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MILITARY SPECIFICATION

TANK, STORAGE, LIQUID OXYGEN TMU-24/E

1. SCOPE

1.1 This specification covers a skid-mounted, 400-gallon tank for air transport and storage of liquid oxygen, designated TMU-24/E.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

0-T-634	Trichloroethylene, Technical
HH-I-551	Insulation Block, Pipe Covering and Boards, Thermal (Cellular Glass)
UU-T-81	'Tags, Shipping and Stock
PPP-T-60	Tape, Pressure-Sensitive Adhesive, Waterproof, for Packaging

Military

MIL-C-104	Crates, Wood, Lumber and Plywood Sheathed, Nailed and Bolted
MIL-P-116	Preservation, Methods of
MIL-V-173	Varnish, Moisture- and Fungus -Resistant (for the Treatment of Communications, Electronic, and Associated Electrical Equipment)
MIL-P-514	Plates, Identification, Instruction and Marking, Blank
MIL-R-3065	Rubber, Fabricated Parts
MIL-C-3767/12	Connector, Plug, Electrical (Power, Three-Wire, Polarized, Spring-Loaded Pivoted, Grounding Type) Type UP131M
MIL-T-5021	Tests, Aircraft and Missile Welding Operators, Qualifications
MIL-I-6866	Inspection, Penetrant Method of
MIL-I-6868	Inspection Process, Magnetic Particle
MIL-A-8421	Air Transportability 'Requirements, General Specification for
MIL-R-13689	Reflectorized Sheeting, Adhesive (Retro-Reflective)
MIL-H-27301	Hose Assembly, Metal, Cryogenic Liquid Transfer
MIL-P-27456 .	Purging Unit, Air, Liquid Oxygen Storage Tanks GSU-62/M
MIL-T-27730	Tape, Antiseize, Tetrafluoroethylene, with Dispenser

FSC 3655

STANDARRDS

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U, S. Military Property
MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-808	Finishes, Protective, and Codes for Finishing Schemes for Ground and Ground Support Equipment
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment
MIL-STD-831	Test Reports, Preparation of
MIL-STD-838	Lubrication of Military Equipment
MIL-STD-1186	Cushioning, Anchoring, Bracing, Blocking, and Waterproofing, with Appropriate Test Methods
MS33586	Metals, Definition of Dissimilar
MS33656	Fitting End, Standard Dimensions for Flared Tube Connection and Gasket Seal

Air Force-Navy Aeronautical

AN929	Cap Assembly, Pressure Seal, Flared Tube Fitting

DRAWINGS

Ordnance Corps

C8987830	Assembly, LOX Coupling, Male Half, All Sizes
C8987831	Assembly, LOX Coupling, Female Half, AU Sizes
B8987832	Gasket, LOX and LN2, All Sizes
B8987839	Ring, Retaining, LOX and LN2, All Sizes
C8987855	Seat, LOX Coupling, 1 Inch
C8987856	Cone, LOX Coupling, 1 Inch
C8987857	Nut, LOX Coupling, 1 'Inch
C8987869	LOX Cap, 1 Inch
C8987870	LOX Plug, 1 Inch

Air Force

48B7796	Ring Assembly-Tiedown, 10,000 Pounds
59C6671	Hose, Transfer-Cryogenic Liquid, Assembly of
66C1627	Fitting Assembly - Vacuum Disconnect

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications, The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation forbids or request for proposal shall apply.

American Society of Mechanical Engineers

ASME Boiler and Pressure Vessel Code

" Section VIII Unfired Pressure Vessels

(Application for copies should be addressed to the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.)

3. REQUIREMENTS

3.1 Preproduction. This specification makes provisions for preproduction testing.

3.2 Components. The tank shall consist of the following major components:

Item Name	See Requirement
Liquid storage tank assembly	3.8.1
Control housing assembly	3,8.2
Skid base	3.8,3,

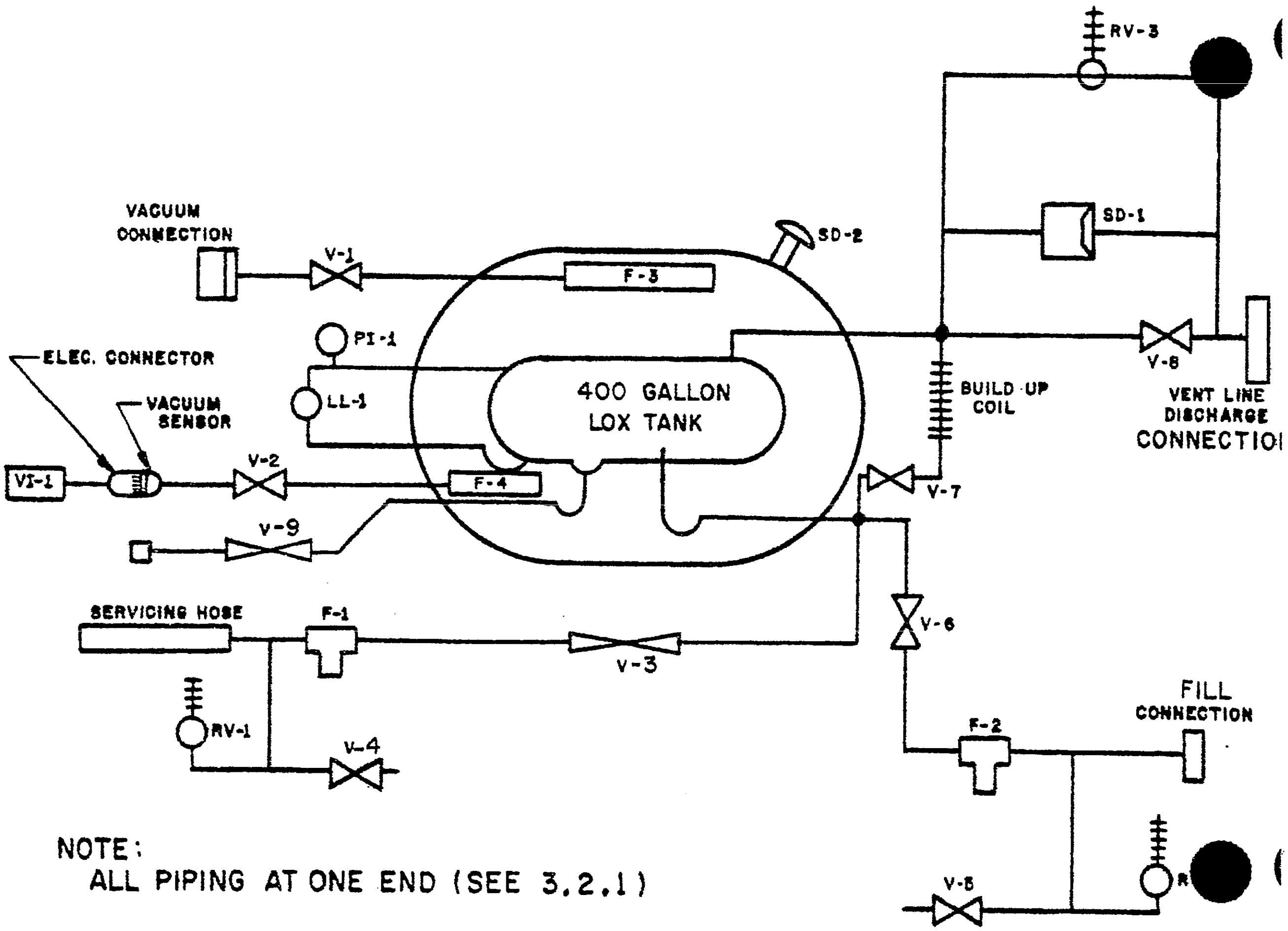
3.2.1 Component schematic. Figure 1 is a component schematic of the tank lines, valves, relief devices, and instruments, The piping is shown on both ends for illustration purposes only. The actual tank design has all components with exception of the outer shell relief device located on one end of the tank.

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

3.4 Materials

3.4.1 Fungusproof materials. Materials that are nutrients for fungi shall not be used where it is practical to avoid them. Where used and not hermetically sealed, they shall be treated with varnish conforming to MIL-V-173. Fungicidal treatment will not be necessary for materials used in a hermetically sealed enclosure,

3.4.2 Metals. Wherever practicable, lightweight metals shall be used in the construction the tank. Metals shall be of the corrosion-resistant type or treated to resist corrosion due to the environmental conditions specified in 3.7.5.1 through 3.7.5.8.



SD-1 INNER SHELL SAFETY HEAD
SD-2 OUTER SHELL SAFETY HEAD
F-1 SERVICING LINE FILTER
F-2 FILL-DRAIN LINE FILTER
F-3 VACUUM FILTER (POWDER INSULATED TANKS)
F-4 VACUUM INDICATOR FILTER (POWDER INSULATED TANKS)
LL-1 TANK LIQUID LEVEL INDICATOR
PI-1 VAPOR PHASE PRESSURE GAGE
RV-1 SERVICING LINE PRESSURE RELIEF VALVE
RV-2 FILL-DRAIN LINE PRESSURE RELIEF VALVE
RV-3 INNER SHELL PRESSURE RELIEF VALVE
V-1 VACUUM LINE SHUTOFF VALVE
V-2 VACUUM INDICATOR SHUTOFF VALVE
V-3 SERVICING LINE SHUTOFF VALVE
V-4 SERVICING LINE DRAIN VALVE
V-5 FILL-DRAIN LINE DRAIN VALVE
V-6 FILL-DRAIN LINE SHUTOFF VALVE
V-7 PRESSURE BUILD-UPC CONTROL VALVE
V-8 VAPOR VENT LINE SHUTOFF VALVE
V-9 SUMP DRAIN LINE SHUTOFF VALVE
VI-1 ANNULAR SPACE VACUUM INDICATOR

*FIGURE 1. Component Schematic

3,4,2.1 Chilled surfaces. All metallic surfaces of the tank that contact high-purity oxygen or that are in a location where they will be chilled sufficiently during operation to cause condensation of moisture from the atmosphere shall be fabricated from corrosion-resistant materials that require no paint or other organic chemical coatings to protect them from corrosion.

3.4.2.2 Dissimilar metals. Unless protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MS33586.

3,4,3 Gasketing and insulating materials, Plastic, rubber, or similar gasketing and insulating materials shall be compounded to insure their suitability for the intended application and, where applicable, their resistance to hydrocarbons Or low temperatures.

* 3.4.3.1 Nonmetallic components. Packings, gaskets, seals, and other nonmetallic components that come into contact with high-purity oxygen shall be compounded of materials compatible with use in a pure oxygen or nitrogen atmosphere under the conditions to which they will be subjected, and that are not adversely affected or deteriorated by continued use in an oxygen or nitrogen atmosphere. Polytetrafluoroethylene gasketing material for other than the 138987832 gasket shall be impregnated with not less than 25 percent pulverized glass fiber filler to improve its dimensional stability under compression,

3,4.4 Rubber goods. All rubber goods, such as door seals, et cetera, shall be fabricated from rubber compounds conforming to MIL-R-3065 to insure their resistance to ozone attack,

* 3.4.5 Combustible materials. Readily combustible materials shall not be used.

3,5 Design. The tank shall be a complete, self-contained, liquid oxygen transport and storage unit, including all parts, controls, instruments, and accessories, designed for:

a, Being filled with liquid oxygen at a supply location

* b. Being air transported while filled with liquid oxygen and pressurized to 50 psig (see 6.3)

c. Storing the liquid with low evaporation loss rates during transport and at destination until needed, and at that time transferring the liquid into smaller servicing containers.

* 3.5.1 Reliability, The tank shall have a MTBF of not less than 21 servicing cycles at 0.9 confidence, (See 6.4.1 and 6.4.2.)

3.5.2 Maintainability. Parts and assemblies shall be located and mounted to provide adequate clearance for repair and other maintenance and, wherever practicable, to allow removal and replacement of failed parts or assemblies without removing disconnecting any parts or assemblies other than mounting bolts or fasteners, panels or covers, or tubing and control cables to the part or assembly being removed.

3.5.2.1 Operating clearances. To the maximum practicable extent, maintainability provisions shall incorporate features insuring operating clearance for facilitating maintenance and servicing at low ambient temperatures by personnel wearing heavy gloves or mittens and handicapped by bulky clothing and footgear.

3.5.2.2 Intricate devices. Intricate locking devices, controls, and threaded fastenings that can be easily overtorqued by personnel lacking feel through thick gloves or numbness shall be avoided where possible.

3.5.2.3 Cover or plate fasteners. Covers or plates that must be removed for component adjustments or for component or part removal shall be equipped with substantial quick-disconnect fastenings,

3.5.3 Transport acceleration forces. The tank shall be designed to withstand the transport acceleration and vibration forces specified in 3.7.4.1 through 3.7.4.3,

3.5.4 Lifting and tiedown provisions

3.5.4.1 Forklift provisions. The tank design shall incorporate provisions which will permit lifting and handling of the complete, filled tank by forklift trucks.

* 3.5,4.2 Hoisting and tiedown attachment devices, Tiedown devices for compliance with MIL-A-8421 shall be provided. These shall include four or more tiedown ring assemblies conforming to Drawing 48B7796. The tiedown devices shall serve for both tiedown and hoisting, and shall permit hoisting of the complete, assembled tank filled to design capacity with liquid oxygen, considering vertical accelerations of 3g. The rings shall be so located on the tank that transportation personnel can easily rig safe slings from common cable and spreader bar components for hoisting by a single-hook, overhead crane.

3.5.5 Liquid loss. The tank shall be designed to insure the minimum practicable loss of oxygen for purging, cool-down, pressure building, et cetera.

3.5.6 Common parts. The tank shall be designed to provide for the maximum practicable interchangeability of hardware and fastening devices by using the minimum number of types and sizes of bolts, screws, nuts, washers, and other common hardware.

3.5.7 Detachable fittings. Wherever practicable, the tank shall be designed to include readily detachable- and attachable-type fittings in the liquid and vapor lines to permit rapid component removal and replacement, Disconnect points shall be clearly indicated and identified.

3,5,8 Protective covers. All cover plates, gaskets, and fittings necessary for protection of contained apparatus during operation, storage, and shipment of the tank shall be provided.

3,5.9 Cold weather operation. The tank shall be designed for full operational use in any ambient temperature (see 6.4.3) between -65° and +125°F without special provisions for winterization.

* 3.5.10 Lubricants. The tank shall be designed to fully comply with the requirements specified herein when components needing lubrication are serviced with military specification or federal specification lubricants in accordance with MIL-STD-838.

3.6 Construction. The tank shall be constructed to withstand the strains, shocks, vibrations, and other detrimental conditions incident to operation, maintenance, shipping, and storage with minimum loss of service time for maintenance, repair, and periodic servicing.

3.6,1 Foolproofness. Where improper installation of an item could cause malfunctioning of that item or the system in which it is installed, an unsymmetrical mounting means shall be provided. This mounting shall be so designed that the item can only be installed in its proper operating position,

* 3,6,2 Component mounting, Components that need not be removed or repositioned for use shall be securely mounted to the liquid storage tank assembly or other major components in a manner that will insure against damage or unnecessary movement during operation and transport. All subbases and other fixtures needed for safe and secure component mounting shall be provided and installed.

3.6,3 Tubing and lines. Tubing and lines shall be located in protected positions, securely fastened to frame or body structures, and provided with metal protective loom or grommets at each point where they pass through members, except where a through-the-frame connector is provided,

3.6.4 Pressure vessels. Unless otherwise specified herein, the liquid storage tank assembly, piping, and connections thereto shall be fabricated in accordance with section VIII of the ASME Boiler and Pressure Vessel Code.

3.6.5 Control panel. A control panel shall be provided, and shall be of sufficient size for installation of the instruments and controls used in normal operation of the tank. It shall be so installed on the tank that all instruments, controls, et cetera, mounted thereon will be readily visible and accessible to an operator standing on the ground in front of the control panel. All valve handles and gage faces shall be not less than 27 inches above ground level. Whenever practicable, instruments that must be monitored in making a control or adjustment action shall be so located that an operator or maintenance man can simultaneously make the control or adjustment action and see and adequately read the related instrument.

