Product Manual

Perma-Cyl® MicroBulk Storage Systems

450 ZX VHP

Designed and Built by:

Chart Inc.

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Contents

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Preface

General

The Perma-Cyl 450 ZX VHP is the latest addition to the Perma-Cyl MicroBulk Storage Systems Series. It is designed and built with a rugged internal support system for mobility full of liquid within its protective metal pallet. Unlike the Mega-Cyl Series, the Perma-Cyl 450 ZX VHP features the internal float and spray system for single-hose auto shut-off with the Orca™ MicroBulk Delivery System. With the on-board external aluminum heat exchanger, the Perma-Cyl 450 ZX VHP is rated at a flow rate of 2000 SCFH while sustaining 420 to 450 psig. The vessel is bolted to a dedicated metal pallet for full protection and transportability with an overhead crane or forklift. The portable design makes the Perma-Cyl 450 ZX VHP the ideal quick-response solution for demanding industrial gas applications, like laser-assist gas.

Product Highlights

- Internal Perma-Cyl top fill float assembly for single-hose auto shut off with the Orca unit
- Rugged internal support system allows full mobility when unit is full of product
- High flow external aluminum vaporizer and pressure builder system provides up to 2000 SCFH at 420 to 450 psig
- Metal pallet incorporates forklift slots and crane lifting lugs while protecting plumbing and tank during transportation and application use
- Pallet has durable exterior coating for maximum corrosion resistance

Product Manual

This product manual describes the specifications, installation, operation and maintenance of the Perma-Cyl 450 ZX VHP model. Included within this manual is information regarding the safe operation and handling of liquid nitrogen, argon, oxygen and carbon dioxide within the cylinder. It should be thoroughly read and understood by anyone that operates the equipment. If there are any questions regarding the operation of the Perma-Cyl 450 ZX VHP, contact Chart Technical Service at 800-400-4683.

The schematic, piping illustrations and parts list in the Specifications section show a reference number for each component used on the cylinders. The reference numbers will be used throughout this manual to draw specific attention to a component while describing its function, operation, or repair.

The safety requirements for operating the tank and handling or transporting extremely cold liquid products are shown in the Safety section. Use this safety section as a “Safety Checklist” each time the equipment is being used.

The Introduction section discusses the general design of the tank and outlines the responsibilities of the distributor and the filler of the tank. Information on handling the tank and shipping is also included in this section.

In the Operation section there is information on the initial inspection, purging the tank, filling the tank, and gas and liquid withdrawal. This section also includes fill weights and calibration charts.

The Troubleshooting section contains a table of issues and remedies that may arise in the use of the Perma-Cyl 450 ZX VHP.

Please refer to the Maintenance section for general maintenance instructions and identification of various parts on the Perma-Cyl 450 ZX VHP.

Terms

Throughout this manual safety precautions will be designated as follows:

Warning! Description of a condition that can result in personal injury or death.

Caution! Description of a condition that can result in equipment or component damage.

Note: *A statement that contains information that is important enough to emphasize or repeat.*

Acronyms / Abbreviations

The following acronyms / abbreviations are used throughout this manual:

Ar	Argon
ASME	American Society of Mechanical Engineers
BAR	Pressure (Metric)
CGA	Compressed Gas Association
CO_2	Carbon Dioxide
DOT	Department of Transportation
FPT	Female Pipe Thread
H_2O	Water
Kg	Kilogram
LAR	Liquid Argon
LIN	Liquid Nitrogen
LOX	Liquid Oxygen
M^3	Cubic Meters
MPT	Male Pipe Thread
N_2	Nitrogen
N_2O	Nitrous Oxide
NFPA	National Fire Protection Association
O_2	Oxygen
ODT	Outside Diameter Tubing
PB	Pressure Builder
PN	Part Number
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch (Gauge)
SCFH	Standard Cubic Feet/Hour

Safety

General

While Chart equipment is designed and built to the most rigid standards, no piece of mechanical equipment can ever be made 100% foolproof. Strict compliance with proper safety and handling practices are necessary when using a cryogenic manifold device or other compressed gas equipment. We recommend that all of our customers re-emphasize safety and safe handling practices to all their employees and customers. While every possible safety feature has been designed into the Perma-Cyl 450 ZX VHP and safe operations are anticipated, it is essential that the customer carefully read and fully understand all Warning and Caution notes listed below.

Warning! ***Excess accumulation of oxygen creates an oxygen enriched atmosphere (defined by the Compressed Gas Association as an oxygen concentration above 23 percent). In oxygen enriched atmospheres flammable items burn vigorously and could explode. Certain items considered noncombustible in air may burn rapidly in such an environment. Keep all organic materials and other flammable substances away from possible contact with oxygen; particularly oil, grease, kerosene, cloth, wood, paint, tar, coal, dust and dirt which may contain oil or grease. DO NOT permit smoking or open flames in any area where oxygen is stored, handled or used. Failure to comply with this warning may result in personal injury.***

Warning! ***Nitrogen and argon vapors in air may dilute the concentration of oxygen necessary to support or sustain life. Exposure to such an oxygen deficient atmosphere can lead to unconsciousness and serious injury, including death.***

Warning! ***Before removing cylinder parts or fittings, completely empty the liquid cylinder of liquid and release the entire vapor pressure in a safe manner. External valves and fittings can become extremely cold and may cause painful burns to personnel unless properly protected. Personnel must wear protective gloves and eye protection whenever removing parts or loosening fittings. Failure to do so may result in personal injury because of the extreme cold and pressure in the cylinder.***

Caution! ***Only use replacement equipment which is compatible with liquid oxygen and has been cleaned for oxygen use. Do not use regulators, fittings, hoses, etc., which have been previously used in compressed air service. Failure to comply with these instructions may result in serious damage to the liquid cylinder and personal injury.***

Caution! ***The Perma-Cyl 450 ZX VHP should be moved using a fork truck that lifts the cylinders from beneath the pallet. The Perma-Cyl 450 ZX VHP must be used and stored in a vertical position. Do not lay, store, or ship a liquid cylinder on its side. Failure to comply with these procedures may result in damage to the liquid cylinder.***

Safety Bulletin

Portions of the following information are extracted from Safety Bulletin SB-2 from the Compressed Gas Association, Inc. Additional information on oxygen, nitrogen, argon, and cryogenics is available from the CGA (www.cganet.com).

Cryogenic containers, stationary or portable, are from time to time subjected to assorted environmental conditions of an unforeseen nature. This safety bulletin is intended to call attention to the fact that whenever a cryogenic container is involved in any incident whereby the container or its safety devices are damaged, good safety practices must be followed. The same holds true whenever the integrity or function of a container is suspected of abnormal operation.

Incidents which require that such practices be followed include: highway accidents, immersion of a container in water, exposure to extreme heat or fire, and exposure to most adverse weather conditions (earthquake, tornadoes, etc.). Under no circumstances should a damaged container be left with product in it for an extended period of time.

Prior to reusing a damaged container, the unit must be tested, evaluated, and repaired as necessary. It is highly recommended that any damaged container be returned to Chart for repair and re-certification.

