

OPERATING AND MAINTENANCE MANUAL

CRYOGENIC LIQUIFIED GAS TANK

M2000/M3000/M5000/V2000/V3000/V5000 MB TANK

(VESSEL ON SKID)

FOR AIR LIQUIDE

Do not attempt to use or maintain these units until you read and understand these instructions. Refer to the Taylor-Wharton's Safety First booklet (TW-202) for handling cryogenic material. Do not permit untrained persons to use or maintain this equipment. If you do not understand these instructions, contact your supplier for additional information.



Taylor-Wharton
Since 1742

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WARNING

FOLLOWING SAFETY PRECAUTIONS ARE FOR YOUR PROTECTION. BEFORE PERFORMING INSTALLATION, OPERATING, OR MAINTENANCE PROCEDURES READ AND FOLLOW ALL SAFETY PRECAUTIONS IN THIS SECTION AND IN REFERENCE PUBLICATIONS. FAILURE TO OBSERVE ALL SAFETY PRECAUTIONS CAN RESULT IN PROPERTY DAMAGE, PERSONAL INJURY, OR POSSIBLE DEATH. IT IS THE RESPONSIBILITY OF THE PURCHASER OF THIS EQUIPMENT TO ADEQUATELY WARN THE USER OF THE PRECAUTIONS AND SAFE PRACTICES FOR THE USE OF THIS EQUIPMENT AND THE CRYOGENIC FLUID STORED IN IT.

SAFETY PRECAUTIONS FOR LIQUID OXYGEN

Oxygen is a colorless, odorless, and tasteless gas that can be condensed into a liquid at the low temperature of -183°C (297°F degrees below zero Fahrenheit) under normal atmospheric pressure. Approximately one-fifth of normal air is oxygen. As a liquid, oxygen is pale blue in color. Oxygen is non-flammable but vigorously accelerates the burning of combustible materials.

Keep Combustibles Away from Oxygen and Eliminate Ignition Sources

Many substances, which do not normally burn in air, require only a slight spark or moderate heat to set them aflame in the presence of concentrated oxygen. Other substances, which are only moderately combustible in air, can burn violently when a high percentage of oxygen is present.

Do not permit smoking or open flame in any area where liquid oxygen is stored, handled, or used. Keep all organic materials and other flammable substances away from possible contact with liquid oxygen. Some of the materials that can react violently with oxygen are oil, grease, kerosene, cloth, wood, paint, and dirt, which contains oil or grease. Under certain conditions flammable materials, which have become permeated with liquid oxygen, are impact sensitive and can detonate if subjected to shock.

Keep Area and Exterior Surfaces Clean to Prevent Ignition

As normal industrial soot and dirt can constitute a combustion hazard, all equipment surfaces must be kept very clean. Do not place oxygen equipment on asphalt surfaces, or allow grease or oil deposits to remain on benches or concrete surfaces in the vicinity of the oxygen equipment. Use cleaning agents, which will not leave organic deposits on the cleaned surfaces. Equipment to be used in contact with liquid oxygen should be handled only with clean gloves or hands washed clean of oil.

Maintain Adequate Ventilation

Enclosed areas containing oxygen equipment should be ventilated to prevent accumulations of oxygen and thereby minimize combustion hazards.

Extreme Cold - Cover Eyes and Exposed Skin

Accidental contact of liquid oxygen or cold issuing gas with the skin or eyes may cause a freezing injury similar to frostbite. Handle the liquid so that it won't splash or spill. Protect your eyes and cover the skin where the possibility of contact with the liquid, cold pipes and cold equipment, or the cold gas exists. Safety goggles or a face shield should be worn if liquid ejection or splashing may occur or cold gas may issue forcefully from equipment. Clean, insulated gloves that can be easily removed and long sleeves are recommended for arm protection. Cuffless trousers should be worn outside boots or over the shoes to shed spilled liquid. If clothing should be splashed with liquid oxygen or otherwise saturated with the gas, air out the clothing immediately, removing it if possible.

Such clothing will be highly flammable and easily ignited while the concentrated oxygen remains, and should not be considered safe for at least 30 minutes.

Replacement Parts Must be Suitable for Oxygen Service

Many materials, especially some non-metallic gaskets and seals, constitute a combustion hazard when in oxygen service, although they may be acceptable for use with other cryogenic liquids. Make no substitutions for recommended spare parts. Also, be sure all replacement parts are thoroughly "Cleaned For Oxygen Service" in accordance with Compressed Gas Association (CGA) Pamphlet G-4.1 "Cleaning for Oxygen Service" or equivalent industrial cleaning specifications.

Observe Safety Codes When Locating Oxygen Equipment

Before locating oxygen equipment, become thoroughly familiar with National Fire Protection Association

(NFPA) Standard No. 50, "Bulk Oxygen Systems", and with all federal, state and local safety codes. The NFPA Standard covers the general principles recommended for the installation of bulk oxygen systems on industrial and institutional consumer premises.

CAUTION: When installing field fabricated piping, make certain a suitable safety valve is installed in each section of piping between shut-off valves.

For more detailed information concerning safety precautions and safe practices to be observed when handling cryogenic liquids consult CGA pamphlet P-12 "Handling Cryogenic Liquids" available from the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, Va. 22202.

SAFETY PRECAUTIONS FOR LIQUID NITROGEN

Nitrogen is an inert, colorless, odorless, and tasteless gas, which makes up four-fifths of the air you breathe. Liquid nitrogen is obtained by cooling air until it becomes a liquid and then removing the oxygen, which makes up the other fifth of the air. Liquid nitrogen is at a temperature of 320°F degrees below zero Fahrenheit (-196°C) under normal atmospheric pressure.

