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PERFORMANCE SPECIFICATION

TANK, STORAGE, LIQUID OXYGEN/LIQUID NITROGEN, TMU-24/E

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

1. SCOPE

1.1 Scope. This specification covers two types of skid-mounted, 400-gallon tanks for air transport and storage of liquid oxygen and liquid nitrogen.

1.2 Classification. Tanks covered by this specification are of the following types:

Type I	Liquid Oxygen 400 Gallon
Type II	Liquid Nitrogen 400 Gallon

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are cited in sections 3 and 4 of this specification. These lists do not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of these lists, document users are cautioned that they must meet the requirements specified in the documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data that may be of use in improving this document should be addressed to: Resources & Logistics Services Division, WR-ALC/TILCC, 420 Second Street, Suite 100, Robins AFB, GA 31098-1640, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 3655

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of these documents are those listed in the specific issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto cited in the solicitation (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-H-27301	Hose Assembly, Metal, Cryogenic Liquid Transfer

STANDARDS

FEDERAL

FED-STD-595	Colors Used in Government Procurement

DEPARTMENT OF DEFENSE

AN929	Cap Assembly, Tube, Pressure Seal
MIL-STD-810	Environmental Engineering Considerations and Laboratory

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-838	Lubrication of Military Equipment
MIL-HDBK-1791	Designing for Internal Aerial Delivery in Fixed Wing Aircraft
MIL-HDBK-808	Finish, Protective, and Codes for Finishing Schemes for Ground and Ground Support Equipment

(Unless otherwise indicated, copies of the above specifications and standards are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents and drawings form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues are those cited in the solicitation.

COMMERCIAL ITEM DESCRIPTION

FEDERAL

A-A-50271	Plate, Identification
A-A-58092	Tape, Antiseize, Polytetrafluorethylene

DRAWINGS

US AIR FORCE

48B7796	Ring Assembly-Tiedown, 10,000 Pounds
68A39469	Plug
68A39470	Body
68A39471	Vacuum Pump Out and Relief Assembly
68A39472	Cap
68A39473	Vacuum Pump Out Assembly Filter Assembly
7545352	Requirements for Finishes SA-ALC Ground Support Equipment

ORDNANCE CORPS

C8987830	Assembly, LOX Coupling, Male Half, All Sizes
C8987831	Assembly, LOX Coupling, Female
B8987832	Gasket, LOX and LN2, All Sizes
B8987833	Gasket, LOX or LN2-Dummy Drawing
B8987839	Ring, Retaining
A8987840	Ring, Retaining-Dummy Drawing
C8987855	Seat, LOX Coupling, 1 inch
C8987856	Cone, LOX Coupling
C8987857	Nut, LOX Coupling
C8987869	Cap, LOX, 1 inch
C8987870	Plug, LOX
C8987876	Seat, LN2 Coupling
C8987877	Cone, LN2 Coupling
C8987878	Nut, LN2 Coupling
C8987888	Assembly, Liquid Nitrogen (LN2) Coupling, Male
C8987889	Assembly, Liquid Nitrogen (LN2) Coupling, Female
C8987890	Cap, LN2
C8987891	Plug, LN2

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

2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of the documents which have been adopted by the DoD are those listed in the specific issue of the DoDISS cited in the solicitation. Unless otherwise specified, the documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE/AMERICAN SOCIETY FOR QUALITY (ANSI/ASQ)

ANSI/ASQC Z1.4	-	Sampling Procedures and Tables for Inspection by Attributes (DoD-adopted)

(Application for copies should be addressed to American Society for Quality, P.O. Box 3066, Milwaukee, WI 53201-3066, or to the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Boiler and Pressure Vessel Code

Section VIII	-	Unfired Pressure Vessels

(Application for copies should be addressed to American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017-2392.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 1417	Liquid Penetrant Examination, Standard Practice For (DoD adopted)
ASTM E1444	Particle Examination, Magnetic (DoD adopted)

(Application for copies should be addressed to American Society for Testing and Materials, 100 Barr Harbor Drive, Conshohocken, PA 19428-2959.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE ARP901	-	Bubble-Point Test Method
SAE ARP1176	-	Oxygen System and Component Cleaning and Packaging
SAE AS4395		Tube Connection, Fitting End - Flared, Design Standard (DoD-adopted)
SAE AS8090		Equipment, Towed Aerospace Ground, Mobility

(Application for copies should be addressed to Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained. If there is a conflict between the contents of this specification and an associated specification, the associated specification will apply.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle cost (see 4.5.1).

3.3 Materials. All materials shall be suitably treated to resist corrosion due to electrolytic decomposition and any other atmospheric conditions that may be encountered during operational use or storage. The use of toxic chemicals, hazardous substances, or ODCs shall be avoided, whenever feasible (see 4.5.1).

3.4 Interface.

3.4.1 Tank assembly base. The tank assembly, including all its accessories, shall be mounted on a structurally rigid skid-type base. This base shall serve as a skid base when the unit is placed on a flat, level, hard surface. The base shall also serve as a rigid platform to allow lifting, handling, and transporting of the complete unit. The overall size of the base shall be not less than the dimensions of the vertical projection of the tank assembly including the control housing. The bottom of the base shall be covered to provide sufficient strength for movements of the full tank over loading ramps or rails with 0.5 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 (see 4.5.1, 4.5.6.3).

3.4.1.1 Skid base ends. Each end of the skid base shall be curved at the bottom with a 3-inch minimum radius over at least 90°, or turned up at a 30° to 45° angle so that the bottom rises to a height of not less than 1.25 inches above a flat surface on which the tank is placed (see 4.5.1, 4.5.6.3).

3.4.1.2 Forklift entries. The skid base shall have two lateral forklift entries, each 3.25 ± 0.13 inches high by 10 ± 0.13 inches wide, spaced 40 ± 0.5 inches centerline distance. The forklift entries shall be placed approximately equidistant from the vertical center-of-gravity (CG) of the full tank. The entries shall extend the entire width of the skid base, and shall not contain any obstructions that could impede movement of the forklift tines through the length of the entries. The entries shall restrain the forklift tines as necessary to prevent damage during lifting or movement of the tank assembly (see 4.5.1, 4.5.6.3).

3.4.2 Liquid servicing hose. One 10-foot length of cryogenic liquid hose, conforming to MIL-H-27301, shall be provided with the tank assembly. The tank assembly shall provide protection and storage for the hose while connected to the servicing line. The storage provisions shall securely retain and protect the hose when the tank is subjected to the accelerations specified herein. One end of the hose shall be connected to the 1-inch external pipe thread of the servicing line disconnect fitting(see 4.5.1). . The other end of the hose shall be as follows:

a. For the Type I liquid oxygen tank, the other end of the hose shall be provided with a 1-inch close nipple and a 1-inch female liquid oxygen coupling half assembly consisting of a coupling plug, nut, cone, and retaining ring conforming to drawings C8987870, C8987857, C8987856, and A8987840, respectively, assembled as shown on drawing C8987831 (see 4.5.1).

b. For the Type II liquid nitrogen tank, the other end of the hose shall be provided with a 1-inch close nipple and a 1-inch female liquid nitrogen coupling half assembly consisting of a coupling plug, nut, cone, and retaining ring conforming to drawings C8987891, C8987878, C8987877, and A8987840, respectively, assembled as shown on drawing C8987889(see 4.5.1) .