In the event of known or suspected container vacuum problems (even if extraordinary circumstances such as those noted above have not occurred), do not continue to use the unit. Continued use of a cryogenic container that has a vacuum problem can lead to embrittlement and cracking.

The remainder of this safety bulletin addresses those adverse environments that may be encountered when a cryogenic container has been severely damaged. These are oxygen deficient atmospheres, oxygen enriched atmospheres, and exposure to inert gases.

Caution! Before locating oxygen equipment, become familiar with the NFPA standard No. 55 "Compressed Gases and Cryogenic Fluids Code" (www.nfpa.org) and with all local safety codes.

Oxygen Deficient Atmospheres

Warning! Nitrogen and argon vapors in air may dilute the concentration of oxygen necessary to support or sustain life. Exposure to such an oxygen deficient atmosphere can lead to unconsciousness and serious injury, including death.

The normal oxygen content of air is approximately 21%. Depletion of oxygen content in air, either by combustion or by displacement with inert gas, is a potential hazard and users should exercise suitable precautions.

One aspect of this possible hazard is the response of humans when exposed to an atmosphere containing only 8 to 12% oxygen. In this environment, unconsciousness can be immediate with virtually no warning.

When the oxygen content of air is reduced to about 15 to 16%, the flame of ordinary combustible materials, including those commonly used as fuel for heat or light, may be extinguished. Somewhat below this concentration, an individual breathing the air is mentally incapable of diagnosing the situation because the onset of symptoms such as sleepiness, fatigue, lassitude, loss of coordination, errors in judgment and confusion can be masked by a state of "euphoria," leaving the victim with a false sense of security and well being.

Human exposure to atmosphere containing 12% or less oxygen leads to rapid unconsciousness. Unconsciousness can occur so rapidly that the user is rendered essentially helpless. This can occur if the condition is reached by an immediate change of environment, or through the gradual depletion of oxygen.

Most individuals working in or around oxygen deficient atmospheres rely on the "buddy system" for protection - obviously the "buddy" is equally susceptible to asphyxiation if he or she enters the area to assist the unconscious partner unless equipped with a portable air supply. Best protection is obtainable by equipping all individuals with a portable supply of respirable air. Life lines are acceptable only if the area is essentially free of obstructions and individuals can assist one another without constraint.

If an oxygen deficient atmosphere is suspected or known to exist:

1. Use the "buddy system." Use more than one "buddy" if necessary to move a fellow worker in an emergency.
2. Both the worker and "buddy" should be equipped with self-contained or airline breathing equipment.

Oxygen Cleaning

When replacing components, only use parts which are considered compatible with liquid oxygen and have been properly cleaned for oxygen service (Refer to CGA Bulletin G-4.1 "Equipment Cleaned for Oxygen Service"). Do not use regulators, fittings, or hoses which were previously used in a compressed air environment on these tanks. Only oxygen compatible sealants or Teflon tape should be used on threaded fittings. All new piping joints should be leak tested with an oxygen compatible leak-test solution.

Oxygen Enriched Atmospheres

An oxygen-enriched atmosphere occurs whenever the normal oxygen content of air is allowed to rise above 23%. While oxygen is nonflammable, ignition of combustible materials can occur more readily in an oxygen-rich atmosphere than in air; and combustion proceeds at a faster rate although no more heat is released.

It is important to locate an oxygen system in a well ventilated location since oxygen-rich atmospheres may collect temporarily in confined areas during the functioning of a safety relief device or leakage from the system.

Oxygen system components, including but not limited to, containers, valves, valve seats, lubricants, fittings, gaskets and interconnecting equipment including hoses, shall have adequate compatibility with oxygen under the conditions of temperature and pressure to which the components may be exposed in the containment and use of oxygen. Easily ignitable materials shall be avoided unless they are parts of equipment or systems that are approved, listed, or proven suitable by tests or by past experience.

Compatibility involves both combustibility and ease of ignition. Materials that burn in air may burn violently in pure oxygen at normal pressure, and explosively in pressurized oxygen. In addition, many materials that do not burn in air may do so in pure oxygen, particularly when under pressure. Metals for containers and piping must be carefully selected, depending on service conditions. The various steels are acceptable for many applications, but some service conditions may call for other materials (usually copper or its alloy) because of their greater resistance to ignition and lower rate of combustion.

Similarly, materials that can be ignited in air have lower ignition energies in oxygen. Many such materials may be ignited by friction at a valve seat or stem packing, or by adiabatic compression produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

Warning! ***If clothing should be splashed with liquid oxygen it will become highly flammable and easily ignited while concentrated oxygen remains. Such clothing must be aired out immediately, removing the clothing if possible, and should not be considered safe for at least 30 minutes.***

Nitrogen and Argon

Nitrogen and argon (inert gases) are simple asphyxiates. Neither gas will support or sustain life and can produce immediate hazardous conditions through the displacement of oxygen. Under high pressure these gases may produce narcosis even though an adequate oxygen supply sufficient for life is present.

Nitrogen and argon vapors in air dilute the concentration of oxygen necessary to support or sustain life. Inhalation of high concentrations of these gases can cause anoxia, resulting in dizziness, nausea, vomiting, or unconsciousness and possibly death. Individuals should be prohibited from entering areas where the oxygen content is below 19% unless equipped with a self-contained breathing apparatus. Unconsciousness and death may occur with virtually no warning if the oxygen concentration is below approximately 8%. Contact with cold nitrogen or argon gas or liquid can cause cryogenic (extreme low temperature) burns and freeze body tissue.

Persons suffering from lack of oxygen should be immediately moved to areas with normal atmospheres. SELF-CONTAINED BREATHING APPARATUS MAY BE REQUIRED TO PREVENT ASPHYXIATION OF RESCUE WORKERS. Assisted respiration and supplemental oxygen should be given if the victim is not breathing. If cryogenic liquid or cold boil-off gas contacts worker's skin or eyes, the affected tissue should be flooded or soaked with tepid water (105-115ºF or 41-46ºC). DO NOT USE HOT WATER. Cryogenic burns that result in blistering or deeper tissue freezing should be examined promptly by a physician.

Introduction

Tank Design

The Perma-Cyl 450 ZX VHP is a vacuum insulated cylinder that was designed to furnish liquid and gaseous oxygen, nitrogen, argon or CO_2 on a reliable, economical basis. The tank holds 450 liters of cryogenic product. The tank is pressure rated at 500 psig. This 450 liter tank DOES NOT have an internal pressure builder or internal vaporizer.

The insulation system is comprised of multiple layers of foil and paper that are incorporated with a very low vacuum. The vacuum is factory sealed and with the aid of internal molecular sieve it should remain low for the life of the container. This insulation system coupled with design of the support system minimizes the pressure rise when the tank is left idle. If the container is left unused for a period of time the pressure will build to the safety relief valve setting. However, if the container is used in gas withdrawal service after pressure has built, the economizer system will automatically reduce the head pressure in the container without loss of product.

The design and construction of the Perma-Cyl 450 ZX VHP is aimed at building the most durable tank available today. The inner vessel is constructed of stainless steel and designed to the applicable pressure vessel code. The outer container is constructed of stainless steel to make the Perma-Cyl 450 ZX VHP a maintenance free container. The unit is mounted in a hot dipped galvanized carbon steel pallet.