Extreme Cold - Cover Eyes and Exposed Skin

Accidental contact of liquid nitrogen or cold issuing gas with the skin or eyes may cause a freezing injury similar to frostbite. Handle the liquid so that it won't splash or spill. Protect your eyes and cover the skin where the possibility of contact with the liquid, cold pipes and cold equipment, or the cold gas exists. Safety goggles or a face shield should be worn if liquid ejection or splashing may occur or cold gas may issue forcefully from equipment. Clean insulated gloves that can be easily removed and long sleeves are recommended for arm protection. Cuffless trousers should be worn outside boots or over the shoes to shed spilled liquid.

Keep Equipment Area Well Ventilated

Although nitrogen is non-toxic and non-flammable, it can cause asphyxiation in a confined area without adequate ventilation. Any atmosphere, which does not contain enough oxygen for breathing, can cause dizziness, unconsciousness, or even death. Nitrogen being colorless, odorless, and tasteless cannot be detected by the human senses and will be inhaled normally as if it were air. Without adequate ventilation, the expanding nitrogen will displace the normal air without warning that a non-life-supporting atmosphere is present. Store liquid containers outdoors or in other well-ventilated areas.

Dispose of Waste Liquid Nitrogen Safely

Dispose of waste liquid nitrogen out-of-doors where its cold temperature cannot damage floors or driveways and where it will evaporate rapidly. An outdoor pit filled with clean sand or gravel will evaporate liquid nitrogen safely and quickly.

CAUTION: When installing field fabricated piping, make certain a suitable safety valve is installed in each section of piping between shut-off valves.

For more detailed information concerning safety precautions and safe practices to be observed when handling cryogenic liquids consult CGA pamphlet P-12 "Handling Cryogenic Liquids" available from the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA 22202.

NOTE: Argon is an inert gas whose physical properties are very similar to those of nitrogen. For handling of liquid argon, follow the safe practices described for the handling and use of liquid nitrogen.

INTRODUCTION

This manual provides information for the user to operate and maintain Taylor-Wharton's M2000 and M3000 and V2000 and V3000 model cryogenic storage tanks. These tanks are suitable for the storage and delivery of liquid oxygen, nitrogen or argon at a maximum allowable working pressure of 1.6 MPa(232 psig) for M series MB tank or 3.5 MPa(507.5 psig) for V series MB tank. The MB tank with a vaporizer can be suitable for the 8 hours continuous delivery of 100NM³/Hr gaseous product.

Tank specifications is in table 1, and flow diagram is drawing in this manual .

TABLE 1 TECHNICAL DATA

MB2000 SERIES

TANK MODEL	Gross Volume (m ³)	Net Volume (m ³)	Height (m)	Dimensions (mm)	Weight (Ton)	Full Weight (Ton)			STATIC EVAPORATION LIN (volume %/day)	MAWP (MPa)
						LOX	LIN	LAr		
M2000	2.176	1.96	2.799	1350	1.4	3.64	2.98	4.13	<1	1.6
V2000	2.15	1.93	2.799	1350	1.68	3.89	3.24	4.38	<1	3.5

MB3000 SERIES

TANK MODEL	Gross Volume (m ³)	Net Volume (m ³)	Height (m)	Dimensions (mm)	Weight (Ton)	Full Weight (Ton)			STATIC EVAPORATION LIN (volume %/day)	MAWP (MPa)
						LOX	LIN	LAr		
M3000	3	2.7	2.824	1500	2.18	5.27	4.37	5.95	<1	1.6
V3000	3	2.7	2.824	1500	2.4	5.49	4.59	6.17	<1	3.5

MB5000 SERIES

TANK MODEL	Gross Volume (m ³)	Net Volume (m ³)	Height (m)	Dimensions (mm)	Weight (Ton)	Full Weight (Ton)			STATIC EVAPORATION LIN (volume %/day)	MAWP (MPa)
						LOX	LIN	LAr		
M5000	4.99	4.49	3	2000	2.8	7.93	6.43	9.06	<1	1.6
V5000	4.99	4.49	3	2000	3.55	8.67	7.18	9.8	<1	3.5

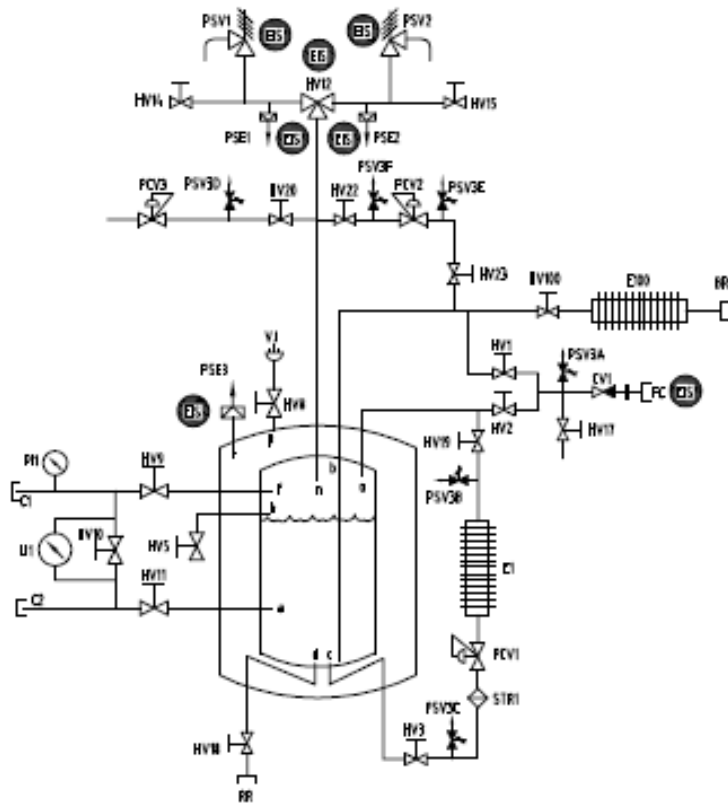
BASED ON NET VOLUME, CALCULATION BASED ON LIQUID AT SATURATED @ 0 BAR.

