INSTRUCTION MANUAL

FOR

MICROBULK

MB1000 / MB2000 / MB3000 / MB5000 / MB7500

(A.S.M.E. PRESSURE CODE)

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.

TABLE OF CONTENTS

WARNING

The following safety precautions are for your protection. Before installing, operating, or maintaining this unit read and follow all safety precautions in this section and in the reference publications. Failure to observe all safety precautions can result in property damage, personal injury, or possibly 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.

CAUTION: *When installing field-fabricated piping, it is recommended to 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 OXYGEN

Oxygen is a colorless, odorless, and tasteless gas that can be condensed into a liquid at the low temperature of 297 degrees below zero Fahrenheit (-183ºC) 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; however it vigorously accelerates the burning of combustible materials.

Keep Combustibles Away from oxygen and eliminate ignition sources.
Many substances that 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 sub stances, 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, tar, and dirt that contains oil or grease. Under certain conditions flammable materials that 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 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. Cuff-less 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.

SAFETY PRECAUTIONS FOR LIQUID NITROGEN AND LIQUID ARGON

Nitrogen is an inert, colorless, odorless, and tasteless gas making 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. Air is roughly one-fifth oxygen. Liquid nitrogen is at a temperature of -320°F (-196°C) under normal atmospheric pressure.

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.***

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 equipment, or the cold gas exists. Safety goggles or a face shield should be worn if liquid ejection or splashing can occur or cold gas can issue forcefully from equipment. Insulated gloves that can be easily removed and long sleeves are recommended for arm protection. Trousers without cuffs 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 not containing enough oxygen for breathing can cause dizziness, unconsciousness, or even death. Nitrogen, a colorless, odorless, and tasteless gas, 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 resulting in a non-life-supporting atmosphere. Store liquid containers outdoors or in 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.

SAFETY PRECAUTIONS FOR CARBON DIOXIDE

WARNING

Carbon Dioxide can cause asphyxiation and death in confined, poorly ventilated areas. Cold Carbon Dioxide gas can cause severe frostbite to the eyes or skin. Do not touch frosted pipes or valves. If accidental exposure occurs, consult a physician at once. If a physician is not readily available, warm the areas affected by frostbite with water that is near body temperature.

KEEP WORK AREA WELL VENTILATED

Carbon dioxide affects the important acid-base balance in the body. Carbon dioxide is formed from normal functioning of the body, but the body can tolerate increased amounts of carbon dioxide only in limited concentration. This is recognized in OSHA standards where a Threshold Limit Value of 5,000 parts per million by volume (0.5 percent concentration) has been adopted. For safety, concentrations above this level should not be permitted; increased concentrations can cause bodily harm or death. Additionally, carbon dioxide can cause asphyxiation by displacing oxygen resulting in dizziness, unconsciousness or death.

Ten percent carbon dioxide in air can be endured for only a few minutes; twelve to fifteen percent soon causes unconsciousness; twenty five percent may cause death if exposure lasts for several hours. Carbon dioxide cannot be detected by human senses and will be inhaled like air. Carbon dioxide is heavier than air and will accumulate in low-lying areas. Carbon dioxide concentrations will be greater in these areas. If adequate ventilation is not provided, carbon dioxide may displace normal air without warning that a life-depriving atmosphere is developing.

COVER EYES AND SKIN

If released to atmosphere, liquid carbon dioxide will turn to carbon dioxide snow. Accidental contact of carbon dioxide snow or cold gas with the eyes or skin may cause severe frostbite. Handle liquid so that it will not vent or spill. Protect your eyes with safety goggles or a face shield. Cover the skin to prevent contact with snow or cold gas, or with cold pipes and equipment. Protective gloves can be quickly, and easily removed and long sleeves are recommended for protection.

GROUP ALL PIPING

The rapid discharge of liquid carbon dioxide through a line, which is not electrically grounded, will result in a build-up of static electricity. Contact with this electrical charge could be startling and potentially dangerous to operating personnel. Such lines should be grounded before use.

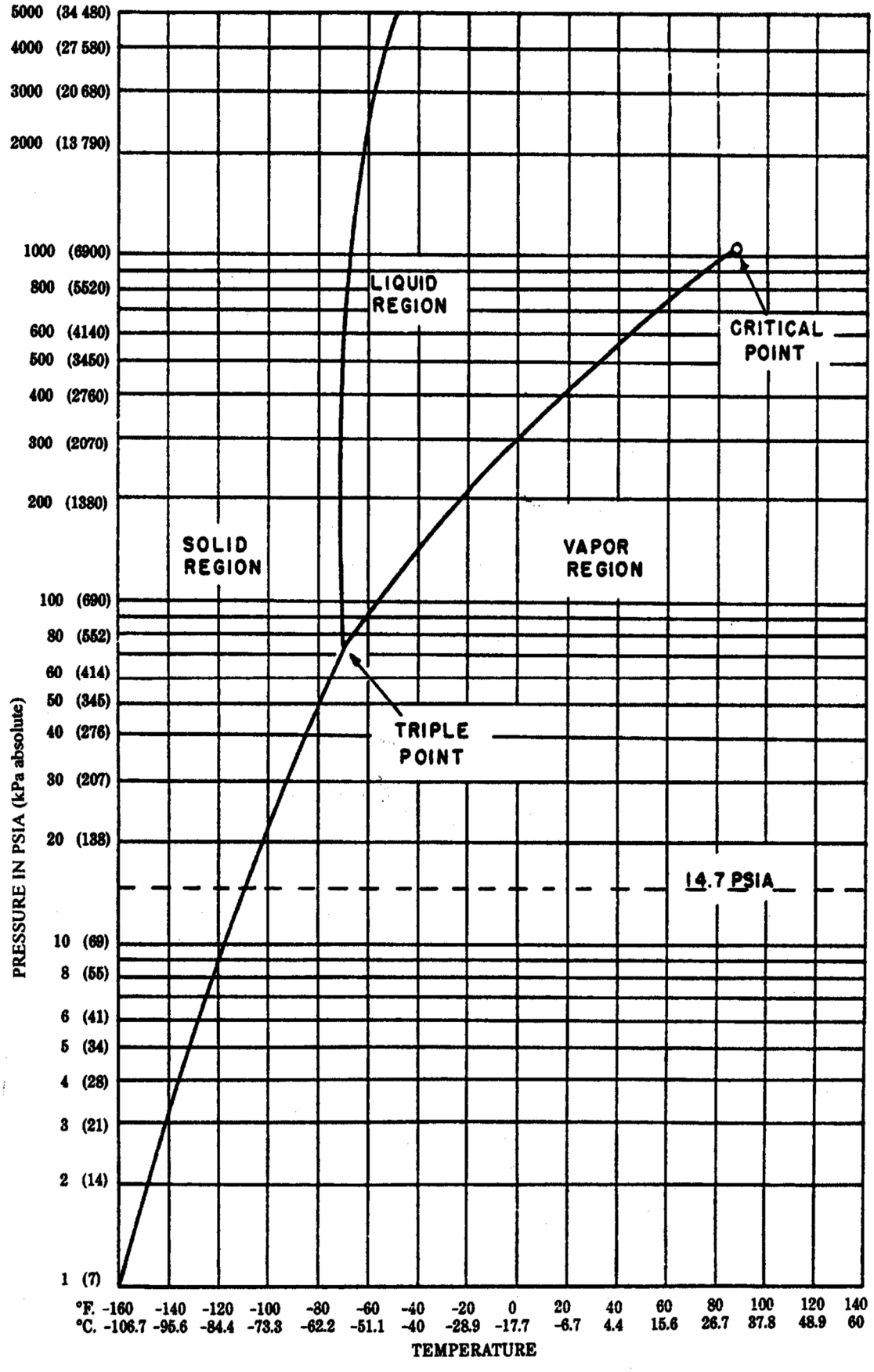
NOTE: *For additional information of properties of carbon dioxide and proper handling refer to CGA pamphlets G-6, "Carbon Dioxide" and G-6.1, "Standard for Low Pressure Carbon Dioxide Systems at Consumer Sites". These publications are available from the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA, 22202.*

