Product Manual

Orca™ MicroBulk Delivery System
ST Series (LN_2/LAR)

Designed and Built by:

Chart Inc.

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Contents

Revision Log

Revision Level	Date	Description
A	03/26/2015	Original
B	06/09/2015	Update Delivery Operation details in Operations section; update header on all pages.

Preface

General

Chart's MicroBulk delivery system has revolutionized the gas industry by making on-site distribution for smaller accounts a profitable reality. The Orca ST Series delivery unit has been designed to complete an entire fill operation in 3-15 minutes (depending on storage volume) with no pump cooling or product loss (inert service). Automatic fill termination with the Perma-Cyl® MicroBulk Storage System vessels eliminates safety hazards and lost product associated with overfilling. In total, the Chart MicroBulk system increases asset utilization, reduces labor costs and maximizes distribution efficiency.

Chart offers the complete MicroBulk delivery system as a solution to reliably and effortlessly manage a diverse range of applications. At the foundation of the MicroBulk system, the Orca ST Series delivery unit offers fast, reliable and accurate on-site delivery to Perma-Cyl storage vessels or small bulk tanks. Next the Perma-Cyl line offers the widest range of sizes and piping options and the greatest flexibility with accommodations for indoor and outdoor installation. Finally, the innovative Cyl-Tel® Liquid Level Gauge accurately monitors liquid contents and provides a seamless connection to a variety of Chart telemetry platforms.

Product Highlights

- Fast on-site filling of the Perma-Cyl storage system
- Low maintenance exclusive submerged pump for instant starts and continuous delivery
- Filling of small bulk tanks
- Instantaneous push-button delivery of product
- Simple valves to operate
- "Smart" flow metering system reduces required operator training
- NIST/California Weights and Measures approved delivery metering system
- Special delivery hose minimizes contamination, cool down and pressure loss
- Vessel designed with robust inner support system for rugged road conditions
- Electronic control allows for fast in-and-out deliveries and invoicing
- Automated subcool feature
- Single dispense circuit for easy fast deliveries for bulk or MicroBulk
- Stainless steel plumbing with bronze valves for long service life and reliability
- Flowcom® 3000 Flow Metering System
- New spin adapter for safer and faster filling

Product Manual

The ST Series Product Manual is designed to be used in conjunction with Orca ST Series models. It should be thoroughly read and understood by anyone that operates, or is exposed to this equipment. If there are any questions regarding the operation of the tank, contact Chart's Technical Service division at 1-800-400-4683.

The safety requirements for operating the tank and handling or transporting extremely cold liquid products are shown in the Safety section. It is imperative that all persons having contact with the Orca delivery system become thoroughly familiar with all maintenance, safety precautions, and procedures contained in this product manual.

The Introduction section discusses the general features of the tank and the theory of operation.

For detailed information on how to operate the Orca system, refer to the Operations section. Here you will find the various filling procedures as well as pressure transfer instructions.

The Troubleshooting section will become an invaluable tool for answering various possible questions that may arise while using the Orca system.

Please refer to the Specifications section for a complete listing of part numbers, liquid level charts, drawings and other technical information.

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:

ASME	American Society of Mechanical Engineers
BAR	Pressure (Metric)
CGA	Compressed Gas Association
DOT	Department of Transportation
GAWR	Gross Axle Weight Rating
GPM	Gallons Per Minute
GVWR	Gross Vehicle Weight Rating
LAR	Liquid Argon
LN_2/LIN	Liquid Nitrogen
LPM	Liters Per Minute
MAWP	Maximum Allowable Working Pressure
NIST	National Institute of Standards and Tech.
NPSH	Net Positive Suction Head
PB	Pressure Builder
PN	Part Number
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch (Gauge)
RV	Relief Valve
RTD	Resistance Temperature Device
VAC	Voltage - Alternating Current
VDC	Voltage - Direct Current
VFD	Variable Frequency Drive

Safety

Safety Summary

While every possible safety precaution has been taken to ensure safe operation and maintenance of the Orca ST Series delivery system, it is imperative that all persons having contact with the Orca delivery system become thoroughly familiar with all maintenance, safety precautions, and procedures contained in this product manual. If for any reason any part or parts of this manual become confusing or the information provided is not completely understood contact a Technical Service Representative at Chart Inc. 1-800-400-4683 before proceeding with the operation or repair of the vessel.

Compatibility and Cleaning

Always keep the Orca delivery system clean and free from grease and oil. Use care when cleaning with high-pressure water or steam cleaning equipment. DO NOT direct the cleaning nozzle into the electronic components. When replacing components, use only parts which are considered compatible with liquid oxygen. Do not use regulators, fittings, or hoses, which were previously used in compressed air or carbon dioxide environments. Use only oxygen compatible sealants on threaded connections. All new joints should be leak tested with an oxygen compatible leak test solution at a minimum of 35 psig. Failure to comply with these instructions may result in serious personal injury, death, or damage to the container. Once a system has been contaminated, the vessel may not be returned to oxygen service without extremely extensive cleaning methods.

Caution! ***Before removing any parts or loosening of fittings empty the cryogenic container of liquid contents and release any vapor pressure in a safe manner. External valves and fittings can become extremely cold. Personnel must wear protective gloves and eye protection whenever removing parts or loosening fittings. Failure to do so may result in personal injury due to the extreme cold and tank pressure. Accidental contact of liquid gases to skin or eyes may cause a freezing injury similar to a burn.***

Warning! ***If cryogenic liquid or cold boil-off gas contacts a worker's skin or eyes, the affected tissues should be promptly flooded or soaked with tepid water (105-115°F; 41-46°C). DO NOT USE HOT WATER. A physician should examine cryogenic burns that result in blistering or deeper tissue freezing promptly.***

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 at www.cganet.com.

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

Good safety practices dictate the contents of a damaged or suspect container be carefully emptied as soon as possible. Under no circumstances should a damaged container be left with product in it for an extended period of time. Further, a damaged or suspect container should not be refilled unless the unit has been repaired and re-certified.

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.) As a general rule, whenever a container is suspected of abnormal operation, or has sustained actual damage, good safety practices must be followed.

In the event of known or suspected container vacuum problems (even if an extraordinary circumstance 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. Further, the carbon steel jacket could possibly rupture if the unit is exposed to inordinate stress conditions caused by an internal liquid leak.

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.

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.

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 Enriched Atmospheres

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

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

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

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

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

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

Nitrogen and Argon

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

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

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

Introduction

Theory of Operation

Although the Orca ST Series system can have a variety of pump options for output pressure capability, all units have the same general functional operating characteristics. They have the ability to be filled with a cryogenic product and deliver that product to the end customer safely and efficiently.

Terminology of Cryogenics

Cryogenic

A product retaining a temperature of -150° C (-238° F) or colder. Orca delivery systems maintain gases efficiently in a cryogenic liquid state. Gases can be most efficiently stored as liquids. Gases may be liquefied by compression or cooling them until they liquefy. In order to be maintained in a liquid state, each gas must be kept at or below their respective boiling temperatures.

Cryogenic Temperatures

The Orca ST Series delivery systems employ cryogenic temperatures to store the product in its liquid state.

Gas-Boiling Temperatures (at 0 psig)

Argon -302° F
Nitrogen -320° F
Oxygen -297° F

States of Matter

Matter can exist as a gas, liquid, or a solid. Two phase liquid is a liquid with gas bubbles or slugs of gas due to lack of pressure to maintain equilibrium. Gas and liquid can exist at a range of temperatures.

Saturation

Defined as the point at which liquid and vapor coexist at the same pressure (temperature).

Liquid density, temperature, and equilibrium pressure change with the saturation level of the liquid. Saturation can also be described as an energy state. Liquid molecules at a higher energy state (warmer) take up more space.

Equilibrium

In a closed vessel the gas and liquid temperatures are the same. If there is a temperature difference between the gas and liquid (with the tank closed), the gas and liquid will change their temperatures until they are equal.

Saturation Pressure

Pressure (usually in psi) that is used to describe the current condition of a liquid and gas within a closed container.

Subcool

Raising the vapor (gas) space pressure above the normal vapor pressure of a saturated liquid, creating Net Positive Suction Head or NPSH.

Two-Phase Liquid

The mix of liquid and gas due to the pressure dropping below the saturation pressure of the liquid caused by the lack of proper subcool. This will cause damage to the pump!

Cavitation

Defined as the formation of vapor bubbles in a liquid, it manifests as partial or full loss of pump prime due to the lack of proper subcool. The pressure of the liquid flowing to the pump has dropped below the saturation pressure. Audible changes in the pump often are an indication of partial loss of prime. The pump will stop pumping during full loss of prime.

Vaporization

Changing liquid into vapor by warming the liquid for the purpose of subcooling or for gas use. The Orca ST Series delivery system uses a pressure building coil, located on the roadside of the vessel to accomplish this.

Vapor Pressure

Pressure of the vapor space within the tank. Measured by reading the tank pressure gauge or the Flowcom® Flow Meter System.

Condensation

The conversion of vapors into liquid by cooling the vapors. The Orca ST Series storage vessel pressure during normal operation will rise above the saturation pressure of the liquid. This warmer gas will condense to the colder liquid pressure during transit. The liquid splashes into the gas space during normal movement of the truck/trailer. The splashing condenses the gas and drops the pressure. This is know as "splashdown."

Condensation and the Perma-Cyl® Storage System

An example of condensation can be seen in the filling theory of a Perma-Cyl tank. Top filling a Perma-Cyl tank without venting is possible due to condensing warmer gas into liquid.

Condensation and the Orca

Just like top filling of a Perma-Cyl tank, top filling the ST Series tank allows filling without venting.

Depressurization Flash Losses

Dropping the vapor space pressure below the saturation pressure of the liquid causing the liquid to boil. During the venting of the tank below the saturation pressure of the liquid, the liquid temperature will drop, the density will increase, weight of the liquid will decrease, and the saturation pressure will drop.