3,6.5.1 Control panel protection. The control panel shall be protected by a pandar door when the tank is not in use for liquid transfer, The control panel shall be so mounted or recessed into the control housing assembly that it will be shielded from rain and snow when the door or panel is open,

3.6.6 Controls, instruments, and accessories. All automatic and manual controls, instruments, fittings, safety devices, and accessories needed for safe and efficient operation of the tank shall be provided.

3,6,6.1 Instruments, All instruments necessary for indicating the information needed in controlling the equipment and determining its performance shall be securely mounted on the control panel.

3.6.6.2 Controls. Insofar as practicable, all manually operated controls used in normal operation of the equipment shall be located on the control panel,

* 3.6.6,3 Installation, The controls, pressure gages, and instruments shall be installed in locations where they will not be contacted by liquid leaking from lines or connections and where water cannot drip on them as a result of vapor condensing on cold lines.

3.6.7 Parts fabrication. Sheet-metal parts shall be of such thickness, rigidity, and strength as to withstand dents, warping, vibration, radiated heat, et cetera, encountered in service and maintenance and under the conditions specified herein.

3.6.8 Locking devices. Where practicable, all screws, pins, bolts, et cetera, ' be equipped with locking devices. Safety wire, self-locking nuts, cotter pins, lockwashers, et cetera, will be acceptable. Where practicable, lockwashers shall be secured to bolts or screws. Cotter pins shall be of a type fabricated from corrosion-resistant steel or other corrosion-resistant material.

3.6.9 Thread sealer. Tape conforming to MIL-T-27730 or other pipe thread sealing materials specifically approved by the procuring activity shall be applied to threads prior to assembly of all pipe threaded fittings subject to contact by liquid or gaseous oxygen. The tape shall be applied starting with the third thread to prevent contaminating the system.

3.6.10 Cleaning solvent drains. Provisions shall be included to insure that cleaning solvent and flushing liquids can be readily and thoroughly removed from the liquid storage tank assembly, from the pressure buildup system, and from the associated tank piping and components following cleaning operations. Readily removable and replaceable threaded plugs or similar devices may be used in locations where it would be impractical to provide drain valves.

3.6.11 Pressure relief devices. Pressure relief devices shall be provided in any line or component that can be so isolated by closing valves, or otherwise, that dangerous pressures could develop. All pressure relief devices shall be installed at readily accessible locations. Provisions shall be incorporated to insure discharge of pressure without damage to equipment or danger to personnel. Safety valves shall be sized and selected in accordance with section VIII of the ASME Boiler and Pressure Vessel Code.

3.6.12 Special operation and maintenance tools. When specified (see 6,2), a complete set of all special tools other than common handtools required for proper operation and maintenance of the tank and its components shall be provided.

3.6,13 Certification of welders, All welding shall be accomplished by welders certified in accordance with MIL-T-5021, class A.

3.7 Performance. The tank shall meet the requirements specified herein when tested in accordance with the test methods specified under 4,6.

3.7.1 Storage capacity. The tank shall store or transport under the conditions specified herein not less than 400 U. S, gallons of 99.5 percent pure liquid oxygen at its atmospheric pressure boiling temperature. The liquid storage tank assembly shall have an internal volume of not less than 440 U. S. gallons in order to provide an expansion (vapor) space of not less than 10 percent of the total design capacity.

3.7.2 Heat leak evaporation rate. The tank heat leak evaporation loss shall not exceed the equivalent of 19 pounds of oxygen per 24-hour day when:

a. The liquid storage tank assembly inner shell is filled to not less than 50 percent of design capacity with liquid oxygen or liquid nitrogen at atmospheric pressure

b. The tank is in a location where the ambient temperature is not less than 125°F

c. The upper surface of the tank is continuously exposed to solar or equivalent heat radiation of 100 to 120 watts per square foot for not less than 8 hours each day

d. Not less than 30 days have elapsed since evacuation of the tank annular insulation space

* e. The tank has been subjected to all nondestructive tests specified herein.

3.7.3 Vacuum retention. The liquid storage tank assembly annular insulation space absolute pressure shall not show any increase attributable to leakage or outgassing within 7 days (168 hours) when:

a. Prior to the 7-day test period, the annular insulation space is evacuated to the absolute pressure necessary for compliance with the performance requirements of 3.7.2 and the tank is subjected to the transportability and handling tests specified in 4.6.8.1, 4.6.8.4, and 4,6.8.5

b. The vacuum line is sealed after evacuation to prevent further evacuation proof to completion of the 7-day test period and the final absolute pressure measurement

c. The vacuum retention testing specified under 4.6.9 is accomplished during the 7-day test period

d. The tank inner shell is pressurized to not less than 30 psi with oxygen or nitrogen gas throughout the 7-day test period

e. The tank is subjected to ambient temperatures throughout the test period,

3.7.4 Air transportability

3.7.4.1 Flight and taxiing acceleration forces, The tank shall withstand the air transport flight and taxiing acceleration forces specified in MIL-A-8421, except the lateral loads shall be 3g instead of 1.5g, when empty or filled with liquid oxygen to any level up to and including design capacity.

* 3.7,4.2 Vibration forces. The tank shall not be damaged by the vibration forces specified under method 514 of MIL-STD-810 for class 6 equipment when empty or filled with cryogenic liquid to any level up to and including design capacity.

* 3.7.4.3 Emergency landing acceleration forces. The tank shall withstand the emergency landing load shock forces specified in MIL-A-8421 when filled with liquid oxygen except the shock pulse shall be an approximate one-half sine wave of not less than 30 ms or more than 40 ms duration. The peak acceleration of the shock pulse shall be not less than 18g for all three directions of shock input.

3,7.4.4 The fully loaded tank shall withstand like forces as imposed by the flight and taxiing acceleration loads specified in 3,7.4.1 while being transported on a railroad car, seagoing vessel, or truck,

3.7.5 Environmental conditions. The tank shall operate under and withstand the following environmental conditions without damage:

3.7.5,1 Operating temperatures. The tank shall perform all functions required herein in any ambient temperature between -65″ and +125°F, including exposure to solar or equivalent heat radiation of 100 to 120 watts per square foot at the higher temperature, without shelter or external winterization provisions,

3,705.2 Storage temperatures. The tank shall not be damaged by storage in any ambient temperature from -80° to +160°F for not less than 72 hours.

3.7,5.3 Humidity, The tank shall not be damaged by operation or storage in any relative humidity up to and including 100 percent, including conditions wherein condensation takes place in the form of water and frost.

3,7.5.4 Fungus. The tank shall not be damaged by exposure to moistfun~ growth such as encountered in tropical and subtropical climates,

3.7.5,5 Salt atmosphere, The tank shall not be damaged by operation or storage in an atmosphere containing salt-laden moisture such as encountered near bodies o f salt water and in transportation on shipboard,

3.7.5.6 Rain. The tank shall not be damaged by operation or storage under heavy rainfall as encountered in any locale, including the tropics.

3,7.5.7 Sand and dust. The tank shall not be damaged by operation or storage in an atmosphere containing airborne sand and dust particles such as encoountered in normal and desert operations.

3,7.5.8 Wind. The tank components shall not be damaged by storage and operation in wind velocities up to and including 70 mph.

3,8 Details of components

3.8.1 Liquid storage tank assembly

3.8.1.1 Liquid storage tank assembly components. The liquid storage tank assembly shall consist of the following:

a. Inner shell
b. Outer shell
c. Inner shell suspension system
d. Insulation
e. Piping and connections
f. Pressure buildup system
g. Safety devices
h. Controls
i. Instruments,

* 3.8.1.2 Fabrication. The liquid storage tank assembly shall be a welded vessel designed-and fabricated in accordance with section VIII of the ASME Boiler and Pressure Vessel Code to contain, and retard evaporation loss of, liquid oxygen as necessary to insure compliance with the performance requirements specified in 3. 3.7.1 and 3.7.2. In addition, the inner shell shall be certified under the code for the specified working pressure (see 6.4.4),

3.8.1.2.1 Component arrangement. The liquid storage tank assembly shall be fabricated with the inner shell suspended within the outer shell to maintain a vacuum-tight annular insulation space of sufficient distance between corresponding points on the shells and heads to meet the requirements specified herein.

* 3.8.1.2.2 Dissimilar metal vacuum joints. Any dissimilar metal vacuum joints (see 6,4.5) used in the tank construction shall withstand:

a. Thermal shocks from 125°1? to the atmospheric pressure boiling temperature of liquid nitrogen

b. Axial vibration at a frequency of 60 cps and a double amplitude of not less than 0.050 inch with only one end of the joint fastened to the vibration input device and while submerged in liquid nitrogen at its atmospheric pressure boiling temperature

c. Lateral vibration at a frequency of 60 cps and a double amplitude of not less than 0.200 inch with only one end of the joint fastened to the vibration input device and while submerged in liquid nitrogen at its atmospheric pressure boiling temperature

without developing leakage detectable with a helium mass spectrometer operated at its maximum sensitivity.

3.8.1.3 Inner shell. The inner shell shall physically store the liquid oxygen. Insofar as practicable, it shall be designed to have the minimum surface area consistent with the requirements specified herein,

3.8.1.3.1 Inner shell attachments. The inner shell shall be equipped with all parts, fittings, and accessories necessary to provide for support, liquid transfer, tool draining, venting, safety, and determination of liquid level.

* 3,8.1 .3.2 Inner shell material. The inner shell shall be fabricated from material with sufficient strength, rigidity, and vacuum-holding properties to insure compliance with the requirements specified herein, and that is resistant to corrosion caused by contact with liquid or gaseous oxygen, liquid or gaseous nitrogen, moist air, water, or cleaning solvents such as trichloroethylene.

3.8.1.3.3 Design pressure. The inner shell shall be designed and constructed for a maximum working pressure adequate to permit the vapor space pressure relief valve setting specified in 3.8.1,9.3 and for a normal working pressure of not less than 50 psig for transferring liquid oxygen under the conditions specified herein, Design and construction shall also be such as to insure against:

a. Distortion or damage when the liquid storage tank assembly annular insulation space is evacuated to a high vacuum or is pressurized to the outer shell pressure relief device maximum opening pressure

b, Collapse of or damage to the inner shell when it is evacuated to an absolute

* 3,8.1,3,4 Sump and drain provisions. The inner shell shall be constructed with a sump, a sump drain line, and a smooth inside bottom surface throughout an arc of not less than 3 inches on each side of the vertical centerline for the entire length of the inner shell to insure complete drainage into the sump. The drain line shall have an inside diameter of at least 1/2 inch, shall include provisions that will insure gravity drainage to the level of the sump without inner shell pressurization, and shall include provisions that will insure against liquid entering the line from the inner shell during normal storage, transport, or liquid transfer operations. The drain line shall include a readily accessible, manually operated valve to facilitate draining of the sump and obtaining liquid samples for analysis. The sump shall be not less than 3 inches in diameter.

3.8.1.3.5 Baffles. One lateral and one longitudinal baffle constructed to be effective for the prevention of liquid sloshing and surging during tank transportation shall be fabricated within the inner shell.

3.8.1 .3.5.1 Baffle clearance space. The longitudinal baffle shall be installed to Provide a clearance space of not less than 3 inches between the longitudinal baffle and the inside bottom of ‘the inner shell throughout its length. The lateral baffle shall be installed with a cutout at the bottom that will provide a clear space arc not less than 3 inches in length on each side of the vertical centerline at the inside bottom of the inner shell without restriction to flow, and provide a clearance of not less than 3 inches between the inside bottom of the inner shell and the lateral baffle at the vertical centerline. Openings shall be provided in the tops of the baffles to permit pressure equalization between the compartments.

3,8.1,4 Outer shell. The outer shell shall provide support for the inner shell and inner shell suspension system. The underside of the outer shell shall be reinforced as necessary to comply with the requirements specified herein.

3.8.1.4,1 Outer shell material. The outer shell shall be fabricated from material having sufficient strength, rigidity, and vacuum-holding properties to insure compliance with the requirements specified herein.

3.8.1 .4.1.1 The outer shell sections through which piping connections to the inner shell pass shall be fabricated from material resistant to corrosion caused by contact with oxygen, nitrogen, moist air, salt atmosphere, or water, to protect against corrosion in case the protective coating is damaged by the extreme changes in temperature that it must undergo on and adjacent to the lines carrying liquid and cold vapors. Corrosion-resistant, low thermal conductive sleeves may be used to thermally isolate the liquid and vapor carrying lines from the outer shell.

3.8,1,4.2 Design pressure, The outer shell shall be designed and constructed for a working pressure that will insure sufficient strength and rigidity to prevent distortion or damage when the annular insulation space is evacuated to a high vacuum or pressurized to the outer shell pressure relief device maximum opening pressure.

3.8.1.4.3 Vacuum line. The outer shell shall be provided with a vacuum line and fittings designed for effective evacuation of the annular insulation space. The vacuum line shall-incorporate a filter (if powder insulation is used), a shutoff valve, and a vacuum line disconnect fitting. If a powder-type insulation is used, the vacuum line shall be installed to exhaust gases from the highest point of the annular insulation space, adjacent to the outer shell, The installation shall, to facilitate pumping down, incorporate features that will aid the flow of gases through the insulation to the vacuum line. AH permanent joints in the vacuum line shall be welded. Disconnect points shall use flanged and bolted fittings,

3.8.1 .4.3.1 Vacuum line shutoff valve, The vacuum line shutoff valve shall be of a type suited to high vacuum service, and that can be readily opened or closed with one hand. The valve shall seal the vacuum line as necessary for compliance with 3.7.3 when closed with one hand, and shall provide the least practicable resistance to gas flow when open.

3.8.1 .4.3,1.1 Vacuum line shutoff valve mounting. The vacuum line shutoff valve shall be solidly mounted in an accessible location where it cannot be mistaken for a tank control valve. It shall be so mounted to supporting members that force applied in opening or closing the valve will not damage the vacuum line piping.

3,8.1 .4.3,2 Vacuum line filter. A vacuum line filter shall be provided if a powder or similar type insulation that could be drawn into the vacuum pump is used. The vacuum line filter shall be a removable unit extending into the tank annular space, an shall have an effective filtering area of not less than 250 square inches. The filter shall present the minimum practicable restriction to gas flow consistent with effectively preventing insulation passing from the annular space into the vacuum pump line. In addition, the filter shall be designed to withstand backflow of gases as would be associated with inadvertent opening of the vacuum shutoff valve to the atmosphere.

3.8.1 .4.3.3 Vacuum line disconnect fitting. The vacuum line shall terminate in a fitting conforming to Drawing 66C1627.

3.8.1,4 .3.3.1 Vacuum line disconnect fitting mounting. The vacuum line disconnect fitting shall be mounted in a location accessible from outside the control housing assembly for attachment of a vacuum pump hose. The disconnect fitting shall be so mounted that forces applied to the disconnect fitting during attachment or removal of the vacuum pump hose or while the vacuum pump hose is attached will not damage the vacuum line.

3,8.1.5 Inner shell suspension system. The inner shell shall be supported and , positioned within the outer shell by a suspension system that will thermally isolate the inner shell from the outer shell and provide an annular insulation space as specified in 3.8.1.2,1, 3.8.1.5.1 Strength. The inner shell suspension system shall be of sufficient strength and rigidity to solidly support and prevent damage to or unnecessary movement of the inner shell when it is filled to design capacity with liquid oxygen and subjected to the forces specified in 3.7.4.1 through 3.7.4,3,

3,8.1.5.2 Heat transfer resistance, The inner shell suspension system shall be fabricated from material possessing the maximum practical resistance to heat flow, and shall provide the minimum practicable heat transfer area between the inner and outer shells without sacrifice of necessary strength and rigidity.

3,8.1.6 Annular space insulation. The annular insulation space shall contain an insulation that will, together with evacuation of the annular space, insure compliance with 3.7.2. The insulating material shall be of a composition that will not ignite or burn when heated to 400°F in 99.5 percent pure oxygen gas at a pressure of not less than 10 psig. Application of the insulation shall be such as to insure against settling or displacement in service.

