Product Manual

Orca™ MicroBulk Delivery System
HL Series External Pump
Oxygen/Nitrogen/Argon

Designed and Built by:

Chart Inc.

407 7th Street NW
New Prague, MN 56071 USA
(800) 400-4683

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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 HL Series external pump delivery unit has been designed to minimize pump cool down time and complete an entire fill operation in 3-15 minutes (depending on storage volume) once the pump is cooled. 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 HL 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 with auto shut-off
- Single hose delivery system minimized contamination, cool down losses and pressure drop
- Push-button Flowcom® 3000 Flow Meter System with manual override to simplify operator training
- Electronic pump speed control allows driver to safely optimize delivery rate
- NIST/California Weights and Measures approved delivery metering system
- Auto Subcool - standard on all pump models, simplifies operator training and reduces product loss
- Updated electronics for operating to -40°F / -40°C
- Larger cabinet with removable access panels for ease of maintenance and servicing
- Calibrated meter column system that can be easily removed for recalibrating or service
- Vessel designed with robust inner support system for rugged road conditions
- Stainless steel plumbing with bronze valves for long service life and reliability

Product Manual

The HL Series External Pump Product Manual is designed to be used in conjunction with 2016 Orca HL Series External Pump and newer models (and SN 27617). 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
LOX	Liquid Oxygen
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
PPE	Personal Protective Equipment
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch (Gauge)
PTO	Power Take-Off
RV	Relief Valve
RTD	Resistance Temperature Device
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 HL Series External Pump 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. Slightly 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 will lead 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.

Personal Protective Equipment (PPE)

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

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

Introduction

Theory of Operation

Although the Orca HL 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 HL 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 HL 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 HL 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 HL 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 HL 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-18) 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 (V-51) 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 (V-51).
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

    d. AOV-2 Recirculation Valve (confirm visually by description on top of AOV)

    Additionally, verify the following valves on the Orca tank are closed:

    a. V-10 Equalization Valve

    b. AOV-1 Dispense Valve (confirm visually by description on top of AOV)

    c. Force Feed Pressure Build

    Confirm manual override handles are in the horizontal position.

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 (50 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. If equipped with a road relief valve (V-2) make sure it 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 (V-18).
4. When the Orca tank is full, liquid will vent out of the full trycock valve (V-18). 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. If equipped with a road relief valve (V-2) make sure to open it.
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, if equipped with a road relief valve (V-2), keep it 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
- Maximum total threshold has been exceeded
- Flow rate is unstable
- System alarm reached on the control panel (VFD)

Power Supply

PTO (480V) - Chassis Mounted

With the Orca delivery system securely positioned and ready for delivery, follow these steps to start and use the power take-off.

1. Engage PTO per heavy duty truck OE's recommendation (if unknown, consult your local OE truck dealership)

    a. Confirm provided instructions meet OE truck recommendations and can be easily understood by all operators.

Note: *Damage may occur to PTO system or transmission if proper PTO engagement is not followed. It is highly recommended to develop instructions and place a label on the dash.*

Note: *Safety interlocks need to be in place to prevent the PTO shaft from spinning above 1800 RPM or while traveling down the road.*

Caution! Avoid PTO driveline area while truck engine is running. Even if PTO is not engaged, some transmissions allow for the PTO to spin.

2. Set speed to desired operating speed.

Note: *Label in cab should determine the max speed (typically 1100 engine RPM) 1800 RPM is the required PTO shaft speed.*

Note: *Many OE trucks have different ways to achieve operating speed. Confirm provided instructions meet OE truck recommendations and can be easily understood by all operators.*

Warning! During PTO operation, if excessive vibration is noticed, contact your local heavy duty truck service provider. Failure to do so may result in additional damage or loosening of moving components.

Generator (480V) - Trailer Mounted

1. See OE generator supplier recommendation for remote start operation.

Note: *Remote start could be hard wired and not require additional user interaction.*

2. Use remote start located in plumbing cabinet to start the 480V system.

Note: *It is a good practice to follow all OE generator service and daily operation checks before operation of power source.*

Operating in Temperatures below 32° F

Generator

1. See generator operating recommendation for cold weather operating, maintenance, and block heater usage.

Note: *The electrical panel heater is thermostatically controlled (40°F - 55°F) and has power any time the generator is running.*

2. Start the engine.
3. It may be required to leave engine running between sites.

Truck

Note: *The electrical panel heater is thermostatically controlled (40°F - 55°F) and has power anytime the truck key is in the "ON" position.*

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 piping cabinet doors.

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

Note: *AOV4 opens allowing pump to cool down. The Flowcom® Flow Meter System also powers up and captures saturation pressure and starts the cool down timer.*

2. The Flowcom system should power up. If not, turn the system on by pressing the power button.

Note: *If errors (red text) appear during the Flowcom system start up, consult the Flowcom system manual.*

3. 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.*

4. Select mode must be in 'Auto' mode on the Control Mode Switch (SW210).

Note: *This is a keyed switch and should be left in auto mode while making deliveries.*

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 the normally open contact (CR216) allowing pump control from the Flowcom system.*

5. Review vessel pressure, close Road Relief Valve (V-2) if equipped or blow down below 17 psi.

Caution! If arrival pressure is close to 40 psi MAWP, the pump cool down and subcool build may exceed the 40 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 system to re-establish pSat).

6. 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.

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

8. 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 will cause difficulty with the pump catching prime.

9. Monitor the liquid temperature. In certain conditions vapor lock can occur causing a temperature rise.

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

Note: *When pump timer reaches "zero" and pump icon turns blue, pump can be operates.*

Caution! Monitor discharge pressure. Pressure may exceed safety relief. This may be more frequent during the first delivery of the day.

10. Press the 'Start' command 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'.*

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

12. Follow the Power Supply section of this manual for either PTO or Generator set starting.

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. Monitor pressure: if valve is not open high pressure can be achieved.*

14. 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'.*

15. 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-3) as needed to satisfy the subcool requirement of 4.3 psi
(Current Vessel Pressure - Saturation Pressure = Subcool)
(pVTank - 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.*

16. 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 closes recirculation valve (AOV-3).*

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

18. 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.*

Note: *Press Flowcom info button for additional delivery information*

19. 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).

20. 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" (V-41).

21. Flowcom meter system stops the pump.

22. Close the "Delivery Hose End Valve" (V-41) if not already closed.

23. On the Bulk Tank or Liquid Cylinder, close the fill valves and open the line drain.

24. 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.

If equipped with a road relief, reduce vessel pressure below 20 psi with main vapor vent and open road relief valve.

Note: *Flowcom system must remain on and in 'Delivery' mode. The anti-tow will automatically turn off the Flowcom system.*

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. On the Flowcom interface press clear two times to clear the totalizer and them press delivery. Keep the Flowcom system powered on once complete.
6. 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 20 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) if equipped.
3. Turn off the Control Panel Power by turning momentary Control Power Switch to the "OFF" position (SW206).

Note: *The control mode switch (SW210) must 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. 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. This step also powers off the Flowcom® Flow Meter System.*

6. 480V power down:
   a. PTO: Disengage per OE's recommendation.
   b. Generator: Switch the generator from 'On' to 'Off'. Refer to OE generator recommendations.
7. 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

Roadside Safety Equipment

The Chart installed fire extinguisher is located on the exterior of the cabinet.

Curbside Safety Equipment

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).

