Product Manual

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

Designed and Built by:

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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 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 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
- Exclusive low maintenance submerged pump for instant starts and continuous delivery
- Single hose delivery system minimizes contamination, cool down losses and pressure drop
- Push-button Flowcom® 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 operations 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 recalibration 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 Product Manual is designed to be used in conjunction with Orca HL 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.

In the Components & Systems section you will find photos and description of all working parts of the Orca system.

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

Reference the Preventative Maintenance section for a schedule of maintenance to follow to keep your Orca system running smoothly.

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

Terms

Throughout this manual safety precautions will be designated as follows:

Warning! Description of a condition that can result in personal injury or death.

Caution! Description of a condition that can result in equipment or component damage.

Note: *A statement that contains information that is important enough to emphasize or repeat.*

Acronyms / Abbreviations

The following acronyms / abbreviations are used throughout this manual:

ASME	American Society of Mechanical Engineers
BAR	Pressure (Metric)
CGA	Compressed Gas Association
DOT	Department of Transportation
GAWR	Gross Axle Weight Rating
GPM	Gallons Per Minute
GVWR	Gross Vehicle Weight Rating
LAR	Liquid Argon
LN_2/LIN	Liquid Nitrogen
LPM	Liters Per Minute
MAWP	Maximum Allowable Working Pressure
NIST	National Institute of Standards and Tech.
NPSH	Net Positive Suction Head
OE	Original Equipment
PB	Pressure Builder
PN	Part Number
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch (Gauge)
PTO	Power Take-Off
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 HL Series delivery system, it is imperative that all persons having contact with the Orca delivery system become thoroughly familiar with all maintenance, safety precautions, and procedures contained in this product manual. If for any reason any part or parts of this manual become confusing or the information provided is not completely understood contact a Technical Service Representative at Chart Inc. 1-800-400-4683 before proceeding with the operation or repair of the vessel.

Compatibility and Cleaning

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

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

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

Safety Bulletin

Portions of the following information are extracted from Safety Bulletin SB-2 from the Compressed Gas Association, Inc. Additional information on oxygen, nitrogen, argon, and cryogenics is available from the CGA at www.cganet.com.

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

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

Incidents which require that such practices be followed include: highway accidents, immersion of a container in water, exposure to extreme heat or fire, and exposure to most adverse weather conditions (earthquake, tornadoes, etc.) As a general rule, whenever a container is suspected of abnormal operation, or has sustained actual damage, good safety practices must be followed.

In the event of known or suspected container vacuum problems (even if an extraordinary circumstance such as those noted above has not occurred), do not continue to use the unit. Continued use of a cryogenic container that has a vacuum problem can lead to embrittlement and cracking. Further, the carbon steel jacket could possibly rupture if the unit is exposed to inordinate stress conditions caused by an internal liquid leak.

Prior to reusing a damaged container, the unit must be tested, evaluated, and repaired as necessary. It is highly recommended that any damaged container be returned to Chart for repair and re-certification.

The remainder of this safety bulletin addresses those adverse environments that may be encountered when a cryogenic container has been severely damaged. These are oxygen deficient atmospheres, oxygen enriched atmospheres, and exposure to inert gases.

Oxygen Deficient Atmospheres

Warning! Nitrogen and argon vapors in air may dilute the concentration of oxygen necessary to support or sustain life. Exposure to such an oxygen deficient atmosphere can lead to unconsciousness and serious injury, including death.

The normal oxygen content of air is approximately 21%. Depletion of oxygen content in air, either by combustion or by displacement with inert gas, is a potential hazard and users should exercise suitable precautions.

One aspect of this possible hazard is the response of humans when exposed to an atmosphere containing only 8 to 12% oxygen. In this environment, unconsciousness can be immediate with virtually no warning.

When the oxygen content of air is reduced to about 15 to 16%, the flame of ordinary combustible materials, including those commonly used as fuel for heat or light, may be extinguished. Somewhat below this concentration, an individual breathing the air is mentally incapable of diagnosing the situation because the onset of symptoms such as sleepiness, fatigue, lassitude, loss of coordination, errors in judgment and confusion can be masked by a state of "euphoria," leaving the victim with a false sense of security and well being.

Human exposure to atmosphere containing 12% or less oxygen leads to rapid unconsciousness. Unconsciousness can occur so rapidly that the user is rendered essentially helpless. This can occur if the condition is reached by an immediate change of environment, or through the gradual depletion of oxygen.

Most individuals working in or around oxygen deficient atmospheres rely on the "buddy system" for protection - obviously the "buddy" is equally susceptible to asphyxiation if he or she enters the area to assist the unconscious partner unless equipped with a portable air supply. Best protection is obtainable by equipping all individuals with a portable supply of respirable air. Life lines are acceptable only if the area is essentially free of obstructions and individuals can assist one another without constraint.

If an oxygen deficient atmosphere is suspected or known to exist:

1. Use the "buddy system." Use more than one "buddy" if necessary to move a fellow worker in an emergency.
2. Both the worker and "buddy" should be equipped with self-contained or airline breathing equipment.

Oxygen Enriched Atmospheres

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

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

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

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

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

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

Nitrogen and Argon

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

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

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

Introduction

Theory of Operation

Although the Orca 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 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! 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.*

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

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 '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.*

5. Close Road Relief Valve (V-2) if equipped.

Caution! If the road relief valve was not closed and arrival pressure is close to 50 psi MAWP, the pump cool down and subcool build may exceed the 50 psi MAWP. Open the main vent and vent down to 17 psi and close the vent. Turn off the Flowcom meter system, wait one minute and turn the power back on (this allows the liquid to re-stabilize and the Flowcom meter system to re-establish pSat).

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

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

10. Press 'Start' on the Flowcom interface or the remote pendant to start the pump in recirculation mode.

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

11. 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)
(p VTank - pSat V Tank = pSub VTank).

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

12. 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-2).*

13. 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.*

14. 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).
15. 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”.
16. Flowcom meter system stops the pump.
17. Close the “Delivery Hose End Valve” (V-41) if not already closed.
18. On the Bulk Tank or Liquid Cylinder, close the fill valves and open the line drain.
19. Disconnect the hose (and adapters) from the receiving tank, install the dust plugs and stow the hose.