ABOVE ALL SIZES AND WEIGHT IS OLIY FOR REFERENCE, AND WILL NOT TO BE INFORMED AT ONCE IF THERE ARE CHANGES.

REMARK:

- 1、the back pressure regulator PCV3 of the M series tank is setting 1.5 MPa, and setting 3.4 MPa for V series tank。
- 2、the build-pressure regulator PCV2 of the M series tank is setting 1.2 MPa, and setting 3.0 MPa for V series tank。
- 3、the safety valves PSHV3、PSV2 of M series tank is setting 1.6MPa, and setting 3.5MPa for V series tank。
- 4、the withdrawing connection RR and gas supply connection BR and gas supply connection BRC is 1/2"FNPT。

FLOW DIAGRAM



LEGEND

HV1	FILLING LIQUID (BOTTOM) VALVE	PSE1	BURSTING DISC
HV2	FILLING GAS (TOP) VALVE	PSE2	BURSTING DISC
HV3	PRESSURE BUILD-UP VALVE	PSE3	VACUUM PUMP DOWN CONNECTION
HV5	FULL TRYCOCK/VENT VALVE	PI1	TANK PRESSURE GAUGE
HV100	GAS SUPPLY VALVE	LI1	LIQUID LEVEL GAUGE
HV8	VACUUM PROBE VALVE	E1	PRESSURE BUILDING COIL
HV9	GAS ISOLATION VALVE	E100	ATMOSPHERIC VAPORISER
HV10	EQUALIZATION VALVE	PCV1	PRESSURE REGULATOR
HV11	LIQUID ISOLATION VALVE	PCV2	ECONOMIZER REGULATOR VALVE
HV12	SAFETY CHANGEOVER VALVE	PCV3	BACK PRESSURE REGULATOR VALVE
HV14	SAFETY LINE PURGE VALVE	VJ	VACUUM PROBE
HV15	SAFETY LINE PURGE VALVE	STR1	STRAINER
HV17	FILL LINE PURGE VALVE	FC	FILLING CONNECTION
HV18	BOTTOM LIQUID VALVE	CV1	CHECK VALVE FILLING PORT
HV19	ISOLATION VALVE FOR PBU	PSV3A	THERMAL EXPANSION VALVE
HV20	ISOLATION VALVE FOR PCV3	PSV3B	THERMAL EXPANSION VALVE
HV22	ISOLATION VALVE FOR PCV2	PSV3C	THERMAL EXPANSION VALVE
HV23	ISOLATION VALVE FOR PCV2	PSV3D	THERMAL EXPANSION VALVE
C1	INSTRUMENT GAS CONNECTION	PSV3E	THERMAL EXPANSION VALVE
C2	INSTRUMENT LIQUID CONNECTION	PSV3F	THERMAL EXPANSION VALVE
PSV1	SAFETY VALVE		
PSV2	SAFETY VALVE		
BR	GAS SUPPLY CONNECTION		
RR	LIQUID CONNECTION		

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FUNCTIONAL DESCRIPTION

TANK CONSTRUCTION

The MB tanks are vertical tanks with a maximum allowable working pressure of 1.6MPa (232 psig) for M series tank and 3.5MPa (507.5 psig) for V series tank. The pressure vessel is suspended inside a vacuum jacket by neck-tube, and with super insulated of multilayer inorganic glass-fiber nonwovens and aluminum foils under high vacuum. All piping is designed to withstand the stresses caused by expansion and contraction of the pressure vessel, its support system and piping itself.

The pressure vessel is designed and constructed in accordance with the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. The inner vessel and outer vessel is constructed of 304 stainless steel and the piping is stainless steel.

The tank evacuated to a high vacuum through a PSE3. The PSE3 will be closed down automatically after pump-vacuum. DO NOT OPEN the PSE3.

MAIN PARTS FUNCTIONAL

FILLING CONNECTION (FC)	a device to prevent filling the vessel with the wrong product, each product (LIN/LOX/LAR) have its own standard fitting.
CHECK VALVE CUSTOMER (CV1)	prevents flow out of the tank through the valve;
BOTTOM FILL VALVE (HV1)	while filling through the valve tends to increase tank pressure;
TOP FILL VALVE (HV2)	Filling through the valve tends to reduce tank pressure;
FULL TRYCOCK VALVE (HV5)	used to determine fill termination;
GAS SUPPLY VALVE (HV100)	Product use valve, it locates the outside of atmospheric vaporizer line outlet, it shut off or open the product to use high quality gas.
BOTTOM LIQUID VALVE (HV18)	provide liquid only withdrawal from the tank.
PRESSURE BUILD-UP VALVE (HV3)	It lets the liquid of the container flow to the build-up pressure line when it is opened.
PRESSURE REGULATOR (PCV1)	When tank pressure decreases to PCV1 set-point , it opens and liquid flows from the bottom of the tank through; When tank pressure increases above the regulator's set point it closes and the pressure building process stops
RESSURE BUILDING COIL (E1)	This liquid product is vaporized in the coil and expanded gaseous product returns to the top of the tank maintaining tank pressure;
ECONOMIZER REGULATOR VALVE (PCV3)	When tank pressure exceeds the set point of PCV3,the gas will flow from the top of the tank through CV2 and finally exits through .
BACK PRESSURE REGULATOR VALVE (PCV3)	When tank pressure exceed PCV3 set-point , it opens and pressure reduce .it can prevent PSV1 and PSV2 frequent action and let it works longer.
SAFETY VALVE (PSV1, PSV2)	OvePCV1ressure protection for the pressure inner vessel,The pressure relief valves provide primary protection for the inner vessel;
VACUUM BURSTING DISC (PSE3)	The tank vacuum jacket is protected from ovePCV1ressure .
BURSTING DISC (PSE1, PSE2)	OvePCV1ressure protection for the pressure inner vessel, the rupture disks are secondary safety devices.
ESAFETY LINE PURGE VALVE (HV14, HV15)	It releases the high pressure gas of safety line when replace safety valve PSV1 or PSV2,and can be one connector to withdrawing gas to test .
TANK PRESSURE GAUGE (PI1)	Tank pressure is indicated by PI1;
LIQUID LEVEL GAUGE (LI1)	percentage based on calibrated in inches of water and a conversion chart located next to the liquid level gauge is used to convert the gauge reading to volume of liquid.
GAS ISOLATION VALVE (HV9)	a bypass valve connecting the instrument lines should be installed between the isolation valves and the device;
LIQUID ISOLATION VALVE (HV11)	connected to a pressure tap attached to the bottom to the pressure vesse:

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EQUALIZATION VALVE (HV10)	To balance the pressure of liquid phase and gas phase ,the NI will be zero when it is opened.
VACUUM PUMP DOWNCONNECTION (PSE3)	the port used to pump air from the tank insulation space. It is normally blanked-off and never opened unless the tank requires a field re-evacuation after a repair;
VACUUM PROBE VALVE (HV8)	a thermocouple that is installed to allow connection of a vacuum gauge to measure the quality of the vacuum in the insulation space;
VACUUM PROBE (VJ)	opened during vacuum measurement to expose the vacuum probe sensors to the tank insulation space.
FILL LINE PURGE VALVE (HV17)	used to vent the fill line during fill hose cool-down, and to drain liquid product trapped between the fill connection and the fill valves after a fill is completed.
ATMOSPHERIC VAPORISER (E100)	One heat exchanger that absorbs heat energy of around atmosphere and make the liquid vaporize gas .

INSTALLATION

HANDLING

Dimension and connection data for the MB tanks can be found on additional copies of these drawings may be requested from the factory. Please include information on the tank model number and part number in making requests for this drawing. The drawing part number is listed in the applicable Specification chart in this manual.

Tank installation is the customer's responsibility. The MB tank with pallet for equipment to hand or transit expediently .no especial demand for the toft to use temporarily, advise build one toft for fixation long time ,and refer to local codes for recommended foundation specifications. Employ experienced personnel to move and install the tank. This tank must be shipped and lifted empty, and with a warm inner vessel.

The tank can be used forklift handling or crane lifting bases on local condition .

INSTALLATION CHECKS

Before off-loading the tank, inspect it carefully for possible shipping damage. Report any damage to the carrier and the factory. In addition, check tank pressure and vacuum as follows:

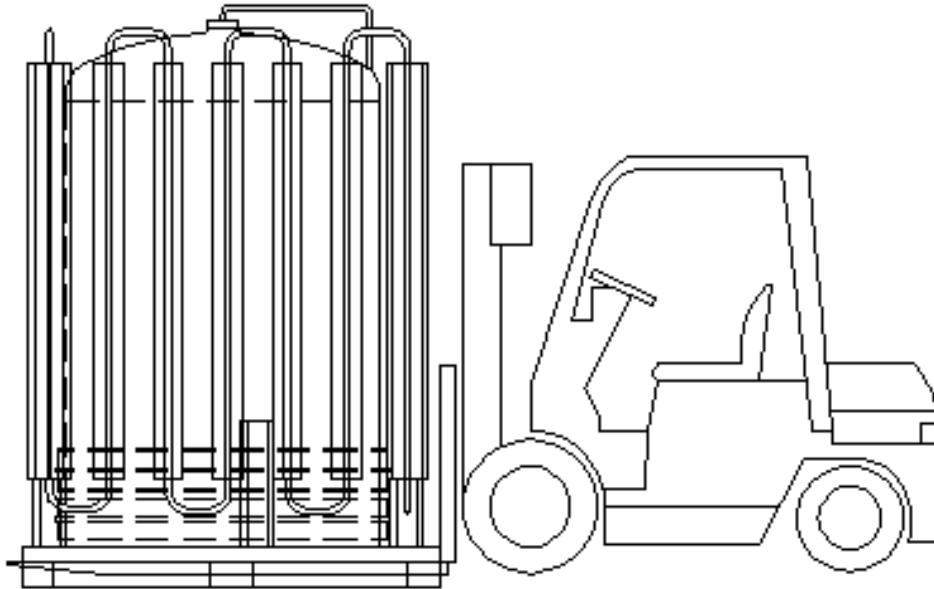
1. Tanks are shipped pressurized with nitrogen gas at about 0.175MPa. Open the gauge vapor phase isolation valve (RS) and read tank pressure indicated on pressure gauge or a pressure gauge installed by user. Record the "as received" tank pressure. close the vapor phase isolation valve.

Tank pressure may change due to temperature variations, accidental opening of valves, packing leaks, or minor leaks at the fill connection. If a positive pressure is not indicated on the pressure gauge and no repairable leaks are found, contact the factory in accordance with conditions specified in the tank warranty.