3.5 Design.

3.5.1 Tank assembly. The tank assembly shall be a self-contained liquid oxygen or nitrogen transport and storage unit, consisting of a storage tank with inner and outer shells, a control housing assembly, necessary controls and accessories, and a skid base (see 4.5.1). The tank assembly shall be capable of:

a. Being filled with liquid oxygen or nitrogen at a supply location (see 4.5.1).

b. Being transported per requirements of MIL-HDBK-1791 while filled with liquid oxygen or nitrogen and pressurized to 50 pounds per square inch gage (psig) (see 4.5.1).

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 (see 4.5.1).

3.5.2 Reliability. The tank assembly shall have a mean time between failures (MTBF) of not less than 21 servicing cycles at a 0.9 confidence level (see 4.5.1, 4.5.17, 4.5.19).

3.5.3 Maintainability. Parts and assemblies shall be located and mounted to provide adequate clearance for repair and other maintenance and, where practicable, to permit removal and replacement of any part or assembly by removing or disconnecting only mounting bolts or fasteners, panel doors, tubing, or control cables to the part or assembly being removed. The tank assembly, where practicable, shall 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. The design shall ensure clearance for operation, servicing and maintenance at low ambient temperatures by personnel wearing heavy gloves or mittens, bulky clothing and footgear. The design shall ensure maintenance and servicing can be performed using only common handtools. Intricate locking devices, controls, or fasteners that can be easily overtorqued by personnel lacking feel through thick gloves or numbness shall be avoided. Component installation design shall be such that the items can only be installed in their proper operating position to avoid reverse installation (see 4.5.1, 4.5.20).

3.5.4 Pressure vessels. The liquid storage tank assembly, piping, and connections thereto shall meet the requirements of section VIII of the ASME Boiler and Pressure Vessel Code (see 4.5.1, 4.5.2). Also, the inner shell shall be certified under the code for the specified working pressure (see 6.2).

3.5.5 Inner shell.

3.5.5.1 Design pressure. The inner shell shall have a maximum working pressure the same as the inner shell pressure relief device (see 3.5.5.2). The normal working pressure shall be not less than 50 psig for transferring liquid oxygen or nitrogen. The inner shell shall withstand an absolute pressure of 100 microns of mercury (Hg) or less with the annular space at atmospheric pressure. The shell shall not sustain damage when the annular space is evacuated to a high vacuum or is pressurized to the outer shell pressure relief device maximum opening pressure (see 4.5.1, 4.5.2).

3.5.5.2 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 to atmosphere should this pressure become excessive and the pressure relief valve fail to open. The safety head relief pressure shall be not greater than 1-1/2 times the inner shell maximum working pressure (see 4.5.1, 4.5.2.1).

3.5.5.3 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 open at a pressure sufficiently below the inner shell bursting-disc type safety head breaking pressure to ensure 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 under the conditions specified (see 4.5.1, 4.5.16.4.1).

3.5.5.4 Sump and drain provisions. The inner shell shall have a sump with a drain line, and a smooth inside bottom surface throughout an arc of not less than 3 inches length on each side of the vertical centerline for the entire length of the shell for proper drainage under gravity, without inner shell pressurization. The drain line shall include an accessible, manual valve for draining the sump and obtaining liquid samples for analysis. The sump shall be not less than 3.0 inches in diameter and the drain line shall have an inside diameter of not less than 0.5 inch (see 4.5.1).

3.5.5.5 Baffles. The inner shell shall include lateral and longitudinal baffles to prevent liquid sloshing and surging during tank transportation. The baffles shall not restrict flow during liquid transfer operations or drainage, and shall permit pressure equalization between compartments (see 4.5.1).

3.5.6 Outer shell.

3.5.6.1 Design pressure. The outer shell shall be designed for a working pressure that will ensure sufficient strength and rigidity to prevent distortion or damage when the annular space is evacuated to a high vacuum or pressurized to the outer shell pressure relief device maximum opening pressure (see 4.5.1, 4.5.2).

3.5.6.2 Vacuum seal-off valve. The outer shell shall have a vacuum seal-off valve that will serve as the vacuum pump-out for evacuation of the annular space, an isolation valve, and the outer shell safety relief device. The seal-off valve components and assembly shall conform to drawings 68A39469, 68A39470, 68A39471, 68A39472, and 68A39473 (see 4.5.1).

3.5.7 Annular space insulation. The annular insulation space shall contain an insulation that will, together with evacuation of the annular space, ensure compliance with the tank evaporation rate requirement (see 3.6.2). The insulating material shall be of a composition that will not ignite or burn when heated to 400 °F in 99.5% pure oxygen gas at a pressure of not less than 10 psig. The insulation shall not settle or be displaced in service. If a getter (impurity absorbing) material is used in the annular space, it shall be secured in direct thermal contact with the inner shell (see 4.5.1, 4.5.10).

3.5.8 Liquid line. A single liquid line shall be provided between the inner and outer shells for filling and emptying the tank. The line shall be not less than 1 inch in diameter. The line shall permit liquid withdrawal at a height not less than 1.0 inch or more than 1.25 inches above the bottom of the inner shell to preclude withdrawing sediment with the liquid. The installation shall ensure 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 lateral axis. The installation shall also ensure that the inner shell can be gravity drained to the level of the standpipe through the liquid fill line or liquid servicing line without pressurization (see 4.5.1).

3.5.9 Liquid fill line. The tank assembly shall have a liquid fill line for filling the tank with liquid oxygen or nitrogen. The fill line shall have a manual shutoff valve as near as possible to its connection to the liquid line (see 3.5.8). The line shall have a diameter of not less than 1 inch and shall terminate outside the control housing in a 1-inch external pipe thread for installation of the disconnect coupling. The fitting mounting shall withstand a torque of 300 ft-lb per inch of nominal line size applied to the fitting in either direction. The mounting shall have clearance to allow use of a 24-inch wrench (see 4.5.1, 4.5.14). The disconnect coupling shall be as follows:

a. For the Type I oxygen tank, the disconnect coupling shall consist of a coupling cap, seat, and gasket, conforming to drawings C8987869, C8987855, and B8987833, respectively, assembled as shown on drawing C8987830. The horizontal centerline distance between the fill line termination and the servicing line termination shall be a minimum of 9.0 inches (see 4.5.1, 4.5.14).

b. For the Type II nitrogen tank, the disconnect coupling shall consist of a coupling cap, seat, and gasket, conforming to drawings C8987890, C8987876, and B8987833, respectively, assembled as shown on drawing C8987888. The horizontal centerline distance between the fill line termination and the servicing line termination shall be a minimum of 9.0 inches (see 4.5.1, 4.5.14).

3.5.10 Liquid servicing line. The tank assembly shall have a liquid servicing line for transferring liquid oxygen or nitrogen from the inner shell. The servicing line shall have a manual shutoff valve as near as possible to its connection to the liquid line (see 3.5.8). The line shall have a diameter of not less than 1 inch and shall terminate outside the control housing in a 1-inch external pipe thread disconnect fitting, oriented to discharge vertically upward, for attachment of the liquid servicing hose (see 3.4.2). The fitting mounting shall withstand a torque of 300 ft-lb per inch of nominal line size applied to the fitting in either direction. The mounting shall have clearance to allow use of a 24-inch wrench (see 4.5.1, 4.5.14).