Cabinet Safety Equipment

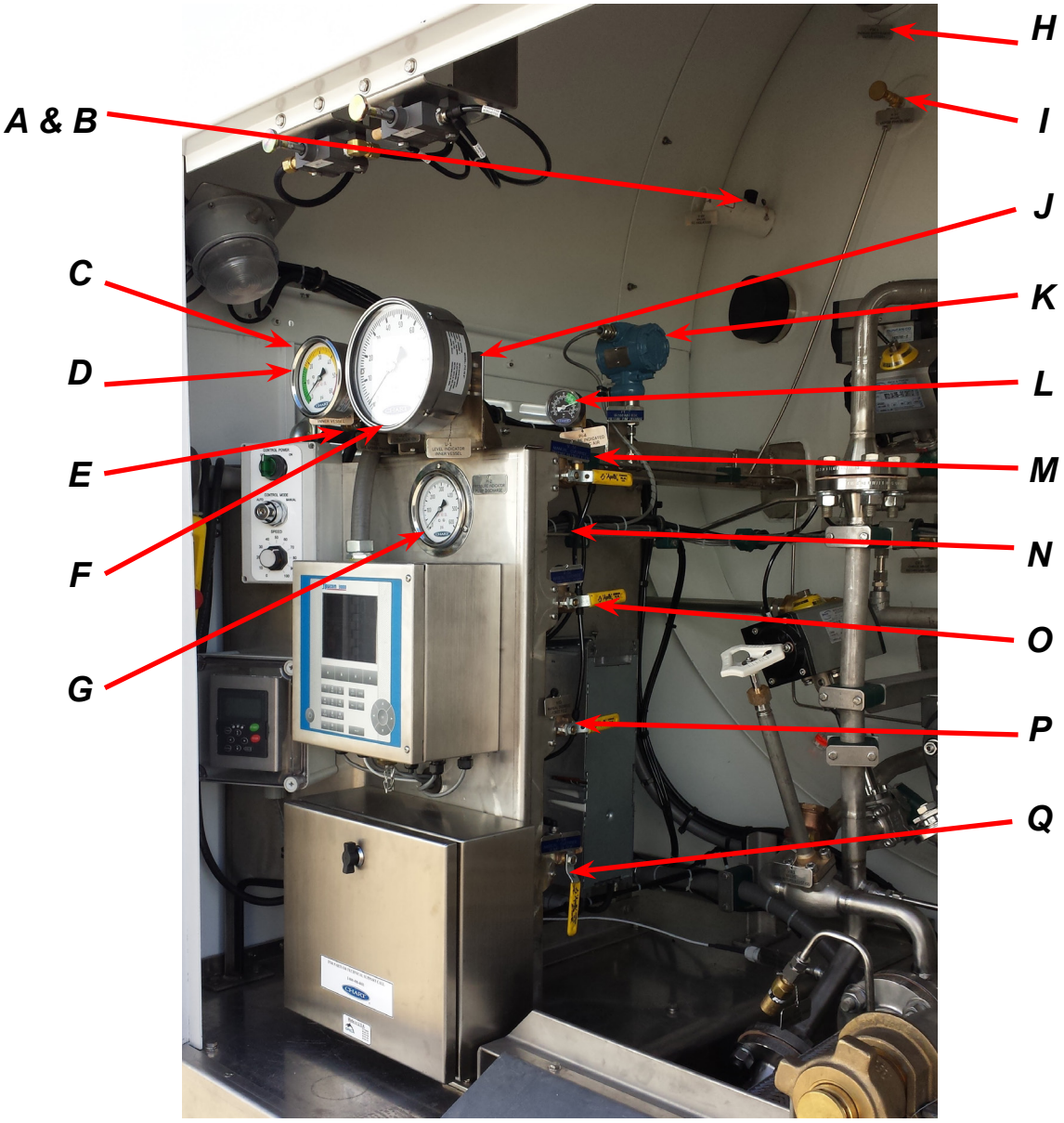
The emergency stop button in the cabinet is located on the pendant.

Components & Systems

Roadside ***Center*** ***Curbside***

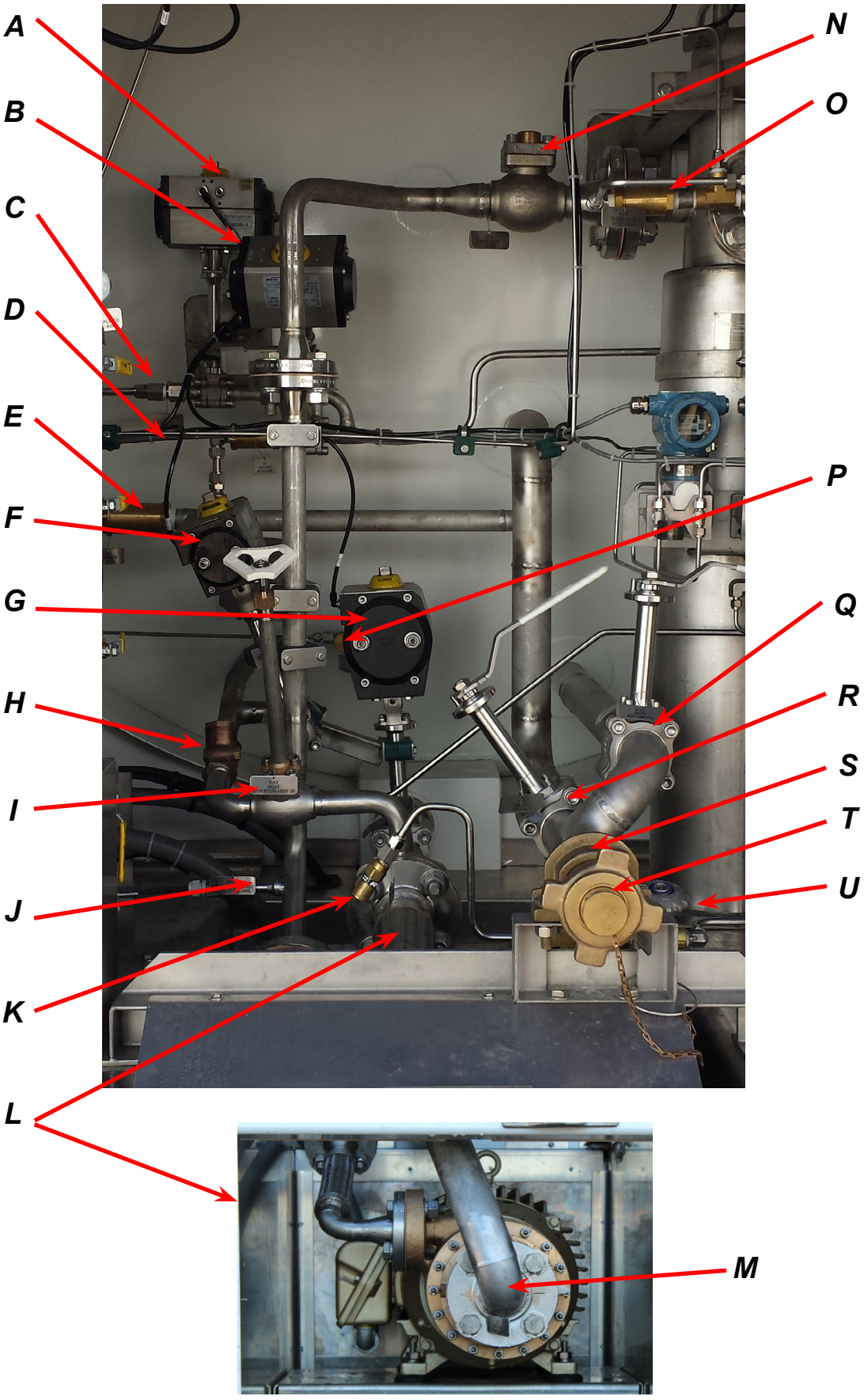
This is the view of the Orca HL Series delivery system cabinet. In this section we will discuss in detail, plumbing cabinet components and systems. To aid in this we will break the cabinet into three areas - Roadside, Center (system control and monitoring), and Curbside.

