

CylTec

CRYOGENICS

Cryogenic Liquid Cylinder Operating Manual 180 HP - 200 HP - 240HP – 265HP



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Preface

Cyl-Tec cryogenic liquid cylinders are vacuum insulated, stainless steel containers designed for the storage and transportation of liquid nitrogen, oxygen, argon, carbon dioxide, and nitrous oxide. They have been designed and engineered by Cyl-Tec to meet and exceed the rigorous standards of the U.S. DOT 4L and Transport Canada 4LM specifications for portable cryogenic cylinders. The most advanced manufacturing methods have been incorporated into the design of these cylinders to guarantee longer holding times, reliability and safety of use. The HP series cylinders are capable of providing continuous gas flow rates of up to 450 scfh in Oxygen, Nitrogen, and Argon service, up to 130 scfh in Carbon Dioxide and Nitrous Oxide service.

Please read this manual thoroughly before attempting to use or maintain this product. Keep this manual in a safe place for reference. Do not allow the use or maintenance of this product by un-trained persons. Whenever handling, operating, or maintaining cryogenic liquid cylinders, compliance with proper safety and handling practices must be followed at all times. Several safety features have been incorporated into these cylinders in order to ensure safe operation. However, it is strongly recommended that the user of these cryogenic liquid cylinders carefully read all cautions and safety information contained in this manual.

Cryogenic Liquid Cylinders

1. General Information

Cyl-Tec cryogenic liquid cylinders are designed to transport, store and dispense liquid oxygen, nitrogen, argon, carbon dioxide, and nitrous oxide. The HP series cylinders are factory set to automatically maintain a normal operating pressure between 300 and 315psig (2.07-2.17Mpa), with the pressure building portion set as 300psig (2.07Mpa) and the economizer portion set 315psig (2.17Mpa). The operating pressure can be adjusted by the adjusted (see pg 11), but the cylinders are factory set to allow the highest operating pressure allowed by the design. If a significantly lower end process operating pressure is needed, the pressure building regulator can be adjusted, but it is highly recommended to use a separate line regulator rated for use with cryogenic liquid cylinders to regulate and maintain the end process operating pressure.

Carefully inspect packaging and contents immediately upon arrival. Please make a note of any loss or damage on the shipping document, keep a copy and immediately call Cyl-Tec Customer Service at (630) 844-8800 to report the damage.

WARNING: Pressure Vessel Hazard

Cyl-Tec HP series cryogenic liquid cylinders are categorized as high pressure vessels. The high pressure HP series has a service pressure of 350 psi. Withdrawal of cryogenic gas or liquid, caused by the abrupt release of pressure, may result in personal injuries. Only professionally trained personnel should attempt to operate or perform any maintenance on these cylinders.

Design Safety

The cylinders are designed, tested and approved under the US DOT 4L and Transport Canada 4LM regulations. This product is an all Stainless steel cryogenic liquid cylinder, consisting of an inner and outer vessel, inner vessel support system, foot-ring, and top works protective ring, designed to withstand many years of service in industrial, chemical, and medical applications. Cyl-Tec HP series cryogenic liquid cylinders are designed with the following features:

1. The insulation system is provided by multi layer spiral wrapped cryogenic insulation of the inner vessel, a high vacuum between the vessels, special vacuum maintenance products, and a inner vessel support system which was designed to minimize heat communication between the vessels while providing safe support during handling.
2. The cylinder has 2 safety relief devices to protect the inner pressure vessel and 2 safety devices to protect the outer vessel from over pressurization. Each device is sized and installed in accordance with CGA Pamphlet S-1.1 "Safety Relief Devices for Cylinders." The primary safety device of the inner pressure vessel is a re-settable pressure relief valve located on the right side of the pressure gage. The secondary inner vessel safety device is a pre-set single use safety head with bursting disc located on the left side of the pressure gage. A reverse buckling rupture disc located on the top head with a plastic cover acts as the primary safety device for the outer vessel, and an o-ring seal plug located on the top head with a plastic cover is the secondary device for the outer vessel.

WARNING: Do not tamper with or remove any of these devices, or remove any of the protective seals or covers on these devices.

These devices are installed to for your safety. The reverse buckling rupture disc is made of extremely thin metal and can be easily damaged, which may cause loss of vacuum.

Safe Operation and Handling

1. Keep work and use area well ventilated

When filling, storing and operating a cryogenic liquid cylinder, favorable ventilation of the area must be ensured and maintained. Higher concentrations of nitrogen, argon, carbon dioxide, and nitrous oxide can cause asphyxiation in a confined area. An atmosphere or area that does not contain adequate oxygen for breathing can cause dizziness, unconsciousness, and even death. Higher than normal concentrations of oxygen can lead to creating a dangerous oxygen enriched atmosphere. The Compressed Gas Association defines an oxygen enriched atmosphere as an environment that contains more than 23% oxygen). Under such an environment, flammable substances can burn violently or even explode. Other substances, which are considered to be inflammable, can burn in an oxygen enriched atmosphere. Special precautions should be taken to keep all flammable materials away from liquid cylinders containing oxygen.