The inner pressure vessel is protected from over-pressurization by a safety relief valve. The Perma-Cyl 450 ZX VHP pressure is set at 500 psig with a rupture disc set at 700 psig. The outer container of vacuum space is protected by a reverse buckling rupture disc that is set at a maximum of 25 psig.

System Design

The Perma-Cyl 450 ZX VHP is the newest addition to the Perma-Cyl family of liquid cylinders, designed for high pressure, high flow industrial gas applications. With the on-board, heat-exchanger system, the Perma-Cyl 450 ZX VHP is rated at a flow rate of 2000 SCFH while sustaining 420 to 450 psig. Flows over 2000 SCFH can be achieved with reduced duty cycles and added vaporization.

The Perma-Cyl 450 ZX VHP is contained completely within a 42" deep x 34" wide x 73.8" high pallet. The pallet system can be moved by fork truck or lifted by the lugs at the top of the pallet. The portable design makes it a quick-response solution for demanding industrial gas applications, such as industrial laser-assist gas.

The piping uses industry proven valves and components. The operation of the system is simple and is modeled after a standard liquid cylinder.

Responsibilities

Chart is stating below the responsibilities of the Distributor and the Filler of the Perma-Cyl 450 ZX VHP.

1. The cylinder must be in safe condition.

   The filler is responsible for confirming that the Perma-Cyl 450 ZX VHP to be filled is in its proper working condition. This includes:

   - It has an acceptable vacuum
   - The relief system is in place and functioning
   - There is no structural damage to the cylinder
   - All warning labels are in place and legible

2. Do not overfill.

   The Perma-Cyl 450 ZX VHP is not to be filled beyond the recommended filling limits described in this manual.

3. Dispense only to knowledgeable users.

   The filler must determine that the user is knowledgeable about the general characteristics of the product and proper safety precautions for its use. Do not allow customers to fill their own cylinders.

4. Dispose of cylinders properly.

   To eliminate the risk of injury from the improper reuse of cryogenic (vacuum jacketed) cylinders, before disposal, destroy the cylinder's pressure retaining capability.

   We Recommend:

   - Purge the cylinder's contents.
   - Drill multiple holes through the cylinder and its vacuum casing or otherwise puncture the tank. Make sure this is done before the scrap dealer takes possession.

Handling the Perma-Cyl 450 ZX VHP

The Perma-Cyl 450 ZX VHP is mounted on a hot dipped galvanized carbon steel pallet. The preferred handling method is a forklift that lifts the pallet-mounted tank from beneath the pallet. However, overhead lifting by using lugs located on the top of the pallet or on top of the cylinder is permitted. Lifting of the Perma-Cyl 450 ZX VHP should be performed only with equipment rated for the weight of the cylinder, pallet and contents combined (see Specifications section of this manual).

This container should remain upright at all times. Never lay the unit on its side to move or transport it. Careless handling can cause damage to the support system and internal plumbing, which may result in serious personal injury.

Shipping the Perma-Cyl 450 ZX VHP

The transportation of the Perma-Cyl 450 ZX VHP is permitted at pressures up to the relief valve setting. The inner vessel is coded per DOT 4L.

The transportation of the Perma-Cyl 450 ZX VHP is permitted at pressures less than 25.3 psig. The inner vessel of these models are coded for ASME.

Operation

Initial Inspections

When the container is first received it should be inspected for shipping damage. Never fill a damaged container.

The Perma-Cyl 450 ZX VHP is shipped with low purity nitrogen gas. For this reason any container that is to be put into oxygen or argon service should be thoroughly purged with the applicable gas.

Purging the Perma-Cyl 450 ZX VHP

Before any operation that involves pressure or handling of cryogenic fluids, be sure that all safety precautions are taken. Review the Safety section of this manual.

The Perma-Cyl 450 ZX VHP system is designed to be used for liquid nitrogen, argon or oxygen service. Chart does not encourage unnecessary and frequent changing of service to the vessel. However, if it is necessary to make a service change or to remove any moisture or foreign material from the tank and tank lines, the vessel must be purged to ensure product purity.

Note: *To prevent drawing atmospheric contaminants back into the tank, a positive pressure of at least 5 psig must be maintained in the tank.*

Caution! While purging through the various lines, observe the tank pressure indicating gauge. Make sure that the pressure does not go below 5 psig.

Warning! Protective eyeglasses and gloves must be worn.

1. Attach the source of liquid or gas purge product to the Fill Line.
2. Open the source tank feed valve and the Perma-Cyl 450 ZX VHP Fill Valve allowing liquid or gas to flow slowly into the tank. Build pressure to over 100 psi.

Note: *Build pressure by repeating steps 1 and 2, when the pressure drops below 20 psi.*

3. Close the Perma-Cyl 450 ZX VHP Fill Valve and close the source tank feed valve. Purge the trapped space by opening the Fill Line Drain.
4. With the Perma-Cyl 450 ZX VHP Fill Valve closed, open the Gas Use Valve. Purge for one minute. Close the Gas Use Valve.
5. With the PB Feed Valve closed, crack the compression fitting on the downstream side of the PB Feed Valve. Purge for one minute. Tighten the compression fitting.
6. Vent the tank by opening the Vent Valve. Close the Vent Valve when the tank is approximately 20 psig.
7. Repeat steps 1 through 6 three times.
8. After purge is complete, check gas in tank for purity. If gas does not meet the purity standard, repeat the above procedure.

Purging the Perma-Cyl 450 ZX VHP with a Vacuum Pump

Before any operation that involves pressure or handling of cryogenic fluids, be sure that all safety precautions are taken. Review the Safety section of this manual.

1. Open the vent valve to remove any pressure that has built in the inner vessel.
2. Open the pressure building valve to boil away any cryogenic liquid that remains in the vessel.
3. After the liquid has been boiled away and the outside of the container shows no frost, close the pressure building valve.
4. Warm the inner vessel with warm nitrogen gas through the liquid valve. Check the gas temperature as it escapes through the open vent valve.
5. Close the liquid valve, gas use and pressure building valves.
6. Attach a vacuum pump to the vent valve and evacuate the inner vessel to 26 inches of mercury.
7. Break the vacuum to 5 psig with high purity gas, either nitrogen, argon or oxygen, as required by the service of the container.
8. Repeat steps 6 and 7 twice.
9. Close all valves and remove the vacuum and gas purge lines. The container is now ready for filling.

Filling Procedures

The Perma-Cyl 450 ZX VHP may be filled with liquid from a liquid supply unit either by a pressure or a pumping transfer. If internal pressure of the cylinder is at least 20 psi less than the maximum allowable pressure of the delivery unit, liquid may be transferred by a pressure transfer. If the normal working pressure of the cylinder is equal to or greater than the maximum allowable pressure of the supply unit, liquid must be pumped into the tank.

Before filling the cylinder it should be visually inspected for possible damage or unsuitability for intended use. If damage is detected (e.g., serious dents, loose fittings, etc.), remove the unit from service and conduct the necessary repairs as soon as possible.