PROPERTIES OF CARBON DIOXIDE

Under normal atmospheric conditions, Carbon Dioxide exists as a colourless, odourless gas, which is about 1.5 times heavier than air.

When confined to a storage tank, carbon dioxide can exist in any three states of matter; SOLID, LIQUID and GAS; depending on pressure. The point at which all three states may exist is 75 psia [60.4 psig (4 bar)]. This is the triple point. At temperatures and pressure below these values, carbon dioxide may either be a solid or a gas, depending on the conditions.

At temperatures and pressures above the triple point, carbon dioxide liquid with overlaying gas may exist in equilibrium within a closed vessel.


5000 (34 480)
4000 (27 580)
3000 (20 680)
2000 (13 790)
1000 (6900)
800 (5520)
600 (4140)
500 (3450)
400 (2760)
300 (2070)
200 (1380)
100 (690)
80 (552)
60 (414)
50 (345)
40 (276)
30 (207)
20 (138)
10 (69)
8 (55)
6 (41)
5 (34)
4 (28)
3 (21)
2 (14)
1 (7)
PRESSURE IN PSIA (kPa absolute)
LIQUID REGION
CRITICAL POINT
SOLID REGION
VAPOR REGION
TRIPLE POINT
14.7 PSIA
°F. -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140
°C. -106.7 -95.6 -84.4 -73.3 -62.2 -51.1 -40 -28.9 -17.7 -6.7 4.4 15.6 26.7 37.8 48.9 60
TEMPERATURE

INTRODUCTION

This manual provides information for the operation and maintenance of Taylor-Wharton's MICRO BULK cryogenic gas supply systems. These products store cryogenic liquid and dispense it as a warm pressurized gas. The MICRO BULK is designed for applications requiring nitrogen, argon and oxygen at maximum allowable working pressure of 17.2 Bar (1.72 MPa) for M series, 24 Bar (2.4 MPa) for HP series or 34.5 Bar (3.45 MPa) for VHP series. The HP series and VHP series can also be used for carbon dioxide application. The MICRO BULK tank with vaporizer can be suitable for the 8 hours continuous delivery of 50NM^3/Hr (MB1000), 100NM^3/Hr (MB2000~MB5000) and 150NM^3/Hr (MB7500) gaseous product.

Additional product specifications, flow diagram, views, and important dimensions are shown throughout this manual.

SPECIFICATION

MB1000 SERIES

TANK MODEL	Gross Volume (m^3)	Net Volume (m^3)	Height (m)	Diameter (mm)	Weight (kg)	Full Weight (kg)				NER (volume % /day)	MAWP (MPa)
						LOX	LIN	LAR	CO2		
MB1000MP	1.02	0.92	2.21	1100	900	1947	1640	2180	N/A	<1	1.72
MB1000HP	1.02	0.92	2.21	1100	970	2017	1710	2250	1993	<1	2.41
MB1000VHP	1.02	0.92	2.21	1100	1040	2087	1780	2320	2063	<1	3.45

MB2000 SERIES

TANK MODEL	Gross Volume (m^3)	Net Volume (m^3)	Height (m)	Diameter (mm)	Weight (kg)	Full Weight (kg)				NER (volume % /day)	MAWP (MPa)
						LOX	LIN	LAR	CO2		
MB2000MP	2.15	1.94	2.72	1350	1290	3500	2860	3990	N/A	<1	1.72
MB2000HP	2.15	1.94	2.72	1350	1430	3640	3000	4130	3400	<1	2.41
MB2000VHP	2.15	1.94	2.72	1350	1610	3820	3180	4310	3580	<1	3.45

MB3000 SERIES

TANK MODEL	Gross Volume (m^3)	Net Volume (m^3)	Height (m)	Diameter (mm)	Weight (kg)	Full Weight (kg)				NER (volume % /day)	MAWP (MPa)
						LOX	LIN	LAR	CO2		
MB3000MP	2.96	2.70	2.86	1500	1650	4710	3820	3580	N/A	<1	1.72
MB3000HP	2.96	2.70	2.86	1500	1820	4880	3990	5550	4540	<1	2.41
MB3000VHP	2.96	2.70	2.86	1500	2180	5240	4350	5910	4900	<1	3.45

MB5000 SERIES

TANK MODEL	Gross Volume (m^3)	Net Volume (m^3)	Height (m)	Diameter (mm)	Weight (kg)	Full Weight (kg)				NER (volume % /day)	MAWP (MPa)
						LOX	LIN	LAR	CO2		
MB5000MP	5.00	4.50	3.0	1840	2640	7780	6280	8910	N/A	<1	1.72
MB5000HP	5.00	4.50	3.0	1840	2950	8080	6590	9220	7520	<1	2.41
MB5000VHP	5.00	4.50	3.0	1840	3550	8690	7190	9820	8120	<1	3.45

MB7500 SERIES

TANK MODEL	Gross Volume (m^3)	Net Volume (m^3)	Height (m)	Diameter (mm)	Weight (kg)	Full Weight (kg)				NER (volume % /day)	MAWP (MPa)
						LOX	LIN	LAR	CO2		
MB7500MP	7.50	6.75	3.6	2030	3622	11303	9048	12999	N/A	<1	1.72
MB7500HP	7.50	6.75	3.6	2030	4101	11782	9527	13478	11621	<1	2.41
MB7500VHP	7.50	6.75	3.6	2030	4650	12331	10076	14027	12170	<1	3.45

Based on Net Volume, calculation based on liquid at saturated 0 Bar.
All of the above sizes and weight is only for reference.
REMARKS:

1. Back Pressure regulator, PCV3 is set at 13.8 bar / 1.38 MPa for M series tank, 22.7 Bar / 2.27 Mpa for H series tank and 31 bar / 3.1 MPa for V series tank.
2. Pressure Build-up Regulator, PCV1 is set at 12 bar / 1.2 MPa for M series tank, 20.7 bar / 2.07 Mpa for H series tank and 27.6 bar / 2.76 MPa for V series tank.
3. Economizer Regulator, PCV2 is set at 13 bar / 1.3 MPa for M series tank, 22 bar / 2.2 Mpa for H series tank and 29 bar / 2.9 MPa for V series tank.
4. Safety Valve, PSV-1 & PSV-2 of M series tank is setting 17.2 Bar, H series tank is setting 24 Bar and setting 34.5 Bar for V series tank.
5. Withdrawal connection RR and gas supply connection BR is ½"FNPT.