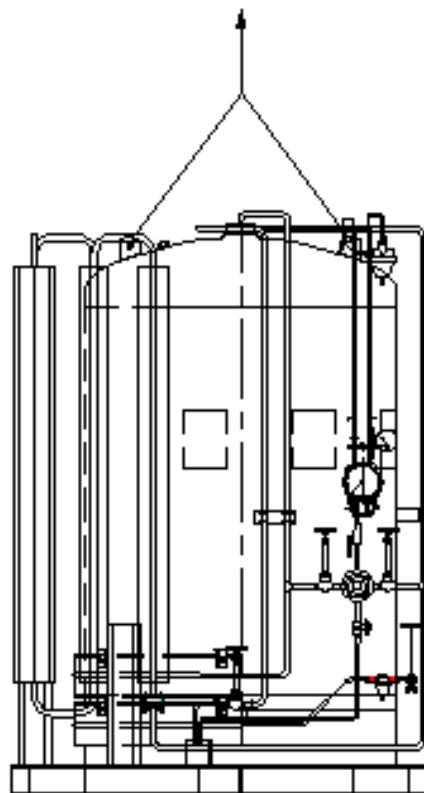
2. Check insulation space vacuum by connecting a Hasting-Raydist Model TV-4A or VT-6 vacuum gauge to the tank vacuum probe. Open the tank vacuum probe isolation valve, wait 60 minutes, and take a reading. If the "as received" vacuum (tank at ambient temperature) is greater than 2 Pa (0.02 mm Hg) absolute, contact the factory.

EQUIPMENT LIFTING DIAGRM

1) FORKLIFT HANDING



2) CRANE LIFTING



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OPERATION

These instructions are for experienced operators. Before operating the storage tank become thoroughly familiar with the safety precautions in this manual and in reference publications. Make certain all applicable provisions set forth in the Installation section have been followed before placing a tank in operation. Study the Flow Diagram, Know the location and function of all tank components.

PURGE PROCEDURE

Before placing a tank in service, determine the level of purity in the pressure vessel. If pressure vessel contents purity is unacceptable, perform a product purge to reduce contaminants. The following procedure is recommended for most applications:

1. Attach the liquid purge product source to tank fill connection. Product delivery pressure should be approximately 0.7MPa (7 bar).

CAUTION: A positive pressure must always be maintained in the tank during the purge procedure to prevent drawing atmospheric contaminants back into the tank.

2. Close all valves except vapor RS & liquid phase isolation valves RI, and pressure building isolation valves HV3.

3. Open tank gas supply valve HV100 and vent inner vessel to 0.034 MPa (0.34 bar) as indicated on the tank pressure gauge PI1, inner vessel.

4. Open bottom fill valve HV1 slightly to allow liquid to flow slowly into bottom of tank. Flow must be gradual enough to allow the liquid to vaporize in the bottom fill line and pressure building coil so the pressure builds up in the inner vessel. Momentarily open top fill valve HV2 to flood the exposed section of line, then close valve.

5. When tank pressure gauge PI1, inner vessel indicates maximum desired purge pressure, close the liquid supply source. Close pressure building isolation valve HV3.

6. After liquid has drained from the tank, close vapor & liquid phase isolation valves RS and RI. the equalization valve RE should be opened just before closing vapor & liquid phase isolation valves to prevent damage to the liquid level gauge N1.

7. Carefully loosen the adapters on both sides of the liquid level gauge to relieve pressure. Disconnect the instrument lines and fully open vapor & liquid phase isolation valves. Visually check the resultant gas streams for signs of moisture. Vent lines for approximately two minutes. If no moisture is evident, close the vapor & liquid phase isolation valves. If moisture is evident, continue venting until the stream is free of moisture.

8. Open product supply valve HV100 if provided to check for moisture as in Step 7.

9. Open tank gas supply valve HV100 and trycock valve and check for moisture as in step 7.

10. Repeat purge procedures 2 through 9 until acceptable product purity is achieved.

11. Reconnect the liquid level gauge (installed by user), open vapor & liquid phase isolation valves and close equalization valve (installed by user).

12. After completion of tank purge, make sure that all valves are closed except the vapor & liquid phase isolation valves.

FILLING A WARM TANK

Perform the following steps to fill a tank for the first time or when returning a tank to service after it has been emptied and allowed to warm.

- 1 Close all valves except vapor & liquid phase isolation valves RS and RI.
- 2 Check the name of the contents on the supply source against the product name on the tank to be certain that the proper product is being transferred into the tank.
3. Connect supply source fill hose to tank fill connection. Make certain connection is leak tight. Purge the fill hose.

NOTE: The tank was pressurized at the factory with nitrogen gas. Before the tank is to be filled with any product, it must be purged with product until analysis indicates an acceptable purity. Use the steps outlined in the Purge Procedure section above as a guide.

4. Open tank trycock valve HV5. Vent tank pressure to about 0.034MPa.
5. Fully open top fill valve HV2 and pressure building isolation valve to fill tank as rapidly as possible.
6. Monitor tank pressure on tank pressure gauge (inner vessel). If tank pressure rises to within 90% of tank pressure relief valves setting, close tank top fill valve and stop fill immediately. and vent tank pressure to at least 0.345MPa (50 psig) below tank pressure relief valve set point. Open tank top fill valve and resume filling.
7. When liquid spurts from tank trycock valve, close supply source valve to stop fill. Close tank trycock valve.
8. When residual liquid in the fill hose vaporizes, close tank top fill valve.

CAUTION: To avoid injury, do not touch fill hose or connections with bare hands. During filling, these parts are cooled to extremely low temperatures.

9. Open fill line drain valve to relieve fill hose pressure. Close fill line drain valve.
10. When pressure is released disconnect fill hose. Close valve pressure building isolation valve.

FILLING A COLD TANK

Perform the following steps to fill a tank containing liquid product or one that has been recently emptied, but still cold.

NOTE: Make certain the top HV2 and bottom fill valves HV1 are closed.

- 1 Check the name of the contents on the supply source against the product name on the tank to be sure that proper product is being transferred into the tank.
- 2 Connect supply source fill hose to tank fill connection. Make certain connection is leak tight. Purge fill hose.
- 3 Open supply source liquid delivery valve.
4. Fully open tank top fill valve HV2, and start to fill.