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

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

Printing a Ticket

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

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

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

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

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

5. Close the printer door.

Securing the Orca Delivery System for Movement

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

1. Vent the Orca tank to pressure (PI-1) below 25 psig if needed by opening the ‘Main Vent’ valve (V-5). Close this valve when proper pressure has been obtained.
2. Open the ‘Road Relief Valve’ (V-2) 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) can be left in “Auto” or switched off. When switched off, auto mode relay (CR216) de-energizes and returns to normally open.*

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

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

7. 480V power down:
   a. PTO: Disengage per OE's recommendation.
   b. Generator: Switch the generator from 'On' to 'Off'. Refer to OE generator recommendations.
8. 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

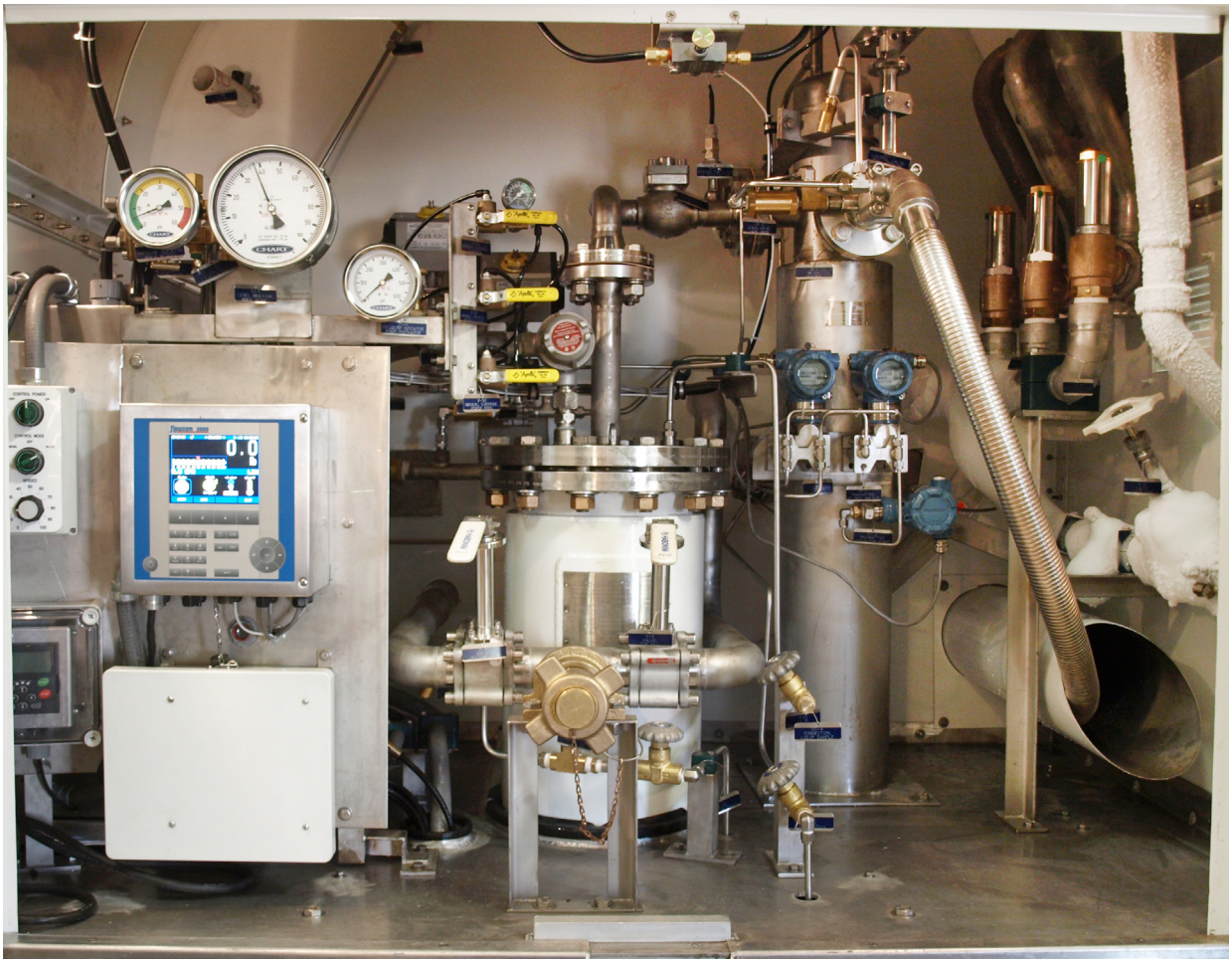
Curbside Safety Equipment

Located 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.