Entrainment

Liquid carried along with venting gas. This can occur during violent depressurization of a tank and during the top filling of a tank with the vent valve open. Large product losses will occur during this event.

Liquid Growth

As liquid warms to higher saturation pressures, the volume increases. Warm liquid is less dense. Less dense liquid takes up more volume. Liquid growth is a safety concern if the liquid is allowed to grow until it fills the storage vessel. This condition is called liquid full or hydraulically full. During this condition the pressure rises rapidly, the safeties will relieve, and the tank will vent liquid.

Pressure Drop

Pressure lost due to the flow of liquid. The faster liquid flows through the piping circuit, the higher the pressure drop.

Stratification

Warm liquid is less dense. In a tall vertical tank this less dense liquid will find its way to the top of the tank. Colder more dense liquid will remain at the bottom. The layering of temperature zones from top to bottom is called stratification.

Operations

Filling the Orca Delivery System - First Use

The Orca ST Series delivery system is shipped under pressure with a low purity nitrogen atmosphere to keep out moisture. IT MUST BE PURGED PRIOR TO USE. While purging through the various lines, observe the tank pressure indicating gauge (PI-1). Make sure that the tank pressure does not go below 5 psig. Before filling, be sure that protective eyeglasses and gloves are being worn.

A bottom fill method is recommended the first time the Orca delivery system is filled and any other time the tank is "warm" (warmer than the boiling temperature of the product you will be dispensing). Precool the Orca tank by blowing cold gas from the source tank into the bottom fill line (V-17). Open the vapor vent valve (V-5) and check the temperature of the exit gas. When the exit gas is cold enough to frost the vent assembly stop the flow of gas from the source tank and slowly start the flow of liquid. Keep the vapor vent valve (V-5) open to manage tank pressure.

Note: *Cooling the tank slowly will prevent uneven cooling and uneven contraction. Stainless steel from ambient to cryogenic temperatures will shrink 1/32" per 12" of length. Uneven shrinking can cause high stresses in supports and attachments, resulting in damage to the tank.*

1. Attach the source of liquid or gas purge product to the top and bottom fill CGA connection (DC-2) on the Orca tank.
2. Open the source tank feed valve and the bottom fill valve (V-17) on the Orca tank allowing gas to flow slowly into the tank. Build the tank pressure to 30 psi.
3. Close the bottom fill valve on the Orca tank and close the source tank feed valve. Purge the trapped space by opening the fill line drain (V-9) on the tank.
4. Crack the compression fittings on either side of the liquid level gauge (Ll-1), allowing gas to flow. Terminate the purge prior to the line getting cold. Tighten compression fittings and leak check.
5. With the bottom fill valve closed, open the fill line drain and the top fill valve (V-3). Purge for two minutes. Close the top fill valve and the fill line drain.

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

6. Open the bottom fill valve and the fill line drain. Purge for two minutes. Close the bottom fill valve and the fill line drain.

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

7. Open the (V-18A) trycock. Purge for two minutes. Close trycock valves.
8. With the recirculation valve (AOV-2) closed, crack the compression fitting at the outlet of the pressure building coil, and purge for two minutes. Tighten the compression fitting and leak check.
9. Manually open the dispense valve (AOV-1) by opening the dispense valve pneumatic override valve (AOV-1) and open hose valve (V-41).
10. Purge for two minutes. Close the low flow dispense valve (V-41) and manually close dispense valve (AOV-1) by closing dispense valve pneumatic override valve (AOV-1).
11. Vent tank to 5 psi using the vapor vent valve (V-5).
12. Repeat steps 7 and 8 three times.
13. After purging is complete, check the gas in the Orca tank for purity.
14. After purging the tank, but before filling, verify that the following valves on the Orca tank are open:
    a. V-11 Vapor Phase Valve
    b. V-12 Liquid Phase Valve
    c. V-13 Pump Discharge Isolation Valve

Filling the Orca Delivery System - Normal Use

The piping has a top and bottom fill circuit (DC-2). If filling the Orca tank with liquid saturated at a higher pressure (temperature) than what currently is in the tank, bottom filling is recommended. If filling the Orca tank with liquid saturated at a lower pressure (temperature) than what currently is in the tank top filling is recommended. This will minimize the tank pressure rise and minimize the venting required to manage the Orca tank pressure. Filling the tank with liquid saturated at pressures at or above the tank pressure rating (38 psig) will require excessive venting.

Lowering the saturation pressure of a liquid will require the liquid to boil. Cold gas is heavy! Minimize venting during filling. Try to use as cold a source of liquid as possible.

Note: *Either pressure transfer or pump filling can accomplish filling the Orca system. The best results will be obtained when the pressure in the supply unit is at least 25 psig more than the receiving unit (Orca tank). As pressure fluctuates, adjusting the vapor vent valve (V-5) on the Orca tank and the fill/drain valve on the supply unit may regulate the pressure.*

Whenever possible, the Orca unit should be on a level surface when filling. If the vehicle is not level, instrument readings as well as the full trycock points may not be accurate. Wear gloves and protective goggles when working with any cryogenic material. Contact with cryogenic materials can result in severe frostbite and injuries similar to burns. Make sure that the road relief valve (V-2) is closed prior to filling the Orca tank.

Purging the Fill Line

Connect the fill hose from the supply tank to the Orca tank fill connection.

1. Open the fill line drain valve (V-9) on the Orca tank.
2. Slightly open the bottom fill valve on the supply tank.
3. Run product through the line to thoroughly purge the fill hose for 2-3 minutes.
4. Once the fill hose is purged, close the fill line drain (V-9) on the Orca tank and bottom fill valve on the supply tank until ready to commence filling of the Orca tank.

Top Filling the Orca Delivery System

If the source liquid is cold, top filling lowers the product losses during filling. The top fill valve (V-3) on the Orca tank has a spray header that will splash the incoming cold liquid onto the somewhat warmer gas in the tank. The cold liquid will condense the warmer gas reducing the tank pressure. Check the tank. If the tank is cold, top filling is recommended. This will result in the pressure in the tank being reduced.

1. If necessary, start the pressure-building device on the supply unit.
2. Check the chart on the inside back door of the cabinet for specifications for each type of gas and the recommended filling levels for the product you are about to fill. With the supply tank connected open the top fill valve (V-3) on the Orca tank fill circuit.
3. When the liquid level in the Orca tank is at the halfway point, open the full trycock valve.
4. When the Orca tank is full, liquid will vent out of the full trycock valve (V-18A). Close the full trycock valve and close the liquid supply tank fill and drain valves. Open the fill line drain valve (V-9).
5. Close the full trycock (V-18) and allow the hose to drain into the Orca system for five minutes.
6. Close the top fill valve (V-3).
7. When the hose indicates no pressure, close the fill line drain (V-9) and remove the hose from the CGA fill connection (DC-2).
8. Replace the CGA fill fitting cover onto the Orca tank fill connection (DC-2) and stow the delivery hose.
9. Open road relief valve (V-2).
10. Close the plumbing cabinet doors.

Filling Levels - CGA-341

The Orca delivery system can be filled using the 95% full trycock method as the full indication if the weight doesn't exceed the road weight limits or the truck gross vehicle weight rating and the gross axle weight rating (GVWR/GAWR). Tanks operating under CGA-341 must have a relief system that prevents the tank pressure from exceeding 25.3 psig. The Orca delivery system is supplied with a road relief system that can be used to maintain the tank pressure at or below 25.3 psig (typical cracking pressure is 17 psig).

Filling Levels - MC-338

The DOT regulations limit the fill levels based on the tank's pressure control valve settings. This volume assures that when the pressure control valve discharges the tank is not liquid full. This fill volume varies with the starting saturation pressure of the liquid. DOT fill levels are based on the weight of the liquid. Differential liquid level gauges are an acceptable means of weight determination along with the full trycock.

Maintaining Cold Liquid

Cold liquid is liquid saturated at 15 psi or less

Saturation Pressure psi	Liquid Nitrogen Temp °F	Liquid Oxygen Temp °F	Liquid Argon Temp °F
0	-320	-297	-303
10	-312	-288	-293
15	-309	-284	-289

Reasons for Cold Liquid

1. Cold liquid is denser. Denser liquid has more cubic feet of gas per gallon of liquid.
2. Filling low-pressure cylinders (22 psi) with warm liquid (above 15 psi) results in the main safety venting for extended periods of time after the fill is complete.
3. Cold liquid (10 psi or less) is essential if filling open dewars. Cold liquid will minimize vent losses, optimize fill times, and improve safety.
4. Collapsing of vapor space in receiving tank is achieved.

How to Maintain Cold Liquid

The Orca delivery system can be supplied with an optional secondary relief system (road relief circuit). This secondary relief system will maintain the liquid at a specified saturation by setting the road relief regulator to your required saturation pressure. It is recommended to set the secondary relief system to 10 psi if open dewars or low pressure cylinders are to be filled. After filling the Orca tank, vent the contents to your desired pressure. During daily operation, keep the road relief valve (V-2) open during transit. It is extremely important to close the road relief valve before performing a delivery.

Current Saturation of Liquid

Upon arriving at your delivery site, the Orca tank pressure indicator (PI-1) will reflect the current saturation pressure. During travel the liquid splashes condensing the warmer vapor. This is referred to as "shake down." During normal delivery operations the tank pressure will rise. This is not an increase in your saturation but an increase in your subcool. During normal deliveries your saturation pressure will remain the same as at arrival.

Flow Termination Methods

A typical Perma-Cyl tank transfer is terminated by the Flowcom® Flow Meter System. Listed below are methods available for the operator to terminate the flow.