2. Extreme Cold

Cyl-Tec cryogenic liquid cylinders are designed to hold liquid oxygen, argon or nitrogen with extremely cold temperatures of -196°C (-320°F) . Extreme care should be taken when operating or maintaining the cylinder to avoid serious frostbite and even death. Operators must wear protective gloves, safety goggles, and long-sleeved clothing when operating or maintaining the cylinder.

3. Safe Handling

Cyl-Tec cryogenic liquid cylinders are very rugged and are designed to provide many years of reliable service, but care must be taken to properly handle, store, or transport the cylinder and not allow any abuse such as tip over, dents, dropping, etc. which can adversely affect the cylinder operation. The cylinder should be kept vertical at all times, and never allowed to be tipped over or laid on its side. The larger 240HP and 265HP models come standard with swivel caster wheels, or with an optional square base with handle and four caster wheels as shown on the front cover of this manual.

4. Oxygen Cleaning

Only use approved compatible spare parts that are marked “cleaned for oxygen service”. For information on cleaning refer to Compressed Gas Association (CGA) pamphlet G-4.1 “Cleaning for Oxygen Service”, Failure to comply with these instructions may result in serious damage such as fire and or personnel injuries.

5. Pressure relief valve on product transfer lines

Appropriate pressure relief valves should be equipped on any product transfer line between any two shut-off valves to prevent trapping cryogenic liquid or vaporized gas which can cause pressure build up and can lead to equipment damage, and or personnel injury.

6. Transportation

Cyl-Tec’s liquid cylinders are portable cryogenic pressure vessels, tested and approved for over the road transportation under US DOT 4L and Transport Canada 4LM specifications. Though these cylinders are extremely durable, care should be taken to avoid any rough handling or tipping over which may cause damage. The cylinder consists of an inner vessel protected by an outer vessel, with a vacuum area between the vessels. The cylinder has special pickup ports cut into the four (4) handling ring posts which can be used to move the cylinder with a liquid cylinder hand cart or overhead crane and proper spreader bar or sling. When moving the following suggestions must be complied with:

- a) Cylinders should be moved by using an appropriate cart, overhead crane or hoist. When moving cylinders by overhead crane or hoist, use a proper sling engaged securely into all four (4) of the pickup holes in the 4 handling ring posts. Make sure the sling, crane, or hoist is balanced and rated to handle the weight of a full cylinder safely.
- b) Do not roll a cryogenic liquid cylinder by the handling ring or by holding the liquid level indicator plastic protective cover. Never lay or store cylinders on their side.
- c) Cylinders should be stored and operated in a vertical position.
- d) When loading a cylinder onto a truck from the ground, use a level ride power lift gate, or crane and proper sling.
- e) After loading, heavy duty ratchet style nylon load straps should be used to fix the cylinder securely to the truck.

Cylinder Features

1. Operating Components (Plumbing)

Cyl-Tec cryogenic liquid cylinders are constructed with all operating controls situated at the top of the cylinder for ease in gas withdrawal and liquid dispensing operations. In a stand-alone operating environment it enables users, through use of the vent, liquid, pressure building and pressure relief devices to completely control the cylinder's operation.

2. Gas withdrawal

Gas withdrawal is accomplished through an internal vaporizer that will provide continuous flow rates up to 450 scfh. If higher flow rates are needed, external vaporizers can be added to provide flow rates up to 750 scfh. The gas withdrawal hookup is an isolation valve conveniently marked GAS USE with a stainless steel tag. The cylinder is shipped from the factory with proper CGA gas use fittings for the intended gas service.

3. Pressure building System

An internal automatically controlled pressure building system is provided with these cylinders to maintain the desired gas pressure while continuous gas withdrawal is taking place this system is controlled automatically by the pressure building/economizer regulator, but can be isolated by actuating the pressure building valve directly behind the regulator. This valve is conveniently marked PRESSURE BUILDING with a stainless steel tag.

4. Outer vessel

The outer vessel is constructed of high strength stainless steel; the heavier gage of this outer vessel on the Cyl-Tec liquid cylinder makes it the strongest, most damage resistant outer vessel in the industry. The internal vaporizer and pressure building coils are attached to the inside of this outer vessel. The insulation system and vacuum is contained between the outer and inner vessel, and the extra rugged design of this cylinder this cylinder will help protect it from damage and keep the cylinder operating properly.

5. Inner pressure vessel and vessel support

The inner vessel and its support systems are constructed of high strength stainless steel. This system provides protects the inner vessel from vibrations and shock loads. The inner pressure vessel is the pressure rated vessel that contains the product, and each inner vessel is 100% hydraulically tested to two times the rated maximum service pressure. In addition, each weld is 100% x-ray inspected and then completely trace helium leak checked.

6. Foot ring

The 180HP and 200HP come standard with a foot ring constructed of extra heavy gage high strength stainless steel and is securely welded to the cylinder bottom. The shape of the one piece foot ring is such as to be able to absorb shock and help protect the cylinder from damage.

7. Caster wheels and optional square base

The larger 240HP and 265HP models come standard with 5 heavy duty swivel casters mounted to the bottom of the cylinder. These casters are lined with urethane to prevent damage to flooring. An optional removable stainless steel square base with four heavy duty swivel casters and a convenient handle is available. A picture of a 240 HP on a square base is shown on the cover of this manual.