SYSTEM DESCRIPTION

The MICRO BULK consists of a cryogenic liquid vessel, piping, external vaporizer, and external pressure builder.

The vessel consists of a pressure vessel suspended inside a jacket. The space between the pressure vessel and the jacket is evacuated and insulated with a micro-fiberglass / aluminum foil radiation shield. Both the inner pressure vessel and vacuum jacket are constructed of type-304 stainless steel. All piping is designed to withstand the stress caused by expansion and construction of the pressure vessel, its support system and pipiping itself. All models are designed and constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

Piping circuits allow the vessel to vent, fill, pressurize, and provide pressurized gas. Piping is Type-304 stainless steel. Valves are stainless steel. Fittings are machined from forged brass and Type-316 stainless steel.

Instrumentation consist of a pressure gauge and a differential pressure gauge. The pressure gauge allows the vessel pressure to be monitored. Accurate measurement of the vessel contents is provided by the differential pressure gauge.

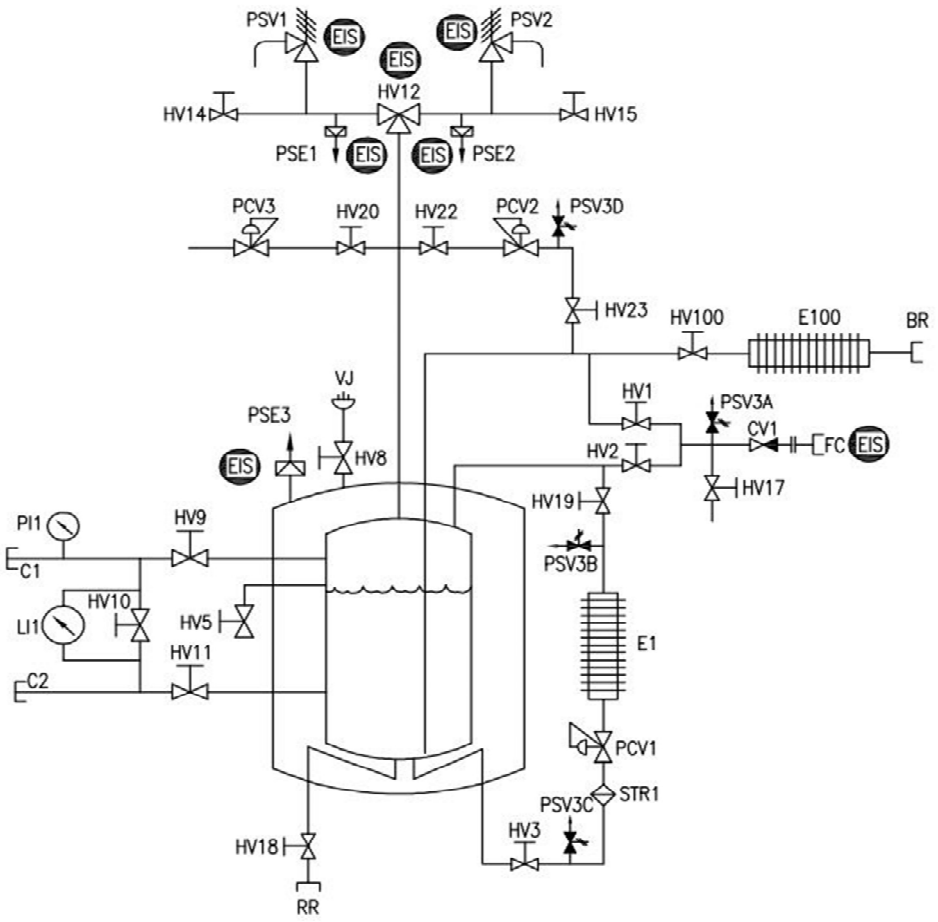
The MICRO BULK automatically maintains pressure by vaporizing cryogenic liquid in a controlled fashion. All energy for building pressure and vaporizing liquid is provided by heat from ambient air. The pressure building coil is attached to the outer jacket. The free standing vaporizer is attached to the pallet.

The Micro Bulk is evacuated to a high vacuum through vacuum pump connection (PSE3). The PSE3 will be closed down aoutomatically and is protecting the outer vacuum jacket tank from over pressure. DO NOT OPEN the PSE3.

PIPING CIRCUITS

The following information describes the operation of the piping circuits of the system. The descriptions refer to the main components of each circuit and are grouped by function. Reference the piping schematic shown below. These component and circuit descriptions should be understood before attempting operation.

PIPING SCHEMATIC



LEGEND

HV1	BOTTOM FILL LINE	PSE–2	BURSTING DISC
HV2	TOP FILL LINE	PSE3	VACUUM PUMP & VACUUM RELIEF VALVE
HV3	PB INLET VALVE	PSV1	SAFETY VALVE
HV5	TRYCOCK / VENT VALVE	PSV2	SAFETY VALVE
HV8	VACUUM PROBE VALVE	PSV3A	THERMAL EXPANSION VALVE
HV9	GAS ISOLATION VALVE	PSV3B	THERMAL EXPANSION VALVE
HV10	EQUALIZATION VALVE	PSV3C	THERMAL EXPANSION VALVE
HV11	LIQUID ISOLATION VALVE	PSV3D	THERMAL EXPANSION VALVE
HV12	SAFETY CHANGEOVER VALVE	PCV1	PRESSURE BUILD–UP REGULATOR
HV14	SAFETY LINE PURGE VALVE	PCV2	ECONOMIZER REGULATOR
HV15	SAFETY LINE PURGE VALVE	PCV3	BACK PRESSURE REGULATOR
HV17	FILL LINE PURGE VALVE	PI1	TANK PRESSURE GAUGE
HV18	LIQUID WITHDRAWAL VALVE	LI1	LIQUID LEVEL GAUGE
HV19	PB OUTLET VALVE	E1	PRESSURE BUILDING COIL
HV20	ISOLATION VALVE	E100	ATMOSPHERIC VAPORISER
HV22	ISOLATION VALVE	BR	GAS SUPPLY CONNECTION
HV23	ISOLATION VALVE	RR	LIQUID CONNECTION
HV100	GAS SUPPLY VALVE	FC	FILLING CONNECTION
VJ	VACUUM PROBE	STR1	STRAINER
PSE–1	BURSTING DISC	CV1	CHECK VALVE FILL PORT

MB00–9C07 (REV 2)

Product & Vent Circuits

The gas supply valve (HV-100) communicates with the bottom of the vessel. Liquid is removed from the vessel from this valve through atmospheric vaporizer (E100) and gas supply connection (BR) for the use of high quality gas.