* 3,8.1 .6.1 If a getter material is utilized in the annular space, it shall be secured in direct thermal contact with the inner shell. In addition, a means of heating the material to at least 300°F during evacuation to expedite reactivation shall be provided. The heating element shall be operable on 115 ±5V, 60- or 400-cycle, single-phase electrical power. The wires shall terminate outside the tank in a UP131M plug connector conforming to MIL-C-3767/12.

3.8.1.7 Piping and connections

3.8.1.7.1 Intertank piping connections. Piping connections between the inner and outer shells shall be held to the minimum necessary for insuring safety and performance in accordance with the requirements specified herein. Connecting piping shall be of corrosion-resistant material possessing the maximum practicable resistance to heat flow, and shall be installed to provide the maximum practicable length of heat transfer path combined with the minimum practicable heat transfer area.

3,8.1 .7.1.1 Liquid line. A single liquid line shall be provided between the inner and outer shells—for filling and emptying the tank in accordance with 3.8.1,7.1.2 and 3.8.1.7.1.3. The liquid line shall in no case be of less than 1 inch diameter. The liquid fill line, liquid servicing line, and pressure buildup coil feed line shall so connect to the single liquid line outside the outer shell that each will function independently of the others without interference or interdependence.

3.8,1 .7.1.1.1 Liquid line installation, The liquid line shall be installed with a standpipe or other arrangement that will withdraw liquid at a height of not less than 1 inch nor more than 1-1/4 inches above the bottom of the inner shell to preclude withdrawing sediment with the liquid, In addition, the liquid line installation shall be such as to:

a, Insure against liquid entering the line from the inner shell when all liquid line valves are closed and the tank is tilted 10 degrees along either the longitudinal or the lateral axis

b. Insure that the inner shell can be gravity drained to the level of the standpipe through the liquid fill or liquid servicing line without pressurization

c. Minimize heat transfer between the inner and outer shells

d. Expose the least practicable length of line outside the outer shell.

3.8.1 .7.1.1.2 Liquid line insulation. The liquid line parts and fittings outside the outer shell shall be insulated with type H, class 1 pipe covering conforming to HH-I-551. The insulation shall be so applied, covered, and sealed that entrance of moisture will be prevented.

* 3.8.1 .7,1.2 Liquid fill line, The liquid fill line shall be sized and installed to provide for filling the tank with liquid oxygen through the liquid line specified in 3.8.1,7.1.1 at a rate of not less than 50 gpm without the pressure drop through the fill line (including the liquid fill line filter) and the liquid line exceeding 5 psig. The liquid fill line shall terminate outside the control housing assembly in a 1-inch external pipe thread for installation of the disconnect coupling, shall be of the minimum practicable length to reduce evaporation losses, and shall have a diameter of not less than 1 inch.

3.8,1 .7.1.2.1 Liquid fill line shutoff valve. A manually operated shutoff valve having a free passage–size approximately equal to that of the liquid fill line diameter when fully opened shall be provided in the liquid fill line as near as practicable to its connection to the liquid line specified in 3.8.1.7.1.1, General design, construction, and mounting of the valve shall be as specified in 3,8,1 .10.1 through 3.8.1.10,1.4. shutoff valve shall be so located and installed that liquid flow to the liquid servicing line or to the pressure buildup coil will not be restricted.

3.8,1 .7.1.2.2 Liquid fill line disconnect coupling. A l-inch, male, liquid oxygen coupling half assembly consisting of a coupling seat, gasket, and cap conforming to Drawings C8987855, B8987832, and C8987869, respectively, assembled as shown on Drawing C8987830, shall be installed on the liquid fill line pipe thread. The horizontal centerline distance between the fill line termination and the servicing line termination shall be a minimum of 9 inches.

* 3,8,1 .7.1.2.2.1 Liquid fill line shutoff valve and disconnect coupling mounting. The disconnect coupling shall be solidly mounted as near as practicable to the liquid fill line shutoff valve in a location readily accessible to an operator standing on the ground outside the control housing assembly. The disconnect coupling mounting location shall provide sufficient clearance around the coupling for use of strap wrenches or other tools to assist in attachment or removal. The disconnect coupling and shutoff valve shall both be so mounted to supporting structures or members that force applied in operating the valve, or a torque of 300 lb ft per inch of nominal line size applied to the disconnect coupling in either direction of rotation with a 24-inch wrench, will not damage the tank piping or connections. The mounting of the liquid fill line valve and of the liquid fill line disconnect coupling to supporting members shall be accomplished with material possessing the maximum practicable resistance to heat flow to reduce

to a minimum evaporation of liquid filled into the tank through the liquid fill line. The liquid fill line disconnect coupling shall be located to provide clearance for attachment of the fill hose without interference between the fill hose and the servicing hose.

* 3.8.1 .7.1.2.3 Liquid fill line filter. The liquid fill line shall be provided with a filter through which all liquid entering the inner shell through the fill line must flow. The filter shall be located between the liquid fill line shutoff valve and the liquid fill line disconnect coupling. The filter location and instillation shall be such as to insure ready access for inspection cleaning, or removal.

* 3.8.1 .7.1.2.3.1 Liquid (fill) line filter performance, The liquid (fill) line filter shall remove 98 percent by weight of all particles whose smallest dimension is 10 microns or greater (lO-micron nominal rating). The filter shall further remove 40 microns or greater (40-micron absolute rating). In addition, the filter shall be sized to pass liquid oxygen at a flow rate of 50 gpm without the pressure drop exceeding 3 psig when the filter has previously ingested not less than 5 grams of particles having the following size distribution:

Size of Particle (Microns)	Percentage by Weight
10 to 20	36 ±3
20 to 40	24 ±3
40 to 60	16 ±3
Over 60	24 ±3

The filter shall not permit bypass of the element under any combination of conditions, and shall withstand a pressure drop of 50 psi across the element without damage.

* 3.8.1.7.1.2.3.2 Liquid (fill) line filter design. The filter shall be of either T or Y configuration with the element constructed from stainless-steel or monel. Sintered or powdered metal material shall not be utilized unless backed up by a wire-wound or wire-mesh cloth element, in which the wires have been fused under controlled conditions, so as to positively prevent migration of particles that may be shed by the sintered or powdered metal portion. The filter element shall be fused to the housing in a manner which will prevent bypass of the element (see figure 2). Elastomeric seals shall not be used in the filter design or construction. The proper direction of flow shall be plainly marked on each side of the filter housing in a prominent location.

3.8.1.7.1.2.4 Liquid fill line insulation. The liquid fill line, valve, filter, and fittings, other than the disconnect coupling specified in 3.8.1.7.1.2.2, shall be insulated as specified in 3.8.1.7.1.1.2,

3.8.1.7.1.3 Liquid servicing line. The liquid servicing line shall be sized and installed to provide for transferring liquid oxygen from the inner shell through the liquid line specified in 3.8.1 .7.1.1 at a rate of not less than 25 gpm without the pressure drop through the liquid line and the liquid servicing line (including the liquid servicing

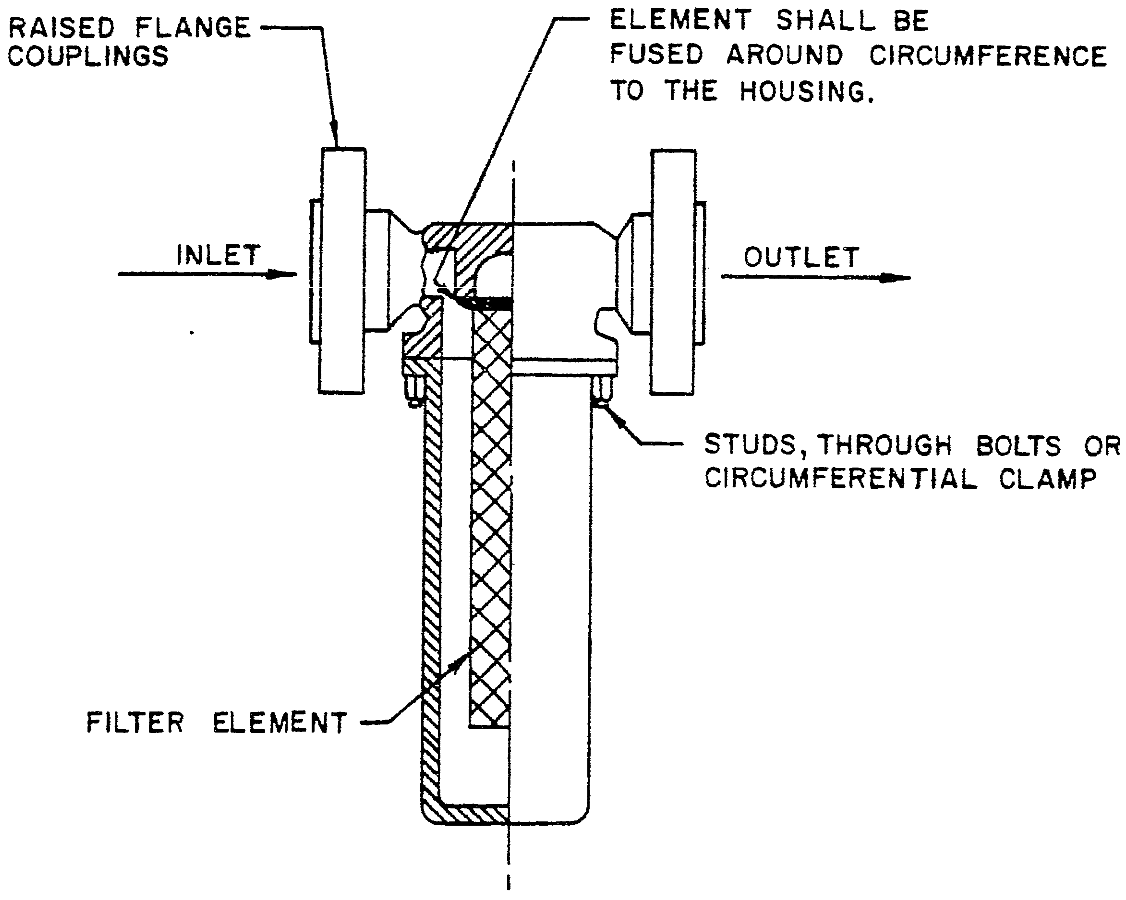


*FIGURE 2. Filter General Design and Construction

line filter) exceeding 2 psig. The liquid servicing line shall be of minimum practicable length to minimize evaporation losses and shall have a diameter of not less than 1 inch.

3,8.1 .7.1,3.1 Liquid servicing line shutoff valve. A manually operated shutoff valve having a free passage size approximately equal to that Of the liquid servicing line inner diameter when fully open shall be provided in the liquid servicing line as near as practicable to its connection to the liquid line specified in 3,8,1.7.1.1, General design, construction and mounting shall be as specified in 3.8.1.10.1 through 3.8.1.10.1.4. The shutoff valve shall be so located and installed that liquid flow from the liquid fill line or to the pressure buildup coil will not be restricted.

3.8.1,7 .1.3,2 Liquid servicing line disconnect fitting. The liquid servicing line shall terminate outside the control housing assembly in a l-inch external pipe thread oriented to discharge vertically upward, for attachment of the liquid servicing hose.

* 3.2.1 .7.1,3.2.1 Liquid servicing line shutoff valve and disconnect fitting mounting. The disconnect fitting shall be solidly mounted as near as practicable ‘to the servicing line shutoff valve in a location readily accessible to an operator standing on the ground outside the control housing assembly, where the disconnect fitting will not be subjected to bending or other damaging stresses when the hose is secured in its storage provisions, and where there will be sufficient clearance around the fitting for use of strap wrenches or other tools to assist in liquid servicing hose attachment or removal or replacement of the disconnect fitting itself. The disconnect fitting and the servicing line shutoff valve shall both be so mounted to supporting structures’ or members that force applied in operating the valve, or a torque of 300 lb ft per inch of nominal line size applied to the disconnect fitting in either direction of rotation with a 24-inch wrench, will not damage tank piping or connections, The mounting of the servicing line shutoff valve and the disconnect fitting to supporting members shall be accomplished with material possessing considerable resistance to heat flow to reduce to a minimum evaporation of liquid serviced through the line and hose. The fitting shall be located to provide clearance for attachment and use of the servicing hose without interference with other components.

* 3.8.1 .7.1,3,3 Liquid servicing line filter. The liquid servicing line shall be provided with a filter identical to the one used in the liquid fill line, and through which all liquid transferred from the tank through the liquid servicing line and hose must flow. The filter shall be installed between the servicing line shutoff valve and the servicing line disconnect fitting. The filter location and installation shall be such as to insure ready access for inspections cleaning, or removal.

* 3.8.1 .7,1.3.4 Liquid servicing line insulation, The liquid servicing line valve, filter, fittings, and attachments, including the disconnect fitting, shall be insulated as specicied in 3,8,1.7.1.1.2.

* 3.8.1.7.1.4 Liquid servicing hose. One 10-foot length of cryogenic liquid hose, part No. 59C6671-2 conforming to MIL-H-27301, shall be provided with the tank, One end of the hose shall be connected to the 1-inch external pipe thread of the liquid

servicing line disconnect fitting. The other end of the hose shall be provided with 1-inch close nipple and a 1-inch female liquid oxygen coupling half assembly consisting of a coupling cone, coupling nut, retaining ring, and plug conforming to Drawings (28987856, C8987857, 38987839, and C8987870, respectively, assembled as shown on Drawing C8987831.

3.8.1,7,1,4.1 Liquid servicing hose storage_ provisions. Provisions shall be incorporated for the protection and storage of the liquid servicing hose while connected to the servicing line and when not in use for liquid transfer, The storage provisions shall securely retain and protect the hose when the tank is subjected to the accelerations specified under 3.7,4, The hose shall be readily released and removed from the storage provisions when needed for liquid transfer.

3.8.1 .7.1,5 Vapor vent line. The vapor vent line shall be of not less than 1 inch inside diameter, and shall be sized and installed to provide for:

a. Cooling down of the liquid storage tank assembly to permit filling as described below within 15 minutes, without the inner shell vapor pressure exceeding 15 psig, after all components (including the inner shell) have stabilized at 125°F,

b. Filling the tank with liquid oxygen at any rate up to and including 50 gpm without the inner shell vapor pressure exceeding 15 psig when the tank assembly is cold.

c. Venting liquid through the line when the inner shell is being filled and the tank contains between 400 and 410 gallons of liquid.

3.8.1,7 .1.5.1 Vapor vent line installation. The vapor vent line shall be installed to minimize heat–transfer between the inner and outer shells. The line shall extend along the tip inside of the inner shell and shall be so equipped with spray holes or similar provisions that cleaning fluid pumped into the inner shell through the vapor vent line will be sprayed against the inside top of the inner shell to flush sediment and other contaminant materials from the tank,

3,8.1,7,1.5.2 Vapor vent line shutoff valve. A manually operated shutoff valve having a free pas sage–size approximately equal to that of the vapor vent line inner diameter when fully open shall be provided in the vapor vent line as near as practicable to the point where it enters the outer shell. The valve shall provide a positive shutoff when closed. General design, construction, and mounting shall be as specified in 3.8.1 .10.1 through 3,8.1.10.1.4.

3.8.1 .7.1.5.2.1 Vapor vent line shutoff valve mounting. The vapor vent line shutoff valve shall be solidly mounted in a location readily accessible to an operator standing on the ground in front of the control panel. The vapor vent line shutoff valve shall be so mounted to supporting members that force applied in opening or closing the valve will not damage the vapor vent line piping.

3.8.1.7.1.5,3 Vapor vent line discharge. The vapor vent line shall discharge toward the ground outside the control housing assembly in a location where high concentrations of gas and liquid overflow will not constitute a hazard or impinge or spray on other tank components, The line shall terminate in a 1-inch, female pipe thread in an area which is convenient for attachment of a hose from a purging unit conforming to MI L-P -27456, or an overboard vent line during air transportation,

3.8.1.7.2 Liquid level gage lines. If a differential-pressure-type liquid level gage is furnished, separate liquid level gage sensing lines shall be provided to the inner shell and shall be of the minimum size consistent with dependable operation of the gage.