7. Insulation System

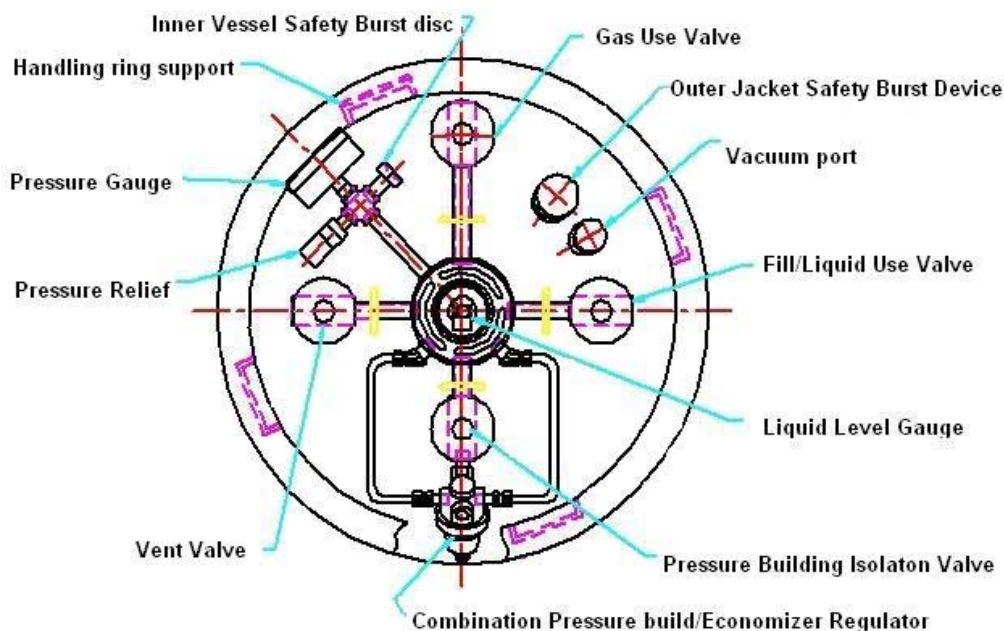
The insulation system is comprised of combining a special foil and cryogenic insulation material specifically designed to work as a system for insulating cryogenic systems and containment devices. This material is orbitally wrapped over the inner pressure rated vessel, which is sealed inside the outer vessel with a research grade vacuum and special vacuum maintenance materials commonly referred to as getters. This combination of special materials, techniques, and vacuum combine to provide a durable and efficient insulation system with superior product holding times.

Specifications

| Model | | 180-HP | 200-HP | 240-HP | 265-HP |
|--------------------------------|---------|--------|--------|--------|--------|
| <u>Capacity</u> | | | | | |
| Liquid (Gross) | Liters | 196 | 212 | 248 | 281 |
| Liquid (Net) | Liters | 185 | 202 | 241 | 266 |
| Gas (N2) | ft3 | 4071 | 4334 | 4899 | 5548 |
| Gas (O2) | ft3 | 5021 | 5325 | 6124 | 6934 |
| Gas (Ar) | ft3 | 4854 | 5183 | 5958 | 6745 |
| Gas (CO2) | ft3 | 3898 | 4143 | 4529 | 5394 |
| Gas (N2O) | ft3 | 3780 | 3928 | 5447 | 5114 |
| <u>Performance</u> | | | | | |
| NER (N2) | % / Day | 1.9 | 1.8 | 1.6 | 1.5 |
| NER (O2, Ar) | % / Day | 1.2 | 1.2 | 1.0 | 1.0 |
| NER (CO2, N2O) | % / Day | 0.5 | 0.4 | 0.5 | 0.4 |
| Gas Flow (N2, O2, Ar)) | Ft / Hr | 400 | 450 | 450 | 450 |
| Gas Flow (CO2, N2O) | Ft / Hr | 120 | 130 | 130 | 130 |
| <u>Dimensions</u> | | | | | |
| Height | inches | 64.5 | 66.4 | 56.0 | 61.0 |
| Diameter | inches | 20 | 20 | 26 | 26 |
| Empty Weight (round base) | pounds | 320 | 330 | 415 | 425 |
| Capacity (N2) | pounds | 295 | 314 | 355 | 402 |
| Capacity (O2) | pounds | 416 | 441 | 507 | 574 |
| Capacity (Ar) | pounds | 502 | 536 | 616 | 697 |
| Capacity (CO2) | pounds | 446 | 474 | 518 | 617 |
| Capacity (N2O) | pounds | 434 | 451 | 545 | 586 |
| <u>Pressure Ratings</u> | | | | | |
| Relief Valve Settings | PSIG | 350 | 350 | 350 | 350 |
| US DOT Rating | DOT | 4L292 | 4L292 | 4L292 | 4L292 |

Cylinder Operation

Diagram of Control Parts (top of cylinder)