The vent / trycock valve (HV-5) is attached to a vertical tube in the upper portion of the vessel. Opening the vent valve reduces pressure in the vessel during filling. It also serves as a "full trycock", venting liquid from the vessel when the liquid level exceeds 90%.

Fill Circuits

The Fill circuit may be used for filling from the Taylor-Wharton MICRO BULK Cryogenic Delivery System or for filling by a cryogenic pump. A check valve (CV-1) will prevent product from escaping the vessel. The fill line purge valve (HV-17) used to vent the fill line during fill hose cool-down, and to drain liquid product trapped between the fill connection and the fll valve after a fill is completed.

Pressure Building Circuit

The pressure building circuit serves to build pressure after filling the vessel. The circuit is also used to ensure sufficient driving pressure during high product withdrawal periods. Opening the pressure building outlet valve (HV-19) and pressure building inlet valve (HV-3) permits the circuit to function. When the pressure inside the vessel drops below the pressure builder setting, the pressure building regulator (PCV-1) opens. This creates a path from the liquid in the bottom of the container to the gas space in the top. This path contains an external pressure building coil (E-1) to vaporize product as it flows from the bottom to the top of the vessel. Liquid is expanded to a vapor and pressure is increased in the vessel.

External Pressure builder, and Economizer Circuit

The pressure builder(PB) inlet circuit provides pressurized cryogenic liquid to an external pressure builder. Opening the PB Inlet Valve (HV-3) allows liquid, driven by the pressure within the vessel, to flow into the external pressure builder. The pressure builder uses heat from the ambient air to convert the liquid into a gas and warm it.

The economizer circuit reduces product loss due to normal evaporation of the liquid within the vessel. The pressure builder outlet valve (HV-19) and the economizer circuit isolation valve (HV-23) must be open for the circuit to function. The economizer regulator (PCV-2) opens when the pressure within the vessel exceeds the economizer set point. This allows gas from the top of the vessel to flow into the vaporizer circuit/ liquid withdrawal. Provided that gas from the vaporizer is being withdrawn for use, the vessel pressure will be reduced. The primary safety valve (PSV-1 & PSV-2) will be prevented from opening, avoiding product loss.

The economizer circuit may be isolated for maintenance without emptying or depressurizing the vessel. Closing the isolation Economizer outlet valve (HV-22) and the economizer circuit isolation valve (HV-23) to isolates the circuit.

Safety Devices

The MICRO BULK features safety valves to prevent over-pressurization of the vessel. The safety valves (PSV-1 and PSV-2) relieve pressure when it exceeds the maximum operating pressure of the vessel. The valve resets when pressure drops below this point. In addition, the primary safety valve is supported by a secondary relief device consisting of a rupture discs (PSE-1 and PSE-2). The rupture disc requires replacement in the event a safety valve malfunctions and allows vessel pressure to reach the burst pressure rating of the disc. The rupture discs will replaced with secondary safety valve which is setting higher than primary safety valve for LCO2 service. A Dual Safety Divert valve (HV-12) permits the operation of one set of protection devices while the other set is isolated at the same time and permits maintenance of the device without the need to vent tank pressure. To activate one set of devices while isolating the other move the selector valve handle all the way to the end of its travel toward the devices to be activated.

The back pressure regulator (PCV-3) will open and tank pressure reduce. It can prevent PSV1 and PSV2 frequent action and let its work longer. Safety line purge valves (HV14 & HCV-15) is manually open to release the high presure when replace safety valve (PSV1 & PSV2) and can be one connector to withdrawing gas to test.

Instrumentation Circuits

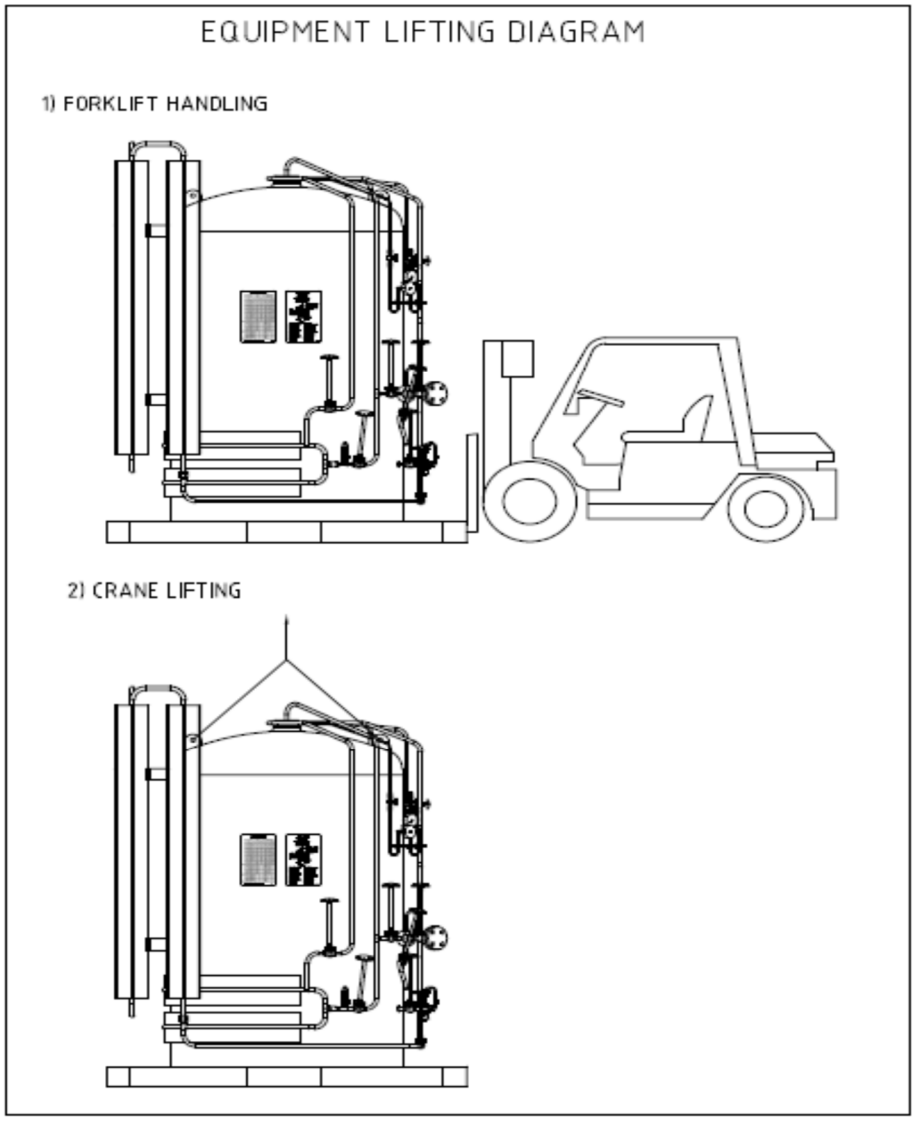
The instrumentation consists of a WIKA combo pressure gauge and liquid level gauge or differential pressure gauge. The pressure gauge (PI-1) displays the inner vessel pressure in pounds-per-square-inch and kilo pascals. The liquid level gauge (LI-1) measures the difference in pressure between the top and bottom of the vessel. Product within the vessel creates a higher pressure at the bottom of the vessel than at the top. Readings on the liquid level gauge are in inches of water. This reading, when compared to the contents chart attached to the front of the vessel, allows accurate monitoring of the amount of product within the vessel. Isolation valves (HV-9 and HV-11) allow maintenance of the circuit without emptying and depressurizing the vessel. The equalization valve (HV-10) must be opened before the isolation valves are closed. Two ¼" female pipe thread connections (C-1 and C-2) are provided to allow easy connection of telemetry devices or other differential pressure measurement instruments. The connections are provided plugged.