- Close the dispense valve on the hose - preferred for both bulk tank and liquid cylinder.
- Press the "Stop" button on the Flowcom display or on the pendant
- Press the "E-Stop" button

Note: *Pressing the "E-Stop" button should only be used in an emergency situation.* ***DO NOT*** *use this method on a regular basis.*

The Flowcom Flow Meter System will initiate flow termination if any of the following situations arise:

- Flow rate change is greater than the flow drop setting with the flow drop time (e.g. Perma-Cyl float closes, preferred method).
- Flow rate is lower than the flow rate set point
- Flow rate is higher than the high flow rate set point
- Max total threshold has been exceeded
- Flow rate is unstable
- System alarm reached on the control panel (VFD)

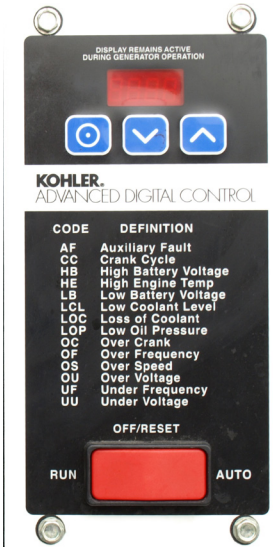
Generator Operation

With the Orca delivery system securely positioned and ready for delivery, follow these steps to start and use the generator.

1. Open all generator cabinet doors (both roadside and curbside).
2. Turn the generator toggle switch to the "Auto" mode.

Note: *The Remote Start is now enabled.*

3. Use the Remote Start in the Delivery System Cabinet for deliveries throughout the day.



4. When delivery is completed, secure and latch all generator cabinet doors.

5. At the end of the day, or if the unit is to be out of service for more than 12 hours, turn the toggle switch to off.

Operating the Generator in Temperatures below 32° F

1. Plug in the block heater for 3 hours minimum before operating the generator.

2. Check to make sure the electrical panel heater is plugged in.

Note: *The electrical panel heater is thermostatically controlled and has power any time the generator is running. It can also be plugged into house power along with the generator heater.*

3. Start the engine following the Generator Operation steps.

4. Leave engine running between sites.

5. Open the generator cabinet doors while operating the pump.

Delivery Operation - Auto Mode: Perma-Cyl, Liquid Cylinder, or Bulk Tank

Position the Orca delivery system and secure the unit with the appropriate safety equipment.

1. Open the generator cabinet doors on both sides to allow for proper air flow.

2. Turn the generator switch to 'Auto'.

3. Verify the piping cabinet air supply valve (Emergency) is open.

4. Open the piping cabinet doors.

Note: *Opening the piping cabinet doors engages the anti-tow valve, locks the brakes, and supplies air to the piping cabinet.*

5. Turn on the Flowcom® Flow Meter System by pressing the power button.

6. Turn on Control Panel Power by turning momentary control power switch (SW206) to the 'ON' position.

Note: *With no active VFD faults (VFD contacts 24/25 closed), 12-volt power closes the main 480-volt contacts.*

7. Select 'Auto' mode on the Control Mode Switch (SW210). Switch may have been left in 'Auto' from previous delivery.

Note: *Control mode switch and panel relays enable Flowcom system control of the pump and control valves. 12-volt power flows through control mode switch to "Auto Mode" relay (CR216), closing normally open contact (CR216) allowing pump control from the Flowcom meter system.*

8. Close Road Relief Valve (V-2)

Caution! If the road relief valve was not closed and arrival pressure is close to 38 psi MAWP, the pump cool down and subcool build may exceed the 38 psi MAWP. Open the main vent and vent down to 17 psi and close the vent. Turn off the Flowcom meter system, wait one minute and turn the power back on (this allows the liquid to re-stabilize and the Flowcom meter system to re-establish pSat).

9. Remove the stowed hose (Tran-1) and remove dust plug from the end of the hose. Connect to the receiving tank using appropriate adapter end (if required).

   a. Bulk Tank: Open hose drain and delivery hose end valve to purge fill circuit, then close both.

   b. Bulk Tank / Liquid Cylinder: Open fill valves to proper amount.

10. Check receiving tank pressure and estimate the condition of the receiving tank ("warm" or "cold").

11. Set pump speed to 50% on the Speed Select Dial (POT107).

12. Start the generator/480 VAC supply by pressing 'Start/Stop' on the generator remote control (if required). This will power up the VFD with 480 volts.

13. Press ‘Start’ on the Flowcom interface or the remote pendant to start the pump in recirculation mode.

Note: *This action closes the pump run output (OUT#5) starting the pump in recirculation mode. The normally open pump run relay closes (CR328), energizing pump input (VFD contact 8) starting the pump which will ramp to speed based on speed selection (POT107). VFD output #1 closes energizing relay (CR322) when the pump speed exceeds 39.5 Hz the mode switch light illuminates (Green) and the 3-way return valve (AOV-5) changes to direct liquid to the meter.*

14. Adjust the pump discharge pressure by adjusting pump speed with speed select dial (POT107).

Note: *Pump discharge pressure needs to be a minimum of 50 psi above the receiving tank pressure and no lower than 150 psi.*

The Flowcom® Flow Meter System opens and closes the “PB Force Feed Valve” (AOV-2) as needed to satisfy the subcool requirement of 4.3 psi
(Current Vessel Pressure - Saturation Pressure = Subcool)
(p VTank - pSat V Tank = pSub VTank).

Note: *In cases of a large delivery (i.e. dispensing over half the Orca delivery system), the operator should manually build subcool to minimize the number of cycles the “PB Force Feed Valve” actuates to conserve the air supply.*

15. Confirm hose connections and press ‘Start’ to initiate dispensing.

Note: *The dispense valve output energizes (Flowcom OUT#1) which energizes the control panel valve relay (CR320). This closes the dispense valve normally open relay contact (CR320), powering the dispense valve solenoid (SV210), which supplies air to the dispense valve pneumatic actuator opening the dispense valve (AOV-1) and opens recirculation valve (AOV-3).*

16. Open “Delivery Hose End Valve” (V-41) within 10 seconds of pressing ‘Start’.

Note: *This is done after starting the pump and adjusting pressure in case the receiving vessel does not have a check valve in the fill circuit. If confirmed that a check valve is in the fill circuit (i.e. Perma-Cyl), the delivery hose end valve could have been opened earlier.*

17. Monitor receiving tank filling conditions.
    a. Bulk Tank: Adjust top and bottom fill.
    b. Liquid Cylinder / Perma-Cyl: Vent as needed to maintain proper pressure (i.e. in the case of a warm tank).
18. When filling is complete:
    a. Perma-Cyl: Float in the Perma-Cyl tank will close the fill circuit when filling is complete.
    b. Bulk Tank / Liquid Cylinder: Terminate the flow by closing the “Delivery Hose End Valve”.
19. Flowcom meter system stops the pump.
20. Stop the generator by pressing ‘Start/Stop’ on the remote control or at the generator control panel.
21. Close the “Delivery Hose End Valve” (V-41) if not already closed.
22. On the Bulk Tank or Liquid Cylinder, close the fill valves and open the line drain.
23. Disconnect the hose (and adapters) from the receiving tank, install the dust plugs and stow the hose.

Connect to another Perma-Cyl tank or receiving tank or proceed to the section titled “Printing A Ticket” in this manual if delivery at this site is complete.

Once delivery at this site is complete, proceed to the section titled “Securing the Orca Delivery System for Movement” in this manual.

Printing a Ticket

Once the delivery is complete the next step is to print a ticket.

1. Open the printer door.
2. Insert paper/ticket into the printer by pressing the 'Release' button on the printer, slide the paper/ticket into position and press the 'Forward' or 'Reverse' buttons to lock the paper/ticket into place.

Note: *There is an arrow on the side of the printer that shows where the printing will start.*

3. On the Flowcom interface, exit the 'Delivery' screen by pressing the 'Exit' button and press the 'Print' button. A signal is sent to the printer to print the following: Transaction Number, Vehicle Number, Date, Time at Start, Time at Stop, Product Type and Total.
4. When the printer is finished printing, press the 'Release' button to remove the paper/ticket.

Note: *The operator can print a duplicate ticket if needed by pressing the 'Print' button a second time.*

5. Close the printer door.

Securing the Orca Delivery System for Movement

After filling the tank and printing a ticket, you must follow the steps below to prepare the Orca delivery system for travel.

1. Vent the Orca tank to pressure (PI-1) below 25 psig if needed by opening the 'Main Vent' valve (V-5). Close this valve when proper pressure has been obtained.
2. Open the 'Road Relief Valve' (V-2).
3. Turn off the Control Panel Power by turning momentary Control Power Switch to the "OFF" position (SW206).

Note: *The control mode switch (SW210) can be left in "Auto" or switched off. When switched off, auto mode relay (CR216) de-energizes and returns to normally open.*

4. Clear delivery total by pressing "Clear", "Clear", and "Deliver" to enter delivery mode.
5. Power the Flowcom® Flow Meter System off.
6. Close the piping cabinet doors.

Note: *Closing the cabinet doors deactivates the anti-tow valve allowing normal brake operation and stops air supply to the plumbing cabinet.*

7. Switch the generator from 'Auto' to 'Off/Reset' (this can be left in Auto throughout the workday but should be switched off at the end of the day to prevent discharging the generator starting battery).
8. Close the generator cabinet doors.
9. Stow all safety equipment.

Pendant Operation

Start Button

- Press the start button once - pump will start-up and recirculate
- Press the start button again - pump will deliver liquid
- After pressing the stop button a ticket can be printed by pressing the start button

Stop Button

- Pressing the stop button will end the delivery and puts the Flowcom interface into print mode

Note: *If the stop button is pushed, the totalizer needs to be zeroed prior to restarting the pump.*

Safety Equipment

Curbside Safety Equipment

Located on the rear curbside of the trailer are safety cones and wheel chocks for use at each delivery stop.

Located just above the fender on the curbside is an Emergency Stop Button. Pushing this button will shut off all power to the system (the generator will remain running). Located just below is an Emergency Shutoff lever. Pushing this lever down will stop all air from flowing to the piping cabinet.

