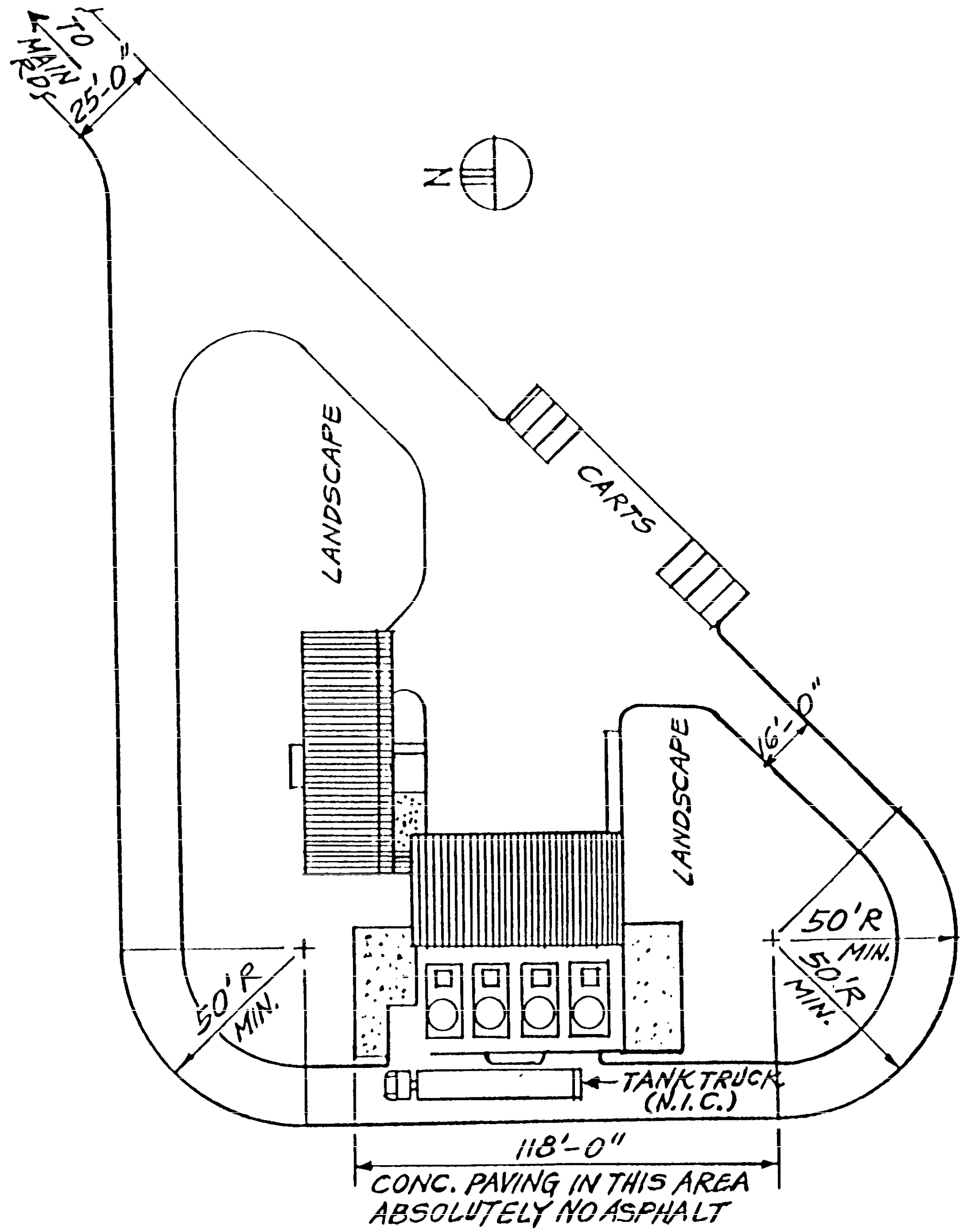
4.7.2 Generating Facilities. Due to the explosion hazard, a minimum clearance of 200 feet (61 meters) shall be maintained between the LOX/LN_2 generating facilities and the aircraft and automobile parking areas, fuel storage and transfer areas, refueling areas, power plant buildings, central heating plant buildings, shops with processes producing hydrocarbon vapors or gases and similar facilities that might produce atmospheric contamination. Generation facilities should be located upwind of previously mentioned hazards.

a) To preclude the production of contaminated gases, the LOX/LN_2

generating facility shall be located as far as possible and as high as practical from the above-cited atmospheric contamination sources, and also from swamps, dumps, or other odor producing areas.

b) The facility shall be located upwind from any contaminated or odor producing source. The facility shall be located in an area where future construction is assured free from atmospheric contamination or odors. Future construction in the vicinity shall be restricted to clean operations.

c) A minimum clearance of 75 feet (23 meters) shall be maintained between the facility and any thoroughfare. This clearance shall be ensured by means of a suitable fence. Details for the installation, maintenance, and operation of the generators are furnished with the equipment.