3.5.11 Vapor vent line. The tank assembly shall have a vapor vent line that will permit filling of the tank as specified (see 3.6.4). The line shall have an inside diameter of not less than 1 inch. The line shall extend along the top inside of the inner shell and shall have spray holes so that cleaning fluid pumped through the vent line will be sprayed against the inside top of the inner shell to flush sediment and other contaminants from the tank. The total area of the spray holes shall be at least as that of the cross sectional area of the vent line. The vent line shall have a manual shutoff valve as near as possible to point where it enters the outer shell, but shall be readily accessible to the operator. The line shall discharge toward the ground in a safe location outside the control housing. The vent line shall terminate in a 1-inch, female pipe thread in an area convenient for attachment of a purging unit hose or an overboard vent line during air transportation (see 4.5.1, 4.5.11.3).

3.5.12 Control housing assembly.

3.5.12.1 Control housing. A control housing shall be provided on one end of the tank assembly to house and protect the tank controls, instrumentation, and accessories. The housing shall be readily removable from the tank assembly for maintenance. The housing top shall be shaped to preclude the accumulation of snow, rain, or sleet. Ventilation openings shall be provided to prevent accumulation of gasses or fog during operation. Doors or hinged panels shall be provided and shall be equipped with latches for securing them in any position from fully closed to wide open even when subjected to wind gusts up to 70 mph. Door or hinged panel latches and position regulating devices shall be readily operable by personnel wearing heavy arctic mittens (see 4.5.1, 4.5.16.9).

3.5.12.2 Control panel. The control housing shall provide for a control panel with all instruments and controls readily visible and accessible. The controls, pressure gages, and instruments shall not be installed where they can be contacted by leaking liquid oxygen or water from vapor condensing on cold lines. All valve handles and gage faces shall be not less than

27.0 inches above ground level. All gages, instruments, and manually operated controls used in normal operation of the unit shall be located on the control panel. The control panel shall be protected by a panel or door when the tank is not in use for liquid transfer. The control panel shall be shielded from rain and snow when the door or panel is open (see 4.5.1, 4.5.16.9).

3.5.13 Pressure buildup system. The tank assembly shall have a pressure buildup system to pressurize the inner shell vapor space to 50 psig when the tank contains 25 gallons or more of liquid oxygen. Operation of the buildup system shall not require control operation other than closing of the vapor vent line valve and opening the pressure buildup manual control valve (see 4.5.1, 4.5.9).

3.5.14 Pressure relief devices. The tank assembly shall include pressure relief devices in any line or component that can be isolated by closing valves, or where dangerous pressures can develop. All pressure relief devices shall be installed in accessible locations and the design shall ensure that a discharge of pressure will not cause danger to personnel or equipment damage. Venting of oxygen vapor shall not cause freezing of the relief devices (see 4.5.1, 4.5.3). Incorporation of safety valves shall be in accordance with section VIII of the ASME Boiler and Pressure Vessel Code.

3.5.15 Valves.

3.5.15.1 Shutoff and control valves. Valves shall provide positive shutoff when closed, and minimum resistance to flow when open. Each manually-operated control or shutoff valve shall be provided with an easily-turned handle with a diameter of 3.0 inches per inch of nominal size, but not less than 1.0 inch. If globe valves are used, those valves 0.5 inch and larger nominal size, handling low-temperature liquid or gas, shall incorporate seats than can be replaced without removal of the valve from the tank piping. Sealing discs or plugs for these valves shall also be replaceable without replacing the valve stems. All valves handling low-temperature liquid and gas shall have their packing glands located not less than the distance specified in table I from the valve center connection centerline (see 4.5.1).

3.5.15.2 Drain valves. Manually-operated valves shall be provided for draining liquid from the fill line disconnect coupling after removing the fill hose, and from the servicing line and its hose. The drain valves shall be readily accessible outside the control housing assembly. The drain valves shall discharge outside the control housing assembly (see 4.5.1).

3.5.16 Instrumentation.

3.5.16.1 Liquid level gage. A gage, flush mounted on the control panel, shall be provided to indicate the quantity of liquid oxygen or liquid nitrogen contained in the tank inner shell with an accuracy of ± 3% of tank design capacity. The gage shall be easily readable and shall have a diameter of not less than 2.5 inches. The gage shall be graduated in gallons of liquid oxygen or liquid nitrogen. If a differential pressure gage is used, the design shall ensure that breakage of the glass face will not subject the sensing element to damaging pressures when the inner shell is pressurized to 65 psig. If this type of gage is used, the assembly shall incorporate pulsation snubbers in the sensing lines to prevent undue fluctuation of the indicating needle.

3.5.16.2 Vapor phase pressure gage. A gage, flush mounted on the control panel, shall be provided to indicate the inner shell pressure. The gage shall be easily readable and shall have a diameter of not less than 2.5 inches. The gage shall be graduated over at least 270° of the dial face, and shall be accurate to within ± 2% of full-scale range. The indicating range shall be approximately 1.5 times the normal working pressure of the tank inner shell. The gage shall not go off-scale before the inner tank relief pressure is reached. A tap that senses gage line pressure shall be provided near the gage using an AS4395E04 flared-type fitting for external test use. The fitting shall be sealed with an AN929-4 type cap (see 4.5.1).

3.5.16.3 Vacuum sensing tap. A vacuum sensing tap into the annular space, terminating in a 1/8-inch female pipe thread fitting, shall be provided for attachment and detachment of vacuum sensing equipment without degrading the vacuum in the annular space (see 4.5.1).

3.5.17 Cleaning solvent drains. The tank assembly design shall allow complete removal of cleaning solvents and flushing liquids after cleaning operations. The use of removable threaded plugs or similar devices is acceptable in locations where drain valves would be impractical (see 4.5.1).

3.5.18 Dimensions. The overall outside dimensions of the tank assembly, with all access openings closed, shall not exceed 88 inches in length; 54 inches in width, and 60 inches in height (see 4.5.1).

3.5.19 Weight. The weight of the empty tank and its accessories, including the pallet base, shall not exceed 1,550 pounds (see 4.5.1).

3.5.20 Tubing and lines. Tubing and lines shall be located in protected positions, securely fastened to frame or body structures, and provided with protection where they pass through members, except where a connector is provided at the frame (see 4.5.1, 4.5.2).

3.5.21 Locking devices. Where practicable, all screws, pins, bolts, and other similar hardware, shall be equipped with locking devices. Safety wire, self-locking nuts, cotter pins, or lock-washers will be acceptable. Where practicable, lock-washers shall be secured to bolts or screws. Cotter pins shall be fabricated from corrosion-resistant material (see 4.5.1).

3.5.22 Hoisting and tiedown attachments. Tiedown devices that shall serve for both tiedown and hoisting purposes shall be provided in accordance with MIL-HDBK-1791. These shall include four or more tiedown ring assemblies conforming to drawing 48B7796. The tiedown devices shall permit hoisting, with a 3g acceleration force, of the complete tank assembly filled to design capacity with liquid oxygen. The rings shall be located on the tank assembly so that transportation personnel can easily rig safe slings from common cable and spreader bar components for hoisting by a single-hook overhead crane .(see 4.5.1, 4.5.6.4)

3.5.23 Compartments. A compartment for storage of all tools required in normal operation and maintenance of the tank assembly shall be provided, with provisions for locking it with a common padlock. Another compartment, weatherproof and a minimum size of 9 by 11.5 by 2 inches, shall also be provided for the equipment operation handbook and the maintenance and inspection record (see 4.5.1).