Plumbing Cabinet - Roadside



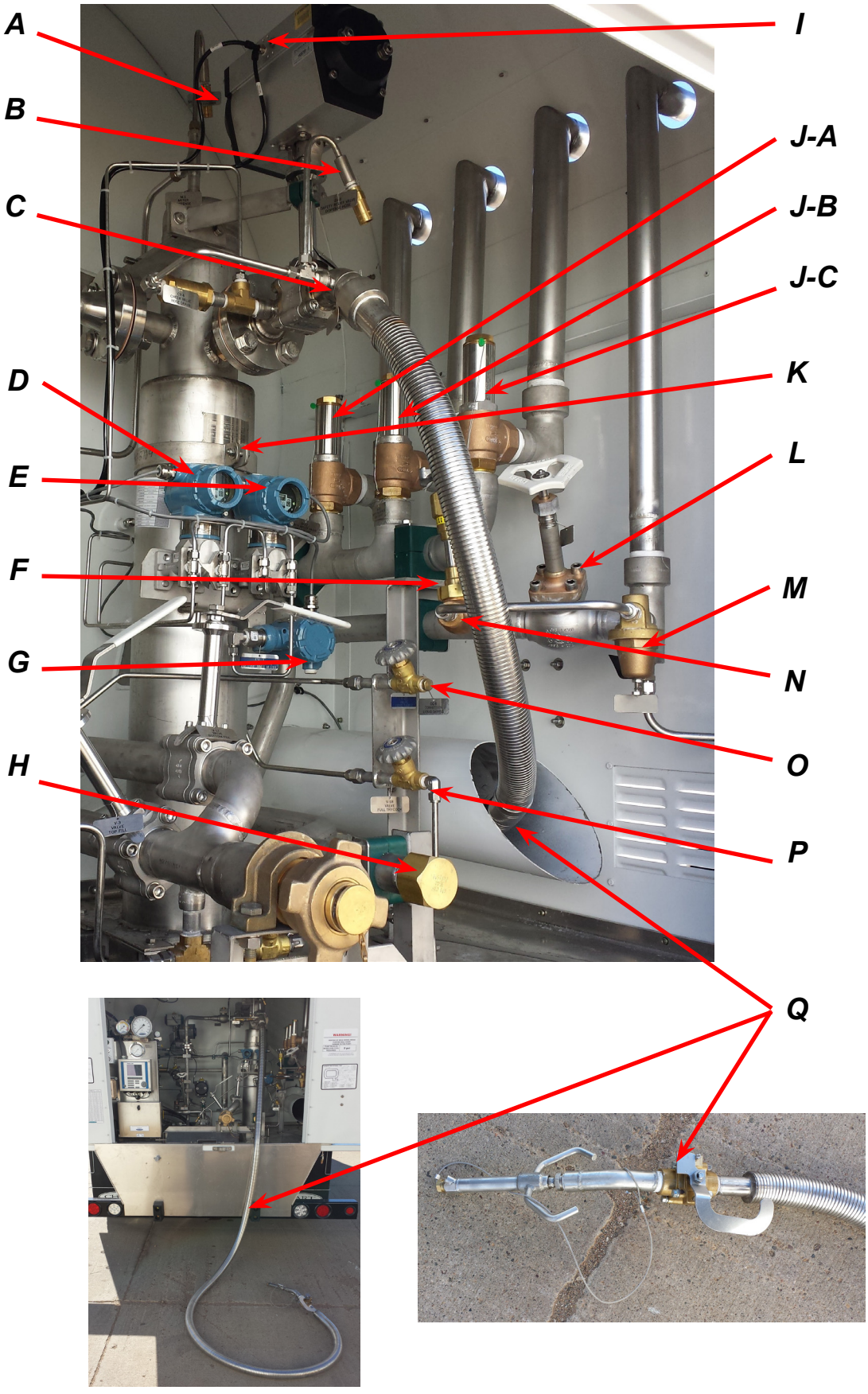
Item	Tag	Part Number	Description
A	V-99	10482381	Valve TC Isolation
B	TC-1	4210049	Vacuum Thermocouple
C	V-12	20890787	Valve LI-1 Liquid Phase
D	PI-1	20890787	Pressure Indicator Inner Vessel
E	V-10	20890787	Valve LI-1 Equalization
F	LI-1	20890787	Liquid Level Indicator Inner Vessel
G	PI-2	20860869	Pressure Indicator Pump Discharge
H	PSE-1		Pressure Safety Element Outer Vessel
I	V-31	10907239	Valve Vapor Phase Isolation
J	V-11	20890787	Valve LI-1 Vapor Phase
K	PT-1	20832592	Transmitter Pressure Inner Vessel
L	PI-4	20937291	Pressure Indicator Pneumatic Air
M	V-51	11809868	Manual Override-Dispense
N	V-13	10907239	Valve Pump Discharge Gauge Isolation
O	V-52	11809868	Manual Override-Pump Cool Down
P	V-53	11809868	Manual Override-Force Feed
Q	V-54	11809868	Manual Override-Pump Return

Plumbing Cabinet - Center



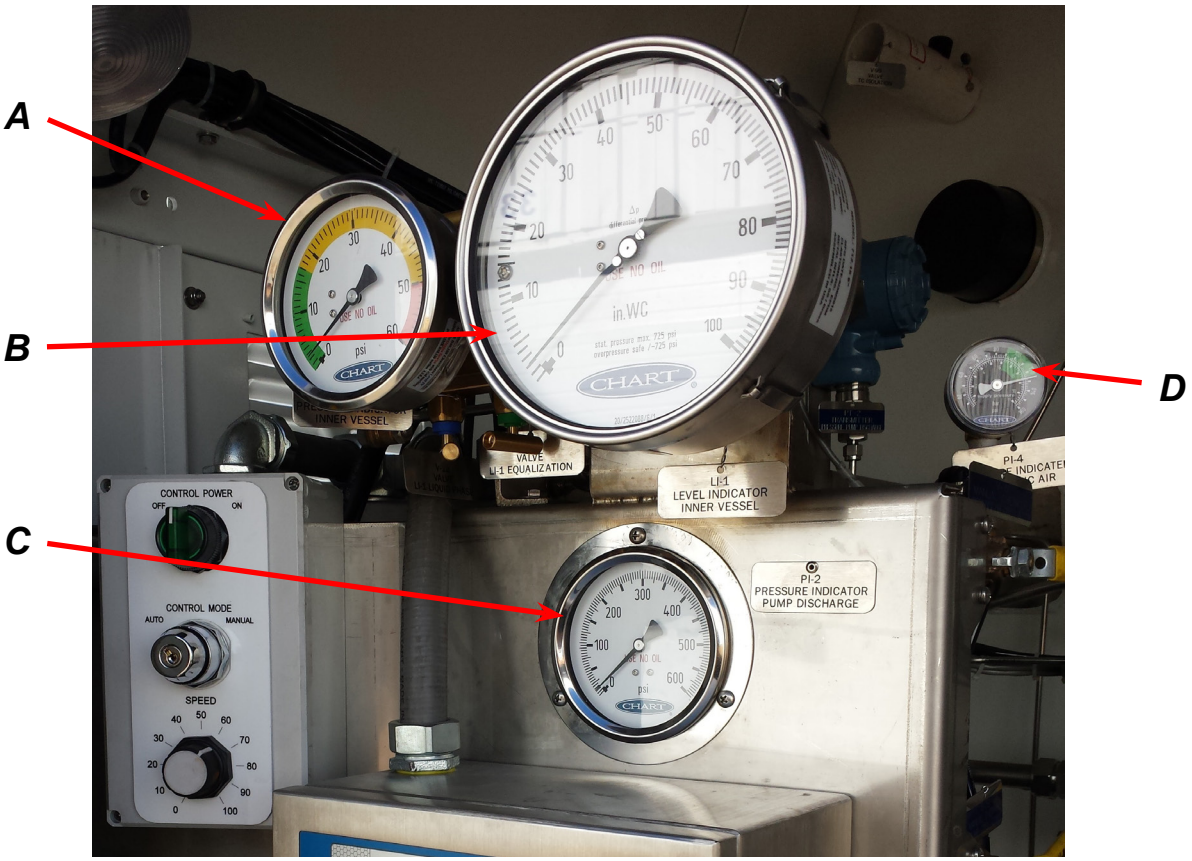
Item	Tag	Part Number	Description
A	AOV-3	20844232	Air Operating Valve Force Feed
B	AOV-2	20929927	Air Operating Valve Recirculation
C	OR-1	20920472	Orfice PB Feed
D	CV-7	11051090	Check Valve Recirculation
E	CV-2	20896229	Check Valve PB Outlet
F	AOV-5	20686470	Air Operating Valve Pump Cool Down
G	AOV-4	20811344	Air Operating Valve Pump Block
H	CV-9	1712152	Check Valve Vapor Return Assist
I	V-43	20917654	Valve Vapor Return Assist ISO
J	RTD-1	FL1254580	Resistance Temperature Device LTD Feed Column
K	SV-4	1810802	Safety Relief Valve Fill Line
L	P-1	20882327	Pump External
M	S-2	250853	Strainer Pump Inlet
N	CV-8	15094361	Check Valve Liquid Feed
O	CV-4	11051090	Check Valve Hose Drain
P	V-32	10907239	Valve Liquid Phase ISO
Q	V-17	20811343	Bottom Fill
R	V-3	20811343	Top Fill
S	DC-1		Connection Fill Line
T	S-1	20902507	Strainer Fill Line
U	V-9	1713202	Valve Fill Line Drain