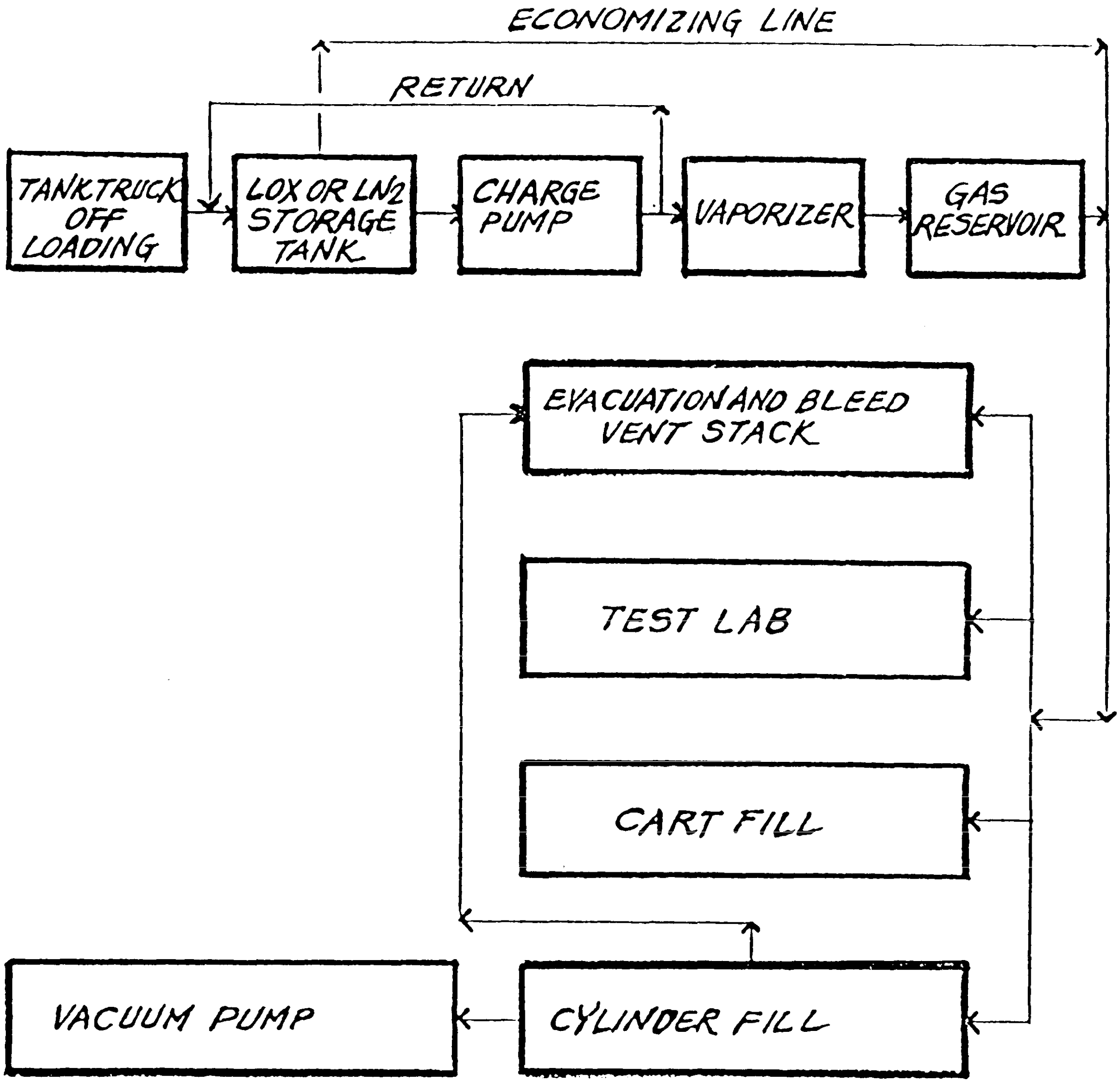
PLOT PLAN
SCALE: NONE

TITLE LOX/LN_2 Transfer and Storage: Facility: Plot Plan	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 1 of 8