The Perma-Cyl 450 ZX VHP is regulated by the US DOT/ Transport Canada for transporting liquid oxygen, nitrogen or argon. The filling of these liquid cylinders must be done by product weight. This will allow enough gas space above the liquid to keep the Perma-Cyl 450 ZX VHP from becoming liquid full if its pressure rises to the relief valve settings. The filling weight table indicates the correct product weight for the various relief valve settings. The relief valve setting for the Perma-Cyl 450 ZX VHP is 500 psig. The steps below will show the proper way to use the filling weight table.

1. Sample the residual gas that is in the Perma-Cyl 450 ZX VHP. Purge the cylinder if necessary to insure the proper purity.
2. Place the Perma-Cyl 450 ZX VHP on the filling scale. Record the weight. Compare this weight to the registered tare weight on the data plate. The difference is the weight of the residual gas.
3. Connect the transfer hose to the liquid valve. Record the weight. The difference between this weight and the initial weight is the weight of the transfer hose.
4. To determine the total filling weight add the tare weight of the Perma-Cyl 450 ZX VHP, the hose weight and the proper filling weight from the table in this section. The table indicates the product across the top and the relief pressure down the side. Connect the two columns to find the proper weight.
5. Open the cylinders vent and liquid valves. Open the transfer line shut-off valve to begin the flow of product.
6. When the scale reads the calculated total filling weight turn off the liquid valve on the cylinder. Close the vent valve.
7. Close the transfer line shut-off valve and relieve the pressure in the transfer line. Remove the transfer line. Remove the cylinder from the scale.

Gas Withdrawal

The Perma-Cyl 450 ZX VHP will deliver gas at various flow rates and temperatures for different applications. The flow rate is controlled by the equipment which is being supplied gas from the Perma-Cyl 450 ZX VHP. The continuous flow rate indicates the flow rate that will normally provide gas at a reasonable temperature and should not be exceeded. Higher flow rates may provide very cold gas that could damage the equipment that they are attached to. To supply gaseous product follow this step by step procedure.

1. Connect the proper regulator to the liquid cylinders gas use outlet.
2. Connect the proper tubing or hose between the final line regulator and the receiving equipment.
3. Open the pressure building valve.
4. Allow pressure to build to the operating pressure (450 psig).
5. Open the gas use valve.
6. Adjust the gas use regulator for the proper delivery pressure.
7. When the gas delivery is completed, close all valves.

Caution! All valves on an empty Perma-Cyl 450 ZX VHP should always be kept closed to protect the inner vessel and plumbing from being contaminated.

The operator should review the safety precautions found in the Safety section of this manual before conducting a gas or liquid withdrawal operation. Safety glasses and gloves should always be worn.

At flow rates up to 2000 SCFH (duty cycle dependent) the Perma-Cyl 450 ZX VHP is capable of delivering warm gas through the line regulator. As the flow rate increases the temperature of the gas decreases. If the cold temperature becomes a problem at a desired flow rate, an external vaporizer can be added. Attach this vaporizer directly in series with the gas use connection and place the line regulator at the exit of the vaporizer.

Caution! Pressure should be allowed to escape from the transfer hose before it is completely removed. A hose drain and relief valve should be installed in all transfer lines.

Liquid Withdrawal into Liquid Cylinders

The Perma-Cyl 450 ZX VHP can be used to dispense liquid through the Liquid Feed/Withdrawal line.

1. Vent the receiving tank below the initial pressure of the Perma-Cyl 450 ZX VHP.
2. Confirm that the PB Feed Valve on the receiving tank is closed.
3. Note the receiving tanks relief valve setting.
4. Open the PB Feed Valve on the Perma-Cyl 450 ZX VHP.
5. If the receiving tanks relief valve setting is less than the Perma-Cyl 450 ZX VHP, close the PB valve at the receiving tanks relief valve setting.
6. Attach the transfer hose.
7. Initiate the transfer of liquid by slowly opening the liquid valves.
8. Open the vent of the receiving tank to minimize pressure rise.
9. If the receiving tanks relief valve setting was less than the Perma-Cyl 450 ZX VHP, open the PB Feed Valve on the Perma-Cyl 450 ZX VHP to maintain pressure at the relief valve.
10. When the tank is full, close the Feed/Withdrawal valve on the Perma-Cyl 450 ZX VHP.
11. Crack open the end of the hose to allow the hose to vent and open the receiving tanks liquid valve.

Liquid Withdrawal into Open Dewars

The Perma-Cyl 450 ZX VHP can fill open Dewars. To prevent excessive flashing of liquid, start the delivery with cold liquid.

1. Vent the Perma-Cyl 450 ZX VHP to less than 20 psig.
2. Open the PB Feed Valve build pressure to 50 psig.
3. Connect the transfer hose with the phase separator on the Perma-Cyl 450 ZX VHP Liquid Feed/Withdrawal line.
4. Slowly open the Liquid Feed/Withdrawal line dispensing the liquid into the open dewar.
5. Throttle the feed valve to minimize splashing and flashing.
6. Close the feed valve when the dewar is full.

Liquid Withdrawal into Perma-Cyl Liquid Cylinders

The Perma-Cyl 450 ZX VHP can be used to dispense liquid into a fill line of the Perma-Cyl (top fill). Flow rates of 10-15 gallons/minute can be achieved. Because of the pressure rating of the Perma-Cyl 450 ZX VHP special caution should be taken when dispensing into cylinders rated at lower pressures.

1. Vent the receiving tank below the initial pressure of the Perma-Cyl 450 ZX VHP.
2. Confirm that the PB Feed Valve on the receiving tank is closed.
3. Note the receiving tanks relief valve setting.
4. Open the PB Feed Valve on the Perma-Cyl 450 ZX VHP.
5. If the receiving tanks relief valve setting is less than the Perma-Cyl 450 ZX VHP, close the PB valve at the receiving tanks relief valve setting.
6. Attach the transfer hose to the fill line of the Perma-Cyl Cylinder.
7. Initiate the transfer of liquid by slowly opening the liquid valve on the Perma-Cyl 450 ZX VHP.
8. Open the vent of the receiving tank only if the pressure is well above the initial pressure of the Perma-Cyl 450 ZX VHP.
9. If the receiving tanks relief valve setting was less than the Perma-Cyl 450 ZX VHP, open the PB Feed valve on the Perma-Cyl 450 ZX VHP to maintain pressure at the relief valve.
10. A pressure spike or an audible sound (float closing) will occur when the tank is full, close the Feed/Withdrawal valve on the Perma-Cyl 450 ZX VHP.
11. Crack open the end of the hose to allow the hose to vent.
12. Remove the hose when the hose has safely vented.

Caution! The container can become contaminated once it is emptied, if the liquid and vent valves are not closed.

Fill Weights

The contents of the Perma-Cyl 450 ZX VHP can be determined by means of a differential pressure gauge, calibrated in inches of water column, which is mounted to the left front gauge bracket. The calibration charts on the following pages show contents conversions for O_2, N_2, Ar, CO_2, and N_2O.