3.5.24 Thread sealer. Tape conforming to CID A-A-58092 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/gaseous oxygen or nitrogen. The tape shall be applied starting with the third thread to prevent contaminating the system (see 4.5.1).

3.5.25 Lubricants. The tank shall meet all the requirements specified herein when components requiring lubrication are serviced with military or federal specification lubricants in accordance with MIL-HDBK-838 (see 4.5.1).

3.6 Performance.

3.6.1 Storage capacity. The tank shall store or transport, under the conditions specified herein, not less than 400 U.S. gallons of 99.5% pure liquid oxygen or liquid nitrogen at its atmospheric pressure boiling temperature. The 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% of the total design capacity (see 4.5.5).

3.6.2 Heat leak evaporation rate. The tank heat leak evaporation loss shall not exceed the equivalent of 19 pounds of oxygen per 24-hour period when the tank is filled to not less than 50% of capacity with liquid oxygen or nitrogen and subjected to the tests specified (see 4.5.8.1).

3.6.3 Pressure buildup system. The tank assembly pressure buildup system shall pressurize the inner shell vapor space to 50 psig within 10 minutes after closure of 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 (see 4.5.9).

3.6.4 Liquid fill line flow rate. The fill line shall be capable of filling the tank with liquid oxygen or liquid nitrogen through the liquid line at a rate of 50 gpm minimum with a maximum pressure drop through the fill line, filter, and the liquid line of 16 psig. With a flow rate of 25 gpm minimum, the pressure drop shall not exceed 6 psig (see 4.5.11.1).

3.6.5 Liquid servicing line flow rate. The liquid servicing line shall be capable of transferring liquid oxygen or liquid nitrogen from the inner shell through the liquid line, servicing line, and filter at a rate of 25 gpm minimum with a maximum pressure of 6 psig (see 4.5.11.2).

3.6.6 Vapor vent line. The vapor vent line shall permit the tank assembly to cool down within 15 minutes and allow filling flow rates up to and including 50 gpm without the inner shell vapor pressure exceeding 15 psig, when the tank assembly is subjected to the conditions and tests specified (see 4.5.11.3). The vent line shall allow venting of liquid when the inner shell is being filled and the tank contains between 400 and 410 gallons of liquid.

3.6.7 Vacuum retention. The tank assembly, after evacuation of the annular space, shall not show any increase in absolute pressure attributable to leakage or outgassing within 7 days (168 hours) when subjected to the tests specified (see 4.5.7.1).

3.6.8 Dissimilar metal vacuum joints. Any dissimilar metal vacuum joints used in the tank shall withstand thermal shocks, and axial and lateral vibration as specified (see 4.5.16.1.1).

3.6.9 Shutoff and control valve cycling and leakage. The valves shall withstand a closing torque of at least 300 in.-lb per inch of nominal size, with the valve bodies at either ambient temperature or the atmospheric pressure boiling temperature of liquid oxygen or nitrogen. When subsequently closed with a torque of 60 ± 5 in.-lb per inch of nominal size and a pressure of 50 psig applied to the inlet, the valves shall not leak more than 2 cubic inches of free air, oxygen, or nitrogen gas per hour per inch of nominal size. The valves shall be capable of not less than 2000 cycles of operation 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 for Type I or Type II tank valves, respectively (see 4.5.13).

3.6.10 Line filters. The liquid fill line and the liquid servicing line shall each have a filter for the filtering of all liquid flowing into and out of the inner shell. Filters shall be of the in-line configuration conforming to drawing 68B39474. Each filter shall be installed such that it is readily accessible for inspection, cleaning, or removal. Sintered or powdered material shall not be used unless provisions are made to prevent media migration. The proper direction of flow shall be plainly marked on each side of the filter. The filters shall be a non-bypass type and shall withstand a pressure drop of 50 psi across their elements. Each filter shall remove 98% by weight of all particles whose smallest dimension is 10 microns or greater (10-micron nominal rating). The filter shall further remove all particles whose smallest dimension is 40 microns or greater (40-micron absolute rating). In addition, the filter shall be capable of a liquid oxygen flow rate of 50-gpm at a maximum pressure drop of 3 psig, having previously ingested a minimum of 5 grams of particles of the sizes shown in table II (see 4.5.12.1, 4.5.12.2, 4.5.12.3).

3.6.10.1 Vacuum line filter. A vacuum line filter shall be provided if a powder or similar type insulation, which can be drawn into the vacuum pump, is used. The filter shall be a removable unit extending into the tank annular space, and shall have an effective filtering area of not less than 250 square inches (see 4.5.12.4).

3.6.11 Transportability.

3.6.11.1 Flight and taxiing acceleration forces. The tank assembly shall withstand the air transport flight and taxiing acceleration forces specified in MIL-HDBK-1791, except the lateral loads shall be 3g instead of 1.5 g, when empty or filled with liquid oxygen to any level up to and including design capacity. These same forces shall also apply while the tank assembly is being transported on a railroad car, ship, or truck (see 4.5.6.1, 4.5.18).

3.6.11.2 Emergency landing acceleration forces. The tank assembly shall withstand the emergency landing load shock force specified in MIL-HDBK-1791**,** except the shock pulse shall be an approximate one-half sine wave of not less than 30 milliseconds (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 (see 4.5.6.2, 4.5.18).

3.7 Finish and color. All exposed metal parts and surfaces, except parts and surfaces that contact high purity oxygen/nitrogen, shall be cleaned, treated, and finished per AF drawing 7545352 (see 6.3) (see 4.5.1). The final finish paint coating shall be colored as follows:

a. For the Type I, liquid oxygen tank assembly, the control housing, frame, and tank shall be painted dark green, FED-STD-595, number 24052.

b. For the Type II, liquid nitrogen tank assembly, the control housing, frame, and tank shall be painted gray, FED-STD-595, number 36118.

3.8 Item identification. A nameplate, permanently marked with the information below, shall be securely attached to the outside of the control housing assembly in a readily visible location (see 4.5.1).

Tank, Storage, (Type I, Liquid Oxygen or Type II, Liquid Nitrogen), TMU-24/E
Specification MIL-PRF-27720
Stock Number
Manufacturer's Part Number (or identification)
Contract or Order Number
Manufacturer's Name or Trade-Mark and CAGE code
U.S. Property

3.9 Special markings.

3.9.1 Tank marking. Tank assembly marking shall be in the form of decals, which shall be Government furnished property. Each tank shall require 3 each of the decals, one centered on each side of the tank and one on the tank end opposite the control cabinet (see 4.5.1). For the two types of tank assemblies, the decals shall be as follows:

a. For Type I, liquid oxygen tank, tank description and warning markings shall be decals described by San Antonio Air Logistics Center/SFRM Part Number 8221044.

b. For Type II, liquid nitrogen tank, tank description and warning markings shall be decals described by San Antonio Air Logistics Center/SFRM Part Number 221045-1.

3.9.2 Control marking. All valves, gages, controls, and indicators used during operation shall be identified by securely attached nameplates. The nameplates shall be in accordance with CID A-A-50271. Tags shall not be used. The indicating scale of each instrument, such as pressure gages, temperature indicators, and liquid level indicators, used for normal operation and control of the tank, shall be permanently and clearly marked with green and red to show the proper operating and the improper or danger zones respectively (see 4.5.1).