LEGEND

- PROCESS LINE
- ELECTRICAL INSTRUMENTATION AND CONTROL LINE
- PNEUMATIC SIGNAL LINE
- AUTOMATIC CONTROL VALVE
- CHECK VALVE
- (S) SOLENOID VALVE (SOV); FO: FAIL OPEN POSITION; FC: FAIL CLOSED POSITION
- (FT) FLOW TRANSMITTER ON FIELD BOARD
- (FE) IN-LINE FLOW ELEMENT
- (HS) FIELD OVERRIDE HAND SWITCH AT SOLENOID VALVE
- (PE) IN-LINE PRESSURE ELEMENT
- (PT) PRESSURE TRANSMITTER ON FIELD BOARD
- (PI) LOCAL PRESSURE INDICATOR
- (MS) ELECTRIC MOTOR STARTER
- (PC) MULTIPLE CHANNEL MICROPROCESSOR BASED PROGRAMMABLE CONTROLLER WITH BUILT-IN PID LOOP FUNCTIONS
- (M) ELECTRIC MOTOR
- (I/O) ON-OFF SWITCH
- (I/P) ELECTRICAL TO PNEUMATIC SIGNAL CONVERTER
- (LLE) LIQUID LEVEL ELEMENT
- (LLT) LIQUID LEVEL TRANSMITTER ON FIELD BOARD
- (LLA) H/L LIQUID LEVEL HIGH AND LOW ALARM TO PC IN CONTROL CENTER
- RELIEF VALVE
- VACUUM RUPTURE DISC

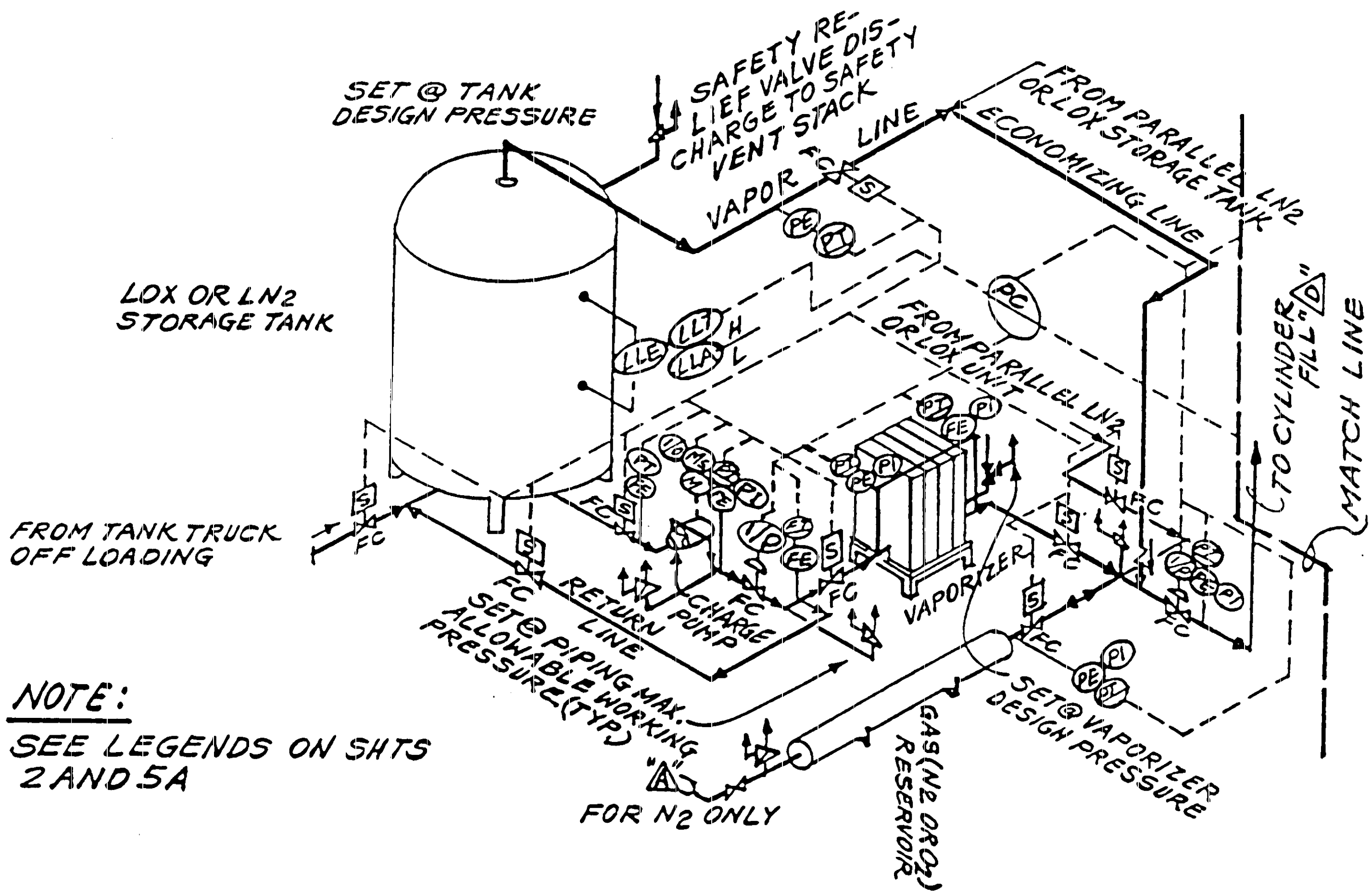
TITLE LOX/LN_2 Transfer and Storage: Facility: Legend	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 2 of 8