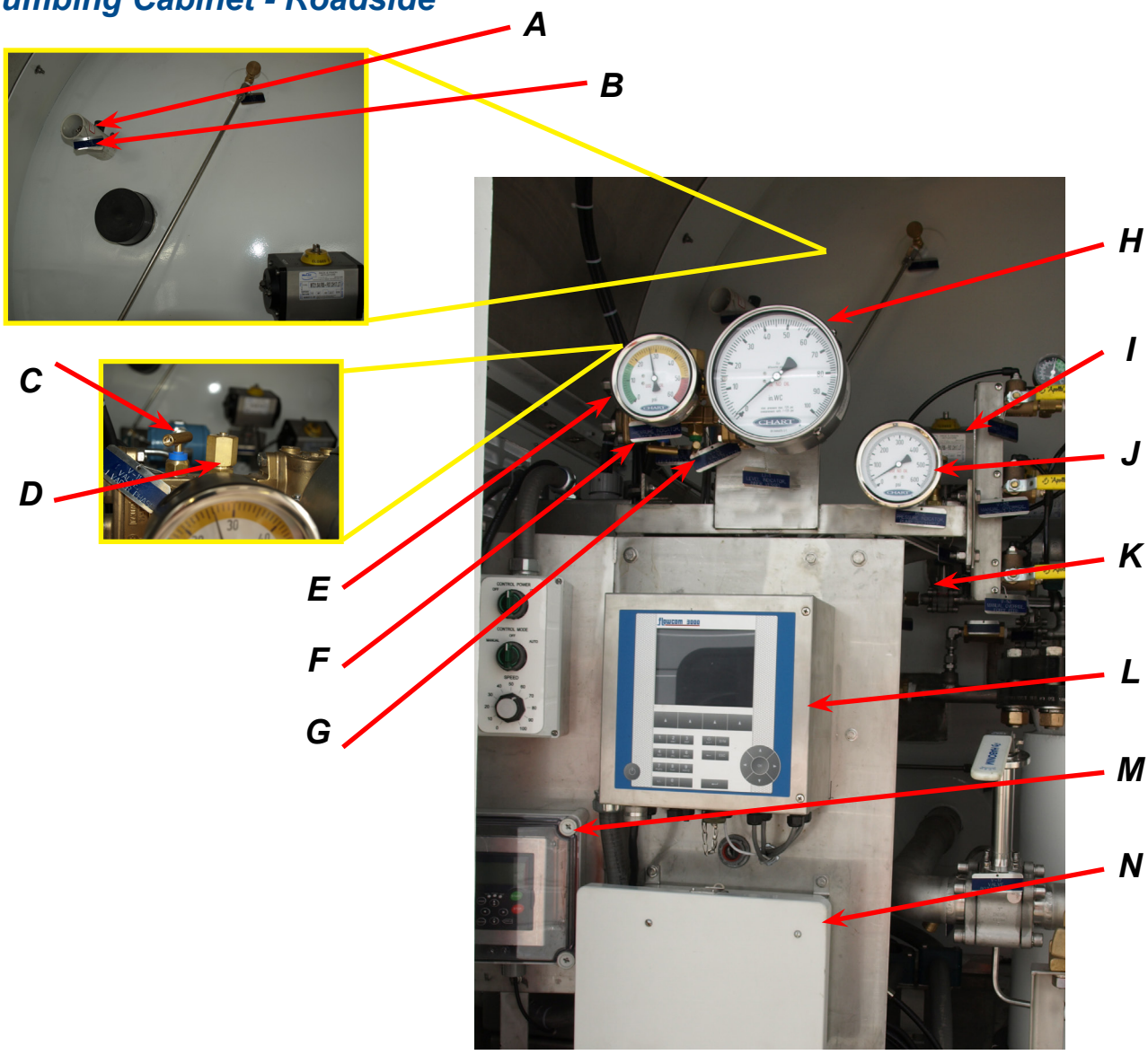
Components & Systems



Roadside **Center** **Curbside**

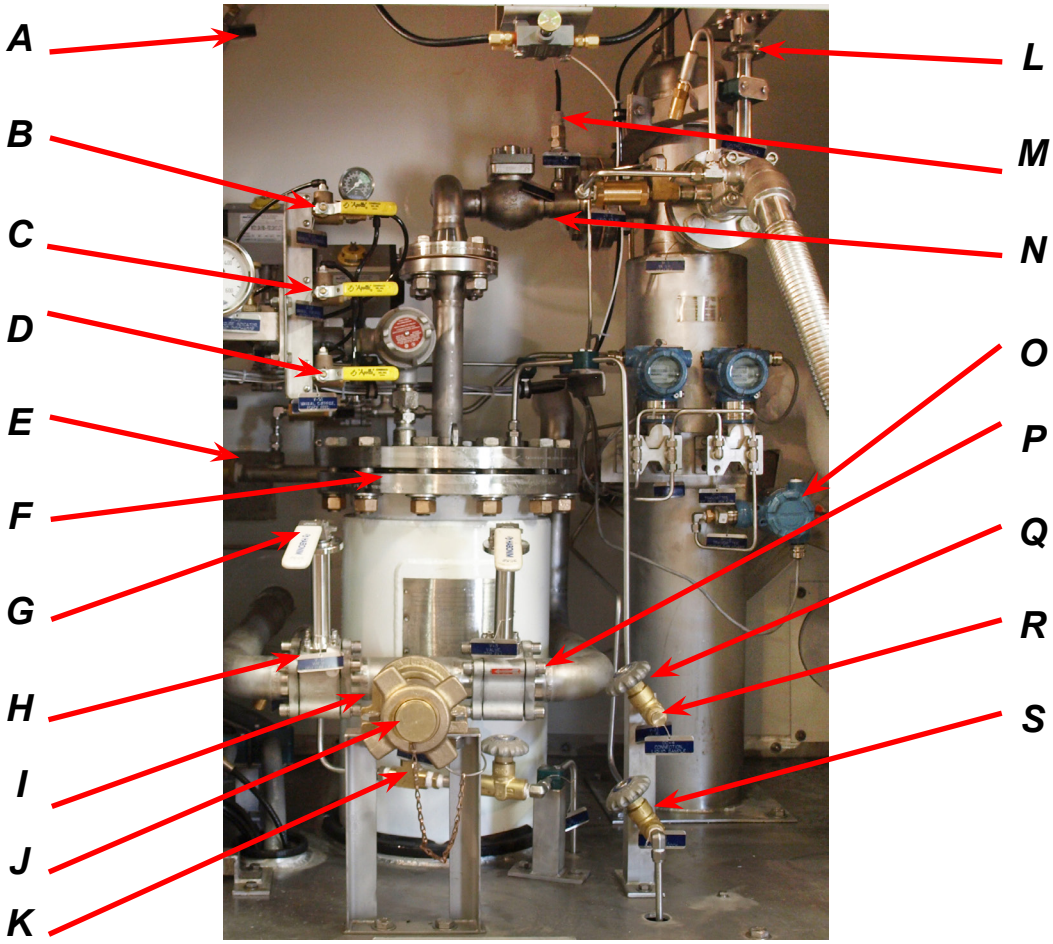
This is the view of the Orca HL Series delivery system cabinet. In this section we will discuss in detail, plumbing cabinet components and systems. To aid in this we will break the cabinet into three areas - Roadside, Center (system control and monitoring), and Curbside.

Plumbing Cabinet - Roadside



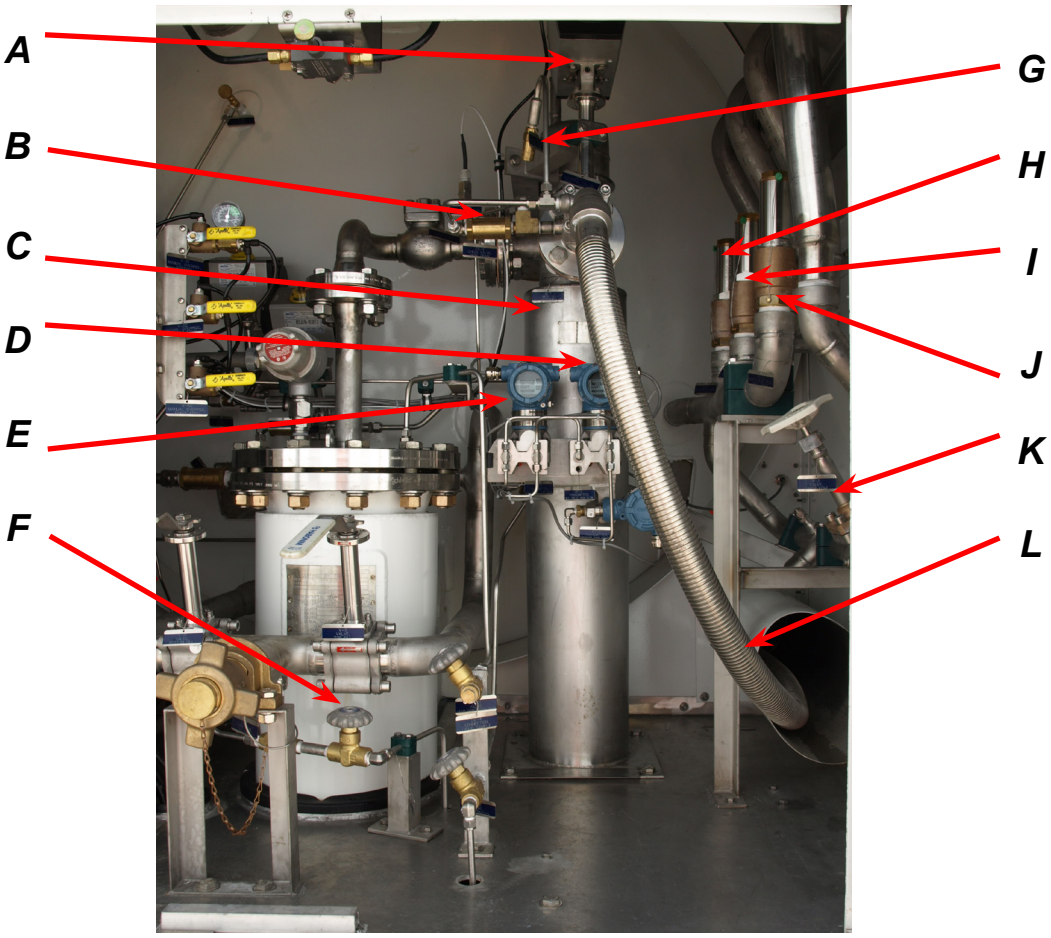
Item	Tag	Part Number	Description
A	TC-1	4210049	Vacuum Thermocouple
B	V-99	10482381	Valve, TC Isolation
C	V-11	10907239	Valve, LI-1 Vapor Phase
D	PT-1	20832592	Transmitter, Pressure Inner Vessel
E	PI-1		Pressure Indicator, Inner Vessel
F	V-12		Valve, LI-1 Liquid Phase
G	V-10		Valve, LI-1 Equalization
H	LI-1	20890787	Level Indicator, Inner Vessel
I	V-13	14717177	Valve, Pump Discharge Gauge ISO
J	PI-2	20860869	Pressure Indicator, Pump Discharge
K	OR-1	20898255	Orifice, PB Feed
L		FL1253000	Flowcom 3000
M			Remont VFD Display
N			Printer Box