INSTALLATION

Handling

Dimension and connection data for the MB tanks can be found on the General Arrangement Drawing supplied with the tank and included in this manual. Additional copies of the drawing may be requested from the factory. Please include information on the tank model number and part number in making requests for these drawing. The drawing part number is listed in Specification chart in this manual.

The MICRO BULK should be handled only by a forklift or crane. Ensure that handling equipment has adequate rated capacity for the system weight listed on the specification page. The MICRO BULK is a rugged product intended for years of industrial use. However, take care when moving the unit. Abuse (dropping or careless handling by forklift) may affect the integrity of the insulation system or damage piping. Always transport, operate, and store the unit in the vertical position.



Tank installation is the customer's responsibility. The Micro Bulk tank with pallet for equipment to handle or transit expediently, no special demand for the toft to use temporarily, advise to build one toft for fixation long time, 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.

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:

- Tanks are shipped pressurized with nitrogen gas at 20 psig (1.4 bar/138 kPa). Open the gauge ISOLATION VALVE (HV10) and read tank pressure indicated on the PRESSURE GAUGE (PI1). Record the "as received" tank pressure. Close the ISOLATION VALVE. Tank pressure may change due to temperature variations, accidental opening of valves, packing leaks, or minor leaks at the fill connections. 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.

- Check insulation space vacuum by connecting a Hasting-Raydist Model TV-4A or VT-6 vacuum gauge to the tank VACUUM GAUGE TUBE. Open the tank VACUUM GAUGE VALVE (HV8), wait 60 minutes, and take a reading. If the "as received" vacuum (tank at ambient temperature) is greater than 20 microns (0.02 mm Hg) absolute, contact the factory.

OPERATIONS

These instructions are for operators experienced with cryogenic equipment. Before operating this product, become 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 and know the location and function of all 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 the contaminants. The following procedure is recommended for most application:

1. Attach the liquid purge product source to tank FILL CONNECTION (FC). Product delivery pressure should be approximately 100 psig (6.9 bar / 690 kPa).
   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 Instrumentation Isolation Valves (HV9,HV10,HV11), PRESSURE BUILDING ISOLATION VALVE (HV3).

3. Open GAS SUPPLY VALVE (HV100) and vent inner vessel to 5 psig (0.34 bar/34 kPa) as indicated on the tank PRESSURE GAUGE (PI1).

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 BUILD COIL (25) 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) indicates maximum desired purge pressure, close the liquid supply source. Close BOTTOM ISOLATION VALVE (HV3).

6. After liquid has drained from the tank, close THREE INSTRUMENT ISOLATION VALVES (HV9, HV10, HV11). The EQUALIZATION VALVE (HV10) should be opened just before closing VAPOR (HV9) and LIQUID (HV11) ISOLATION VALVES to prevent damage to the LEVEL GAUGE (LI1).

7. Carefully loosen the adapters on both sides of the LEVEL GAUGE (LI1) to relief pressure. Disconnect the instrument lines. Fully open LIQUID & VAPOR ISOLATION VALVES (HV9 & HV11) and visually check the resultant gas streams for signs of moisture. Vent these lines for approximately two minutes. If no moisture is evident, close the LIQUID (HV11)

and VAPOR (HV9) ISOLATION VALVES. If moisture is evident, continue venting until the stream is free of moisture.

NOTE: Be careful when opening the gauges valves since some residual liquid may have remained in tank or the instrument lines.

8. Open PRODUCT SUPPLY VALVE (HV100) to check for moisture as in Step 7.

9. Open GAS SUPPLY VALVE (V100) and FULL TRYCOCK VALVE (HV5) and check for the moisture as in step 7.

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

11. Reconnect the LEVEL GAUGE, open VAPOR & LIQUID ISOLATION VALVES and close EQUALIZATION VALVE.

12. After completion of tank purge, make sure that all valves are closed except the VAPOR & LIQUID ISOLATION VALVES.

Filling by Pressure Transfer

Filling by pressure transfer is accomplished by lowering the pressure in the MICRO BULK below that of the source vessel. Typically the source vessel is a truck-mounted vessel. The pressure is reduced in the MICRO BULK by venting gas through the full trycock valve (V5). Liquid is pushed by pressure from the truck-mounted vessel and into the MICRO BULK.

CAUTION: Follow the safety precautions at the beginning of this manual. Accidental contact with liquid or cold gas can occur during filling.

A cryogenic transfer hose equipped with a relief valve and dump valve should be used to connect the MICRO BULK to the fill connection. Follow the instructions below to fill by pressure transfer:

- When liquid issues from the full trycock valve, the vessel is full. The designed gas head space will remain above the liquid.
- Once liquid stops issuing from the full trycock valve (HV5), close the trycock valve.
- Close the liquid source supply valve.
- Disconnect the transfer hose from the Fill connection (FC).