Filling Weight Table					
Relief Valve Setting	Argon	Nitrogen	Oxygen	Carbon Dioxide	Nitrous Oxide
PSIG	LBS	LBS	LBS	LBS	LBS
0 to 45	1316	752	1069	--	--
46 to 75	1287	732	1039	--	--
76 to 105	1257	712	1019	1069	1029
106 to 170	1207	693	990	1039	1000
171 to 230	1178	683	970	1029	980
231 to 295	1138	673	950	1009	960
296 to 360	1118	643	921	990	941
361 to 450	1099	603	900	970	920
**451 to 540	1059	574	871	910	861
BAR	KG	KG	KG	KG	KG
0 to 3.1	597	341	485	--	--
3.2 to 5.2	584	332	471	--	--
5.3 to 7.2	570	323	462	485	467
7.3 to 11.7	547	314	449	471	454
11.8 to 15.9	534	310	440	467	444
16.0 to 20.3	516	305	431	458	435
20.4 to 24.1	507	292	417	449	426
24.2 to 31.0	498	273	408	440	417
**31.1 to 37.2	480	260	395	413	390

**Normal factory setting.

Note: *Filling weights are shown as the maximum weight allowed by code. Their related volumes may vary with product density.*

Calibration Charts

Standard Calibration Chart															
Perma-Cyl 450 ZX VHP															
H_2O	Oxygen			Nitrogen			Argon			CO_2			N_2O		
IN	GAL	LB	CU FT	GAL	LB	CU FT	GAL	LB	CU FT	GAL	LB	CU FT	GAL	LB	CU FT
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1.0	10	120	2.0	14	187	0.7	8	80	0.9	9	83	0.9	9	79
4.0	3.8	36	437	6.9	47	645	2.6	31	297	3.4	35	303	3.1	33	289
6.0	7.7	73	882	13.1	89	122	5.5	64	615	7.0	70	616	6.4	68	591
8.0	12.0	115	1389	19.4	131	1811	8.9	103	996	11.1	112	978	10.2	109	946
10.0	16.6	158	1904	25.8	174	2400	12.5	145	1406	15.4	155	1351	14.3	151	1318
12.0	21.0	200	2420	32.1	217	2989	16.2	188	1819	19.6	197	1724	18.3	194	1689
14.0	25.5	243	2935	38.4	259	3578	19.8	231	2232	23.8	240	2097	22.3	237	2061
16.0	30.0	286	3451	44.7	302	4168	23.5	273	2645	28.1	283	2470	26.3	279	2433
18.0	34.5	328	3966	51.1	345	4756	27.2	316	3058	32.3	325	2842	30.3	322	2804
20.0	39.0	371	4481	57.4	387	5345	30.8	359	3471	36.6	368	3215	34.4	365	3176
22.0	43.4	414	4997	63.7	430	5934	34.5	401	3883	40.8	411	3588	38.4	407	3548
24.0	47.9	456	5512	70.0	473	6522	38.2	444	4296	45.1	453	3961	42.4	450	3919
26.0	52.4	499	6027	76.4	515	7111	41.8	487	4709	49.3	496	4334	46.4	493	4291
28.0	56.9	542	6543	82.7	558	7700	45.5	529	5122	53.5	539	4707	50.4	535	4662
30.0	61.3	584	7058	89.0	601	8289	49.2	572	5535	57.8	581	5080	54.5	578	5034
32.0	65.8	627	7573	95.3	643	8878	52.8	615	5947	62.0	624	5453	58.5	621	5406
34.0	70.3	670	8089	101.7	686	9467	56.5	657	6360	66.3	667	5826	62.5	663	5777
36.0	74.8	712	8604				60.2	700	6773	70.5	709	6199	66.5	706	6149
38.0	79.3	755	9120				63.9	743	7186	74.8	752	6572	70.5	749	6521
40.0	83.7	798	9635				67.5	785	7599	79.0	795	6945	74.6	791	6892
42.0	88.2	840	10150				71.2	828	8012	83.2	837	7318	78.6	834	7264
44.0	92.7	883	10666				74.9	871	8424	87.5	880	7690	82.6	877	7635
46.0	97.2	926	11181				78.5	913	8837	91.7	923	8063	86.6	919	8007
48.0	101.7	968	11696				82.2	956	9250	96.0	965	8436	90.6	962	8379
50.0							85.9	999	9663	100.2	1008	8809			
52.0							89.5	1041	10076						
54.0							93.2	1084	10489						
56.0							96.9	1127	10901						
58.0							100.5	1169	11314						

Metric Calibration Chart															
Perma-Cyl 450 ZX VHP															
H_2O	Oxygen			Nitrogen			Argon			CO_2			N_2O		
IN	Liters	KG	M^3	Liters	KG	M^3	Liters	KG	M^3	Liters	KG	M^3	Liters	KG	M^3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	4.0	5	3	7.6	6	5	2.7	4	2	3.6	4	2	3.2	4	2
4.0	14.4	16	12	26.2	21	18	10.0	14	8	13.0	16	9	11.8	15	8
6.0	29.0	33	25	49.7	40	35	20.7	29	17	26.5	32	17	24.2	31	17
8.0	45.7	52	39	73.6	60	51	33.5	47	28	42.1	51	28	38.8	49	27
10.0	62.7	72	54	97.6	79	68	47.3	66	40	58.2	70	38	54.0	69	37
12.0	79.6	91	69	121.5	98	85	61.2	85	52	74.2	89	49	69.2	88	48
14.0	96.6	110	83	145.4	118	101	75.1	105	63	90.3	109	59	84.4	107	58
16.0	113.5	130	98	169.4	137	118	89.0	124	75	106.3	128	70	99.6	127	69
18.0	130.5	149	112	193.3	156	135	102.8	143	87	122.4	148	81	114.8	146	79
20.0	147.4	168	127	217.2	176	151	116.7	163	98	138.4	167	91	130.0	165	90
22.0	164.4	188	142	241.2	195	168	130.6	182	110	154.5	186	102	145.3	185	100
24.0	181.3	207	156	265.1	214	185	144.5	201	122	170.5	206	112	160.5	204	111
26.0	198.3	226	171	289.0	234	201	158.4	221	133	186.6	225	123	175.7	223	122
28.0	215.2	246	185	313.0	253	218	172.3	240	145	202.7	244	133	190.9	243	132
30.0	232.2	265	200	336.9	272	235	186.1	259	157	218.7	264	144	206.1	262	143
32.0	249.2	284	214	360.8	292	251	200.0	279	168	234.8	283	154	221.3	282	153
34.0	266.1	304	229	384.8	311	268	213.9	298	180	250.8	302	165	236.5	301	164
36.0	283.1	323	244				227.8	318	192	266.9	322	176	251.8	320	174
38.0	300.0	343	258				241.7	337	204	282.9	341	186	267.0	340	185
40.0	317.0	362	273				255.6	356	215	299.0	360	197	282.2	359	195
42.0	333.9	381	287				269.5	376	227	315.0	380	207	297.4	378	206
44.0	350.9	401	302				283.3	395	239	331.1	399	218	312.6	398	216
46.0	367.8	420	317				297.2	414	250	347.2	419	228	327.8	417	227
48.0	384.8	439	331				311.1	434	262	363.2	438	239	343.1	436	237
50.0							325.0	453	274	379.3	457	249			
52.0							338.9	472	285						
54.0							352.8	492	297						
56.0							366.6	511	309						
58.0							380.5	530	320						

Troubleshooting

The following table is arranged in a Trouble/Probable Cause/Remedy format. The probable causes for specific problems are listed in descending order of significance. That is, check out the first cause listed before proceeding to the next.