Plumbing Cabinet - Center



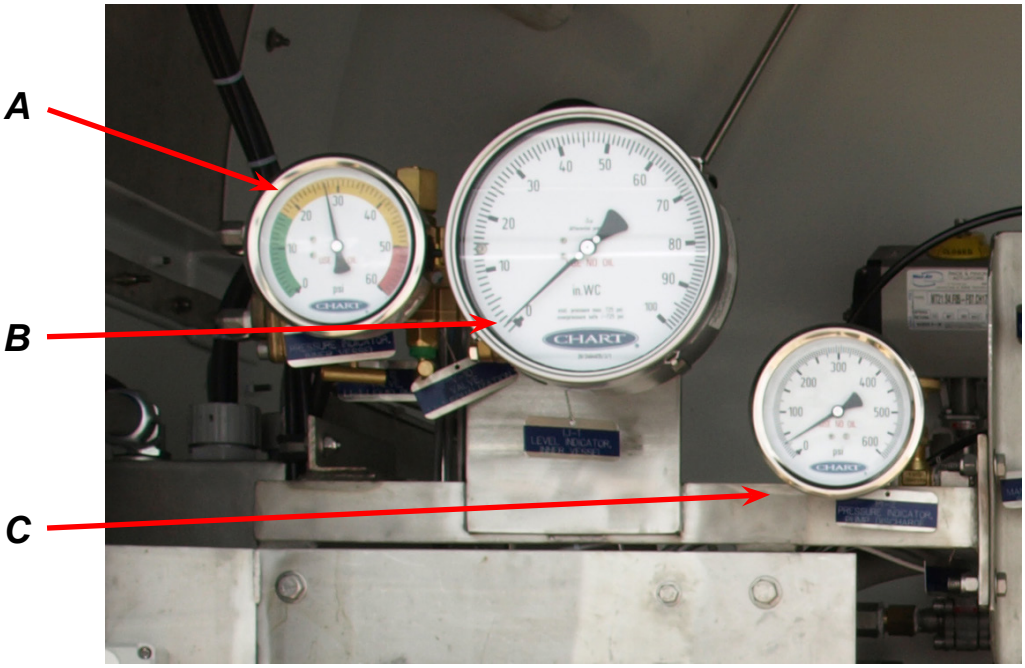
Item	Tag	Part Number	Description
A	V-31	10907239	Valve, Vapor Phase ISO
B	AOV-3	20844232	Air Operation Valve, Force Feed
C	AOV-2	20844232	Air Operation Valve, Recirculation
D	CV-7	11051090	Check Valve, Recirculation
E	CV-2	20896229	Check Valve, PB Outler
F	P-1	11941383	Pump, Submerged
G	V-32	10907239	Valve, Liquid Phase ISO
H	V-17	20811343	Valve, Bottom Fill
I	SV-4	1810802	Safety Relief Valve Fill Line
J	DC-2		Connection, Fill Line
K	S-1		Strainer Fill
L	AOV-1	20832118	Air Operation Valve, Dispense
M	RTD-1	FL1145110	Resistance Temperature Device Liquid Feed Column
N	CV-8	20581252	Check Valve, Liquid Feed
O	PT-2	20832592	Transmitter, Pressure Pump Discharge
P	V-3	20811343	Valve, Top Fill
Q	V-23	1713202	Valve, Liquid Sample/Sump Drain
R	DC-4		Connection, Liquid Sample (3/8” NFPT)
S	V-18A / V-18B	1713202	Valve, Full Trycock 90% / Valve, Full Trycock 95%

Plumbing Cabinet - Center



Item	Tag	Part Number	Description
A	SV-3	11505995	Safety Relief Valve, Meter Column
B	CV-4	11051090	Check Valve, Hose Drain
C	M-1	FL0800133	Meter, Dispense
D	DP-1	20881767	Transmitter, Diff. Press. Low Flow
E	DP-2	20881768	Transmitter, Diff. Press. High Flow
F	V-9	1713202	Valve, Fill Line Drain
G	SV-5	11505995	Safety Relief Valve, Dispense Hose
H	SV-1C	20874952	Safety Relief Valve, Vent Circuit
I	SV-1B	20874952	Safety Relief Valve, Vent Circuit
J	SV-1A	20874949	Safety Relief Valve, Vent Circuit
K	V-5	13410261	Valve, Vapor Vent
L	TRAN-1	20864870	Transfer Hose, Dispense

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

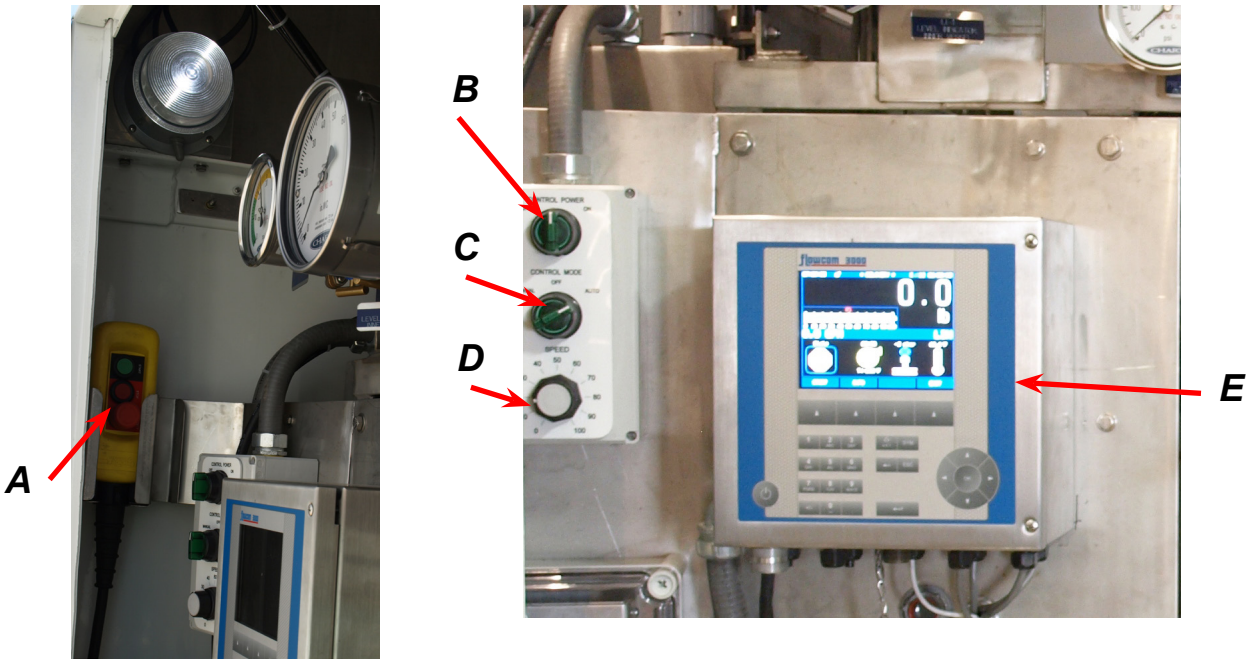
With normal use, the gauge panel will not require any regular maintenance. However, in the event that the differential pressure gauge becomes stuck, complete the following step to reset the gauge.