BLOCK FLOW DIAGRAM

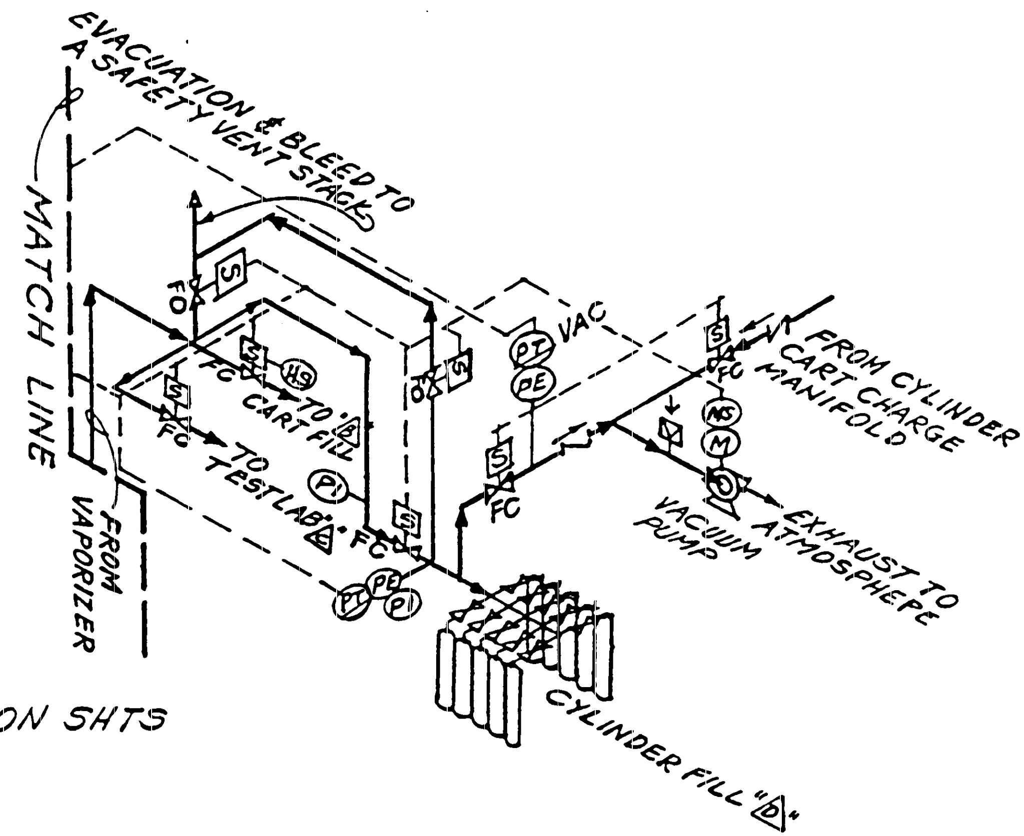
TYP. LOX OR LN2 UNIT - SCALE: NONE

TITLE LOX/LN_2 Transfer and Storage: Facility: Block Flow Diagram	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 3 of 8



