Product Manual

Perma-Cyl® MicroBulk Storage System w/ FlexFill™ Piping Option

1000/1500/2000/3000/5500

Designed and Built by:

Chart Inc.

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Part Number 20930593 Rev. C

Contents

Revision Log

Revision Level	Date	Description
A	11/24/2015	Original manual
B	02/22/2016	Add information on thermocouple to the end of 5500 VHP Operation section
C	09/08/2016	Add information for 5500 MP model; update Filling Weight Table

Preface

General

The new Perma-Cyl FlexFill storage vessel is equipped with a top and bottom fill circuit in place of the top float assembly so the driver can control the tank pressure while filling the Perma-Cyl® MicroBulk Storage System. The FlexFill option uses the ullage technology adopted from our LNG fueling system which allows the inner vessel to safely go liquid full. Once the meter on the Orca™ MicroBulk Delivery System senses a flow rate reduction, the pump is automatically shut down. This patented automatic dispensing system simulates the same process drivers have used for years to safely fill Perma-Cyl storage tanks without venting.

The FlexFill feature is critical for applications like laser assist gas and medical gas supply where a significant drop in downstream pressure during the Perma-Cyl tank refill could result in equipment alarms. The new FlexFill feature works with all Orca delivery unit models, both new and existing units.

**Perma-Cyl tanks with the FlexFill Piping Option are presently not approved for service with CO_2.*

Product Highlights

- Allows top and bottom filling for accurate pressure control in the Perma-Cyl tank during refill
- Provides the same safe, single hose, no-loss, auto shut-off fill with the Orca delivery system as the top fill float design
- Backward compatible - works with new and existing Orca delivery units without modifications
- Incorporates the filling technology from the LNG vehicle & dispenser system
- Comes standard with dual relief valves and rupture discs
- Utilizes separate pressure build and economizer regulators

Product Manual

This manual contains information regarding the safe operation and maintenance of a Perma-Cyl tank w/ FlexFill piping option. It should be thoroughly read and understood by anyone that operates the equipment.

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/Operation section discusses the general features of the tank and the theory of operation.

In the Installation section there are illustrations for how to uncrate and install the tank.

The remaining sections describe the specific tank models covered by this manual. They contain warranty information, troubleshooting help, technical specifications/illustrations, and parts lists. They should be reviewed first and referred to as the rest of the manual is read.

The Illustrations & Parts Listing section contains schematics, piping illustrations, and parts list that show a reference number for each component used on the tank. The reference numbers may refer to the same functional component between the various models. The reference numbers will be used throughout this manual to draw specific attention to a component while describing its function, operation, or repair.

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
BARG	Pressure (Metric) Gauge
CGA	Compressed Gas Association
CO_2	Carbon Dioxide
DOT	Department of Transportation
FPT	Female Pipe Thread
ID	Inner Diameter
Kg	Kilogram
LAR	Liquid Argon
MAWP	Maximum Allowable Working Pressure
N_2	Nitrogen
Nm^3	Normal Cubic Meters
Nm^3h	Normal Cubic Meters/Hour
NER	Normal Evaporation Rate
NFPA	National Fire Protection Association
NPT	National Pipe Thread
O_2	Oxygen
PB	Pressure Builder
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch (Gauge)
SCF	Standard Cubic Feet
SCFH	Standard Cubic Feet/Hour
UFC	Uniform Fire Code

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® MicroBulk Storage System w/ FlexFill™ Piping Option and safe operations are anticipated, it is essential that the customer carefully read and fully understand all Warning and Caution notes listed below.

Warning! ***The Perma-Cyl tank, with its stainless steel support system is designed, manufactured, and tested to function normally for many years of service. It is never safe to drop a liquid cylinder or let it fall over in oxygen or any cryogenic service. In the event a liquid cylinder is inadvertently dropped, tipped over, or abused, slowly raise it to its normal vertical position and immediately open the vent valve to release any excess pressure in a safe manner. As soon as possible, remove the liquid product from the vessel in a safe manner. If the vessel has been used in oxygen service, purge it with an inert gas (nitrogen). If damage is evident or suspected, return the unit to Chart prominently marked "LIQUID CYLINDER DROPPED, INSPECT FOR DAMAGE".***

Warning! ***Any welding that is done on the outside of the Perma-Cyl System can cause loss of vacuum and will VOID any warranty on the unit.***

Warning! ***Before removing cylinder parts or loosening 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 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! ***All valves on an empty Perma-Cyl system should always be kept closed to protect the inner vessel and plumbing from being contaminated.***

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.

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 has 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.

Caution! Failure to comply with these instructions may result in serious damage to the system and personal injury.

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.

Personal Protective Equipment (PPE)

The following personal protective equipment is recommended when working around cryogenic liquid:

- Safety glasses with side shields to prevent cryogenic liquid from splashing into the eyes
- Chemical / Liquid resistant gloves to prevent cryogenic burns on exposed hands
- Long sleeve shirts to protect the arms
- Cuffless trousers worn over closed shoes

Introduction/Operation

General

The Perma-Cyl® MicroBulk Storage System w/ FlexFill™ Piping Option is designed to store and deliver liquid oxygen, nitrogen or argon as a cryogenic liquid or gas. The Perma-Cyl tank can build and maintain pressure from the automatically regulated pressure building circuit. A continuous gas flow is provided from the cylinders. Regardless of size, all Perma-Cyl tank models operate on the same principals of operation.

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. Failure to comply with these instructions may result in serious damage to the system and personal injury.***

Initial Inspection

Receiving inspection is one of the most important operations in the life of the tank and should be done thoroughly and conscientiously so as to find any possible indications of damage and prevent expensive surprises during the first use of the vessel at the site. Upon receipt of a Perma-Cyl tank, remove the protective wrapping and inspect for the following:

- Any shipping damage including dents, cuts, broken and bent plumbing components. Report any findings to the shipping company immediately.
- Examine welded and brazed joints on plumbing for cracks or deformation, especially on valves and fittings.
- Check burst discs and relief valves for dirt/damage.
- Check to ensure there is positive pressure on the inner vessel, normally about 20-25 psig. Tanks are shipped with NF purity nitrogen gas. Purging is necessary prior to filling.
- If the tank passes all the above criteria, it is ready for first fill. Follow the first fill procedures in the Installation portion of this manual.

Note: *The PC5500 is the only Perma-Cyl tank that is equipped with a vacuum thermocouple.*

- On the 5500 Perma-Cyl tanks check the insulation space pressure with a suitable thermocouple vacuum gauge (follow procedure below). Make a note of the ambient temperature when the vacuum is read. Temperature changes affect the vacuum reading in a warm empty vessel.
  - If warm vacuum is above 20 microns, consult factory.

Vacuum Check Procedure - Perma-Cyl 5500 Only

The standard Chart vacuum probe is a Teledyne-Hastings DV-6R probe. Select a compatible instrument to read the output of the vacuum probe.

Caution! ***Unauthorized changing of the vacuum probe will void vessel warranty.***

1. Remove rubber cap on probe outlet to expose contact. Note that the probe housing need not be opened to do this.
2. Plug the instrument in to the probe and calibrate the instrument.
3. Open the vacuum probe isolation valve. Wait for five minutes and take vacuum reading. Note that valve handle protrudes through protective housing and can be turned without opening the housing.
4. Close the isolation valve and take a second reading. Monitor the rate of rise in vacuum probe with isolation valve closed. If the vacuum continues to rise at a constant rate, it is possible that the probe assembly is leaking. Consult the factory.
5. Verify that the isolation valve is closed.
6. Replace the rubber probe cap.
7. Compare the vacuum reading obtained now to the reading taken prior to shipping.

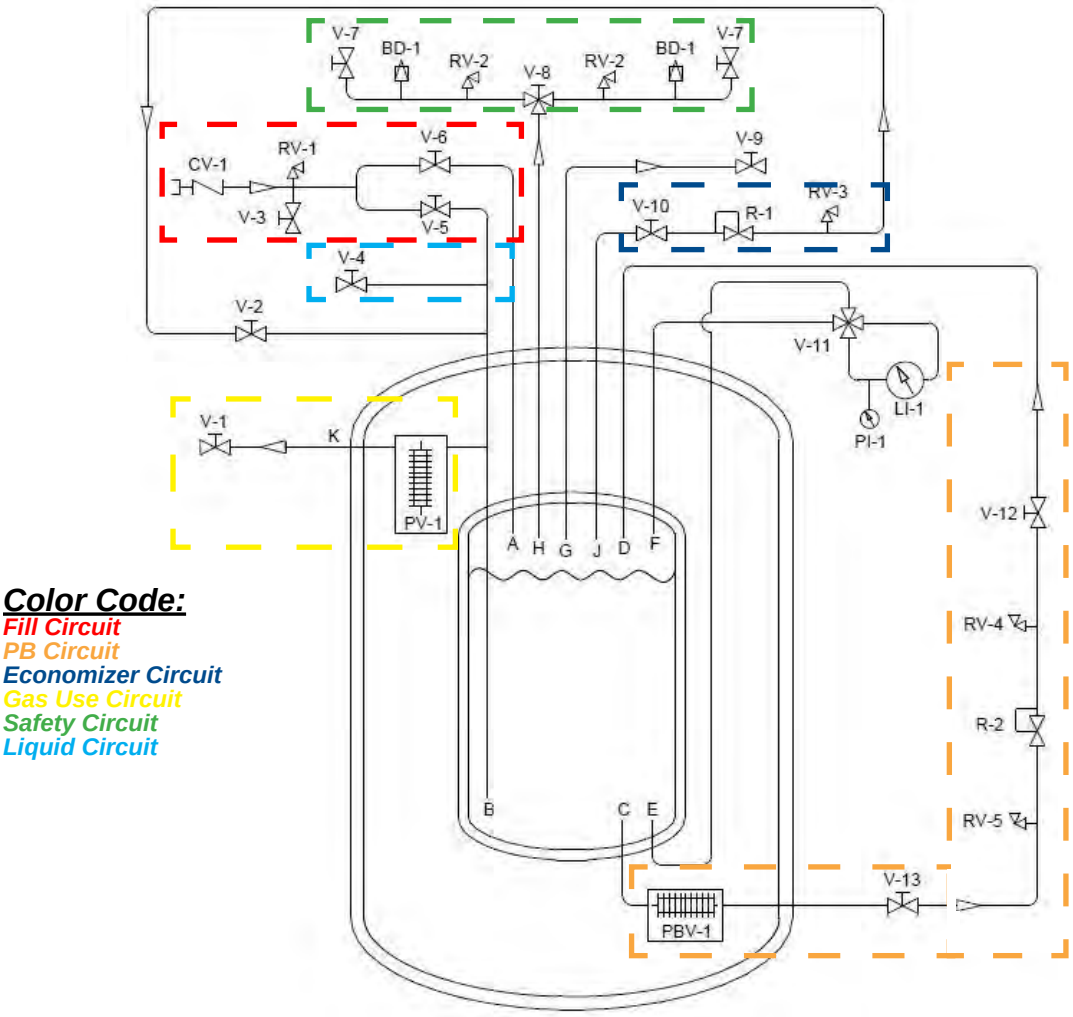


Figure 1 - Schematic for 1000HP/VHP, 1500HP/VHP, 2000HP and 3000HP models.

Primary Plumbing Circuits
(Refer to Figure 1)

Fill

The Perma-Cyl w/ FlexFill has a top and bottom fill circuit that replaces the top float assembly so the driver can control the tank pressure while filling the Perma-Cyl MicroBulk Storage Tank. The fill circuit consists of a top fill valve (V-6), a bottom fill valve (V-5), a fill check valve (CV-1), and a hose drain valve (V-3). The fill line check valve has a service fitting on the inlet side that provides the sole connection for the liquid delivery vehicle.

The hose drain valve (V-3) can be used to both purge the fill hose before filling the tank or to depressurize the fill hose after filling the tank.

The driver controls the pressure in the vessel during the fill process by adjusting the flow through the top and bottom fill valves. Product flowing into the bottom of the tank will raise the pressure and product flowing into the top of the tank will lower the pressure. Adjusting each valve properly will allow the driver to hold a consistent pressure in the tank throughout the entire delivery.

During a first fill, only fill the vessel to 75% full to allow liquid expansion experienced with a new "hot" tank. Each fill there after can be filled to 100% full. Please refer to the Installation section of this manual for detailed filling procedures.

Caution! If liquid can be trapped in the transfer system, a suitable relief valve must be installed to prevent over pressurization.

Caution! ***Before making a liquid transfer either into or out of this vessel, be sure that protective eyeglasses and gloves are being worn. If the transfer is being made to an open top vessel, the transfer pressure should be as low as possible and a phase separator should be used to eliminate splashing and hose whip.***

Pressure Build

The pressure build circuit is used to build pressure back in the vessel after a delivery or to maintain pressure as liquid is withdrawn from the vessel. The vessel pressure is set by adjusting the PB regulator (R2). Standard PB set points are:

MP - 125 psig

HP - 300 psig

VHP - 450 psig

As the tank pressure drops below the PB set point, the regulator opens and allows liquid to flow off the bottom of the tank, through the internal PB vaporization coils, through the R-1 and back into the gas phase of the tank. The pressure build circuit can be isolated by closing valves V-12 & V-13.

Some models of Perma-Cyl tanks can be equipped with external pressure build vaporizers which allow for much quicker recoveries after the tank has been blown down to fill it or for high flow applications.

Economizer

The economizer circuit allows the customer to utilize the natural heat leak that occurs in every cryogenic storage vessel. When the pressure is above the setpoint of the economizer regulator, the economizer regulator (R-1) opens. This allows gas to be withdrawn directly off the headspace of the tank and travel through the internal vaporization coils, to warm the cold gas, and out the gas use valve. This will result in lowering the pressure of the tank. The economizer regulator can be isolated by closing valves V-2 and V-10.

Note: *The economizer circuit will only work if the customer is using product out of the vessel.*

Liquid Use

The liquid use circuit can be used for both a liquid application or a high flow gas use application. This circuit draws liquid directly up the dip tube and out through the liquid use valve (V-4). Some models have a bottom withdrawal valve that draws liquid out the bottom of the inner. For a high flow gas use application the liquid can be piped through a stand alone external process vaporizer. This can more than double the standard flow rates that can be achieved through the internal vaporization coils.

Gas Use

The gas use valve (V-1) leverages the internal vaporizer on the Perma-Cyl system to supply gaseous product to the end user.

Note: *The liquid is drawn up the dip tube, through the top knuckle and back down through the internal vaporization coil before exiting out the gas use valve.*

The internal vaporizer can support specific flow rates. The gas use valve used is a 1/2" globe valve. The line size for the gas use should be sized properly for the pressure and flow rate that is desired.

The Perma-Cyl tank will deliver gas at various flow rates and temperatures for different applications. The equipment that is being supplied gas from the Perma-Cyl tank controls the flow rate. Higher flow rates may provide very cold gas that could damage the equipment to which they are attached. To supply gaseous product, follow this step by step procedure.

1. Connect the proper regulator/regulating manifold to the liquid cylinder's gas use outlet.
2. Connect the proper piping between the final line regulator and the receiving equipment.
3. Open the pressure building valve.
4. Allow pressure to build to the operating pressure (refer to gauge).
5. Open the gas use valve.
6. Adjust the gas use regulator for the proper delivery pressure.

Caution! ***All valves on an empty Perma-Cyl tank 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 before conducting a gas or liquid withdrawal operation. Protective eyeglasses and gloves should always be worn.

At low flow rates, the Perma-Cyl tank 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.

Safety Circuit

The Perma-Cyl w/ FlexFill Piping Option tanks are equipped with dual spring operated relief valves (RV-2) and dual burst discs (BD-1). The dual safety manifold with diverter valve (V-8) is standard on these vessels. This allows for change out of safety relief devices without the need to empty the tank. These devices are used to automatically relieve excess pressure in the vessel and cannot be isolated by use of a valve. Replacement of these relief devices should only be on a "like for like" basis. Substitutes should be avoided unless approved by the manufacturer. Purge valves (V-7) can be used to relieve pressure before removing safety devices.

Vent/Full Trycock

The vent valve (V-9) is used to relieve excess pressure in the cylinder. On Perma-Cyl systems the vent valve is a gray handled globe valve. When installed indoors, the vent line should be piped outdoors using 1/2" nominal copper or the equivalent stainless steel hose. The vent valve also serves as the full trycock during filling operations. When the Perma-Cyl tank is filled by trucks other than Orca™ MicroBulk Delivery System trucks, the full trycock must be used to fill the vessel. When liquid starts to spit out of this valve while being filled, the filling process should be terminated.

Other Piping Circuits and Components

Phase Lines and Liquid Level Gauges

The Perma-Cyl tank is equipped with both a low pressure phase line (F) located on the top of the vessel and a high pressure liquid phase line (E) located on the bottom of the vessel. These lines are connected to a differential pressure gauge (Ll-1) which is used to indicate the amount of product in the vessel. The standard DP gauge used by Chart is the Cyl-Tel® Liquid Level Gauge. Customers can specify other models as options such as the WIKA Analog DP Gauge (see photos 1 & 2 on next page).

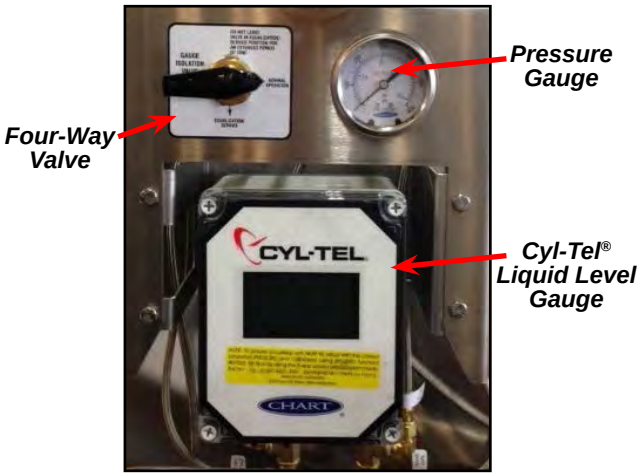


Photo 1

Four-Way Valve (see photos 1 & 2)

The four-way valve (V-11) is used as the primary isolation valve between the DP gauge and the phase lines from the tank. This four-way valve also provides an easy method to check the zero on the DP gauge. By turning the valve into the equalization position, the DP gauge can be zeroed and isolated from the tank pressure for removal or replacement.

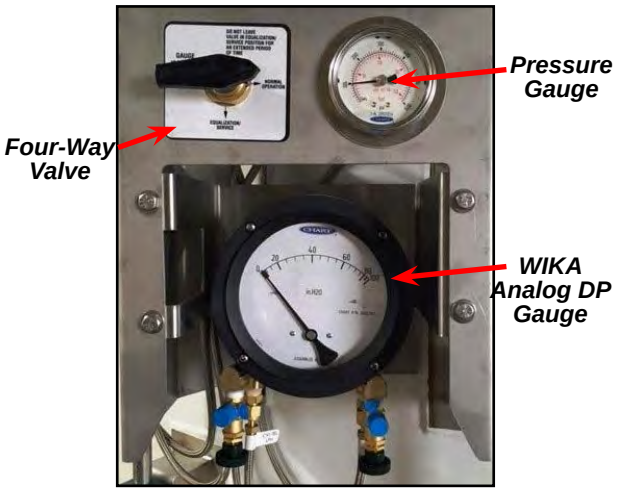


Photo 2

Pressure Gauge (see photos 1 & 2)

A single pressure gauge (R-1) on the Perma-Cyl tank is also tied into the low phase line and gives the operator a pressure reading in the gas phase of the vessel. This pressure gauge can also be isolated with the four-way valve.

Vacuum Evacuation Port

Unlike bulk tanks, Perma Cyl storage vessels are normally not provided with an on-board method of taking a vacuum reading. The vacuum evacuation port is sealed using a stainless steel disk with O-rings and a protective cover is placed over it (see Photo 3). Due to the relatively small volume of the annular vacuum space, taking vacuum readings is normally not recommended since the vacuum level is slightly reduced when taking this reading. The troubleshooting portion of this manual gives steps on how to determine if the vacuum might be weak. In the event that the vacuum does need to be checked, a trained vacuum technician would have to bring the appropriate equipment to get this done. In most cases where a vacuum has been compromised, it is often more economical to swap out the tank.

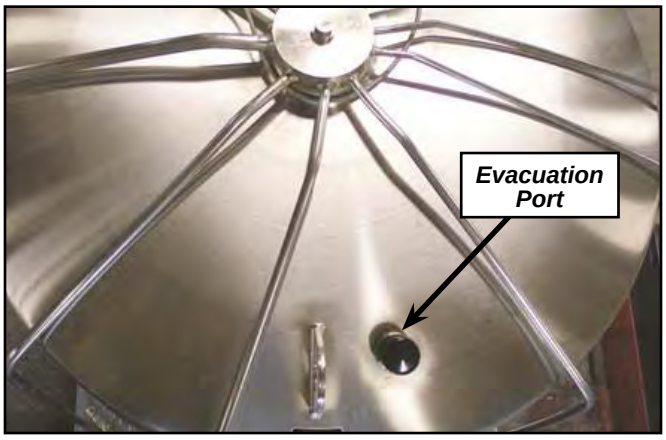
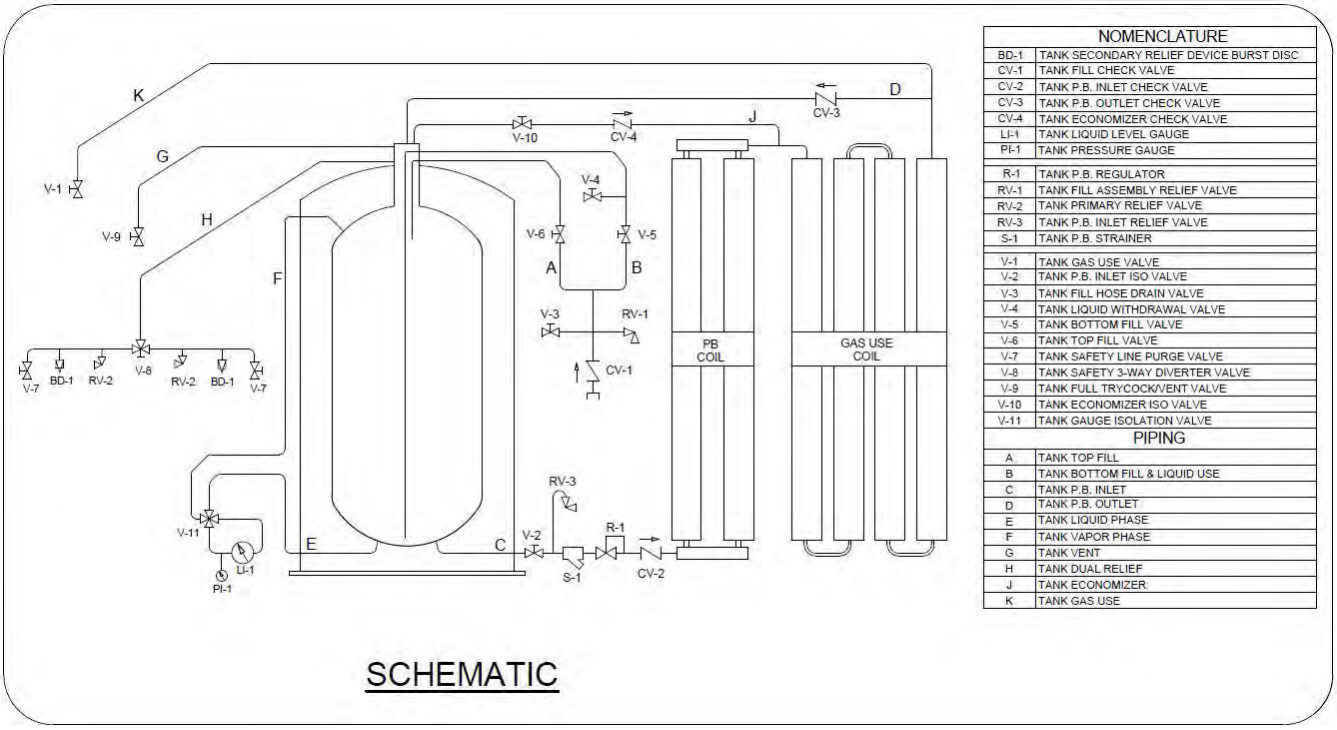


Photo 3 - Vacuum Evacuation Port with Cover



NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
CV-2	TANK P.B. INLET CHECK VALVE
CV-3	TANK P.B. OUTLET CHECK VALVE
CV-4	TANK ECONOMIZER CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PI-1	TANK PRESSURE GAUGE
R-1	TANK P.B. REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK P.B. INLET RELIEF VALVE
S-1	TANK P.B. STRAINER
V-1	TANK GAS USE VALVE
V-2	TANK P.B. INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK/VENT VALVE
V-10	TANK ECONOMIZER ISO VALVE
V-11	TANK GAUGE ISOLATION VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK P.B. INLET
D	TANK P.B. OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK VENT
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE

Figure 2 - Schematic for 2000/3000 VHP

2000/3000VHP Operation

The plumbing design for the 2000/3000 VHP Perma-Cyl system is different from the models described in the previous section. These models do not contain internal vaporization or pressure build coils. For the 2000 and 3000 models, all pressure building and process vaporization is provided by two external vaporizers. This plumbing configuration is commonly referred to as Option 09 or the ZX package.