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

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

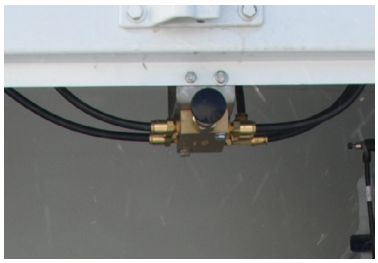
3. Open the vapor and liquid level valves.
4. Close the equalizer valve.

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

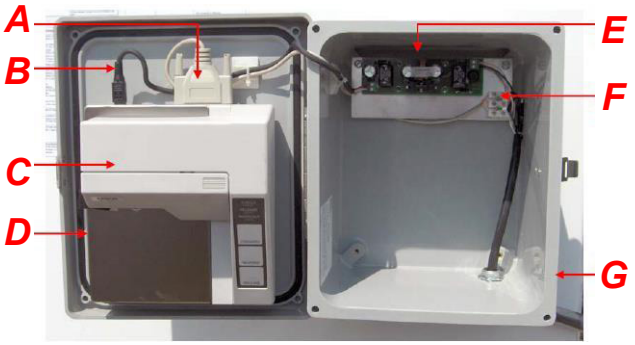
The Cutler-Hammer Variable Frequency Drive (VFD) has an internal temperature sensor that does not allow the VFD to operate at temperatures below -20°F / -28°C and will not run the pump if below -4°F / -20°C. If the VFD temperature is between -20°F / -28°C and -4°F / -20°C, the VFD will conduct a self-warming 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 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.

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

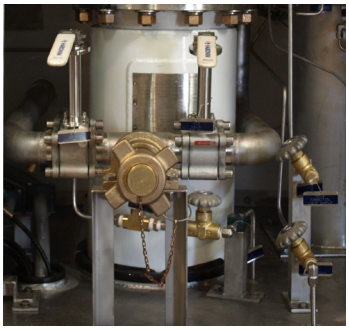


Item	Description	PN
A	Printer Data Cable	11764436
B	Printer Power Cord-6'	11764428
C	Printer Ribbon	11693421
D	Printer-Epson	13086077
E	DC/DC 12-24 VDC Converter	FL0172049
F	Terminal Block	11801276
G	Printer Box	11720142

Submerged Pump

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

Fill Circuit



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

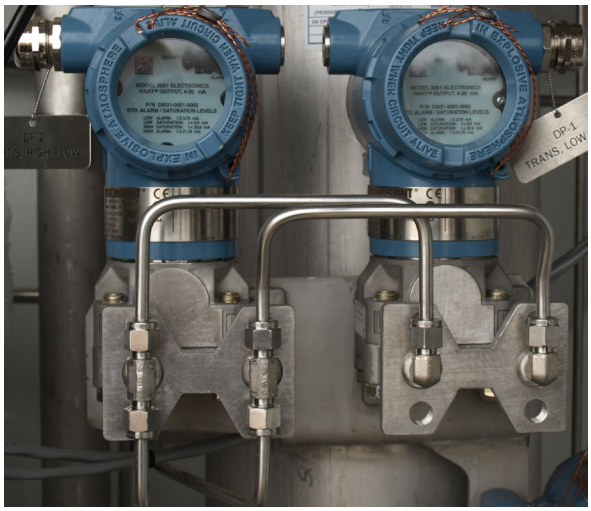
Metering System

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

Meter Section

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

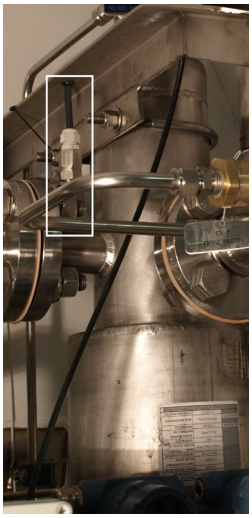
Differential Pressure Transmitter (DP Transmitter)



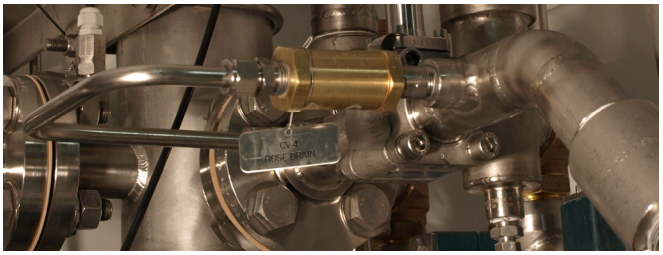
This is a Rosemount Pre-Set Differential Pressure Transmitter used on the Orca system. It is connected to the meter section and the Flowcom meter system. The DP transmitter measures a change in pressure (pressure drop) across the meter section and relays this information to the Flowcom meter system in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

RTD - Resistance Temperature Device

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



Hose Drain Check Valve



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

Flowcom Flow Meter System

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

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

Fuse Box (Truck Mounted Units)

The 480V fuse box is located on the road side of the unit just behind the cab.

Gauge

Located on the road side front of the Orca tank on MC-338 units only.