Function of the control parts

Regulator

The Regulator is a combination Pressure building (PB) and Economizer regulator with the function of automatic setting/regulating of the pressure building and economizer circuits. The regulator on a HP series cylinders is factory set at 300 Psig (2.07Mpa) for pressure building, 315Psig (2.17Mpa) for the economizer circuit. The regulator can be adjusted from 80 to 320 Psig (0.55Mpa-2.2Mpa). A fixed pressure difference of about 15 Psig is factory set between the pressure building and economizer regulating pressures prior to collecting gas from the head space of the Inner Vessel by the Economizer Regulating Circuit. The economizer circuit is automatic and needs no regulation. The pressure building function can be isolated by closing the pressure building valve, which stops the flow of liquid product into the pressure building coil, which is designed to vaporize the product and produce gas pressure which may be needed for the end process. The pressure building system is designed to produce more than 450 scfh continuously on the 200HP, 240HP, 265HP and 400 scfh on the 180 HP, and may need to be open continuously with high gas use, or opened periodically, or closed, depending on the application.

Pressure Building Valve

The Pressure building (PB) Valve isolates the pressure building economizer regulator. After opening the PB valve, liquid will be allowed to enter the Pressure Building Coil, be vaporized, and enter the Pressure Building Regulator which sends the vaporized gas into the inner vessel head space. The PB Valve should be opened only when it is desired to build pressure for gas use. Close the PB valve when the cylinder will not be used for any extended period of time to avoid loss of product through the preset pressure relief valve. The PB valve is conveniently marked PRESSURE BUILDING with a stainless steel tag.

Gas Use Valve

The Gas Use Valve is connected the inner vessel head space, and is used to supply pressurized gas to the end process. This valve requires proper CGA end use gas fittings suitable for the supplied gas. The Gas use valve is conveniently marked GAS USE with a stainless steel tag.

Fill/Liquid Valve

Fill/Liquid Valve is connected to the liquid withdrawal eductor tube inside the inner vessel. This valve is used in the filling or withdrawing of liquid, and should only be opened by trained professionals when it is desired to withdraw liquid or during the cylinder filling operation the proper CGA end use liquid fittings are supplied from the factory and are required for connecting liquid withdrawal transfer lines or hoses to the Fill/Liquid valve to draw liquid from the cylinder. The liquid valve is conveniently marked LIQUID with a stainless steel tag.

Vent Valve

As pump filling is adopted, Vent Valve can control liquid filling or gas withdrawing on top of the Inner Vessel. It has the appropriate CGA connection required for connecting transfer line (referred to as above diagram). The vent valve is conveniently marked VENT with a stainless steel tag.

Liquid Level Gauge

The Liquid Level Gauge is designed to indicate the liquid volume of Inner vessel. Read the approximate level of liquid from the sight indicator under the clear plastic protective cover on the top of the cylinder. Note: It is only designed to indicate the approximate level of liquid in the vessel, and should not be used to fill the vessel, which should be done on a certified scale and by weight. **See the Specification chart in this manual for appropriate filling weights.**

Pressure Gauge

The Pressure Gauge indicates the pressure inside the Inner vessel in Psig. On the HP series, the pressure gauge from the factory is a 0-400 psig scale gauge.

Safety Pressure Relief Devices

There are 2 safety devices for protecting the inner vessel from over-pressurization on the Outer Top Head of each Cyl-Tec HP series cryogenic liquid cylinder. The first is a spring loaded automatically resetting Pressure Relief Device (PRD) with a factory set pressure of 350Psig/2.41Mpa), which is marked on the PRD. The second is the Inner Vessel Safety Burst Disc with a factory set maximum burst pressure of 584Psig/4.04Mpa. There are also 2 safety devices for protecting the outer vessel from over-pressurization on the Outer Top Head of each Cyl-Tec HP series cryogenic liquid cylinder. The first is a reverse buckling Outer Jacket Vacuum Burst Disc (with Max. burst pressure of 25Psig/0.17Mpa). The second is an o-ring seal plug located on the top head with a plastic cover. **Warning: Do not remove or tamper with any safety devices or their protective covers.**

CGA Fittings Chart

| Filling Content | | Valve | | |
|-----------------|--------------|-------------|---------|---------|
| | | Fill/Liquid | Vent | Gas Use |
| Oxygen | CGA Standard | CGA-440 | CGA-440 | CGA-540 |
| Nitrogen | | CGA-295 | CGA-295 | CGA-580 |
| Argon | | CGA-295 | CGA-295 | CGA-580 |
| Carbon Dioxide | | CGA-320 | CGA-295 | CGA-320 |
| Nitrous Oxide | | CGA-326 | CGA-295 | CGA-326 |

Gas Withdrawal

When a HP series cryogenic liquid cylinder is used for gas withdrawal, the normal operating pressure range is from approximately 80-320psig (0.55-2.20Mpa).

The supply of gaseous product is the primary function of the HP series cryogenic liquid cylinder. An additional line regulator designed for the gaseous product to be dispensed must be connected to the gas use valve fitting to regulate the pressure to the application.

To supply gaseous product follow this step by step procedure:

- a. Connect the proper fill line regulator to the cryogenic liquid cylinder's gas use outlet.
- b. Connect the proper hose between the final line regulator and the receiving equipment.
- c. Open the pressure building valve.
- d. Allow pressure to build to economizer's original setting value.
- e. Open the gas use valve.
- f. Adjust the gas use regulator for the proper delivery pressure. When the gas delivery is completed, close all cryogenic liquid cylinder valves.

