Product Manual

Orca™ MicroBulk Delivery System
ST Series (LOX, LN_2 & LAR)

Designed and Built by:

Chart Inc.

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Contents

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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
- Filling of small bulk tanks
- 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
- Optimized plumbing and pump location for fast pump cool down designed specifically for MicroBulk deliveries

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
LOX	Liquid Oxygen
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. Ensure all fittings are oil free. 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.***

Caution! ***Avoid spilling product on asphalt. Use steel or aluminum plate if necessary. If product does spill, avoid stepping in or on it.***

Warning! ***Do NOT use open flame in or around the plumbing cabinet. Use warm water if thawing of components is necessary.***

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 not 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.

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 to 5 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 to 5 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.

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. As listed below alternative methods are available for the operator to terminate the flow.

- Press the “Stop” button on the Flowcom display or on the pendant
- Close the dispense valve on the hose
- 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
- 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)

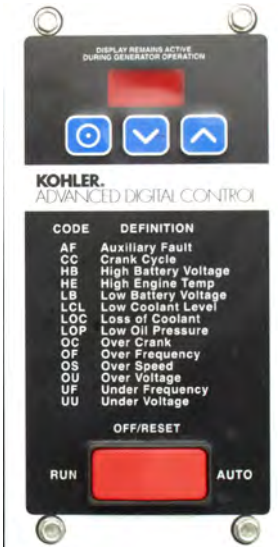
Generator Operation

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 door and quickly close the Road Relief Valve (V-2). Then latch both cabinet doors.

Note: *Opening the cabinet door engages the anti-tow valve, locks the brakes, and opens the block valve (cools the pump).*

Note: *The cabinet door switch also powers the Flowcom® Flow Meter System which will check for system errors, capture current vessel pressure and assign valve to liquid saturation pressure (pSat), enter delivery mode and start pump cool down logic.*

5. If the Flowcom meter system was not left on, press the ⏻ power button.

Note: *The pump icon on the Flowcom meter system will start in red (meaning warm), at -238°F the icon will turn yellow and an 8 minute timer will begin. Pump icon will change to blue when ready.*

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 meter system to re-establish pSat).***

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

Note: *With no active VFD faults (VFD contacts 24/25 closed), 12-volt power closes the main 480 volt normally-open relay (C206), closing the three 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. Remove the stowed hose (Tran-1) and remove the dust plug. 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.

9. Check receiving tank pressure and estimate the condition of the receiving tank (‘warm’ or ‘cold’).

10. Monitor the vessel pressure and vent (V-5) to maintain pressure below MAWP.

Note: *Venting of vessel only needs to be done at high liquid level or high initial pressure.*

Caution! Venting with low liquid levels <u>will</u> cause difficulty with the pump catching prime.

11. Monitor the liquid temperature. In certain conditions vapor lock can occur causing a temperature rise. If the temperature increases, vent vapor with pump cool down vent valve (V-34).

Note: *If the temperature warms to -238°F, the timer will reset to 8 minutes.*

12. The ‘Start’ command is displayed on the Flowcom interface when the cool down timer times out.

Note: *If the delivery total was not cleared at the previous delivery press ‘Clear’, ‘Clear’, and then press ‘Deliver’.*

13. Set the pump speed to 50% on the speed select dial (POT107).

14. Press ‘Start/Stop’ on the generator remote control to start the generator and power the VFD.

15. Press ‘Start’ on the Flowcom interface or the remote pendant to start 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.*

16. Monitor pump catching and maintaining prime.

Caution! If prime is not caught, stop the pump, wait until pump stops spinning (10-20 seconds), then restart the pump.

Note: *In cases of a warm meter (e.g. first delivery of the day), the pump will lose prime. Press the ‘Stop’ button, wait for the discharge pressure to drop below 50 psig, then press ‘Start’.*

17. 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 psig above the receiving tank pressure and no lower than 150 psig.*

The Flowcom meter system opens and closes the “PB Force Feed Valve (AOV-2) as needed to satisfy the subcool requirement.
(Current Vessel Pressure - Saturation Pressure = Subcool)
(p VTank - pSat VTank = 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.*

18. 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).*

19. Check the pump discharge pressure and verify prime is maintained.

20. 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.*

21. 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.
22. When filling is complete:
    a. Bulk Tank / Liquid Cylinder: Terminate the flow by closing the "Delivery Hose End Valve".
    b. Perma-Cyl: Float in the Perma-Cyl tank will close the fill circuit when filling is complete.
23. Press the 'Stop' button on the Flowcom interface or the pendant.
24. Stop the generator by pressing 'Start/Stop' on the remote control or at the generator control panel.
25. Close the "Delivery Hose End Valve".
26. On a Bulk Tank or Liquid Cylinder close fill valves and open line drain.
27. Disconnect the hose (and adapters) from receiving tank, install dust plugs and stow the hose.

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: *Optionally the operator could select "OFF" on Control Mode switch (SW210); this mode switch can be left in "Auto" which de-energizes opening normally open contact (CR216).*

4. Clear delivery total by pressing "Clear", "Clear", and "Deliver" to enter delivery mode.
5. The Flowcom interface can be left on as the door switch will turn the interface off.

Note: *This allows for a better snapshot of the subsequent vessel arrival condition and quicker pump cool down for the next delivery. The Flowcom interface will power up to the screen it left (Delivery Screen) when the doors are re-opened.*

6. Close the piping cabinet doors.

Note: *Closing the cabinet doors deactivates the anti-tow valve allowing normal brake operation, block valve closes and the Flowcom interface is powered off.*

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. Located just below is an Emergency Shutoff lever. Pushing this level down will stop all air from flowing to the pneumatic valves.

