ORCA OPERATION MANUAL
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ORCA MICRO-BULK DELIVERY SYSTEM

CHART INC

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MANUAL #11656742 REV 1

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Section 1 Overview

Service

The ORCA Cryogenic System has been designed for years of safe and dependable operation. In the event service is required, contact:

Chart Inc. at 1.800.400.4683.

Address

The ORCA Micro-Bulk Delivery System is designed and manufactured by:

Chart Inc.

Distribution & Storage Division

407 Seventh Street Northwest

New Prague, MN 56071

Manual Explanation

This Operation Manual is designed to be used for the **ORCA Models HL-2000, HL-2800, HL-3300 and 4200** and contains information regarding the safe Operation of the ORCA Micro-Bulk Delivery System in Nitrogen/Argon Services. **It should be thoroughly read and understood by anyone that operates, or is exposed to this equipment.** This manual is intended to provide the cryogenic service employee with the necessary information needed to operate the ORCA Micro-Bulk Delivery System. The schematics and parts lists refer to reference numbers for each component. The reference numbers will be used throughout this manual to draw specific attention to a component while describing its function, or operation.

Designed Use

The Standard ORCA Micro-Bulk Delivery System is designed for the safe and efficient transport of Nitrogen/Argon.

Design Modification

DO NOT use this product in any manner not consistent with the instructions outlined in this Operation or Service & Repair Manual! NEVER alter the design, or perform service that is not consistent with the instructions outlined in this Manual without the prior written approval of Chart Inc.!

Compatibility and Cleaning

Always keep the ORCA clean and free from grease and oil. Use care when cleaning the ORCA with high-pressure water or steam cleaning equipment. **DO NOT** direct the cleaning nozzle into the ends of the Alternator or Pump Motor. When replacing ORCA Components use only parts, which are considered compatible with Liquid Nitrogen/Argon. Do not use regulators, fittings, or hoses, which were previously used in Compressed Air or Carbon Dioxide Environments on the ORCA. 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 Nitrogen/Argon Service without extremely extensive cleaning methods.

Safety Summary

While every possible safety precaution has been taken to ensure safe operation and maintenance of the ORCA Delivery Vessel, it is imperative that all persons having contact with the ORCA become thoroughly familiar with all maintenance, safety precautions, and procedures contained in this Operation Manual. **If for any reason any part or parts of this manual becomes 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.**

General

The ORCA Tank consists of an inner pressure vessel encased within an outer carbon steel vacuum shell. The container operates under low to medium pressure (0-50psi), and is protected from over-pressurization by use of a Safety Relief Valve System. Safety relief devices are used to protect the inner vessel and vacuum casing, sized and manufactured in accordance with ASME and other standards.

Cryogenic

A product retaining a temperature of **-150o F or colder**. ORCA Systems maintain gases efficiently in a cryogenic liquid state. Gases can be most efficiently stored as liquids. **For example, Liquid Nitrogen will expand in volume 750 times when warmed to a gaseous state.** Gases may be liquefied by compression or cooling them until they liquefy (see Vaporization/Condensation). 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 System employs 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**

Warnings

Fatal of severe injury, fire, explosion, or suffocation may result depending on the type of liquid used in this system if the operating personnel fail to observe the safety precautions.

Nitrogen and Argon Vapors in the air may dilute the concentration necessary to support or sustain life. Exposure to such an Oxygen Deficient Atmosphere can lead to unconsciousness, serious injury, or even death. 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. Inhalation of high concentrations of these gases can cause anoxia, resulting in dizziness, nausea, vomiting, unconsciousness, and possibly death! Unconsciousness and death may occur with virtually no warning if the oxygen content is below 8%.

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 and may cause painful burns to personnel unless properly protected. Personnel must wear protective gloves and eye protection whenever removing parts or loosening fittings. Failure to do so may result in personal injury 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.

Handle liquid so that it will not splash or spill. Protect your eyes and cover skin where the possibility of contact with liquid, cold pipes, cold equipment, or cold gas exists. Safety goggles and/or a face shield should be worn if liquid ejection, splashing, or cold gas contact is possible. Clean, insulated gloves that can easily be removed and long sleeves are mandatory for arm protection. Cuff-less trousers should be worn over the shoes to shed any spilled liquid.