3.8.1.8 Pressure buildup system. The pressure buildup system shall function to pressurize the inner shell vapor space to 50 psig when the tank contains 25 gallons or more of liquid oxygen. It shall further pressurize the inner shell vapor space to 50 psig within 15 minutes after closing the vapor vent line shutoff valve and initiating buildup when the tank is filled to between 15 and 20 percent of rated capacity, and has been vented to atmospheric pressure for not less than 4 hours.

3,8,1,5.1 Pressure buildup system components. The pressure buildup system shall consist of a vaporization coil and manual control valve, together with the connections, piping, mountings, instruments, and accessories needed for proper and safe operation.

3.8.1.8.2 Method of operation. The pressure buildup system shall operate by vaporizing a portion of the liquid contained in the liquid storage tank assembly and pressurizing the inner shell vapor space with the resultant vapors. The liquid supplied to the pressure buildup system shall be obtained through the liquid line specified. in 3.8.1.7.1.1. Vaporization of the liquid shall be accomplished in an atmospheric air heated coil that forms a direct external connection between the inner shell liquid and vapor phases through the pressure control system.

3.8.1.8.3 Vaporization coil. The vaporization coil shall be designed and constructed to receive liquid from the inner shell and vaporize it at the rate necessary for compliance with the performance requirements of 3.8.1.8 by heat exchange with ambient air, and discharge the resultant vapors into the inner shell vapor space. The vaporization coil shall include all shrouding, baffling, and ducting necessary for insuring proper airflow distribution over the heat exchange surfaces.

3.8.1.8,3,1 Vaporization coil materials. The vaporization coil and its associated piping, supports, attachments, and connections shall be constructed from materials not attacked or adversely affected by contact with liquid oxygen or nitrogen, gaseous oxygen or nitrogen, water, dust, mud, moist air, or cleaning solvents.

3.8.1.8.3.2 Vaporization coil installation. The vaporization coil shall be installed where it will be protected from adverse environmental conditions and mechanical damage. The vaporization coil shall be so connected to the liquid line specified in 3.8.1.7.1.1 that it will function independently of the liquid fill line and liquid servicing line without interference or interdependence. The connection of the vaporization coil to the vent line shall be located in a readily accessible area and shall permit easy disconnection of the vaporization coil from the vent line. A cap shall be provided to seal the hole in the vent line resulting from disconnection of the vaporization coil.

3.8.1.8,4 Operating controls. Operation of the pressure buildup system shall not require control operation other than closing of the vapor vent line valve and opening of the pressure buildup manual control valve.

3.8.1.8.4.1 All manually actuated controls used in normal operation of the pressure buildup system shall either be mounted on the control panel or easily accessible within the control housing assembly.

3.8.1.9 Safety devices. Where necessary, pressure relief devices shall be provided for protection of the liquid storage tank assembly and its associated components. All pressure relief devices and drains shall be installed in readily accessible locations and, except for the outer shell rupture disc, shall discharge all vented liquid or vapor toward the ground in a location which will insure against:

a. Damage to equipment or danger to personnel, and

b. Creating fog where it will obscure controls, instruments, or fittings in the control housing assembly.

All safety devices shall be fabricated from corrosion-resistant material not adverse affected by extended contact with oxygen, moist air, water, or cleaning solvents such as trichloroethylene.

3.8.1.9.1 Inner shell safety head. A bursting-disc-type safety head using a readily replaceable disc in a union-type fixture shall be provided to relieve the inner shell vapor phase pressure in the atmosphere should this pressure become excessive and the pressure relief valve fail to open. The safety head relief pressure shall be not less than 1-1/2 times the inner shell maximum working pressure.

3.8.1 .9.1.1 Inner shell safety head installation, The inner shell safety head shall be installed with a sufficient length of tubing between itself and the vapor vent line to prevent frosting of the safety head unless the safety head actually ruptures to relieve the inner shell pressure. The discharge shall be into the vapor vent line between the vapor vent line shutoff valve and the vent line discharge.

3.8.1.9.2 Outer shell safety head. A bursting-disc-type safety head or a flat-plate-type safety disc assembly in which the plate bears on an O-ring shall be provided on the outer shell for venting the annular insulation space to the atmosphere should the annular insulation space pressure become excessive. If a bursting-disc-type safety head is provided, it shall be equipped with a vacuum support to prevent inward distortion when the annular insulation space is evacuated. The flat-plate-type safety disc assembly may be used only if the plate will be retained against the O-ring with sufficient pressure to provide a positive seal against the entrance of gases or moisture under all conditions of operation, even when no vacuum exists in the annular insulation space.

3.8,1 .9.2,1 Outer shell safety head installation. The outer shell safety head shall be installed on the end of the tank farthest removed from the control housing assembly. Design and installation shall be such that discharge from the safety head will be directed away from the control housing assembly and personnel adjacent thereto.

* 3.8.1.9.3 Inner shell vapor space pressure relief device, An automatic pressure relief device shall be connected into the vapor vent line between the outer shell and the vent line shutoff valve to relieve excess pressure. The relief device shall be designed to open at a pressure sufficiently below the inner shell bursting-disc-type safety head breaking pressure to insure against rupture of the safety head unless the relief device fails, but not less than 50 psig, and shall be sized to insure against the inner shell vapor space pressure exceeding 65 psig when:

a. The tank is filled to not less than 90 percent of design capacity

b. The tank is placed in an ambient temperature of not less than 125°F

c. The buildup valve is left wide open

d, All other valves are closed.

3.8.1 .9.3.1 Inner shell vapor space pressure relief device installation. The inner shell vapor space pressure relief valve shall be designed and installed in a manner that will prevent freezing of the relief device when venting oxygen vapor.

3.8.1 .9.3.2 The outlet of the relief device shall discharge all vented material into the vapor vent line between the vapor vent line shutoff valve and the vent line discharge.

3.8.1.9.4 Liquid fill line pressure relief and drain valves

3.8.1 .9.4.1 Pressure relief valve. An automatic pressure relief valve shall be provided in the liquid fill line between the shutoff valve and the disconnect coupling for venting excess ‘pressure from the fill line. The relief valve shall be designed to open at a pressure in excess of that at which the inner shell vapor space pressure relief valve opens, but less than the safe working pressure of the fill line.

3.8,1 .9.4.1.1 Fill line automatic pressure relief valve installation. The liquid fill line automatic pressure relief valve shall be installed with a sufficient length of tubing between itself ‘and the fill line to prevent frosting of the relief valve unless the relief valve actually opens to relieve the fill line pressure.

3,8.1 .9,4.2 Fill line drain-valve. A manually operated valve for draining liquid from the fill line disconnect coupling when removing the fill hose shall be provided in the fill line between the shutoff valve and the disconnect coupling, as near the connect coupling as practicable. The drain valve shall be located and installed to be readily accessible to an operator standing on the ground outside the control housing assembly. If practicable, the automatic pressure relief valve and the drain valve may be combined into one unit. The drain valve shall discharge outside the control housing assembly.

3.8.1.9.5 Liquid servicing line pressure relief and drain valves

3,8.1,9.5.1 Pressure relief valve. An automatic pressure relief valve shall be provided in the liquid servicing line between the shutoff valve and the servicing hose for venting excess pressure from the servicing line and servicing hose. The relief valve shall be designed to open at a pressure in excess of that at which the inner shell vapor space pressure relief valve opens but less than the safe working pressure of the servicing line and servicing hose.

3.$.1 .9.5,1,1 Servicing line automatic pressure relief valve installation. The servicing line automatic pressure relief valve shall be installed with a sufficient length of tubing between itself and the servicing line to prevent frosting of the relief valve unless the relief valve actually opens to relieve the servicing line pressure.

3.8.1 .9.5.2 Servicing line drain valve. A manually operated valve for draining liquid from the servicing line and servicing hose shall be provided in the servicing line between the shutoff valve and the hose disconnect fitting as near the hose disconnect fitting as practicable. The drain valve shall be located and installed to be read accessible to an operator standing on the ground outside the control housing assembly If practicable, the automatic pressure relief valve and the drain valve may be combined into one unit. The drain valve shall discharge outside the control housing assembly.

3.8.1.9.6 Additional pressure relief valves. Additional automatic pressure relief valves shall be installed in each circuit or component not specified and which can be so isolated by closing valves or other action that a dangerous pressure could build up. These relief valves shall each be designed to open at a pressure sufficiently low to insure against damage to the component or circuit affected. However, the operating pressure shall be in excess of the inner shell vapor space pressure relief valve operating pressure.

3.8.1.10 Controls

3.8,1 .10.1 Shutoff and control valves. Shutoff and control valves shall be provided wherever needed for control of the inner shell vapor phase pressure, vapor phase venting, liquid transfer, and tank instrumentation.

* 3.8.1 .10.1.1 Valve design and construction. Valves shall be designed and constructed to provide positive shutoff when closed and minimum resistance to flow when open. The globe valves Of l/2-inch and larger nominal size handling low temperature liquid

or gas shall incorporate renewable seats that can be removed and replaced without disassembling the valve body from the tank piping. The sealing discs or plugs for these valves shall also be renewable without replacing the valve stem. All valves handling low temperature liquid and gas shall be so designed or modified that the packing gland is located not less than the distance specified in table I from the valve connection centerline. The stem and the stem housing on these valves shall either be fabricated from 18-8 stainless-steel or other equally low heat conductive material, or the stem and stem housing shall be provided with 18-8 stainless-steel or other equally low heat conductive material inserts equal in length to not less than one-half the distances specified in table I. Liquid level gage control and other instrument control and isolation valves may be of conventional construction.

TABLE I

Separation of Valve Packing Gland From Valve Connection Centerline

Valve Nominal Size (In Inches)	Separation of Packing Gland From Connection Centerline (In Inches)
1/4	4
3/8	4
1/2	7
3/4	7
1	9
1-1/4	9
1-1/2	11
2	11
2-1/2	12
3	12

3,8.1 .10.1.1.1 Valve handles. Each manually operated control or shutoff valve shall be provided with a tee, cross, or other easily turned type handle with a diameter equal to 3 inches per inch of valve nominal size, but not less than 1 inch.

3.8.1.10.1.1.2 Valve cycling and leakage_ performance. When closed with a torque of 60 ±5 lb in. Per inch of nominal size, and with the valve body at either ambient temperature or the atmospheric pressure boiling temperature of liquid oxygen or nitrogen, the valves shall not leak more than 2 cubic inches of free air, oxygen, or nitrogen gas per hour per inch of nominal size from 50 psig to a downstream pressure of 0 psig. The valves shall be capable of not less than 2,000 cycles of operation (see 6.4.6) when subjected to a differential pressure of 50 psig while closed, including at least 1,000 cycles at ambient temperature and 1,000 cycles with the valve body at the atmospheric pressure boiling temperature of liquid oxygen or nitrogen without adjustment, repair or maintenance, and without the above specified leakage rate being exceeded before, during, or after the cycling.

3.8.1'10.1.1.3 Valve overtorque performance, The valves shall be designed an constructed to withstand a closing torque of 300 ±10 lb in. per inch of nominal size. with the valve bodies at either ‘ambient temperature or the atmospheric pressure boiling temperature of liquid oxygen or nitrogen. Such operation shall not result in a parts failure or a leakage rate in excess of that specified in 3.8.1 .10..1.1,2 when subsequently closed with a torque of 60 ±5 lb in. per inch of valve nominal size.

3.8.1.10.1.2 Valve material, The valves shall be fabricated from corrosion-resistant material not adversely affected by extended contact with oxygen, nitrogen, argon, hydrogen, helium, moist air, water, or cleaning solvents such as trichloroethylene.

* 3.8.1.10.1.3 Valve packing. Valve packing shall be of a material safe for use in contact with liquid or gaseous oxygen or nitrogen, and that will effectively seal the valve stern without causing difficulty of operation.

3.8.1.10.1.4 Valve mounting. All valves used during liquid transfer shall be so mounted and installed that they can be readily opened or closed, and so that their control handles will be readily available to a operator standing at the control panel. All valves shall be so mounted to supporting members or large size piping that force applied to the control handles in opening or closing the valves will not damage the tank piping, and so mounted that the operator will be protected from liquid spray if a fitting or coupling leaks or breaks,

3.8.1.11 Instruments. AH instruments necessary for effective and safe operation of the tank shall be provided. These shall include the following:

3.8.1.11.1 Liquid level gage. A liquid level gage designed for flush mounting on the control panel and having a dial diameter of not less than 2-1/2 inches shall be provided to indicate the quantity of liquid oxygen contained in the liquid storage tank assembly inner shell with an accuracy of ±3 percent of tank design capacity.

* 3.8.1.11.1.1 Gage construction. If a differential-pressure type liquid level gage is furnished, the gage design and construction shall be such that breakage of the glass face will not subject the sensing element to damaging pressures when the inner shell is pressurized to 50 psig.

3.8.1.11.1.2 Graduations. The liquid level gage shall be graduated in gallons of liquid oxygen. The graduations shall be printed on the gage face in black on a white background,

3.8.1.11.1.3 Liquid level gage mounting. The liquid level gage shall be securely mounted on the control panel in a position where it will be readily visible to an operator standing at the control panel during liquid transfer or servicing,

3.8.1.11.1.4 Pulsation snubbers. If a differential-pressure type liquid level gage is furnished, it shall be provided with restriction orifices in each sensing line to act as pulsation snubbers for preventing undue fluctuation of the indicating needle.

3,8.1,11.2 Vapor phase pressure gage. A pressure gage with a dial diameter of not less than 2-1/2 inches shall be provided for indicating the inner shell vapor phase pressure. The gage shall be designed for flush mounting, shall be graduated over approximately 270 degrees of the dial face\ and shall be accurate to within ±2 percent of full scale range.

3.8.1.11.2.1 Range. The indicating range of the vapor phase pressure gage shall be approximately 1-1/2 times the normal working pressure of the inner shell unless a higher range is necessary to prevent the indicator from moving off scale before reaching the relief pressure of the inner shell safety head and the vapor space pressure relief valve specified in 3.8.1 .9.1 and 3.8.1.9.3.

3.8.1.11.2.2 Vapor phase pressure gage installation, The vapor phase pressure gage shall be so installed that no combination of valve or control settings can interfere with it indicating the inner shell vapor space pressure, The gage shall be securely mounted on the control panel in a position where it will be readily visible during liquid storage or transfer to personnel standing in front of the control panel.

3.8.1.11.2.3 Pressure sensing tap. A tap into the pressure gage line shall be provided for attachment and use of external test equipment. The tap shall terminate in a -4 size flared tube connection conforming to MS33656 installed on the control panel near the pressure gage. The fitting shall be sealed with an AN929-4 cap assembly,

3.8.1 .11.3 Vacuum indicator. A vacuum indicator shall be provided to indicate the actual absolute pressure within the tank assembly annular insulation space.

3.8.1 .11.3.1 Type. If electrically operated, the vacuum indicator shall be of the intermittent-reading type having ‘externally attached batteries. It shall be wired to consume current and to indicate the absolute pressure only when the reading switch is closed. The reading switch shall be spring-loaded or otherwise constructed to require physical pressure for closing and to automatically open when the pressure is released.

3.8.1,11,3.2 Vacuum connection, If a powder insulation is used, the connection to the annular insulation space shall be made through a filter that will prevent insulating material from entering the gage sensing element. Provisions shall also be incorporated that will permit replacing the sensing element without destroying or appreciably degrading the vacuum in the annular insulation space.

* 3,8,1 .11.3.3 Mounting. The vacuum indicator and the reading switch shall be mounted on the control panel where they will be readily visible and accessible to an operator standing at the control panel.

3.8,2 Control housing assembly. A sturdy, heavy-gage, sheet-metal housing assembly shall be fabricated on one end of the liquid storage tank assembly. The housing shall contain and provide protection for the tank controls, instrumentation, and accessories.

3,8.2.1 Control housing assembly design and construction. The control housing assembly shall be designed and constructed to protect the enclosed components from mechanical damage, direct solar radiation, rain, sleet, snow, mud, sand, and other adverse weather and environmental conditions. The control housing assembly shall be so constructed that it, or applicable sections thereof, can be readily removed from the liquid storage tank assembly for maintenance or removal of components.

3.8.2.1.1 The control housing assembly shall be constructed from material resistant to corrosion caused by wetting with condensed water, and so that retention of condensed water within the control housing will be effectively prevented.