2000 and 3000 VHP Primary Plumbing Circuits

(Refer to Figure 2)

Fill

The Fill Plumbing Circuit on these two models is the same as the models described in the previous section (see page 8).

Pressure Build

The pressure build circuit for the 2000 and 3000 VHP Perma-Cyl models is used to build pressure back in the vessel after a delivery or to maintain pressure as liquid is withdrawn from the vessel. The vessel pressure is set by adjusting the PB Regulator (R1) shown in Figure 2. Standard PB set points found in the 09 plumbing option kits are:

MP - 125-09

HP - 300-09

VHP - 450-09

Liquid is drawn off the bottom of the tank, runs through the PB regulator (R-1), then is vaporized by running through both the PB vaporizer and the gas use vaporizer. The vaporized gas then splits and a portion flows through check valve CV-3 and back to the headspace of the tank. The other portion goes directly to the customer through the gas use valve V-1. Liquid serving both the PB and gas use can be shut off by closing valve V-2.

Note: *Closing valve V-1 or V-2 will cut off any process gas going to the customer through the gas use valve.*

Economizer

The economizer circuit allows for the customer to utilize the natural heat leak that occurs in every cryogenic storage vessel. The economizer circuit for the 2000 and 3000 VHP models is comprised of a check valve (CV-4) which draws gas directly off the top of the tank and sends it through the gas use vaporizer in order to warm up the cold vapor prior to exiting the tank through the gas use valve. Flow through the 1 psig cracking pressure check valve (CV-4) only occurs when regulator R-1 closes. Valve V-10 shuts off the economizer circuit.

Liquid Use

The liquid use circuit for both the 2000 and 3000 VHP models is similar to the other Perma-Cyl models. This circuit draws liquid directly up the dip tube and out through the liquid use valve (V-4). For high flow gas use applications, the liquid can be piped from the liquid use valve (V-4) to a stand-alone external vaporizer that is properly sized for the flowrate. In this scenario, the gas use valve on the tank is not used so the PB and gas use external vaporizers on the tank become dedicated to pressure building only.

Gas Use

The gas use valve (V-1) on the 2000 and 3000 VHP Perma-Cyl models is the primary connection point to supply process gas to the customer. Unlike the other Perma-Cyl models, the liquid for the process gas comes directly off the bottom of the tank (C) and travels through the PB regulator (R-1). The unique design of this model allows for both the PB vaporizer and the gas use vaporizer to be utilized for process gas vaporization. After exiting the gas use vaporizer, the gas splits and supplies both the pressure build and the gas use as explained in the pressure build explanation for this particular model of tank.

Note: *Since all the liquid for both the PB and gas use requirements of this model tank travels through one regulator (R-1), the limiting factor on flow is this regulator. A high flow kit is offered for the 2000 and 3000 VHP tanks. This kit adds an additional PB regulator in parallel with the existing PB regulator (R-1) allowing for flows up to 3500 SCFH (see Photo 4).*

Photo 4 - High Flow Kit

All other plumbing circuits that are covered on pages 9 and 10 of this manual also apply to the 2000 and 3000 VHP Perma-Cyl models. These include the safety circuit, vent/full trycock, high/low phase lines, liquid level gauges and pressure gauges.

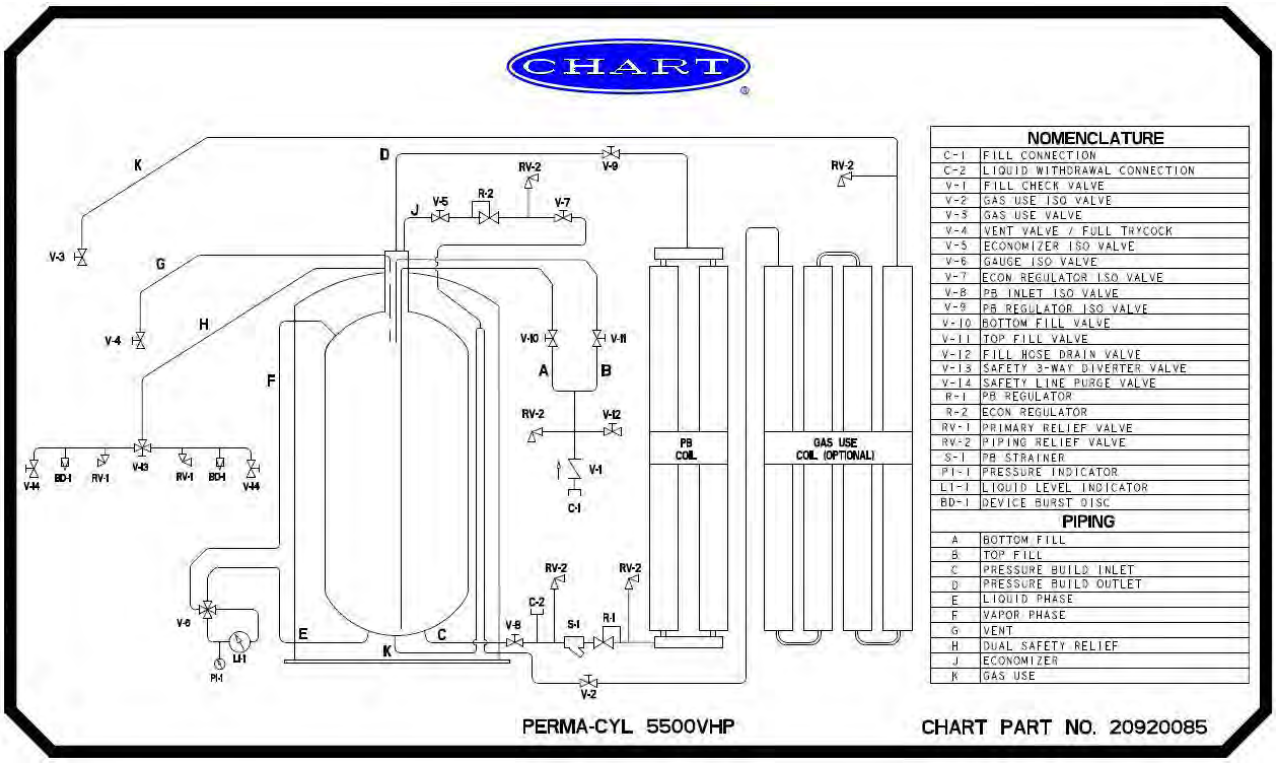


Figure 3 - Schematic with vaporizer for 5500 MP/VHP models.

5500 MP/VHP Operation

For the 5500 model, a single external vaporizer provides all pressure building vaporization. An optional 3500 SCFH hang-on or optional 5000 SCFH stand alone vaporizer may be added to the plumbing to provide all process vaporization. This plumbing configuration is referred to as Option 07 and is unique to the 5500 model.

Photo 5 - Perma-Cyl 5500 VHP

5500 MP/VHP Primary Plumbing Circuits
(Refer to Figure 3)

Fill

The standard fill plumbing circuit is exactly the same as all the other Perma-Cyl models (refer to page 8, Fill). A bulk fill connection option kit is offered to add a 1-1/2" CGA connection in place of a standard flare fitting.

Photo 6 - Fill Circuit

Pressure Build

The pressure build circuit for the 5500 Perma-Cyl model is used to build pressure back in the vessel after a delivery or to maintain pressure as liquid is withdrawn from the vessel. The vessel pressure is set by adjusting the PB regulator (R-1). Standard PB set points found in the 07 option kits are:

LP - 35-07 (MP version only)

MP - 125-07

HP - 300-07

VHP - 450-07

Photo 7 - External PB Vaporizer Option 07

As the tank pressure drops below the PB set point, the regulator opens and allows liquid to flow out the bottom of the tank, run through the PB regulator, vaporize in the PB coil, then go back into the gas phase of the tank. The pressure build circuit can be shut off by closing V-8 (see Photo 10). The PB regulator can be serviced by also closing V-9.

Note: *In a high flow scenario, the limiting factor in flow is the regulator. A high flow kit is offered that adds an additional PB regulator in parallel with the existing one (R-1) to allow for higher flows (see Photo 4).*

Economizer

The economizer circuit allows for the customer to utilize the natural heat leak that occurs in every cryogenic storage vessel. The economizer circuit for the 5500 VHP model is comprised of an economizer regulator (R-2) set at 15 psi above the PB regulator. When the tank pressure reaches the economizer regulator's set point, the economizer regulator opens and allows gas to flow directly from the head space to the gas use circuit. The economizer feature can be turned off by closing V-5. The economizer regulator can be serviced by closing V-5 and V-7.

Photo 8 - Economizer Plumbing Circuit

As long as both economizer valves are open, the economizer feature will always work. This includes all gas use vaporizer options. Even if the customer supplies their own vaporizer, the economizer function is never lost. For the LP (35-07) plumbing option, the economizer regulator is plumbed so it vents to atmosphere. This is common for liquid applications.

Liquid Use - VHP

The liquid use circuit for the 5500 VHP model is different than the other Perma-Cyl models. Liquid can be withdrawn from the bottom of the tank through the PB circuit (C) from C-2 (see Photo 10). For high flow gas applications, see the Gas Use section on the next page.

Liquid Use - MP

The liquid use circuit for the 5500 MP model is the same as the 5500 VHP model except it has an auxiliary liquid withdrawal port. The tank can be ordered with a plugged 1/2" FPT connection or a 1/2" ACME VJ valve. The VJ valve is available on either the left or right side of the tank.

Photo 9 - VJ Valve

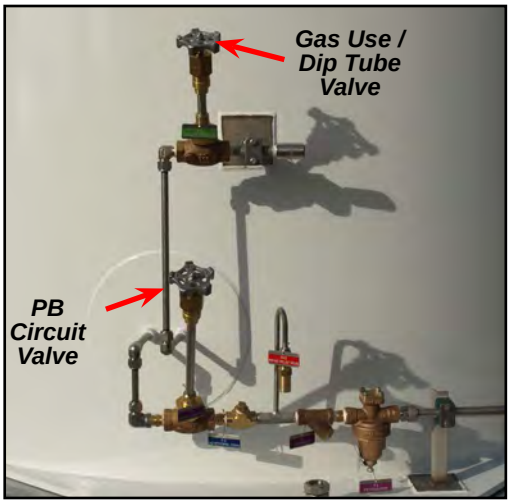


Photo 10 - Gas Use and PB Isolation Valve

Gas Use

The gas use circuit on the 5500 VHP model is the primary connection point to supply process gas to the customer. The gas use circuit on this model is different from other Perma-Cyl models. The gas use coil shown in Figure 3 is the optional 3500 SCFH vaporizer. Without this gas use coil option, the gas use circuit stops at the gas use isolation valve (V-2) (see Photo 10). Gas use coil options include a 3500 SCFH hang-on vaporizer (see Photo 11) or a stand alone 5000 SCFH vaporizer (to be plumbed on-site).

The gas use circuit works by the pressure in the vessel forcing the liquid out the gas use connection (K) and up a tube in the annular space. It then connects to the economizer inlet above the height of the liquid so the economizer works regardless of the amount of liquid in the vessel. The line goes back down to the bottom of the annular space before exiting and passing through either the optional hang on process vaporizer or stand alone process vaporizer.

Photo 11 - 5500VHP with optional hang on vaporizer

Vacuum Integrity

The 5500 model vessels are equipped with PN 4210049 Hastings 1415671S #DV-6R vacuum thermocouple gauge tubes (see Photo 12). Vacuum integrity may be tested with a vacuum meter. Deterioration or loss of vacuum will be apparent by cold spots, frost or condensation on the jacket, or evidenced by abnormally rapid pressure buildup. Unless one of these conditions is evident, the vacuum level should not be suspected. In the event one of the above conditions exist, see Vacuum Check Procedure on page 7 of this manual.

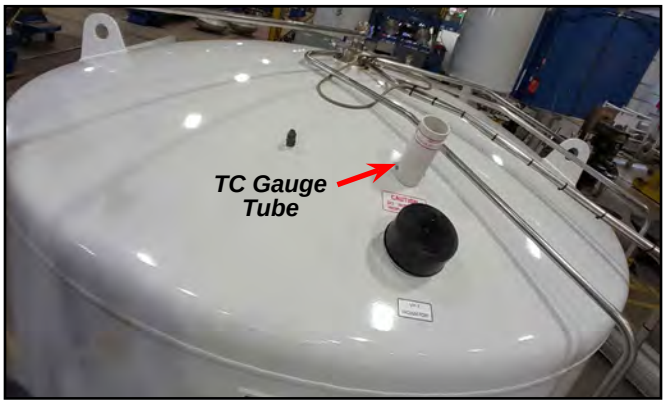


Photo 12 - Thermocouple gauge tube

Installation

Unloading and Placement of the Perma-Cyl Tank

The ASME style Perma-Cyl storage tanks have both a galvanized steel pallet base and lifting lugs on the top of the tank. Check the tare weight of the Perma-Cyl tank and unload using a properly sized forklift or crane.

Caution! ***Chart ASME Perma-Cyl tanks are not designed to be lifted or transported over the road unless empty. Do not attempt to lift with the lifting lugs if the tank has product in it.***

Tanks may be placed on a pre-cast concrete, asphalt pad, or on a properly compacted gravel bed if code and local regulations allow. NFPA requires a 'firm concrete or masonry foundation'.

The tank should be placed in a location with access to all sides of the unit. The tank should also receive a maximum amount of sunlight and airflow to assist in keeping the vaporizers and piping from accumulating large quantities of ice.

If surrounded by fencing, allow at least three feet around the entire perimeter of the tank for access. One must be able to check the gauges and controls.

Depending on local codes, the pallet base or the tank itself may need to be anchored to the foundation. Anchoring hole dimensions can be found on the spec drawing for each size Perma-Cyl tank. Anchor bolt sizes and depths should be specified per local building codes.

Installation Common Codes and Standards

The installer will need to find out what local city ordinances and which rules they are mandated to follow. Along with building codes one of the following standards may apply: Uniform Fire Code (UFC), Compressed Gas Association (CGA), and the National Fire Protection Association (NFPA).

Note: *Regulations vary in every part of the country. Always consult local codes!*

Conducting a Site Evaluation

Before a Perma-Cyl System is installed a site evaluation should be conducted. This trip to the customer's site will help identify any special needs that each site invariably has. While on site, note what application the Perma-Cyl System will be used for and what service it will be in. Decide whether the installation will be inside or outside. The proximity to the Orca™ MicroBulk Delivery System fill point and the user's equipment should be taken into account in making this decision. When the placement has been set, take measurements of how much and where the piping will be run.

Installation Tools and Supplies

Installation of the Perma-Cyl System requires that certain tools and supplies are available. For simple and economical installations, the following supplies and tools should be maintained, however, not all installations will require them.

Supplies

- Silicone Sealant (clear and white)
- PVC Cement
- 1/4" Plastic Screw Anchors
- Self-tapping Screws
- 9" Cable Ties
- Duct Tape
- Teflon Tape
- Chalk or Marker
- Leak Check Solution

Tools

Electric Hammer Drill:
Used for drilling holes and chiseling brick. Some accessories include:

- 3/4" x 21" Scaling Chisel
- 2-1/2" Core Bit
- 1" x 21" Drill Bit (Masonry)
- 1/4" x 13" Masonry Bit
- 1/2" Masonry Bit

7-1/4" Builder's Circular Saw:
Used for scoring brick and cutting wood exteriors. Some accessories include:

- Masonry Cutoff Wheel
- Combination Blade

Reciprocating Saw:
Used for cutting through wood walls. Some accessories include:

- 1/4" and 3/8" Masonry Bits
- Set of Twist Drills
- 2-1/2" Hole Saw

Oxy-Acetylene Torch:
Used for cutting rebar in poured concrete walls and floors.

Warning! When using the above mentioned tools, suitable eye and ear protection must be worn. Failure to do so could result in serious personal injury.

Additional Required Supplies

- Hand Truck with Strapping Attachment
- Torpedo Level
- Carpenter Square
- Extension Cord
- Oetiker Clamp Pliers
- Step Ladder
- Caulk Gun
- Assorted Hand Tools
- Flashlight

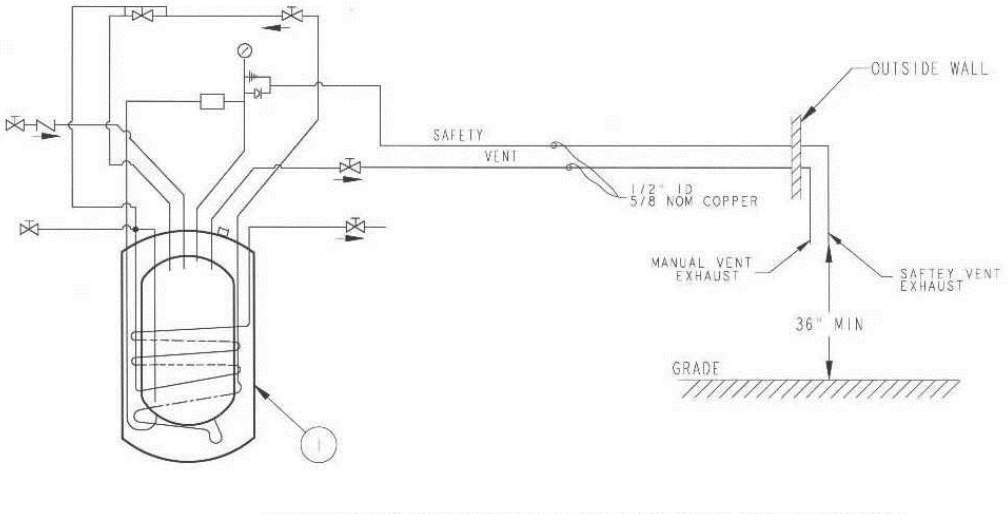


Figure 4 - Internally Sited/Filled Indoors/Pipe Out Safeties

Photo 13 - Indoor Installation

Indoor Installations

(Inert: Any Size / Oxygen: 230-700L)

Required:

- Room size - Air volume must allow oxygen level to stay between 18% to 25%
- Increased ventilation
- Valves vented outside (including mobile tanks)
- Oxygen monitors recommended for LAR and LN_2

Preferred:

- Sealed off away from other work areas
- Ground level next to outside wall

Internally Sited / Filled Indoors / Pipe Out Safeties

Some indoor installations allow for direct filling of the cylinder because of a close proximity to a doorway. These installations do not require the use of a wall box but still need to have safeties vented outside. A drain valve should be included in the safety line. This valve should be operated periodically to prevent moisture build-up in the line causing blockage. A 1/2" nominal copper should be used for both lines. Once through the wall, both lines should be directed downward and kept a minimum of 36" above the grade.

Wall Box

Indoor installations allow the tank to be positioned in very close proximity to the end user's equipment. This can be accomplished very easily using a Perma-Cyl Wall Box. The wall box contains a vent valve, fill line, pressure gauge and safety pipe out. All connections on the wall box are 1/2" FPT.

Installation of Hoses and Lines

General

Running the liquid fill hose and vent hoses from the fill box to the tank, will most likely be done differently at each location. By following the basic rules and guidelines listed below, the lines can be run easily and as simply as possible. A typical wall box installation is diagrammed below. Note the guidelines for piping to be used.

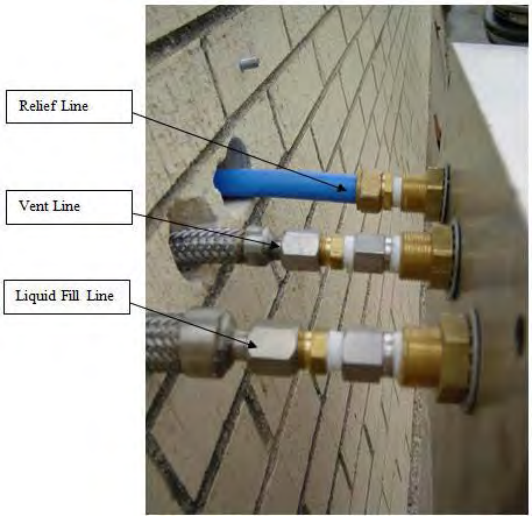


Photo 14 - Line Connection to Fill Box Panel

Line Connection to Fill Box Panel

1. Fasten NPT connection on vent hose to the NPT fitting on the back of the control panel.
2. Fasten NPT connection on fill hose to the NPT fitting on the back of the control panel.
3. Fasten NPT connection on safety vent to the NPT connection on the back of the wall box.
4. Feed all lines back into building while pushing panel back into the fill box.
5. Loosely fasten panel into box (it will be removed for pressure checking later).

Photo 15 - Wall Box

Connections on the wall box are provided for the vent line, liquid fill and relief line.

- Liquid Fill Line - The liquid fill should be piped using a minimum diameter of 3/4” nominal copper. The equivalent size stainless steel braided hose can also be used. The line should be connected from the fill connection in the wall box to the liquid fill check valve on the Perma-Cyl System. When piping this line there are a few guidelines that should be followed.
  - Bends and elbows should be kept at a minimum. When needed they should be made with a wide bend radius. A minimum bend radius of 6” should be observed.
  - The length of the line from the tank to the box should be kept to a minimum. Bare copper line can be used for lines. If bare copper is used, it should be insulated using air conditioning foam to keep condensation from dripping off the piping.
  - Line size should be a minimum 5/8” ID.
- Vent Line - The vent line should be run using 1/2” nominal copper or the equivalent size stainless steel braided hose. This line should connect the vent valve in the wall box to the vent valve on the Perma-Cyl System.
- Relief Line - The relief line should be run using 1/2” nominal copper. Kitec tubing or braided stainless steel hose can also be used. Relief lines should be no smaller in diameter than the outlet of the relief valve.

Caution! ***Restrictions in the relief valve outlet piping should be avoided to eliminate the possibility of excessive back pressure when the relief valve opens. Restrictions could reduce the required flow rate of the relief valve and pose a potential safety hazard.***

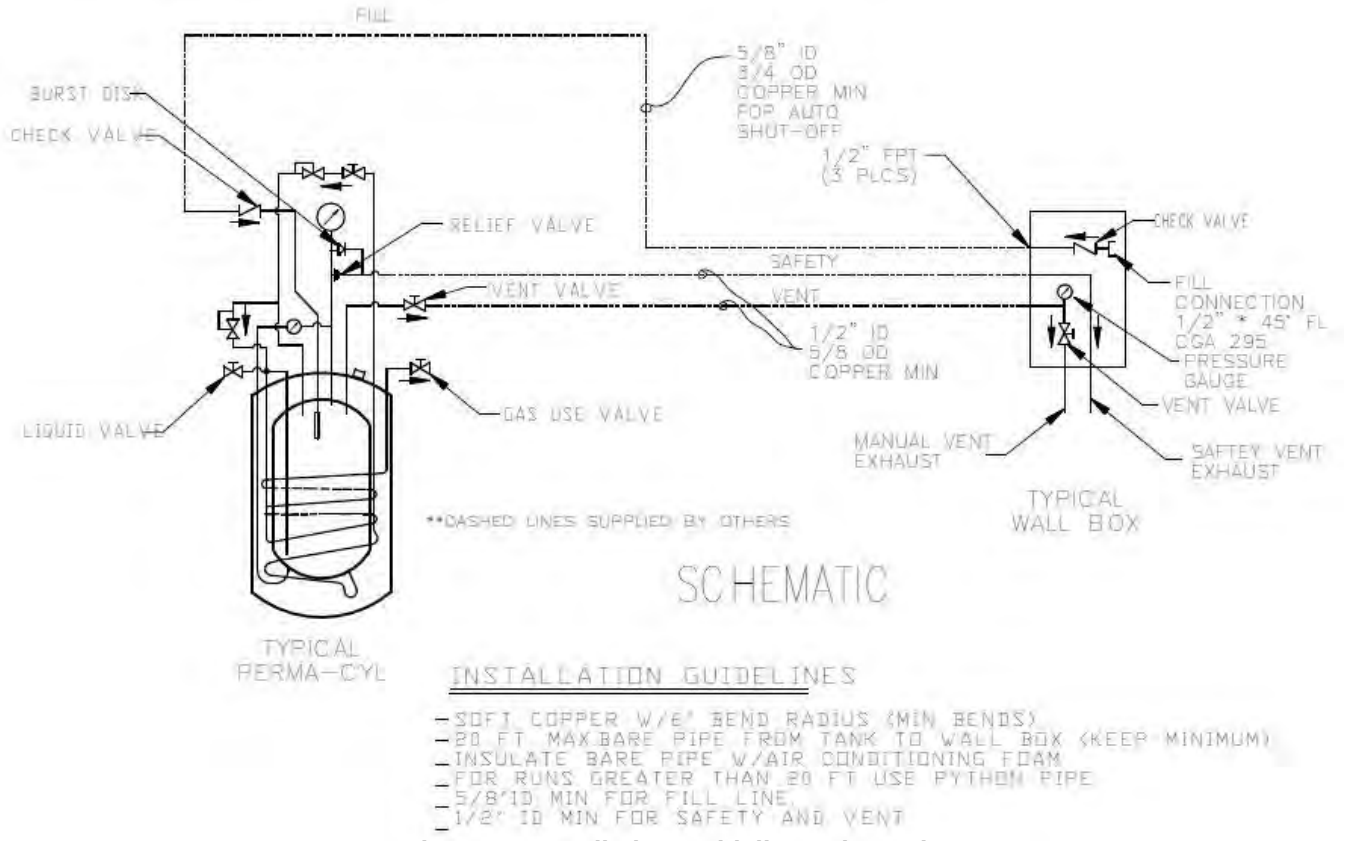


Figure 5 - Installation Guideline Schematic

Bolting to Floor

The Perma-Cyl tank is equipped with a flange on the bottom that has four holes for attachment. To ensure a safe environment, the tank or pallet base should be bolted to the floor.