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.**

In the event of known or suspected container vacuum problems (even if an extraordinary circumstance such as those noted above have not occurred), do not continue to use the unit.

Continued use of a cryogenic container that has a vacuum problem can lead to Carbon Steel 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 by qualified personnel. 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 Gasses.

Oxygen Deficient Atmospheres

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** or **16%**, the flame of ordinary combustible materials, including those commonly used as a 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.

Human exposure to atmospheres 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 immediate change of environment, or through the gradual depletion of oxygen.

Most individuals 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 an unconscious partner unless equipped with a portable air supply. Equipping all individuals with a portable supply of respirable air ensures best protection.

DO NOT attempt to remove an individual without utilizing proper rescue equipment or you may also become a casualty. If the exposed person is unconscious, obtain assistance and put into effect the established emergency procedures. Lifelines are acceptable only if the area is essentially free of obstructions and individuals can assist one another without constraint.

All new piping joints should be leak tested with a compatible leak-test solution. Once a system has been contaminated through improper or careless parts cleaning or replacement, the vessel may not be returned to service without extremely extensive and complex cleaning methods. If oxygen deficient atmosphere is suspected or known to exist: Use the "Buddy System". Use more than one "Buddy" if necessary to remove a fellow worker in an emergency. Both the worker and "Buddy" should be equipped with self-contained breathing equipment.

If an Oxygen deficient atmosphere is suspected or known to exist: Use the "Buddy System." Use more than one "Buddy" if necessary to remove a fellow worker in and emergency. Both the "Worker and the Buddy" should be equipped with a Self-Contained Breathing Equipment. Persons suffering from lack of oxygen should be immediately moved to areas with normal atmospheres. **A 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.

Oxygen Enriched Atmospheres

An Oxygen Enriched Atmosphere occurs whenever the normal oxygen content of air is allowed to rise above **23%**. While oxygen is non-flammable, ignition of combustible materials can occur more readily in an Oxygen-Rich Atmosphere than in air; and combustion proceeds at a faster rate. 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 conditions of temperature and pressure to which the c In an oxygen-enriched atmosphere, flammable items burn vigorously and can explode. Excess accumulation of oxygen creates an Oxygen-Enriched Atmosphere (defined by the Compressed Gas Association as an oxygen concentration above **23%**). Certain items considered non-combustible in air might burn rapidly in such an environment. Keep all organic materials and other flammable substances away from possible contact with oxygen; particularly oil, grease, kerosene, cloth, wood, paint, tar, coal, dust, and dirt which may contain oil or grease. Do not permit smoking or open flame in any area where oxygen is stored, handled, or used. Failure to comply with this warning may result in serious personal injury including death. Components may be exposed in the containment and use of oxygen. 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 alloys) 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.

ORCA Theory of Operation

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

One key feature of the ORCA System is the "SMART" Flow Meter that is designed to sense the filling status of Perma-Cyls and terminate the delivery automatically when filling is completed. This provides the benefit of greater safety and operator freedom during the filling process.

The ORCA System leverages the principles of cryogenics to minimize losses in delivering gas molecules to the use point. The following section of this manual will discuss the theory behind the ORCA System by explaining the principles of cryogenics and provide the user with information necessary to properly understand and identify components and system functions.

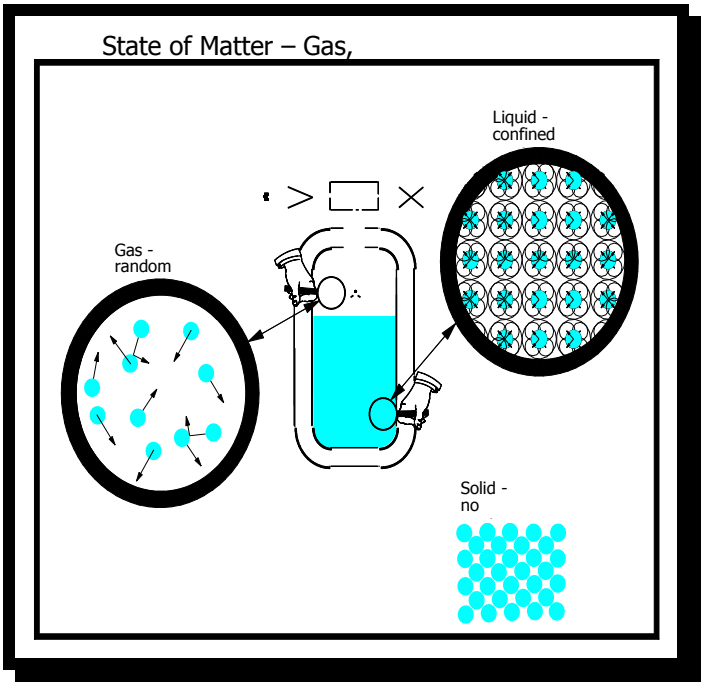
Terminology of Cryogenics

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. Temperature is a measure of the amount of energy within the solid, liquid, or gas.