Plumbing Cabinet - Curbside



Item	Tag	Part Number	Description
A	AOV-1	20832118	Air Operating Valve Dispense
B	SV-5	11505995	Safety Relief Valve Dispense Hose
C	Tran-1	20864870	Transfer Hose Dispense
D	DP-2	FL1254580	Transmitter Diff Press High Flow
E	DP-1	FL1254580	Transmitter Diff Press Low Flow
F	V-2	1718802	Valve Road Relief (if equipped)
G	PT-2	20832595	Transmitter Pressure Pump Discharge
H	DC-3		Connection Vapor Recovery
I	SV-3	11505995	Safety Relief Valve Meter Column
J-A	SV-1A	20874949	Safety Relief Valve Vent Circuit (50 psi)
J-B	SV-1B	20874952	Safety Relief Valve Vent Circuit (75 psi)
J-C	SV-1S	20874952	Safety Relief Valve Vent Circuit (75 psi)
K	M-1	FL0800133	Meter Dispense
L	V-5	13410261	Main Vapor Vent
M	PCV-2	1720414	Road Relief Regulator (if equipped)
N	V-23	1713202	Liquid Sample Valve
O	DC-4		Connection Liquid Sample
P	V-18	1713202	Valve Full Trycock
Q	V-41	11007881	Valve Dispense Hose

Control Gauge Panel



Item	Tag	Part Number	Description
A	PI-1	20860868	Pressure Indicator, Inner Vessel
B	LI-1	20890787	Level Indicator, Inner Vessel
C	PI-2	20860869	Pressure Indicator, Pump Discharge
D	PI-4	20937291	Pressure Indicator, Pneumatic Air

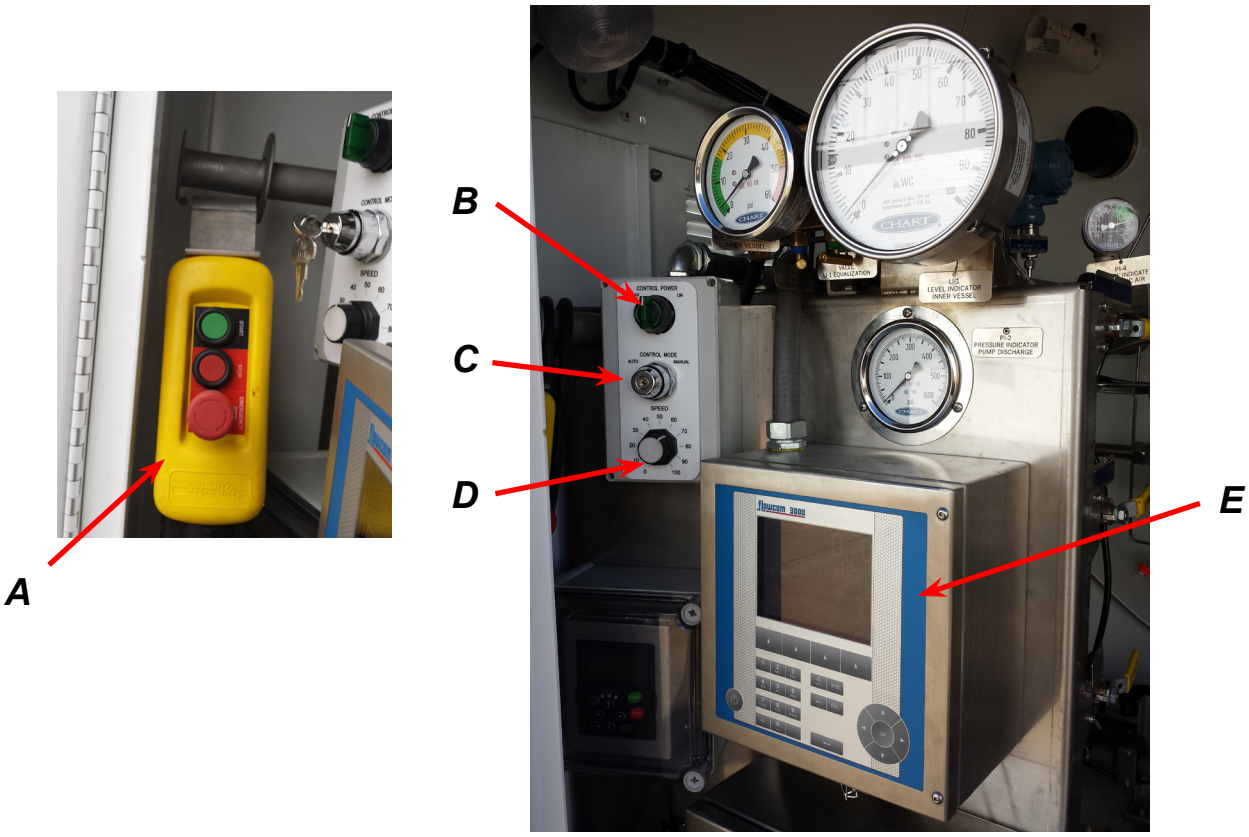
With normal use, the gauge panel will not require any regular maintenance. However, in the event that the differential pressure gauge becomes stuck, complete the following step to reset the gauge.

1. Crack the equalizer gauge line valve.
2. Close the vapor and liquid level valves.

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

3. Open the vapor and liquid level valves.
4. Close the equalizer valve.

Control Panel



Item	Part Number	Description
A	11410712	E-Stop push button
B	11410632	Control Power Switch
C	11410704	Mode Selection Switch 3-position
D	11410641	Pump Speed Dial
E	F11253000	Flowcom 3000

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.

Electrical Panel/Heater

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 / -28°C and will not run the pump if below -4°F / -20°C. If the VFD temperature is between -20°F / -28°C and -4°F / -20°C, the VFD will conduct a self-warming procedure that slowly turns the pump until the VFD warms to -4°F / -20°C. Once -4°F / -20°C 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 / -20°C, 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.

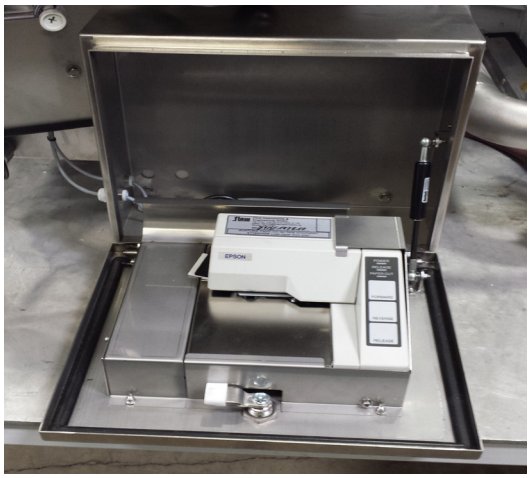
At temperatures below 40°F / 4°C the heaters in the electrical panel will turn on while the truck is in the “key on position”. At -40°F / -40°C ambient conditions it may take up to 15 minutes with the truck in the “key on position” before the unit can make the first delivery. At temperatures above 55°F / 13°C the heaters in electrical panel will turn off.