Roadside Safety Equipment

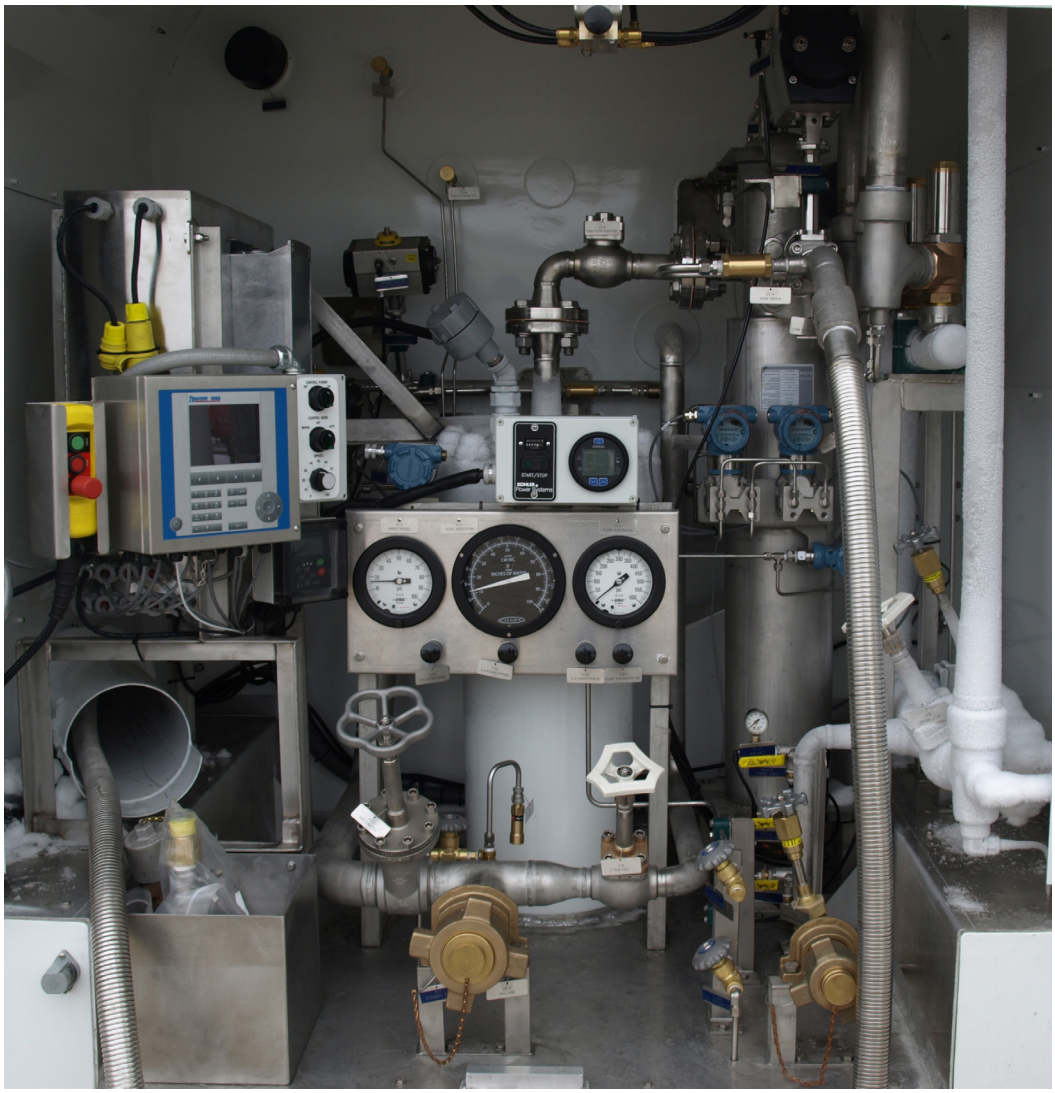
An emergency stop button is also located on the roadside of the trailer just above the fender.

Also on the roadside is a fire extinguisher and another air supply emergency shut off lever.

Cabinet Safety Equipment

The emergency stop button in the cabinet is located on the pendant.

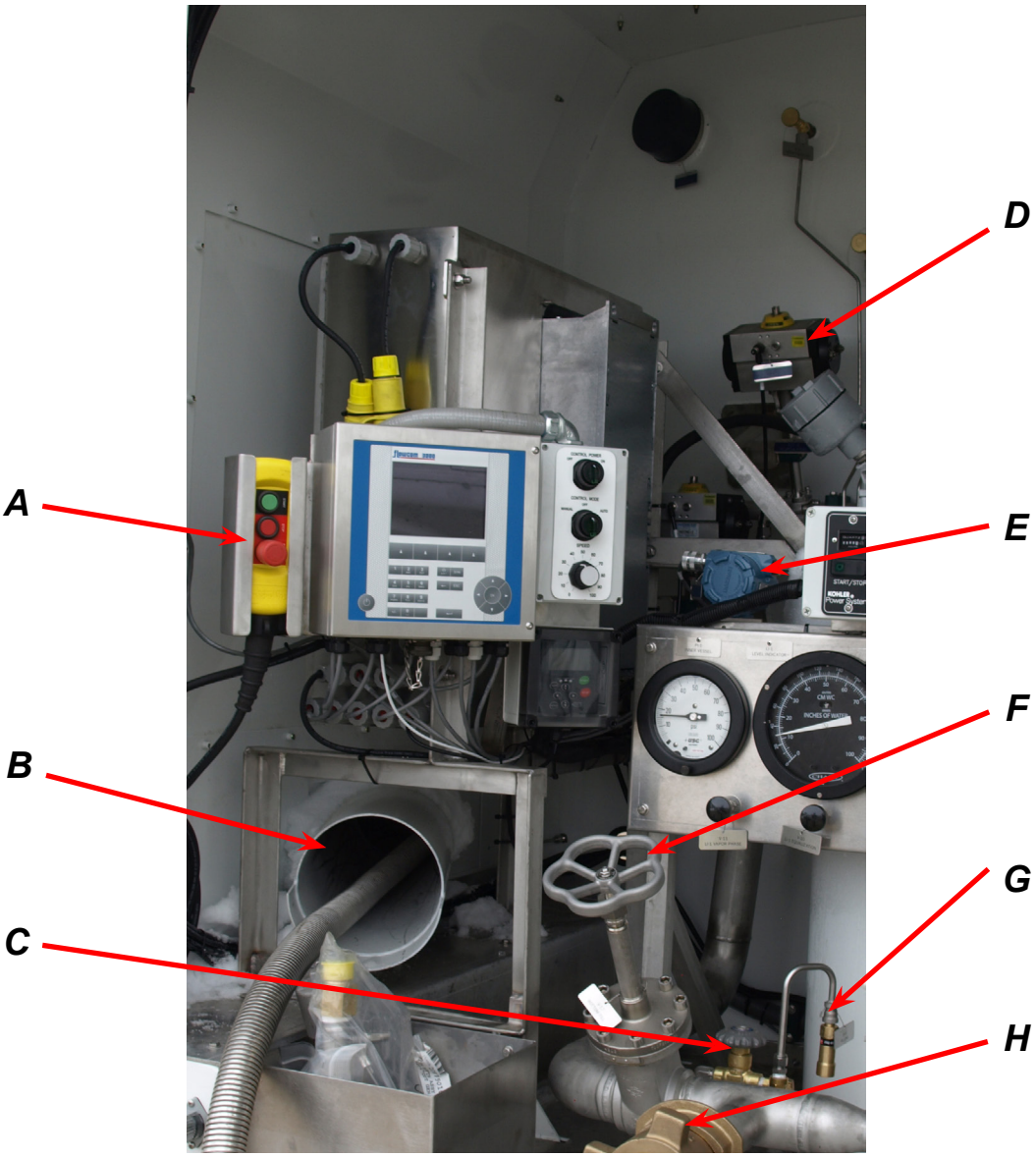
Components & Systems



Roadside **Center** **Curbside**

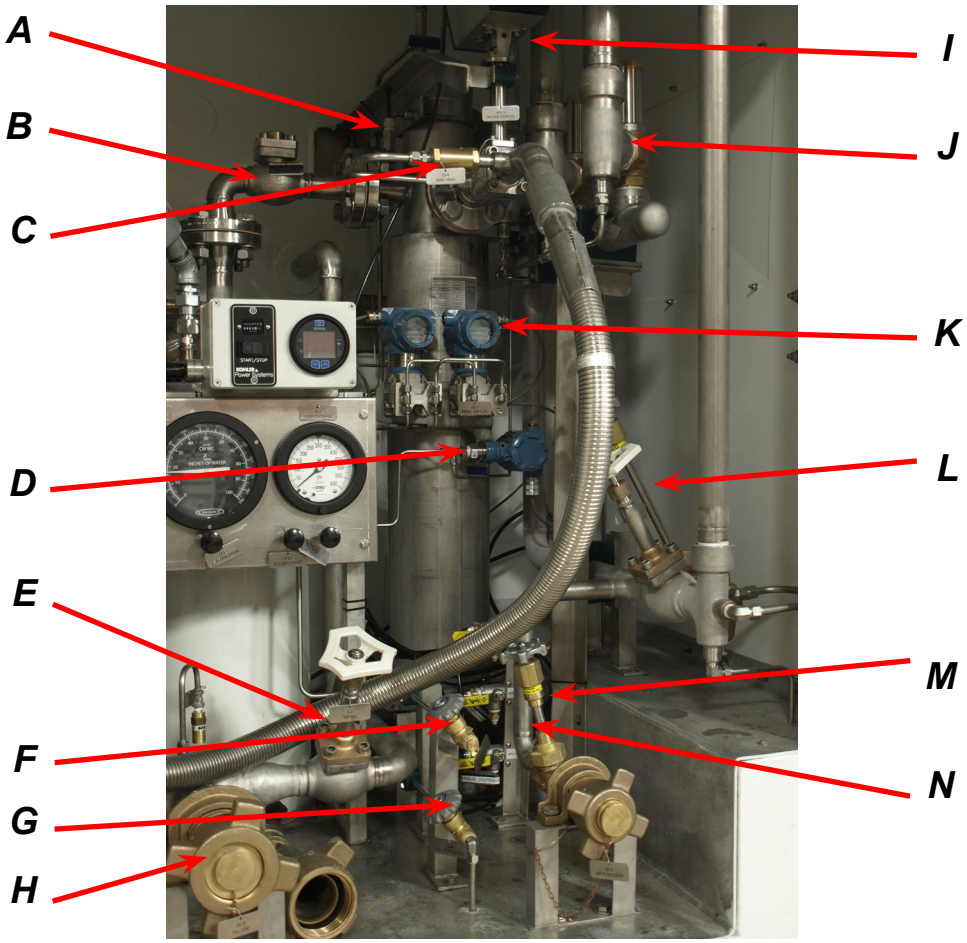
This is the view of the Orca ST Series delivery system cabinet. In this section we will discuss in detail, plumbing cabinet components and systems. To aid in this we will break the cabinet into three areas - Roadside, Center (system control and monitoring), and Curbside.