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

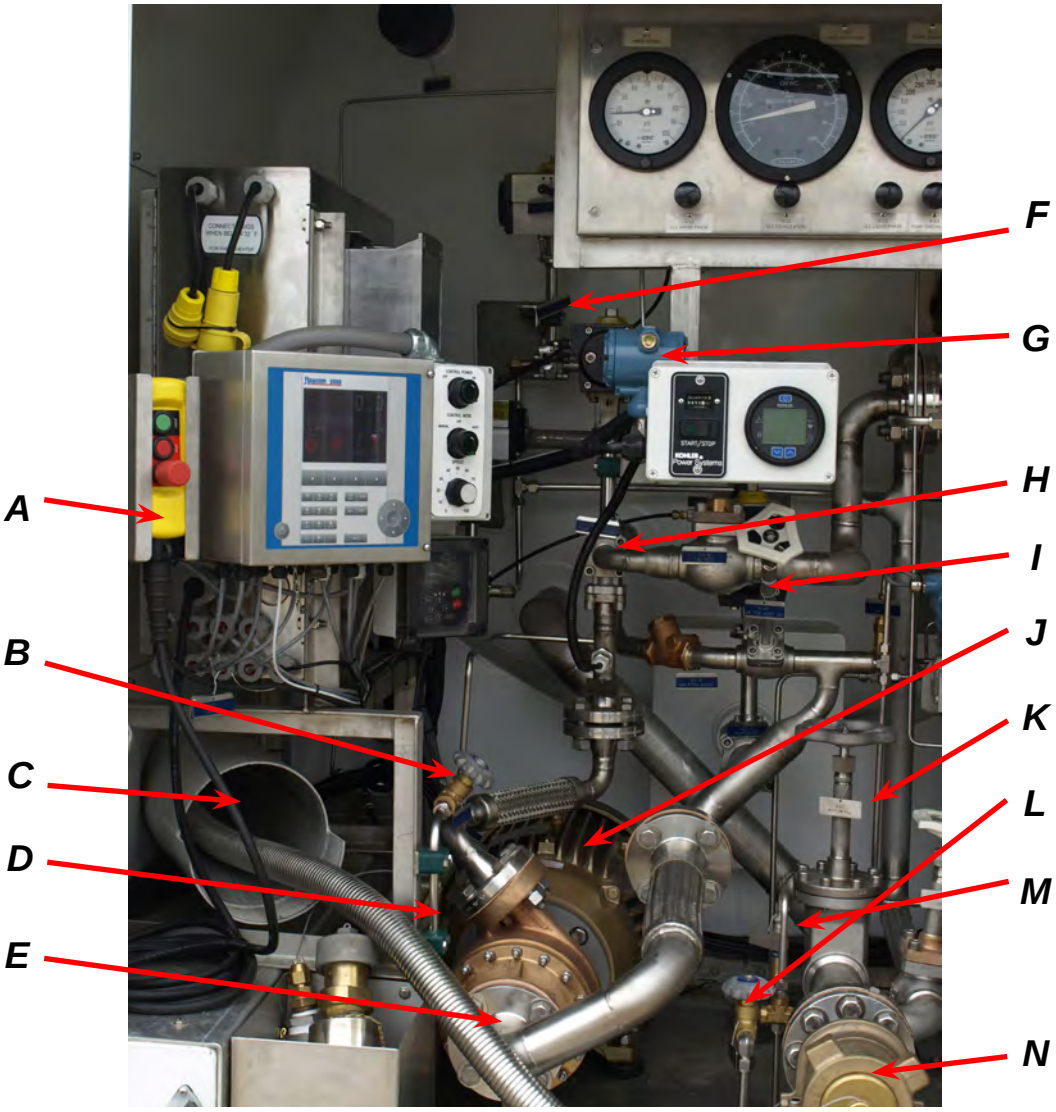
The emergency stop button in the cabinet is located on the pendant.