NOTE: Filling through the bottom fill valve will increase tank pressure since gas in the vapor space is compressed, whereas filling through the top fill valve decreases tank pressure since gas in the ullage space is cooled and re-liquefied.

5. Open tank full trycock valve HV5 when tank liquid level gauge indicates 3/4 full.
6. When liquid spurts from tank full trycock valve HV5, close supply source delivery valve to stop fill. Close full trycock valve.
7. When residual liquid in the fill hose vaporizes, close tank top fill valve.

CAUTION: To avoid injury, do not touch fill hose or connections with bare hands. During filling, these parts are cooled to extremely low temperatures.

8. Open fill line drain valve to relieve fill hose pressure. Close fill line drain valve. When pressure is released disconnect fill hose.

NORMAL OPERATION

During normal operation, tank pressure forces product through the inner line and the gas supply valve HV100 to an external vaporizer that feeds the user's pipeline. To compensate for lowering of tank pressure as product is withdrawn, the pressure building regulator PCV1 allows a regulated amount of liquid to flow to the pressure building coil E1. Vaporized liquid is returned to the tank to provide the driving force for uninterrupted pipeline withdrawal. During periods when the withdrawal rate is low and tank pressure rises above the set point of economizer regulator PCV2, the economizer circuit becomes operational. Liquid withdrawal is interrupted and gas flows through the economizer regulator PCV2 to the vaporizer thereby supplying the pipeline with gas that would otherwise be vented to the atmosphere.

To prepare the tank for normal product withdrawal, open the following valves:

- Pressure build-up valve (HV3)
- Liquid level valves (RS, RI)
- Gas supply valve (HV100)
- All other valves should be closed.

TAKING A TANK OUT OF SERVICE

Schedule shut-down operation to coincide with low liquid level in the tank. If a large quantity of liquid is in the tank, drain it into a trailer for use elsewhere or for disposal at a safe location. For tanks so equipped, small quantities of liquid can be vaporized by the pressure building coil E1 and vented through the tank full trycock valve, provided appropriate safety precautions are taken. For shutdowns of short duration, retain residual liquid in the tank. Close all valves except tank vapor and liquid phase isolation valves RS and RI.

For shutdowns of a prolonged duration, perform the following steps.

TANKS IN OXYGEN SERVICE

- 1 Drain liquid from tank. Open the tank full trycock valve HV5 and reduce tank pressure to atmospheric. Close the tank full trycock valve HV5.
- 2 Connect a source of warm nitrogen gas to tank fill connection. Admit nitrogen purge gas through tank top fill valve. Vent tank through the tank gas supply valve HV100. Two or three times during purge, close the tank gas supply valve HV100 and build tank pressure to about 0.175MPa (25.38psig). Release pressure and continue purge.
- 3 Open the tank trycock valve and the pressure building isolation valve and check exit gas with a nitrogen gas analyzer. Allow one hour between samples reading for the gas to adequately mix. Discontinue purge when only nitrogen gas is indicated. Close tank trycock valve.
- 4 Close the tank gas supply valve HV100. Build tank pressure to 0.175MPa. Close tank top fill valve HV2. Disconnect nitrogen gas hose from tank fill connection.
- 4 Warm tank inner vessel before shipping to a new location.

MAINTENANCE

GENERAL

The need for maintenance usually becomes apparent from inspection of the tank before filling, routine observation during and after filling, and indications of improper operation. Typical trouble indications would be unusually high or low tank or pipeline pressure, leakage from valves or piping connections, and excessive venting through relief valves. Prompt action to correct damage or malfunction is required to assure reliable operation. Keep a permanent log of all inspections, vacuum readings, and repairs performed. Such a log can be valuable in evaluating tank performance and scheduling maintenance.

Always observe the safety precautions at the front of this manual and follow the instructions given in this section. Before working on the tank or piping system, isolate the piping section to be repaired from the tank, and relieve pressure on the component or piping.

Do not allow unqualified persons to attempt repairs on this equipment. Field repairs to instruments and controls must be made by a qualified instrument specialist. Refer to the Trouble-Remedy Guide in this manual for assistance in troubleshooting.

Make certain all parts that will come in contact with cryogenic liquid or gaseous product have been cleaned for in conformance with CGA Pamphlet G-4.1, "Cleaning Equipment for Oxygen Service", or other equivalent standard. If parts are purchased cleaned for oxygen service, they should be suitably packaged to prevent contamination.

LEAK TESTING

After making repairs requiring disassembly or part replacement, leak test all valves or piping joints that were taken apart and reconnected. Apply the leak detector to the test surface per the manufacturer's instructions. Large leaks instantly form large bubble clusters, while fine leaks produce white foam that builds up more slowly. All leaks must be repaired and retested before the tank is returned to service.

WARNING: For O₂ System Users: Residue of leak detectors can be flammable. All surfaces to which the leak detector solutions have been applied must be adequately rinsed with potable water to remove all traces of residue. Reference CGA G 4.1. Section 5.

HAND VALVES

The most common trouble with manual valves will be leakage at the stem packing. Packing leaks are usually indicated by frost or ice accumulation more than half way up the valve stem extension. If packing leakage cannot be stopped by tightening, add or replace packing. Use preformed packing, which can be ordered from the valve manufacturer.

CONTROL VALVES

These tanks have three automatic valves that control operating pressures, PCV1 and PCV2 and PCV3 .

the pressure building regulator PCV1 opens on falling tank pressure and closes on rising pressure. This valve is factory set at 1.2MPa for M series tank and 3.0MPa for V series tank.

The back pressure regulator PCV3 is a backpressure device that opens on rising tank pressure and closes on falling pressure. This valve is factory set at 1.5 MPa for M series tank and 3.4 MPa for V series tank.