Trouble	Probable Cause	Remedy
Perma-Cyl 450 ZX VHP builds excessive pressure.	Low usage.	If daily usage is under 100 SCF, the cylinder will build pressure. In liquid service, the cylinder should be equipped with low pressure relief valve and regulator.
	Cylinder is over filled.	If the cylinder is filled past the vent trycock or past the DOT specified fill weight, the pressure may rise rapidly after a fill.
	Pressure building regulator is set improperly or leaks.	If the pressure builds and stays at a pressure higher than desired, adjust the pressure building regulator to a new setting. If the pressure builds to the relief valve setting replace the regulators.
	Vacuum is deteriorating.	This can be accompanied by cold or frost occurring evenly over the cylinder surface. Refer to the troubleshooting section on frost.
Perma-Cyl 450 ZX VHP pressure is too low.	Pressure building regulator is set too low.	Adjust the regulator as described in the Maintenance section of this manual.
	Pressure building regulator is not opening properly.	Bench test the regulator for full flow at the set pressure as described in the Maintenance section of this manual.
	Economizer regulator is set below the pressure building regulator setting.	The economizer regulator must be set 15-25 psi greater than the pressure building regulator as described in the Maintenance section of this manual.
	Usage is too high.	Refer to the Specifications section for the maximum recommended delivery rates.
	Cylinder is leaking.	Check for frost on lines or on top of head. Listen for hissing, soap test joints for leaks. Isolate leak and call Chart for repair details.
Frost occurs on head or knuckle.	Residual frost remains from last fill or recent product use.	This is normal. Ice may remain for days after a fill or heavy use.
Frost occurs evenly over the cylinder surface.	The gas withdrawal rate is high. Both the PB and gas use vaporizers are frosted.	This is normal.
	Cylinder has lost vacuum	This is accompanied by high rate of pressure rise or high loss rate. Call Chart for return instructions.
Miscellaneous frost spots on cylinder.	Cylinder may have internal damage.	Call Chart for evaluation or repair/return instructions.
Delivery gas is too cold.	Rate exceeds recommended delivery rate.	Refer to the Specifications section for recommended maximum delivery rates.
In liquid delivery, liquid is mixed with high amount of gas.	Cylinder pressure is higher than optimum for liquid withdrawal.	Reset the cylinder pressure for liquid use. Also, use a phase separator on the end of the transfer hose.
In CO_2 service, cylinder does not deliver product properly.	Possible dry ice blocks have formed in system.	Pressure the cylinder to 100 psi or above to re-liquefy from CO_2 dry ice.

Maintenance

Adjusting Regulator Pressure Ranges

Use the following procedure to change the pressure range for either the pressure building or economizer regulator.

1. Remove the liquid product from the cylinder. Vent the cylinder of all pressure.
2. Remove the regulator from the cylinder.
3. Place the regulator body in a vise with the bonnet and adjusting screw pointed up.
4. Back out the adjusting screw until there is no spring pressure on it.
5. Carefully remove the spring.
6. Replace the spring and reassemble.
7. Bench set the regulator as shown in this section.

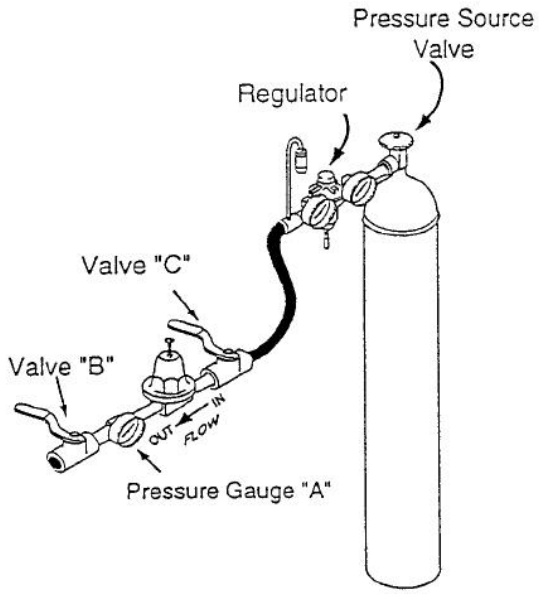


Figure 1 - Pressure Building Regulator

Alternate Regulator Springs			
Pressure Builder		Economizer	
Pressure (PSI)	Spring PN	Pressure (PSI)	Spring PN
2-25	57-1003-1	0-30	57-1024-1
15-65	57-1019-1	30-50	57-1021-1
40-100	57-1011-1	51-80	57-1015-1
100-250	57-1020-1	81-150	57-1016-1
		151-250	57-1034-1
		251-400	57-1030-1

Bench Setting a Pressure Building Regulator

1. Connect the pressure building regulator to a nitrogen pressure source as shown in the Figure 1.
2. Close Valve B.
3. Open pressure source valve (follow appropriate safety rules).
4. Open Valve C slowly.
5. Pressure Gauge A will indicate the pressure to which the regulator has been set. The pressure can be increased by turning the adjusting screw in or decreased by turning the screw out; however, after each adjustment outward it will be necessary to open and then close Valve B to relieve excess pressure.
6. This procedure may be repeated as many times as necessary to obtain the proper setting.
7. After the proper setting is obtained, secure the lock nut on the adjusting screw.

Note: *Factory setting is 450 psig.*

Bench Setting an Economizer Regulator

1. Connect the inlet of the economizer regulator to a pressure source as shown in the Figure 1.
2. Open the valve at the pressure source (follow appropriate safety rules).
3. Slowly open Valve B just enough to allow some gas to escape.
4. Pressure Gauge A will indicate the setting to which the economizer regulator is set. This setting may be increased by turning the adjusting screw in, or lowered by turning the adjusting screw out.
5. Gas will flow through the economizer regulator when the pressure of the gas reaches the pre-set setting.

Note: *Factory setting is 450 psig.*

Procedure for Adjusting Combo Pressure Building/Economizer Regulator

1. Connect the combo regulator to a pressure source as shown in Figure 2.
2. Close valve #2.
3. Open the pressure source valve (follow the appropriate safety rules).
4. Open valve #1 slowly.
5. Pressure Gauge "A" will indicate the pressure to which the regulator has been set. The pressure can be increased by turning the adjusting screw in or decreased by turning the adjusting screw out. However, after each adjustment outward it will be necessary to open and then close Valve #2 to relieve excess pressure.
6. This procedure may be repeated as many times as necessary to obtain the proper setting.
7. After the proper setting is obtained, secure the lock nut on the adjusting screw.

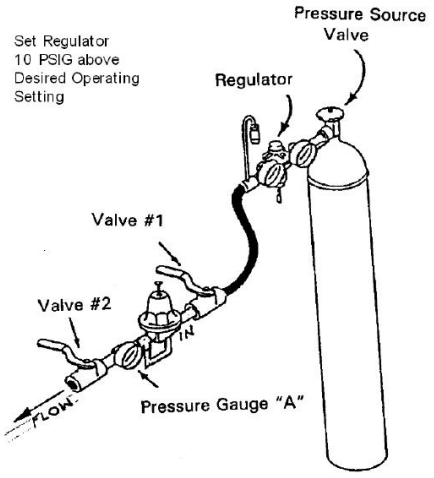


Figure 2 - Combo Regulator

Rebuilding the Operational Valves

When a defective valve is suspected, follow this procedure to repair it. Refer to Figure 3 for identification of parts.