Components & Systems

Roadside **Center** **Curbside**

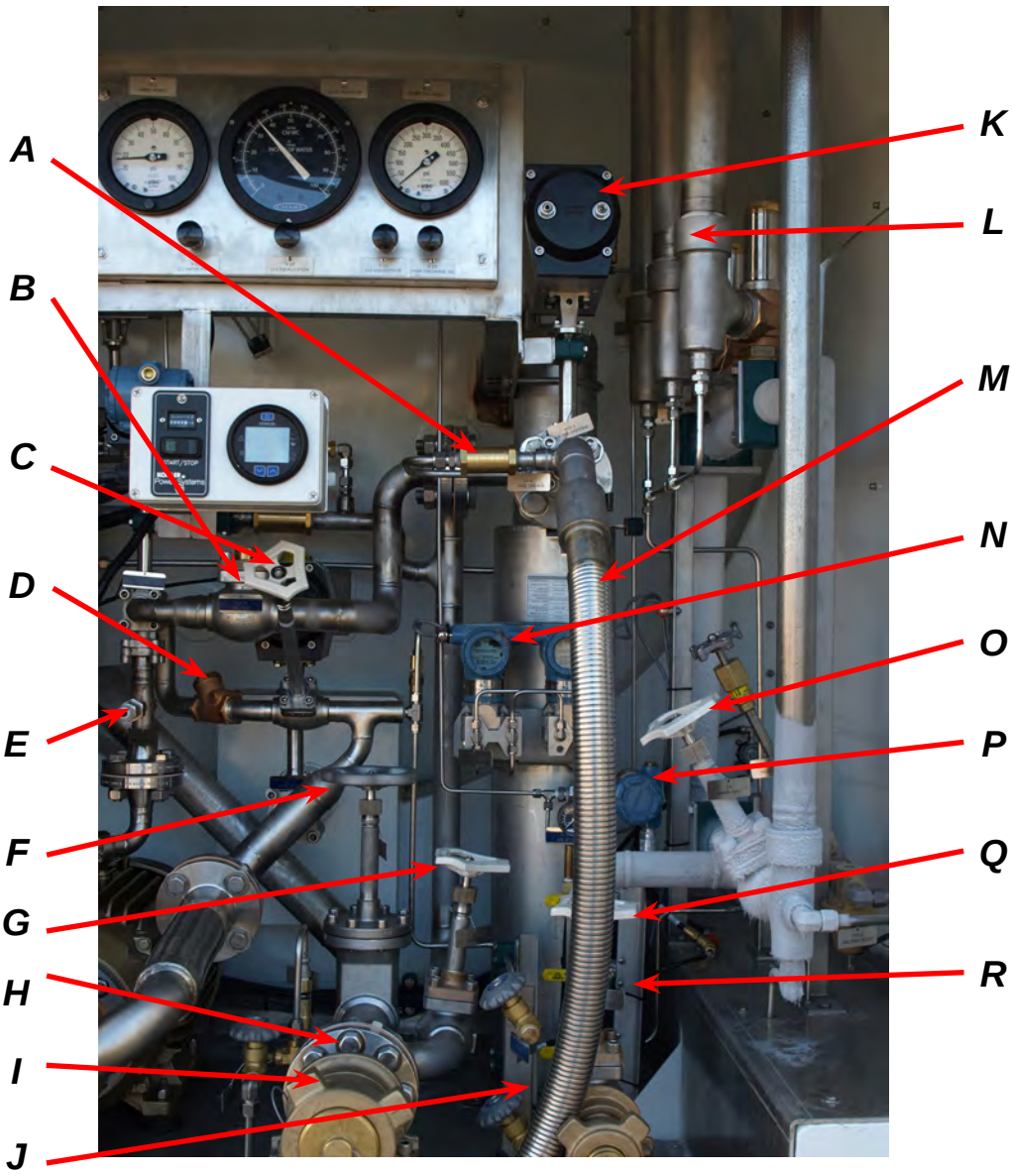
This is the view of the Orca ST Series delivery system cabinet. In this section we will discuss in detail, plumbing cabinet components and systems. To aid in this we will break the cabinet into three areas - Roadside, Center (system control and monitoring), and Curbside.

Plumbing Cabinet - Roadside



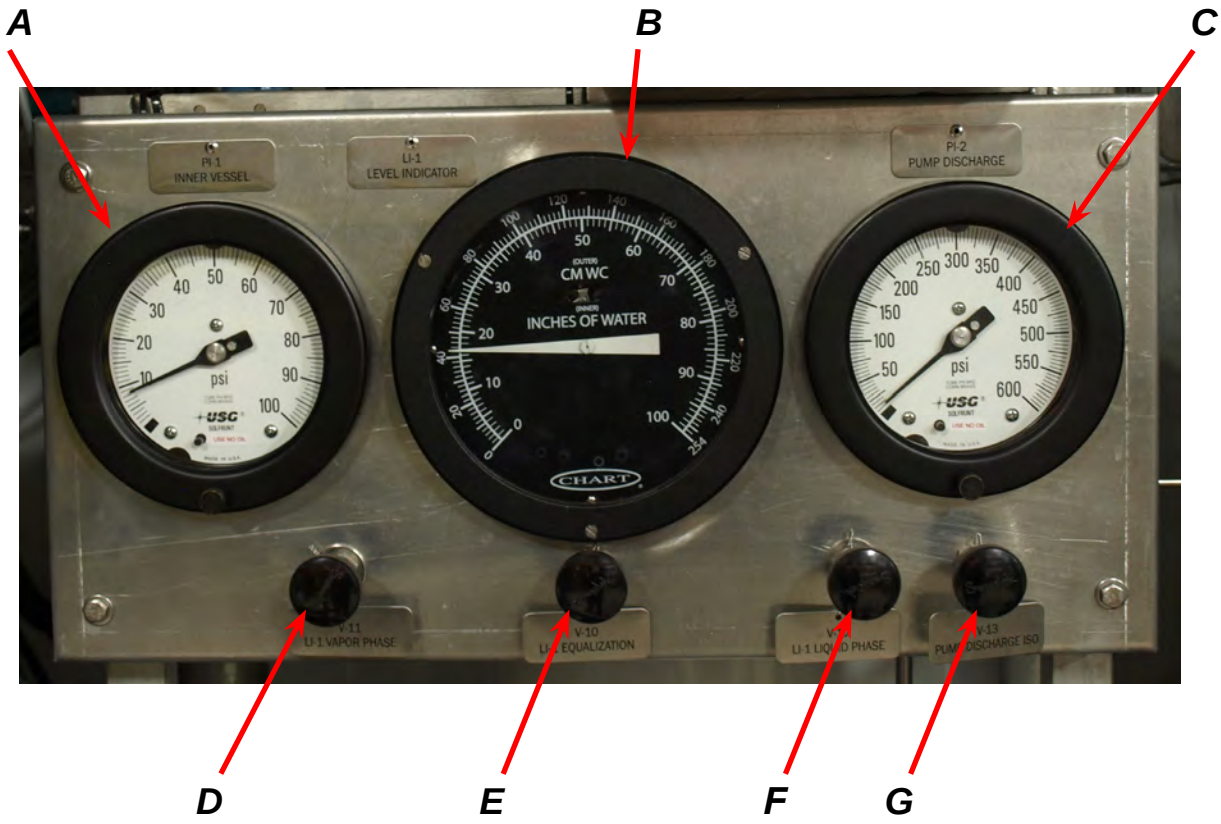
Item	Tag	Part Number	Description
A		20860692	Electrical Pendant
B	V-34	1713202	Valve, Cool Down Vent
C		20854521	Hose Storage Tube
D		11934175	1” FlexiTallic Gasket (Outlet)
E		11934204	2” FlexiTallic Gasket (Inlet)
F	AOV-2	20821333	Air Operating Valve, Recirculation
G	PT-1	20832592	Transmitter, Pressure Inner Vessel
H	AOV-5	20853476	Air Operating Valve, Pump Cool Down
I	AOV-4	20811344	Air Operating Valve, Pump Block
J		11844567	External Pump (TC-30)
K	V-17	20785160	Valve, Bottom Fill
L	V-9	1713202	Valve, Fill Line Drain
M	SV-4	11670000	Safety Relief Valve, Fill Line
N	S-1	11060480	Strainer Fill