AUTOMATIC CONTROL & PIPING DIAG. (PARTIAL)
SCALE: NONE

TITLE LOX/LN_2 Transfer and Storage Facility: Automatic Control and Piping Diagram (Partial)	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 4A of 8



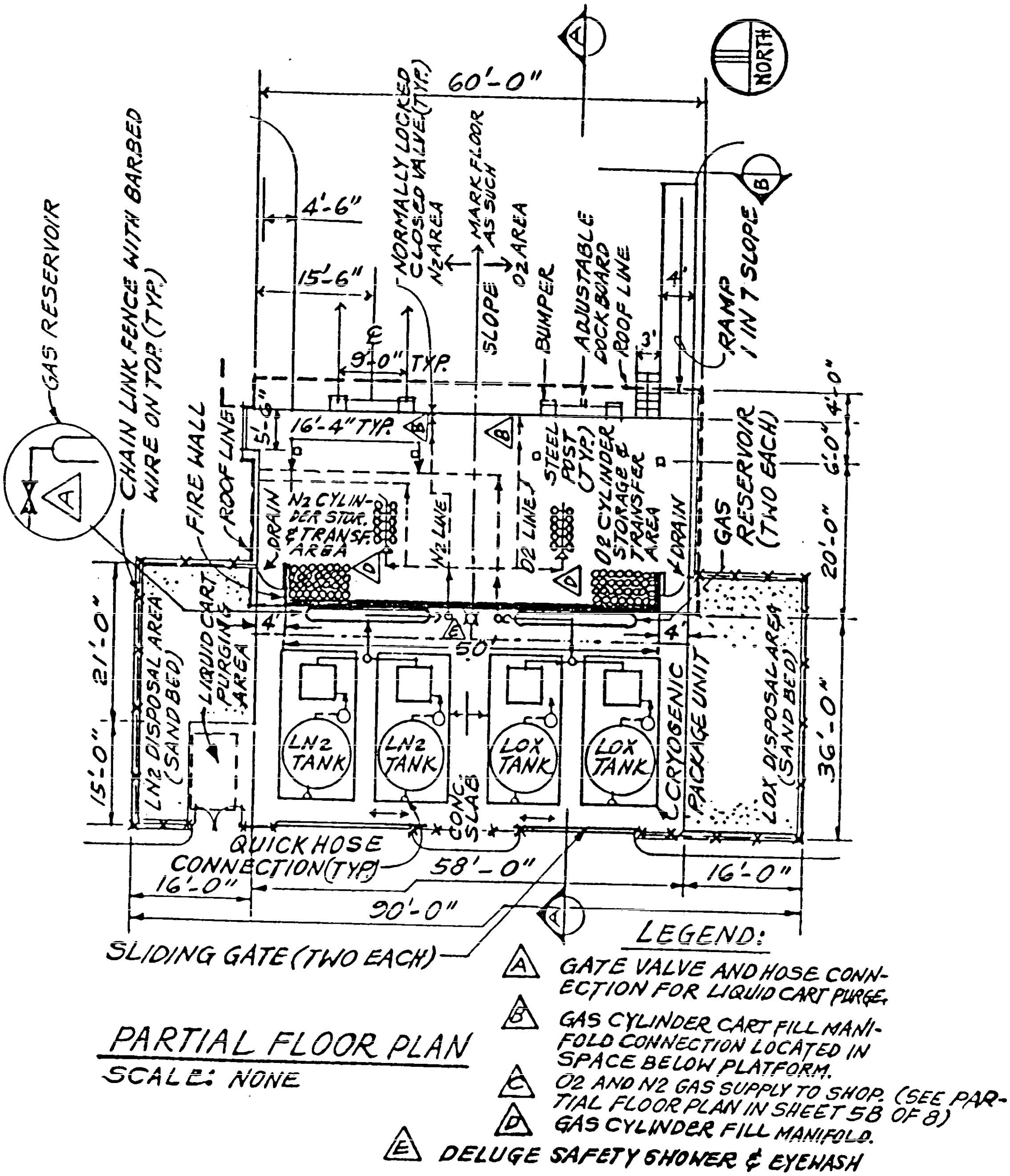
NOTE:

SEE LEGENDS ON SHTS 2 AND 5A

AUTOMATIC CONTROL & PIPING DIAG. (PARTIAL)