1. Place tank in position with gauges facing forward.
2. Mark holes on floor, move tank.
3. Drill holes using the appropriate size masonry bit.
4. Blow out dust and insert masonry anchors.
5. Move tank back into position over holes and install lag bolts.
6. Tighten bolts.

Outdoor Installations

(Any Size)

Required:

- Open area
- Well ventilated
- At or above ground level

Photo 16 - Outdoor Installation

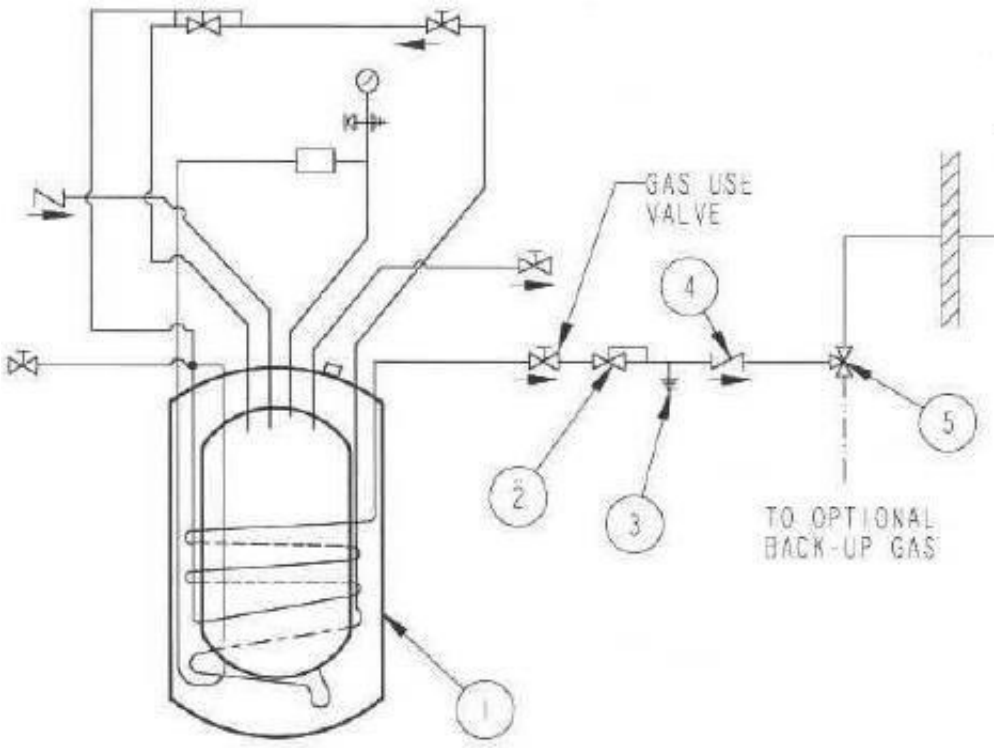


Figure 6 - Externally Sited/Gas Use Installation

Externally Sited / Gas Use Indoors

Outdoor installations can offer better accessibility for the Orca™ Delivery System for filling purposes. Also, lines do not need to be run except from the tank to the user's equipment. Outdoor installations should be made on a concrete pad. Local soil conditions and seismic codes will affect the thickness and reinforcement required for the concrete pad. The Perma-Cyl unit should be bolted to the concrete pad using appropriate sized anchor bolts. Also in outdoor installations, a fence can provide added protection for the Perma-Cyl system and work to eliminate tampering with any plumbing component.

Outdoor Installation Schematic

At a minimum, installation should include a final line regulator and a check valve. A typical piping schematic is depicted in Figure 6.

Item #	Description
2	Final Line Regulator
3	Safety Relief Valve
4	Check Valve
5	Coupling Valve for optional back up gas supply

First Fill/Purge Procedure

Note: *The Perma-Cyl tank is shipped with low purity nitrogen gas. Purging is necessary prior to filling. During first fill, only fill the vessel to 75% full to allow for liquid expansion experienced with a new (warm) tank. Each fill thereafter can be filled to 100% full. All valves on an empty Perma-Cyl tank should always be kept closed to prevent the inner vessel and plumbing from being contaminated.*

Purging and First Fill Procedure

1. Attach the source of liquid purge to the fill connection of the Perma-Cyl tank.

2. If the fill hose has not been kept under pressure since the last delivery, it will need to be purged. Purge the fill hose and connector through the purge valve, if so equipped, or by loosening the fill connection until vapor flows from the connection and then retighten. Use the hose drain on the tank piping if equipped as such.

3. If the Perma-Cyl tank is pressurized, open the vent valve and blow down to approximately 5 psi. To prevent drawing atmospheric contaminants back into the tank during the purging operation, a positive pressure of at least 5 psig should be maintained in the tank.

4. Partially fill the Perma-Cyl tank with product according to the table in the next column.

   Let liquid build pressure close to safety setting.

   Leak check all plumbing circuits while the tank is under maximum pressure.

   While vent gas is still warm and tank is under pressure, move the four-way valve to the 'Equalization' position and loosen the fittings on either side of the liquid level gauge to allow the gauge lines to purge with gas. Check the gas stream coming out of the fittings for evidence of moisture. Continue to flow the gas until lines have been purged and there is no visible signs of moisture. Tighten fittings to stop the flow of gas. Move the four-way valve to the 'Normal Operation' position.

   Vent all product out of the liquid valve and close before pressure drops below 5 psig.

Metered Product per Purge Cycle	
Filling Weight Table	
Tank Size	**Product Amount**
1000 L Perma-Cyl tank	2000 standard cubic feet
1500 L Perma-Cyl tank	3000 standard cubic feet
2000 L Perma-Cyl tank	4000 standard cubic feet
3000 L Perma-Cyl tank	5000 standard cubic feet
5500 L Perma-Cyl tank	7000 standard cubic feet

5. Fill Perma-Cyl tank with product as indicated in the table. Primarily use the bottom fill on a FlexFill style tank. Make sure some product is also routed through the top fill lines to purge them prior to totally filling the tank.

Open the PB circuit and set to maximum psi. Ensure liquid is flowing through this circuit as indicated by frosting on the pipes. Let liquid in the tank build pressure close to safety setting. Once desired pressure is reached, open liquid valve. When liquid is out of the tank and pressure is still high, open the vent and gas use valves. If a final line manifold is already connected to the gas use valve, purge through the manifold to insure that there is a flow through the gas use circuit and any moisture is purged out before liquid is introduced into this circuit.

Once pressure is blown down to 5 psig, close the liquid, vent and gas use valves.

6. Fill the Perma-Cyl tank with product and let the liquid in the tank build pressure close to the safety setting. Ensure the product is flowing through and purging the economizer lines. Control the pressure by opening the gas use and vent valves. Once pressure is approximately 5 psig, close the gas use and vent valves.

7. Fill the Perma-Cyl tank with product per the table and let the liquid in the tank build pressure to close to the safety setting. Once the desired psig has been reached, open the gas use and vent valves. Once pressure is approximately 5 psig, close the gas use and vent valves.

Note: *The purge gas should be cooling the tank. If the tank vent line is HOT, always purge until the vent line is cool or even frosted. A new, warm tank should go through a minimum of four or five purge cycles before filling with liquid.*

Filling the Tank After the Cool Down Process is Complete

1. If equipped with a bottom fill valve, the bottom fill valve and the tank vent valve are the valves to be used to fill a warm tank.

2. Have the driver start the pump and slowly deliver the liquid into the tank. Observe the tank pressure and control the pressure by venting the tank down or by using the top fill valve to control the pressure.

3. As the filling proceeds and the tank gets cooler, you should be able to pinch off and, in some cases, close the vent valve. We recommend that you do not fill the tank to the full trycock on the first fill. Fill to 75% in order to allow for liquid expansion as the tank contents absorb heat while the metal continues to cool down over time.

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
No gas to gas-use equipment. OR Insufficient pressure to gas-use equipment	Perma-Cyl tank empty.	1. Switch to emergency gas supply. 2. Call gas supplier for delivery.
	Gas-use valve to final line regulator is closed or other valves downstream are closed.	1. Open valve or valves, as needed. 2. Insure there is no obstruction in the line or valve.
	Pressure builder is not building sufficient pressure.	1. Open pressure building regulator control valve and allow pressure to build. 2. Adjust setting on regulator to a higher pressure. 3. If tank pressure fails to rise, see section on low tank pressure.
	Final line pressure regulator set too low or malfunctioning.	1. Ensure gas use valve is open and tank pressure is at least 25 psi higher than desired working pressure of final regulator. 2. Call service technician.
	Inappropriate type of regulator (high-pressure or 2-stage or too small) installed as final line regulator and is not able to supply sufficient gas flow.	1. Ensure gas use valve is open and tank pressure is at least 25 psi higher than desired working pressure of final regulator. 2. Inspect final line regulator or its specifications to determine if it has a suitable flow capacity for the required inlet and outlet pressures. 3. Call appropriate equipment supplier or service technician.
	Gas supply line, hose, or network contains excessive pressure drop.	1. Check line for sufficient diameter. 2. Remove all unnecessary bends, elbows, reducers, and small diameter valves. 3. Check for leaks in the gas supply line.
	Unknown	1. Call service technician
Frost or ice on sides, bottom, top-center and / or plumbing of tank.	Normal condition during and following gas use, liquid use or filling.	1. None 2. User to check tank for frost / leaks before use.
	Tank is being used for continuous flow application and is not receiving sufficient ambient heat to melt the frost or ice. (Tank may have heavy ice build-up continuous ice or frost.)	1. Move tank to a warmer location. 2. Add additional environmental heat and / or warm airflow to warm outer piping, components and sides of the tank. 3. Add switchover system to allow tank to rest and warm up when not in use.
	Leak in gas supply lines, gas-use equipment, or tank plumbing. (Frost is present on tank even after an extended period with no gas or liquid use.)	1. Evacuate and ventilate room. 2. If possible, locate and correct leak, 3. User to check tank for frost / leaks each morning before starting gas use. 4. Call appropriate equipment service technician.

Trouble	Probable Cause	Remedy
Frost or ice on sides, bottom, top-center and / or plumbing of tank. (continued)	Weak vacuum or failed vacuum.	1. Check if tank pressure is routinely high even during gas use and / or if tank has cold or ice spots even when not in operation as sign of vacuum problem. 2. Condensation or sweating is seen over the entire outer shell as a sign of vacuum problem. 3. Call gas service agent.
	Unknown.	1. Call gas service agent.
Routinely low pressure in tank.	PB shut-off valve is closed. (If PB is not operating, no frost ring will appear at the bottom of the tank or on external PB vaporizer during gas use.)	1. Open pressure building regulator control valve and allow pressure to build. 2. Call service agent to repair, replace or adjust regulator.
	Pressure builder setting is too low. (If PB is not operating, no frost ring will appear at the bottom of the tank or on external PB vaporizer during gas use.)	1. Adjust regulator to higher pressure and allow pressure to build. 2. Call service agent to repair, replace or adjust regulator.
	Economizer regulator setting is too low or economizer regulator is stuck open.	1. Adjust regulator to higher pressure (should be at least 15 psig above pressure build regulator setting). 2. Check to ensure regulator is not stuck open.
	Relief valve(s) stuck open.	1. Evacuate and ventilate the room. 2. Check exhaust of relief valve to see if gas is flowing at a pressure below the pressure stamped on the valve. 3. Tap lightly on the side of the relief valve to attempt to dislodge any obstruction holding valve open. Repeat several times, if needed. 4. Call gas service technician to replace relief valve, if necessary.
	Large gas leak from tank plumbing or from gas use system.	1. Evacuate and ventilate the room. 2. If possible, locate and repair leak or call gas equipment service technician.
	Gas or liquid withdrawal rate exceeds the tank specifications.	1. Excess usage will cause tank pressure to decrease as PB is unable to maintain pressure. Decrease withdrawal rate to within design specifications. 2. Increase pressure setting on PB regulator. 3. If withdrawing gas, consider: (a) withdrawing liquid and using external vaporizer, (b) installing larger tank, (c) installing additional tank(s), or (d) splitting application. 4. If withdrawing liquid, consider: (a) installing larger tank, (b) splitting application or (c) installing additional tank(s). 5. Call gas service agent.
	Unknown	1. Switch to emergency gas cylinder. 2. Call gas service technician.
Gas supply to gas-use equipment is too cold.	Ambient temperature surrounding the Perma-Cyl tank is too cold.	1. Move tank to warmer location. 2. Install freestanding ambient vaporizer on gas supply line in warmer location or install in-line gas heater.

Trouble	*Probable Cause*	*Remedy*
Gas supply to gas-use equipment is too cold. (continued)	Gas withdrawal rate from Perma-Cyl tank exceeds the capacity of tank's ambient vaporizer.	1. Reduce gas withdrawal rate to within specified parameters. 2. Install freestanding ambient vaporizer on gas supply line in warm location or install in-line heated vaporizer on gas supply circuit. 3. Install larger tank with greater withdrawal rate capacity.
Routinely high tank pressure.	Normal when little or no gas has been used for several days.	1. None - Routine use of gas will automatically reduce the tank pressure. 2. Gas usage must exceed NER of tank, if not, contact gas supplier for different tank model.
	Economizer function on regulator is malfunctioning.	1. If tank is in a mixer application and the usage is low, consider drawing gas off the vent line, as the economizer will not work completely in non-consistent draws. 2. Call gas service technician to clean, repair, or replace regulator.
	Tank is over-filled	1. If tank is filled to or beyond proper fill level, pressure builds very rapidly and relief valve may open. 2. Use gas or liquid as soon as possible to reduce tank contents. 3. Vent tank until no liquid is coming out the vent valve.
	Pressure building function on regulator is set too high or regulator is malfunctioning.	1. Reduce pressure setting by turning adjustment knob counter-clockwise to the desired pressure setting and continuing normal gas use until pressure drops. 2. Close PB isolation valve and carefully observe pressure to ensure tank pressure does not drop too low during use. 3. Call gas service technician to adjust PB regulator.
	Weak or failed vacuum.	1. Observe if condensation and / or frost are present even during periods of non-use as possible sign of vacuum problem. 2. Call gas service technician.
	Unknown.	1. Call gas service technician.
Hissing sounds or evidence of gas leaking near tank, gas lines, or gas-use equipment.	Normal for short periods of time from some regulators and relief valves.	1. Evacuate and ventilate room or area, if necessary. 2. If possible, observe leak. If leak is not large, does not last long, does not occur frequently and is in well-ventilated area, no action may be needed. If in doubt, call appropriate equipment service technician. 3. If above combined conditions do not exist, call equipment service technician and observe "Safety" precautions.

Trouble	Probable Cause	Remedy
Hissing sounds or evidence of gas leaking near tank, gas lines, or gas-use equipment. (continued)	Large leaks, leaks from elsewhere in the system, sustained leaks, or frequent leaks (not normal).	1. Evacuate all personnel from affected areas. Ventilate room / area. 2. If possible, locate the leak and repair it or call gas service or gas-use equipment service technician.
High gas usage.	Unrecognized increase in actual gas use.	1. None for Perma-Cyl tank or gas supplier 2. Gas user to determine reason for increase in gas use.
	Leak in gas supply line or network or in gas-use equipment or tank plumbing, e.g. relief valve.	1. Evacuate and ventilate room, if necessary. 2. If possible, locate and repair leak or call gas-use equipment service agent. 3. User to check tank for frost / leaks before operations.
	Tank pressure routinely too high and venting.	1. See troubleshooting section on routinely high tank pressure.
	High flash or vaporization losses in liquid use application due to high pressure / temperature liquid in tank.	1. Vent tank to approximately 25 psi. Follow safety procedures. 2. In future only refill the Perma-Cyl tank with low-pressure cryogenic product.
	Error in gas delivery or supplier invoice.	1. Check gas usage history / pattern against supplier invoices. 2. Call gas supplier, if necessary.
Perma-Cyl tank cannot be filled.	Perma-Cyl tank is full.	1. None
	Fill line is blocked or inoperative.	1. Check for obstructions in the fill line. Clear if necessary. 2. Gently tap on check valve to assure proper operation. 3. Ensure top & bottom fill valves are open. 4. Call gas service technician.
	Orca™ MicroBulk Delivery System is not functioning properly.	1. Refer to Orca system Troubleshooting.
	Transfer hose is obstructed, e.g. hose is bent excessively, crimped or plugged.	1. Clean obstruction, inspect hose for damage, and, if everything is satisfactory, continue the filling.
Perma-Cyl tank does not initiate automatic fill shut off properly.	Fill line piping created too much pressure drop.	1. Ensure fill line is piped with 3/4” nominal copper (or equivalent) with minimal 90° bends. 2. Re-route fill piping.
	Improper fill procedure.	1. Review Orca system/Perma-Cyl tank filling procedure. 2. Ensure that all vent and use valves of the tank are closed.
	Only works with Chart Orca MicroBulk delivery vehicle. For other type trucks use full trycock.	N/A
Liquid withdrawal contains high level of gas.	Saturated liquid pressure in Perma-Cyl tank is too high. (Temperature or energy level of contents is too high due to excess pressure.)	1. Ensure PB shut-off valve is closed. 2. Open vent valve to allow excess pressure to vent until desired pressure is obtained. Follow “Safety” guidelines and procedures for venting. 3. Install secondary lower pressure relief valve to reduce saturated pressure of liquid in the future. 4. In future only refill the Perma-Cyl tank with low-pressure cryogenic product.

Trouble	Probable Cause	Remedy
Vacuum pump-out port and / or vacuum plug are open or damaged.	Pump-out plug or port have been damaged or tampered with.	1. If possible, transfer any remaining contents to another tank. 2. Call gas service technician to replace and repair tank.
	Inner vacuum space leak has dislodged safety pump-out plug.	1. If possible, transfer any remaining contents to another tank. 2. Cover pump out port to keep moisture from getting into the annular space. 3. Call gas service technician to replace and repair tank.

Warning! Use only parts which are cleaned and approved for oxygen service. Chart recommends the use of only Chart approved parts.

Specifications

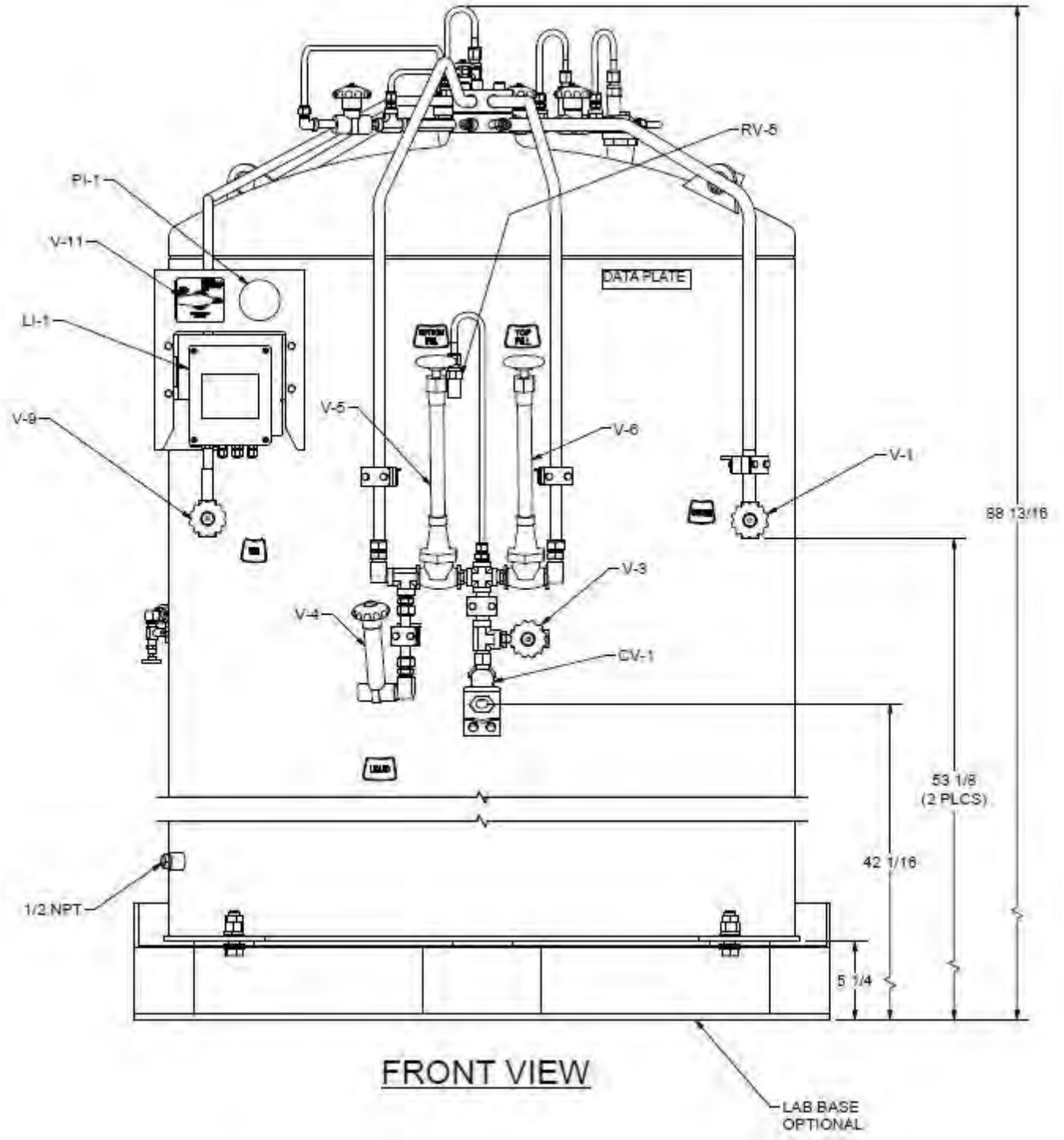
Model	1000L HP/VHP Plate Base	1500L HP/VHP Pallet Base	2000L HP/VHP Pallet Base	3000L HP/VHP Pallet Base	3000L HP/VHP Horizontal Forklift Base	5500L VHP Pallet Base
CAPACITY (Liters)						
Gross	1,056	1,550	2,042	2,911	2,911	5,430
Net	950	1,455	1,945	2,707	2,707	5,106
CAPACITY (Gallons)						
Gross	279.0	409.5	539.5	770	770	1,436
Net	251.0	384.4	513.9	715	715	1,350
MAWP						
psig	350/500	350/500	350/500	350/500	350/500	500
barg	24.1/34.5	24.1/34.5	24.1/34.5	24.1/34.5	24.1/34.5	34.5
MAXIMUM PRE-SET OPERATING PRESSURE						
psig	300/450	300/450	300/450	300/450	300/450	450
barg	20.7/31.0	20.7/31.0	20.7/31.0	20.7/31.0	20.7/31/0	31.0
DESIGN SPECIFICATIONS						
DOT/ASME	ASME	ASME	ASME	ASME	ASME	ASME
STORAGE CAPACITY (1)						
Nitrogen						
SCF	24,350	35,790	47,847	66,592	66,592	125,600
Nm^3	689	1,013	1,257	1,750	1,750	3,560
Oxygen						
SCF	30,070	44,220	59,089	82,239	82,239	155,000
Nm^3	850	1,250	1,553	2,161	2,161	4,390
Argon						
SCF	29,400	43,220	57,786	80,425	80,425	151,600
Nm^3	832	1,223	1,519	2,115	2,115	4,290
THERMAL PERFORMANCE (2) (NER%/Day)						
N_2	1%	1%	1%	1%	1%	.7%
O_2 - Ar	.62%	.62%	.62%	.62%	.62%	.43%
GAS DELIVERY RATE (LN_2/LAR/LOX)						
SCFH	960	1,350	1,350/2,000(3)	1,350/2,000(3)	2,000	3,500/5,000(4)
Nm^3h	25.2	35.4	35.4/52.4	35.4/52.4	52.4	141
DIMENSIONS						
Diameter (in/mm)	42 / 1,067	48 / 1,219	48 / 1,219	59 / 1,499	59 / 1,499	80 / 2,030
Height (in/mm)	82 / 2,083	92/91 - 2,337/2,311	118.5/119.5 - 3,010/3,035	122/122.5 - 3,099/3,112	71 / 1,803	118 / 3,000
Tare Weight (lbs/kg)	1,500/1,750* 680/794	2,200/2,500** 998/1,134	2,600/2,950** 1,179/1,338	3,300/4,250** 1,497/1,928	3,800/4,250** 1,724/1,928	8800** 3,998
PALLET BASE DIMENSIONS						
Dimensions (in)	46-5/8 x 50-5/8	52-5/8 x 66-5/8	52-5/8 x 66-5/8	60-1/2 x 75-1/2	N/A	101-1/2 x 85-1/2