Troubleshooting

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

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

Symptom	Probable Cause	Remedy
Unstable flow of product.	Depletion of subcool.	Add subcool by opening pressure building coil. Required pressure is 4.3 psi above saturation pressure.
	Auto subcool valve not opening.	 ***Caution! Do not use fire or flame to thaw valve on an oxygen unit!!!***
	Vessel transmitter fault.	
	Manual valves closed.	Ensure all valves are open.
	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
	AOV-1 not opening.	
	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.
Audible change in pump.	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
	Flow rates through restrictive lines.	 ***Caution! Serious damage to pump can occur if pump is run dry!***
	Pump pressure too high.	Reduce pump pressure.
	Worn bearings in pump.	Remove and replace pump.
Pump not catching prime.	Insufficient subcool. AOV-3 not opening. AOV-2 not closing.	Add subcool by opening pressure building coil. Required pressure is 4.3 psi above saturation pressure.
		 ***Caution! Venting during delivery will cause depletion of subcool, and may also cause damage to pump!***
	Liquid level low.	Check liquid level gauge. Delivery of product should not be attempted at low liquid levels.
		 ***Caution! Serious damage to pump can occur if pump is run dry!***
Paper out. (Print / Exit)	Add paper, check cables	Verify that the cables to the printer are plugged in, that the printer is turned on, and that there is paper in the printer.
Lower pump speed, lower pressure or recirc is continuous.	AOV-2 valve not operating properly	Adequate air supply 12 volt supply to solenoid

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

Preventive Maintenance

General

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

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

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

Maintenance Schedule

- 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 Interval (or less): PTO driveline system (PTO mounting hardware, PTO driveline joints and hardware)
  - 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.

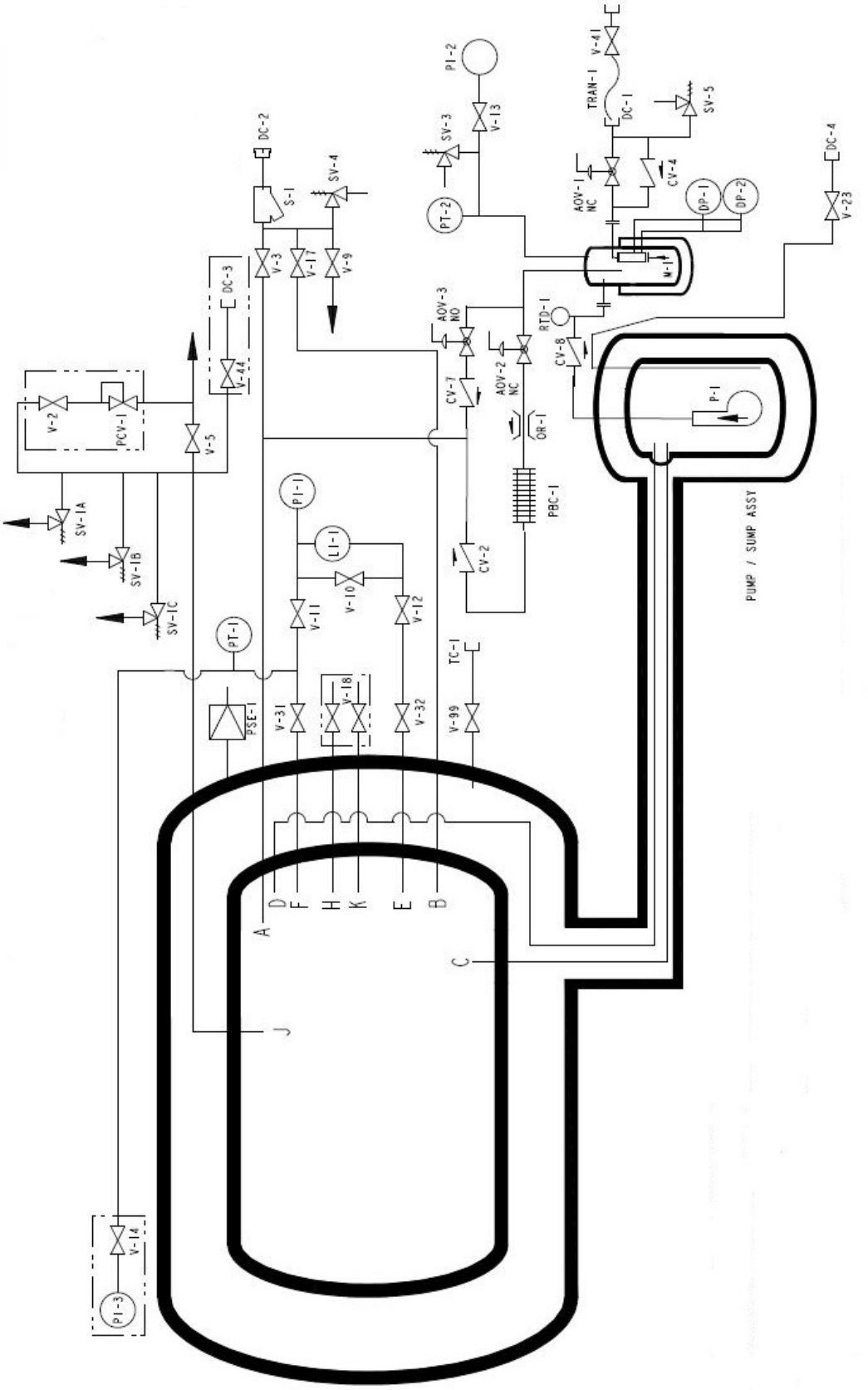
Specifications

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


PI-2
V-13
SV-3
PT-2
TRAN-1
V-41
DC-1
SV-5
DC-4
V-23
AOV-1 NC
CV-4
DP-1
DP-2
W-1
DC-2
S-1
SV-4
V-3
V-17
V-9
DC-3
V-44
AOV-3 NO
RTD-1
CV-8
CV-7
AOV-2 NC
OR-1
P-1
V-2
PCV-1
V-5
PBC-1
PUMP / SUMP ASSY
SV-1A
SV-1B
SV-1C
PI-1
LI-1
V-10
V-11
V-12
CV-2
PT-1
TC-1
PSE-1
V-31
V-18
V-32
V-99
A
D
F
H
K
E
B
C
J
V-14
PI-3

Nomenclature

Ref No.	Description	PN
AOV-1	AIR OPERATING VALVE, DISPENSING	20832118
AOV-2	AIR OPERATING VALVE, RECIRCULATION	20929927
AOV-3	AIR OPERATING VALVE, FRCE FEED	20844232
CV-2	CHECK VALVE, PB OUTLET	20896229
CV-4	CHECK VALVE, HOSE DRAIN	11051090
CV-7	CHECK VALVE, RECIRCULATION	11051090
CV-8	CHECK VALVE, LIQ FEED	20581252
DC-1	CONNECTION, DISPENSE	1-1/2 FPT
DC-4	CONNECTION, LIQUID SAMPLE	3/8 FPT
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	FL1174810
OR-1	ORIFACE, PB FEED	20898255
P-1	PUMP, SUBMURGED	11941383
PBC-1	PRESSURE BUILDING COIL	14037200
PI-1	PRESSURE INDICATOR, INNER VESSEL	20890787
PI-2	PRESSURE INDICATOR, PUMP DISCHARGE	20860869
PI-3	PRESSURE INDICATOR, INNER VESSEL	20860868
PSE-1	PRESSURE SAFETY ELEMENT, OUTER VESSEL	10826172
PT-1	TRANMITER, PRESSURE INNER VESSEL	20832592
PT-2	TRANMITER, PRESSURE PUMP DISCHARGE	20832592
RTD-1	RESISTANCE TEMPERATURE DEVICE LIQ FEED COLUMN	FL1145110
S-1	STRAINER FILL	20902507
SD-2	PRESSURE SAFETY ELEMENT, OUTER VESSEL	10899110
SV-1A	SAFETY RELIEF VALVE, VENT CIRCUIT	20874949
SV-1B	SAFETY RELIEF VALVE, VENT CIRCUIT	20874952
SV-1C	SAFETY RELIEF VALVE, VENT CIRCUIT	20874952
SV-3	SAFETY RELIEF VALVE, METER COLUMN	11505995
SV-4	SAFETY RELIEF VALVE, FILL LINE	1810802
SV-5	SAFETY RELIEF VALVE, DISPENSE HOSE	11505995