Plumbing Cabinet - Curbside



Item	Tag	Part Number	Description
A	CV-4	11051090	Check Valve Hose Drain
B	CV-8	20581252	Check Valve Liquid Feed
C	V-43	13410261	Auxilary Vapor Return
D	CV-9	20861409	Check Valve Auxilary Vapor Return
E	RTD-1	FL1145110	Resistance Temperature Device
F	V-17	20785160	Valve, Bottom Fill
G	V-3	13410261	Valve, Top Fill
H	S-1	250853	Strainer, Fill
I	DC-2	11742085	Connection, Fill Line
J-1	V-23	1713203	Liquid
J-2	V-18A	10616790	Valve, Full Trycock DOT
K	AOV-1	20832118	Air Operating Valve, Dispensing
L-1	SV-1A	20852077	RV Brass 57 PSI
L-2	SV-1B	20852077	RV Brass 57 PSI
L-3	SV-1C	20852076	RV Brass 38 PSI
M	Tran-1	20864870	Transfer Hose, Dispense
N-1	DP-1	20881253	Transmitter, Differential Pressure Low Flow
N-2	DP-2	20881754	Transmitter, Differential Pressure High Flow
O-1	V-5	13410261	Valve, Vapor Vent
O-2	V-2	10616790	Valve, Road Relief
P	PT-2	20832592	Transmitter, Pressure Pump Discharge
Q	V-44	13410261	Valve, Vapor Recovery
R-1	AOV-1	11773885	Air valve, Force Feed
R-2	AOV-5	11773885	Air Valve Pump Cool Down
R-3	AOV-3	11773885	Air Valve, Dispensing

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 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 contractor
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

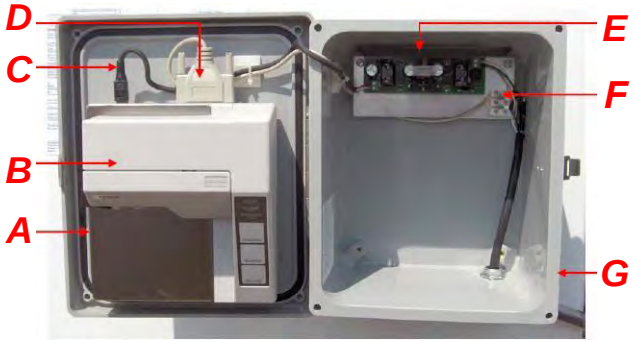
The Cutler-Hammer Variable Frequency Drive (VFD) has an internal temperature sensor that does not allow the VFD to operate at temperatures below -20° F and will not run the pump if below -4°F. If the VFD temperature is between -20°F and -4°F, the VFD will conduct a self-warming procedure that slowly 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 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



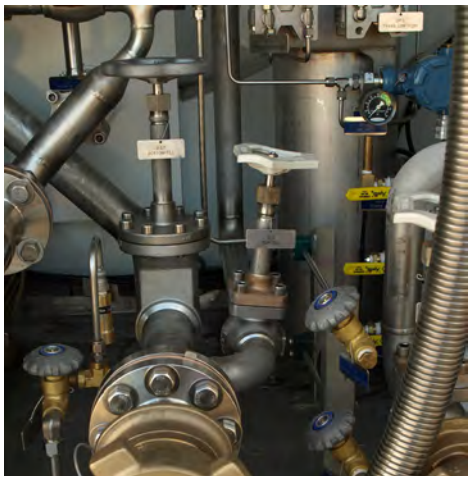
Item	Description	PN
A	Printer-Epson	13086077
B	Printer Ribbon	11693421
C	Printer Power Cord-6’	11764428
D	Printer Data Cable	11764436
E	DC/DC 12-24 VDC Converter	FL0172049
F	Terminal Block	11801276
G	Printer Box	11720142

External Pump

The external pump is a specifically designed variable speed centrifugal pump that is designed to operate in liquid nitrogen, argon or oxygen. The pump is mounted inside the cabinet and must be cooled down prior to operating.