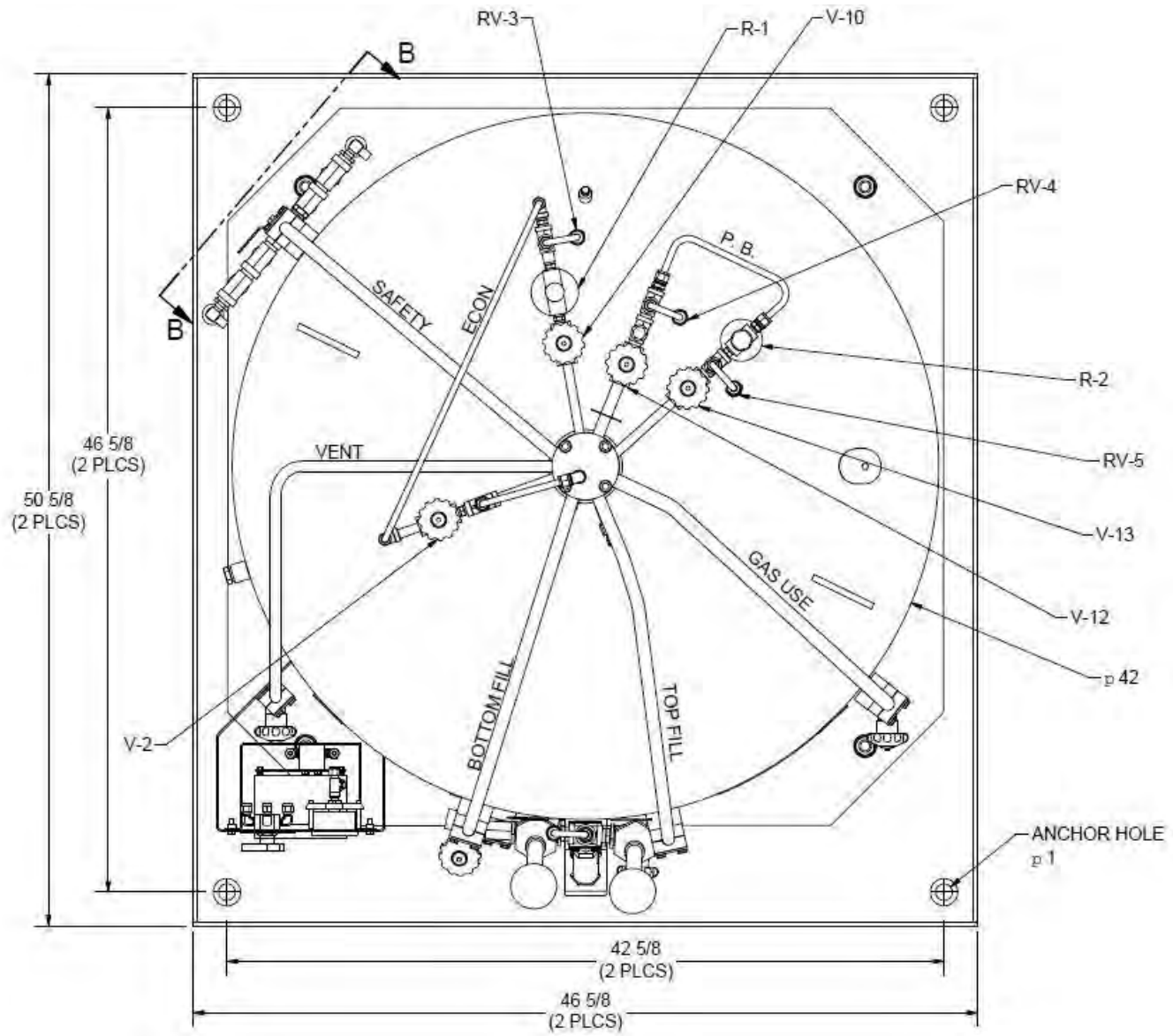
All specifications are subject to change without prior notice.
1) Values are based on net capacity at 0 psig (0 barg) for ASME vessels.
2) Values are based on gross capacity.
3) Optional 3,500 SCFH (92 Nm^3h) flow kit available.
4) Flow rate dependent on process vaporizer option.
All dimensions are measured from the floor to the top of the highest plumbing component.

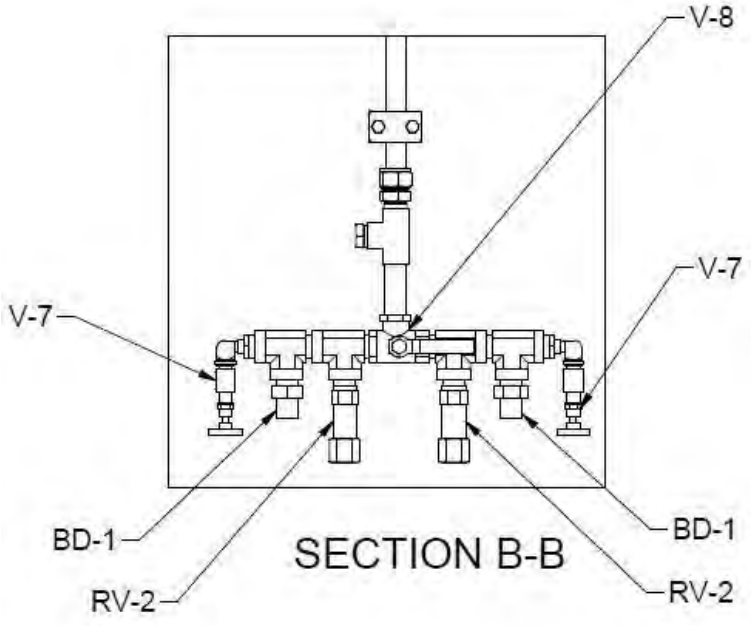
Patents: 6,128,908 • 5,954,101 • 6,799,429
ASME - American Society of Mechanical Engineers, Section VIII, Division 1
Contact Factory for Canadian Approvals.
**Weights do not include lab base option. (base option; 265 lbs)*
***Weights include lab bases.*

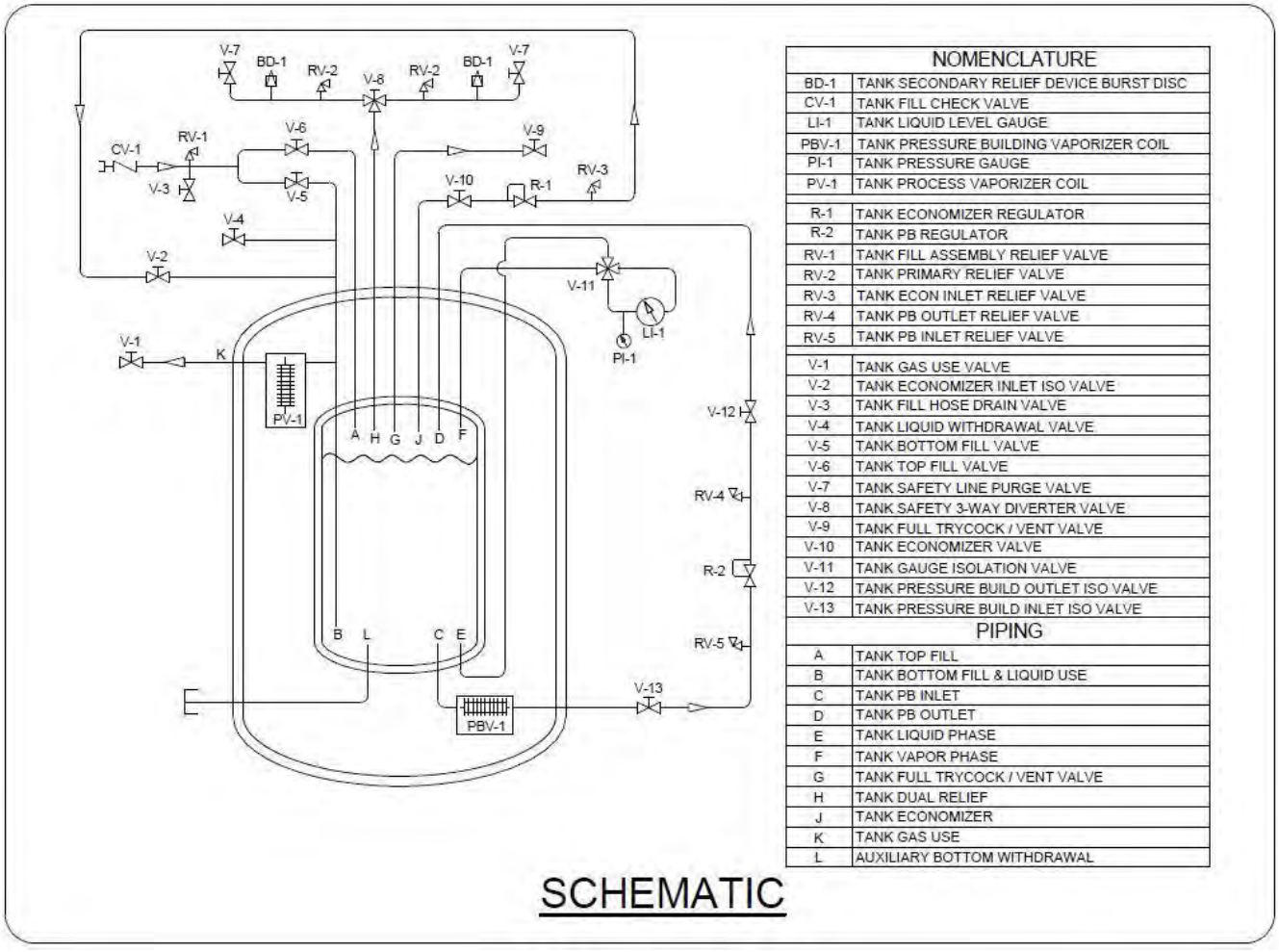
Illustrations & Parts Listing

1000 HP/VHP FlexFill




RV-3
R-1
V-10
B
B
RV-4
P. B.
SAFETY
ECON
R-2
RV-5
46 5/8
(2 PLCS)
VENT
50 5/8
(2 PLCS)
V-13
GAS USE
V-12
p 42
V-2
BOTTOM FILL
TOP FILL
ANCHOR HOLE
p 1
42 5/8
(2 PLCS)
46 5/8
(2 PLCS)


V-8
V-7
V-7
BD-1
BD-1
RV-2
RV-2
SECTION B-B



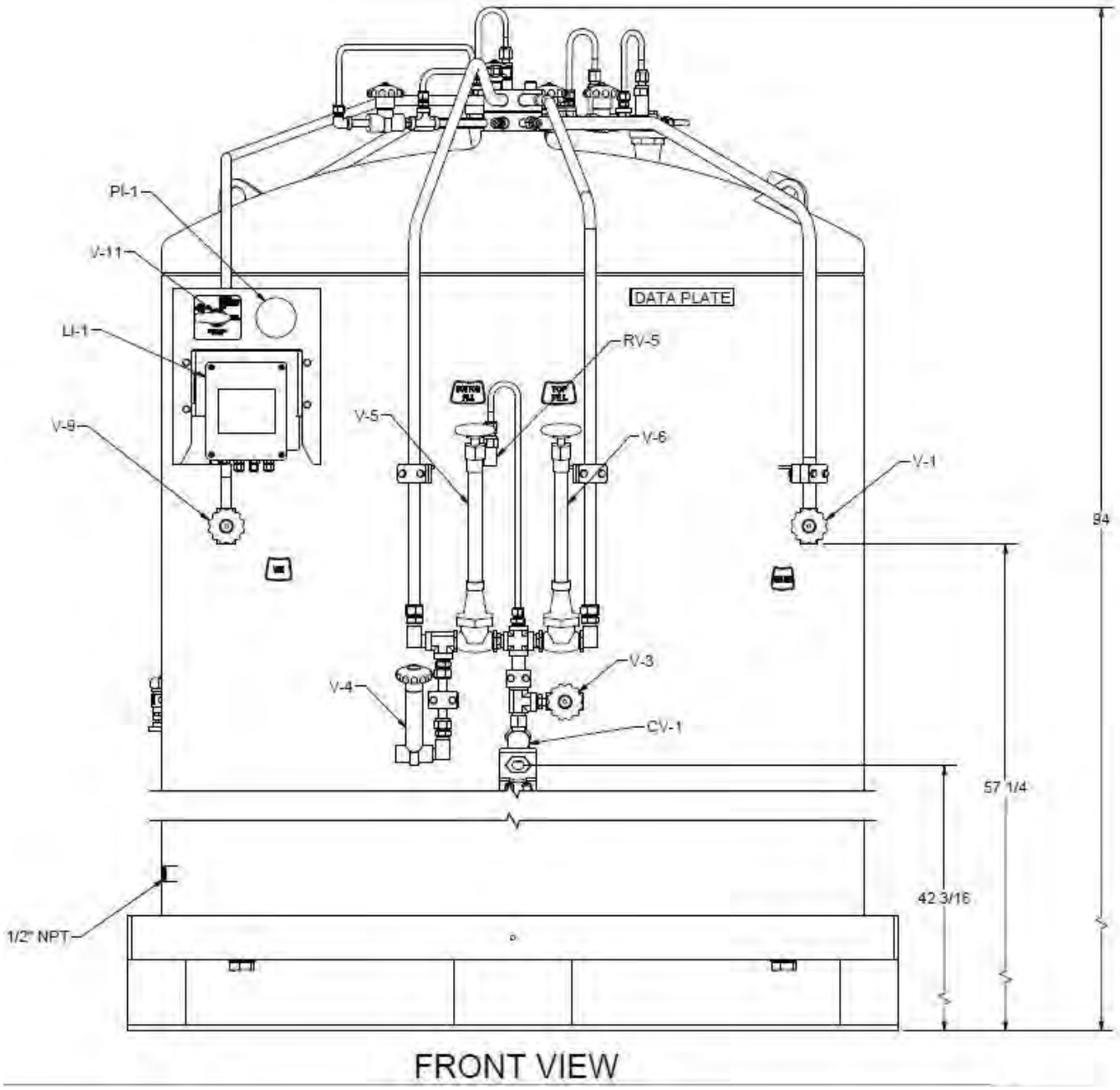
NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PBV-1	TANK PRESSURE BUILDING VAPORIZER COIL
PI-1	TANK PRESSURE GAUGE
PV-1	TANK PROCESS VAPORIZER COIL
R-1	TANK ECONOMIZER REGULATOR
R-2	TANK PB REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK ECON INLET RELIEF VALVE
RV-4	TANK PB OUTLET RELIEF VALVE
RV-5	TANK PB INLET RELIEF VALVE
V-1	TANK GAS USE VALVE
V-2	TANK ECONOMIZER INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK / VENT VALVE
V-10	TANK ECONOMIZER VALVE
V-11	TANK GAUGE ISOLATION VALVE
V-12	TANK PRESSURE BUILD OUTLET ISO VALVE
V-13	TANK PRESSURE BUILD INLET ISO VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK PB INLET
D	TANK PB OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK FULL TRYCOCK / VENT VALVE
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE
L	AUXILIARY BOTTOM WITHDRAWAL

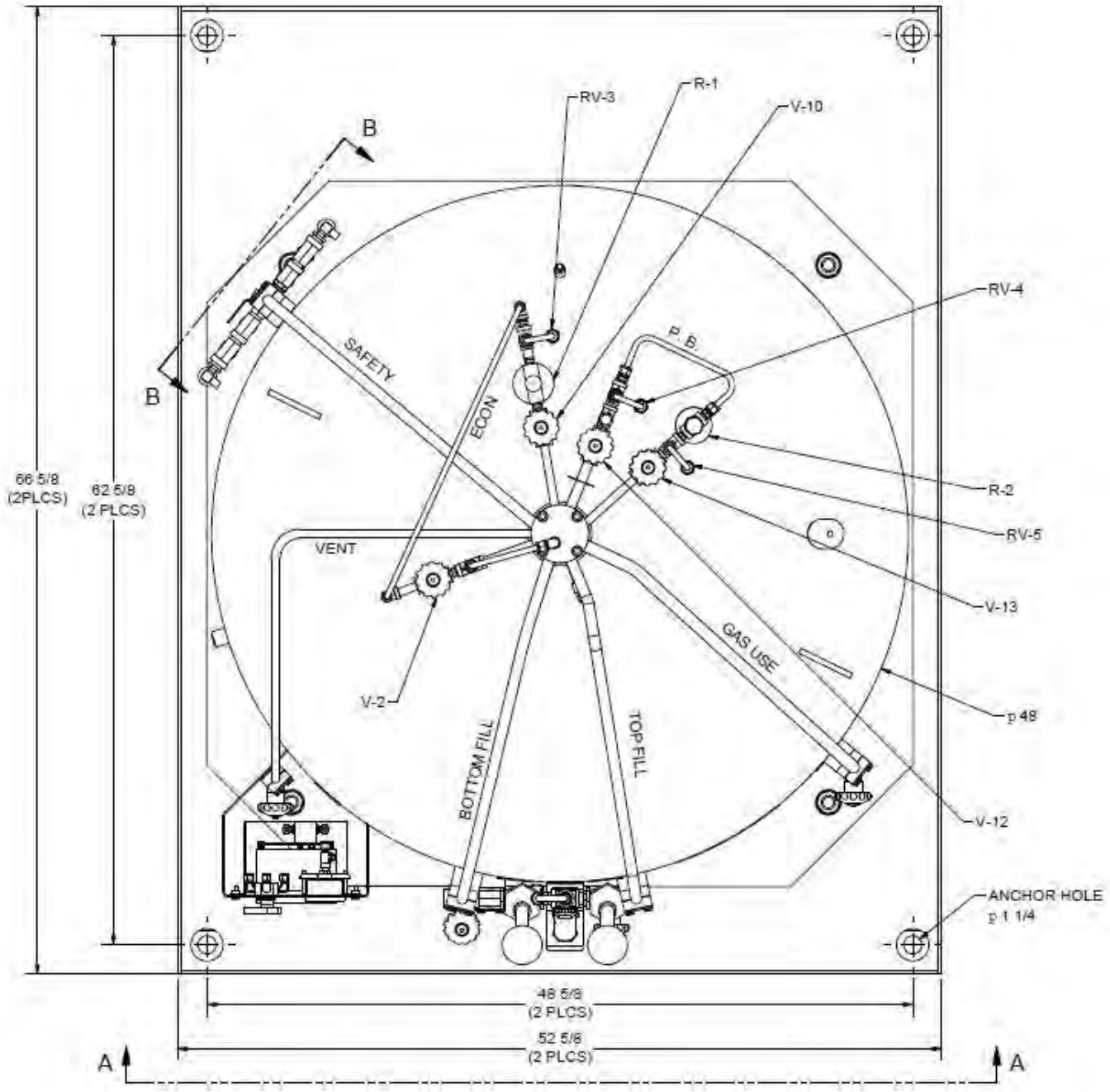
Item	PN	Description
BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
BD-1	11526622	RPD ASSY INLINE 1/2MPT 700 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
LI-1	20910598	CYL-TEL GEN 5 0-200"H_2O
LI-1	20923160	DIFF PG 4.5" 0-60" H_2O VITON (O_2, N_2)
LI-1	20923161	DIFF PG 4.5" 0-60" H_2O VITON (AR)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11501177	REGULATOR .250FPT @ 140 PSI
*R-1	20885664	REGULATOR .250FPT @ 325 PSI
*R-1	10619675	REGULATOR .250NPT @ 475 PSI
*R-2	2110032	REGULATOR .250FPT @ 125 PSI
*R-2	2110742	REGULATOR .250FPT @ 300 PSI
*R-2	10619667	REGULATOR .250NPT @ 450 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI
*RV-2	20599868	RV BRS 1/2MPT 350 PSI

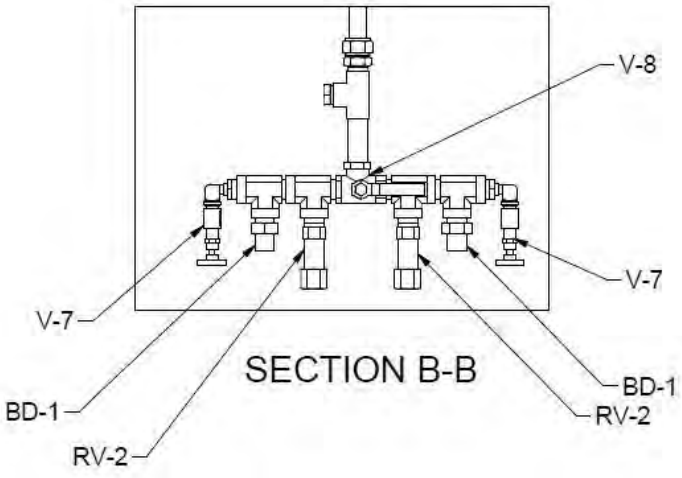
Item	PN	Description
*RV-2	20894583	RV BRS 1/2MPT 500 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI
RV-4	1812702	RV BRS 1/4MPT 550 PSI
RV-5	1810702	RV BRS 1/4MPT 550 PSI
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	11905999	VALVE SHUTOFF 1/4FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11905999	VALVE SHUTOFF 1/4FPT

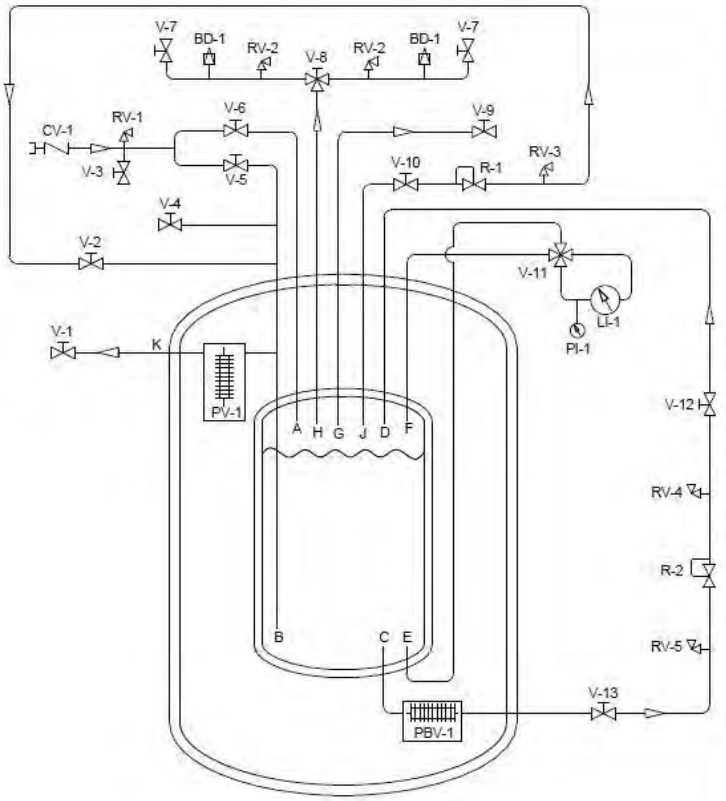
*Part numbers are dependent on the plumbing option kit chosen for the vessel.