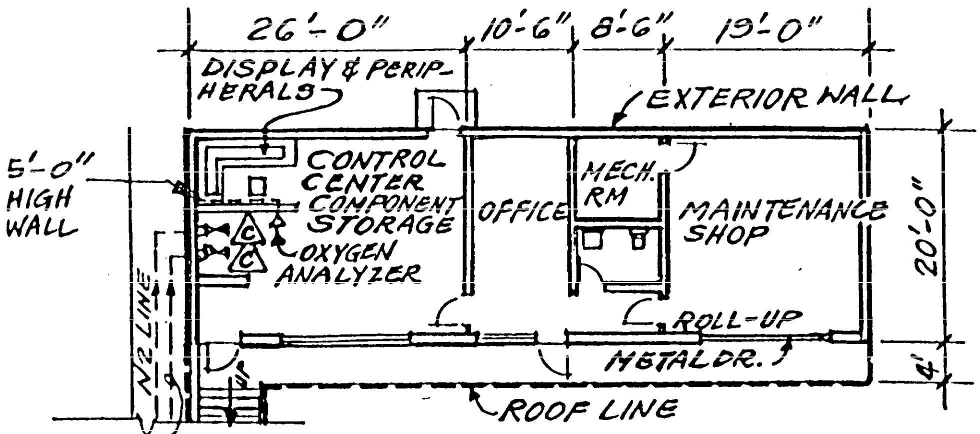
SCALE: NONE

TITLE	DATE	FACILITY PLATE NO.	Sheet
LOX/LN_2 Transfer and Storage Facility: Automatic Control and Piping Diagram (Partial)	03/91	141-87	4B of 8

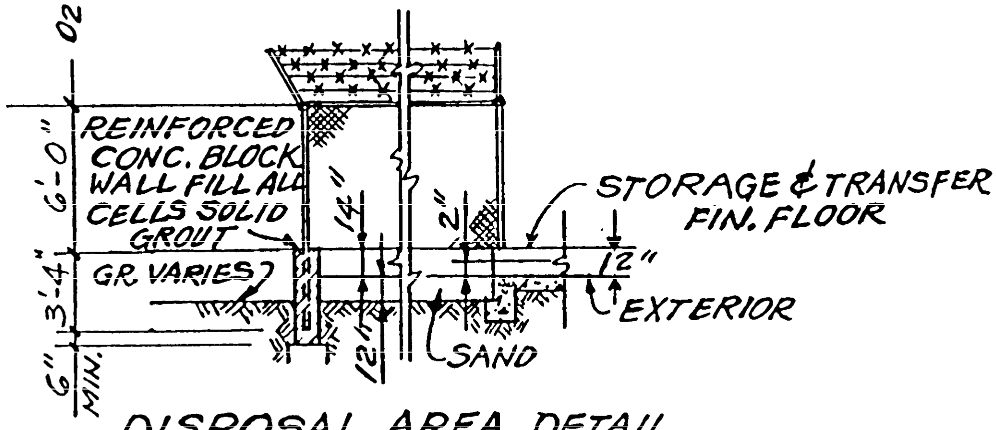


PARTIAL FLOOR PLAN
SCALE: NONE

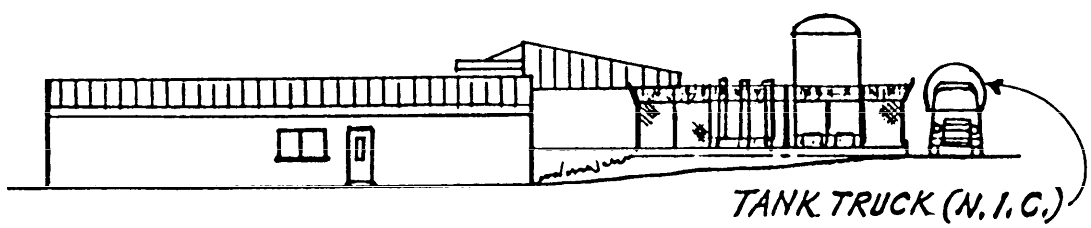
TITLE LOX/LN_2 Transfer and Storage: Facility: Pertial Floor Plan	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 5A of 8