Liquid Withdrawal

If the HP series cryogenic liquid cylinder is to be used for liquid withdrawal service, the cylinder must be refitted with a 22psig low pressure relief valve to minimize product loss due to flash-off associated with higher pressures. To withdraw liquid from a cryogenic liquid cylinder, connect a transfer line designed for dispensing cryogenic liquid product to the cylinder liquid valve fitting on the receiving vessel.

Caution: The transfer line must have properly rated pressure relief devices installed between any two valves in the filling system to avoid any chance of trapping cryogenic liquid product which can vaporize and rapidly build pressure.

When Cyl-Tec HP series cryogenic liquid cylinders are used for liquid withdrawal, the flow rate of the product can vary depending on the gas phase pressure and liquid saturation temperature. For Safety, inner vessel pressure should be kept as low as possible during liquid use. Open the Fill/Liquid Valve to obtain the preferred rate of flow. Close the Fill/Liquid Valve when the receiving vessel has been filled. To prevent contamination, when the cylinder has been emptied, all valves should be closed. Normal liquid withdrawal operations are performed at low pressure (approximately 22psig, **excluding CO₂**). The pressure building valve is customarily closed during liquid withdrawal. Transfer of liquid at higher pressures can lead to excessive splashing of the cryogenic liquid which could be extremely hazardous. All personnel should be fully instructed in the cautions associated with handling cryogenic fluids and the proper clothing and protective gear to be used.

Basic Liquid Withdrawal Procedures

- a. Connect the cryogenic transfer hose to the liquid valve of the cylinder. Open the fill valve and vent valve of the receiving equipment.
- b. Do not open the pressure building circuit of the liquid cylinder, as this will generate excessive pressure and liquid flow rates.
- c. Open the liquid valve on the cylinder. This valve can be adjusted to obtain the proper liquid flow rate.
- d. When the transfer is completed, close the receiving equipment's inlet valve if applicable. Close the liquid valve, relieve pressure from hose, and disconnect.

Cylinder filling – General Considerations

The HP series cryogenic liquid cylinders can be filled with liquid oxygen, argon, or nitrogen also, as well as liquid carbon dioxide and liquid nitrous oxide. Only trained personnel familiar with the hazards associated with handling the extreme cold of cryogenic liquids and of handling liquid and gaseous oxygen should be allowed to fill or operate cryogenic liquid cylinders. Overfilling this cylinder is not allowed, and may cause rapid and hazardous release of gas and liquid product through the cylinders safety relief devices. Cyl-Tec HP series cryogenic liquid cylinders are equipped with a liquid valve and a vent valve that are used during the filling procedure. The liquid valve is equipped with an eductor tube that extends to the bottom. Filling can be accomplished by either pressure transfer or pump filling which are outlined in this section.

1. Check the cylinder for damage and readiness for filling. Do not fill liquid product into liquid cryogenic cylinders that are not certified ready for that product. Check for proper CGA end use fittings and protective devices, product labeling to determine the correct product that is certified to be filled before proceeding. Purging the cylinder alone is not adequate for certifying the liquid cylinder is safe, and ready to accept any particular liquid product. Some trace contamination may have entered the cylinder from a previous fill, and must be removed, or the cylinder was previously in other gas service, and has not been properly certified to be used in another service. Sampling of the residual gas in the cylinder can be done only by qualified technicians. Appropriate Pressure Relief Devices (PRDs) must be equipped on the transfer lines between any two valves or restrictions. Keep the transfer lines as short as possible. Use only equipment rated for cryogenic use. All equipment must be cleaned for Oxygen service if liquid oxygen is to be filled.

Cylinder Filling – General Considerations (continued)

- 2. Determine the total filling weight.** Place the cylinder on the scale. Record the weight. Compare this weight to the cylinder tare weight on the data plate. The difference may be the weight of residual product in the cylinder, but make sure the scale is accurate and within calibration before proceeding. Add the tare weight of the cylinder, the transfer line weight and the proper filling weight from the Specifications table in this manual. Overfilling the cylinder is not allowed, and may cause rapid and hazardous release of gas and liquid product through the safety relief devices.
- 3. Always fill the cylinder by weight on a calibrated scale.** Cryogenic liquid cylinders should always be filled by weight to ensure that there is sufficient head space in the cylinder, allowing for expansion of the liquid product as it warms. See the chart on page 11 for proper filling weights.
- 4. Use the appropriate filling method for your application.** Below are brief explanations of 2 popular methods for filling cryogenic liquid cylinders. These explanations are for informational purposes only, and are not meant to be followed without proper training in the handling and filling of cryogenic liquid cylinders.