1500 HP/VHP FlexFill




RV-3
R-1
V-10
B
B
RV-4
SAFETY
ECON
P. B.
R-2
RV-5
V-13
66 5/8
(2PLCS)
62 5/8
(2 PLCS)
VENT
V-2
GAS USE
p 48
BOTTOM FILL
TOP FILL
V-12
ANCHOR HOLE
p 1 1/4
48 5/8
(2 PLCS)
52 5/8
(2 PLCS)
A
A


V-8
V-7
V-7
SECTION B-B
BD-1
BD-1
RV-2
RV-2



NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PBV-1	TANK PRESSURE BUILDING VAPORIZER COIL
PI-1	TANK PRESSURE GAUGE 0-400 PSI
PV-1	TANK PROCESS VAPORIZER COIL
R-1	TANK ECONOMIZER REGULATOR
R-2	TANK PB REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK ECON INLET RELIEF VALVE
RV-4	TANK PB OUTLET RELIEF VALVE
RV-5	TANK PB INLET RELIEF VALVE
V-1	TANK GAS USE VALVE
V-2	TANK ECONOMIZER INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK / VENT VALVE
V-10	TANK ECONOMIZER VALVE
V-11	TANK GAUGE ISOLATION VALVE
V-12	TANK PRESSURE BUILD OUTLET ISO VALVE
V-13	TANK PRESSURE BUILD INLET ISO VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK PB INLET
D	TANK PB OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK FULL TRYCOCK / VENT VALVE
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE

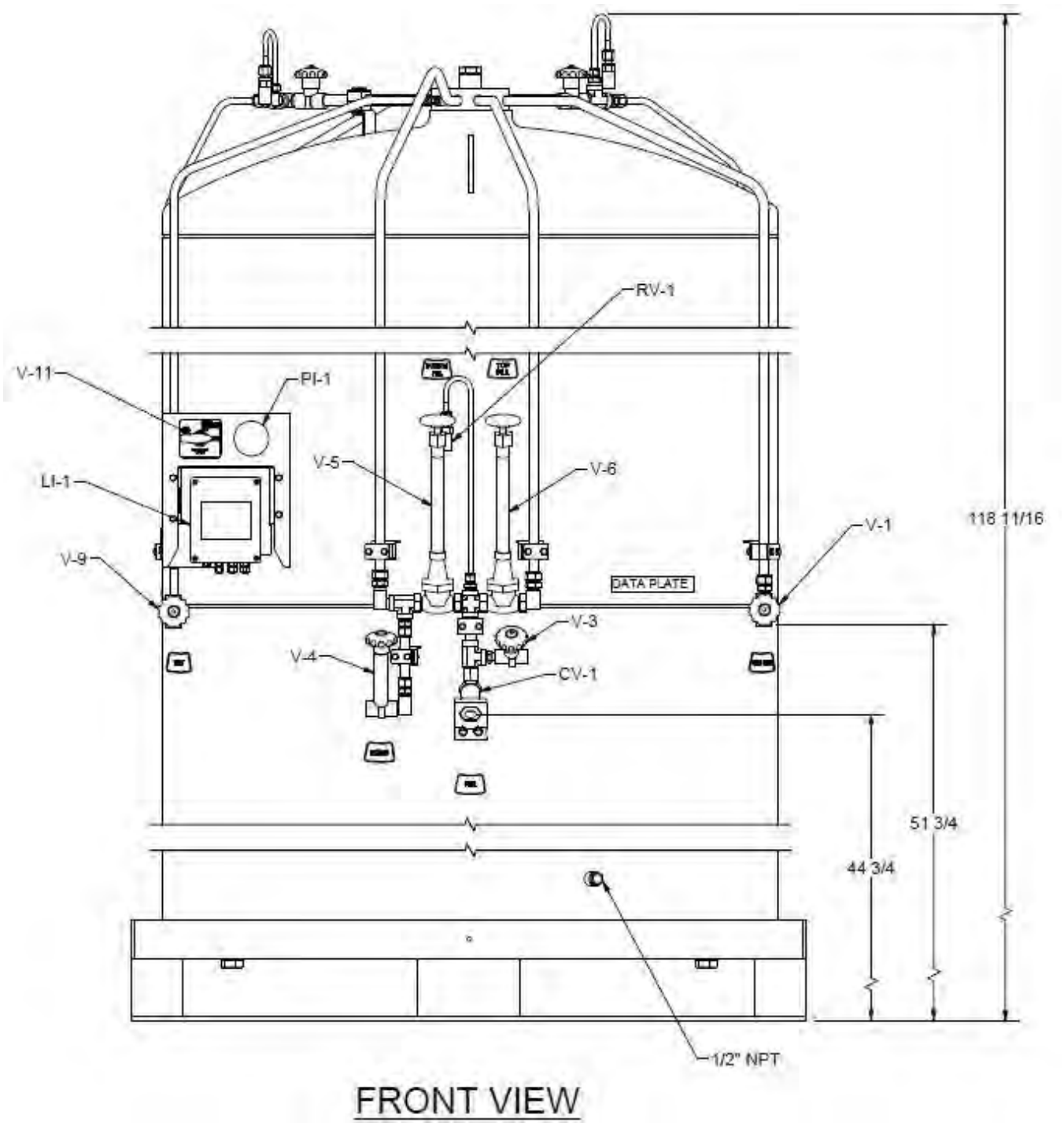
SCHEMATIC

Item	PN	Description
*BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
*BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
*BD-1	11526622	RPD ASSY INLINE 1/2MPT 700 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
*LI-1	20910598	CYL-TEL GEN 5 0-200"H_2O
*LI-1	20923162	DIFF PG 4.5" 0-100" H_2O VITON (O_2, N_2)
*LI-1	20909588	DIFF PG 4.5" 0-150" H_2O VITON (Ar)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11501177	REGULATOR .250FPT @ 140 PSI
*R-1	20885664	REGULATOR .250FPT @ 325 PSI
*R-1	10619675	REGULATOR .250NPT @ 475 PSI
*R-2	2110032	REGULATOR .250FPT @ 125 PSI
*R-2	2110742	REGULATOR .250FPT @ 300 PSI
*R-2	10619667	REGULATOR .250NPT @ 450 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI
*RV-2	20599868	RV BRS 1/2MPT 350 PSI

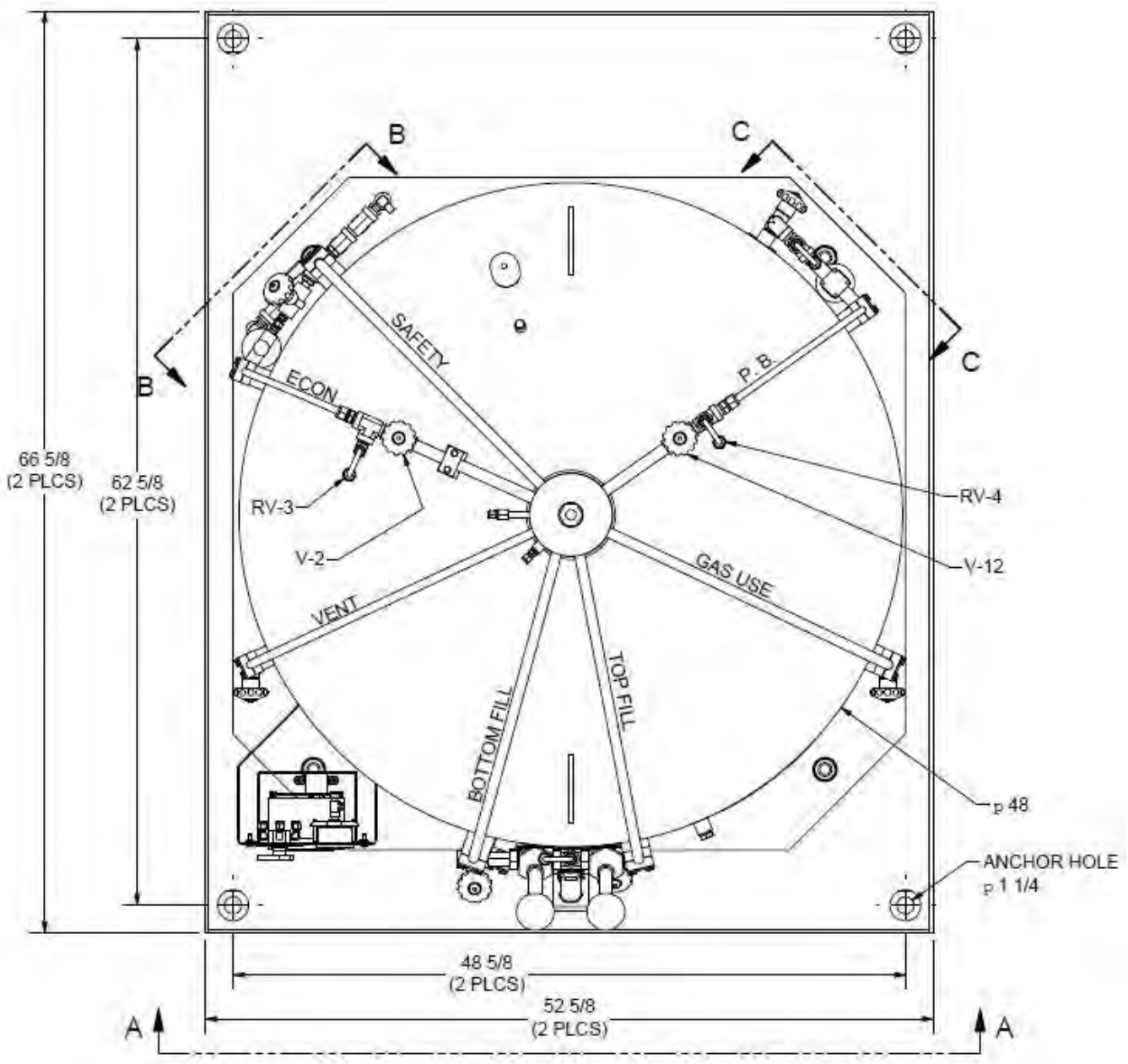
Item	PN	Description
*RV-2	20894583	RV BRS 1/2MPT 500 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI
RV-4	1812702	RV BRS 1/4MPT 550 PSI
RV-5	1810702	RV BRS 1/4MPT 550 PSI
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	11905999	VALVE SHUTOFF 1/4FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11905999	VALVE SHUTOFF 1/4FPT

*Part numbers are dependent on the plumbing option kit chosen for the vessel.

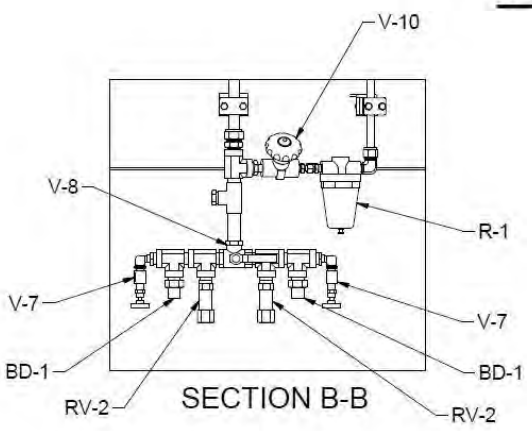
2000 HP FlexFill



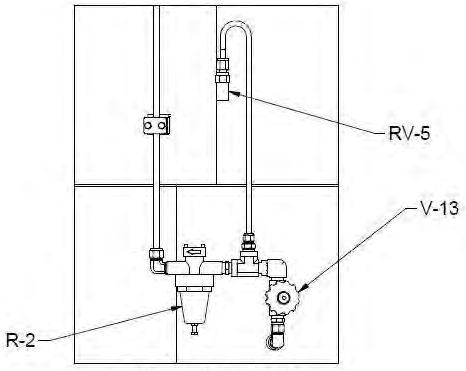
FRONT VIEW



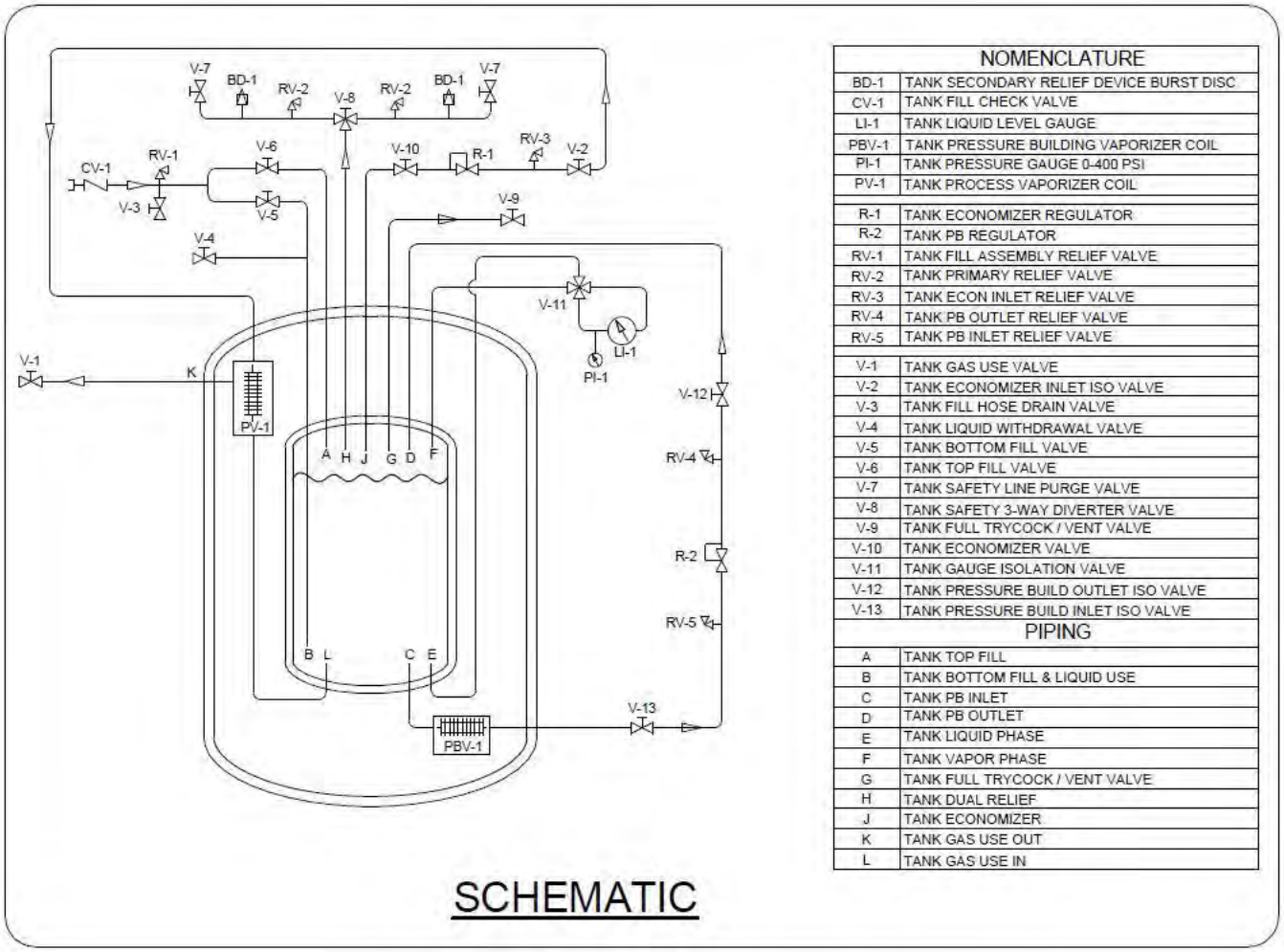
TOP VIEW



SECTION B-B



SECTION C-C



NOMENCLATURE	
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CV-1	TANK FILL CHECK VALVE
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PI-1	TANK PRESSURE GAUGE 0-400 PSI
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R-2	TANK PB REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK ECON INLET RELIEF VALVE
RV-4	TANK PB OUTLET RELIEF VALVE
RV-5	TANK PB INLET RELIEF VALVE
V-1	TANK GAS USE VALVE
V-2	TANK ECONOMIZER INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
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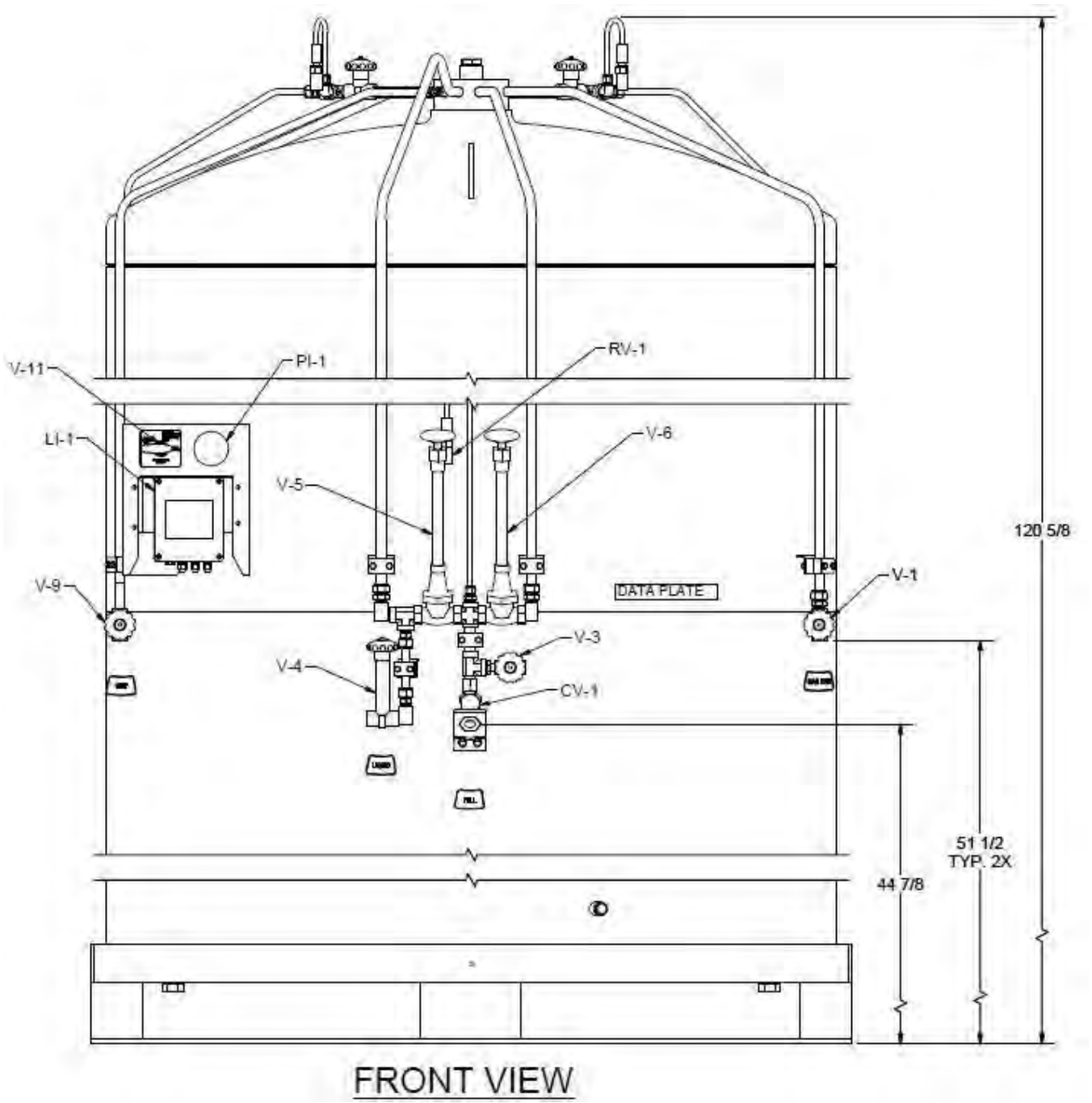
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK / VENT VALVE
V-10	TANK ECONOMIZER VALVE
V-11	TANK GAUGE ISOLATION VALVE
V-12	TANK PRESSURE BUILD OUTLET ISO VALVE
V-13	TANK PRESSURE BUILD INLET ISO VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK PB INLET
D	TANK PB OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK FULL TRYCOCK / VENT VALVE
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE OUT
L	TANK GAS USE IN

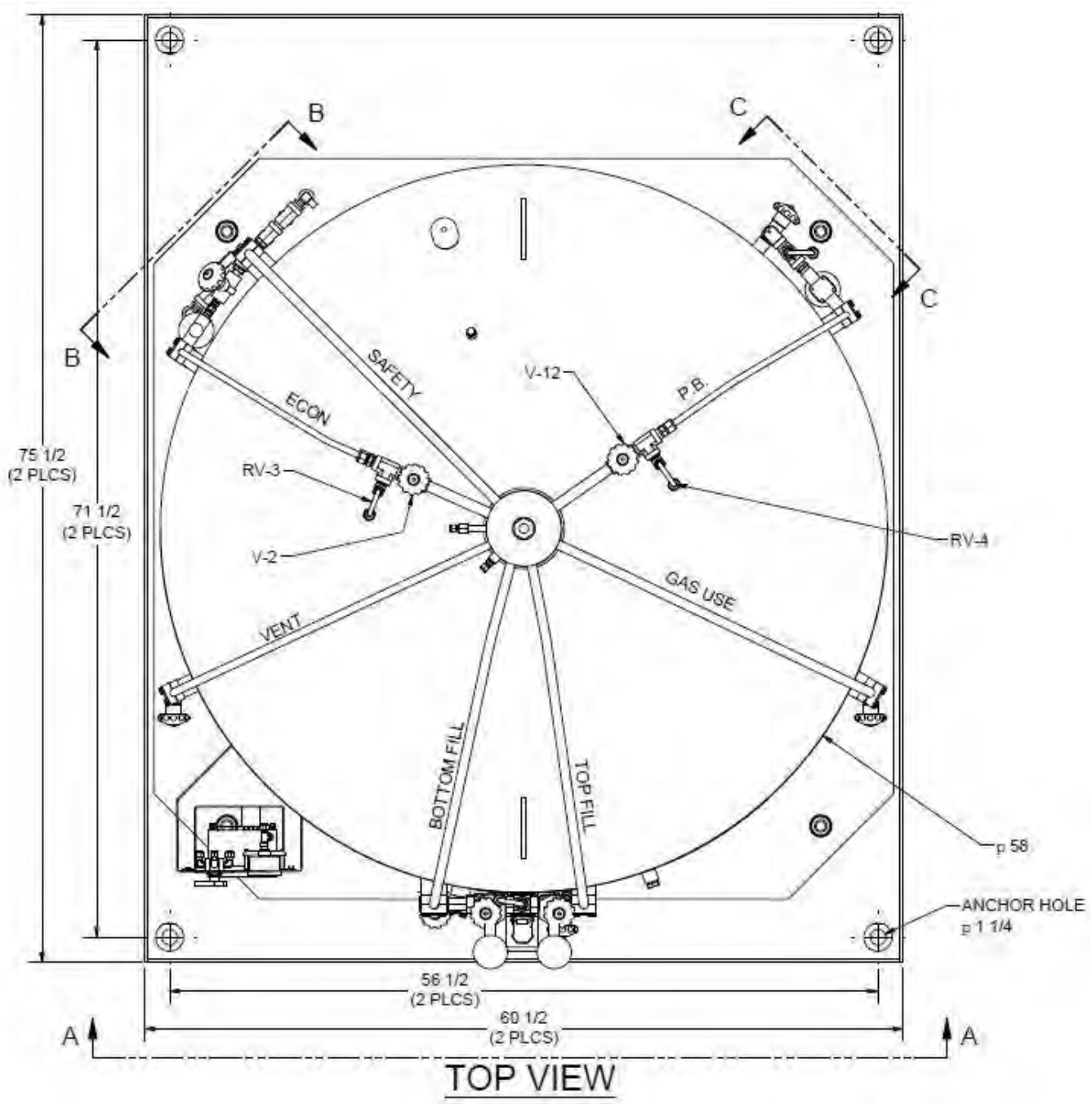
Item	PN	Description
BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
LI-1	20910598	CYL-TEL GEN 5 0-200"H_2O
LI-1	20923162	DIFF PG 4.5" 0-100" H_2O VITON (O_2, N_2)
LI-1	20909588	DIFF PG 4.5" 0-150" H_2O VITON (Ar)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11501177	REGULATOR .250FPT @ 140 PSI
*R-1	20885664	REGULATOR .250FPT @ 325 PSI
*R-2	11779806	REGULATOR .500FPT @ 125 PSI
*R-2	11690211	REGULATOR .500FPT @ 300 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI
*RV-2	20599868	RV BRS 1/2MPT 350 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI

Item	PN	Description
RV-4	1812702	RV BRS 1/4MPT 550 PSI
RV-5	1810702	RV BRS 1/4MPT 550 PSI
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	11905999	VALVE SHUTOFF 1/4FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11905999	VALVE SHUTOFF 1/4FPT

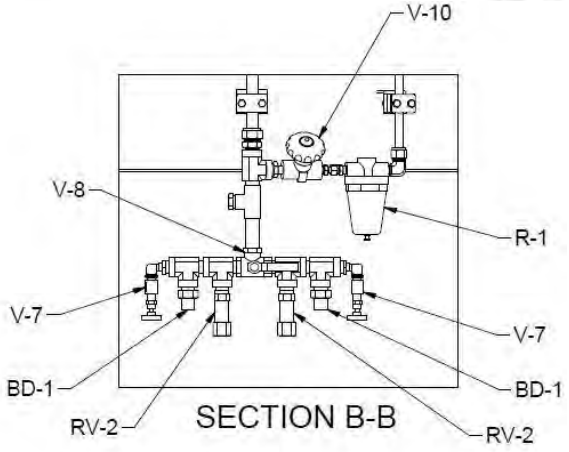
*Part numbers are dependent on the plumbing option kit chosen for the vessel.