3.9.3 Warning plates.

3.9.3.1 Servicing line. A weatherproofed red warning plate containing the following information shall be provided adjacent to the liquid servicing line (see 4.5.1):

WARNING

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

3.9.3.2 Air transport. A weatherproofed red warning plate containing the following information shall be provided adjacent to the vent line disconnect fitting (see 4.5.1):

WARNING

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

3.9.4 Operating and precautionary instructions. An information panel containing brief operating and precautionary instructions to preclude injury or damage shall be permanently affixed on or near the tank control panel (see 4.5.1).

3.9.5 Transportation data plate. A data plate containing transportation data shall be provided as specified in SAE AS8090 (see 4.5.1).

3.9.6 Lifting instruction data plate. A data plate containing instructions necessary for lifting or moving the tank (empty or filled to any level up to design capacity) safely with a forklift truck shall be securely attached to the outside of the control housing assembly near the transportation data plate. Instructions shall include information on rigging a safe lifting sling from common cable and spreader bar components and safely lifting the full tank with a 3g acceleration (see 4.5.1).

3.9.7 Insulation identification plate. If insulation is installed in the tank annular space, an identification plate completely identifying the insulation shall be permanently affixed in an accessible location within the control housing assembly. If a powder-type insulation is used, the plate shall indicate the insulation weight in pounds (see 4.5.1).

3.10 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable (4.5.1).

3.11 Purge Temperature conditions. To satisfy purging requirements, the tank assembly and all related components must be capable of withstanding a purge air inlet temperature of up to 350 °F for minimum duration time of 4 hours (while the fill line outlet air temperature is maintained at 220°F) without obtaining any damage (see 4.5.15).

3.12 Environmental conditions. The tank assembly shall operate under and withstand the following environmental conditions without damage, including damage, which could contaminate its contents:

a. 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 (see 4.5.16.2, 4.5.16.3, 4.5.18).

b. Storage temperature. The tank shall not be damaged by storage in any ambient temperature from –80° to +160 °F for not less than 72 hours (see 4.5.16.2, 4.5.16.3, 4.5.18).

c. Vibration forces. The tank assembly, when empty or filled to any level up to design capacity with cryogenic liquid, shall not be damaged by vibration forces that will typically be encountered during its transportation in aircraft, railroad car, ship, or truck (see 4.5.16.1,4.5.18).

d. Humidity. The tank assembly shall not be damaged by operation or storage in any relative humidity up to and including 100% (see 4.5.16.4, 4.5.18).

e. Fungus. The tank assembly shall not be damaged by exposure to moist fungus growth such as encountered in tropical or subtropical climates (4.5.16.5, 4.5.18).

f. Salt spray. The tank assembly shall not be damaged by operation or storage in an atmosphere containing salt-laden moisture such as encountered near bodies of salt water and in transportation on shipboard (see 4.5.16.6, 4.5.18).

g. Rain. The tank assembly shall not be damaged by operation or storage under heavy rainfall as encountered in any locale, including the tropics (see 4.5.16.7, 4.5.18).

h. Sand and dust. The tank assembly shall not be damaged by operation or storage in an atmosphere containing airborne sand and dust particles such as encountered in normal or desert operations (see 4.5.16.8, 4.5.18).

i. Wind. The tank assembly shall not be damaged by storage or operation in wind velocities of up to and including 70 miles per hour (mph) (see 4.5.16.9, 4.5.18).

3.13 General cleaning instructions. Following completion of fabrication and assembly operations, the tank shall be thoroughly cleaned and degreased to remove dirt; excess soldering, brazing, or welding flux; welding slag, scale, metal chips, loose or chipped paint, spilled chemicals or other foreign materials. Cleaning and degreasing shall be performed on surfaces contacting oxygen in accordance with SAE-ARP1176 and to meet the following requirements:

a. When the tank is filled to 90% or more of design capacity with filtered liquid oxygen or nitrogen and left undisturbed for at least 2 hours, the residue remaining after evaporation of the first liter of liquid withdrawn through the fill drain line, with its filter removed, shall contain:

(1) No solid particles with any dimension greater than 500 microns (see 4.5.4.3).

(2) No fibrous particle (see 6.3) with a length greater than 3000 microns (see 4.5.4.3).

(3) No more than 25 milligrams total of both solid and fibrous particles (see 4.5.4.3).

b. When the liquid remaining in the tank after withdrawal of the above 1 liter sample is discharged through the liquid fill drain line and installed filter at a rate not less than 50 gallons per minute, the total amount of contaminant collected on the filter shall not exceed 0.1 gram (see 4.5.4.4).

c. Tank surfaces, fittings, and other parts that will be in contact with high purity oxygen shall be degreased in accordance with SAE-ARP1176. Precautions shall be taken to insure that solvents do not contact parts fabricated from incompatible materials. Petroleum and other flammable solvents shall not be used on such surfaces. All cleaning materials and solvents shall be thoroughly removed from the tank components following the cleaning and degreasing process (see 4.5.4.1, 4.5.4.2).

4. VERIFICATION

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

a. First article inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 First article inspection. First article inspection shall be performed on one tank assembly when first article is required (see 3.1). This inspection shall include the examinations of 4.3 and the tests specified (see 4.5).

4.2.1 Requirements cross reference matrix. See table III for requirements cross reference matrix.

4.3 Conformance inspection. This inspection shall consist of the tests in 4.3.1 and 4.3.2.

4.3.1 Individual tests.

4.3.1.1 Relief valves. Each relief valve shall be subjected to the test specified (see 4.5.3).

4.3.1.2 Tank. Each tank shall be subjected to the following tests as specified (see 4.5).

a. Examination of product (see 4.5.1).

b. Pressure test (see 4.5.2)(individual test excludes 4.5.2.1).

c. Cleaning effectiveness tests (see 4.5.4).

d. Individual article vacuum retention test (see 4.5.7.2).

e. Evaporation loss rate individual acceptance test (see 4.5.8.2).

4.3.2 Sample tests. In addition to the individual tests, component tests shall be conducted, using commercial sampling techniques such as those contained in ANSI/ASQC Z1.4 (see 6.2), as shown below:

a. Bursting disc sampling test. Bursting discs shall be subjected to the testing specified (see 4.5.2.1).

b. Valve sampling test. Sample valves, selected from each type (same size, design, and construction) shall be subjected to the testing specified (see 4.5.13.1 through 4.5.13.3).

c. Liquid line filter sampling test. Sample filters, selected from each type (same size, design, and construction) shall be subjected to the absolute and nominal rating testing specified (see 4.5.12.1 and 4.5.12.2).

d. Dissimilar metal vacuum joint sampling tests. Sample joints, selected from each type (same size, design, and construction) shall be subjected to the testing specified (see 4.5.16.1.1).

4.4 Test conditions. Unless otherwise indicated in the test methods, all tests shall be conducted at an atmospheric pressure of 28 to 32 inches of mercury, a temperature of 77±18 °F, and a relative humidity of 80% or less. If these conditions are not obtainable, corrections shall be made to compensate.

4.5 Tests.

4.5.1 Examination of product. The tank assembly shall be examined to determine conformance to this specification with respect to materials, interface, design, color, identification and other markings, and interchangeability. A mechanical inspection of all components and parts shall be conducted. All mechanical parts shall be checked for free and proper functioning.