3. Methods of Filling

Pressure Transfer Filling

The Pressure Transfer method for cryogenic liquid cylinder filling uses no pump, and works from the pressure differential between the bulk tank source and the receiving cylinder. The principle is that liquid product will always flow from a vessel of higher pressure to a cylinder of lower pressure. The pressure transfer filling method is commonly used to fill cryogenic liquid cylinders by connecting an insulated cryogenic transfer line between the filling header or bulk delivery source and the Liquid Valve of the cryogenic liquid cylinder, and placing the cylinder on a calibrated scale suitable for filling cryogenic liquid cylinders. Before starting, make sure the properly rated cryogenic transfer line (hose) is properly attached, and the operator has on proper clothing, a protective face shield, and insulated gloves before starting the filling process. The cylinder Vent Valve is usually opened during pressure transfer filling, especially on a “warm” cylinder, to allow the vapor to escape while the cylinder cools down. This opening or throttling of the vent valve also helps keep the pressure in the cylinder low enough to make the fill process as efficient as possible, and keep the pressure below the pressure relief valve setting.

- **Pump Transfer Filling**

The top fill pump transfer method requires the receiving cylinder to be “ready” to accept liquid product, meaning that if the cylinder was empty and idle for an extended period of time before filling, it has warmed up to room temperature and needs to be cooled down to at or near cryogenic temperature before the pressure transfer of liquid product can commence. This method has the advantage of reducing liquid loss and avoiding frequent opening of the automatic pressure relief valve. Caution: Make certain that there is a proper pressure relief device installed between any 2 shut-off valves in a filling system. Connect the transfer hose to the Vent Valve with the other valves closed. Cyl-Tec cryogenic liquid cylinders have a diffuser on the vent tube, which sprays the liquid down over the head space of the inner vessel during the top filling process to help keep the pressure low throughout the fill process. Open the vent valve and any valves on the pump and start the pump.

Note: Filling cylinder with CO₂. When filling CO₂ into the HP series cylinder, keep the filling pressure over 85 psi to avoid forming dry ice inside the cylinder. During the CO₂ filling process, closing the vent valve to maintain cylinder pressure above 85 psig and below the pressure relief valve setting is many times necessary.

Service and Maintenance

Caution: The following section lists guidelines for some basic maintenance and troubleshooting. Do not perform or attempt to perform any maintenance on cryogenic liquid cylinders without proper training. Return cylinder to Cyl-Tec for all repairs. Use insulated gloves, safety glasses and other appropriate protective clothing when performing any maintenance. Please contact Cyl-Tec if any parts are damaged.

1. Vacuum Performance

Cyl-Tec cryogenic liquid cylinders consist of an inner and outer vessel. The space between the two vessels (annular space) acts as a highly efficient thermal barrier which consist of spiral wrapped Super Insulation, a vacuum and a vacuum maintenance system. The insulation system is very effective in preventing heat from entering the inner container. However, the perfect vacuum condition can not be maintained indefinitely since trace gas molecules begin to outgas into the vacuum space from the moment of manufacture. The vacuum maintenance system consists of special materials (palladium oxide and molecular sieve) which absorb trace gas molecules from the vacuum space. The vacuum maintenance system can perform for several years, but eventually becomes saturated, and can no longer maintain the vacuum integrity of the container. The following symptoms may appear when the vacuum becomes compromised.

- a. The outer vessel and or top works begin to show signs of frosting, with liquid in the container, and the Pressure Builder/Economizer circuit turned off.
- b. The outer vessel appears to sweat in hot and humid conditions.
- c. The pressure relief valve opens continuously until the vessel is emptied.

If a loss of vacuum integrity is suspected, the container's Normal Evaporation Rate (NER) should be checked. The results obtained should be compared with the NER values in the specification table.

● NER Testing Procedures

- a) Fill the vessel with 150 pounds (68kg) of liquid nitrogen by weight. Record the weight, time, and date.
- b) Close the liquid valve and the pressure building valve, open the vent valve and leave it open during the whole process.
- c) Allow the container to stabilize for 24 hours, and then reweigh it. Record the weight, time, and date. Repeat this last step 48 hours later. Do not move the container during this 48 hour period.

NER Test (continued)

- d) The following formula provides daily Normal Evaporation Rate. Unit is kg/per day.

$$\text{Daily Normal Evaporation} = \left[\frac{\text{Weight (step c) - weight (step d)}}{\text{Time Between step c and step d in hours}} \right] \times 24$$

- e) The following formula provides the actual Normal Evaporation Rate.

$$\text{Daily NER} = \left[\frac{\text{Daily Evaporation (kg/per day)/0.8083(kg/L)}}{\text{Inner Vessel Volume}} \right] \times 100\%$$

The test result value should be less than 2 times the standard NER value. Compare the test results with the NER value in the specifications table of this manual. Any test result greater than 2 times the listed value is indicative of a failed or failing vacuum. If NER is found to be high, please contact Cyl-Tec customer service department 1 888-429-5832 for disposition.

3. Pressure Builder/Economizer Regulator

● Regulator Removal and Replacement Procedure

- a. Close the pressure building valve.
- b. Completely vent the container to atmospheric pressure.
- c. Loosen and remove both of the brass compression fittings on the regulator.
- d. Remove the regulator from the container by unscrewing the valve body and elbow from the output side of the pressure building valve.
- e. Repair the regulator and re-adjust its set point using a test bench with gauge.
- f. To install a new or a readjusted regulator, apply Teflon tape to the elbow on the container and screw the valve body onto the elbow.
- g. Reconnect the brass compression fittings the regulator and tighten. Be careful not to over tighten the connections.
- h. Check all connections for leakage.