3.8.2,1.2 If practicable, the top of the control housing assembly and the tops of all protuberances therefrom shall be shaped and slanted to resist the retention of snow, rain, or sleet, Doors and panels that must be opened for use of the tank shall be so constructed and installed that snow or ice will not lodge thereon in a manner that will prevent easy operation or access,

3,8.2,2 Size. The control housing assembly shall be of sufficient size to provide ready access to the enclosed components for operation, servicing, maintenance, and repairs, and to provide space for the storage of accessories and tools,

3.8,2.3 Access openings. Doors or hinged panels shall be provided in the control housing assembly as necessary for access for operation, inspection, servicing, maintenance, and repair of the equipment. The doors and hinged panels whose positions may have to be regulated shall be provided with means for securing them in an position from fully closed to wide open when subjected to wind gusts up to and including 70 mph.

3.8.2.3,1 Hinges and latches. All doors and hinged panels shall be equipped with sturdy hinges and latches that will ‘hold them securely closed during storage. Latches shall also be provided for securely holding open the doors and panels that must be opened for tank use, The latches shall securely retain the doors or panels in the set position even when subjected to wind gusts up to and including 70 mph,

3,8.2,3.2 I-Aches. The latches and position regulating devices on all doors and hinged panels that must be opened for normal operation, servicing, and maintenance of the tank shall be readily operable by personnel wearing heavy arctic mittens.

3.8.2.4 Ventilation provisions, Ventilation openings or other air circulation provisions shall be provided in the control housing assembly as necessary to prevent accumulation of gases or the accumulation of fog resulting from moist air being chilled in the control housing during liquid transfer or servicing. The ventilation openings shall be so located or shielded that the entrance of rain, snow, or other precipitation will be effectively prevented.

3.8.2.5 Liquid servicing hose storage provisions, Provisions for protection and storage of the liquid servicing hose shall be furnished. The liquid servicing hose storage provisions shall include quick-disconnect fasteners which will securely retain the hose in its proper storage position and protect it against damage when the tank is subjected to the forces specified in 3.7,4.1 through 3.7.4.3 and which can be easily and quickly released for servicing by personnel wearing heavy gloves.

3.8.3 Skid base. The liquid storage tank assembly shall be mounted on a fabricated metal skid-type base designed to serve as:

a. A skid base for the liquid storage tank assembly and its accessories when the equipment is placed on a flat, level, hard surface, and;

b. A rigid protective platform for the liquid storage tank assembly and its accessories when the equipment is lifted, handled, or transported,

The overall size of the base shall be not less than the dimensions of the vertical projection of the liquid storage tank assembly including the control housing. The bottom of the base shall be covered to provide sufficient strength and rigidity for movements of the full tank over loading ramps or rails with l/2-inch-wide rollers. The top of the base shall be covered to prevent entrance of dirt, debris, and precipitation, Drain openings shall be provided at the bottom.

* 3.8.3.1 Skid base ends, Each end of the skid base shall be curved with a radius of not less than 3 inches or turned up at a 30 to 45 degree angle so that the bottom rises to a height of not less than 1-1/4 inches above a flat surface on which the tank is placed.

* 3.8.3.2 Forklift entries. The skid base shall incorporate two lateral forklift entries, each 3-1/4 ±1/8 inches high by 10 ±1/8 inches wide, spaced 40 ±1/2 inches centerline distance. The forklift entries shall be placed approximately equidistant from the vertical center-of-gravity of the full tank. The entries shall extend the entire width of the skid base, and shall not contain any obstructions or irregularities that could impede movement of the forklift tines through the length of the entries. The entries shall restrain the forklift tines from tilting or oscillation as necessary to prevent damage to the tank or its accessories during a lifting or movement operation.

3.8.4 Compartments

3.8.4.1 Tool compartment. A compartment for storage of all tools required in normal operation and maintenance of the tank shall be provided. Provisions shall be incorporated for locking the tool compartment with a common padlock.

3.8.4.2 Handbook and record compartment. A compartment shall be provided integral to each end item for containing the equipment operation handbook and the equipment maintenance and inspection record. The compartment shall be weatherproof if not contained in an enclosure and a minimum size of 9 by 11-1/2 by 2 inches.

3.9 Part numbering of interchangeable parts. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable, The item identification and part number requirements of MIL-STD-100 shall govern the manu-manufacturer's part numbers and changes thereto,

3.10 Dimensions, The overall dimensions of the tank, when all access openings are closed, shall not exceed 88 inches in length, 54 inches in width, and 60 inches in height.

3.11 Weight. The weight of the empty tank and its accessories, including the pallet base, shall not exceed 1,550 pounds.

3.2 Finishes and protective coatings

3.12.1 Surfaces contacting oxygen. All surfaces, parts, fittings, et cetera, of the tank that will be in contact with high-purity oxygen shall be thoroughly cleaned with a nonflammable solvent, such as trichloroethylene, to remove all metal shavings, oil, grease, and other foreign material. No other cleaning, priming, or painting with organic materials shall be performed on these surfaces,

3.12.2 Exposed parts and surfaces, AH exposed metal parts and surfaces, except parts and surfaces that contact high-purity oxygen, shall be cleaned, treated, and finished as specified in MIL-STD-808. When more than one finish process is permitted by MIL-STD-808 for a part or surface, the most applicable finish process shall determined by the contractor unless otherwise specified herein.

3.12,2.1 Finish code FF-909 shall apply to all exterior parts and surfaces of the tank.

*

3.13 Operational markings

3.13.1 Tank markings. The tank shall be marked as follows by applying reverse silk-screened reflectorized tape conforming to MIL-R-13689.

3.13.1.1 The lettering LIQUID OXYGEN shall be applied on each side of the tank in approximately the center with 6-inch green block-type letters.

3.13.1.2 The lettering NO SMOKING WITHIN 50 FEET and the lettering FRAGILE, DO NOT DROP shall be applied in two lines with 2-1/2-inch red reflective letters on each side of the tank below the lettering LIQUID OXYGEN and on both ends in approximately the center.

3.13.2 Control marking. All valves, gages, controls, and indicators used in operation of the tank shall be identified by securely attached nameplates of such composition that exposure to oil, dirt, light, et cetera, will not fade or cause them to become eradicated. Tags shall not be used.

3,13.3 Warning plates

* 3,13.3.1 A weatherproofed red warning plate containing the following information shall be provided adjacent to the liquid servicing line:

WARNING

TANK IS NOT TO BE FILLED THROUGH
THIS LINE - FOR SERVICING ONLY.

* 3.13,3.2 A weatherproofed red warning plate containing the following information shall be provided adjacent to the vent line disconnect fitting:

WARNING

ALL VALVES MUST BE CLOSED AND AN OVERBOARD
VENT LINE ATTACHED TO THE VENT LINE DISCONNECT
FITTING DURING AIR TRANSPORT.

3.13.4 Operating <u>and precautionary instructions.</u> Brief operating and precautionary instructions shall be permanently affixed on or near the control panel, The instructions shall be clear, concise, and adequate to enable operation of the tank without damage to the equipment or injury to personnel. Instruction panels shall be made from sheet aluminum or sheet zinc of not less than 0.050 inch thickness, anodized or etched to produce raised markings with a black or other dark color background, and with a border of not less than l/4-inch.

3.13.5 Transpo<u>rtation data plate.</u> A transportation data plate in accordance with MIL-P-514 shall be securely attached to the outside of the control housing assembly adjacent to the nameplate. The transportation data plate shall include the following information:"

TRANSPORTATION DATA PLATE

Shipping weight	Overall width
Shipping cubage	Overall height
Overall length	C. G. location

T. 0. or T. M. Number.

* 3,13,6 L<u>ifting instruction plate.</u> An instruction plate containing all information necessary for transportation personnel to:

a. Safely lift and move the tank (empty or filled to any level with liquid oxygen) with a forklift truck

b. Rig a safe lifting sling from common cable components and safely lift the full tank with a 3g acceleration

shall be securely attached to the outside of the control housing assembly near the transportation data plate. The lifting instruction plate shall be of the same material and prepared in the same manner as the transportation data plate.

3.13.7 Color marking. The indicating scale of each instrument (pressure gage, vacuum indicator, liquid level indicator, et cetera) used for normal operation and control of the tank shall be permanently and plainly marked with green and red to show the proper operating and the other-than-proper-operating or danger zones, respectively.

3.13.8 Insulation identification plate. An insulation identification plate made similar to the plate specified in 3.13,4 and containing all information necessary to completely identify the insulation material installed in the liquid storage tank assembly annular insulation space shall be permanently affixed in a readily accessible and protected location that will be within the control housing assembly when it is closed for transport or storage. If a powder-type insulation is utilized, the plate shall indicate the pounds of insulating material installed.

3.14 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130.

3.14.1 Tank nameplate location. The tank nameplate shall be securely attached the outside of the control housing assembly in a readily visible location.

3.15 Workmanship. All parts of the tank shall be be fabricated and finished in a workmanlike manner, Particular attention shall be given to the following:

a, Freedom from blemishes, defects, burrs, and sharp edges

b. Accuracy of dimensions, radii of fillets, and marking of parts and assemblies

c. Thoroughness of soldering, welding, brazing, painting, and riveting

d. Thorough removal of rust, slag, scale, flux, and other foreign materials from inside of the liquid storage tank assembly and from all piping, valves? connections, filter housing, and other surfaces that contact oxygen product

e, Alignment of parts and tightness of assembly screws, bolts, rivets, et cetera

f. That rivets are tight and properly headed.

3.16 General cleaning instructions. Following completion of fabrication and assembly operations, the tank shall be thoroughly cleaned and degreased to remove dirt; excess solderings brazing and welding flux; welding slag; scale; loose, spattered or excess solder; metal chips; loose or chipped paint; spilled chemicals; and other foreign materials, Cleaning shall be continued until visual inspection shows no evidence of contamination or foreign matter, ultraviolet inspection of surfaces contacting oxygen product shows no evidence of fluorescence, and particulate contamination of liquid oxygen withdrawn does not exceed the following:

a. When the tank is filled to 90 percent or more of design capacity with filtered liquid oxygen and allowed to set for not less than 2 hours, the residue remaining after evaporation of the first liter of liquid withdrawn through the sump drain line shall contain:

(1) No solid particle with any dimension greater than 1,000 microns

(2) No fibrous particle (see 6.4.7) with a length greater than 6,000 microns

(3) No more than 25 milligrams total of both solid and fibrous particles,

b. When the liquid oxygen remaining in the tank after withdrawal of the 1 liter sample specified above is discharged through the liquid fill line specified in 3.8.1,7.1,2 and the filter specified in 3,8.1 .7.1.2.3 at not less than 50 gpm, the total amount of contaminant collected on the filter shall not exceed 0.1 gram.

3.16.1 Decreasing. Tank surfaces, parts, fittings, et cetera, that will be in contact with high-purity oxygen shall be degreased by one of the following methods. Pre-cautions shall be taken to insure that solvents do not contact parts fabricated from incompatible materials.

* Method A – Vapor decreasing process, using type II stabilized trichloro-ethylene conforming to O-T-634 in a standard commercial vapor degreaser or by blowing decreasing vapors into the component in such a manner that the vapor will condense on and properly clean all surfaces requiring decreasing. Operation of a commercial vapor degreaser shall be in accordance with the manufacturer's recommendations. Following the vapor decreasing treatment, all solvent shall be removed by baking in an oven; by purging with hot, dry, oil-free air or nitrogen; or by vacuum evacuation.

Method B - Solvent decreasing process, using stabilized trichloroethylene or commercial oxygen-safe cleaning solvent at ambient temperatures to thoroughly wash all surfaces requiring decreasing. If the solvent contains more than 1 percent oil after cleaning and being drained from the component, the decreasing operation shall be repeated with clean solvent. Following the decreasing process, all solvent shall be removed by baking in an oven; by purging with hot, dry, oil-free air or nitrogen; or by vacuum evacuation.

Method C - Detergent decreasing processes, in which the components to be cleaned are washed with hot inhibited alkaline cleanser until free from oil, grease, and other contaminant materials, Following this treatment, all surfaces (internal and external) shall be rinsed thoroughly with fresh, clean, hot water and dried by blowing with filtered and dried oil-free air or nitrogen or by baking at a temperature of 250″ to 300°F until all water is removed.

3.16,1.1 Petroleum and other flammable solvents shall not be used on such surfaces.

3,16,1.2 AU cleaning materials and solvents shall be thoroughly removed from the tank components following the cleaning and decreasing processes,

* 3.17 Lubrication, All tank machined bearing surfaces that are normally lubricated in operation and that do not come into contact with the contained product shall be thoroughly lubricated with the recommended military specification or federal specification lubricants to be ready for immediate operation.

4. QUALITY ASSURANCE PR0VISIONS

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

4.2 Classification of tests. The inspection and testing of the tank shall be classified as follows:

a. Preproduction testing .... See 4.4

b. Acceptance tests . . . . See 4.5.

4.3 Test conditions

4.3.1 Tools. Special tools and field equipment shall be used to the maximum practicable extent during testing. Use of these tools shall be sufficient to determine their usefulness. Instances where the special tools furnished are inadequate shall be recorded in detail.

4,3.2 Instrumentation

4.3.2,1 Pressures, Pressures in excess of 1 mm Hg absolute and pressure differentials, except pressure drops in the fill line and servicing lines shall be measured by means of the pressure gages and differential pressure meters furnished as part of the tank.

4.3,2.1,1 Absolute pressures below 1 mm Hg shall be measured by the use of calibrated instruments designed to read total pressures (including permanent gases and condensable vapors).

4,3.2.1.2 Pressures in excess of atmospheric shall be recorded in pounds per square inch gage. Pressures up to and including atmospheric shall be recorded in microns or millimeters of mercury absolute, as applicable. Differential pressures shall be recorded in inches of water, inches of mercury, or pounds per square inch, as applicable.

4.3.2.1.3 Barometric pressure, Barometric pressure shall be measured by a properly calibrated mercurial barometer and recorded in millimeters of mercury absolute,

4,3.2,2 Temperatures, Temperatures shall be measured by appropriately located thermometers, or by thermocouples used with calibrated potentiometers. Temperatures shall be recorded in degrees Fahrenheit,

4.3.3 Flow rates

4.3.3.1 Liquid. Liquid oxygen flow rates shall be determined by either of the following methods:

a. Passing the liquid through a properly calibrated recording- or totaling-type liquid flowmeter designed to handle the liquid being measured

b. Collecting the liquid and weighing it on an accurate scale,

4.3.3.1.1 Liquid flow rates shall be recorded in gallons per minute of the liquid at its atmospheric pressure boiling temperature.

4.3.3.2 Gas. Gaseous oxygen flow rates shall be determined bypassing the material through a properly calibrated recording- or totaling-type gas meter designed to handle the gas being measured.

4.3.3.2.1 Gaseous flow rates shall be converted to weight flow rates for the material handled, expressed in pounds per hour, pounds per minute, et cetera, as applicable.

4.3.4 Observations. During the progress of all tests, such characteristics as ease of control, -pressure regulation, freedom from leaks, and ease Of operation shall be observed to determine whether the tank complies with all requirements specified herein.

4.3.5 Vacuum pumping. A vacuum pump shall be connected to the liquid storage tank assembly vacuum line disconnect fitting and the annular insulation space evacuated as necessary for compliance with the performance requirements of 3.7.2.

4.3.5.1 Vacuum line seal. Upon completion of the vacuum pumping, the vacuum pump shall be disconnected and the vacuum line so sealed that further vacuum pumping cannot be accomplished without breaking the seal. The vacuum line shall remain sealed throughout all testing specified herein.

4.3.6 Test data

4.3.6.1 Correction of data. If the tests specified herein cannot be conducted under the specified conditions, the tests may, upon approval of the procuring activity, be conducted under other conditions and the performance under the specified conditions calculated from the test results obtained, The manner of calculation shall be demonstrated, and actual test data proving the correctness of the calculation methods shall be presented for review by the procuring activity.