Heater is located behind VFD in electrical panel

Vent Circuit

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

Ticket Printer

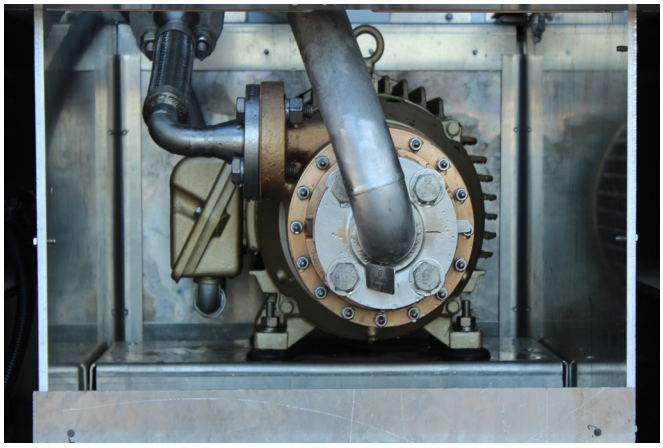


Item	Description	PN
A	Printer-Epson	13086077
B	Printer Ribbon	11693421
C	Printer Power Cord-6'	11764428
D	Printer Data Cable	11764436
E	DC/DC 12-24 VDC Converter	FL0172049
F	Terminal Block	11801276
G	Printer Box	FL1140017

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.

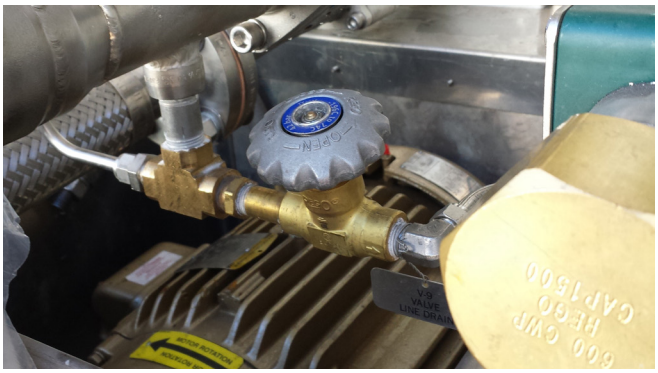
Metering System

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.

Fill Line Drain

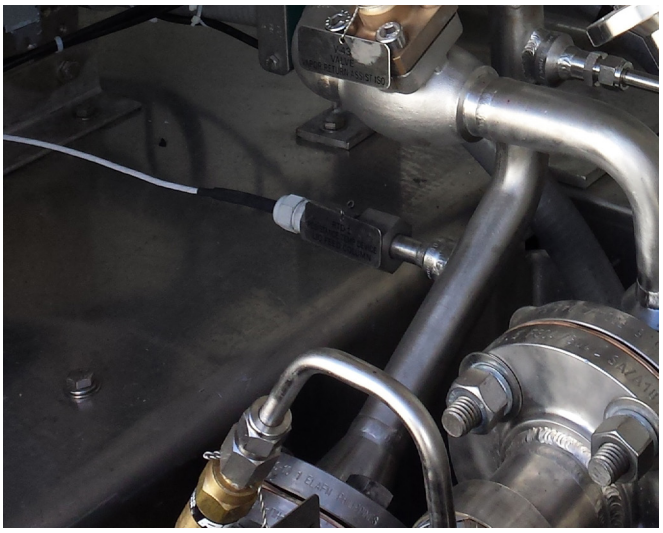


Open this valve to remove pressure / product that remains in fill line circuit after fill is complete.

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 only be considered as a guide. 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 Service Manual.

Symptom	*Probable Cause*	*Remedy*
No control panel power (light not on)	Breaker blown in 12 volt control circuit. 12-volt circuit open. Panel door open / panel door switch off.	Replace breaker / reset breaker in fuse block in truck. Verify connector is plugged in at front of tank. Also inspect wires from connector to control panel for break, cuts, etc. Repair if necessary.
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. Worn bearings in pump.	Slow pump speed down using control on pendant. Remove and replace pump.
Control valves do not open.	No air supply to the valve or low air. System in manual mode. No 12-volt power to the solenoid. Actuator failure.	Verify that there is sufficient air in air tanks. Valve requires 100 psi to operate. Verify solenoid is plugged into junction box, and that wires are not broken. 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.	
	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 4.3 psi above saturation pressure.
	No 12 volt signal	Check 12 volt power supply
	No air supply to actuator	Check air supply (must be greater than 90 psi)
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!***

Symptom	*Probable Cause*	*Remedy*
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
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

- 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.
  - Weekly Interval: PTO driveline system (PTO mounting hardware, PTO driveline joints and hardware) see PTO manufacturer recommendations.
  - 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.