Note: *Cabinet mounted for easier access.*

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. The check valve is designed to prevent the 'reverse of flow' during filling.

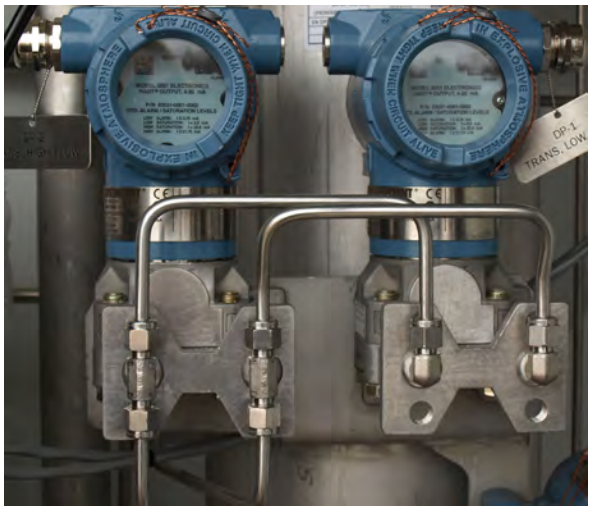
Metering System

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: Meter Section, Differential Pressure Transmitter, RTD Resistance Temperature Device, Hose Drain Check Valve, and 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.

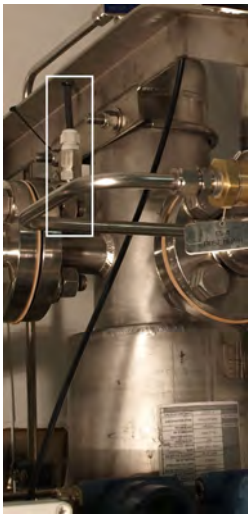
Differential Pressure Transmitter (DP Transmitter)



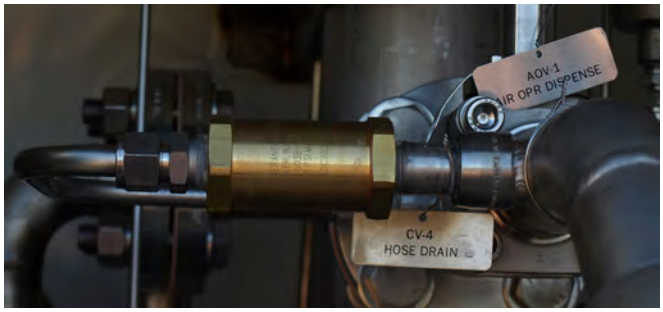
This is a Rosemount Pre-Set Differential Pressure Transmitter used on the Orca system. It is connected to the meter section and the Flowcom meter system. The DP transmitter measures a change in pressure (pressure drop) across the meter section and relays this information to the Flowcom meter system in 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 between the pump cool down flanges. The probe is threaded into the cool down flange so it can accurately measure the temperature of the liquid in the sump. 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 audit trail information, initiate the print out of the delivery ticket and to clear the counter. The buttons on the face of the flow meter can be used as a back up to the Remote Pendant. The totalizer window displays the amount of product dispensed. The status/flow rate window displays the mode the flow meter is in and a percentage of the flow rate while the product is being dispensed.

Note: *If programming assistance is required 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.

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	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 5 to 7 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.	
	Loss of 480 volt phase loss.	 ***Caution! Serious damage to pump can occur if pump is run dry!***
	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 5 to 7 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 5 to 7 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.
  - 6 Months: Replace pump seals. Seals may last longer, but will vary depending on operation.
  - 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.