4.3.6.2 Operational data. Operational data shall be recorded at the intervals specified under the individual test instructions, The data recorded shall include the following:

a. Liquid storage tank

(1) Vapor phase pressure (psig)

(2) Liquid level gage reading (gallons)

b. Servicing data

(1) Pressure of liquid entering transfer hose (psig)

(2) Flowmeter reading (gpm)

(3) Pressure on liquid at end of transfer hose (psig)

(4) Actual delivery rate of liquid (gpm).

4.3,6.3 Psychrometric data. Wet- and dry-bulb temperature readings shall be recorded at the intervals specified under the individual tests,

4.3.6.4 Barometric pressure. The barometric pressure shall be measured and recorded at the intervals specified under the various test procedures specified under 4.6.

4.3.6.5 Tolerances

4,3.6.5,1 Data on absolute pressures measured in the range from 0 to 10 microns Hg shall be accurate to within 0,5 micron Hg.

4.3,6.5,2 Data on absolute pressures measured in the range from 10 to 50 microns Hg shall be accurate to within 2 microns Hg.

4.3.6,5,3 Data on absolute pressures measured in the range from 50 to 250 microns Hg shall be accurate to within 5 microns Hg.

4.3.6.5.4 Data on absolute pressures measured in the range from 250 to 500 microns Hg shall be accurate to within 10 microns Hg.

4.3.6.5.5 Data on absolute pressures measured in the range from 500 to 1,000 microns Hg (1 mm Hg) shall be accurate to within 20 microns Hg.

4.3.6.5.6 Data on absolute pressures measured in the range from 1 mm Hg to and including atmospheric shall be accurate to within 0.1 mm Hg.

4.3.6.5.7 Data on gage pressures measured in the range from atmospheric to 10 psig shall be accurate to within 1/2 psig.

4,3.6.5.8 Data on gage pressures measured in the range from 10 to 50 psig shall be accurate to within 1 psig.

4.3.6.5.9 Data on gage pressures in excess of 50 psig shall be accurate to within 2 percent of the actual numerical reading.

4.3.6.5.10 Data on weights, weight flow rates, and volume flow rates shall be accurate to within 1 percent of the actual numerical reading.

4.3.6.5.11 Data on gas and vapor flow rates shall be accurate to within 1 percent of the actual numerical reading.

4.3.6.5.12 Data on temperatures shall be accurate to within 2°F.

4.3.6.6 Pressure test record. A record of the pressures at which each tank component is tested and the length of time during which it is subjected to the pressure shall be retained.

4.3.7 Preliminary run-in, The nature and extent of running-in shall be determined by the manufacturer, shall be performed prior to the testing specified herein. All necessary adjustments other than normal control adjustments shall be made during this run-in and shall remain undisturbed thereafter.

4,4 Preproduction testing (see 6.2)

4.4.1 Test sample. One tank shall be subjected to the preproduction tests specified in 4.4.3.

4.4.2 Test report. After the preproduction tests are completed, a test report shall be prepared in accordance with MIL-STD-831 and three copies of the report furnished to the procuring activity.

4.4.2.1 Reliability and maintainability information. The following information shall be included as an appendix to the test report:

a. A description of and the appropriate information below concerning any preproduction tests that were conducted prior to those described in the test report and that were intended to apply to the contract

(1) All failures, servicing, adjustments, maintenance, and irregular functioning shall be identified by accumulated operating time, cycles, or position in the test procedure, as appropriate, Test conditions at the time of the events identified shall be recorded.

(2) Test operator and maintenance technician actions, test equipment and test facility failures, and other events that might act as grounds for a request that an equipment failure not be counted as a reliability failure, shall be recorded, Detailed descriptions of the events and the analysis to substantiate any such requests made shall be included and shall be clearly cross-referenced to each applicable failure,

(3) A summary of the engineering analysis and of any tests conducted to determine assignable causes for any failure or irregular functioning

(4) A summary of the engineering analysis leading to any corrections made to design, construction, quality control, or other procedures, or leading to any corrections to be made to production items, or proposed to be made. The summary shall also include an analysis of the predicted effectiveness of such corrections. Failures that have been corrected by design changes or by other means shall be counted as reliability failures until the corrections have been both analyzed and verified by test sufficiently to substantiate the effectiveness of the correction to the satisfaction of the procuring activity.

(5) Clock time and man-hours required for each maintenance and service action taken during the tests, Only the time needed for actually preparing for an performing the tasks shall be measured and reported, A brief description of the experience and qualifications of the personnel taking such actions shall be included. The information shall include a summary of the data resulting from the servicing and maintenance tests required by 4.6.17. In addition, the clock time and the man-hours required for actual access and disassembly shall be recorded for any teardown inspections done for mechanical checks in accordance with 4.6.20. The number and description of parts and assemblies removed and causing interference shall be noted for each teardown and inspection made, Administrative time, such as filling out records, and logistics time, such as obtaining parts from stock, shall not be included,

(6) Test activity or contractor comments on item features or requirements that, if modified, should improve the item

(7) Test activity or contractor comments on use or maintenance conditions to be avoided or cultivated to increase the reliability or useful life of the item

b. Any of the above information that is already included in the test report body or in other documents submitted to the procuring activity need not be repeated in the information required by this paragraph, but clear reference to the location and to the date of submission of the data shall be included,

c. All table and column headings and all abbreviations and symbols used shall be clearly defined where used or in a table of abbreviation and symbol definitions placed in the front part of the appendix.

4.4.3 Preproduction tests. The preproduction tests shall consist of all the tests described under 4.6.

4.5 Acceptance tests. The acceptance tests shall consist of the following:

a. Individual tests . . . . See 4.5.1

b. Sampling plans and tests . . . . See 4.5.2.

4.5.1 Individual tests

4.5.1.1 Spring-loaded relief valve. Each spring-loaded relief valve shall be subjected to the test specified in 4.6.1.

4.5.1.2 Tank. Each tank shall be subjected to the following tests as described under 4.6:

a. Examination of product . . . . See 4.6.2

b. Mechanical inspection . . . . See 4.6.3

c. Functional check . . . . See 4.6.4

d. Pressure test . . . . See 4.6.5

e. Cleaning effectiveness tests . . . . See 4.6.6.1 through 4.6.6.4

f. Individual article vacuum retention test . . . . See 4.6.9.2

* g. Evaporation loss rate individual acceptance test . . . . . See 4.6.10.2.

4.5.2 Sampling plans and tests

4.5.2.1 Bursting disc sampling test

4.5.2.1.1 Bursting disc lot. A bursting disc lot shall consist of discs manufactured under essentially the same conditions and submitted for inspection at substantially the same time.

4.5.2.1.2 Bursting disc sampling and test. Three bursting discs from each lot of fifty or less shall be selected at random and each subjected to a gradually increasing clean, dry, oil-free air or nitrogen pressure until it ruptures. In case a disc fails at a pressure outside the limits established by the tank manufacturer for compliance with this specification, five additional sample bursting discs from the same lot shall be tested in the same manner.

4.5.2 .1.2.1 Bursting disc rejection and retest. If more than one of the original samples or any of the five additional sample bursting discs fail at a pressure outside the specified limits, the entire lot shall be rejected.

4,5.2,2 Valve sampling test

4.5.2.2.1 Valve lot. A lot shall consist of valves manufactured under essentially the same conditions and submitted for inspection at substantially the same time.

4.5.2.2,2 Valve sampling and test. One of each type (same size, design, and construction) valve from each lot of one hundred or less shall be selected at random and subjected to the testing specified in 4.6.15.1 through 4.6.15.3. In case the valve fails to fulfill all specified test requirements, three additional sample valves from the lot shall be tested in the same manner.

4.5.2,2.2.1 Valve rejection and retest. If any of the three additional sample valves fail to fulfill all specified test requirements, the entire lot shall be rejected.

4.5,2.3 Liquid line filter sampling test

4.5.2.3.1 Filter lot. A lot shall consist of filters manufactured under essentially the same conditions and submitted for inspection at substantially the same time.

4.5.2.3.2 Filter sampling and test, One of each type (same size, design, and con struction) filter from each lot of 75 or less shall be selected at random and subjected to the absolute and nominal rating testing specified in 4.6.14.1 and 4.6.14,2. In case a filter fails to fulfill all specified test requirements, two additional sample filters from the same lot shall be tested in the same manner,

4.5.2 .3.2.1 Filter rejection and retest. If either of the two additional sample filters fail to fulfill all specified test requirements, the entire lot shall be rejected.

* 4.5.2.4 Dissimilar metal vacuum joint sampling tests

* 4.5.2.4.1 Joint lot. A lot shall consist of joints manufactured under essentially the same conditions and submitted for inspection at substantially the same time.

* 4.5.2.4.2 Joint sampling and test. One of each size, style, and construction dissimilar metal vacuum–joint from each lot of 25 or less shall be selected at random and subjected to the testing specified in 4,6.8.2.2. In case the joint fails to fulfill all specified requirements, three additional samples from the lot shall be tested in the same manner.

* 4,5,2,4.3 Joint rejection and retest. If any of the three additional sample joints fails to fulfill all specified test requirements, the entire lot shall be rejected,

4.6 Test methods

4,6.1 Spring-loaded relief valve test. Prior to installation on the tank, the spring-loaded relief valve shall be subjected to a gradually increasing pressure of clean, dry, oil-free air, oxygen, or nitrogen at its inlet until it starts to discharge, The pressure shall then be reduced until the valve completely reseals, This procedure shall be repeated until the valve has started to discharge and resealed, not less than two times, Following this test, the valve shall be checked for leakage by application of a soap film (film across the outlet and over all outside surfaces) with not less than the maximum working pressure of the component which the valve will be used to protect, being applied at the valve inlet, Failure to open or reseal within the specified limits or an indication of leakage during the soap film test shall be cause for rejection,

4.6.2 Examination of product. The tank shall be inspected to determine compliance with the requirements specified herein with respect to dimensions, workmanship, finish, and marking. The tank shall also be subjected to a thorough inspection to determine quality, ease of adjustment, alignment, and functioning of all parts,

4.6.2.1 Dimensions and weight. The overall dimensions and total weight, including all equipment arid accessories, of the complete] y as assembled empty tank shall be determined and recorded on the test data sheets. The dimensions and weight shall not exceed the limits specified in 3.10 and 3.11.

4.6.3 Mechanical inspection. A mechanical inspection of all components and parts shall be conducted. All pertinent data concerning conditions, defects of manufacturer, damage in transit, and damage through use prior to test shall be recorded.

4.6.4 Functional check, All mechanical parts shall be checked for free and proper functioning.

4,6.5 Pressure test, Each component and circuit of the tank that operates under positive pressure in normal service shall be pressure tested in accordance with section VIII of the ASME Boiler and Pressure Vessel Code, Automatic pressure relief devices need not be installed for this test. Any distortion, damage, or leaks resulting from the pressure testing shall be cause for rejection of the components affected.

4.6,6 Cleaning effectiveness tests

4.6,6.1 Visual inspection. All equipment, pipes, and components that will contact liquid oxygen shall be visually examined for evidence of corrosion products, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals, or other contamination or foreign matter. Any evidence of contamination or foreign matter shall require recleaning and retest.

4.6.6.2 Ultraviolet light inspection. All accessible surfaces and parts that will contact liquid oxygen shall be visually inspected for hydrocarbons with ultraviolet light. Any evidence of fluorescence shall require recleaning and retest.

4.6.6,3 Particulate matter. Following the cleaning and degreasing operations specified herein and equipment final assembly, the liquid storage tank assembly inner shell shall be filled to not less than 90 percent of design capacity with liquid oxygen or liquid nitrogen. The tank shall then be permitted to set undisturbed for not less than 2 hours. Following the 2-hour period, a 2-liter or larger Dewar flask shall be placed under the discharge end of the sump drain line specified in 3.8.1.3.4, the sump drain line shutoff valve opened, and not less than 1 liter of the first liquid discharged through the line collected in the Dewar flask. This sample shall be evaporated to dryness and the residue examined for particulate matter. The liquid storage tank and the associated piping and fittings shall be recleaned and this test repeated until the particulate matter remaining as residue contains:

a, No solid particle with any dimensions greater than 1,000 microns

b. No fibrous particle with a length greater than 6,000 microns

c. No more than 25 milligrams total of both solid and fibrous particles.

4.6.6.4 Total solids. Following withdrawal of the l-liter sample specified in 4.6,6.3, the remaining load of contained liquid shall be discharged through the liquid fill line specified in 3.8.1 .7.1,2 and the filter specified in 3,8.1 .7.1.2.3 at a rate of not less than 50 gpm. The filter shall be thoroughly cleaned and the removed material collected, dried, and weighed after each use, If more than 0.1 gram of contaminant material is collected on the filter during discharge of the liquid from the tank, the liquid storage tank assembly and the associated piping and fittings shall be recleaned. Cleaning a testing shall be repeated until the amount of contaminant collected on the filter from discharging the specified liquid storage tank assembly load is less than 0.1 gram.

4.6,7 Liquid storage capacity test. The tank storage capacity shall be determined by filling a liquid into the inner shell with the tank setting on its skid base on a flat, level, surface until the filling liquid overflows through the vapor vent line specified in 3.8.1,7.1.5, recording the liquid level gage reading in terms of liquid oxygen, and then either measuring the volume of the filling liquid or determining its volume from weights before and after filling. The inner shell shall then be filled completely to determine total internal volume, and the quantity of filling liquid determined as above, The actual liquid volume when filled to overflow through the vapor vent line and when completely filled shall both be recorded in U. S, gallons and shall be accurate to within 1 gallon, The tank storage capacity at which liquid starts to discharge through the vapor vent line and the total internal volume shall comply with 3,7.1 and 3.8,1 .7.1,5 or the tank shall be considered to have failed the test,

4.6.8 Transportability and handling test

* 4.6.8.1 Air transport flight and taxiing acceleration for c es. The completely assembled tank shall be filled to design capacity with a cryogenic liquid having a density of not less than 9.5 pounds per U, S, gallon and pressurized to not less than 45 psig. While so filled and pressurized, the tank with the servicing hose secured in

the storage provisions specified in 3,8.2.5 shall be subjected to the flight and taxiing acceleration force loads specified in MIL-A-8421, as modified by 3.7.4.1. Failure to satisfactorily pass the specified tests for demonstrating compliance with the requirements of 3.7.4.1 shall be cause for rejection.

* 4,6.8,1.1 Liquid nitrogen may be used as the filling liquid if the acceleration levels are increased to not less than 1.42 times the specified values.

* 4. 6.8,2 Vibration. The completely assembled tank shall be filled to design capacity with liquid nitrogen and pressurized to not less than 45 psig. While so filled and pressurized, the tank with the servicing hose secured in the storage provisions specified in 3,8.2,5 shall be subjected to the vibration testing specified in method 514 of MIL-STD-810 for class 6 equipment. During and after each phase of testing the tank, the test instrumentation, and the data being accumulated shall be observed for resonance of piping, instruments, accessories, braces, brackets, and other installed parts, devices and equipment; loosening or loss of threaded, riveted, or o the r fasteners; and other damage or indications of impending failure of the overall tank or any of its components, Full details of resonances, loosening of parts or fasteners, or other damage or indications of impending failure shall be recorded on the test data sheets, Programmed vibration testing not completed because of a failure or impending failure, including any remaining resonance dwell, shall be repeated after corrective action.

4,6.8.2.1 The tank shall be carefully examined after each test phase and following completion of the overall test. Fractures or bending of piping, braces, or brackets; fracture or failure of welded, brazed, or soldered joints, connections, or fittings; loosening or loss of parts or of threaded, riveted or other type fasteners; damage to or loss of calibration in gages and other instruments; or loss of vacuum in the annular space attributable to either outgassing or leaks shall be considered a failure of the tank to pass the test.