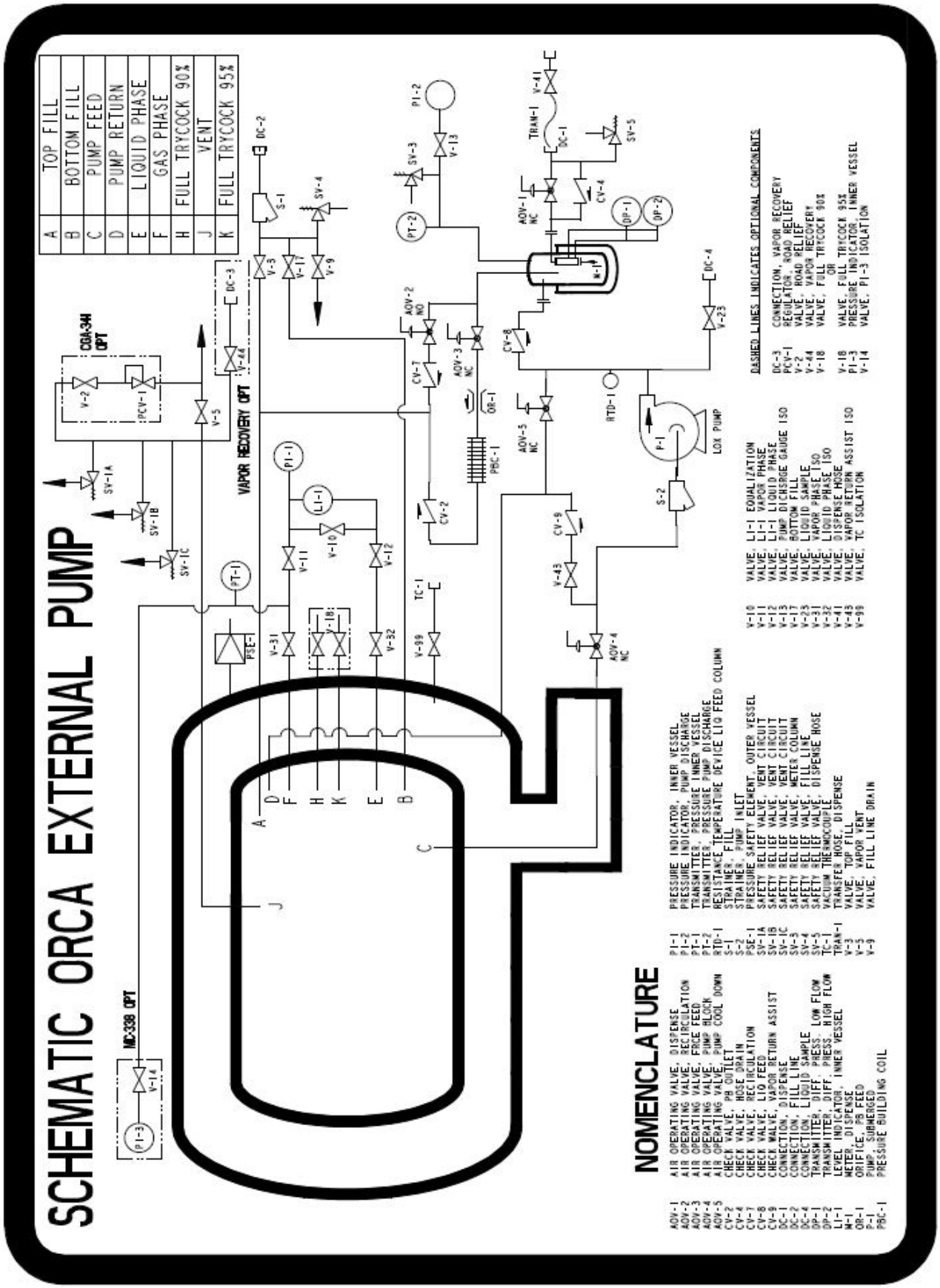
Specifications

Model	HL-1650	HL-2000	HL-2800	HL-3300	HL-4200
Gas Services	LN_2, LAR & LOX	LN_2, LAR & LOX	LN_2, LAR & LOX	LN_2, LAR & LOX	LN_2 Only
Pressure Builder Type	Pump force-feed/ Auto Subcool	Pump force-feed/ Auto Subcool	Pump force-feed/ Auto Subcool	Pump force-feed/ Auto Subcool	Pump force-feed/ Auto Subcool
Design Code	ASME, MC-338, CGA-341	ASME, MC-338, CGA-341	ASME, MC-338, CGA-341	ASME, MC-338, CGA-341	ASME, MC-338, CGA-341
Specifications					
Gross Capacity (gal/ltrs)	1726 / 6534	2144 / 8116	2880 / 10,902	3399 / 12,867	4654 / 17,617
Capacity* **- CGA-341 (gal/ltrs)	1640 / 6207	2037 / 7710	2736 / 10,357	3229 / 12,223	4421 / 16,736
Capacity **- MC-338 (gal/ltrs)	1534 / 5807	1907 / 7219	2560 / 9691	3023 / 11,443	4068 / 15,398
MAWP (psig/bar)	50 / 3.4	50 / 3.4	50 / 3.4	50 / 3.4	50 / 3.4
Overall Length (in/cm)	192 / 488	200 / 508	244 / 620	273 / 693	344 / 874
Overall Height (in/cm)	87 / 221	87 / 221	87 / 221	87 / 221	87 / 221
Overall Width (in/cm)	102 / 259	102 / 259	102 / 259	102 / 259	102 / 259
Tank Diameter (in/cm)	80 / 203	80 / 203	80 / 203	80 / 203	80 / 203
Tare Weight (lbs/kg)	7700 / 3493	8500 / 3856	9400 / 4264	10,500 / 4763	12,200 / 5534

Performance	HL-1650, HL-2000, HL-2800 and HL-3300			HL-4200
Dispense Method/ Technology	External	Submerged Pump		Submerged Pump
Pump	Ext 60	Sub 60	Sub 100 KA	Sub 100 KA
Min. Dispensing Rate (gpm/lpm)	10 / 38	10 / 38	10 / 38	10 / 38
Max. Dispensing Rate (gpm/lpm)	60 / 227	60 / 227	100 / 379	100 / 379
Max. Dispensing Pressure (psig/barg)	260 / 17.9	275 / 19.0	425 / 29.3	425 / 29.3
Max. Receiving Tank Pressure (psig/barg)	210 / 14.5	225 / 15.5	375 / 25.9	275 / 25.9

* With road relief valve at 25.3 psig
** Maximum fill levels depend on vehicle specifications