3000 HP FlexFill

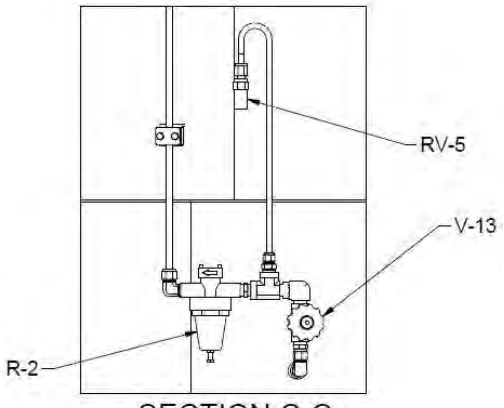




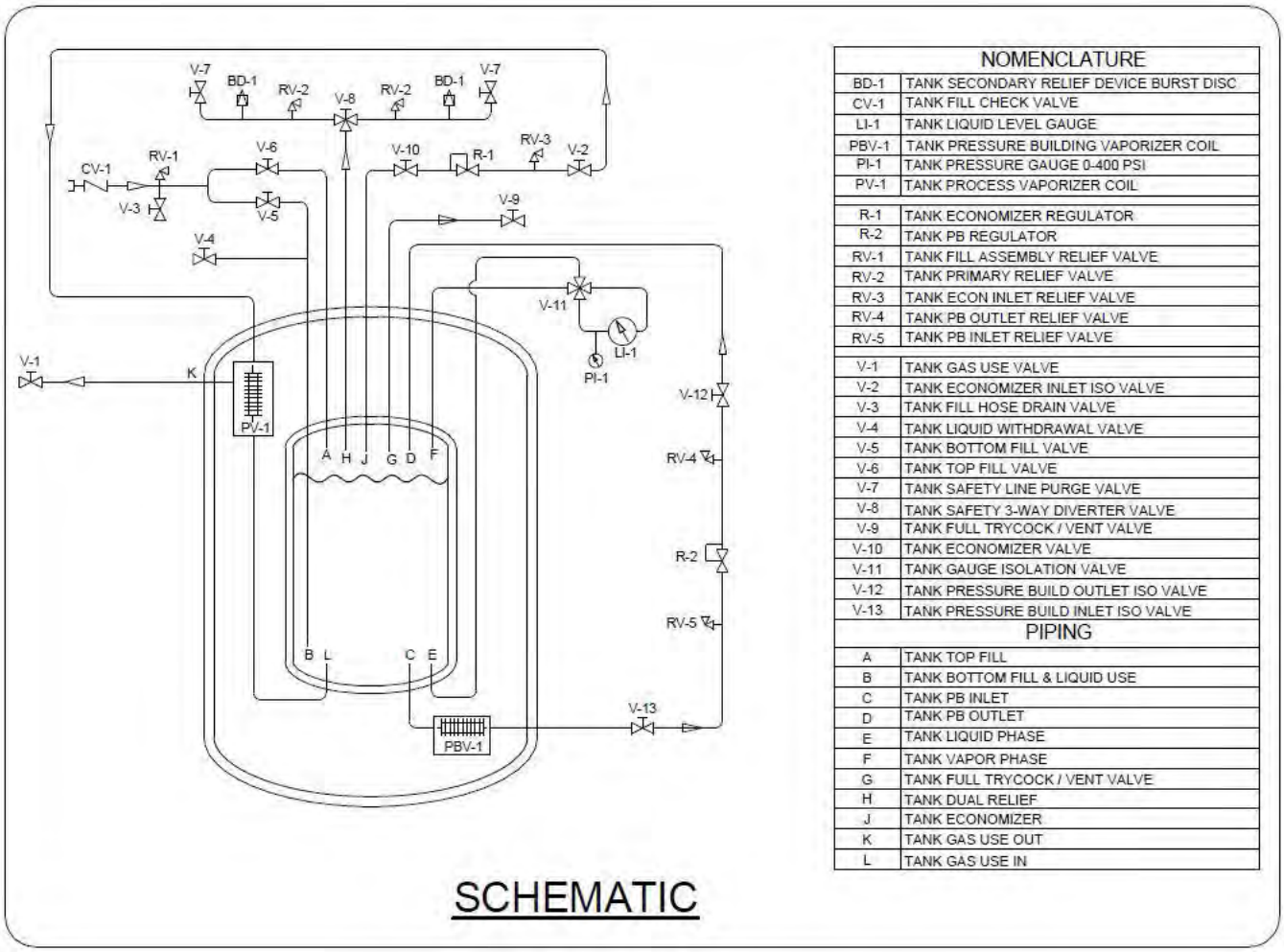
TOP VIEW



SECTION B-B



SECTION C-C



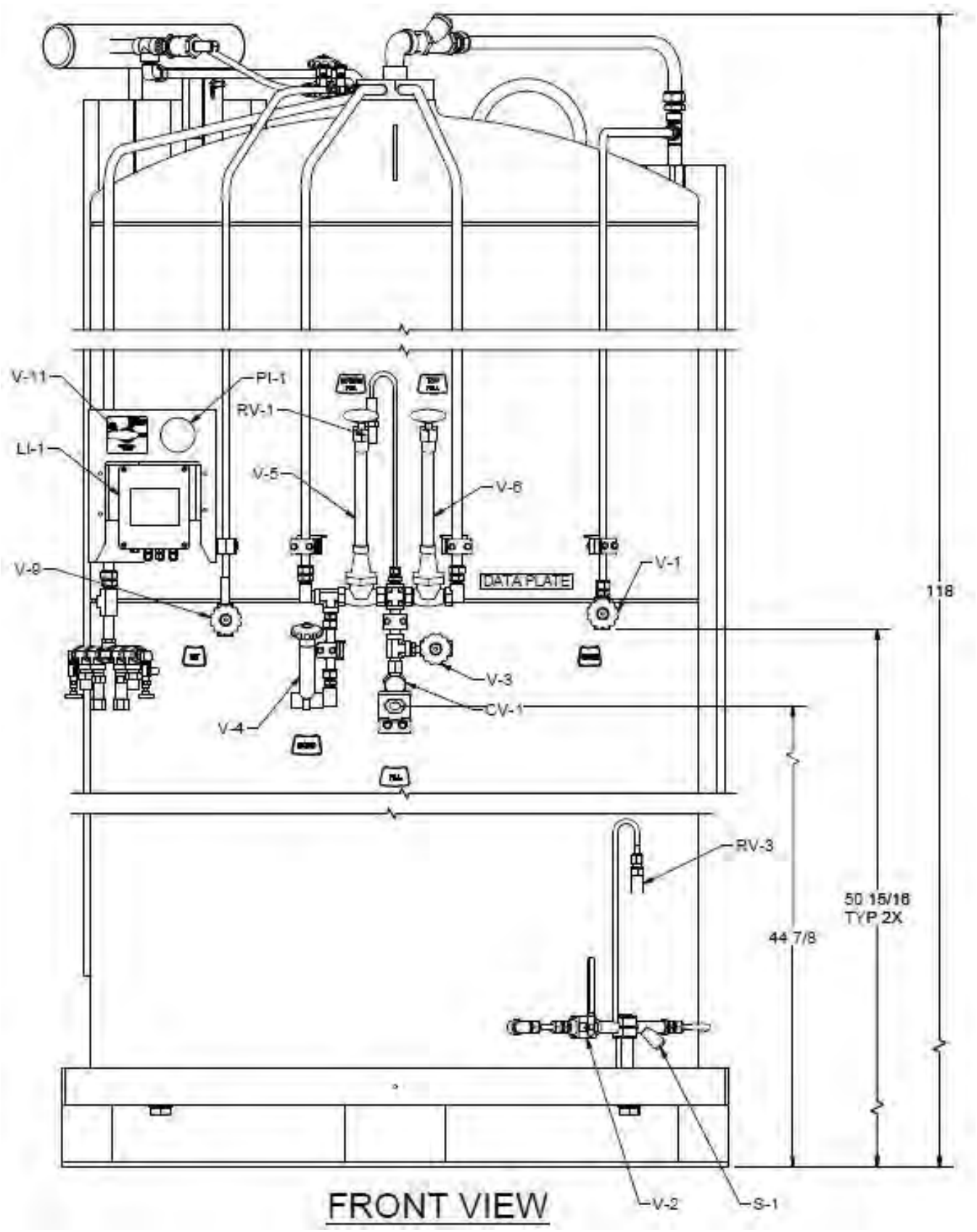
NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PBV-1	TANK PRESSURE BUILDING VAPORIZER COIL
PI-1	TANK PRESSURE GAUGE 0-400 PSI
PV-1	TANK PROCESS VAPORIZER COIL
R-1	TANK ECONOMIZER REGULATOR
R-2	TANK PB REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK ECON INLET RELIEF VALVE
RV-4	TANK PB OUTLET RELIEF VALVE
RV-5	TANK PB INLET RELIEF VALVE
V-1	TANK GAS USE VALVE
V-2	TANK ECONOMIZER INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK / VENT VALVE
V-10	TANK ECONOMIZER VALVE
V-11	TANK GAUGE ISOLATION VALVE
V-12	TANK PRESSURE BUILD OUTLET ISO VALVE
V-13	TANK PRESSURE BUILD INLET ISO VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK PB INLET
D	TANK PB OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK FULL TRYCOCK / VENT VALVE
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE OUT
L	TANK GAS USE IN

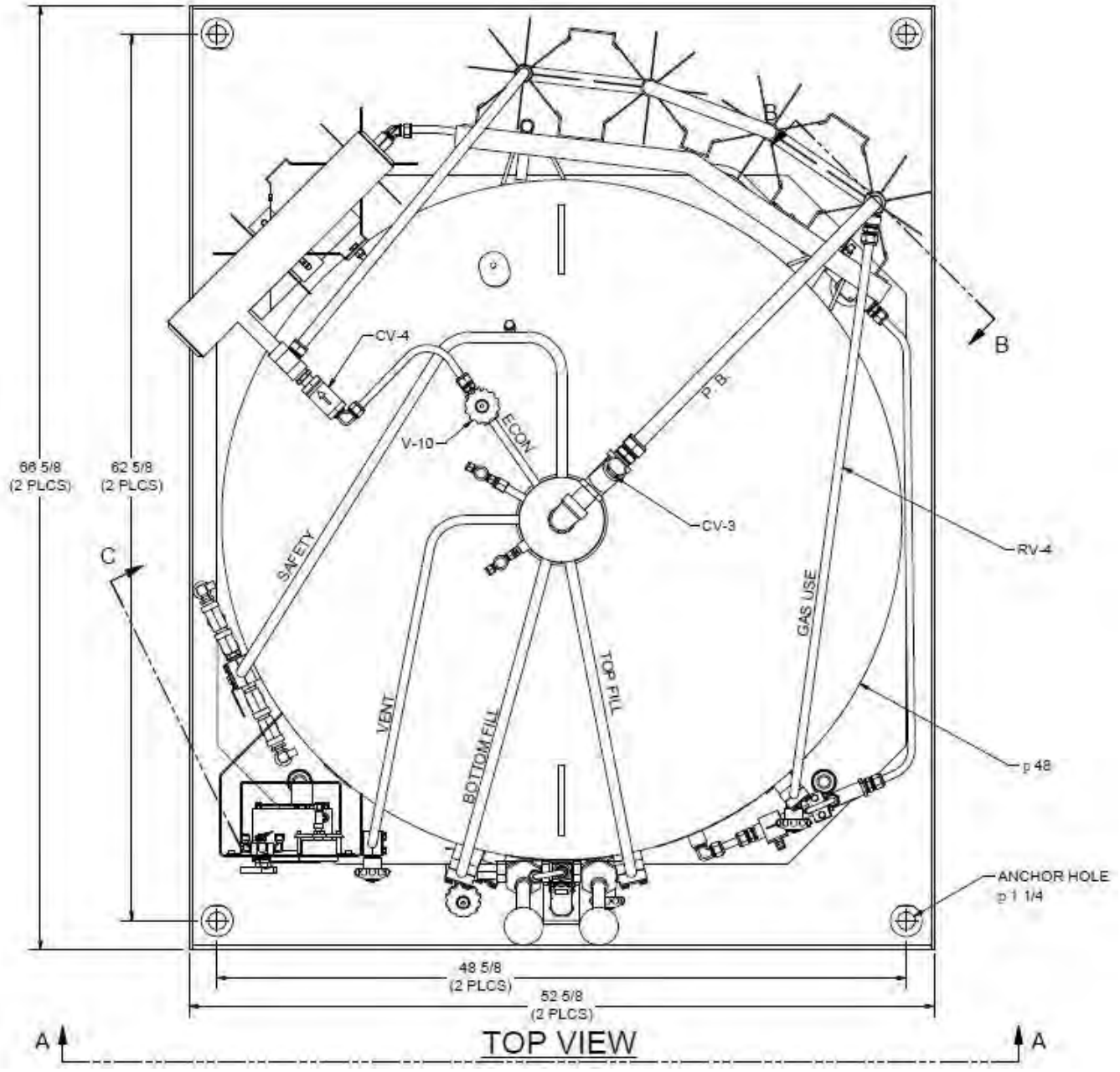
Item	PN	Description
BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
LI-1	20910598	CYL-TEL GEN 5 0-200"H_2O
LI-1	20923162	DIFF PG 4.5" 0-100" H_2O VITON (O_2, N_2)
LI-1	20909588	DIFF PG 4.5" 0-150" H_2O VITON (Ar)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11501177	REGULATOR .250FPT @ 140 PSI
*R-1	20885664	REGULATOR .250FPT @ 325 PSI
*R-2	11779806	REGULATOR .500FPT @ 125 PSI
*R-2	11690211	REGULATOR .500FPT @ 300 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI
*RV-2	20599868	RV BRS 1/2MPT 350 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI

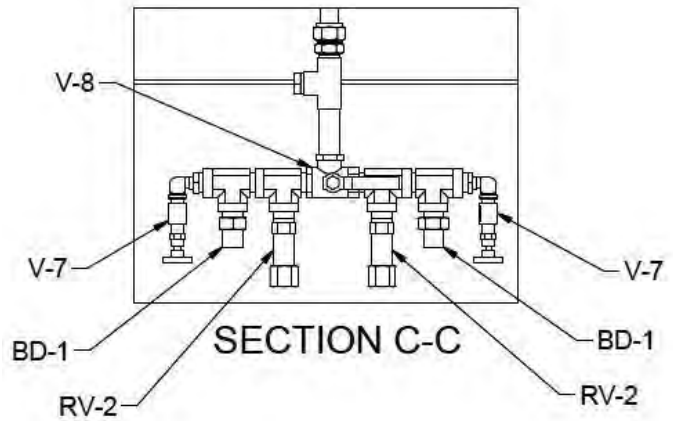
Item	PN	Description
RV-4	1812702	RV BRS 1/4MPT 550 PSI
RV-5	1810702	RV BRS 1/4MPT 550 PSI
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	11905999	VALVE SHUTOFF 1/4FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11905999	VALVE SHUTOFF 1/4FPT

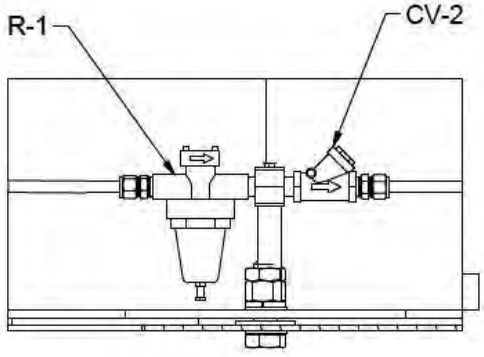
*Part numbers are dependent on the plumbing option kit chosen for the vessel.

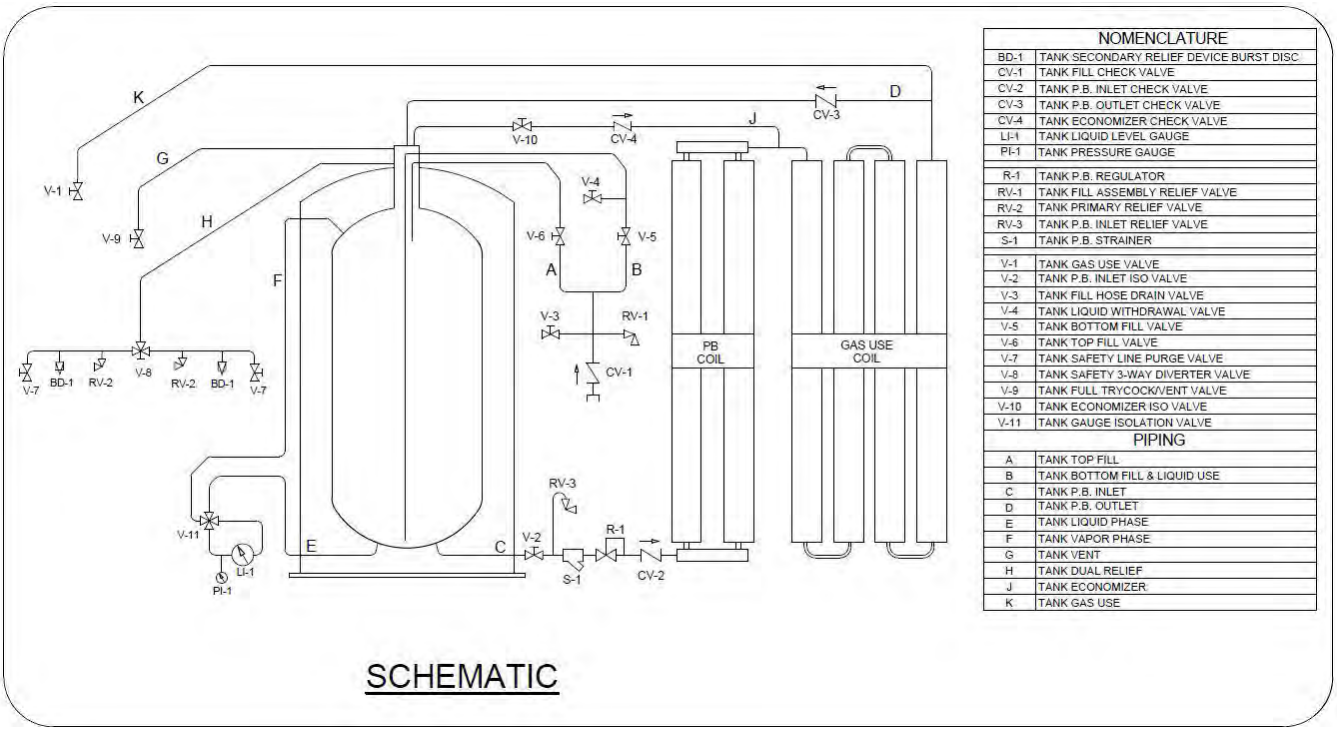
2000 VHP FlexFill




66 5/8
(2 PLCS)
62 5/8
(2 PLCS)
CV-4
V-10
ECON
P.B.
CV-3
RV-4
SAFETY
VENT
BOTTOM FILL
TOP FILL
GAS USE
p 48
ANCHOR HOLE
p 1 1/4
48 5/8
(2 PLCS)
52 5/8
(2 PLCS)
A
B
C
TOP VIEW


V-8
V-7
V-7
BD-1
BD-1
RV-2
RV-2
SECTION C-C


R-1
CV-2
SECTION B-B



NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
CV-2	TANK P.B. INLET CHECK VALVE
CV-3	TANK P.B. OUTLET CHECK VALVE
CV-4	TANK ECONOMIZER CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PI-1	TANK PRESSURE GAUGE
R-1	TANK P.B. REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK P.B. INLET RELIEF VALVE
S-1	TANK P.B. STRAINER
V-1	TANK GAS USE VALVE
V-2	TANK P.B. INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK/VENT VALVE
V-10	TANK ECONOMIZER ISO VALVE
V-11	TANK GAUGE ISOLATION VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK P.B. INLET
D	TANK P.B. OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK VENT
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE

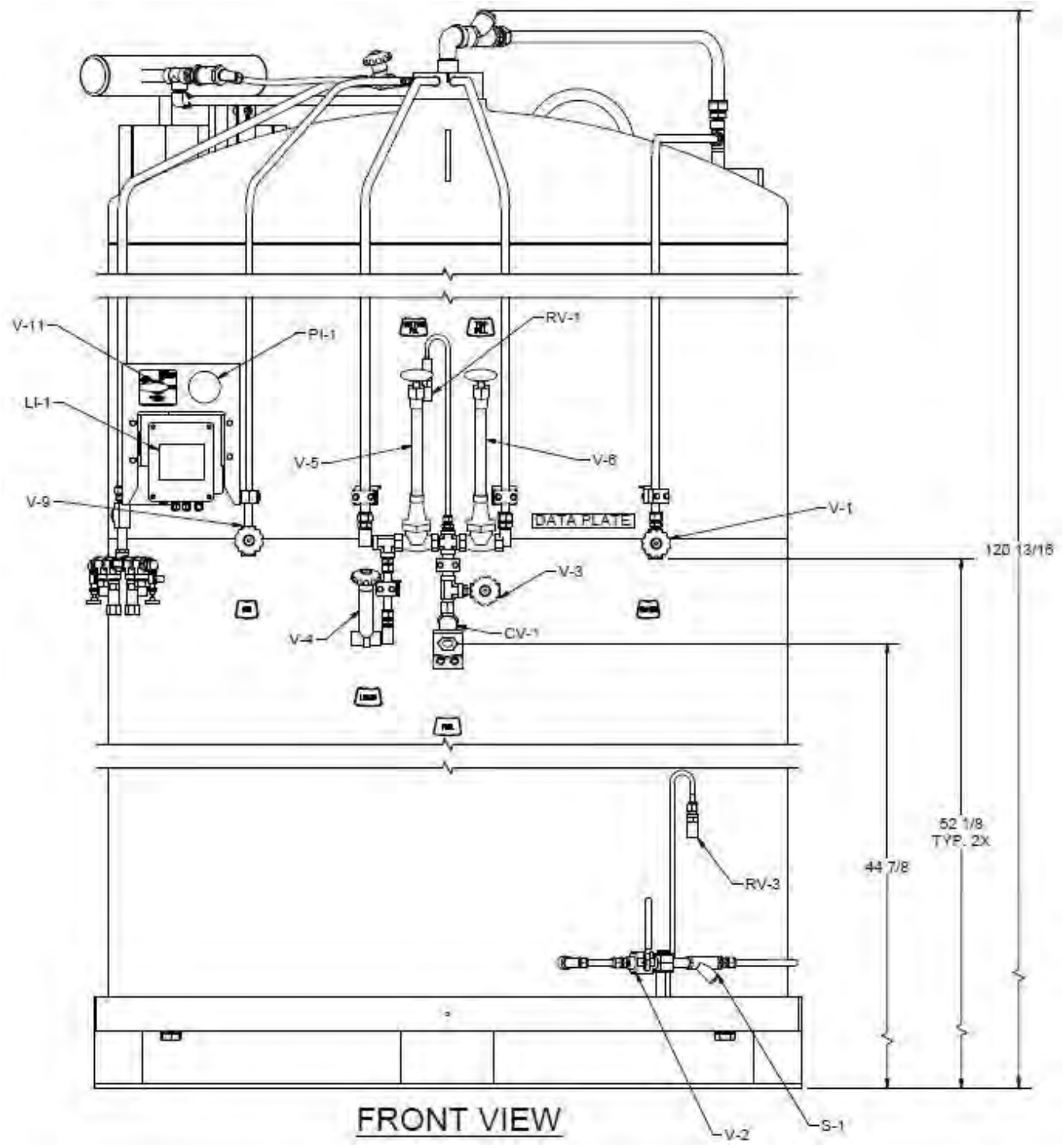
SCHEMATIC

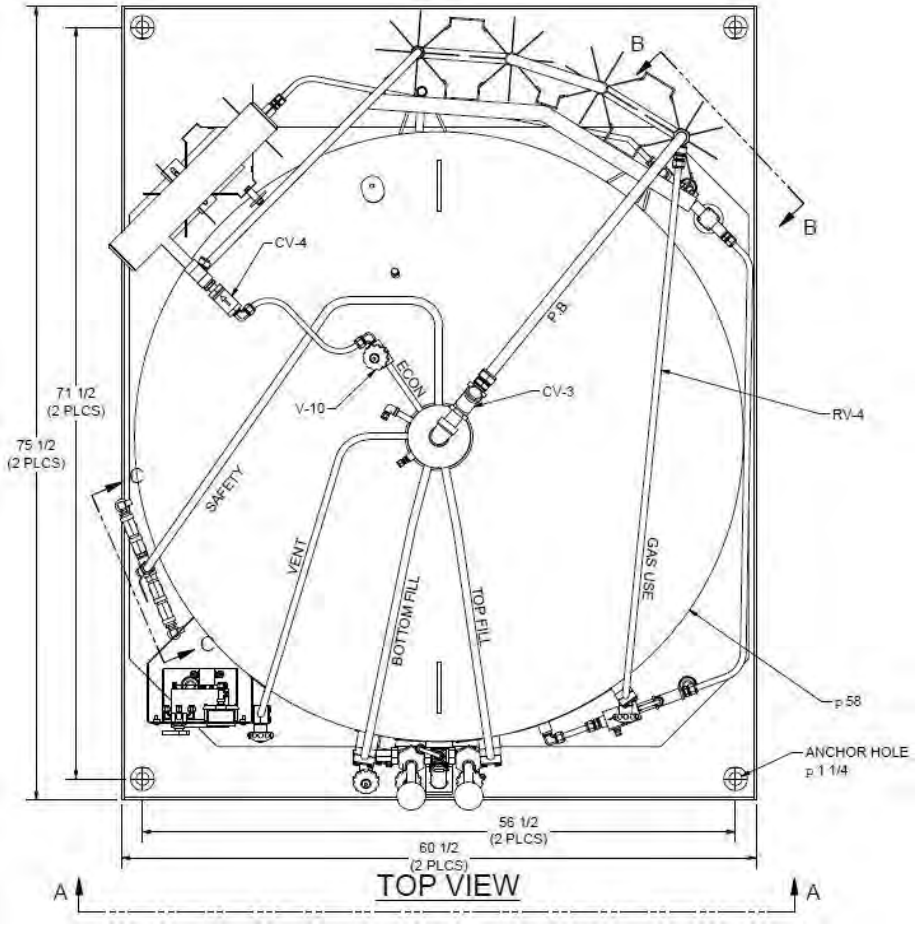
Item	PN	Description
BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
BD-1	11526622	RPD ASSY INLINE 1/2MPT 700 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
CV-2	13462175	KIT CHECK VALVE NIBCO 1/2"FPT
CV-3	11656072	VALVE CHECK BRS FPT
CV-4	13620233	VALVE CHECK BRS 1/2FPTX1/2FPT
*LI-1	20910598	CYL-TEL GEN 5 0-200"H_2O
*LI-1	20923162	DIFF PG 4.5" 0-100" H_2O VITON (O_2, N_2)
*LI-1	20909588	DIFF PG 4.5" 0-150" H_2O VITON (Ar)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11779806	REGULATOR .500FPT @ 125 PSI
*R-1	11690211	REGULATOR .500FPT @ 300 PSI
*R-1	11635511	REGULATOR .500NPT @ 450 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI

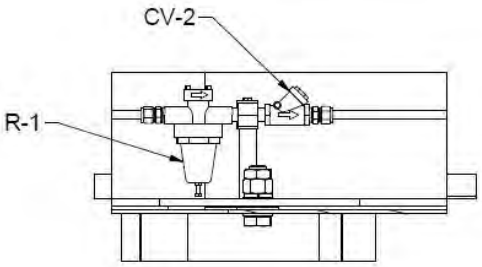
Item	PN	Description
*RV-2	20599868	RV BRS 1/2MPT 350 PSI
*RV-2	20894583	RV BRS 1/2MPT 500 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI
S-1	11529090	STRAINER .500NPT BRZ BODY
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	1712202	VALVE BALL BRS 1/2FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT

*Part numbers are dependent on the plumbing option kit chosen for the vessel.

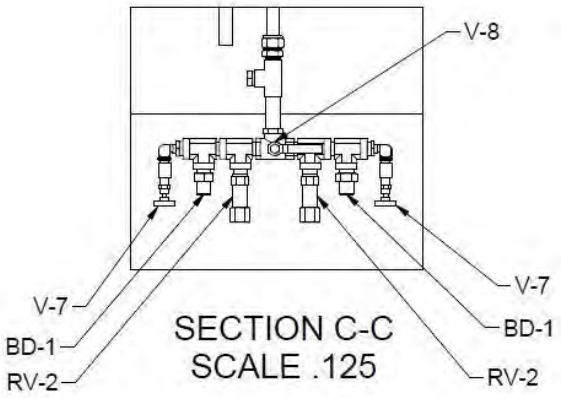
3000 VHP FlexFill



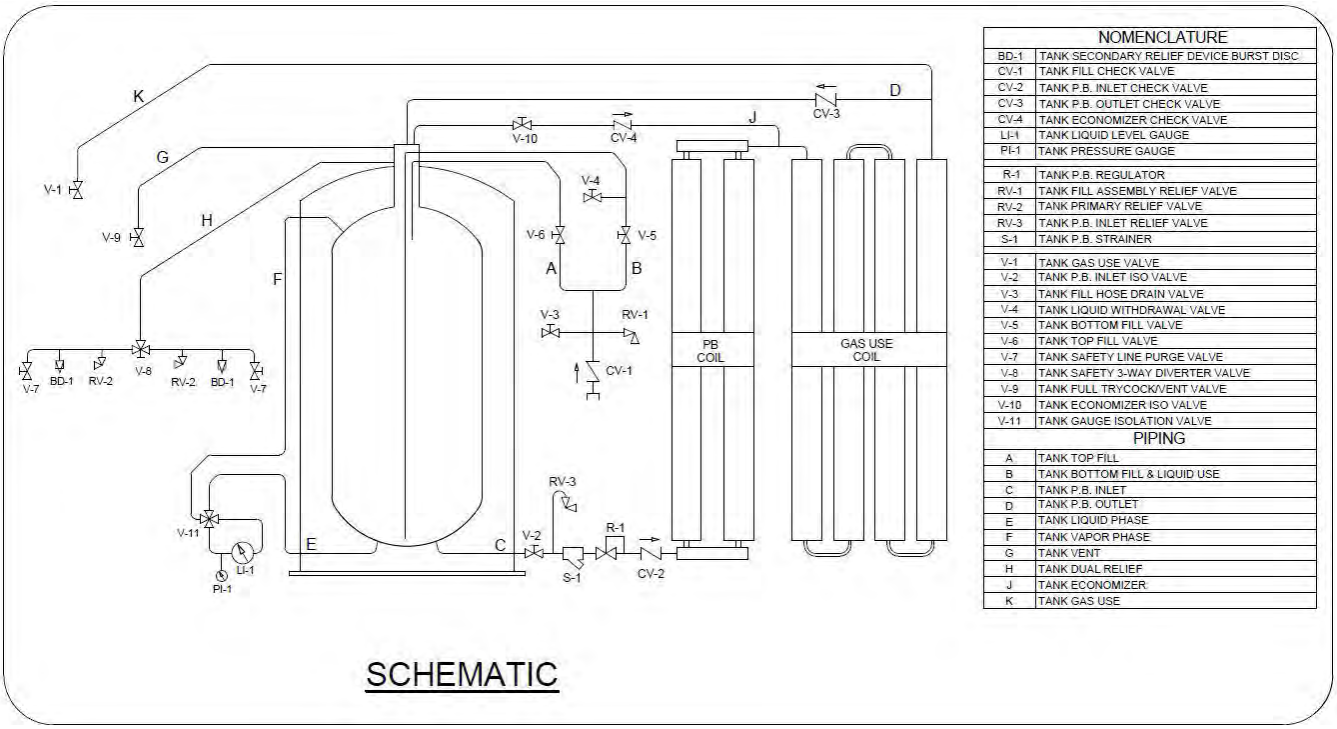




SECTION B-B
SCALE .125



SECTION C-C
SCALE .125



SCHEMATIC

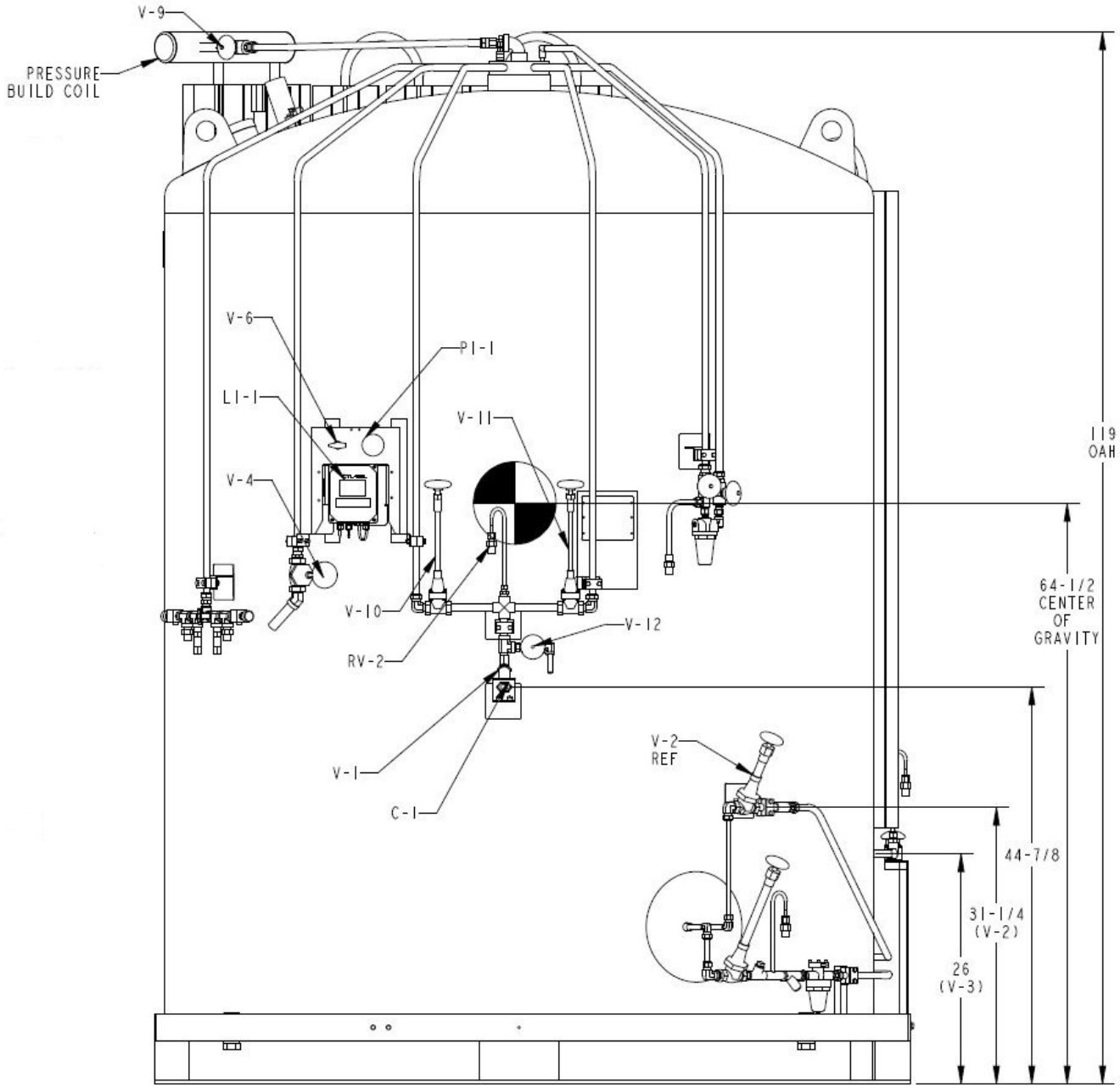
NOMENCLATURE	
BD-1	TANK SECONDARY RELIEF DEVICE BURST DISC
CV-1	TANK FILL CHECK VALVE
CV-2	TANK P.B. INLET CHECK VALVE
CV-3	TANK P.B. OUTLET CHECK VALVE
CV-4	TANK ECONOMIZER CHECK VALVE
LI-1	TANK LIQUID LEVEL GAUGE
PI-1	TANK PRESSURE GAUGE
R-1	TANK P.B. REGULATOR
RV-1	TANK FILL ASSEMBLY RELIEF VALVE
RV-2	TANK PRIMARY RELIEF VALVE
RV-3	TANK P.B. INLET RELIEF VALVE
S-1	TANK P.B. STRAINER
V-1	TANK GAS USE VALVE
V-2	TANK P.B. INLET ISO VALVE
V-3	TANK FILL HOSE DRAIN VALVE
V-4	TANK LIQUID WITHDRAWAL VALVE
V-5	TANK BOTTOM FILL VALVE
V-6	TANK TOP FILL VALVE
V-7	TANK SAFETY LINE PURGE VALVE
V-8	TANK SAFETY 3-WAY DIVERTER VALVE
V-9	TANK FULL TRYCOCK/VENT VALVE
V-10	TANK ECONOMIZER ISO VALVE
V-11	TANK GAUGE ISOLATION VALVE
PIPING	
A	TANK TOP FILL
B	TANK BOTTOM FILL & LIQUID USE
C	TANK P.B. INLET
D	TANK P.B. OUTLET
E	TANK LIQUID PHASE
F	TANK VAPOR PHASE
G	TANK VENT
H	TANK DUAL RELIEF
J	TANK ECONOMIZER
K	TANK GAS USE

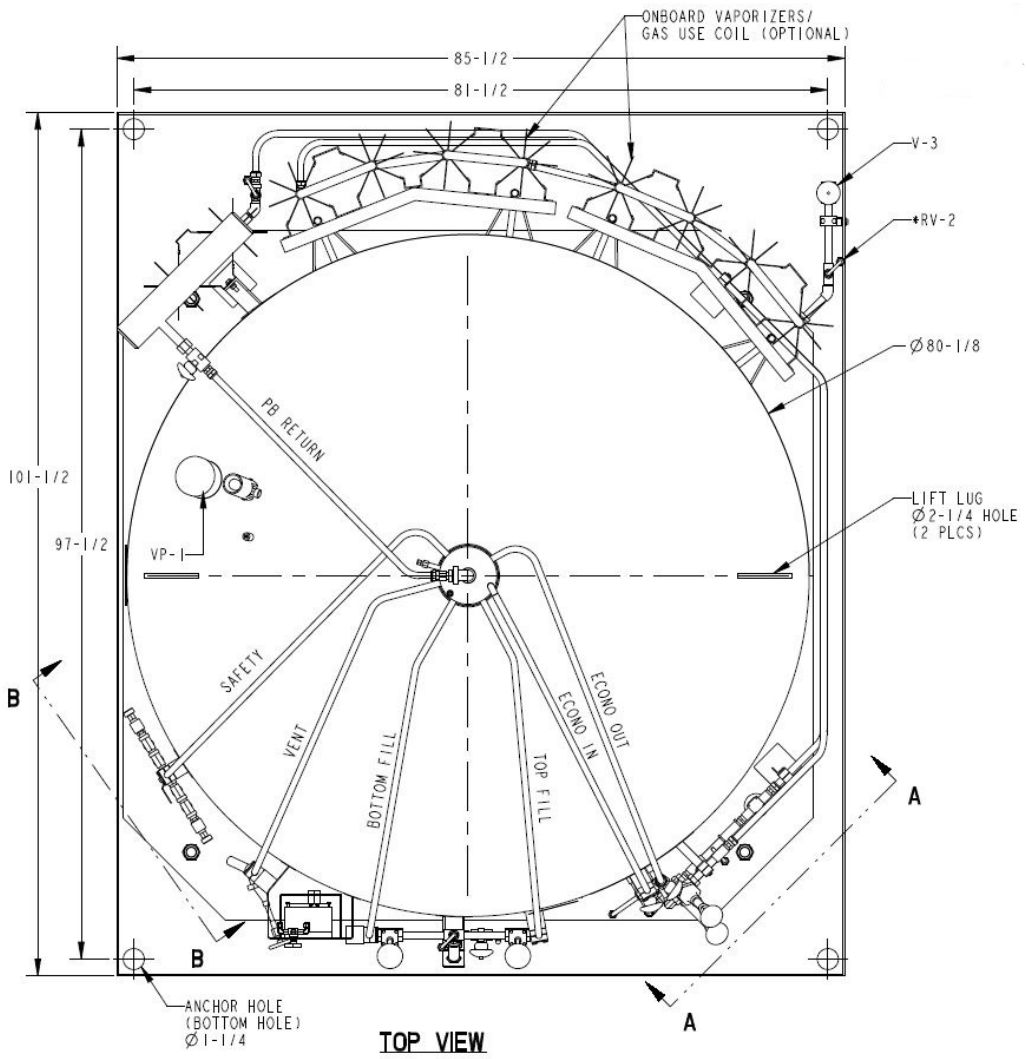
Item	*PN*	*Description*
BD-1	11671281	RPD ASSY INLINE 1/2MPT 375 PSI
BD-1	11526569	RPD ASSY INLINE 1/2MPT 525 PSI
BD-1	11526622	RPD ASSY INLINE 1/2MPT 700 PSI
CV-1	11051090	VALVE CHECK BRS 1/2FPTX1/2 FPT
CV-2	13462175	KIT CHECK VALVE NIBCO 1/2"FPT
CV-3	11656072	VALVE CHECK BRS FPT
CV-4	13620233	VALVE CHECK BRS 1/2FPTX1/2FPT
*LI-1	20786602	CYL-TEL GEN 5 BACK 0-200"H_2O
*LI-1	20923162	DIFF PG 4.5" 0-100" H_2O VITON (O_2, N_2)
*LI-1	20909588	DIFF PG 4.5" 0-150" H_2O VITON (Ar)
PI-1	20827654	PG 2-1/2" 0-600PSI/BAR 1/8MPT
*R-1	11779806	REGULATOR .500FPT @ 125 PSI
*R-1	11690211	REGULATOR .500FPT @ 300 PSI
*R-1	11635511	REGULATOR .500NPT @ 450 PSI
RV-1	1812702	RV BRS 1/4MPT 550 PSI
*RV-2	11488574	RV BRS 1/2MPT 250 PSI

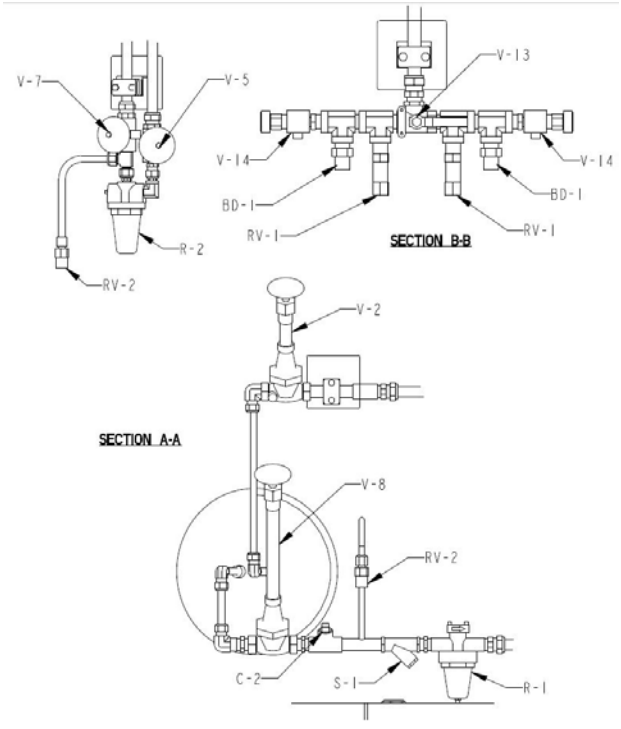
Item	*PN*	*Description*
*RV-2	20599868	RV BRS 1/2MPT 350 PSI
*RV-2	20894583	RV BRS 1/2MPT 500 PSI
RV-3	1812702	RV BRS 1/4MPT 550 PSI
S-1	11529090	STRAINER .500NPT BRZ BODY
V-1	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-2	11905999	VALVE SHUTOFF 1/4FPT
V-3	11905999	VALVE SHUTOFF 1/4FPT
V-4	11625639	VALVE GLOBE BRS 1/2FPT EX STEM
V-5	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-6	10616790	VALVE GLOBE BRS 1/2NPT SCRD
V-7	10907239	VALVE NEEDLE BRS 1/4MPT(ANGLE)
V-8	11773885	VALVE BALL DIV SS 1/2NPT
V-9	11905956	VALVE BRS SH 3/8FPTX3/8 SCH 10
V-10	11905999	VALVE SHUTOFF 1/4FPT
V-11	20683719	VALVE 4-WAY BRS 1/8 FPT

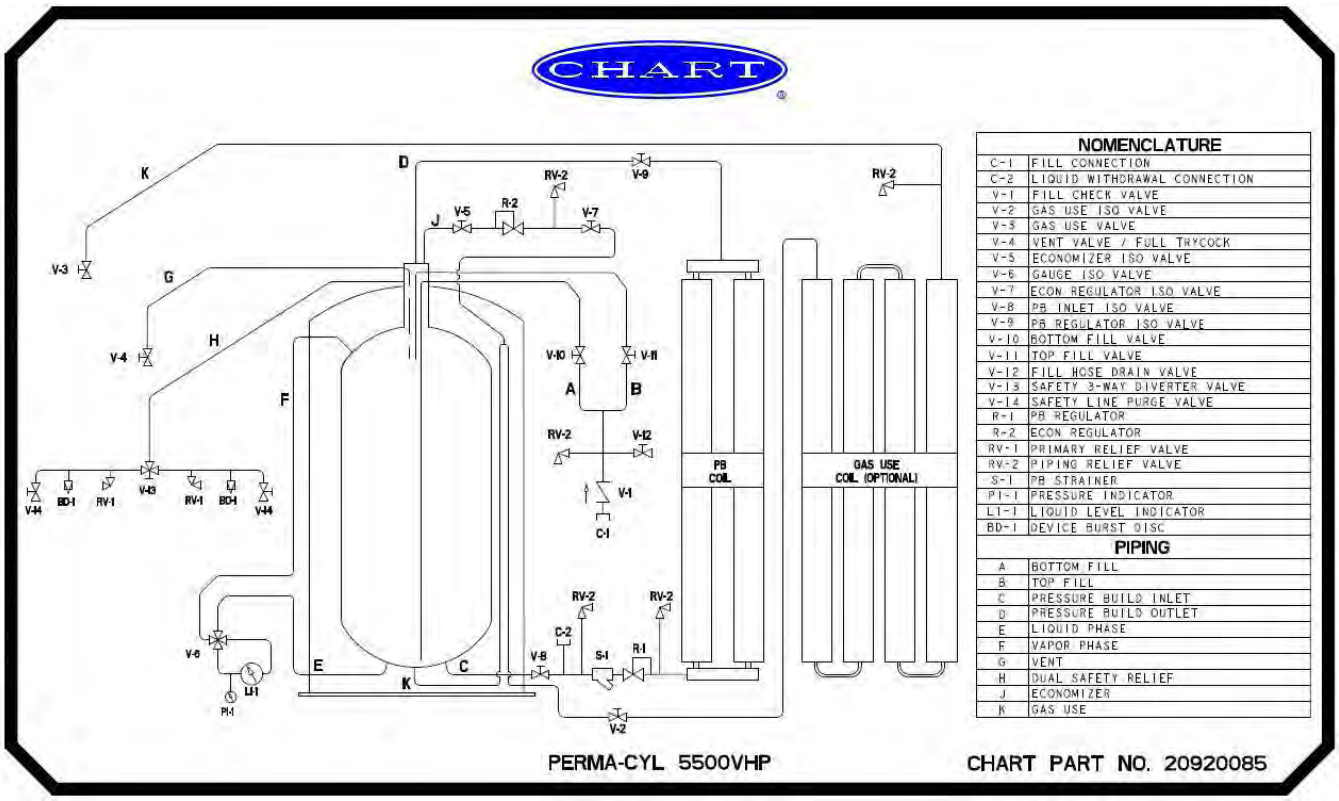
*Part numbers are dependent on the plumbing option kit chosen for the vessel.