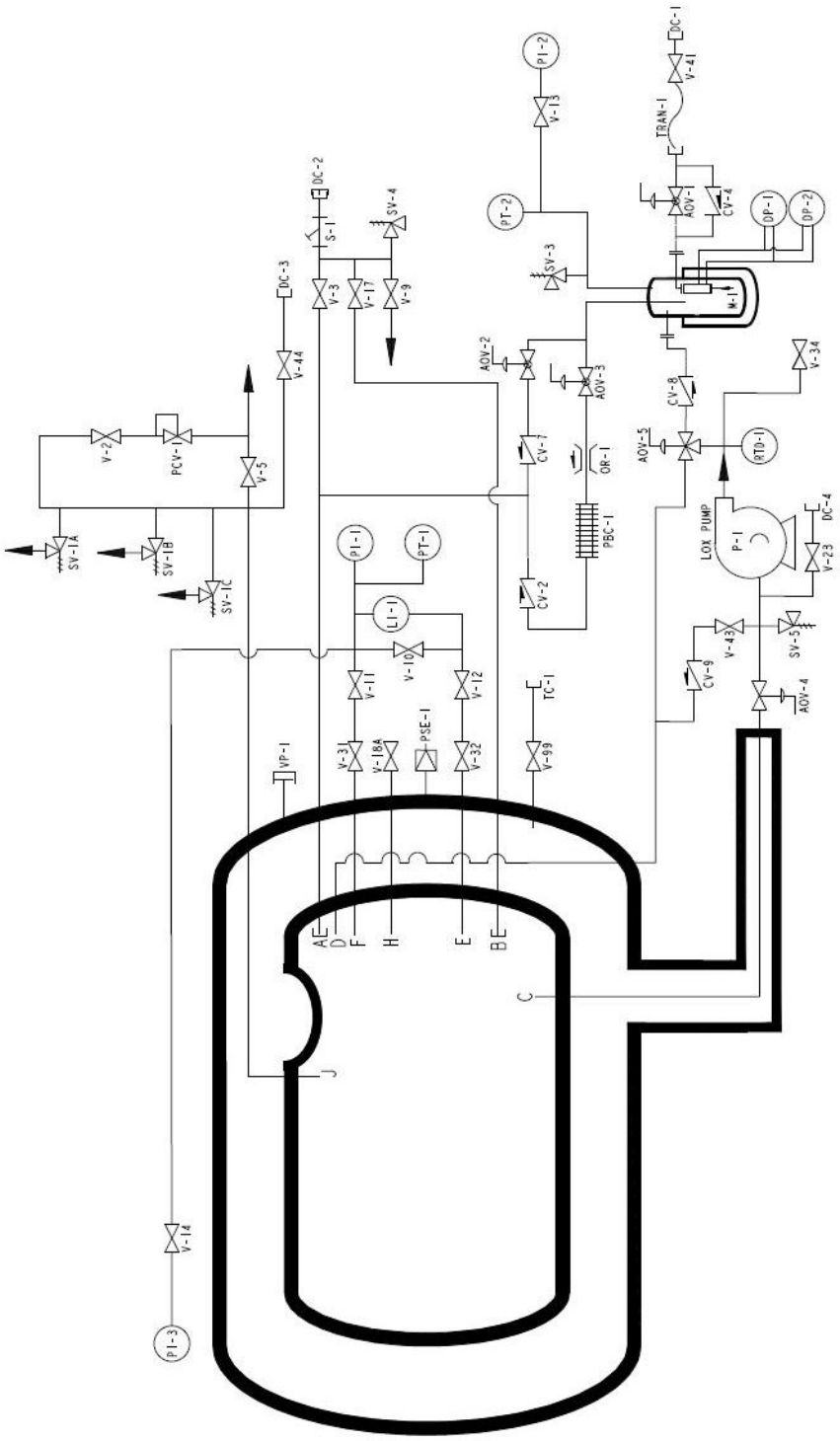
In the event one of the above conditions exists, remove the unit from service as soon as possible and contact the factory for advice on vessel vacuum testing.

Specifications

Model	*ST-4500*
Gas Services	LN_2, LAR, LOX
Dispense Method/Technology	External Pump
Pressure Builder Type	Pump force-feed - w/ auto subcool
Design Code	ASME, MC-338 and CGA-341
Specifications	**Overall Unit**
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)	16,500 / 7,484
Performance	
Dispense Rate (gpm/lpm)	10-60 / 38-227
Max. Dispense Pressure (psig/bar)	260 / 17.9
Max. Receiving Tank Pressure *** (psig/bar)	210 / 14.5
Optimum Receiving Vessel	Perma-Cyl® MicroBulk Storage Systems & Bulk Tanks
Requirements	
Power	12 VDC x 30 AMP & 480 VAC x 50 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 PN 20831834 Rev A



Nomenclature

Ref No.	Description	PN
AOV-1	AIR OPERATING VALVE, DISPENSING	20832118
AOV-2	AIR OPERATING VALVE, RECIRCULATION	20811344
AOV-3	AIR OPERATING VALVE, FORCE FEED	20853476
AOV-4	AIR OPERATING VALVE, PUMP BLOCK	20821333
AOV-5	AIR OPERATING VALVE, PUMP COOL DOWN	20821333
CV-2	CHECK VALVE, PB OUTLET	20861409
CV-4	CHECK VALVE, HOSE DRAIN	11051090
CV-7	CHECK VALVE, RECIRC	11889589
CV-8	CHECK VALVE, LIQ FEED	15094361
CV-9	CHECK VALVE, VAPOR RETURN ASSIST	1712152
DC-1	CONNECTION, DISPENSE	
DC-2	CONNECTION, FILL LINE	10859011
DC-3	CONNECTION, VAPOR RECOVERY	10601150
DC-4	CONNECTION, LIQUID SAMPLE	10552749
DP-1	TRANSMITTER, DIFF. PRESS. LOW FLOW	FL0800133
DP-2	TRANSMITTER, DIFF. PRESS. HIGH FLOW	FL0800133
LI-1	LEVEL INDICATOR, INNER VESSEL	11532088
M-1	METER, DISPENSE	FL0800133
OR-1	ORIFICE, PB FEED	20653912
P-1	PUMP	11844567
PBC-1	PRESSURE BUILDING COIL	14037200
PCV-1	REGULATOR, ROAD RELIEF	1720412
PI-1	PRESSURE INDICATOR, INNER VESSEL	11707191
PI-2	PRESSURE INDICATOR, PUMP DISCHARGE	11702121
PI-3	PRESSURE INDICATOR, INNER VESSEL	11707191
PSE-1	PRESSURE SAFETY ELEMENT, OUTER VESSEL	10899110
PT-1	TRANMITER, PRESSURE INNER VESSEL	20832592
PT-2	TRANMITER, PRESSURE PUMP DISCHARGE	20832592
RTD-1	RESISTANCE TEMPERATURE DEVICE	FL1145110