Filling by Pump Transfer

When a pump is used to fill the container, the pump / top fill valve (HV2) should be used. Closely monitor the vessel pressure during the fill. If the vessel pressure approaches the relief valve setting or the pump pressure rating, shut down the pump. Open the full trycock valve (V5) to reduce pressure as needed. When using a traditional pumping system, the full trycock valve (V5) should remain open during the fill. Monitor the product exiting the trycock valve closely. When liquid issues from the trycock valve (HV5) immediately stop the pump. Once liquid stops issuing from the vent valve close the vent valve. Before disconnecting fill hose

from fill connection (FC) open fill purge valve (HV17) to discharge product from fill hose. After this operation is complete close fill purge valve then disconnect hose from (FC).

Filling a Warm Tank

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

1. Close all valves except the tank VAPOR (HV9) & LIQUID (HV11) ISOLATION VALVES and EQUALIZATION VALVE (HV10).

2. Check name of contents on supply source against product name on tank to be certain that 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. If it is to be filled with any product, the nitrogen gas must be purged from the tank. Purge with product gas until analysis indicates an acceptable purity. Use the steps outlined in the Purge Procedure section above as a guide.

4. Open FULL TRYCOCK VALVE (HV5). Vent tank pressure to about 5 psig (0.34 bar / 34 kPa).

5. Fully open TOP FILL VALVE (HV2) and PRESSURE BUILDING ISOLATION VALVE (HV3) to fill tank as rapidly as possible.

6. Monitor tank pressure on tank PRESSURE GAUGE (PI1). If tank pressure rises to within 90% of tank MAIN SAFETY VALVE setting, close tank TOP FILL VALVE (HV2) and stop fill immediately and vent tank pressure to at least 50 psig (3.45 bar / 345 kPa) below MAIN SAFETY VALVE set-point. Open tank TOP FILL VALVE (HV2) and resume filling.

7. When liquid spurts from tank FULL TRYCOCK VALVE (HV5), close supply source valve to stop fills. Close tanks FULL TRYCOCK VALVE (HV5).

8. When residual liquid in the fill hose vaporizes, close tank TOP FILL VALVE (HV2).
   CAUTION: ***To avoid injury, do not touch fill house or connections with bare hands. During filling, these parts are cooled to extremely low temperatures.***

9. Open fill line drain valve (HV17) to relieve fill hose pressure. Close fill line drain valve.

10. When pressure is released disconnect fill hose. Close 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 AND BOTTOM FILL VALVES (V2 & V1) are closed.

1. Check name of contents on supply source against product name on tank to be sure that proper product is being transferred into tank.

2. Connect supply source fill hose to tank FILL CONNECTION (FC). Make certain connection is leak tight.

3. Open supply source liquid delivery valve.

4. Fully open tank TOP FILL VALVE (HV2) to start tank fill

   NOTE: ***Filling through the BOTTOM FILL VALVE will increase tank pressure since gases in the vapor space are compressed, whereas filling through the TOP FILL VALVE decreases tank pressure since gases in the ullage (vapor) space are cooled and re-liquefied.***

5. Open tank FULL TRYCOCK VALVE (HV5) when tank LEVEL GAUGE indicates ¾ full.

6. When liquid spurts from tank FULL TRYCOCK VALVE (HV5), close supply source delivery valve to stop fills. Close tank FULL TRYCOCK VALVE (HV5).

7. When residual liquid in the fill hose vaporizers, close tank TOP FILL VALVE (HV2).

   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 (HV7) to relieve fill hose pressure. Close fill line drain valve. When pressure is released, disconnect fill hose.

Filling Liquid Carbon Dioxide

1. Attach a liquid fill line from the supply trailer to the *FILLING* connection, and a gas phase line from the trailer to the *FULL TRYCOCK VALVE* connection on the tank.

2. Open the trailer and the tank *VAPOR EQUALIZER (FULL TRYCOCK) VALVE* and wait until both the tank and the trailer pressure gauges reach the same pressure.

3. Open the *LIQUID FILL VALVE* on the tank and the corresponding trailer valve. Start the pump and observe the *LIQUID LEVEL GAUGE* during transfer for fill termination.

   CAUTION: *DO NOT OVER FILL.*

4. When transfer is complete as indicated by the *LIQUID LEVEL GAUGE*, stop the pump, close *LIQUID FILL VALVE* and liquid valve to transfer truck, then close the *VAPOR EQUALIZER (FULL TRYCOCK) VALVE (HV5)* and gas valve to the transfer truck.

5. Blowdown the transfer lines and disconnect from storage tank.

Normal Operation

During normal operation, tank pressure forced liquid through the inner line and the GAS SUPPLY VALVE (HV100) to external VAPORIZER (E100) 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 by gravity 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 ECONOMIZER REGULATOR (PCV2) set-point, 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 (HV9 & HV11),
GAS SUPPLY VALVE (HV100).

All other valves should be closed.

Taking a Tank Out of Service

Schedule the shutdown operation to coincide with low liquid level in the tank. If a large quantity of liquid 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 FULLTRYCOCK VALVE (HV5), provided appropriate safety precautions are taken.

For shutdowns of a short duration, retain residual liquid in the tank. Close all valves except the tank INSTRUMENTATION VAPOR and LIQUID ISOLATION VALVES (HV9 & HV11).

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

<u>Tanks in Oxygen Service</u>

1. Drain liquid product from tank. Open tank FULL TRYCOCK VALVE (HV5) and reduce tank pressure to atmospheric. Close tank FULL TRYCOCK VALVE (HV5).
2. Connect a source of warm nitrogen gas to tank FILL CONNECTION (FC). Admit nitrogen purge gas through tank TOP FILL VALVE (HV2). Vent tank through GAS SUPPLY VALVE (HV100). Two or three times during purge, close tank GAS SUPPLY VALVE (HV100) and build tank pressure to about 25.38 psig (1.75 bar / 175 kPa). Release pressure and continue purge.
3. Open tank TRYCOCK VALVE (HV5) and PRESSURE BUIL-UP VALVE (HV3) 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 (HV5).

4. Close tank GAS SUPPLY VALVE (HV100). Build tank pressure to 25.38 psig (1.75 bar / 175 kPa). Close tank BOTTOM ISOLATION VALVE (HV1). Disconnect nitrogen gas hose from tank FILL CONNECTION (FC).
5. Warm tank inner vessel before shipping to a new location.

Tanks in Nitrogen / Argon Service

1. Drain liquid product from tank. Open tank VENT VALVE and reduce tank pressure to 2 psig (0.14 bar / 14 kPa). Close tank VENT VALVE.
2. Warm tank inner vessel before shipping to a new location.

Withdrawing Product thru External Vaporizer

To withdraw product from the MICRO BULK, install a line regulator downstream of the vaporizer. Connect the outlet of the regulator to the application. Follow these steps:

- Open the pressure building valve (V3). Monitor the pressure gauge (PI-1). When the pressure exceeds the desired delivery pressure, continue.
- Open the gas supply valve (V100).
- Adjust the line regulator to desired delivery pressure.