Plumbing Cabinet - Roadside



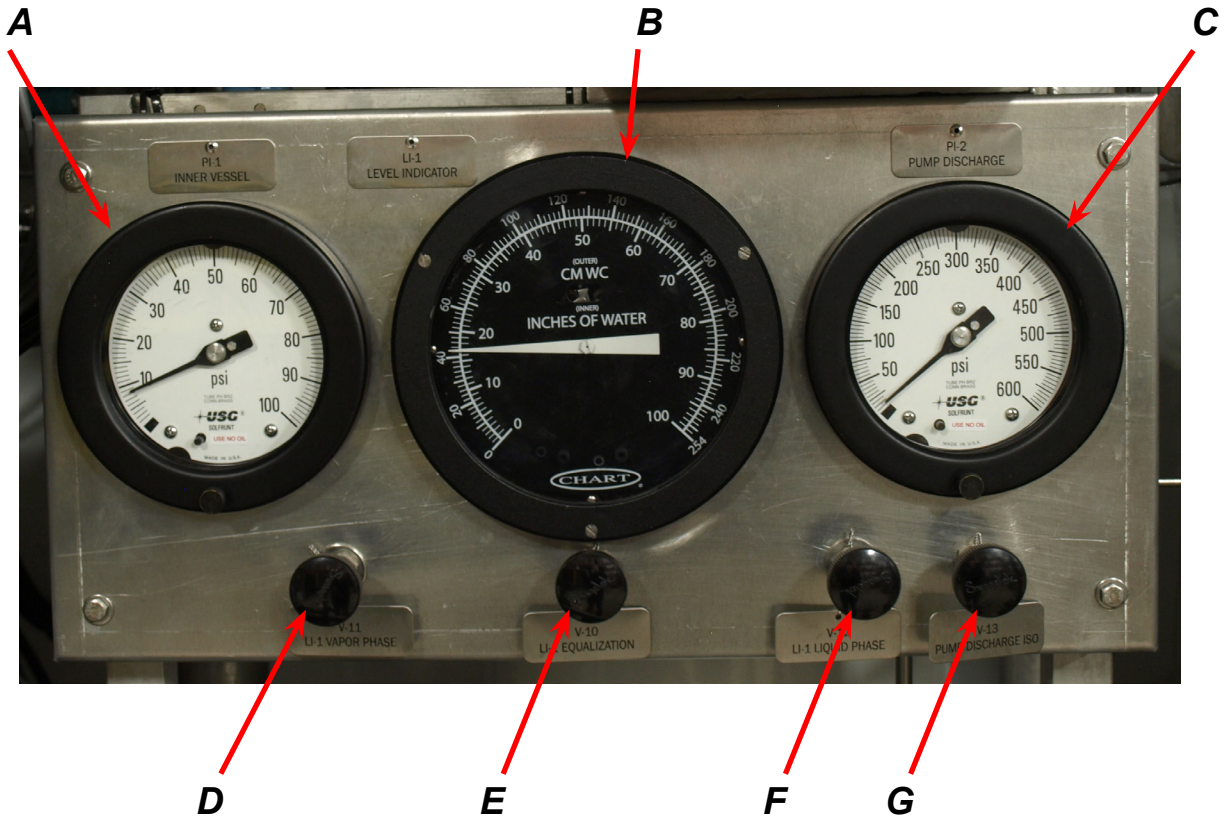
Item	Tag	Part Number	Description
A		20860692	Electrical Pendant
B		20854521	Hose Storage Tube
C	V-9	1713202	Valve, Fill Line Drain
D	AOV-2	20821333	Air Operating Valve, Recirculation
E	PT-1	20832592	Transmitter, Pressure Inner Vessel
F	V-17	20785160	Valve, Bottom Fill
G	SV-4	11670000	Safety Relief Valve, Fill Line
H	S-1	11060480	Strainer Fill

Plumbing Cabinet - Curbside



Item	Tag	Part Number	Description
A	RTD-1	FL1145110	Resistance Temperature Device
B	CV-8	20581252	Check Valve Liquid Feed
C	CV-4	11051090	Check Valve Hose Drain
D	PT-2	20832592	Transmitter, Pressure Pump Discharge
E	V-3	13410261	Valve, Top Fill
F	V-23	1713203	Liquid Sample/Sump Drain
G	V-18A	10616790	Valve, Full Trycock DOT
H	DC-2	10542954	Connection, Fill Line
I	AOV-1	20832118	Air Operating Valve, Dispensing
J-1	SV-1A	20852077	Safety Relief Valve, Vent Circuit
J-2	SV-1B	20852077	Safety Relief Valve, Vent Circuit
K-1	DP-1	20881753	Transmitter, Differential Pressure Low Flow
K-2	DP-2	20881754	Transmitter, Differential Pressure High Flow
L-1	V-5	13410261	Valve, Vapor Vent
L-2	V-2	10616790	Valve, Road Relief
M	V-44	1718772	Valve, Vapor Recovery
N-1	AOV-1	20832118	Air Operating Valve, Dispensing
N-2	AOV-2	20821333	Air Operating Valve, Recirculation
N-3	AOV-3	20821333	Air Operating Valve, Force Feed

Control Gauge Panel



Item	Tag	Part Number	Description
A	PI-1	11707191	Pressure Indicator, Inner Vessel
B	LI-1	11532088	Level Indicator, Inner Vessel
C	PI-2	11702121	Pressure Indicator, Pump Discharge
D	V-11	10907239	Valve, LI-1 Vapor Phase
E	V-10	11701443	Valve, LI-1 Equalization
F	V-12	10907239	Valve, LI-1 Liquid Phase
G	V-13	11701443	Valve, Pump Discharge Gauge

With normal use, the gauge panel will not require any regular maintenance. However, in the event that the differential pressure gauge becomes stuck, complete the following step to reset the gauge.

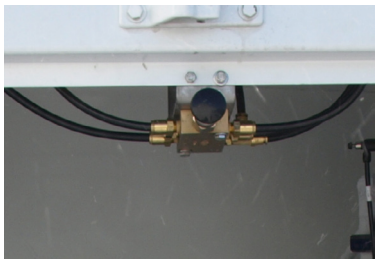
1. Crack open the equalizer gauge line valve.
2. Close the vapor and liquid level valves.
3. Open the vapor and liquid level valves.
4. Close the equalizer valve.

Note: *The gauge should read zero. If the gauge does not read zero, please refer to the gauge maintenance section of this manual.*

Control Panel

Item	Part Number	Description
A	11910632	Control Power Switch 12 VDC, 480 volt contactor
B	11910704	Mode Selection Switch - 3 pos. Selector
C	11910691	Pump Speed dial
D	11910712	E-Stop Push Button

Anti-Tow Valve

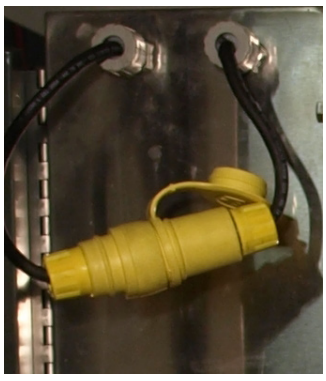


Located at the top of the piping cabinet the Anti-Tow Valve is pneumatically connected to the air brakes and can only be released when the Plumbing Cabinet Doors are closed. The plumbing cabinet doors can only be closed when the delivery hose and remote pendant are stowed back in the cabinet.

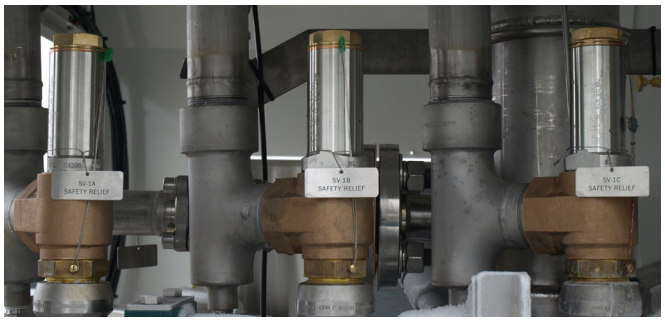
Heater/Inverter

The Cutler-Hammer Variable Frequency Drive (VFD) has an internal temperature sensor that does not allow the VFD to operate at temperatures below -20° F and will not run the pump if below -4°F. If the VFD temperature is between -20°F and -4°F, the VFD will conduct a self-warming procedure that slowly turns the pump until the VFD warms to -4°F. Once -4°F is achieved, the pump will automatically ramp up to the selected speed. In some cases, the VFD will cool slightly as the pump just gets started and will cool to below -4°F, at which time the pump will stop and the VFD will re-warm itself. The initial warming may take up to one minute and the occasional re-warming another minute.

The VFD will not power up if colder than -20°F. It is recommended to plug the heater into the 120 VAC External Plug on nights that drop below 32° F, and into house power on nights below 10°F. The heater switch should be set to Fan so that the fan is continuoulsy circulating air to aid in the heating and the thermostat is wired to 75°F to keep the knob from rotating during transit.