Ref No.	Description	PN
S-1	STRAINER, FILL	11060480
SV-1A	SAFETY RELIEF VALVE, VENT CIRCUIT	20852076
SV-1B	SAFETY RELIEF VALVE, VENT CIRCUIT	20852077
SV-1C	SAFETY RELIEF VALVE, VENT CIRCUIT	20852077
SV-3	SAFETY RELIEF VALVE, DISPENSE	11556590
SV-4	SAFETY RELIEF VALVE, FILL LINE	11670000
SV-5	SAFETY RELIEF VALVE, PUMP FEED	1811562
TC-1	VACUUM THERMOCOUPLE	4210049
TRAN-1	TRANSFER HOSE, DISPENSE	20864870
V-2	VALVE, ROAD RELIEF	10616790
V-3	VALVE, TOP FILL	13410261
V-5	VALVE, VAPOR VENT	13410261
V-9	VALVE, FILL LINE DRAIN	1713202
V-10	VALVE, LI-I EQUALIZATION	11701435
V-11	VALVE, LI-I VAPOR PHASE	11701443
V-12	VALVE, LI-I LIQUID PHASE	11701443
V-13	VALVE, PUMP DISCHARGE GAUGE	11701443
V-14	VALVE, PI-3 ISOLATION	11701435
V-17	VALVE, BOTTOM FILL	20785160
V-18A	VALVE, FULL TRYCOCK DOT	1713202
V-23	VALVE, LIQUID SAMPLE	1713202
V-31	VALVE, VAPOR PHASE ISO	10907239
V-32	VALVE, LIQUID PHASE ISO	10907239
V-34	VALVE, COOL DOWN VENT	1713202
V-41	VALVE, DISPENSE HOSE	11007881
V-43	VALVE, VAPOR RETURN ASSIST ISO	14812798
V-44	VALVE, VAPOR RECOVERY	13410261
V-99	VALVE, TC ISOLATION	10482381
VP-1	VACUUM PORT	10826172

Liquid Level Chart (LN_2 & LAR)

Liquid Nitrogen - 10 psig saturated				
Level (inH2O)	Level (%)	Volume (gal)	Weight (lb)	GasVol (SCF)
0.0	0.0%	0	0	0
0.4	0.0%	0	300	3,600
1.0	0.2%	8	300	4,300
2.0	0.8%	33	500	6,500
3.0	1.6%	68	700	9,700
4.0	2.6%	110	1,000	13,500
5.0	3.7%	159	1,300	17,900
6.0	5.0%	213	1,600	22,700
7.0	6.4%	271	2,000	28,000
8.0	7.9%	334	2,400	33,700
9.0	9.4%	401	2,900	39,700
10.0	11.1%	472	3,300	46,000
11.0	12.8%	545	3,800	52,600
12.0	14.6%	622	4,300	59,500
13.0	16.5%	701	4,800	66,700
14.0	18.4%	783	5,400	74,000
15.0	20.4%	867	5,900	81,600
16.0	22.4%	954	6,500	89,300
17.0	24.5%	1,042	7,000	97,200
18.0	26.6%	1,131	7,600	105,300
19.0	28.8%	1,223	8,200	113,500
20.0	30.9%	1,315	8,800	121,900
21.0	33.2%	1,409	9,400	130,300
22.0	35.4%	1,504	10,100	138,800
23.0	37.6%	1,600	10,700	147,500
24.0	39.9%	1,697	11,300	156,200
25.0	42.2%	1,794	11,900	164,900
26.0	44.5%	1,892	12,600	173,700
27.0	46.8%	1,990	13,200	182,500
28.0	49.1%	2,088	13,900	191,300
29.0	51.4%	2,186	14,500	200,200
30.0	53.7%	2,284	15,100	209,000
31.0	56.0%	2,382	15,800	217,800
32.0	58.4%	2,480	16,400	226,600
33.0	60.6%	2,577	17,000	235,300
34.0	62.9%	2,673	17,700	244,000
35.0	65.2%	2,769	18,300	252,600
36.0	67.4%	2,864	18,900	261,100
37.0	69.6%	2,957	19,500	269,500
38.0	71.8%	3,050	20,100	277,800
39.0	73.9%	3,141	20,700	286,000
40.0	76.0%	3,230	21,300	294,000
41.0	78.1%	3,318	21,900	301,900
42.0	80.1%	3,403	22,400	309,600
43.0	82.0%	3,487	23,000	317,100
44.0	84.0%	3,568	23,500	324,400
45.0	85.8%	3,647	24,000	331,500
46.0	87.6%	3,723	24,500	338,400
47.0	89.3%	3,796	25,000	344,900
48.0	90.9%	3,865	25,400	351,200
49.0	92.5%	3,931	25,900	357,100
50.0	94.0%	3,993	26,300	362,700
51.0	95.3%	4,051	26,700	367,900
52.0	96.6%	4,104	27,000	372,600
53.0	97.7%	4,151	27,300	376,800
54.0	98.6%	4,191	27,600	380,500
55.0	99.4%	4,224	27,800	383,400
56.0	99.9%	4,246	27,900	385,400
57.0	100.0%	4,250	27,900	385,800