PARTIAL FLOOR PLAN
SCALE: NONE

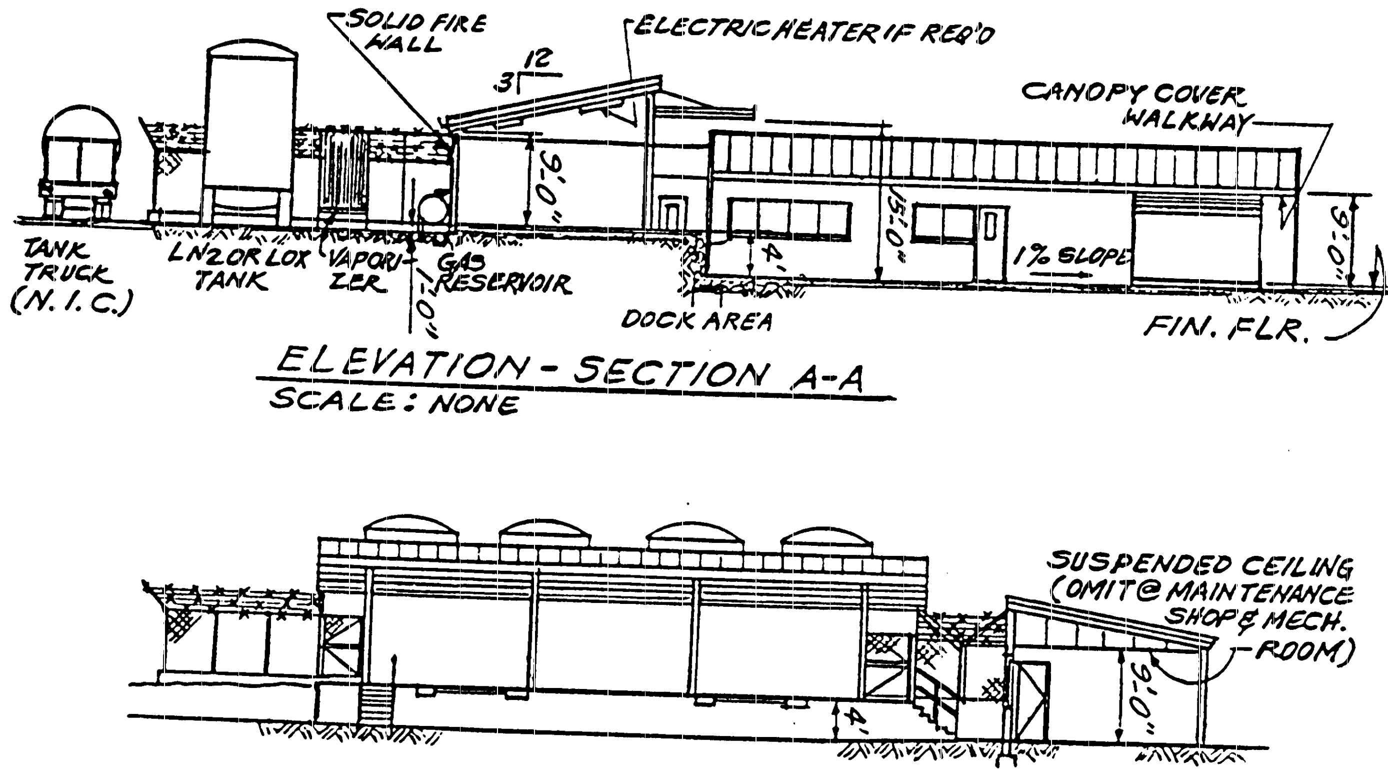


DISPOSAL AREA DETAIL
SCALE: NONE



NORTH ELEVATION
SCALE: NONE

TITLE LOX/LN2 Transfer and Storage: Facility: Pertial Floor Plan Detil, and North Elevation	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 5B of 8



ELEVATION - SECTION A-A
SCALE: NONE

ELEVATION - SECTION B-B
SCALE: NONE

TITLE LOX/LN_2 Transfer and Storage Facility: Elevation Sections A-A and B-B	DATE 03/91	FACILITY PLATE NO. 141-87	Sheet 5C of 8

REFERENCES

NOTE: Unless otherwise specified in the text, users of this handbook should utilize the latest revisions of the documents cited herein.