1. Open the valve and release any pressure that is in the container.
2. If the valve to be repaired is the vent valve, allow it to warm up before it is disassembled.
3. If the valve to be repaired is the pressure building valve, the container should be emptied of product and pressure.
4. Remove the valve handle screw (item 3), washer (item 14), retainer cap and spring assembly (items 2, 4, 8, 10 and 13).
5. Remove the valve handle (item 1) and Teflon thrust washer (item 7).
6. Unscrew bonnet (item 5) to remove stem (item 6) and stem seal.
7. Pick out body insert (item 12) and plug assembly (item 9).
8. Clean seat.
9. Replace parts as needed and reassemble in reverse order.

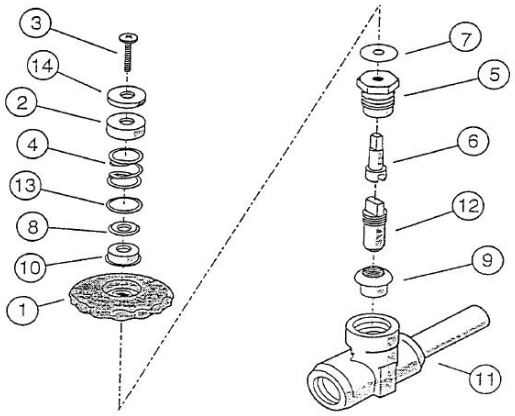


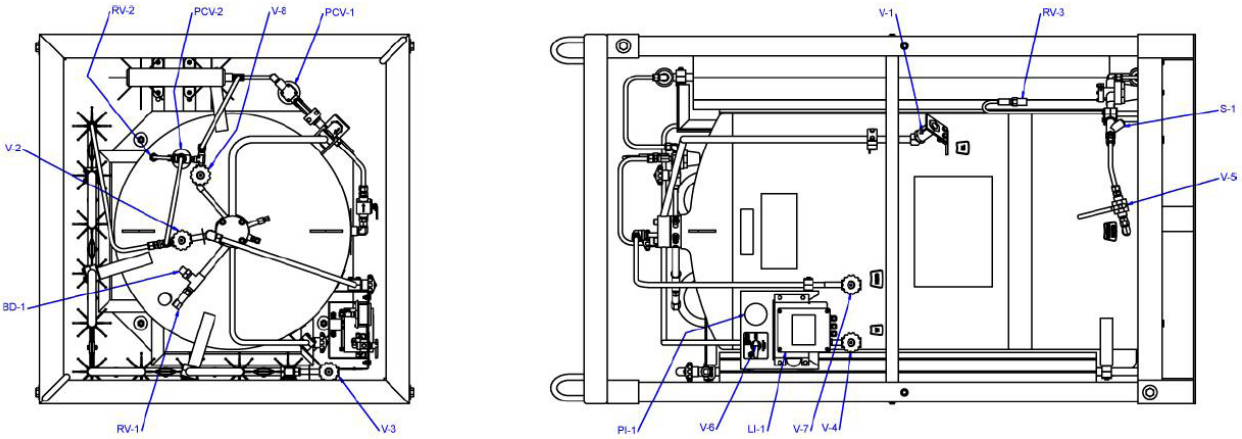
Figure 3 - Globe Valve Components

Item	PN	Qty	Spares*	Description
1	17-1078-9	1	1	Hand wheel
2	17-1086-9	1	1	Spring retainer
3	17-1084-9	1	1	Screw
4	17-1077-9	1	1	Spring
5	17-1081-9	1	1	Bonnet
6	17-1089-9	1	1	Stem
7	17-1088-9	1	1	Gasket
8	17-1087-9	2	2	Washer
9	17-1082-9	1	1	Threaded body insert
10	17-1076-9	1	1	Seal
11	--	--	--	Body assembly
12	17-1083-9	1	1	Seat and nipple assembly
13	17-1080-9	1	1	Washer
14	17-1085-9	1	1	Washer and screw
--	97-1575-9	--	1	Valve repair kit (includes items 1-14, except 11)

*Recommended spare parts

**Parts are also available in complete packages

Parts Identification



Item	PN	Qty	Description	Item	PN	Qty	Description
V-1	11051090	1	Check Valve - 1/2 FPT (Fill)	SK	4010542	2	Dust Cap - 1/2" ODT (Argon or Nitrogen)
V-2	11906060	1	Globe Valve - 3/8 FPT (Liquid Isolation)	SK	1110072	2	Male Connector - 1/2" ODT x 3/8" MPT (Argon or Nitrogen)
V-3	11905981	1	Globe Valve - 3/8 FPT (Gas Use)	SK	1110112	2	Male Connector - 5/8" ODT x 3/8" MPT (Oxygen)
V-4	11905956	1	Globe Valve - 3/8 FPT (Vent)	SK	4010022	1	Gas Outlet - 3/8" MPT x CGA-580 (Argon or Nitrogen)
V-5	1712202	1	Ball Valve - 1/2 FPT (Pressure Builder)	SK	4010012	1	Gas Outlet - 3/8" MPT CGA-540 (Oxygen)
V-6	11939013	1	5-Way Crossover Valve - (LL Gauge Isolation)	SK	4010562	1	Gas Outlet - CGA-320 (CO_2)
V-7	11906043	1	Globe Valve - 3/8 FPT (Liquid Level)	SK	4010602	2	Gas and Liquid Outlet - CGA-326 (N_2O)
V-8	11905999	1	Globe Valve - 1/4 FPT (Economizer Isolation)	SK	4010552	1	Dust Cap - CGA-580 (Argon or Nitrogen)
PCV-1	11635511	1	Regulator - 1/2 FPT set @ 450 PSI (Pressure Builder)	SK	3911206	1	Dust Cap - CGA-540 (Oxygen)
PCV-2	10619675	1	Regulator - 1/4 FPT set @ 475 PSI (Economizer)	SK	4010552	1	Dust Cap - CGA-320 (CO_2)
RV-1	11385111	1	Pressure Relief Valve (Main) - 1/2 MPT 500 PSI	SK	4010552	2	Dust Cap - CGA-326 (N_2O)
RV-2 RV-3	1812702	2	Pressure Relief Valve (Line) - 1/4 MPT 550 PSI		3811599	1	Metal Tag (Gas Use)
BD-1	11526622	1	Safety Rupture Disc - 1/2 MPT x 1/2 MPT (700 PSIG/48.3 BAR) 316SS Disc				
PI-1	13909811	1	Pressure Gauge - 1/8 MPT CBM (0-600 PSI)				
LI-1	13141662	1	Cyl-Tel® Liquid Level Gauge - 1/4 FPT				
S-1	11529090	1	Inline Wye Strainer - 1/2 FPT		11207779	1	Schematic 450 ZX