4.5.2 Pressure test. Each component and circuit of the tank assembly 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. Any distortion, damage, or leaks resulting from this test shall be cause for rejection.

4.5.2.1 Burst disc test. A bursting disc, identical to the one used in the tank assembly, shall be subjected to a gradually increasing pressure, using clean, dry, oil-free air or nitrogen, until the disc ruptures. The burst disc rupture pressure shall no greater than 1-1/2 times the maximum working pressure of the inner shell.

4.5.3 Relief valve test. Prior to installation on the tank, each 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 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.

4.5.4 Cleaning effectiveness tests.

4.5.4.1 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.

4.5.4.2 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.

4.5.4.3 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% of design capacity with liquid oxygen or liquid nitrogen. The tank shall then be left 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, 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 no solid particle with any dimension greater than 500 microns, no fibrous particle with a length greater than 3,000 microns, and no more than 25 milligrams total of both solid and fibrous particles.

4.5.4.4 Total solids. Following withdrawal of the 1-liter sample (see 4.5.4.3), the remaining load of contained liquid shall be discharged through the liquid fill line and the filter 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 tank assembly and the associated piping and fittings shall be recleaned. Cleaning and testing shall be repeated until the amount of contaminant collected on the filter from discharging the specified tank assembly load is less than 0.1 gram.

4.5.5 Liquid storage capacity test. The tank storage capacity shall be determined by filling the inner shell with the tank set on its skid base on a flat, level surface until the filling liquid overflows through the vapor vent line. The volume of liquid in the inner shell shall be not less than 400 U.S. gallons. The inner shell shall then be filled completely to determine total internal volume. The measured volume, accurate to within 1 gallon, shall be not less than 440 gallons.

4.5.6 Transportability and handling test.

4.5.6.1 Air transport flight and taxiing acceleration forces. The tank assembly 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, shall be subjected to the flight and taxiing acceleration force loads specified in MIL-HDBK-1791, as modified by 3.6.11.1. 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. Failure to meet the specified requirements shall be cause for rejection.

4.5.6.2 Emergency landing acceleration forces. The tank assembly 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, shall be subjected dynamically to the emergency landing acceleration force loads specified in MIL-HDBK-1791, as modified by 3.6.11.2. Breaking loose of the unit from its tiedowns, separation of a component from the unit, or any discharge of liquid beyond the tank envelope shall be cause for rejection.

4.5.6.3 Forklift provision test. The tank assembly shall be filled to design capacity with a cryogenic liquid having a density of not less than 9.5 pounds per U.S. gallon. The tank shall then be raised not less than 3 feet above the floor by a forklift using the tine entries, transported by the forklift a horizontal distance of not less than 25 feet to a new location, set on the floor, and the forklift totally backed away from the tine entries. The lifting and movement procedure shall be accomplished not less than 5 times from each side of the tank. There shall be no damage to or any distortion of any tank component or interference with forklift handling.

4.5.6.4 Hoisting and tiedown provision test. The tank assembly shall be filled to design capacity with a cryogenic 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 attached to the tank so 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 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 3 times. There shall be no damage to or any distortion of any tank component.

4.5.7 Vacuum retention tests.

4.5.7.1 First article vacuum retention. Following the air transport flight and taxiing tests, and the lifting provision tests, the tank inner shell shall be filled with liquid oxygen or liquid nitrogen to not less than 60% of design capacity. The annular space shall be evacuated and sealed. The vibration testing specified (see 4.5.16.1) shall be conducted on the tank following evacuation and sealing of the annular space and either prior to or during this vacuum retention test. The tank assembly shall then be permitted to temperature stabilize until a constant annular space absolute pressure determined through precision instrumentation, is obtained. Precision temperature readings shall also be obtained when the pressure readings are taken for temperature correction of the before and after absolute pressure readings. 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 left undisturbed for not less than 7 days (168 hours) as filled and pressurized. Following completion of this testing, the inner shell vapor space pressure shall be reduced to atmospheric and the annular space absolute pressure determined using the same instrument as above. The annular space absolute pressure shall not show any increase attributable to leakage or outgassing, or the tank shall be considered to have failed the test.

4.5.7.2 Individual article vacuum retention. The test for the individual article shall be the same as the first article retention test, except for the vibration portion of the test. During the 7-day vacuum retention period, the individual 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 Hz, inclusive. Either a single, constant frequency or a periodic sweep of the specified frequency range may be used. At the completion of the vacuum retention test, the annular space absolute pressure shall not show any increase attributable to leakage or outgassing, or the tank shall be considered to have failed the test. The tank assembly shall also not show damage, such as fractures of pipes, brackets, welded connections, or other similar types of damage.

4.5.8 Heat leak evaporation loss rate tests.

4.5.8.1 First article heat leak evaporation loss. The first 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 as near atmospheric as necessary pressure drops through the measuring apparatus will permit.

a. Following the vacuum retention test with the liquid storage tank assembly inner shell remaining filled to not less than 50% of design capacity with liquid oxygen or liquid nitrogen, the tank shall be placed in a location where the ambient temperature will remain at a temperature no less than 125 °F throughout the periods specified.

b. 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.

c. 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 and 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 (see 3.6.2), or the tank shall be considered to have failed the test.

d. 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. The tank shall then be subjected to the individual acceptance evaporation loss rate test specified (see 4.5.8.2) to establish comparative data for determining whether production tanks are capable of complying with 3.6.2.

4.5.8.2 Individual article heat leak evaporation loss. Following the vacuum retention test and with the inner shell remaining filled to not less than 50% of design capacity, the tank shall be placed where it will be subjected to local or shop ambient temperatures throughout the following test:

a. 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.

b. Throughout the test, the inner shell vapor phase pressure shall remain as near atmospheric as necessary pressure drops through the flow measuring apparatus will permit. The total weight of vapors vented during the test, the weight of vapors vented since the preceding reading, the average ambient temperature and 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.

c. 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 (see 4.5.8.1) 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 (see 4.5.8.1) for compliance with 3.6.2, or the tank shall be considered to have failed the test.

4.5.9 Pressure buildup tests.

4.5.9.1 Buildup with low liquid level. The tank assembly shall be filled with enough liquid oxygen or liquid nitrogen to ensure between 25 and 30 gallons are in the inner shell after the specified stabilization. The tank shall then be left undisturbed 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.

4.5.9.2 Pressure buildup time. The tank assembly shall be filled with liquid oxygen or liquid nitrogen to between 15 and 20% of capacity and left undisturbed 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 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.

4.5.10 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 bomb to not less than 10 psig with oxygen gas having a purity of 99.5% 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 material shall be considered cause for rejection.

4.5.11 Liquid transfer tests.

4.5.11.1 Fill line. Liquid oxygen shall be transferred into the tank through the liquid fill line at not less than 50 U.S. gallons per minute for a length of time adequate to determine the pressure drop through the fill line, filter and liquid line. The pressure drop shall not exceed 16 psig. With a flow rate of 25 gpm minimum, the pressure drop shall not exceed 6 psig. Liquid nitrogen may be used at a flow rate that will provide a pressure drop equivalent to that resulting from the specified liquid oxygen flow.