* 4.6.8 .2.2 Dissimilar metal vacuum joints used in the tank construction shall be tested as follows:

a. Subject the joint assembly to 10 thermal shocks. Each thermal shock shall be accomplished by first heating the complete joint assembly to not less than 125°F and then, before the joint has cooled below 125°F, quickly submerging the complete joint assembly in liquid nitrogen at its atmospheric pressure boiling temperature, The joint assembly shall remain submerged in the liquid nitrogen until the joint has cooled to approximately liquid nitrogen temperature, The joint assembly will be considered to have reached liquid nitrogen temperature when bubbles cease to emanate from its surface in large numbers.

b. Secure the joint assembly by one end only (with the other end free to move) to a vibration input device which will vibrate the joint assembly in liquid nitrogen. The joint assembly shall then be subjected to axial vibration at a frequency of 60 cps and a double amplitude of not less than 0.050 inch for not less than 30 minutes while the joint assembly is submerged in liquid nitrogen at its atmospheric pressure boiling temperature,

c. Secure the joint assembly as in b, above. The joint assembly shall then be subjected to lateral vibration at a frequency of 60 cps and a double amplitude of not less than 0.200 inch for not less than 30 minutes while the joint is submerged in liquid nitrogen at its atmospheric pressure boiling temperature,

Any leakage rate increase detectable with a helium mass spectrometer operating at its maximum sensitivity, comparing checks prior to and following the temperature shock and vibration testing specified above, shall be cause for rejection.

* 4.6,8.3 Emergency landing acceleration forces, The completely assembled tank shall be filled to design capacity with a liquid having a density of not less than 9,5 pounds per U. S. gallon and pressurized to not "less than 45 psig. While so filled and pressurized, the tank with the servicing hose secured in the storage provisions specified in 3.8.2.5 shall be subjected dynamically to the emergent y landing acceleration force loads specified in MIL-A-8421, as modified by 3.? ,4.3. Breaking loose of the unit from its tiedowns, separation of a component from the main body of the unit, or any discharge of contained liquid beyond the tank envelope shall be cause for rejection,

4.6.8.4 Forklift provision test. The completely assembled tank shall be filled design capacity with a liquid having a density of not less than 9.5 pounds per U.S. gallon. The completely assembled, filled tank shall then be raised not less than 3 feet above the floor by a forklift utilizing the forklift tine entries specified in 3.8.3.2, transported by the forklift a horizontal distance of not less than 25 feet to a new location, set on the floor in the new location, and the forklift backed not less than 10 feet away. The lifting and movement procedure shall be accomplished not less than 5 times from each side of the tank. Any damage to or distortion of any tank component or interference with forklift handling shall be cause for rejection,

4,6.8.5 Hoisting and tiedown provision test. The completely assembled tank shall be filled to design capacity with a liquid having a density of not less than 9.5 pounds per U. S. gallon. Weights totaling not less than 11,000 pounds shall be so attached to the tank that the combined weight of the filled tank and the weights will be supported by the hoisting and tiedown rings when the tank is raised by an overhead crane. The tank and weights combination shall then be raised to a height of not less than 3 feet above the floor by a single-hook overhead crane using the hoisting and tiedown rings, held in that position for not less than 1 minute, and then lowered to the floor. This procedure shall be repeated three times, Any damage to or distortion of any tank component shall be cause for rejection.

4.6.9 Vacuum retention tests

4,6.9.1 Preproduction article vacuum retention. Following the air transport flight and taxiing acceleration forces testing specified in 4.6.8.1 and the lifting provision tests specified in 4,6.8.4 and 4.6.8.5, the liquid storage tank assembly inner shell shall be filled with liquid oxygen or liquid nitrogen to not less than 60 percent of design capacity. The liquid storage tank assembly shall then be permitted to temperature stabilize until a constant annular insulation space absolute pressure is obtained. After temperature stabilization is reached, and with the inner shell vapor space at approximately atmospheric pressure, the annular insulation space absolute pressure shall be determined with an instrument of the type specified in 4.3.2.1.1, The inner shell vapor space shall then be pressurized to not less than 30 psig with gas obtained by vaporizing part of the contained liquid with the pressure buildup system, and the tank allowed to set for not less than 7 days (168 hours) so filled and pressurized. The vibration testing specified in 4.6.8,2 shall be conducted on the tank following evacuation and sealing of the annular insulation space and either prior to or during and as part of the preproduction article vacuum retention test.

4,6.9.1.1 Following completion of the testing specified in 4.6.9.1, the inner shell vapor space pressure shall be reduced to atmospheric and the annular insulation space absolute pressure determined with an instrument of the type specified in 4.3.2.1,1. The liquid storage tank assembly annular insulation space absolute pressure shall not show any increase attributable to leakage or outgassing, or the tank shall be considered to have failed the test.

4,6.9.2 Individual article vacuum retention. The liquid storage tank assembly inner shell shall be filled with liquid oxygen or liquid nitrogen to not less than 60 percent of design capacity. The liquid storage tank assembly shall be permitted to temperature stabilize until a constant annular insulation space absolute pressure is obtained, After temperature stabilization is reached, and with the inner shell vapor space at approximately atmospheric pressure, the annular insulation space absolute pressure shall be determined -with an instrument of the type specified in 4.3.2.1.1. The inner shell vapor space shall then be pressurized to not less than 30 psig with gas obtained by vaporizing part of the contained liquid with the pressure buildup system, and allowed to set for not less than 7 days (168 hours) so filled and pressurized. During the vacuum retention test period, the tank shall be subjected to vibration of not less than 30 minutes duration in one plane. The vibration input to the tank shall be at a constant acceleration amplitude of not less than 1.5g peak vector for the frequency applied. The vibration frequency shall be between 15 and 40 cps, inclusive, Either a single, constant frequency or a periodic sweep of the specified frequency range may be used.

4.6,9.2,1 Following completion of the testing specified in 4.6,9.2, the inner shell vapor space pressure shall be reduced to atmospheric, the annular insulation space absolute pressure determined with an instrument of the type specified in 4,3.2.1.1, and the tank examined for damage as a result of the vibration. The liquid storage tank assembly annular insulation space absolute pressure shall not show any increase attributable to leakage or outgassing and the tank shall not have suffered any fracture of piping, braces, brackets or of a welded, brazed, or soldered connection; loosening or loss of threaded, riveted or other fasteners; or gages and other instruments damaged or out of calibration as a result of the vibration; or the tank shall be considered to have failed the test.

4.6.10 Heat leak evaporation loss rate tests

4.6.10.1 Initial preproduction test. The initial preproduction article heat leak evaporation loss rate test shall consist of the following individual test operations conducted in the order listed. Throughout the complete test, the inner shell vapor phase pressure shall remain at as near atmospheric as necessary pressure drops through the measuring apparatus will permit,

4.6.10.1,1 Following the vacuum retention test and with the liquid storage tank assembly inner shell remaining filled to riot less than 50 percent of design capacity with liquid oxygen or liquid nitrogen, the tank shall be placed in a location where the ambient temperature will remain at not less than 125°F throughout the periods specified,

4.6.10.1.2 The inner shell vapor space shall be vented to atmospheric pressure for not less than 24 hours through the flow measuring apparatus that will be used for determining the evaporation loss rate.

* 4,6,10.1.3 The tank shall remain under the specified ambient temperature and inner shell vapor phase pressure conditions for an additional 72 hours while heat leak evaporation rate losses for the tank are determined by passing all vapors vented from the inner shell through a recording- or totaling-type gas flowmeter. During this 72-hour test period, the upper surface of the tank shall be exposed to the full impact of solar or equivalent heat radiation of 100 to 120 watts per square foot for three separate periods of not less than 8 hours each, with each exposure period followed by a period of not less than 16 hours during which no radiation is applied, The total weight of vapors vented during the test, the weight of vapors vented since the preceding reading, the average ambient temperature to which the tank has been subjected during the preceding period, and the average barometric pressure to which the tank has been subjected during the preceding period shall be recorded at intervals not to exceed 8 hours during the 72-hour test. The actual loss rate for each reading, the average actual loss rate over the entire 72-hour test period, and the average ambient temperature to which the tank was exposed during the 72-hour test period shall be calculated. The evaporation loss rates shall be reported as the pounds of liquid oxygen vaporized per 24-hour day, and shall not exceed the limit specified in 3.7.2, or the tank shall be considered to have failed the test.

4.6.10.1.4 The tank shall be removed from the high temperature test conditions and exposed to ambient temperature conditions for not less than 36 hours to permit temperature stabilization.

4,6.10.1.5 The tank shall then be subjected to the individual acceptance evaporation loss rate test specified in 4,6.10.2 to establish comparative data for determining whether production tanks are capable of complying with 3.7.2.

* 4.6,10.2 Evaporation loss rate individual acceptance test. Following the vacuum retention test and with the inner shell remaining filled to not less than 50 percent of

design capacity, the tank shall be placed where it will be subjected to local or shop ambient temperatures throughout the test. The inner shell vapor space shall be vented to atmospheric pressure for not less than 24 hours through the flow measuring apparatus that will be used for determining the evaporation loss rate, The heat leak evaporation loss rate for the tank shall then be determined by passing all vapors vented from the inner shell through a recording- or totaling-type gas flowmeter for an additional period of not less than 72 hours, Throughout the test, the inner shell vapor phase pressure shall remain at as near atmospheric as necessary pressure drops through the flow measuring apparatus will permit.

* 4.6.10 .2,1 The total weight of vapors vented during the test, the weight of vapors vented since the preceding reading, the average ambient temperature to which the tank has been subjected during the preceding period, and the average barometric pressure to which the tank has been subjected during the preceding period shall be recorded at intervals not to exceed 8 hours throughout the 72-hour test. The actual loss rate in pounds for each reading, the average actual loss rate in pounds over the entire 72-hour test period, and the average ambient temperature to which the tank was exposed during the 72-hour test period shall be calculated. The production item average loss rate for the 72-hour test period shall be corrected from the average temperature experienced during the test period to the average temperature at which the comparative data specified in 4.6.10.1,5 was obtained, and the result reported as the pounds of liquid oxygen vaporized per 24-hour day. This loss rate shall not exceed the limit established by the comparative data obtained in 4.6,10.1.5 for compliance with 3.7.2, or the tank shall be considered to have failed the test.

4.6.11 Pressure buildup tests

4.6.11,1 Buildup with low liquid level. The liquid storage tank assembly shall be filled with enough liquid oxygen or liquid nitrogen to insure between 25 and 30 gallons remaining in the inner shell after the specified stabilization, The tank shall then set with the inner shell vapor space vented to atmospheric pressure for not less than 4 hours, Following this stabilization period, the inner shell vapor vent line shutoff valve shall be closed and the pressure buildup valve opened. The inner shell vapor phase pressure shall reach 50 psig or the tank shall be considered to have failed the test,

4.6.11.2 Pressure buildup time, The liquid storage tank assembly shall be filled with liquid oxygen or liquid nitrogen to between 15 and 20 percent of capacity and permitted to set with the inner shell vapor space vented to atmospheric pressure for not less than 4 hours. The inner shell vapor vent line shutoff valve shall then be closed and the pressure buildup system actuated. The length of time required after closing of the vent valve until the vapor phase pressure has reached 50 psig shall not exceed 10 minutes or the tank shall be considered to have failed the test.

4.6.12 Insulation combustibility, A sample of the insulation material used in the annular space shall be tested for combustibility as follows:

a. Place approximately 0.5 gram of the material in an oxygen bomb

b. Pressurize the oxygen bomb to not less than 10 psig with oxygen gas having a purity of 99.5 percent or better

c. Raise the temperature of the oxygen bomb to not less than 400°F and hold at that temperature for not less than 1 hour

A sudden temperature rise, charring of the insulation material, or other evidence of ignition or burning of the insulation material shall be considered cause for rejection.

4.6.13 Liquid transfer tests

4.6.13.1 Fill line. Liquid oxygen shall be transferred into the tank through the liquid fill line specified in 3.8.1 .7.1.2 at not less than 50 U. S. gallons per minute for a length of time adequate to determine the pressure drop resulting from friction losses in the filter and line. The pressure drop shall not exceed that permitted in 3.8,1.7.1.2, or the tank shall be considered to have failed the test,

* 4.6.13,1.1 Liquid nitrogen may be used at a flow rate which will provide a pressure drop equivalent to that resulting from the specified liquid oxygen flow. If liquid nitrogen is employed for this purpose, data shall be provided to substantiate the flow rate used.

4.6.13.2 Servicing line. Liquid oxygen shall be transferred from the tank through the liquid servicing line specified in 3.8.1 .7.1.3 at not less than 25 U. S. gallons per minute for a length of time adequate to determine the pressure drop resulting from friction losses in the filter and line. The pressure drop shall not exceed that permitted in 3.8.1.7.1.3, or the tank shall be considered to have failed the test.

* 4.6.13.2,1 Liquid nitrogen may be used at a flow rate which will provide a pressure drop equivalent to that resulting from the specified liquid oxygen flow. If liquid nitrogen is employed for this purpose, data shall be provided to substantiate the flow rate used.

* 4.6.13.3 Vapor vent line. The tank shall be subjected to conditions that will insure all liquid storage tank assembly components attaining a temperature of not less than 125°F. After the liquid storage tank assembly components have stabilized at this temperature, liquid oxygen or liquid nitrogen shall be transferred into the inner shell through the fill line until the inner shell has cooled sufficiently to permit filling at the 50 gpm rate specified in 3.8.1.7.1.5. The rate of transfer during cooldown shall be the maximum that will maintain a liquid storage tank assembly inner shell vapor phase pressure of less than 15 psig, The cooldown time shall not exceed 15 minutes, or the tank shall be considered to have failed the test. Following cooldown, the liquid

storage tank assembly shall be filled at a rate of not less than 50 gpm. The inner shell vapor phase pressure shall not exceed that specified in 3.8.1.7.1.5 when filled at the specified rate, or the tank shall be considered to have failed the test.

4.6.14 Filter tests

* 4.6,14.1 Absolute rating. Compliance with the 40-micron absolute rating requirement of 3.8.1 .7.1,2.3.1 shall be substantiated by the bubble point method as follows: The filter element shall be submerged in Solox 190, or equivalent, fluid. The fluid level shall be maintained at not to exceed 1/2 inch above the top of the element. The element shall be slowly pressurized from within and slowly rotated 360 degrees at each pressure increment If the first bubble is emitted from the element at a pressure of less than 6 inches of water, the filter shall be considered to have failed the 40-micron requirement, The pressure shall be increased until the bubble point is determined.

4.6,14,2 Nominal rating. Compliance with the removal of 98 percent by weight of all particles whose smallest dimension is 10 microns or greater as required by 3,8.1 .7.1.2.3.1 shall be substantiated as follows:

Following completion of the fifty-cycle servicing test specified in 4.6.18 the filter shall be allowed to stabilize at 125°F without any intervening servicing, cleaning, adjustment, or repair. Approximately 20 liters of liquid oxygen or liquid nitrogen previously filtered through a 5-micron Millipore, or equivalent, membrane filter shall be contaminated with 10 grams of particles with the following size distribution:

Size of Particle (Microns)	Percentage by Weight
10 to 20	36 ±3
20 to 40	24 ±3
40 to 60	16 ±3
Over 60	24 ±3

The liquid shall be placed in a container, agitated to insure a homogeneous mixture, and then transferred through the filter in a time interval of not more than 45 seconds. The filter shall be so positioned that the flow is vertically down and the discharge is directed into a clean, particle-free co container with provisions to insure positive retention of any particles passing through the filter, and exclusion of external particles. The liquid shall be permitted to vaporize, and the container flushed by use of a wash bottle containing approximately 200-ml of isopropyl alcohol which has been previously filtered through a 5-micron Millipore, or equivalent, membrane filter. The wash solution shall then be filtered through a preweighed 5-micron Millipore, or equivalent, membrane filter. This container wash procedure shall be performed four times. The filter funnel shall then be washed with an additional 200-ml of solvent. Upon completion of the filtering, the filter shall be weighed again. If the weight increase is more than 0.2 gram, the filter shall be considered to have failed the 98-percent retention of all particles 10 microns or larger.

* 4.6.14.3 Filter pressure drop. Liquid oxygen shall be transferred through the filter at a flow rate of not less than 50 gpm for a length of time adequate to determine the pressure drop through the filter after contamination. The liquid oxygen stream shall be contaminated with not less than 5 grams of particles of the size and composition listed under 3.8.1.7.1.2.3.1. The 5 grams of contaminant shall be introduced into the liquid stream at the approximate rate of 1 gram per minute. Introduction of the contaminant shall not require more than 4-1/2 minutes ±30 seconds. The pressure drop after the filter has been so contaminated shall not exceed 2 psig, or the filter shall be considered to have failed the test. The filter shall then be further contaminated with particles until a constant pressure drop of not less than 50 psig across the filter element is reached. Following this, the filter shall be opened and inspected. Any permanent distortion or damage incurred by the filter element or housing as a result of the 50 psig pressure differential shall be cause for rejection.