Schematic

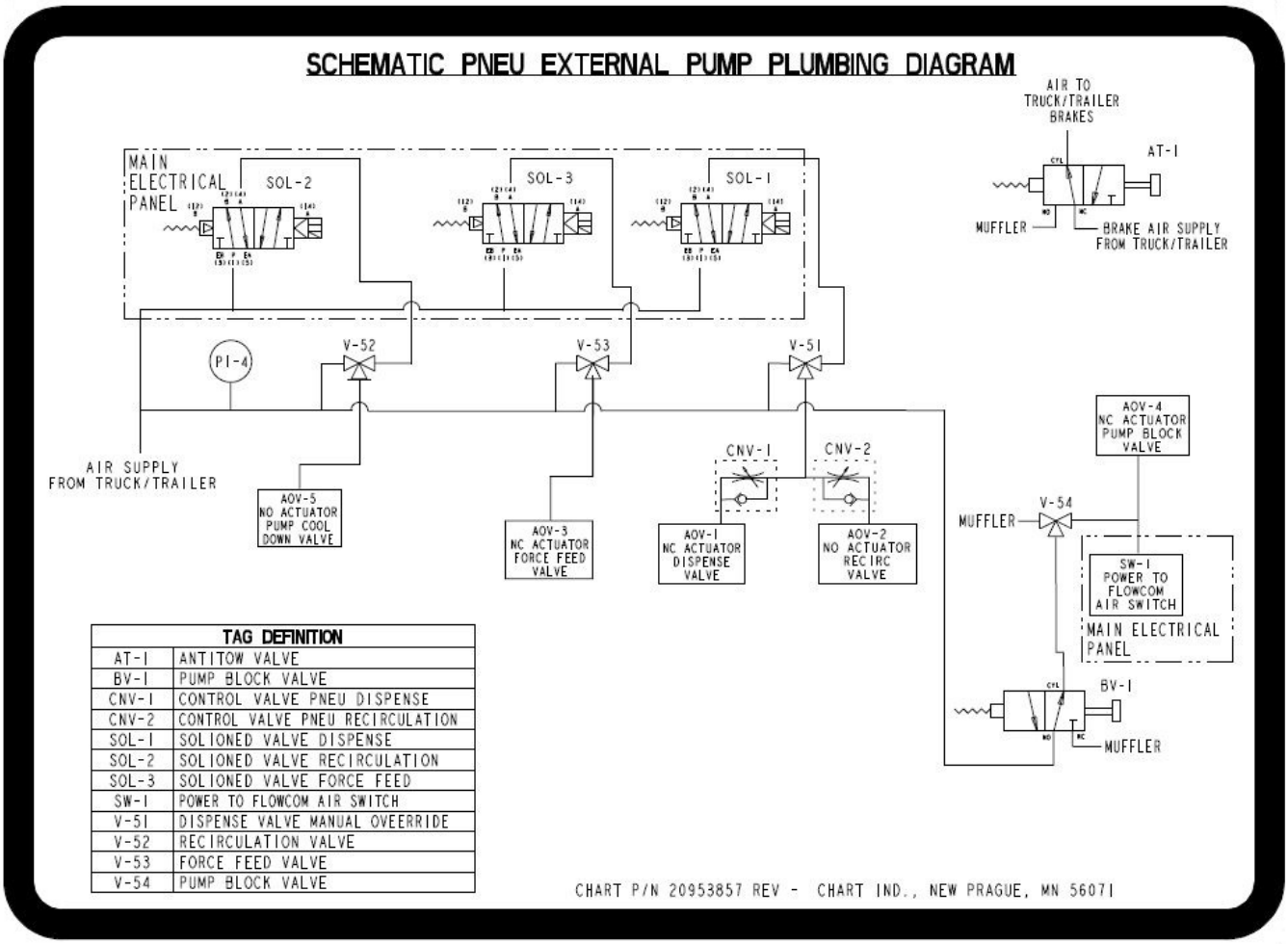

SCHEMATIC ORCA EXTERNAL PUMP
A TOP FILL
B BOTTOM FILL
C PUMP FEED
D PUMP RETURN
E LIQUID PHASE
F GAS PHASE
H FULL TRYCOCK 90%
J VENT
K FULL TRYCOCK 95%
MC-338 OPT
CGA-341 OPT
VAPOR RECOVERY OPT
LOX PUMP
NOMENCLATURE
AOV-1 AIR OPERATING VALVE, DISPENSE
AOV-2 AIR OPERATING VALVE, RECIRCULATION
AOV-3 AIR OPERATING VALVE, PRCE FEED
AOV-4 AIR OPERATING VALVE, PUMP BLOCK
AOV-5 AIR OPERATING VALVE, PUMP COOL DOWN
CV-2 CHECK VALVE, PB OUTLET
CV-7 CHECK VALVE, HOSE DRAIN
CV-8 CHECK VALVE, RECIRCULATION
CV-9 CHECK VALVE, LIQ FEED
CV-43 CHECK VALVE, VAPOR RETURN ASSIST
DC-1 CONNECTION, DISPENSE
DC-2 CONNECTION, FILL LINE
DC-4 CONNECTION, LIQUID SAMPLE
DP-1 TRANSMITTER, DIFF. PRESS. LOW FLOW
DP-2 TRANSMITTER, DIFF. PRESS. HIGH FLOW
LI-1 LEVEL INDICATOR, INNER VESSEL
M-1 METER, DISPENSE
OR-1 ORIFICE, PB FEED
P-1 PUMP, SUBMERGED
PBC-1 PRESSURE BUILDING COIL
PI-1 PRESSURE INDICATOR, INNER VESSEL
PI-2 PRESSURE INDICATOR, PUMP DISCHARGE
PT-1 TRANSMITTER, PRESSURE INNER VESSEL
PT-2 TRANSMITTER, PRESSURE PUMP DISCHARGE
RTD-1 RESISTANCE TEMPERATURE DEVICE LIQ FEED COLUMN
S-1 STRAINER, FILL INLET
S-2 STRAINER, PUMP INLET
PSE-1 PRESSURE SAFETY ELEMENT, OUTER VESSEL
SV-1A SAFETY RELIEF VALVE, VENT CIRCUIT
SV-1B SAFETY RELIEF VALVE, VENT CIRCUIT
SV-1C SAFETY RELIEF VALVE, VENT CIRCUIT
SV-3 SAFETY RELIEF VALVE, METER COLUMN
SV-4 SAFETY RELIEF VALVE, FILL LINE
SV-5 SAFETY RELIEF VALVE, DISPENSE HOSE
TC-1 VACUUM THERMOCOUPLE
TRAN-1 TRANSFER HOSE, DISPENSE
V-3 VALVE, TOP FILL
V-5 VALVE, VAPOR VENT
V-9 VALVE, FILL LINE DRAIN
V-10 VALVE, LI-1 EQUALIZATION
V-11 VALVE, LI-1 VAPOR PHASE
V-12 VALVE, LI-1 LIQUID PHASE
V-13 VALVE, PUMP DISCHARGE GAUGE ISO
V-17 VALVE, BOTTOM FILL
V-23 VALVE, LIQUID SAMPLE
V-31 VALVE, VAPOR PHASE ISO
V-32 VALVE, LIQUID PHASE ISO
V-41 VALVE, DISPENSE HOSE
V-43 VALVE, VAPOR RETURN ASSIST ISO
V-99 VALVE, TC ISOLATION
DASHED LINES INDICATES OPTIONAL COMPONENTS
DC-3 CONNECTION, VAPOR RECOVERY
PCV-1 REGULATOR, ROAD RELIEF
V-2 VALVE, ROAD RELIEF
V-44 VALVE, VAPOR RECOVERY
V-18 VALVE, FULL TRYCOCK 90%
OR VALVE, FULL TRYCOCK 95%
PI-3 PRESSURE INDICATOR, INNER VESSEL
V-14 VALVE, PI-3 ISOLATION

Nomenclature

Ref No.	Description	PN
AOV-1	AIR OPERATING VALVE, DISPENSING	20832118
AOV-2	AIR OPERATING VALVE, PB FEED VALVE	20929927
AOV-3	AIR OPERATING VALVE, FORCE FEED	20844232
AOV-4	AIR OPERATING VALVE, PUMP BLOCK	20811344
AOV-5	AIR OPERATING VALVE, PUMP COOL DOWN	20686470
CV-2	CHECK VALVE, PB OUTLET	20896229
CV-4	CHECK VALVE, HOSE DRAIN	11051090
CV-7	CHECK VALVE, VAPOR RETURN ASSIST	11051090
CV-8	CHECK VALVE, LIQ FEED	15094361
CV-9	CHECK VALVE, VAPOR RETURN ASSIST	1712152
DC-1	CONNECTION, DISPENSE	
DC-2	CONNECTION, FILL LINE	
DC-3	CONNECTION, VAPOR RECOVERY	
DC-4	CONNECTION, LIQUID SAMPLE	
DP-1	TRANSMITTER, DIFF. PRESS. LOW FLOW	20881767
DP-2	TRANSMITTER, DIFF. PRESS. HIGH FLOW	20881768
LI-1	LEVEL INDICATOR, INNER VESSEL	20890787
M-1	METER, DISPENSE	FL0800133
OR-1	ORIFICE, PB FEED	20920472
P-1	PUMP, EXTERNAL	20882327
PBC-1	PRESSURE BUILDING COIL	
PI-1	PRESSURE INDICATOR, INNER VESSEL	20890787
PI-2	PRESSURE INDICATOR, PUMP DISCHARGE	20860869
PI-3	PRESSURE INDICATOR, INNER VESSEL	20860868
PT-1	TRANSMITTER, PRESSURE INNER VESSEL	20832592
PT-2	TRANSMITTER, PRESSURE PUMP DISCHARGE	20832592
RTD-1	RESISTANCE TEMPERATURE DEVICE	FL1254580
PSE-1	PRESSURE SAFETY ELEMENT, OUTER VESSEL	
SV-1A	SAFETY RELIEF VALVE, VENT CIRCUIT	20874949

Ref No.	Description	PN
SV-1B	SAFETY RELIEF VALVE, VENT CIRCUIT	20874952
SV-1C	SAFETY RELIEF VALVE, VENT CIRCUIT	20874952
SV-3	SAFETY RELIEF VALVE, DISPENSE	11505995
SV-4	SAFETY RELIEF VALVE, FILL LINE	1810802
SV-5	SAFETY RELIEF VALVE, DISPENSE HOSE	11505995
TC-1	VACUUM THERMOCOUPLE	4210049
TRAN-1	TRANSFER HOSE, DISPENSE	20864870
V-3	VALVE, TOP FILL	20811343
V-5	VALVE, VAPOR VENT	13410261
V-9	VALVE, FILL LINE DRAIN	1713202
V-10	VALVE, LI-1 EQUALIZATION	20890787
V-11	VALVE, LI-1 VAPOR PHASE	20890787
V-12	VALVE, LI-1 LIQUID PHASE	20890787
V-13	VALVE, PUMP DISCHARGE ISO	10907239
V-14	VALVE, PI-3 ISOLATION	11701435
V-17	VALVE, BOTTOM FILL OR MID FILL	20811343
V-18	VALVE, FULL TRYCOCK 95%	1713202
V-18	VALVE, FULL TRYCOCK 90%	1713202
V-23	VALVE, LIQUID SAMPLE/SUMP DRAIN	1713202
V-31	VALVE, VAPOR PHASE ISO	10907239
V-32	VALVE, LIQUID PHASE ISO	10907239
V-41	VALVE, DISPENSE HOSE	11007881
V-43	VALVE, VAPOR RETURN ASSIST ISO	20917654
V-44	VALVE, VAPOR RECOVERY	20898283
V-99	VALVE, TC ISOLATION	10482381
PCV-1	REGULATOR, ROAD RELIEF	1720412
V-2	VALVE, ROAD RELIEF	1718802
S-1	STRAINER, FILL	20902507
S-2	STRAINER, PUMP INLET	250853