The economizer regulator PCV2 opens on rising tank pressure and closes on falling pressure. This valve is factory set at 1.3 MPa for M series tank and 3.1 MPa for V series tank.

The factory setting of the control valves may be field adjusted. The economizer pressure regulator PCV2 should be set to open at a pressure above the shut-off pressure of the pressure building regulator PCV1.

Before attempting repair of either of the control valves, isolate and depressurize the valves by closing the pressure building isolation valves HV3, and vent pressure to atmosphere. When repairs are complete, purge lines and retighten the thermal expansion relief valve and pressure test all joints that were disassembled.

Order replacement parts from the valve manufacturer. Be sure to give all information on the valve nameplate, including the factory Part Number, as well as Taylor-Wharton part number listed in the "Replacement Parts" provided in this manual to ensure receiving the correct parts for these special valves.

RESETTING CONTROL VALVES

Use the following procedures to change control valve settings or to readjust the valves after completing repairs of the valves.

the pressure building regulator should be set so that tank pressure is held about 0.035MPa above the desired delivery pressure. the economizer pressure regulator PCV2 should be set at least 0.07MPa (10 psig) above the setting of the pressure building regulator PCV1. If both controls are to be reset, set the pressure building regulator before setting the economizer pressure regulator.

NOTE: The tank must contain liquid for setting control valves. The back pressure regulator must be adjusted while product is being withdrawn through the product withdrawal line.

1. SETTING THE PRESSURE REGULATOR PCV1:

- 1) When it is required to set the top pressure in the tank, the automatic pressure regulator PCV1 should be brought into operation. In order to achieve this position, the regulator may be set as follows, All the other valves must be closed except safety relief circuit, instrument circuit and E1 circuit, Gradually turn clockwise the adjusting screw of the pressure regulator PCV1. This will permit liquid to flow into the pressure-raising coil, where it will be vaporized
- 2) The coil E1 will raise the pressure in the tank until an equilibrium pressure is reached at which regulator PCV1 will close. Continue to make small adjustments to PCV1 until the pressure in the tank has reached the required value. The maximum set pressure is limited by the safety valve setting of the tank.

2. SETTING THE ECONOMIZER REGULATOR PCV2:

- 1) Turn the lock-nut of economizer regulator **PCV2** to relax and turn the regulator set screw clockwise to the end of its adjustment, and confirm the valve HV3 open;
- 2) When the pressure of inner vessel raise the setting pressure of PCV2 (the setting pressure of PCV2 is bigger 0.07MPa than PCV1), turn the set screw counterclockwise to open the

PCV2, the inlet pipe of atmospheric vaporizer become clogged that means the valve is opened.

INNER VESSEL AND PIPING SAFETY DEVICES

These tanks are equipped with a dual safety device manifold that permits servicing of one set of safety devices while the other set is in service.

If a pressure vessel tank rupture disc ruptures, determine and correct the cause of the rupture before replacing the device. This device should be replaced annually as a preventive maintenance procedure. The bursting disc on this tank is a sealed assembly that must be replaced as a unit.

Main tank pressure relief valves that leak or fail to operate at the set pressure should be replaced immediately. Repair and recalibration of these valves should only be done by experienced personnel with proper equipment. Return the valves to the manufacturer or to an ASME approved repair station for overhaul or recalibration. In certain cases these valves shall be tested every five years per CGA S-1.3, section 9, "Pressure Relief Device Standards Part 3 – Stationary Storage Containers For Compressed Gases".

Replace thermal expansion relief valves when leakage or improper functioning occurs. Do not attempt to repair or reseal these components since they are of the throw-away type.

PRESSURE AND LIQUID LEVEL GAUGES

The major cause of malfunctioning tank pressure gauge, inner vessel, or liquid level gauge is an open equalization valve or leakage in the gauge lines. Refer to the Trouble-Remedy Guide in this manual for maintenance procedure. If the problem is not readily corrected, replace the gauge with a spare. Return the defective gauge to the manufacturer for repair.

Include a description of the difficulty encountered.

CASING VACUUM MAINTENANCE

CHECKING VACUUM

Some vacuum deterioration may occur over an extended period of time due to outgassing of materials within the vacuum space or from leakage. A history of vacuum readings taken over a period of time can be valuable when evaluating tank performance and scheduling maintenance work.

To detect vacuum deterioration, periodic measurement of the tank vacuum is recommended. A thermocouple-type vacuum probe, located on the lower head of the tank, is provided for this purpose.

To check tank vacuum perform the following steps:

- 1 Remove the protective plastic cap from the gauge tube connector.
- 2 Connect a Hastings-Raydist Model No. TV-4A or VT-6 Vacuum Gauge to the vacuum probe.
- 3 Open the vacuum probe isolation valve and wait at least 60 minutes before taking the vacuum reading.
- 4 After the vacuum reading is recorded, close the vacuum probe isolation valve, disconnect the Vacuum Gauge, and replace the protective cover on the vacuum probe connector.

The vacuum reading obtained on a cold tank is initially less than 50 microns (0.05 mm Hg) absolute;

however, gradual deterioration over an extended period of time is normal. A complete log of vacuum readings, along with dates when they were taken, can be very helpful in evaluating vacuum performance and scheduling maintenance work.

NOTE: If the tank is empty and warm, vacuum space pressure will tend to be high because of the release of gases from adsorbent package inside the vacuum space.

Because re-evacuation is time consuming and usually requires taking the tank out of service, it is not normally attempted until tank performance becomes unacceptable. Even a relatively high degree of deterioration can be tolerated in a tank from which high rates of withdrawal are being made. However, if vacuum deterioration seriously affects tank operation by producing excessive pressure buildup and high loss rates, contact the factory for information about how to determine and correct the cause of the trouble.