- **Regulator Adjustment-----on the Container**

- a. Fill the container with the appropriate cryogenic liquid product.
- b. Open the pressure building valve and allow the container pressure to stabilize for about one hour. Write down the valve point where the pressure stabilizes.
- c. Turn the adjusting screw on the regulator bonnet to increase or decrease pressure to the desired point. When decreasing the setting, the pressure building valve must be closed and the container should be vented to a lower pressure, then repeat step b. above to check if the desired pressure has been achieved.

4. Liquid Level Gauge Replacement

- **Removing the Liquid Level Gauge**

- a. Vent out all pressure from the container, and leave vent valve open.
- b. Remove the protective cover by removing 3 screws from the cover base.
- c. Unscrew the gauge by using a wrench on the brass hex fitting at the base.
- d. Remove the entire gauge and float rod assembly from the container. The float rod assembly is long and can be very cold. Use insulated gloves to protect the skin. Make sure the gloves are clean and dry.

- **Calibration procedure for Liquid Level Gauge**

The liquid level gauge can be calibrated using the following procedure. A tube or column that will hold water to do the calibration. A piece of 2" to 4" O.D. PVC tube with a cemented end cap to hold a 4 ft (1.2m) column of water will be sufficient. Once the column is made, fill it with clean water and brace it up in the vertical position. While holding the hex base of the brass float body, submerge the entire liquid level gauge with float rod attached into the column of water until the water level reaches to the eye hook on the aluminum float rod. At this point the orange magnet or indicating magnet should be at the top its movement range. When the float rod is removed from the water and is hanging freely, the magnet should be at the bottom of its movement range. Adjustments are made by screwing the eye hook at bottom of the float assembly. Turn the screw in to lower the magnets range, and out to increase (raise) the magnets range. Always retighten the lock nut on the eye hook after any adjustments are made.

- **Liquid Level Gauge Installation**

- a. Check the o-ring gasket seal and replace if necessary before installing a new or repaired liquid level gauge. Always use a pre-calibrated liquid level gauge with correct length and weight float rod for the model of cylinder. Each cylinder model has a different float rod and the complete float assembly is calibrated at the factory. If only a new float rod is needed, please give the cylinder model number when ordering.
- b. When installing the liquid level gauge assembly, care must be taken to ensure that the float rod is inserted through guide ring located on the liquid withdrawal line; otherwise the liquid level indicator will not operate properly. The guide ring keeps the float rod centered during use and handling.
- c. After filling, check the float assembly for leaks at the o-ring gasket seal with an approved leak detection solution. On the HP models, build pressure to 250 to 300 psi before leak checking. If leaking is found, replace the o-ring gasket seal and repeat the installation process. Call Cyl-Tec at 1 (888)429-5832 if you experience any problems and we will send out a new calibrated liquid level gauge assembly.

5. **Safe Conversion of a Vessel to a Different Gas Service**

Caution: Service changes should only be performed by trained personnel. Cryogenic liquid cylinders have elaborate internal plumbing systems, which must be completely purged before conversion. Purging and evacuation will not remove 100% of any liquid or solid contamination that may have entered the cylinder.

For this reason, DO NOT Convert a cylinder that has been in Carbon Dioxide (CO₂) service to any other service. CO₂ may contain trace solid or liquid contamination that are very difficult to remove completely with normal evacuation and purging. Always keep CO₂ cylinders in CO₂ service. Use extreme caution when converting inert gas (Nitrogen, Argon) cylinders into Oxygen service. If possible, send the cylinder into Cyl-Tec for service changes, especially when changing from nitrogen or argon into oxygen service. Cyl-Tec will perform a trace hydrocarbon analysis and thorough inspection with UV light to check for any trace contamination, and install oxygen cleaned parts and restraint devices on the cylinder valves if in oxygen service to deter service changes by un-trained personnel. All new cylinders are shipped with these restraint devices installed.

Guidelines for service changes (Nitrogen, Argon, Oxygen)

Wear proper safety gear, face shield and insulated gloves

- a) Vent all of the pressure from the cylinder in a safe and well ventilated area, facing away from yourself or others.
- b) Open the pressure building valve to boil away any residual cryogenic liquid, which will then be vented out through the vent valve. Check pressure gauge, and make sure all liquid product has been boiled off before proceeding.
- c) Remove all product labels associated with the former gas service.
- d) Remove all CGA restraint devices, and the CGA use fittings from the gas and liquid valves. If the fitting have been brazed or soldered into the valve, contact Cyl-Tec.
- e) Close the liquid valve, the gas use valve and the pressure building valve, leaving the vent valve open.
- f) Connect a vacuum pump to the vent valve with a proper flexible pigtail vacuum line with isolation valve, and evacuate the cylinder to below 600mm mercury. Close the vent valve and then the isolation valve and remove the vacuum pump line from the vent valve.
- g) Using a low pressure regulator, and a proper flexible pigtail connect to the gas valve and carefully and slowly purge the cylinder with high purity inert nitrogen or argon gas until the pressure in the inner vessel reaches 5psi (0.03Mpa)
- h) Repeat steps d & e.
- i) Install new product labels and proper CGA gas and liquid valve restraint devices for the new service. Use clean tools and only virgin Teflon tape with no paste of any kind.
- j) If converting from inert service into oxygen service, it is strongly recommended send the cylinder to Cyl-Tec, where we will check the cylinder thoroughly and test for any remaining trace hydrocarbon contamination with a total HC analyzer and UV inspection equipment before marking the cylinder as safe to return to liquid oxygen service.
- k) Close all the valves, and remove the vacuum pump.