* 4.6.14.3.1 Alternate test material. Water may be used at a flow rate which will provide a pressure drop equivalent to that resulting from the specified liquid oxygen flow. If water is employed for this purpose, data shall be provided to substantiate the flow rate used.

4.6.15 Shutoff and control valve tests. The valve shall be subjected to the following tests in the order specified:

4.6.15.1 Cycling. The valve shall be closed with a torque of 60 ±5 lb in. per inch of nominal size, and subjected to a compressed air, oxygen gas, or nitrogen gas inlet pressure of not less than 50 psig with the outlet open to atmospheric pressure. The valve shall then be opened to not less than the three-fourths open position, after which it shall be again closed with a torque of 60 ±5 lb in. per inch of nominal size and the specified inlet pressure reestablished. This shall constitute 1 cycle. One thousand such cycles shall be accomplished without intervening valve lubrication, adjustment, or repair while the valve body is subjected to ambient temperature. The thousand-cycle test shall then be repeated with the valve body submerged in liquid oxygen or liquid nitrogen. Damage to or improper operation of the valve as a result of this test shall be cause for rejection.

4.6.15.2 Overtorque. At the conclusion of the cycling test specified in 4.6.15.1, the valve shall be removed from the liquid bath and permitted to stabilize at ambient temperature. The valve shall then, without intervening lubrication, adjustment, or repair, be fully opened, and closed with a torque of 300 ±10 lb in. per inch of nominal size. Damage to or improper operation of the valve as a result of this test shall be cause for rejection.

4.6.15.3 Leakage. Following the overtorque test specified in 4.6.15.2 and without intervening valve lubrication, adjustment, or repair, the valve shall be fully opened, and closed with a torque of 60 ±5 lb in. per inch of nominal size. The valve shall then be completely immersed in clear water with the inlet subjected to a compressed air, oxygen gas, or nitrogen gas pressure of not less than 50 psig for not less than 10 minutes with the outlet open. Any leakage past the seat, through the packing, or through the valve body shall be collected and measured. Total collected gas leakage exceeding 2 cubic inches of free air, nitrogen gas, or oxygen gas per hour per inch of valve nominal size shall be considered cause for rejection.

* 4.6.16 Disconnect coupling torque resistance test. The liquid fill line disconnect coupling and the liquid servicing line disconnect fitting shall each be subjected to a torque of not less than 300 lb ft per inch of nominal line size applied to the coupling or fitting first in one and then in the other direction of rotation with a 24-inch wrench. Any twisting of, distortion of, or damage to tank piping or connections resulting from this torque testing shall be cause for rejection.

4.6.17 Servicing and maintenance, All normal preventive maintenance and servicing operations specified in the maintenance and instruction handbook prepared by the contractor shall be performed to determine their adequacy, ease of accomplishment, and the accessibility of parts and assemblies for performance of same, unless such instructions are contrary to those necessary for compliance with the requirements specified herein. Insofar as practicable, these tests shall be conducted as part of the normal preventive maintenance, servicing, and inspections performed in accomplishing the testing specified herein. The servicing shall include vacuum pumping and sealing of the vacuum line. Interferences or obstructions to servicing or preventive maintenance shall be reported in detail.

4.6.18 Environmental testing. The tank shall be subjected to the following tests conducted in accordance with the specified methods of MIL-STD-810, At the conclusion of each test, the tank shall be examined for deterioration.

4,6.18.1 Low temperature

4.6.18,1.1 Low temperature exposure. The liquid storage tank assembly shall be filled to design capacity with liquid oxygen or liquid nitrogen and subjected to low temperature in accordance with method 502, procedure I.

4.6.18 .1.1.1 Pressure buildup. Upon completion of the low temperature exposure, the unit shall be stabilized at -65°F, the inner shell vapor vent line shutoff valve closed, and the pressure buildup system actuated. The length of time required after closing of the vent valve until the vapor phase pressure has reached 50 psig shall not exceed 10 minutes,

4.6,18.2 High temperature, The liquid storage tank assembly shall be filled to design capacity with liquid oxygen or liquid nitrogen and sub jetted to high temperature in accordance with method 501, procedure I. The control housing access doors shall be open throughout this exposure,

4.6.18.3 Humidity, The complete tank shall be subjected to humidity in accordance with method procedure I.

* 4.6.18.3.1 Inner shell vapor space pressure relief device venting. During the humidity test specified in 4.6.18.3, with the ambient temperature at not less than 125°F and with the tank remaining filled to not less than 90 percent of design capacity, the vapor vent line shutoff valve specified in 3.8.1.7.1.5.2 shall be tightly closed, the pressure buildup system controls adjusted for maximum buildup rate, and all other valves closed. The inner shell vapor space excess pressure shall be permitted to vent through the relief device specified in 3.8.1.9.3 until the vapor space pressure reaches its maximum reading. The vapor space pressure shall not exceed 65 psig under these conditions, or the tank shall be considered to have failed the test.

4.6.18.4 Fungus. Equipment samples adequately representing applicable portions of the tank that might be damaged by exposure to fungus attack shall be subjected to fungus in accordance with method 508, procedure I.

4.6.18.5 Salt-fog. The complete tank shall be subjected to salt-fog in accordance with method 509, procedure I.

4.6.18.6 Rain. The complete tank shall be subjected to rain in accordance with method 506, procedure I.

4.6.18.7 Sand and dust. The complete tank shall be subjected to sand and dust in accordance with method 510, procedure I.

4.6.18.8 Wind. It shall be demonstrated, by testing or calculations, that the tank will withstand the 70-mph wind specified in 3.7.5.8, 3.8.2.3, and 3.8.2.3.1.

4.6.19 Servicing cycle. The liquid storage tank assembly inner shell shall be filled to design capacity with liquid oxygen or liquid nitrogen and the tank permitted to set with the vapor vent line shutoff valve wide open until all uninsulated components external to the outer shell have warmed to approximately ambient temperature. The tank shall then be subjected to the testing specified in 4.6.19.1 through 4.6.19.3.

4.6.19.1 Following the filling and stabilization specified in 4.6.19, a servicing cycle shall be performed as follows. The servicing cycle operations shall be performed in the order listed:

a. Connect the servicing hose disconnect fitting to a container suitable for use with liquid oxygen or liquid nitrogen

b. Close the vapor vent line shutoff valve

c. Open the pressure buildup manual control valve until the liquid storage tank assembly inner shell vapor phase pressure has risen to not less than 45 psig, after which close the buildup control valve

d. Open the liquid servicing line shutoff valve and transfer not less than 5 gallons of liquid into the receiving container through the servicing hose

e. Close the liquid servicing line shutoff valve

f. Open the vapor vent line shutoff valve to vent the inner shell vapor space to atmospheric pressure

g. Permit the tank to set with the vapor vent line shutoff valve fully open until all ice and frost are gone from the buildup coil, valves, and servicing line, The application of external heat to expedite warmup is permissible.

4.6.19.2 The servicing cycle specified in 4.6.19.1 shall be repeated until the tank has been subjected to not less than 50 such cycles. The tank shall be filled with additional liquid oxygen or liquid nitrogen as necessary for completing the test.

4.6.19,3 The tank shall complete the specified 50 servicing cycles without necessity for servicing or maintenance of any kind other than refilling with liquid, or shall be considered to have failed the test.

4.6,20 Mechanical check. Upon completion of the above tests, a critical inspection shall be made of components to determine their operability and any damage or undue wear incurred during the tests. Teardown and parts measurement shall be made only in those cases where service life is in question. Where teardown and parts measurement are performed, wear or distortion that exceeds limits permitted by the manufacturer for new parts shall be cause for considering the part or parts affected as having failed to satisfactorily complete the test.

4.6.20.1 Steel parts subject to high stress in operation and that are suspected of having defects shall also be subjected to magnetic particle inspection (magnaflux) and shall exhibit no indications of damage attributable to the tests, or shall be considered as having failed the test. Grinding checks and subsurface indications of laps or seams shall not be cause for rejection. Magnetic particle inspection shall be performed in accordance with MIL-I-6868.

4,6.20.2 Nonmagnetic parts suspected of defects shall be subjected to inspection with fluorescent penetrant (black light) and shall exhibit no breaks or other defects that would impair their life or usefulness. Penetrant inspection shall be performed in accordance with MIL-I-6866.

4.6.21 Reliability demonstration and test. Satisfactory completion of all tests required herein will be considered to demonstrate acceptable compliance with the quantitative reliability requirements of this specification.

4.6.22 Maintainability evaluation. The tank shall be inspected and evaluated from the standpoint of ease of maintenance, servicing, and operation, Particular attention shall be given to maintenance with a minimum number of common tools; servicing and operation by personnel wearing heavy gloves, and provisions made to prevent accumulation of dirt, snow, ice, et cetera; that may hinder servicing and operation.

'4.7 Inspection of preparation for delivery, The inspection of the preservation, packaging, packing, and marking shall be in accordance with the requirements of section 5 herein,

5. PREPARATION FOR DELIVERY '

5.1 General instructions

5.1.1 Cleaning, The tank shall be thoroughly cleaned to remove excess and spilled lubrication materials, loose or chipped paint, spilled chemicals, and other foreign materials. All cleaning solvents shall be thoroughly removed from the tank components and accessories prior to delivery,

5.1,2 Repainting. Tank surfaces on which the paint is damaged or defective shall be thoroughly cleaned and repainted as specified under 3.12.

5,1.3 Liquid storage tank assembly purging and sealing. The liquid storage tank assembly inner shell shall be drained of all liquids and purged with not less than 250 standard (68°F and 760 mm Hg) cubic feet of clean, dry, oil-free nitrogen gas introduced through the vapor phase vent line specified in 3.8,1,7.1.5. The fill and servicing line valves shall be opened individually, and the gas flow permitted to purge the respective lines, valves, and fittings. The major portion of the purge gas shall be exhausted through the sump drain line specified in 3.8,1,3,4.

5.1.3.1 Following this purging, the inner shell shall be pressurized to not less than 10 psig nor more than 20 psig with clean, dry, oil-free nitrogen gas, after which every valve and line leading into the inner shell shall be closed. The ends of all pipes, tubes, and couplings shall be securely sealed with pressure-sensitive tape conforming to PPP-T-60. The liquid storage tank assembly annular insulation space shall be evacuated to the absolute pressure recommended in the tank operating and servicing instruction handbook if it is not at or below that pressure. The vacuum line shutoff valve shall be tightly closed after the evacuation and the vacuum line sealed with the cap provided.

5.1,3.2 A type A tag conforming to UU-T-81, with tag and printing waterproofed, stating that the inner shell is clean and pressurized with clean, dry, oil-free nitrogen gas and indicating the date and the pressure to which the annular space has been evacuated, shall be securely attached to the vapor vent line shutoff valve handle in a conspicuous location.

5.1.4 Preservatives. Preservatives and lubricants shall not be applied to any part of the equipment that will come into contact with high purity oxygen.

5.1,5 Securing for shipment. Small items and packages not fastened to major components shall be secured to or packed with major components to insure against accidental loss or damage caused by movement during shipping, 5.2 Preservation and packaging, Preservation and packaging shall be level A or C, as specified (see 6.2).

5.2.1 Level A, Unless otherwise specified, the tank shall be physically and mechanically protected in accordance with method III of MIL-P-116. Unit quantities shall be one each.

5.2.2 Level C. The tank shall be preserved and packaged in accordance with the manufacturer's commercial practice.

5.3 Packing. Packing shall be level A, B, or C, as specified (see 6.2),

5.3.1 Level A. Unless otherwise specified, the tank preserved and packaged as specified in 5,2.1 shall be packed in exterior-type shipping containers conforming to MIL-C-104 and appendix thereto type II, class 2, style 2,

5.3.2 Level B. Unless otherwise specified, the tank preserved and packaged as specified in 5,2.1 and being shipped in less than full carload or full truckload lots, shall be packed as specified in 5.3.1, When shipped in full carload or full truckload lots, the tank shall be provided with a wooden shield constructed to provide protection for the instruments and controls while the tank is in transit or storage. The shield shall enclose the entire instrument and control area and shall be securely fastened to the tank, Exterior shipping containers will not be required,

5.3.3 Level C. The tanks that require overpacking for acceptance by the carrier shall be packed in a manner that will insure safe transportation, at the lowest rate, to the point of delivery. Containers shall meet Consolidated Freight Classification Rules or regulations of other carriers as applicable to the mode of transportation.

5.4 Physical protection. Cushioning, blocking, bracing, and bolting as required shall be in accordance with MIL-STD-1186, except that for domestic shipments, waterproofing requirements for cushioning materials and containers shall be waived. The drop tests of MIL-STD-1186 shall be waived when preservation, packaging, and packing of the item are for immediate use or when the drop tests of MIL-P-116 are applicable.

5.5 Shipment marking. Interior and exterior containers shall be marked in accordance—with MIL-STD-129. The nomenclature shall be as follows:

Tank, Storage, Liquid Oxygen, 400 Gallon Capacity, TMU-24/E, Skid Mounted

6. NOTES

* 6.1 Intended use. The TMU-24/E liquid oxygen storage tank is intended for air transport of liquid oxygen to airbases or other installations, and for storing the material at destination until needed for filling aircraft servicing vehicles, with minimum evaporation loss of the contained fluid.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification

b. Whether a complete set of all special tools other than common handtools is to be provided (see 3.6.12)

c. Location and conditions for preproduction testing (see 4.4)

d. That, when specified, the preproduction tests may be waived if the contractor's item has previously passed the preproduction tests specified herein

e. Required level of preservation, packaging, and packing (see 5.2 and 5.3).

* 6.3 Abbreviations. In order to save space and to avoid the spelling out of repetitious words and phrases, the following abbreviations have been used in the text of this specification:

g .... gravitational units
V .... volts
cps .... cycles per second
gpm .... gallons per minute
Hg .... mercury
lb ft .... pound feet
lb in .... pound inches
ml .... milliliter
mm .... millimeter
ms .... millisecond
mph .... miles per hour
MTBF .... mean-time-between-failures
psi .... pounds per square inch
psig .... pounds per square inch gage

6.4 Definitions. For purposes of this specification, the following definitions will apply:

*

6.4.1 MTBF. MTBF is the average (arithmetic mean) of the operating time between failure or the mean-time-between failure. Note that the point estimate of MTBF from demonstration data (the sum of the test operating time divided by the number of counted failures) is larger than the MTBFmin. demonstrated at a specified confidence as described below. Note also that MTBFmin. considered acceptable and to be demonstrated is often lower than the MTBF reasonably expected and attainable within the current state-of-the-art. MTBF is used as an expression representing MCBF, mean-cycles-between-failure.

6,4.2 Servicing cycle. A servicing cycle is defined as pressurizing the liquid storage tank assembly inner shell vapor space, transferring liquid into another vessel, and repressurizing the inner shell vapor space back to approximately atmospheric pressure.

6,4.3 Ambient conditions. Ambient conditions are the dry-bulb temperature, wet-bulb temperature, and the relative humidity of the atmospheric air surrounding and in the vicinity of the tank, but unaffected by any heat or cold emanating from the tank itself.

6,4.4 Pressures. All pressures referred to herein, unless specified as absolute or denoted by the symbol psia, will be interpreted as pounds per square inch (psi) gage,

* 6,4.5 Dissimilar metal vacuum joint. A dissimilar metal vacuum joint is defined as a mechanical (welded or other type) joint between different base metals, or between alloys with different base metals as the prinicipal constituent, used in the tank construction where the joint must function to seal the liquid storage tank assembly annular insulation space from a different pressure.

6.4.6 Valve cycle of operation. A cycle of operation for a valve is defined as opening the valve from sealing a differential pressure of not less than 50 psig to the not less than three-fourths open position, and reclosing the valve with a torque of 60 ±5 lb in. per inch of valve nominal size.

6.4.7 Fibrous particle. A fibrous particle is defined as a long, slender particle whose maximum cross sectional dimension is 40 microns.

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

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