Ref No.	Description	PN
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-I EQUALIZATION	20890787
V-11	VALVE, LI-I VAPOR PHASE	20890787
V-12	VALVE, LI-I LIQUID PHASE	20890787
V-13	VALVE, PUMP DISCHARGE GAUGE ISO	14817177
V-14	VALVE, PI-3 ISOLATION	11701435
V-17	VALVE, BOTTOM FILL	20811343
V-18	VALVE, FULL TRYCOCK 95%	1713202
V-18	VALVE, FULL TRYCOCK 90%	
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-44	VALVE, VAPOR RECOVERY	20898283
V-99	VALVE, TC ISOLATION	10482381
PCV-1	REGULATOR, ROAD RELIEF	1720412
V-2	VALVE, ROAD RELIEF	1713922
DC-3	CONNECTION, VAPOR RECOVERY - LAR	10496548
DC-3	CONNECTION, VAPOR RECOVERY - LN2	10861509
DC-3	CONNECTION, VAPOR RECOVERY - LOX	10601150
DC-2	CONNECTION, FILL LINE - LN2 1-1/2	10891417
SPIN ADAPTOR	CONNECTION TO PERMA CYLS - 1/2" OD LIN/LAR	20899903
SPIN ADAPTOR	CONNECTION TO PERMA CYLS - 3/4"OD LAR	20875471
SPIN ADAPTOR	CONNECTION TO PERMA CYLS - 5/8"OD LOX	20908769
	SPIN ADAPTOR RV ELBOW 30 DEG	20911012
	RV THAT IS IN SPIN ADAPTOR ELBOW	13618395
SPIN ADAPTOR	SPIN ADAPTER 1"ODT 37 DEGX1MPT	20875017

Liquid Level Chart 1650 Gallon Inert Service (LN_2/LAR)

Argon - 0 psig				Nitrogen - 0 psig			
In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)	In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)
0	0	0	0	0	0	0	0
2.5	7	190	1,841	2	13	147	2,026
5	24	387	3,744	4	42	338	4,670
7.5	48	654	6,327	6	80	595	8,215
10	76	978	9,457	8	126	904	12,478
12.5	108	1,350	13,052	10	179	1,256	17,339
15	144	1,763	17,054	12	237	1,645	22,710
17.5	183	2,214	21,415	14	300	2,066	28,517
20	226	2,698	26,097	16	367	2,514	34,695
22.5	270	3,212	31,065	18	437	2,984	41,186
25	317	3,752	36,289	20	510	3,473	47,938
27.5	366	4,316	41,739	22	585	3,977	54,900
30	417	4,900	47,389	24	662	4,494	62,023
32.5	469	5,502	53,214	26	741	5,018	69,261
35	523	6,120	59,191	28	820	5,547	76,568
37.5	578	6,752	65,295	30	899	6,079	83,900
40	634	7,394	71,506	32	978	6,608	91,211
42.5	691	8,045	77,801	34	1,057	7,133	98,456
45	748	8,702	84,158	36	1,134	7,650	105,590
47.5	805	9,364	90,557	38	1,209	8,155	112,566
50	863	10,027	96,976	40	1,282	8,646	119,337
52.5	921	10,691	103,396	42 (90%)	1,353	9,118	125,852
55	978	11,353	109,794	44	1,420	9,568	132,057
57.5	1,036	12,010	116,151	46 (95%)	1,483	9,991	137,896
60	1,092	12,661	122,444	48	1,534	10,363	142,977
62.5	1,148	13,303	128,653	50	1,585	10,709	147,748
65	1,203	13,934	134,756	52	1,629	11,016	151,970
67.5	1,257	14,552	140,730				
70	1,309	15,154	146,553				
72.5 (90%)	1,360	15,738	152,200				
75	1,409	16,301	157,647				
77.5 (95%)	1,456	16,840	162,866				
80	1,500	17,354	167,830				
82.5	1,555	17,825	172,147				

Liquid Level Chart 2000 Gallon Inert Service (LN_2/LAR)

Argon - 0 psig				Nitrogen - 0 psig			
In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)	In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)
0	0	0	0	0	0	0	0
3	17	197	1,907	2.5	29	197	2,724
6	48	560	5,415	5	83	559	7,714
9	88	1,028	9,947	7.5	152	1,024	14,132
12	136	1,580	15,285	10	233	1,568	21,652
15	189	2,202	21,299	12.5	323	2,178	30,066
18	248	2,883	27,893	15	421	2,841	39,216
21	311	3,617	34,991	17.5	526	3,547	48,969
24	378	4,397	42,531	20	636	4,289	59,206
27	449	5,216	50,456	22.5	750	5,058	69,817
30	522	6,070	58,714	25	867	5,846	80,696
33	598	6,953	67,259	27.5	985	6,646	91,741
36	676	7,861	76,044	30	1,105	7,450	102,848
39	756	8,790	85,026	32.5	1,223	8,252	113,919
42	837	9,734	94,162	35	1,341	9,044	124,853
45	919	10,690	103,409	37.5	1,456	9,819	135,545
48	1,002	11,654	112,727	40	1,567	10,569	145,893
51	1,085	12,620	122,074	42.5	1,673	11,285	155,786
54	1,168	13,585	131,410	45	1,773	11,961	165,108
57	1,251	14,544	140,692	47.5	1,866	12,585	173,731
60	1,332	15,494	149,880	49.5 (90%)	1,935	13,053	185,790
63	1,413	16,430	158,933	50	1,949	13,148	181,504
66	1,492	17,347	167,806	52.5	2,022	13,636	188,237
69	1,569	18,242	176,458	53 (95%)	2,043	13,710	189,203
72	1,643	19,109	184,843	55	2,080	14,028	193,647
75	1,715	19,943	192,915	58	2,121	14,312	197,569
78	1,783	20,740	200,623				
81	1,848	21,494	207,915				
84 (90%)	1,909	22,198	214,729				
87	1,964	22,846	220,996				
90 (95%)	2,015	23,429	226,631				
93	2,058	23,934	231,520				
96	2,103	24,345	235,493				
100	2,122	24,685	238,784				

Liquid Level Chart 2800 Gallon Inert Service (LN_2/LAR)