VACUUM PROBE REPLACEMENT

If the vacuum probe tube is damaged or is suspected of giving inaccurate readings, replace it as follows:

- 1 Make certain that the vacuum probe isolation valve is closed.
- 2 Unscrew the vacuum probe from the vacuum probe isolation valve. Using two wrenches.
- 3 Clean the threads and opening of the vacuum probe isolation valve.
NOTE: Do not use Teflon tape as a sealant on vacuum system fittings.
- 4 Thread the new vacuum probe into the vacuum probe isolation valve by engaging one thread. Apply a suitable high vacuum sealant to remaining exposed threads. Tighten the vacuum probe into vacuum probe isolation valve, using two wrenches. Do not over tighten.
5. Install a new vinyl cover over the vacuum probe connector.

NOTE: If corrosion of the vacuum probe is a problem at a particular location, spray the tube housing with "Krylon Crystal Clear Coating 1301" or equivalent acrylic spray.

Do not spray the contact pins of the electrical connector; this could cause erroneous vacuum readings.

Open the vacuum probe isolation valve and check vacuum following the above described procedure. The waiting period to obtain a stable reading with a new gauge tube may exceed the specified 60 minutes. This is due to out gassing of the new gauge tube and the thread sealant.

ANALYZING VACUUM DETERIORATION

If you decide to re-evacuate because of normal aging and deterioration, contact the factory for re-evacuation procedures. If vacuum deterioration occurs over a relatively short period and pressure is greater than 1,000 microns (1 mm Hg) absolute, suspect that a leak has developed in the external casing of the tank. If deterioration is rapid and causes the vacuum jacket lift plate to function, suspect leakage from the liquid container or internal piping.

NOTE: An abnormally high vacuum reading without other evidence of vacuum loss (excessive pressure, rapid venting, etc.) maybe caused by a fault in the gauging equipment or by improper operation of the equipment. Be sure that the vacuum gauge and the vacuum probe are in good condition and follow operating instructions carefully. Always be sure that the vacuum probe isolation valve has been open for at least 60 minutes before taking a reading.

Try to determine the source of leakage in cases where the vacuum connection has not functioned, visually inspect the following areas in the order in which they are listed:

- a. vacuum probe,
- b. vacuum probe isolation valve,
- c. vacuum pumpout valve,
- d. Sealed insulation ports (on top of the tank),
- e. vacuum pump down connection and vacuum bursting disc.
- f. All liquid and gas phase lines exit points through vacuum jacket.
- g. Any area of the vacuum jacket that might have been exposed to cryogenic liquid spray or temperatures.

Look for signs of damage, corrosion, or damaged valves, and other abnormal conditions. Contact the factory for repair and re-evacuation procedures.

MOVE TANK

This tank must be shipped and lifted empty, and with a warm inner vessel.

TROUBLE-REMEDY GUIDE

TROUBLE	POSSIBLE CAUSES	REMEDY
1. Tank Pressure too low	<ul style="list-style-type: none"> a. Tank Pressure Relief Valve leaking or frozen open b. Tank Rupture Disc rupture c. Piping leaks to atmosphere d. Low liquid level e. Excessive product withdrawal f. Improper filling procedure 	<ul style="list-style-type: none"> Thaw out valve or replace if necessary, Refer to this section. Replace Tank Rupture Disc. Refer to this section. Test and repair tank Refill tank Install higher capacity Pressure Building Coil. Refer to filling instruction in Operation Section.
2. Excessive tank pressure	<ul style="list-style-type: none"> a. Extensive shutdown time b. Low withdrawal rate c. Malfunction of Pressure Building Regulator d. Malfunction of tank Pressure Gauge e. Inner Vessel. Lack of refrigeration caused by low liquid level f. Malfunction of economizer regulator 	<ul style="list-style-type: none"> No Remedy No Remedy Refer to this section Replace Pressure Gauge, Inner Vessel. Refill tank Refer to this section
3. Erratic or erroneous Liquid Level Gauge readings	<ul style="list-style-type: none"> a. Leaking gauge lines b. By-pass valve open c. Liquid Level Gauge needle stuck d. Liquid Level Gauge needle not zero adjusted e. Gauge line reversed f. Liquid Level Gauge damaged or faulty g. Plugged gauge lines 	<ul style="list-style-type: none"> Test and repair leaks. Close by-pass valve Tap Liquid Level Gauge slightly, Inspect needle and bend as required Adjust as required Connect properly Replace Liquid Level Gauge Disconnect lines at Liquid Level Gauge and test for flow
4. Leaking safety valve	<ul style="list-style-type: none"> a. Dirt or ice under valve or disc b. Improper valve set point c. Damaged valve seat or disc 	<ul style="list-style-type: none"> Thaw out valve, Replace if necessary Replace valve Replace valve
5. Ruptured Pressure Vessel Rupture Disc.	<ul style="list-style-type: none"> a. Excessive tank pressure b. Defective Rupture Disc c. Atmosphere corrosion and/or disc fatigue. d. Interior disc corrosion e. Improper Rupture Disc 	<ul style="list-style-type: none"> Refer to this section. Replace Rupture Disc Replace Rupture Disc, Blow out safety device line. Replace Rupture Disc Install correct Rupture Disc
6. Tank vacuum leak	<ul style="list-style-type: none"> a. Leak in Vacuum Jacket bursting disc. b. Vacuum Pump Out Valve leak c. Vacuum Probe or Vacuum Probe Isolation Valve leak 	<ul style="list-style-type: none"> Refer to Analyzing Vacuum Deterioration section. Replace Vacuum bursting disc . Replace Vacuum Pump Out Valve diaphragm. Re-evacuate insulation space. Contact the factory for re-evacuation procedures Replace faulty component. Re-evacuate insulation space. Contact the factory for re-evacuation procedures