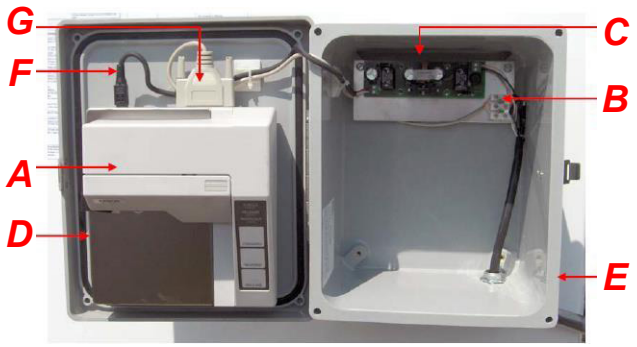


Vent Circuit



The Vent Circuit is located on the curbside of the trailer. A convenient access panel can be removed for access to the vent circuit.

Ticket Printer



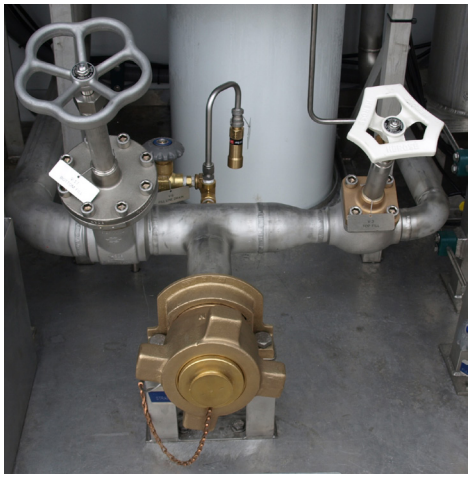
Item	Description	PN
A	Printer Ribbon	11693421
B	Terminal Block	11801276
C	DC/DC 12-24 VDC Converter	FL0172049
D	Printer-Epson	13086077
E	Printer Box	11720142
F	Printer Power Cord-6’	11764428
G	Printer Data Cable	11764436

Submerged Pump

The submerged pump is a specifically designed variable speed centrifugal pump that is designed to operate while submerged in liquid nitrogen or argon. The pump is inside a flanged sump that is connected to the Orca tank and is always filled with cryogenic fluid. This means that the pump is always cooled-down and can be used to deliver product to the Perma-

Cyl® MicroBulk Storage System or other MicroBulk tanks virtually instantaneously.

Fill Circuit



The Orca tank is filled through the top and bottom fill circuit. Using the fill circuits properly will minimize vent losses during filling. The fill line drain should be used to vent the fill hose after filling to relieve any pressure.

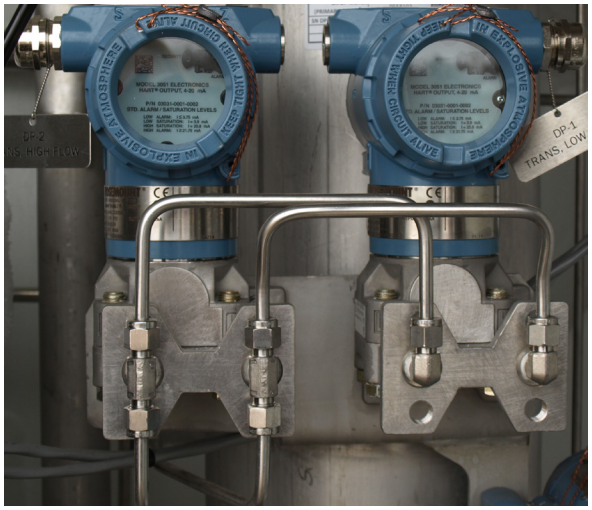
Metering System

The metering system provides an accurate and calibrated means for measuring the amount of product dispensed from the Orca tank to the customer. The system is made up of five components: the Meter Section, Differential Pressure Transmitter, RTD Resistance Temperature Device, Hose Drain Check Valve, and the Flowcom® Flow Meter System.

Meter Section

The Orca system incorporates an Orifice type Meter Section, which unlike turbine meters, has no moving parts to be damaged by gas. This unique feature makes the meter section a low maintenance item. As the liquid flows to the tapered orifice, a high pressure zone is created. Once the liquid flows through this restriction and reaches the larger "back side" of the restricted orifice, a drop in pressure occurs. This difference of pressure is the beginning of how product is metered. A 1/4" line is plumbed into each side of the meter section. These two lines are then plumbed to the Differential Pressure Transmitter which makes this differential pressure an electronic signal.

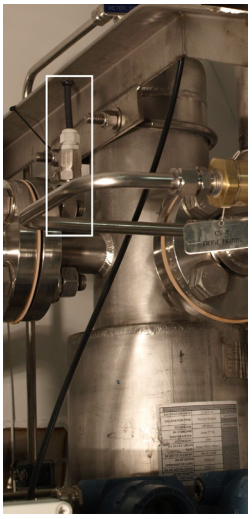
Differential Pressure Transmitter (DP Transmitter)



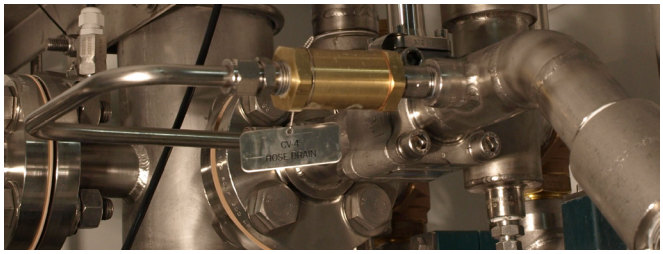
This is a Rosemount Pre-Set Differential Pressure Transmitter used on the Orca system. It is connected to the meter section and the Flowcom meter system. The DP transmitter measures a change in pressure (pressure drop) across the meter section and relays this information to the Flowcom meter system in an electrical signal. The signal sent to the flow meter system is a 4-20 milliamp signal.

RTD - Resistance Temperature Device

The resistance temperature device (RTD) is located at the top of the meter flange. The probe is threaded into the flange so it can accurately measure the temperature of the liquid. The resistance of the element at the end of the probe varies with temperature. The RTD is used to measure accurately the temperature of the liquid being metered. Based on this temperature, a density is assigned.



Hose Drain Check Valve



Following a delivery, the hose drain check valve allows a path for product left in the dispense hose to return to the sump. This valve closes when the pump starts and pressurizes the delivery system. It opens after the pump is shut down and the pressure in the dispense hose increases due to warming and vaporizing of the liquid in the dispense hose.

Flowcom Flow Meter System

The Flowcom® Flow Meter System is used for calculating, integrating, system controlling, and displaying the mass flow. The push button controls allow the operator to start and stop the delivery, to view information, initiate the print out of the delivery ticket and to clear the total.

Note: *If programming assistance is required, refer to Flowcom manual or contact a technical service representative at Chart Inc. at 1.800.400.4683.*

Troubleshooting

Use the following troubleshooting table as a guideline to diagnose your Orca system should problems develop. This table cannot replace the knowledge that an experienced operator or cryogenic technician has, and should be considered as a guide only. The table consists of the Symptom, Probable Cause and Remedy columns. Probable causes for a specific problem are listed in a descending order of significance. That is, check out the first cause listed before proceeding to the next. The error codes reference the Flowcom® Flow Meter System Installation and Sevice Manual.

Symptom	*Probable Cause*	*Remedy*
No control panel power (light not on)	Breaker blown in 12 volt control circuit.	Replace breaker / reset breaker in fuse block in truck.
	12 volt circuit open.	Verify connector is plugged in at front of tank. Also inspect wires from connector to control panel for break, cuts, etc. Repair if necessary.
	Panel door open / panel door switch off.	
Low voltage or high voltage error messages on VFD display.	Alternator spinning too fast or too slow.	Adjust generator voltage accordingly.
Over current error message on VFD remote display.	Pump drawing too much current.	Slow pump speed down using control on pendant.
	Worn bearings in pump.	Remove and replace pump.
Control valves do not open.	No air supply to the valve or low air.	Verify that there is sufficient air in air tanks. Valve requires 100 psi to operate.
	System in manual mode.	
	No 12 volt power to the solenoid.	Verify solenoid is plugged into junction box, and that wires are not broken.
	Actuator failure.	Thaw out valve. ***Caution!*** ***Do not use fire or flame to thaw valve on an oxygen unit!!!***
Error E009 Error E010	Measured temperature is too low. PT100 low signal voltage. PT100 excitation current out of range.	May be caused by any of the following: -Temperature sensor PT100 is not connected properly. -Temperature range switching is defective. -Constant current source is defective. The product parameter does not match the actual product being metered.
Errors on boot-up. Error E011 Error E012 Error E013 Error E014 Error E015	Liquid flow through meter section before meter is turned on. DP transmitter defective. Wiring defective. Leak in DP lines.	Press “STOP” button on control pendant. Verify transmitter is plugged into junction box JB1, and that wires are not broken. Voltage across contacts 1 & 2 on block X7 should measure between 18 & 26 VDC. If not, front board needs to be replaced. Tighten fittings.

Symptom	Probable Cause	Remedy
Unstable flow of product.	Depletion of subcool.	Add subcool by opening pressure building coil. Required pressure is 4.3 psi above saturation pressure.
	Auto subcool valve not opening.	***Caution! Do not use fire or flame to thaw valve on an oxygen unit!!!***
	Vessel transmitter fault.	
	Manual valves closed.	Ensure all valves are open.
	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
	AOV-1 not opening.	***Caution! Serious damage to pump can occur if pump is run dry!***
	Loss of 480 volt phase loss.	
	Two-phase flow. This occurs when a combination of liquid and gas flows through the pump.	Increase subcool. If the saturation pressure is high, the vessel may have to be blown down, then subcool added.
Insufficient subcool.	Delivery started without sufficient subcool.	Add subcool while monitoring subcool pressure prior to initial delivery. Required pressure is 4.3 psi above saturation pressure.
Audible change in pump.	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
	Flow rates through restrictive lines.	***Caution! Serious damage to pump can occur if pump is run dry!***
	Pump pressure too high.	Reduce pump pressure.
	Worn bearings in pump.	Remove and replace pump.
Pump not catching prime.	Insufficient subcool. AOV-3 not opening. AOV-2 not closing.	Add subcool by opening pressure building coil. Required pressure is 4.3 psi above saturation pressure.
		Caution! Venting during delivery will cause depletion of subcool, and may also cause damage to pump!
	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
		Caution! Serious damage to pump can occur if pump is run dry!
Paper out. (Print / Exit)	Add paper, check cables	Verify that the cables to the printer are plugged in, that the printer is turned on, and that there is paper in the printer.
Lower pump speed, lower pressure or recirc is continuous.	AOV-2 valve not operating properly	Adequate air supply 12 volt supply to solenoid

Symptom	*Probable Cause*	*Remedy*
Lower pump speed, lower pressure or recirc is continuous.	AOV-2 valve not operating properly.	Adequate air supply. 12 volt supply to solenoid. Replace actuator/valve.