| Troubleshooting | | |
|---|---|---|
| Problem | Problem Cause | Corrective Action |
| The cylinder builds excessive pressure or builds pressure too fast. | Low usage. | If daily gas usage is under 100 SCF (2.8NM ³), the cylinder will build pressure. In liquid service, the cylinder should be equipped with low pressure relief valve and regulator. Normal pressure rise should not be more than 50 psi (3.4 BAR) per day. |
| | Cylinder is over filled. | If the cylinder is filled past the vent turncock 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. |
| | Vacuum is deteriorating. | This can be accompanied by cold or frost occurring evenly over the cylinder surface. Refer to the troubleshooting section on frost. |
| Cylinder will not build pressure, or pressure remains too low. | Usage is too high. | Referring to the manual, operate according to max. Gas usage and ability of pressure building. |
| | Pressure building valve is closed. | Open pressure building valve. |
| | Pressure building regulator is not opening properly. | Bench test the regulator for full flow at the set pressure. |
| | Pressure building regulator is set too low. | Adjust the regulator to required pressure. |
| | Cylinder or downstream equipment is leaking. | Check for frost on lines or on top of head. Listen for hissing, soap test joints for leaks. |
| | Liquid temperature is too low. | Open pressure building valve or recur to outer pressure. |
| | Pressure relief valve PRD will not reset when cylinder pressure is significantly lower than safety valve setting. | Check PRD relief pressure marked on the device for proper relief rating for application. PRD may be stuck open. This is more common in CO2 service where dry ice may form in the PRD. Carefully, pour hot water over the PRD to try to get it to reset. Call Cyl-Tec if PRD still does not reset- |
| | Pressure gauge doesn't work. | Replace pressure gauge. |
| Safety relief frequently opens. | Lost vacuum, or broken safety relief. | Check pressure that safety opens. Call Cyl-Tec with pressure reading, or return it for repair. |
| Delivery gas is too cold. | Delivery rate exceeds recommended delivery. | Refer to maximum gas delivery rate and pressure. |

Continued on next page

| Troubleshooting – (continued) | | |
|--|--|---|
| Problem | Problem Cause | Corrective Action |
| Pressure Gauge doesn't rise or appear to work on full cylinder. | Pressure Gauge is broken. | Slowly open vent valve to remove all pressure, when sure cylinder is completely empty, and .replace with properly rated pressure gauge. |
| | If in CO2 service, Dry ice may have formed. (see pg 8) | Dry ice forms in CO2 cylinders when pressure drops below 80 psi. To get dry ice to re-liquefy, pressure must be increased. Close gas use, vent and liquid use valves. Open PB valve and allow pressure to build. If problem persists, call Cyl-Tec. |
| | Cylinder is functioning but pressure is very low. | Open PB valve, look for a pressure rise. |
| Frost occurs around the circumference of the shell from the floor. | Cylinder is building pressure with the PB coil. | This is normal if pressure inside cylinder is lower than pressure building regulator setting. |
| | Frost is residual from last fill or earlier use. | This is normal. Some frost or ice often remains on the cylinder for days after the last use or fill. |
| Frost occurs in spirals around circumference of the shell from the floor up. | Cylinder is vaporizing liquid to gas. Pressure building circuit is open. | Normal when PB circuit is open. The frost should melt with two hours after the gas use stops. If frost persists after PB valves is closed and cylinder continues to build pressure rapidly, call Cyl-Tec. |
| Frost occurs on head or knuckle. | Residual frost remains from fill or recent use. | This is normal. Ice may remain for days after a fill or heavy use. |
| | Liquid Level gauge is leaking. | Check for gas escaping from under sight gauge with approved leak check solution. Replace with proper seal o-ring and re-check for leaks. |
| | Regulator is leaking. | Tighten connections and re-check for leaks. |
| Frost occurs evenly over the cylinder surface. | Gas use rate is high. Both coils are frosted. | This is normal under high demand usage. |
| | Regulator not functioning | Close the PB valve. Check frost area. Check regulator for proper setting. Replace if necessary |
| | Cylinder lost vacuum. | This is accompanied by high rate of pressure rise or high loss rate. Return it to Cyl-Tec for repair. |
| Cylinder pressure is higher than optimum or venting when cylinder is received. | PB circuit is open. | Close PB valve. |
| | Delivery liquid is "saturated" or mixed with high amount of gas | Deliver liquid to cylinder with lower pressure. |
| Liquid level Gauge doesn't work on full or partially full cylinder. | Aluminum float rod is not connected properly with upper liquid level gauge assembly. | Remove liquid level gauge and check for proper eye ring connection from the upper device to the aluminum float rod. Make sure float rod is inserted properly through guide hole on the side of the liquid tube. Tighten and check for cylinder leaks. |