5500 VHP FlexFill




ONBOARD VAPORIZERS/
GAS USE COIL (OPTIONAL)
85-1/2
81-1/2
V-3
RV-2
Ø80-1/8
PB RETURN
101-1/2
97-1/2
VP-1
LIFT LUG
Ø2-1/4 HOLE
(2 PLCS)
SAFETY
VENT
BOTTOM FILL
TOP FILL
ECONO IN
ECONO OUT
B
A
ANCHOR HOLE
(BOTTOM HOLE)
Ø1-1/4
TOP VIEW


V-7
V-5
R-2
RV-2
V-13
V-14
V-14
BD-1
BD-1
RV-1
RV-1
SECTION B-B
V-2
SECTION A-A
V-8
RV-2
C-2
S-1
R-1

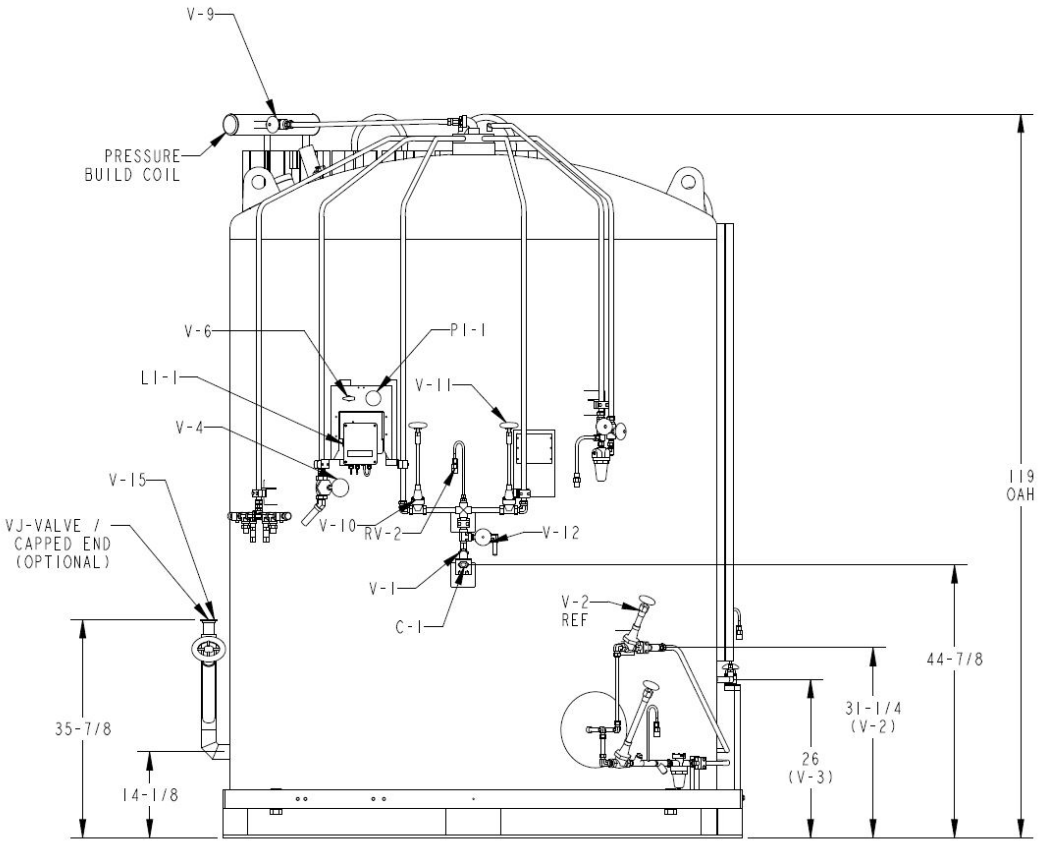


Item	PN	Description
V-1	11051090	VALVE CHECK BRS 1/2FPTX1/2FPT
V-2	1718802	VALVE GLOBE BRS 1/2NPT
*V-3	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-4	10540334	VALVE GLOBE BRS 3/4NPT SCRD
V-5	1713202	VALVE SHUTOFF 3/8 FPT
V-6	20683719	VALVE 4-WAY BRS 1/8FPT
V-7	1713202	VALVE SHUTOFF 3/8 FPT
V-8	1718802	VALVE GLOBE BRS 1/2NPT
V-9	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-10	20915798	VALVE GLOBE BRZ 1/2NPT
V-11	20915798	VALVE GLOBE BRZ 1/2NPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11773885	VALVE BALL DIV SS 1/2 NPT
V-14	10907239	VALVE NEEDLE BRS 1/4MPT (ANGLE)
*R-1	11779806	REGULATOR .500NPT @ 125 PSI
*R-1	11690211	REGULATOR .500NPT @ 300 PSI

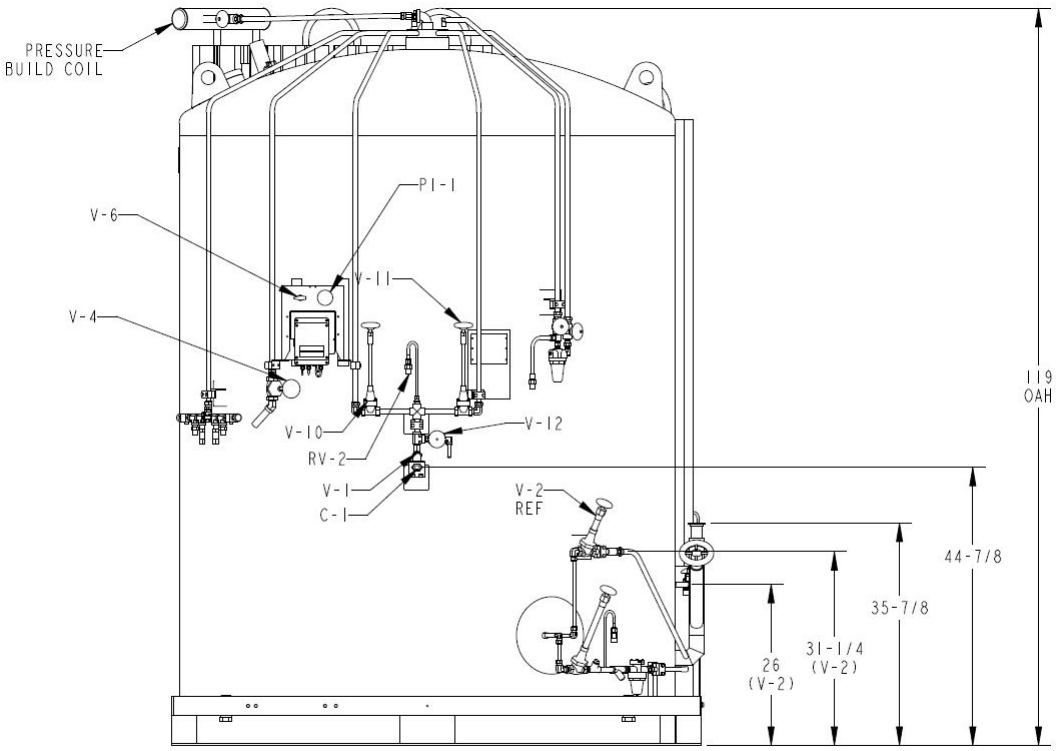
Item	PN	Description
*R-1	11635511	REGULATOR .500NPT @ 450 PSI
*R-2	20934785	REGULATOR .250NPT @ 140 PSI
*R-2	20934016	REGULATOR .250NPT @ 315 PSI
*R-2	20905985	REGULATOR .250NPT @ 465 PSI
*RV-1	11488574	RV BRS 1/2MPT 250 PSI
*RV-1	20599868	RV BRS 1/2MPT 350 PSI
*RV-1	20894583	RV BRS 1/2MPT 500 PSI
RV-2	1812702	RV BRS 1/4MPT 550 PSI
S-1	11529090	STRAINER .500NPT BRZ BODY
PI-1	20827654	PG 2-1/2” 0-600 PSI/BAR 1/8MPT
*LI-1	20786602	CYL-TEL GEN 4 BACK 0-200”H_2O
*LI-1	20923162	DIFF PG 4.5” 0-100” H_2O VITON (O_2, N_2)
*LI-1	20909588	DIFF PG 4.5” 0-150” H_2O VITON (Ar)
BD-1	11526622	RPD ASSY INLINE 1/2MPT 700 PSI
VP-1	--	VACUUM PUMPOUT PORT
C-2	1210642	TEE BRS 1/2FPT MACHINED

*Part numbers are dependent on the plumbing option kit chosen for the vessel.

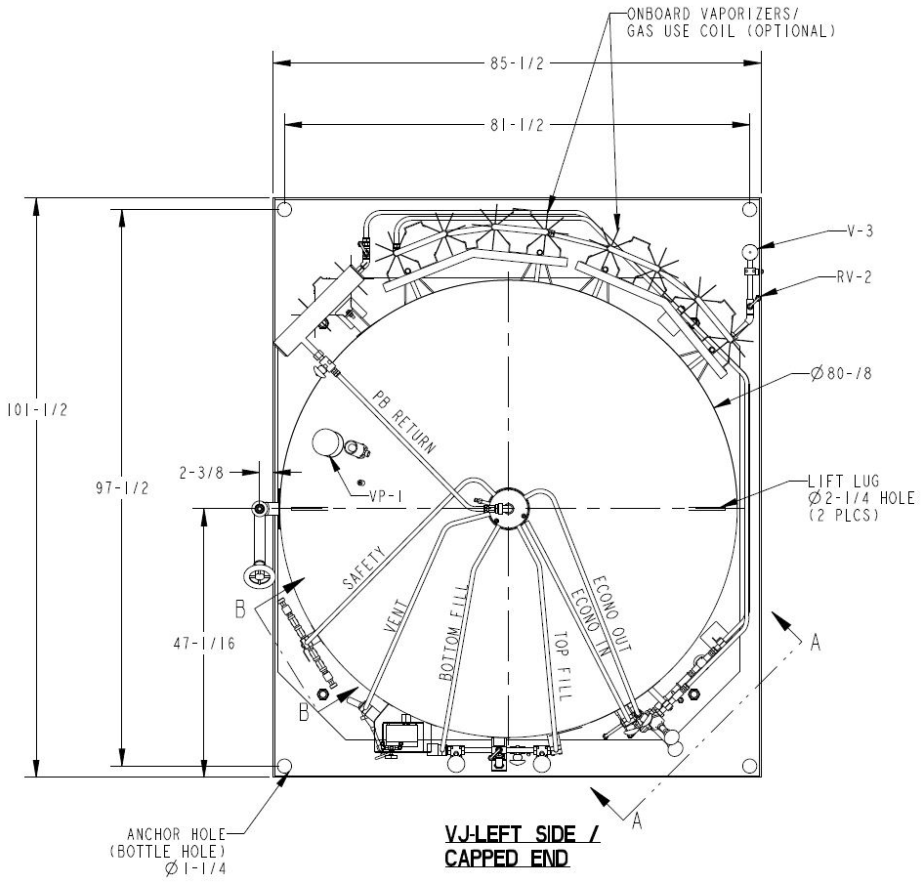
5500 MP FlexFill



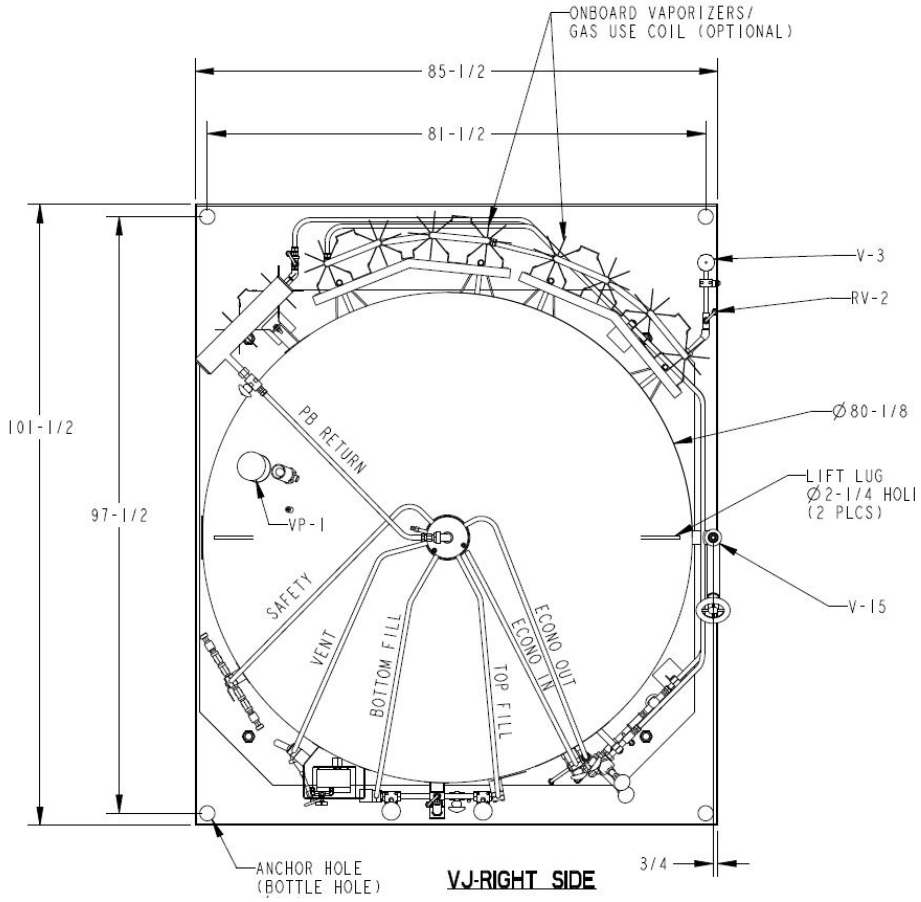
VJ-LEFT SIDE / CAPPED END



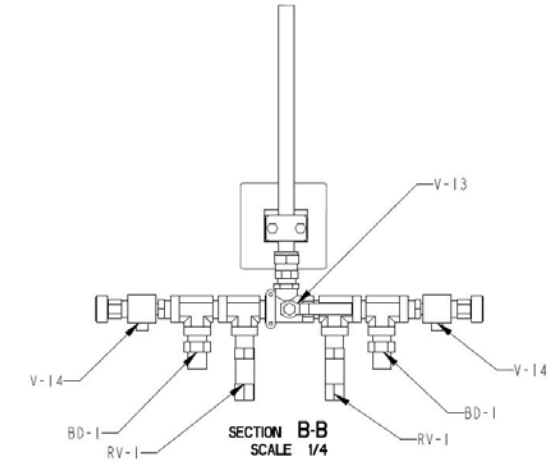
VJ-RIGHT SIDE

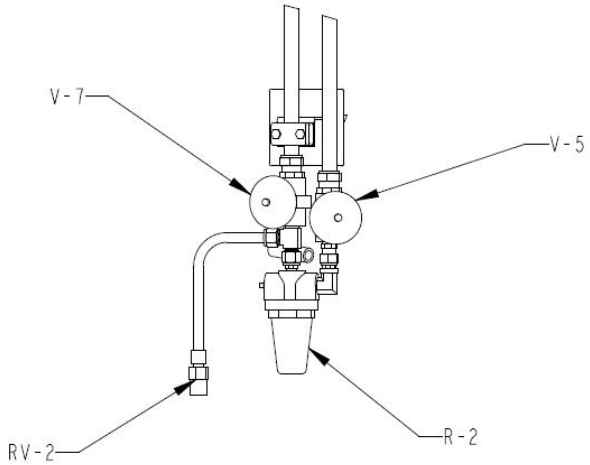


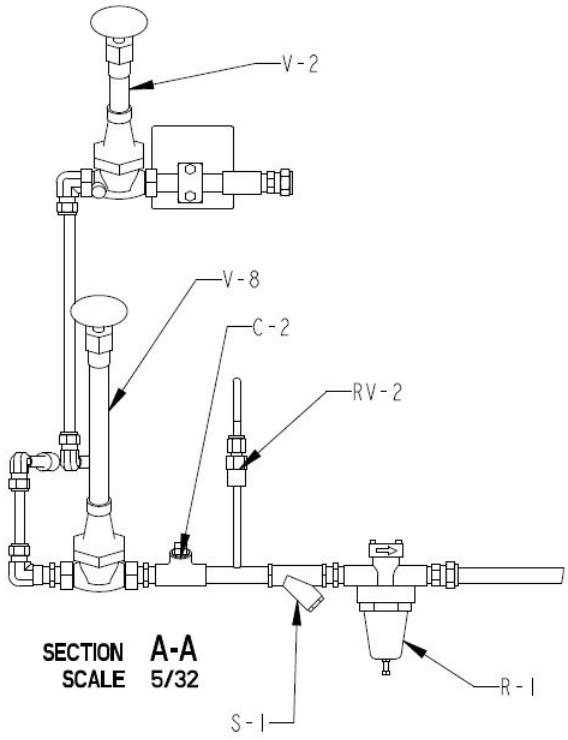
VJ-LEFT SIDE / CAPPED END

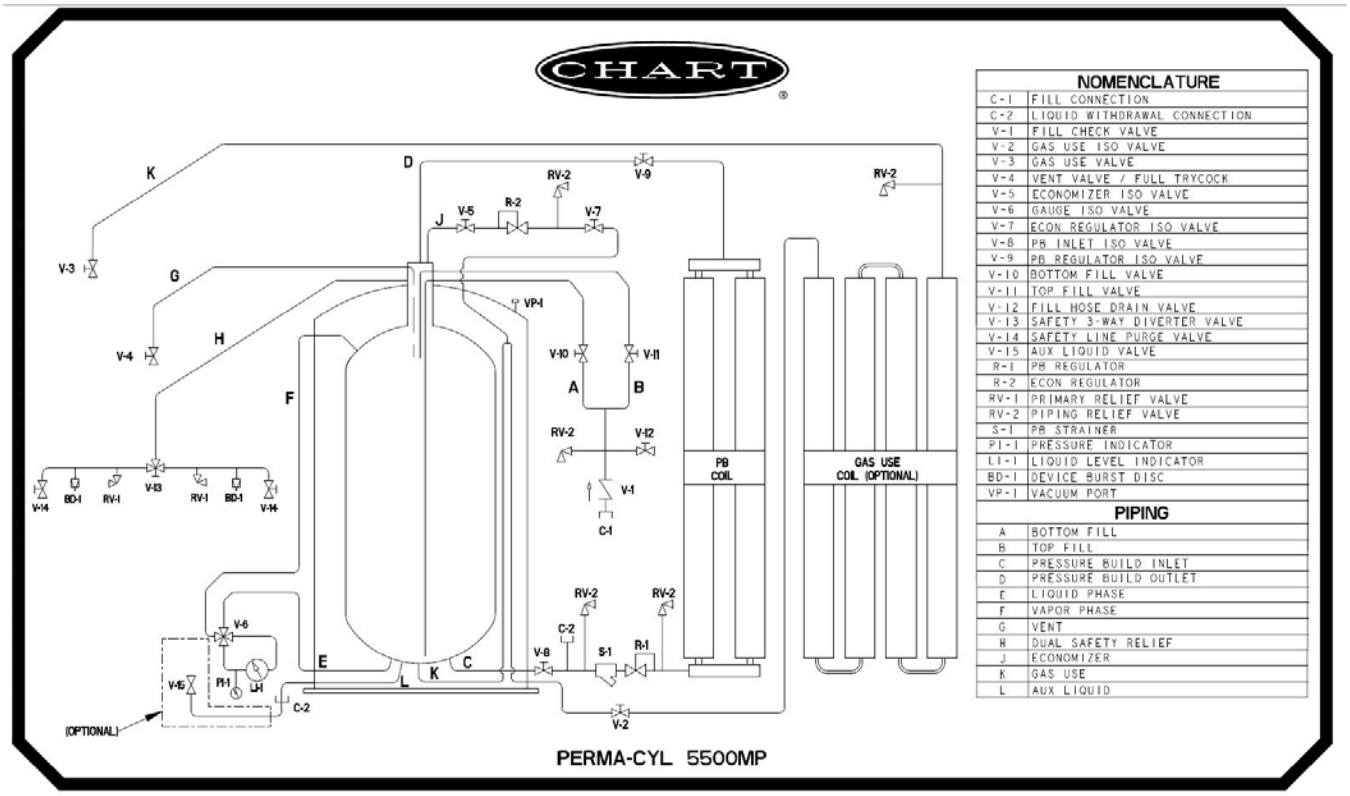


VJ-RIGHT SIDE









NOMENCLATURE	
C-1	FILL CONNECTION
C-2	LIQUID WITHDRAWAL CONNECTION
V-1	FILL CHECK VALVE
V-2	GAS USE ISO VALVE
V-3	GAS USE VALVE
V-4	VENT VALVE / FULL TRYCOCK
V-5	ECONOMIZER ISO VALVE
V-6	GAUGE ISO VALVE
V-7	ECON REGULATOR ISO VALVE
V-8	PB INLET ISO VALVE
V-9	PB REGULATOR ISO VALVE
V-10	BOTTOM FILL VALVE
V-11	TOP FILL VALVE
V-12	FILL HOSE DRAIN VALVE
V-13	SAFETY 3-WAY DIVERTER VALVE
V-14	SAFETY LINE PURGE VALVE
V-15	AUX LIQUID VALVE
R-1	PB REGULATOR
R-2	ECON REGULATOR
RV-1	PRIMARY RELIEF VALVE
RV-2	PIPING RELIEF VALVE
S-1	PB STRAINER
PI-1	PRESSURE INDICATOR
LI-1	LIQUID LEVEL INDICATOR
BD-1	DEVICE BURST DISC
VP-1	VACUUM PORT

PIPING	
A	BOTTOM FILL
B	TOP FILL
C	PRESSURE BUILD INLET
D	PRESSURE BUILD OUTLET
E	LIQUID PHASE
F	VAPOR PHASE
G	VENT
H	DUAL SAFETY RELIEF
J	ECONOMIZER
K	GAS USE
L	AUX LIQUID

Item	PN	Description
V-1	11051090	VALVE CHECK BRS 1/2FPTX1/2FPT
V-2	1718802	VALVE GLOBE BRS 1/2NPT
*V-3	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-4	10540334	VALVE GLOBE BRS 3/4NPT SCRD
V-5	1713202	VALVE SHUTOFF 3/8 FPT
V-6	20683719	VALVE 4-WAY BRS 1/8FPT
V-7	1713202	VALVE SHUTOFF 3/8 FPT
V-8	10616790	VALVE GLOBE BRS 1/2NPT
V-9	10502848	VALVE SHUTOFF BRZ 1/2FPT SHORT
V-10	20915798	VALVE GLOBE BRZ 1/2NPT
V-11	20915798	VALVE GLOBE BRZ 1/2NPT
V-12	11905999	VALVE SHUTOFF 1/4FPT
V-13	11773885	VALVE BALL DIV SS 1/2 NPT
V-14	10907239	VALVE NEEDLE BRS 1/4MPT (ANGLE)
V-15	87-2542-05011	VALVE Y-PATTERN VJ-1/2” NPS
*R-1	20760715	REGULATOR .500NPT @ 35 PSI

Item	PN	Description
*R-1	11779806	REGULATOR .500NPT @ 125 PSI
*R-2	21029469	REGULATOR .250NPT @ 50 PSI
*R-2	20934785	REGULATOR .250NPT @ 140 PSI
*RV-1	20996153	RV BRS 1/2MPT 150 PSI
*RV-1	11488574	RV BRS 1/2MPT 250 PSI
RV-2	1812702	RV BRS 1/4MPT 550 PSI
S-1	11529090	STRAINER .500NPT BRZ BODY
PI-1	20827654	PG 2-1/2” 0-600 PSI/BAR 1/8MPT
*LI-1	20786602	CYL-TEL GEN 4 BACK 0-200”H_2O
*LI-1	20923162	DIFF PG 4.5” 0-100” H_2O VITON (O_2, N_2)
*LI-1	20909588	DIFF PG 4.5” 0-150” H_2O VITON (Ar)
BD-1	11519668	RPD ASSY INLINE 3/8 FPT 375 PSI
VP-1	--	VACUUM PUMPOUT PORT
C-1	--	FILL CONNECTION
C-2	--	LIQUID WITHDRAWAL CONNECTION

*Part numbers are dependent on the plumbing option kit chosen for the vessel.

Warranty

Warranty only applies to original purchaser of Chart equipment and does not transfer to any other party.

Materials, components and workmanship are warranted to be free of defects for 90 days from date of invoice.

Vacuum integrity as measured by conformance to Chart NER (Normal Evaporation Rate) specifications is warranted as follows:

- Perma-Cyl, liquid cylinders - 5 years from date of invoice.
- All Chart repaired liquid cylinders - 2 years from date of invoice.

Damage or abuse caused by purchaser voids Chart warranty obligations.

Freight damage incurred during shipment from Chart to purchaser must be reported immediately to Chart, and before placing equipment into service.

In the event of a valid warranty claim, Chart reserves the right to repair, replace or refund the value of the equipment at its discretion. The warranty applies only to the purchased Chart equipment and in no case is Chart obligated to reimburse the purchaser for consequential damages resulting from the operation of Chart equipment.