Preventive Maintenance

General

This section contains maintenance information. Service and/or repairs are not difficult because parts are easily accessible and replaceable. Before performing any of the procedures in this section be sure you are familiar with the location and function of controls and indicators discussed in other sections. It is recommended that the Safety section of this manual be reviewed and understood fully.

Maintenance required usually becomes apparent during inspection of units before a fill routine, observations during and after a fill, and from improper performance of components. Proper and immediate action to correct any damage or malfunction is advised.

Persons making repairs to piping, valves, and gauges must be familiar with cleanliness requirements for components used in nitrogen, oxygen, or argon service.

Maintenance Schedule

- Trailer Suspension - Follow manufacturer's recommended guidelines for maintenance.
- Generator - Reference vendor guidelines in manual provided.
- MicroBulk Delivery System
  - Mechanical Piping: Driver will observe leaks / plumbing issues and fix or direct issue to appropriate repair service.
  - 1 Month Intervals: Electrical Systems (480 volt & 12 volt) (tighten wiring terminals, terminal strips, switches, electrical contacts).
  - 1 Month Intervals: Check all cabinet bolts, plumbing fasteners, and tank mounting bolts.
  - 1 Year Intervals: The best preventive maintenance for the pump is proper operation.
  - 1 Year Intervals: DOT inspection (MC-338 test and inspect per state and federal guidelines)
  - 5 Year Intervals: DOT Pressure Test (MC-338 test and inspect per state and federal guidelines)

Vacuum Integrity Check (as required)

Since all transport tanks are vacuum insulated, any deterioration or loss of vacuum will be apparent by cold spots, frost, or condensation on the outside of the tank or evidenced by abnormally rapid pressure build-up. Unless one of these conditions is evidenced, the vacuum level should not be suspect.

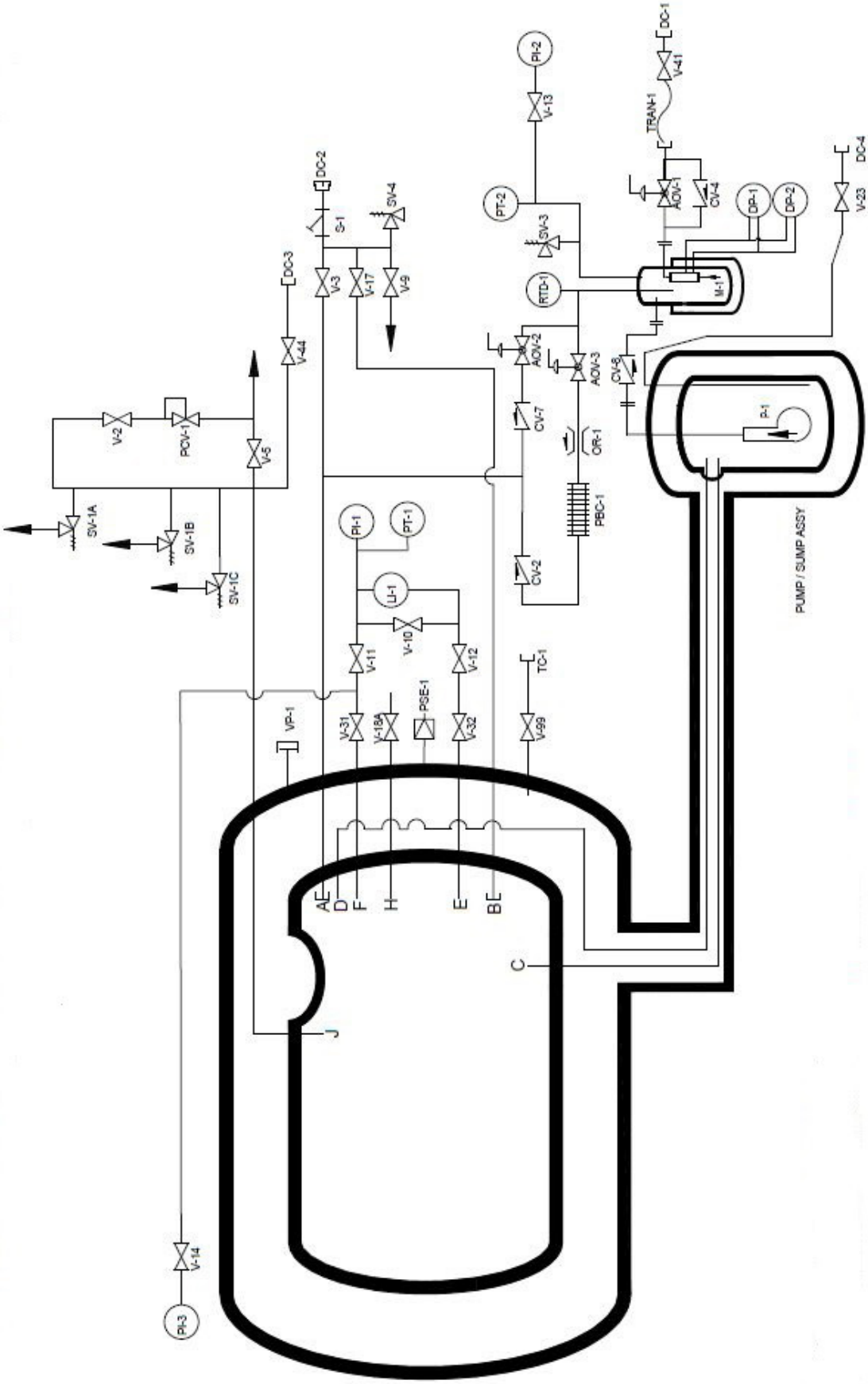
In the event one of the above conditions exists, remove the unit from service as soon as possible and contact the factory for advice on vessel vacuum testing.

Specifications

Model	*ST-4500*
Gas Services	LN_2, LAR
Dispense Method/Technology	Submerged Pump
Pressure Builder Type	Pump force-feed - w/ auto subcool
Design Code	ASME, MC-338 and CGA-341
Specifications	**Overall Unit LN_2/LAR**
Gross Capacity (gal/ltrs)	4,250 / 16,088
Capacity */** CGA-341 (gal/ltrs)	4,038 / 15,285
Capacity ** MC-338 (gal/ltrs)	3,950 / 14,952
MAWP (psig/bar)	38 / 2.62
Overall Length (in/cm)	338 / 858
Overall Height (in/cm)	133 / 337
Diameter/Width (in/cm)	80 / 203
Tare Weight (lbs/kg)	16,913 / 7,671
Performance	
Dispense Rate (gpm/lpm)	10-100 / 38-379
Max. Dispense Pressure (psig/bar)	400 / 27.58
Max. Receiving Tank Pressure *** (psig/bar)	375 / 25.86
Optimum Receiving Vessel	Perma-Cyl® MicroBulk Storage Systems & Bulk Tanks
Requirements	
Power (from truck)	12 VDC x 30 AMP
Power (from generator)	480 VAC x 60 AMP
Truck	Double axle sized for service

* With road relief valve at 25.3 psig
** Maximum fill levels depend on vehicle specifications
*** For optimum single hose, no-loss fill

Schematic


PI-2
V-13
DC-1
V-41
TRAN-1
DC-4
V-23
AOV-1
CV-4
DP-1
DP-2
PT-2
SV-3
RTD-1
M-1
DC-2
S-1
SV-4
V-3
V-17
V-9
DC-3
V-44
AOV-2
AOV-3
CV-6
CV-7
OR-1
P-1
V-2
POV-1
V-5
PBC-1
SV-1A
SV-1B
SV-1C
PI-1
PT-1
LI-1
CV-2
V-10
V-11
V-12
TC-1
VP-1
V-31
V-18A
PSE-1
V-32
V-99
PUMP / SUMP ASSY
A
D
F
H
E
B
C
J
V-14
PI-3