Argon - 0 psig				Nitrogen - 0 psig			
In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)	In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)
0	0	0	0	0	0	0	0
3	19	219	2,121	2.5	33	222	3,064
6	59	692	6,692	5	103	698	9,630
9	113	1,318	12,751	7.5	196	1,325	18,283
12	178	2,065	19,973	10	306	2,067	28,532
15	250	2,912	28,163	12.5	403	2,902	40,053
18	330	3,844	37,177	15	565	3,812	52,039
21	417	4,850	46,902	17.5	709	4,782	66,002
24	509	5,919	57,242	20	860	5,800	80,059
27	605	7,043	68,115	22.5	1,016	6,856	94,626
30	706	8,215	79,445	25	1,176	7,937	109,554
33	810	9,426	91,165	27.5	1,339	9,035	124,707
36	917	10,672	103,209	30	1,503	10,139	139,948
39	1,027	11,945	115,518	32.5	1,666	11,240	155,144
42	1,138	13,239	128,032	35	1,827	12,328	170,160
45	1,251	14,548	140,696	37.5	1,985	13,393	184,859
48	1,346	15,867	153,453	40	2,138	14,425	199,098
51	1,478	17,190	166,251	42.5	2,284	15,412	212,724
54	1,591	18,512	179,034	45	2,422	16,343	225,571
57	1,704	19,827	191,748	47.5	2,549	17,203	237,450
60	1,816	21,129	204,338	49.5 (90%)	2,641	17,823	246,001
63	1,927	22,412	216,749	50	2,664	17,978	248,139
66	2,035	23,671	228,922	52.5	2,763	18,645	257,352
69	2,140	24,899	240,800	53 (95%)	2,779	18,751	258,815
72	2,243	26,090	252,318	55	2,842	19,175	264,669
75	2,341	27,237	263,411	58	2,891	19,512	269,319
78	2,436	28,332	274,007				
81	2,525	29,368	284,027				
84 (90%)	2,608	30,336	293,383				
87	2,684	31,224	301,969				
90 (95%)	2,752	32,019	309,658				
93	2,811	32,704	316,284				
96	2,859	33,253	321,597				
100	2,891	33,635	325,294				

Liquid Level Chart 3300 Gallon Inert Service (LN_2/LAR)

Argon - 0 psig				Nitrogen - 0 psig			
In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)	In H_2O	Liquid (gallons)	Weight (pounds)	Gas (cu ft)
0	0	0	0	0	0	0	0
3	23	263	2,546	2.5	39	266	3,673
6	71	828	8,008	5	123	833	11,500
9	135	1,574	15,221	7.5	234	1,578	21,777
12	212	2,461	23,798	10	364	2,457	33,912
15	298	3,464	33,504	12.5	510	3,443	47,527
18	393	4,567	44,170	15	669	4,517	62,341
21	495	5,755	55,662	17.5	839	5,660	78,123
24	603	7,017	67,866	20	1,016	6,859	94,672
27	717	8,343	80,687	22.5	1,200	8,100	111,807
30	836	9,723	94,037	25	1,389	9,372	129,359
33	959	11,150	107,835	27.5	1,580	10,662	147,170
36	1,084	12,616	122,008	30	1,772	11,960	165,082
39	1,231	14,113	136,485	32.5	1,964	13,254	182,942
42	1,344	15,634	151,200	35	2,154	14,533	200,595
45	1,476	17,173	166,086	37.5	2,339	15,786	217,883
48	1,610	18,724	181,080	40	2,519	17,000	234,641
51	1,743	20,279	196,120	42.5	2,691	18,163	250,692
54	1,877	21,832	211,143	45	2,854	19,260	265,843
57	2,010	23,377	226,088	47.5	3,005	20,277	279,873
60	2,141	24,908	240,889	49 (90%)	3,074	20,740	286,282
63	2,271	26,417	255,484	49.5	3,114	21,010	289,992
66	2,398	27,898	269,806	50	3,141	21,193	292,522
69	2,523	29,344	283,787	52.5	3,258	21,985	303,451
72	2,643	30,746	297,353	53	3,277	22,111	305,193
75	2,759	32,098	310,429	55	3,351	22,616	312,161
78	2,870	33,391	322,929	58	3,411	23,020	317,733
81	2,976	34,614	334,763				
84 (90%)	3,074	35,758	345,825				
87	3,164	36,810	355,994				
90	3,245	37,753	365,117				
93	3,315	39,223	372,996				
96	3,372	39,223	379,332				
100	3,411	39,682	383,771				

Liquid Level Chart 4200 Gallon Inert Service (LN_2 Only)

Nitrogen - 0 psig				Nitrogen - 0 psig			
In H_2O	Liquid (gallons)	Weight (pounds)	Gas (scf)	In H_2O	Liquid (gallons)	Weight (pounds)	Gas (scf)
0	0	0	0	31	2,530	17,073	235,652
1	10	67	931	32	2,634	17,777	245,370
2	38	254	3,499	33	2,738	18,479	255,052
3	75	507	6,995	34	2,842	19,176	264,684
4	120	812	11,209	35	2,944	19,870	274,252
5	172	1,161	16,025	36	3,046	20,557	283,252
6	229	1,548	21,364	37	3,147	21,238	293,144
7	292	1,968	27,168	38	3,247	21,912	302,440
8	358	2,419	33,388	39	3,346	22,577	311,617
9	429	2,897	39,987	40	3,443	23,232	320,661
10	504	3,400	46,931	41	3,538	23,876	329,554
11	582	3,926	54,190	42	3,632	24,509	338,283
12	663	4,473	61,739	43	3,724	25,128	346,830
13	747	5,039	69,553	44	3,813	25,733	355,177
14	833	5,623	77,611	45	3,901	26,322	363,307
15	922	6,223	85,894	46	3,985	26,893	371,199
16	1,013	6,838	94,381	47	4,067	27,445	378,832
17	1,106	7,466	103,055	48 DOT Trycock	4,146	27,979	386,184
18	1,201	8,107	111,900	49	4,222	28,489	393,228
19	1,298	8,759	120,898	50	4,294	28,975	399,937
20	1,396	9,421	130,036	51	4,362	29,435	406,278
21	1,496	10,092	139,296	52 (95%)	4,426	29,865	412,215
22	1,596	10,771	148,666	53	4,485	30,263	417,704
23	1,698	11,457	158,131	54	4,538	30,624	422,689
24	1,800	12,148	167,677	55	4,585	30,943	427,099
25	1,903	12,845	177,291	56	4,625	31,214	430,832
26	2,007	13,545	186,958	57	4,656	31,423	433,721
27	2,111	14,249	196,667	58	4,674	31,539	435,322
28	2,216	14,954	206,404	58.01	4,674	31,539	435,324
29	2,321	15,660	216,155				
30	2,425	16,367	225,909				

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
Pump Submerged Pump LIN/LAR Service	1 Year
Variable Frequency Drive (VFD)	2 Years
Control Panel (480 VAC)	6 Months
Check Valves	1 Year
Safety Relief Valves, Vent	1 Year

*From shipment of Orca 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.