Liquid Argon - 10 psig saturated				
Level (inH2O)	Level (%)	Volume (gal)	Weight (lb)	GasVol (SCF)
0.0	0.0%	0	0	0
0.5	0.0%	0	300	3,300
2.0	0.3%	13	500	4,700
4.0	1.1%	46	900	8,400
6.0	2.1%	91	1,400	13,200
8.0	3.4%	144	2,000	19,100
10.0	4.8%	206	2,700	25,700
12.0	6.4%	273	3,400	33,100
14.0	8.1%	346	4,300	41,100
16.0	10.0%	425	5,100	49,700
18.0	12.0%	508	6,100	58,700
20.0	14.0%	595	7,100	68,200
22.0	16.1%	686	8,100	78,100
24.0	18.4%	780	9,100	88,400
26.0	20.6%	877	10,200	99,000
28.0	23.0%	977	11,400	109,900
30.0	25.4%	1,080	12,500	121,100
32.0	27.9%	1,184	13,700	132,500
34.0	30.4%	1,291	14,900	144,100
36.0	32.9%	1,399	16,100	155,900
38.0	35.5%	1,509	17,400	167,900
40.0	38.1%	1,619	18,600	180,000
42.0	40.7%	1,731	19,900	192,200
44.0	43.4%	1,844	21,100	204,500
46.0	46.0%	1,957	22,400	216,800
48.0	48.7%	2,070	23,700	229,200
50.0	51.4%	2,184	25,000	241,600
52.0	54.0%	2,297	26,300	253,900
54.0	56.7%	2,410	27,500	266,300
56.0	59.4%	2,523	28,800	278,500
58.0	62.0%	2,635	30,100	290,700
60.0	64.6%	2,746	31,300	302,800
62.0	67.2%	2,855	32,500	314,800
64.0	69.7%	2,963	33,800	326,600
66.0	72.2%	3,070	35,000	338,200
68.0	74.7%	3,174	36,100	349,600
70.0	77.1%	3,277	37,300	360,800
72.0	79.5%	3,377	38,400	371,700
73.0	80.6%	3,426	39,000	377,000
74.0	81.7%	3,474	39,500	382,200
75.0	82.8%	3,521	40,100	387,400
76.0	84.0%	3,568	40,600	392,500
77.0	85.0%	3,614	41,100	397,500
78.0	86.1%	3,659	41,600	402,400
79.0	87.1%	3,702	42,100	407,200
80.0	88.1%	3,745	42,600	411,900
81.0	89.1%	3,787	43,100	416,500
82.0	90.1%	3,828	43,500	420,900
83.0	91.0%	3,868	44,000	425,300
84.0	91.9%	3,906	44,400	429,500
85.0	92.8%	3,944	44,800	433,500
86.0	93.6%	3,980	45,200	437,400
87.0	94.4%	4,014	45,600	441,200
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
97.3	100.0%	4,250	48,300	466,900

DOT Volume Fill Level - Trycock

Liquid Level Chart (LOX)

Liquid Oxygen - 10 psig saturated				
Level (inH2O)	Level (%)	Volume (gal)	Weight (lb)	GasVol (SCF)
0.0	0.0%	0	0	0
0.5	0.0%	0	300	3,300
1.0	0.1%	5	300	3,800
2.0	0.5%	20	400	5,400
3.0	0.9%	40	600	7,700
4.0	1.5%	65	900	10,500
5.0	2.2%	94	1,100	13,700
6.0	3.0%	126	1,400	17,300
7.0	3.8%	161	1,800	21,200
8.0	4.7%	199	2,100	25,400
9.0	5.6%	239	2,500	29,900
10.0	6.6%	281	2,900	34,600
12.0	8.8%	372	3,700	44,800
14.0	11.1%	470	4,600	55,700
16.0	13.5%	575	5,600	67,400
18.0	16.1%	685	6,600	79,700
20.0	18.8%	801	7,700	92,600
22.0	21.6%	920	8,800	106,000
24.0	24.6%	1,044	9,900	119,800
26.0	27.6%	1,171	11,100	134,000
28.0	30.6%	1,301	12,300	148,500
30.0	33.7%	1,433	13,500	163,300
32.0	36.9%	1,568	14,800	178,300
34.0	40.1%	1,704	16,000	193,400
36.0	43.3%	1,841	17,300	208,800
38.0	46.6%	1,979	18,600	224,200
40.0	49.8%	2,118	19,800	239,600
42.0	53.1%	2,256	21,100	255,100
44.0	56.3%	2,394	22,400	270,500
46.0	59.6%	2,532	23,700	285,900
47.0	61.2%	2,600	24,300	293,500
48.0	62.8%	2,668	24,900	301,100
49.0	64.4%	2,735	25,600	308,600
50.0	65.9%	2,802	26,200	316,100
51.0	67.5%	2,869	26,800	323,500
52.0	69.1%	2,935	27,400	330,900
53.0	70.6%	3,000	28,000	338,200
54.0	72.1%	3,065	28,600	345,400
55.0	73.6%	3,129	29,200	352,600
56.0	75.1%	3,193	29,800	359,600
57.0	76.6%	3,255	30,400	366,600
58.0	78.0%	3,317	30,900	373,500
60.0	80.9%	3,437	32,000	386,900
62.0	83.6%	3,553	33,100	399,800
63.0	84.9%	3,609	33,600	406,100
64.0	86.2%	3,664	34,100	412,200
65.0	87.5%	3,717	34,600	418,200
66.0	88.7%	3,769	35,100	424,000
67.0	89.9%	3,819	35,600	429,600
68.0	91.0%	3,868	36,000	435,000
69.0	92.1%	3,915	36,500	440,200
70.0	93.2%	3,959	36,900	445,300
71.0	94.2%	4,002	37,300	450,000
72.0	95.1%	4,043	37,600	454,600
74.0	96.9%	4,117	38,300	462,800
76.0	98.3%	4,179	38,900	469,800
78.0	99.5%	4,227	39,300	475,100
79.0	99.8%	4,243	39,500	476,900
79.7	100.0%	4,250	39,600	477,600

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
External Pump - seals only	6 Months
External Pump - everything except seals	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.