Withdrawing Liquid

Attach a transfer hose from the receiver vessel to the MICRO BULK liquid connection (RR) and open the adjacent liquid isolation valve (V11). The pressure in the container will drive liquid product out through the valve as long as the container pressure exceeds that of the receiver.

Changing Gas Service

The MICRO BULK changed for the following gas only; argon, oxygen, or nitrogen service. Follow these steps to properly change gas service:

1. Safely empty all liquid from the container.
2. Open the pressure building inlet and outlet valves (V3 and V19) and the full trycock valve (V5) to vaporize any residual liquid that may remain in the bottom of the vessel. It may require an hour or longer to vaporize all the residual liquid.
3. To ensure purity, it is recommended that the MICRO BULK be evacuated with a suitable vacuum pump. The ultimate vacuum reading should be at least 20 inches of mercury.
4. Replace the fittings for the liquid, top fill, and use connections with the appropriate fittings. Use Teflon tape or another suitable thread sealant when threading the fittings into the connections.
5. Remove any decals identifying the previous gas service. Attach new gas service identification decals.

MAINTENANCE

Routine inspections of the system are recommended. The need for maintenance usually becomes apparent from inspection and indications of improper operation. Typical trouble indications include leakage from valves or piping connections and excessive venting through relief valves. Keep a permanent log of all inspections and repairs performed. Such a log can be valuable in evaluating 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 piping system, isolate the piping section to be repaired from the tank, and releive pressure on the component or piping.

Do not allow unqualified persons to attempt repairs on this equipment. Field repairs to instruments and control must be made by qualified instrument specialist. Refer to the Trouble-Remedy Guide in this manual (page 24) 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.

Suggested Leak Test

After making repairs requiring disassembly or replacement of components, leak test all valves or piping joints that were taken apart and reconnected. Apply leak detector fluid to the test surface. 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 system is returned to service.

WARNING: ***For O2 System Users: Residue of leak detectors can be flammable. All surfaces to which the leak detector solution has 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 ice emerging from the packing gland or retainer threads. If tightening cannot stop packing leakage, replace packing. Use preformed packing, which can be ordered from the valve manufacturer.

Control Valves

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

The PRESSURE BUILDING REGULATOR (PCV1) opens on falling tank pressure and closes on rising pressure. This valve is factory set at 400 psig / 27 bar / 2.7 MPa.

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 450 psig / 31 bar / 3.1 MPa.

The ECONOMIZER REGULATOR (PCV2) opens on rising tank pressure and closes on falling pressure. This valve is factory set at 425 psig / 29 bar / 2.9 MPa.

The factory settings of the control valves may be field adjusted. The ECONOMIZER 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 the control valves, isolate and depressurize the valves by closing the PRESSURE BUILD-UP VALVE (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 setting or to readjust the valves after completing repairs requiring disassembly of the valves.

The PRESSURE BUILDING REGULATOR (PCV1) should be set so that tank pressure is held about 5 psig (0.34 bar / 34 kPa) above the desired delivery pressure. The ECONOMIZER REGULATOR (PCV2) should be set at least 15 psig (1.03 bar / 103 kPa) above the setting of the PRESSURE BUILDING REGULATOR (PCV1), but has always be chosen below the permissible operating pressure (set 2 bar below). If both controls are to be reset, set the PRESSURE BUILDING REGULATOR (PCV1) before setting the ECONOMIZER REGULATOR (PCV2).

Note: ***The tank must contain liquid for setting control valves. The ECONOMIZER REGULATOR must be adjusted while a product is being withdrawn through the product withdrawal line.***

Setting PRESSURE BUILDING REGULATOR (PCV1):

When it is required to set the top pressure in the tank, the automatic pressure building regulator PCV1 should be brought into operation. Closed all valves except safety relief circuit, instrument circuit and PB circuit. The Pressure Building Coil (E1) will raise the pressure in the tank until an equilibrium pressure is reached at which regulator PCV1 will close. Gradually turn clockwise the adjusting screw of the pressure regulator (PCV1). This will permit liquid to flow

into the pressure building coil, where it will vaporized. The maximum set pressure is limited by the safety valve setting of the tank. In order to achieve this position, the regulator may be set as follow:

If the tank pressure is below desired setting: Loosen pressure screw locknut on PRESSURE BUILDING REGULATOR (PCV1). With PRESSURE BUIL-UP ISOLATION VALVE (HV3) and TOP ISOLATION PB VALVE (HV19) open, gradually open REGULATOR by turning pressure screw in (clockwise) to build tank pressure to 5 psig (0.34 bar / 34 kPa) above the desired delivery pressure. Note that the pressure screw must be adjusted in small increments, allowing sufficient time for tank pressure to stabilize each time screw is turned. When desired set point is reached, tighten pressure screw locknut.

If tank pressure is above desired setting: Loosen pressure screw locknut and turn pressure screw out (counterclockwise) to end of adjustment range. Open TANK BLOWDOWN VALVE and vent until tank pressure is 5 psig (0.34 bar / 34 kPa) above the desired delivery pressure. With PRESSURE BUIL-UP ISOLATION VALVE (HV3) and TOP ISOLATION PB VALVE (HV19) open, slowly turn pressure screw in (clockwise) until REGULATOR just opens as indicated by cooling of downstream pipe (at REGULATOR outlet). Tighten pressure screw locknut.

Setting PRESSURE REDUCING REGULATOR (ECONOMIZER) (PCV2):

1. If the tank pressure is below desired setting: Loosen pressure screw locknut on REGULATOR (PCV2). With BOTTOM ISOLATION VALVE and TOP ISOLATION VALVE open, gradually open REGULATOR by turning pressure screw in (clockwise) to build tank pressure to 5 psig (0.34 bar / 34 kPa) above the desired delivery pressure. Note that the pressure screw must be adjusted in small increments, allowing sufficient time for tank pressure to stabilize each time screw is turned. When desired set point is reached, tighten pressure screw locknut.

2. If tank pressure is above desired setting: Loosen pressure screw locknut and turn pressure screw out (counterclockwise) to end of adjustment range. Open TANK BLOWDOWN VALVE and vent until tank pressure is 5 psig (0.34 bar / 34 kPa) above the desired delivery pressure, PB Regulator (PCV1). With BOTTOM ISOLATION VALVE and TOP ISOLATION VALVE open slowly turn pressure screw in (counterclockwise) until REGULATOR just opens as indicated by cooling of downstream pipe (at REGULATOR outlet). Tighten pressure screw locknut.

Inner Vessel and Piping Safety Devices

These MB Tanks are equipped with dual safety device manifold that permits servicing of one set of safety device while the other set is in service. The inner vessel is protected by a TANK SAFETY VALVE acting as a primary relief device and a TANK BURSTING DISC acting as a secondary relief device.