Nomenclature

Ref No.	Description	PN	Ref No.	Description	PN
AOV-1	Air Operating Valve, Dispensing	20832118	S-1	Strainer Fill	11060480
AOV-2	Air Operating Valve, Recirculation	20821333	SV-1A	Safety Relief Valve, Vent Circuit	20852077
AOV-3	Air Operating Valve, Force Feed	20821333	SV-2B	Safety Relief Valve, Vent Circuit	20852077
CV-2	Check Valve PB Outlet	11889589	SV-1C	Safety Relief Valve, Vent Circuit	20852076
CV-4	Check Valve Hose Drain	11051090	SV-3	Safety Relief Valve, Dispense	11007881
CV-7	Check Valve Recirculation	20861409	SV-4	Safety Relief Valve, Fill Line	11670000
CV-8	Check Valve Liquid Feed	20581252	TC-1	Vacuum Thermocouple	12894697
DC-1	Connection, Dispense	10567511	Tran-1	Transfer Hose, Dispense	20864870
DC-2	Connection, Fill Line	10542954	V-2	Valve, Road Relief	10616790
DC-3	Connection, Vapor Recovery	11790731	V-3	Valve, Top Fill	13410261
DC-4	Connection, Liquid Sample	1713202	V-5	Valve, Vapor Vent	13410261
DP-1	Transmitter, Differential Pressure Low Flow	20881753	V-9	Valve, Fill Line Drain	1713202
DP-2	Transmitter, Differential Pressure High Flow	20881754	V-10	Valve, LI-1 Equalization	11701443
LI-1	Level Indicator, Inner Vessel	11532088	V-11	Valve, LI-1 Vapor Phase	10907239
M-1	Meter, Dispense	FL1174810	V-12	Valve, LI-1 Liquid Phase	10907239
OR-1	Orifice, PB Feed	257628	V-13	Valve, Pump Discharge Gauge	11701443
P-1	Pump, Submerged	11941383	V-14	Valve, PI-3 Isolation	11701435
PBC-1	Pressure Building Coil	14037200	V-17	Valve, Bottom Fill	20785160
PCV-1	Regulator, Road Relief	1720412	V-18A	Valve, Full Trycock DOT	10616790
PI-1	Pressure Indicator, Inner Vessel	11707191	V-23	Liquid Sample/Sump Drain	1713202
PI-2	Pressure Indicator, Pump Discharge	11702121	V-31	Valve, Vapor Phase ISO	11701435
PI-3	Pressure Indicator, Inner Vessel	11707191	V-32	Valve, Liquid Phase ISO	11701435
PSE-1	Pressure Safety Element, Outer Vessel	4410611	V-41	Valve, Dispense Hose	11007881
PT-1	Transmitter, Pressure Inner Vessel	20832592	V-44	Valve, Vapor Recovery	1718772
PT-2	Transmitter, Pressure Pump Discharge	20832592	V-99	Valve, TC Isolation	12894697
RTD-1	Resistance Temperature Device	FL1145110	VP-1	Vacuum Port	10826172

Liquid Level Chart (LN_2)

Liquid Nitrogen - 10 psig saturated				
Level In H_2O	Level (%)	Volume (gal)	Weight (lb)	Gas Vol (scf)
0.0	0.0%	0	0	0
0.4	0.0%	0	300	3,600
1.0	0.2%	8	300	4,300
3.0	1.6%	68	700	9,700
5.0	3.7%	159	1,300	17,900
7.0	6.4%	271	2,000	28,000
9.0	9.4%	401	2,900	39,700
11.0	12.8%	545	3,800	52,600
13.0	16.5%	701	4,800	66,700
15.0	20.4%	867	5,900	81,600
17.0	24.5%	1,042	7,000	97,200
19.0	28.8%	1,223	8,200	113,500
21.0	33.2%	1,409	9,400	130,300
23.0	37.6%	1,600	10,700	147,500
25.0	42.2%	1,794	11,900	164,900
27.0	46.8%	1,990	13,200	182,500
29.0	51.4%	2,186	14,500	200,200
31.0	56.0%	2,382	15,800	217,800
33.0	60.6%	2,577	17,000	235,300
35.0	65.2%	2,769	18,300	252,600
37.0	69.6%	2,957	19,500	269,500
39.0	73.9%	3,141	20,700	286,000
41.0	78.1%	3,318	21,900	301,900
43.0	82.0%	3,487	23,000	317,100
45.0	85.8%	3,647	24,000	331,500
47.0	89.3%	3,796	25,000	344,900
49.0	**92.5%**	**3,931**	**25,900**	**357,100**
51.0	95.3%	4,051	26,700	367,900
53.0	97.7%	4,151	27,300	376,800
55.0	99.4%	4,224	27,800	383,400
57.0	100.0%	4,250	27,900	385,800
DOT Volume Fill Level - Trycock				

Liquid Level Chart (LAR)

Liquid Argon - 10 psig saturated				
Level In H_2O	*Level (%)*	*Volume (gal)*	*Weight (lb)*	*Gas Vol (scf)*
0.0	0.0%	0	0	0
0.5	0.0%	0	300	3,300
2.0	0.3%	13	500	4,700
3.0	0.7%	28	700	6,400
6.0	2.1%	91	1,400	13,200
9.0	4.1%	174	2,300	22,300
12.0	6.4%	273	3,400	33,100
15.0	9.1%	385	4,700	45,300
18.0	12.0%	508	6,100	58,700
21.0	15.1%	640	7,600	73,100
24.0	18.4%	780	9,100	88,400
27.0	21.8%	927	10,800	104,400
30.0	25.4%	1,080	12,500	121,100
33.0	29.1%	1,237	14,300	138,300
36.0	32.9%	1,399	16,100	155,900
39.0	36.8%	1,564	18,000	173,900
42.0	40.7%	1,731	19,900	192,200
45.0	44.7%	1,900	21,800	210,600
48.0	48.7%	2,070	23,700	229,200
51.0	52.7%	2,241	25,600	247,700
54.0	56.7%	2,410	27,500	266,300
57.0	60.7%	2,579	29,400	284,700
60.0	64.6%	2,746	31,300	302,800
63.0	68.4%	2,909	33,200	320,700
66.0	72.2%	3,070	35,000	338,200
69.0	75.9%	3,226	36,700	355,200
72.0	79.5%	3,377	38,400	371,700
75.0	82.8%	3,521	40,100	387,400
78.0	86.1%	3,659	41,600	402,400
81.0	89.1%	3,787	43,100	416,500
84.0	91.9%	3.906	44,400	429,500
85.0	**92.8%**	**3,944**	**44,800**	**433,500**
88.0	95.2%	4,047	46,000	444,800
90.0	96.7%	4,108	46,700	451,400
92.0	97.9%	4,161	47,300	457,200
94.0	98.9%	4,205	47,800	462,100
96.0	99.7%	4,238	48,100	465,600
98.0	100.0%	4,250	48,300	466,900
100.0	100.0%	4,250	48,300	466,900
DOT Volume Fill Level - Trycock				

Warranty Statement

Chart Standard Warranty

Chart Purchased Parts

Chart Inc. will pass on all warranties offered to us by our vendors. This is for those items which Chart Inc. purchases from them directly. Below is a list of the major items with their warranty periods. For the items not listed below, Chart Inc. will warranty the replacement period for a time frame of 90 days after the ship date of the Orca ST Series unit. If warranty replacement of part is required, the Orca ST Series unit will be repaired at the nearest Chart Inc. Authorized Service Provider, by the Purchaser, or Chart Inc. personnel in the field. This warranty is subject to the exclusions above.

Major Components

Component	Time Frame*
Resistance Temperature Device (RTD)	1 Year
Differential Pressure Transmitter (DP Transmitter)	1 Year
Spin-on Connections	6 Months
Meter Column	1 Year
Meter Element	Life of Orca System
Differential Pressure Gauge 0-100" H_2O	1 Year
AOV-1 Dispense Valve	1 Year
AOV-2 & AOV-3 Dispense Valve - Subcool	1 Year
Orca ST Series Delivery Hose	1 Year
Flowcom Flow Processor	1 Year
Printer	6 Months
Generator	Mfg Warranty
Pump Submerged Pump LIN/LAR Service	1 Year
Variable Frequency Drive (VFD)	2 Years
Control Panel (480 VAC)	6 Months
Check Valves	1 Year
Safety Relief Valves, Vent	1 Year

*From shipment of Orca ST Series unit.

Workmanship and Vacuum

Chart Inc. warrants all Orca ST Series units manufactured to be free from defects in material and workmanship for one year after shipment, subject to the exclusions listed below and statements on the preceding and following pages. Provided neither the evacuation valve nor the vacuum gauge valve has been tampered or disturbed so as to bleed gas into the annulus, and that no other misuse or abuse of the equipment has caused the excessive pressure. If warranty repair is required, the Orca ST Series unit will be repaired at the nearest Chart Authorized Service Provider, by the Purchaser, or Chart Inc personnel in the field, or at Chart Inc. at the discretion of Chart Inc. and in accordance with the attached Warranty Claims Procedure.

Exclusions

1. Chart Inc. accepts no liability for any work performed or cost incurred by the customer, or others, without Chart Inc. express prior written approval.
2. Chart Inc.'s obligations under this warranty are expressly limited to repair or replacement of any Chart Inc. manufactured component found to be defective within ONE YEAR after ship date of Orca ST Series unit.
3. Chart Inc. is not liable for any other losses, damages, product losses, cost of delays, freight charges, or excess costs for repairs made outside the 48 adjacent United States, including incidental or consequential damages.
4. For Warranty Claims please call Chart Inc. Customer Service Center at 1-800-400-4683.

Claim Procedure

1. All Warranty Claims are to be requested in writing and previously authorized by Chart Inc. The address to sent the request to is:

   Chart Inc.
   Attn: Customer Service
   407 Seventh Street NW
   New Prague, MN 56071

   Telephone approval can be obtained for faster response by contacting Customer Service at 1-800-400-4683. However, this warranty claim is to be followed by a letter in writing to Chart Inc. within 14 days of the claim. Customer Service will issue an RMA (Returned Merchandise Authorization) number that is a tracking number that will be required on all documentation, correspondence, and invoices that maybe sent to Chart Inc. for payment of credit.

2. All Warranty Claims submitted to Chart Inc. for credit must be submitted within 21 days of the date of purchaser receiving their vendors invoice for services rendered. This Credit Request must include the RMA number that was provided by Chart Inc. otherwise the Credit Request will be considered invalid.

3. Documentation, photographs (if applicable) and the RMA number must accompany any invoice before payment will be made by Chart Inc.

4. Vacuum pumping of any units, requires prior authorization from Chart Inc. and all procedures must be adhered to or the warranty will be void.

5. On Chart Inc. purchased parts, Chart Inc. will replace all defective parts at no charge if it is less than 90 days from date of shipment. If the items are listed on the Major Components List and between 90 days and the end of the warranty period stated, Chart Inc. will replace parts at no charge excluding labor and other items listed in the exclusion section. Chart Inc. will send out parts with an invoice at Purchasers full price and will give credit back to your account when the parts in question are received at Chart Inc. and determined to be within the warranty period.

6. Authorization must be obtained from Chart Inc. prior to shipment of any units to our location or any other repair facility for warranty work.