Specifications

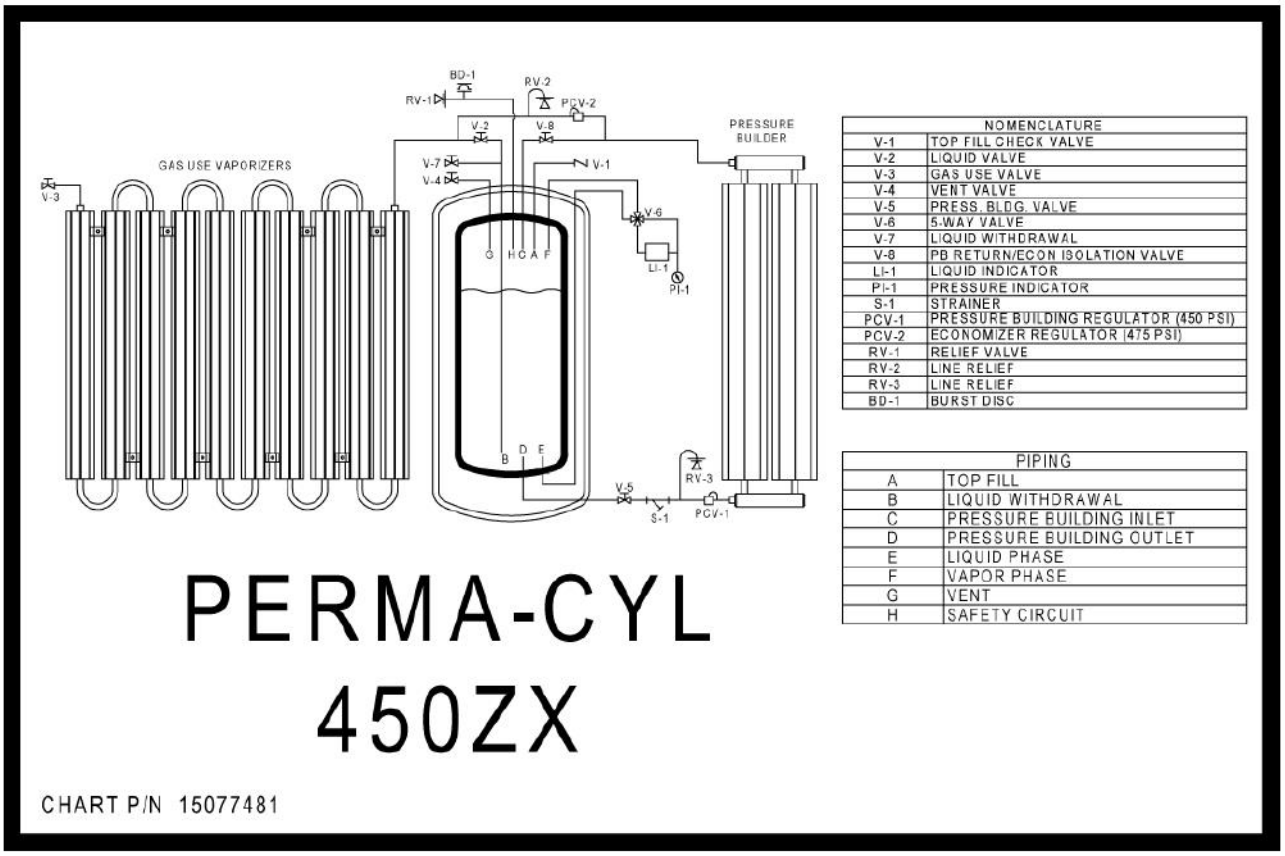
Capacity	
Liquid (Gross) (liters)	450
Liquid (Net) (liters)	420
Gas (LIN) ft^3 / Nm^3	7922 / 208.2
Gas (LOX) ft^3 / Nm^3	10,519 / 276.4
Gas (LAR) ft^3 / Nm^3	10,241 / 269.1
Gas (CO_2) ft^3 / Nm^3	7960 / 209.2
Gas (N_2O) ft^3 / Nm^3	7516 / 197.5
Performance	
NER (LIN) % per day	2.0
NER (LAR / LOX) % per day	1.25
NER (CO_2 / N_2O) % per day	0.5
Gas Flow (LIN / LAR / LOX)* SCFH / Nm^3 / hr	2000 / 52.6**
Gas Flow (CO_2 / N_2O)	665 / 17.5
Dimensions & Pressure Ratings	
Diameter (cylinder) in / cm	30 / 76.2
Height (cylinder) in / cm	61.3 / 155.7
Base Width (frame) in / cm	34 / 86.4
Base Depth (frame) in / cm	42 / 106.7
Base Height (frame) in / cm	73.8 / 187.5
Tare Weight lb / kg	1400 / 636***
Relief Valve Setting psig / barg	500 / 34.5
DOT Rating	4L412
Weight	
Tare lbs / kg	1450 / 660
Full Nitrogen lbs / kg	2253 / 1024
Full Oxygen lbs / kg	2583 / 1174
Full Argon lbs / kg	2834 / 1288

**At 450 psig sustained pressure.*

***Higher flows can be achieved with reduced duty cycles and/or additional vaporization.*

****Weights include tank and pallet, are approximate and vary with pallet design.*

Flow Diagram



NOMENCLATURE	
V-1	TOP FILL CHECK VALVE
V-2	LIQUID VALVE
V-3	GAS USE VALVE
V-4	VENT VALVE
V-5	PRESS. BLDG. VALVE
V-6	5-WAY VALVE
V-7	LIQUID WITHDRAWAL
V-8	PB RETURN/ECON ISOLATION VALVE
LI-1	LIQUID INDICATOR
PI-1	PRESSURE INDICATOR
S-1	STRAINER
PCV-1	PRESSURE BUILDING REGULATOR (450 PSI)
PCV-2	ECONOMIZER REGULATOR (475 PSI)
RV-1	RELIEF VALVE
RV-2	LINE RELIEF
RV-3	LINE RELIEF
BD-1	BURST DISC

PIPING	
A	TOP FILL
B	LIQUID WITHDRAWAL
C	PRESSURE BUILDING INLET
D	PRESSURE BUILDING OUTLET
E	LIQUID PHASE
F	VAPOR PHASE
G	VENT
H	SAFETY CIRCUIT

Controls and Function

#	Plumbing Controls & Function	#	Plumbing Controls & Function
V-1	Fill/Liquid Valve - Used for filling or liquid withdrawal operations	RV-2	Line Safety - Protects over pressurizing between the PB feed valve and PB regulators
V-2	Liquid Use Valve - Use for liquid withdrawal	PI-1	Pressure Gauge - Indicates cylinder pressure
V-3	Gas Use Valve - Use for gas withdrawal	LI-1	Liquid Level Gauge - Indicates cylinder liquid level based on differential pressure within the cylinder
V-4	Vent Valve - Used to vent pressure	BD-1	Burst Disc - Secondary relief device
V-5	Pressure Building Valve - Isolate the pressure building system	PCV-1	Pressure Building Regulators - Used to automatically build as required
RV-1	Safety Relief Valve - Primary relief device	PCV-2	Economizer Regulator - Used to automatically reduce pressure as required