FEDERAL/MILITARY SPECIFICATIONS, HANDBOOKS, NAVFAC GUIDE SPECIFICATIONS, AND NAVFAC P-PUBLICATION:

The following specifications and handbooks form a part of this document to the extent specified herein. Copies are available from Standardization Documents Order Desk, Building 4 D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FEDERAL SPECIFICATION

O-C-101 Calcium Carbide

MILITARY HANDBOOKS (MIL-HDBK)

MIL-HDBK-1002/9 Masonry Structural Design for Buildings

MIL-HDBK-1008A Fire Protection for Facilities Engineering Design and Construction

MIL-HDBK-1028/1 Aircraft Maintenance Facilities

MIL-HDBK-1032/2 Covered Storage

MIL-HDBK-1190 Facility Planning and Design Guide

MILITARY SPECIFICATIONS (MIL)

MIL-F-5509 Fitting, Flared Tube, Fluid Connection

MIL-F-18866 Fitting, Hydraulic Tube, Flared, 37 Degree and Flareless, Steel

MIL-F-22606 Flask, Compressed Gas, and End Plugs; for Air, Oxygen, and Nitrogen

NAVFAC GUIDE SPECIFICATIONS

NFGS-02520 Portland Cement Concrete for Roads and Airfields

NFGS-02561	Joints, Reinforcement, and Mooring Eyes in Concrete Pavements
NFGS-03300	Cast in Place Concrete

NAVFAC P-PUBLICATION

P-89	Engineering Weather Data

NON-GOVERNMENT PUBLICATIONS:

The following publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the Department of Defense Index of Specifications and Standards (DODISS).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B31	Code for Pressure Piping

(Copies are available from American National Standards Institute, 1430 Broadway, New York, N.Y. 10019, (212) 302-1286.)

AMERICAN SOCIETY FOR TESTING AND MATERIAL (ASTM)

ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
ASTM D1752	Preformed Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

(Copies are available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, (215) 299-5400.)

COMPRESSED GAS ASSOCIATION, INC.

CGA C-13	Guidelines for Periodic Visual Inspection and Requalification of Acetylene Cylinders
CGA G-1.2	Recommendations for Chemical Acetylene Metering
CGA G-4.1	Cleaning Equipment for Oxygen Service
CGA G-4.4	Industrial Practices for Gaseous Oxygen

	Transmission and Distribution Piping Systems
CGA V-1	Compressed Gas Cylinder Valve Outlet and Inlet Connections

(Copies are available from Compressed Gas Association, Inc., Crystal Gateway 1, Suite 501, 1235 Jefferson Davis Highway, Arlington, VA 22202, (703) 979-0134.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 50	Bulk Oxygen Systems at Consumer Sites
NFPA 51	Oxygen-Fuel Gas Systems for Welding and Cutting
NFPA 51A	Acetylene Cylinder Charging Plants
NFPA 70	National Electrical Code

(Copies are available from National Fire Protection Association, One Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101)

GLOSSARY

Acetylene. A colorless, extremely flammable or explosive gas, C_2H_2, used as illuminant and for metal welding and cutting.

Calcium Carbide. A chemical manufactured by the reduction of high quality lime by the carbon of selected cokes in high temperatures of the carbide electric furnacing process.

Oxyacetylene. A mixture of oxygen and acetylene used in metal welding and cutting torches.

Oxygen. A colorless, tasteless, odorless gaseous element constituting 21 percent of the atmosphere by volume and essential to most combustion and combustive processes; atomic number 8; atomic weight 15.999.

Nitrogen. A colorless, odorless, almost inert, gaseous element constituting nearly 80 percent of the atmosphere by volume; atomic number 7; atomic weight 14.007.

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PREPARING ACTIVITY
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PROJECT NO.
FACR-1000

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-HDBK-1024/3	2. DOCUMENT DATE (YYMMDD) 91/03/15

3. DOCUMENT TITLE
OXYCETYLENE AND NITROGEN AND BREATHING OXYGEN FACILITIES

4. NATURE OF CHANGE (*Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.*)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (*Last, First, Middle Initial*)	b. ORGANIZATION	
c. ADDRESS (*Include Zip Code*)	d. TELEPHONE (*Include Area Code*) (1) Commercial (2) AUTOVON (*If applicable*)	7. DATE SUBMITTED (*YYMMDD*)

8. PREPARING ACTIVITY

a. NAME Commander Western Division, Code 467.2	b. TELEPHONE (*Include Area Code*) (1) Commercial (415) 244-3331 (2) AUTOVON
c. ADDRESS (*Include Zip Code*) Naval Facilities Engineering Command San Bruno, CA 94066-0720	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340

DD Form 1426, OCT 89 *Previous editions are obsolete.* 198/290