Pneumatic Schematic



Liquid Level Chart - 2800 Gallon - Nitrogen

Nitrogen @ 15 PSIG Saturation Pressure						
Level (in H_2O)	Volume		Weight		Gas Volume	
H_20	Gallons	Liter	Pounds	Kilograms	Cubic Ft	Cubic M
0	0	0	0	0	0	0
2	20	76	344	156	4,744	125
4	71	269	671	304	9,267	244
6	140	530	1,113	505	15,368	404
8	222	840	1,643	745	22,677	596
10	316	1,196	2,244	1,018	30,971	814
12	418	1,582	2,904	1,317	40,087	1,054
14	529	2,002	3,615	1,640	49,895	1,312
16	646	2,445	4,368	1,981	60,284	1,585
18	768	2,907	5,155	2,338	71,155	1,870
20	895	3,388	5,971	2,708	82,420	2,167
22	1,026	3,884	6,810	3,089	93,995	2,471
24	1,159	4,387	7,665	3,477	105,800	2,781
26	1,293	4,895	8,532	3,870	117,761	3,096
28	1,429	5,409	9,404	4,266	129,802	3,412
30	1,565	5,924	10,277	4,662	141,850	3,729
32	1,700	6,435	11,145	5,055	153,832	4,044
34	1,833	6,939	12,003	5,444	165,673	4,355
36	1,964	7,435	12,845	5,826	177,299	4,661
38	2,092	7,919	13,666	6,199	188,630	4,958
40	2,215	8,385	14,460	6,559	199,585	5,246
42	2,333	8,831	15,220	6,904	210,075	5,522
44	2,445	9,255	15,939	7,230	220,004	5,783
46	2,549	9,649	16,610	7,534	229,265	6,027
46.9 (90%)	2,596	9,827	16,908	7,669	233,373	6,135
48	2,645	10,012	17,224	7,813	237,730	6,249
50	2,729	10,330	17,768	8,059	245,245	6,447
50.3 (95%)	2,740	10,372	17,836	8,090	246,179	6,471
52	2,801	10,603	18,229	8,269	251,603	6,614
54	2,856	10,811	18,582	8,429	256,476	6,742
56	2,884	10,917	18,764	8,511	258,998	6,808

Liquid Level Chart - 2800 Gallon - Oxygen

Oxygen @ 15 PSIG Saturation Pressure						
Level (in H_2O)	Volume		Weight		Gas Volume	
H_20	Gallons	Liter	Pounds	Kilograms	Cubic Ft	Cubic M
0	0	0	0	0	0	0
2	12	45	320	145	3,863	102
4	43	163	596	270	7,195	189
6	83	314	967	439	11,683	307
8	132	500	1,414	641	17,076	449
10	187	708	1,923	872	23,226	611
12	249	943	2,487	1,128	30,028	789
14	316	1,196	3,097	1,405	37,402	983
16	387	1,465	3,750	1,701	45,280	1,190
18	462	1,749	4,439	2,013	53,605	1,409
20	541	2,048	5,161	2,341	62,325	1,638
22	623	2,358	5,912	2,682	71,396	1,877
24	708	2,680	6,689	3,034	80,773	2,123
26	795	3,009	7,488	3,396	90,419	2,377
28	884	3,346	8,305	3,767	100,295	2,636
30	975	3,691	9,139	4,145	110,365	2,901
32	1,068	4,043	9,987	4,530	120,596	3,170
34	1,161	4,395	10,844	4,919	130,953	3,442
36	1,256	4,754	11,710	5,312	141,405	3,717
38	1,351	5,114	12,580	5,706	151,918	3,993
40	1,446	5,474	13,454	6,103	162,462	4,271
42	1,541	5,833	14,327	6,499	173,005	4,548
44	1,636	6,193	15,197	6,893	183,515	4,824
46	1,731	6,553	16,062	7,286	193,960	5,099
48	1,824	6,905	16,919	7,674	204,309	5,371
50	1,917	7,257	17,765	8,058	214,528	5,639
52	2,007	7,597	18,598	8,436	224,585	5,904
54	2,097	7,938	19,414	8,806	234,444	6,163
56	2,184	8,267	20,211	9,168	244,070	6,416
58	2,268	8,585	20,986	9,519	253,425	6,662
60	2,350	8,896	21,735	9,859	262,469	6,899
62	2,428	9,191	22,455	10,185	271,161	7,128
64	2,503	9,475	23,141	10,497	279,452	7,346
66	2,574	9,744	23,791	10,791	287,293	7,552
66.6 (90%)	2,596	9,827	23,987	10,880	289,669	7,614
68	2,641	9,997	24,398	11,067	294,624	7,745
70	2,702	10,228	24,957	11,320	301,379	7,922
71.4 (95%)	2,740	10,372	25,462	11,549	305,630	8,034
72	2,757	10,436	25,462	11,549	307,474	8,082
74	2,805	10,618	25,903	11,749	312,802	8,222
76	2,845	10,769	26,268	11,915	317,210	8,338
78	2,874	10,879	26,535	12,036	320,434	8,423
80	2,884	10,917	26,632	12,080	321,606	8,454

Liquid Level Chart - 2800 Gallon - Argon

Argon @ 15 PSIG Saturation Pressure						
Level (in H_2O)	Volume		Weight		Gas Volume	
H_20	Gallons	Liter	Pounds	Kilograms	Cubic Ft	Cubic M
0	0	0	0	0	0	0
3	18	68	464	210	4,484	118
6	59	223	929	421	8,986	236
9	115	435	1,552	704	15,009	395
12	182	689	2,297	1,042	22,216	584
15	258	977	3,143	1,426	30,401	799
18	341	1,291	4,076	1,849	39,416	1,036
21	431	1,632	5,081	2,305	49,144	1,292
24	527	1,995	6,151	2,790	59,486	1,564
27	627	2,373	7,275	3,300	70,358	1,849
30	732	2,771	8,446	3,831	81,680	2,147
33	840	3,180	9,656	4,380	93,381	2,455
36	951	3,600	10,898	4,943	105,396	2,770
39	1,065	4,031	12,166	5,518	117,660	3,093
42	1,180	4,467	13,454	6,103	130,113	3,420
45	1,297	4,910	14,755	6,693	142,696	3,751
48	1,414	5,353	16,063	7,286	155,350	4,084
51	1,531	5,795	17,373	7,880	168,018	4,417
54	1,648	6,238	18,678	8,472	180,642	4,748
57	1,764	6,677	19,973	9,060	193,165	5,078
60	1,878	7,109	21,252	9,640	205,529	5,403
63	1,990	7,533	22,507	10,209	217,673	5,722
66	2,100	7,949	23,734	10,766	229,535	6,034
69	2,207	8,354	24,925	11,306	241,051	6,336
72	2,309	8,741	26,072	11,826	252,151	6,628
75	2,407	9,111	27,170	12,324	262,761	6,907
78	2,500	9,464	28,208	12,795	272,800	7,171
81	2,587	9,793	29,177	13,234	282,176	7,417
81.3 (90%)	2,596	9,827	29,274	13,278	283,116	7,442
84	2,667	10,096	30,067	13,638	290,781	7,644
87	2,738	10,364	30,863	13,999	298,485	7,846
87.1 (95%)	2,740	10,372	30,886	14,010	298,709	7,852
90	2,799	10,595	31,549	14,310	305,116	8,020
93	2,848	10,781	32,097	14,559	310,417	8,160
96	2,880	10,902	32,455	14,721	313,876	8,251
99	2,884	10,917	32,500	14,742	314,316	8,262

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 HL Series unit. If warranty replacement of part is required, the Orca HL 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 HL 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)	18 Months
Control Panel (480 VAC)	6 Months
Check Valves	1 Year
Safety Relief Valves, Vent	1 Year

*From shipment of Orca HL Series unit.

Workmanship and Vacuum

Chart Inc. warrants all Orca HL 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 HL 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 HL 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.