4.5.11.2 Servicing line. Liquid oxygen shall be transferred from the tank through the liquid servicing line at not less than 25 U.S. gallons per minute for a length of time adequate to determine the pressure drop through the servicing line, filter and liquid line. The pressure drop shall not exceed 6 psig. Liquid nitrogen may be used at a flow rate that will provide a pressure drop equivalent to that resulting from the specified liquid oxygen flow.

4.5.11.3 Vapor vent line. The tank assembly and all its components shall be subjected to an ambient temperature of 125°F. After the tank assembly and 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. The rate of transfer during cooldown shall be the maximum that will maintain an 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 tank assembly shall be filled at a rate of not less than 50 gpm. The inner shell vapor phase pressure shall not exceed 15 psig at this flow rate, or the tank shall be considered to have failed the test.

4.5.12 Filter tests.

4.5.12.1 Absolute rating. Compliance with the 40-micron absolute rating requirement specified (see 3.6.10) shall be substantiated by a bubble-point method, such as ARP 901, or other method approved by the procuring activity (see 6.2). The filter element shall be submerged in Solox 190, or equivalent, fluid. The fluid level shall be maintained 0.5 inch maximum above the top of the element. The element shall be slowly pressurized from within and slowly rotated 360° at each pressure increment. The pressure shall be increased until the bubble-point is determined. 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.

4.5.12.2 Nominal rating. Compliance with the removal of 98% by weight of all particles whose smallest dimension is 10 microns or greater as required by 3.6.10 shall be substantiated as shown below. This test shall be conducted after completion of the 50-cycle servicing test specified (see 4.5.17)**.**

a. The filter to be tested shall be stabilized at 125 °F without any intervening servicing, cleaning, adjustment, or repair.

b. Approximately 20 liters of oxygen or nitrogen liquid shall be filtered through a 5-micron Mitex™ membrane filter (see 6.7), or equivalent, to assure the test liquid is clean. This liquid shall then be contaminated with 10.0 grams of particles with a size distribution as shown in table II. The liquid shall be placed in a container, agitated to ensure a homogeneous mixture, and then transferred through the test filter in a time interval of not more than 45 seconds. The test filter shall be positioned so that flow is in a down direction and the discharge is directed into a clean, particle-free container with provisions to ensure positive retention of any particles passing through the test filter, and exclusion of external particles.

c. The liquid shall then be allowed to vaporize, and the container flushed by use of a wash bottle containing approximately 200 ml of isopropyl alcohol solution which has been cleaned by filtering through a 5-micron Mitex™ membrane filter, or equivalent. The wash solution shall then be filtered through a new, pre-weighed 5-micron membrane filter (same type as above). This container wash procedure shall be performed four times using the same pre-weighed filter to filter the wash solution each time. An additional 200 ml of clean solution shall be used to wash the filter funnel and then filtered through the same pre-weighed membrane filter. Upon completion of the wash solution filtering, the pre-weighed filter shall be weighed again. If the weight increase is more than 0.2 gram, the test filter shall be considered to have failed the 98% retention of all particles 10 microns or larger.

4.5.12.3 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. Use of water as an alternate liquid shall be approved by the procuring activity. The liquid oxygen stream shall be contaminated with not less than 5 grams of particles of the size and distribution shown in table II. The 5 grams of contaminant shall be introduced into the stream at the approximate rate of 1 gram per minute, and shall not require more than 5 minutes. The pressure drop after the filter has been so contaminated shall not exceed 3 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.

4.5.12.4 Vacuum line filter. If a powder or similar type insulation is used in the annular space, the existence of a vacuum line filter shall be verified. The manufacturer shall demonstrate to the procuring activity that the effective filtering area is not less than 250 square inches.

4.5.13 Shutoff and control valve tests. The valve shall be subjected to the tests specified below in the order listed.

4.5.13.1 Cycling. The valve shall be closed with a torque of 60 ± 5 in lb per inch of nominal size, and, using compressed air, oxygen or nitrogen gas, subjected to an 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 again be closed with a torque of 60 ± 5 in.-lb per inch of nominal size and the specified inlet pressure reestablished. This shall constitute one 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.

4.5.13.2 Overtorque. At the conclusion of the cycling test specified (see 4.5.13.1), 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 in.-lb per inch of nominal size. Damage to or improper operation of the valve as a result of this test shall be cause for rejection.

4.5.13.3 Leakage. Following the overtorque test specified (see 4.5.13.2) and without intervening valve lubrication, adjustment or repair, the valve shall be fully opened, and closed with a torque of 60 ± 5 in.-lb per inch of nominal size. The valve shall then be completely immersed in clear water with the inlet subjected, using compressed air, oxygen or nitrogen gas, to 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, oxygen or nitrogen gas per hour per inch of valve nominal size shall be considered cause for rejection.

4.5.14 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, applied with a 24-inch wrench, of not less than 300 ft-lb per inch of nominal size to the coupling and fitting, first in one and then in the other direction of rotation. Any twisting of, distortion of, or damage to tank piping or connections resulting from this torque testing, or lack of clearance to use the 24-inch wrench, shall be cause for rejection.

4.5.15 Purging temperature test. The tank assembly shall be subject to a purge test in accordance with Air Force purging requirements. Tests shall be conducted according to current Air Force tech order purge procedures. During testing, the tank assembly is required to withstand a purge air inlet temperature of up to 350 °F for a minimum time of four (4) hours while the fill line outlet air temperature is maintained at 220 °F. Tests shall be conducted (no less than 24 hours after purging) to ensure that no leakage or structural/component deterioration has occurred.

4.5.16 Environmental testing. The tank assembly shall be subjected to the following tests conducted in accordance with the specified methods of MIL-STD-810 (see 6.6). At the conclusion of each test, the tank assembly shall be examined for damage or deterioration, including that which could contaminate its contents.

4.5.16.1 Vibration. The tank assembly shall be filled to design capacity with liquid nitrogen and pressurized to not less than 45 psig. The filled and pressurized tank, with the servicing hose secured in the storage position, shall be subjected to the vibration testing specified in method 514, category 1, basic transportation. The tank assembly shall be carefully examined after each test phase and following completion of the overall test. Damage to or failure of any tank assembly components, loosening of fasteners, loss of instrument calibration, or loss of vacuum in the annular space shall be considered a failure of the tank assembly to pass the test.

4.5.16.1.1 Dissimilar metal vacuum joints vibration test. Vacuum joints of this type, if used, shall be tested as specified below.

a. Subject the joint 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, while still at 125 °F or above, the joint shall be quickly submerged in liquid nitrogen at its atmospheric pressure boiling temperature. The joint shall remain submerged until it has cooled to approximately liquid nitrogen temperature. The joint will be considered to have reached this temperature when bubbles cease to emanate from its surface in large numbers.

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

c. The joint, still secured, shall then be subjected to lateral vibration at a frequency of 60 Hz and a double amplitude of 0.200 inch minimum for not less than 30 minutes while 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.

4.5.16.2 Low temperature exposure. The tank assembly shall be filled to design capacity with liquid oxygen or liquid nitrogen and subjected to low temperature in accordance with method 502.3, procedure I, using a chamber temperature of –80 °F and an exposure duration, after stabilization, of 72 hours minimum.

4.5.16.2.1 Pressure buildup. After 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.

4.5.16.3 High temperature. The tank assembly shall be filled to design capacity with liquid oxygen or liquid nitrogen and subjected to high temperature in accordance with method 501.3, procedure I, using a chamber temperature of 160 °F and an exposure duration, after stabilization, of 72 hours minimum.