If TANK BURSTING 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 TANK BURSTING DISC on this tank is a sealed assembly of which membrane must be replaced as a unit.

If TANK PRESSURE SAFETY VALVE leaks or fails to operate at the set pressure should be replaced immediately. Only experienced personnel with proper equipment should do repair and recalibration of this valve. Return the valves to the manufacturer or to 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 Standard 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 test these components since they are meant to be disposable.

Pressure And Liquid Level Instruments

User adjustment of the pressure gauge or liquid-level gauge is not possible. If the gauges are malfunctioning, they must be replaced. Close both isolation valves (V-8 and V-10) and immediately open the equalization valve (V-9). Loosen one of the tube compression fitting nuts to reduce pressure. When the pressure gauge (PI-1) indicates zero it is safe to work on the circuit.

VACUUM MAINTENANCE

Checking Vacuum

Micro-Bulk cryogenic tanks are carefully design, manufactured, and tested with every effort made to eliminate vacuum space leakage. An absorbent system is sealed inside the casing to help maintain the vacuum over a long period of time. However, some vacuum deterioration over time can be expected due to out-gassing of materials inside the vacuum space. To detect vacuum deterioration, periodic measurement of casing vacuum is recommended. A thermocouple-type-VACUUM PROBE (VJ), located on the upper outer head of the tank, is provided for this purpose.

To check vacuum:

1. Remove the protective plastic cap from the gauge tube connector.
2. Connect a Hasting-Raydist Model TV-4A or VT-6 Vacuum Gauge to the gauge tube.
3. Open the gauge tube isolation valve and wait at least 30 minutes before reading the vacuum gauge.
4. After the vacuum reading is recorded, close the isolation valve, disconnect the vacuum gauge and replace the protective cover back on the gauge tube connector.

The vacuum reading obtained on a cold tank is initially less than 50 microns (0.05 mm Hg) absolute; however, gradual deterioration over a period of many years is normal. Complete logs of vacuum readings, along with dates when they were taken, can be very helpful in evaluating vacuum performance and scheduling work.

Note: If the tank is empty and warm, vacuum space pressure will tend to be high because of the release of gases from absorbent 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 withdrawal is being made. However, if vacuum deterioration seriously affects tank operation by producing excessive pressure buildup and high loss rate, contact the factory for information about how to determine and correct the cause of the trouble.

Vacuum Probe Replacement

If the gauge tube is damaged or is suspected of giving inaccurate reading, replace it as follows:

1. Make certain that gauge tube isolation valve is closed.
2. Unscrew the gauge tube from the valve. Use two wrenches, one on the tube, one on the valve.
3. Clean the threads and opening of the valve.

NOTE: Do not use Teflon tape as a sealant on vacuum system fittings.

4. Thread the new gauge tube into the valve by engaging one thread. Apply a suitable (e.g. Airserco) high vacuum sealant to remaining exposed threads. Tighten tube into valve, using two wrenches. Do not over tighten.
5. Install a new vinyl cover over the gauge tube connector.

NOTE: If corrosion of the gauge tube is a problem, spray the tube housing with "Krylon Crystal Clear Coating 1304" or equivalent acrylic spray. Do not spray the contact pins of the electrical connector; this could cause erroneous vacuum readings.

6. Open the vacuum probe isolation valve (HV8) and check vacuum following previously described procedure. The waiting period to obtain a stable reading with a new gauge tube may exceed the specify 30 minutes. This is due to out gassing of new gauge tube and the thread sealant.

Analyzing Vacuum Deterioration

If you decide to re-evacuate because of slow deterioration over a long period of time, 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 vacuum jacket of the tank. If deterioration is rapid and causes the TANK RUPTURE DISC to rupture, it is 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 gauge tube are good condition and follow operating instructions carefully. Always be sure that the gauge tube valve has been open for at least 30 minutes before taking a reading.

Try to determine the source of leakage in cases where the Vacuum Connection has not functioned, visually inspect the exterior of the outer vessel. Check the following areas in the order in which they are listed:

a. Vacuum probe,
b. Vacuum isolation valve,
c. Vacuum pump out valve,
d. Sealed insulation ports (on top of the tank),
e. Vacuum pump down connection,
f. All liquid and gas phase line at exit point from vacuum jacket,
g. Any area of the vacuum jacket that might have been exposed to cryogenic liquid spray or contact.

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

TROUBLE-REMEDY GUIDE

Trouble	Possible Cause	Remedy
Low operating pressure.	a. Safety valve leaking or frozen open. b. Safety disc ruptured. c. Piping leaks to atmosphere. d. Pressure building / economizer regulator malfunction. e. Excessive product withdrawal. f. Pressure building valve closed. g. Malfunctioning pressure gauge. h. Excessive frost on pressure building coils. i. Low liquid level.	a. Thaw out valve or replace if necessary. b. Replace disc. c. Leak test and repair piping. d. Adjust regulators. Replace if necessary. e. Check for leaks downstream. Reduce product use. f. Open pressure building valve. g. Replace pressure gauge. h. Thaw pressure-building coils. i. Refill tank.
Excessive system pressure.	a. Extensive shutdown time. b. Low withdrawal rate. c. Malfunction of pressure-building / Economizer circuit. d. Malfunction of pressure gauge. e. Bad vessel vacuum.	a. No remedy. b. No remedy. c. Adjust pressure-building / economizer regulators. Replace if necessary. d. Replace gauge. e. Perform NER test. Have vessel repaired and re-evacuated if necessary.
Erratic or Erroneous Content Gauge Reading	a. Leak gauge line. b. Bypass valve open. c. Gauge needle stuck. d. Gauge not zeroed. e. Gauge lines reversed, f. Gauge damaged or faulty g. Plugged gauge lines.	a. Test and repair leaks. b. Close by-pass valve. c. Tap liquid gauge slightly, inspect needle and bend as required. d. Adjust as required. e. Connect properly. f. Replace gauge. g. Disconnect lines at content gauge and test for flow.
Leaking safety valve.	a. Dirt or ice in valve. b. Improper valve set point c. Damaged valve seat.	a. Thaw out valve. Replace if necessary. b. Replace valve c. Replace valve.

Ruptured pressure vessel rupture disc.	a. Excessive vessel pressure. b. Defective rupture disc. c. Atmosphere corrosion and/or discfatigue. d. Interior disc corrosion. e. Relief device failed.	a. Excessive system pressure trouble section. Replace rupture disc. b. Replace rupture disc. c. Replace rupture disc. d. Blow out safety device line. Replace rupture disc. e. Replace relief device and rupture disc.
Tank Vacuum Leak	a. Leak in Vacuum Jacket connection. b. Vacuum Probe or Vacuum Gauge valve leak	a. Replace vacuum pump out plug. Re-evacuate insulation space. b. Replace faulty component. Re-evacuate insulation space.