4.5.16.4 Humidity. The tank assembly shall be subjected to a humidity test in accordance with method 507.3, procedure II, using the cyclic high humidity cycle and a test duration of 7 days.

4.5.16.4.1 Inner shell vapor phase pressure relief device venting. During the humidity test, with the ambient temperature at not less than 125 °F and with the tank remaining filled to not less than 90% of design capacity, the vapor vent line shutoff valve shall be tightly closed. The pressure buildup system shall be 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 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.

4.5.16.5 Fungus. Equipment samples adequately representing applicable portions of the tank assembly that might be damaged by exposure to fungus attack shall be subjected to a fungus test in accordance with method 508.4, using a test duration of 28 days.

4.5.16.6 Salt fog. The tank assembly shall be subjected to salt fog in accordance with method 509.3, procedure I.

4.5.16.7 Rain. The tank assembly shall be subjected to rain in accordance with method 506.3, procedure I.

4.5.16.8 Sand and dust. The tank assembly shall be subjected to the blowing dust test procedure in accordance with method 510.3, using a temperature of 145 °F during the high temperature part of the procedure.

4.5.16.9 Wind. It shall be demonstrated, by testing or calculations, that the tank assembly will withstand 70-mph wind as specified in 3.5.12.1 and 3.12.i. The tank assembly shall be empty for this demonstration.

4.5.17 Servicing cycle. The tank assembly inner shell shall be filled to design capacity with liquid oxygen or liquid nitrogen and the tank left with the vapor vent line shutoff valve wide open until all uninsulated components external to the outer shell have warmed to approximately ambient temperature. Following this stabilization, 50 servicing cycles shall be performed, with the tank being filled with additional liquid as necessary for completing the test. The servicing cycle shall be performed as specified below, 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 control valve until the inner shell vapor phase pressure has risen to not less than 45 psig, and then 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. Allow the tank to remain with the vapor vent line shutoff valve fully open until all ice and frost are gone from the buildup system and servicing line. The application of external heat to expedite warm-up is permissible.

The tank assembly 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.

4.5.18 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. Steel parts subject to high stresses that are suspected of having defects shall be subjected to magnetic particle inspection in accordance with ASTM E1444. Nonmagnetic parts suspected of having defects shall be inspected with fluorescent liquid penetrant in accordance with ASTM E1417.

4.5.19 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.

4.5.20 Servicing and maintenance. All normal preventive maintenance and servicing operations specified in the contractor’s maintenance and instruction handbook shall be performed to determine their adequacy, ease of accomplishment, and the accessibility of parts and assemblies for performance of same. As far as practicable, these tests shall be conducted as part of the normal preventive maintenance, servicing, and inspections performed in accomplishing the testing specified herein. Particular attention shall be given to maintenance with a minimum number of tools; servicing and operation by personnel wearing heavy gloves, and provisions made to prevent accumulation of dirt, snow, and ice, that may hinder servicing and operation.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point packaging activity within the Military Department or Defense Agency, or within the Military Department’s System Command. Packaging data retrieval is available from the managing Military Department or Defense Agency automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The TMU-24/E Types I and II storage tanks are intended for air transport of liquid oxygen and liquid nitrogen, respectively, to airbases or other installations, and for storing the material at destination, with minimum liquid loss, until needed for filling aircraft servicing vehicles.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Issue of the DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2).

c. When first article is required (see 3.1).

d. Item identification (see 3.8).

e. If the sampling inspection level is to be other than normal (i.e., tightened or reduced)(see 4.3.2).

f. Packaging requirements (see 5.1).

g. If tank pressure certification documentation is required (see 3.5.4).

h. A bubble-point test method if other than ARP 901 (see 4.5.12.1).

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

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

6.3.2 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 principal constituent, used in the tank construction where the joint must function to seal the tank assembly annular space from a different pressure.

6.3.3 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 in.-lb per inch of valve nominal size.

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

6.4 Finish. MIL-HDBK-808 can be used as a guide in conjunction with AF7545352.

6.5 Environmental testing. Test methods cited can be found in MIL-STD-810.

6.6 Membrane filter. The 5-micron Mitex™ membrane filter is available from the Millipore Corp., 80 Ashby Rd., Bedford, MA, 01730.

6.7 Part or identifying number (PIN). The PIN is as follows:

M27720 -1 (for type I, oxygen) or
-2 (for type II, nitrogen)

6.8 Subject term (key word) listing.

Annular space
Burst disc
Cryogenic liquids
Inner shell
Outer shell
Pressure vessels
Skid base
Vacuum retention

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

TABLE I. Separation of Valve Packing Gland from Valve Connection Centerline.

Valve Nominal Size (inches)	Separation of Packing Gland from Connection Centerline (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

TABLE II. Particle size distribution.

Size of Particle (microns)	Percentage by weight (± 3%)
10 to 20	36
20 to 40	24
40 to 60	16
Over 60	24

TABLE III. Requirements cross reference matrix.

Requirement	Verification	Requirement	Verification
3.2	4.5.1	3.5.17	4.5.1
3.3	4.5.1	3.5.18	4.5.1
3.4.1	4.5.1, 4.5.6.3	3.5.19	4.5.1
3.4.1.1	4.5.1, 4.5.6.3	3.5.20	4.5.1, 4.5.2
3.4.1.2	4.5.1, 4.5.6.3	3.5.21	4.5.1
3.4.2	4.5.1	3.5.22	4.5.1, 4.5.6.4
3.5.1	4.5.1	3.5.23	4.5.1
3.5.2	4.5.1, 4.5.17, 4.5.19	3.5.24	4.5.1
3.5.3	4.5.1, 4.5.20	3.5.25	4.5.1
3.5.4	4.5.1, 4.5.2	3.6.1	4.5.5
3.5.5.1	4.5.1, 4.5.2	3.6.2	4.5.8.1
3.5.5.2	4.5.1, 4.5.2.1	3.6.3	4.5.9
3.5.5.3	4.5.1, 4.5.16.4.1	3.6.4	4.5.11.1
3.5.5.4	4.5.1	3.6.5	4.5.11.2
3.5.5.5	4.5.1	3.6.6	4.5.11.3
3.5.6.1	4.5.1, 4.5.2	3.6.7	4.5.7
3.5.6.2	4.5.1	3.6.8	4.5.16.1.1
3.5.7	4.5.1, 4.5.10	3.6.9	4.5.13
3.5.8	4.5.1	3.6.10	4.5.12.1, 4.5.12.2, 4.5.12.3
3.5.9	4.5.1, 4.5.14	3.6.10.1	4.5.12.4
3.5.10	4.5.1, 4.5.14	3.6.11.1	4.5.6, 4.5.18
3.5.11	4.5.1, 4.5.11.3	3.7	4.5.1
3.5.12.	4.5.1, 4.5.16.9	3.8	4.5.1
3.5.13	4.5.1, 4.5.9	3.9	4.5.1
3.5.14	4.5.1, 4.5.3	3.10	4.5.1
3.5.15	4.5.1	3.11	4.5.15
3.5.16	4.5.1	3.12	4.5.16, 4.5.18
		3.13	4.5.4

Custodians:
Air Force - 99
DLA – GS
Army – AV
Navy - AS

Preparing Activity:
Air Force - 84

Review activity:
Air Force - 11
Navy - YD
Army - MI

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