Gas is molecules in random motion, liquid is molecules in confined motion, and solid is molecules with no motion (see figure 1).

Figure 1 - States of Matter (Gas, Liquid, and Solid)



Saturation

Defined as point at which liquid and vapor co-exist at the same pressure (temperature).

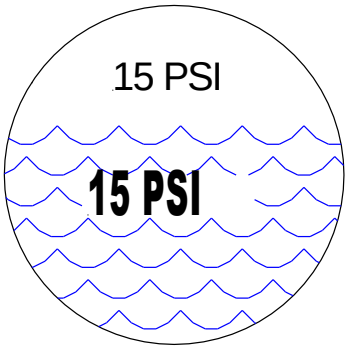
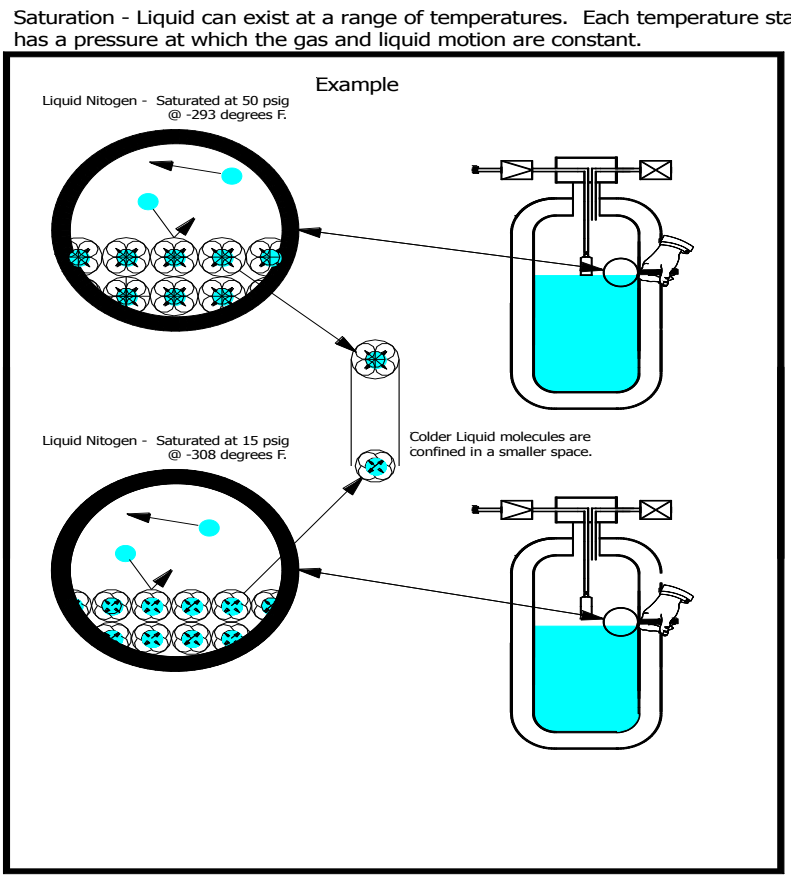


Figure 2

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. Figure 3 depicts liquid nitrogen at 50psig saturation and 15psig saturation.

Figure 3-Liquid Saturation



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 there 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 **N**et **P**ositive **S**uction **H**ead or **NPSH**.

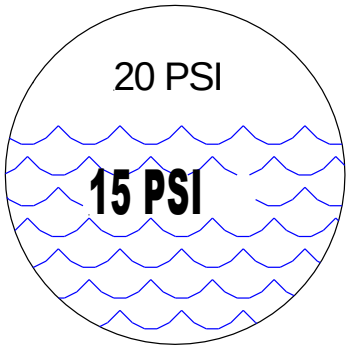


Figure 4

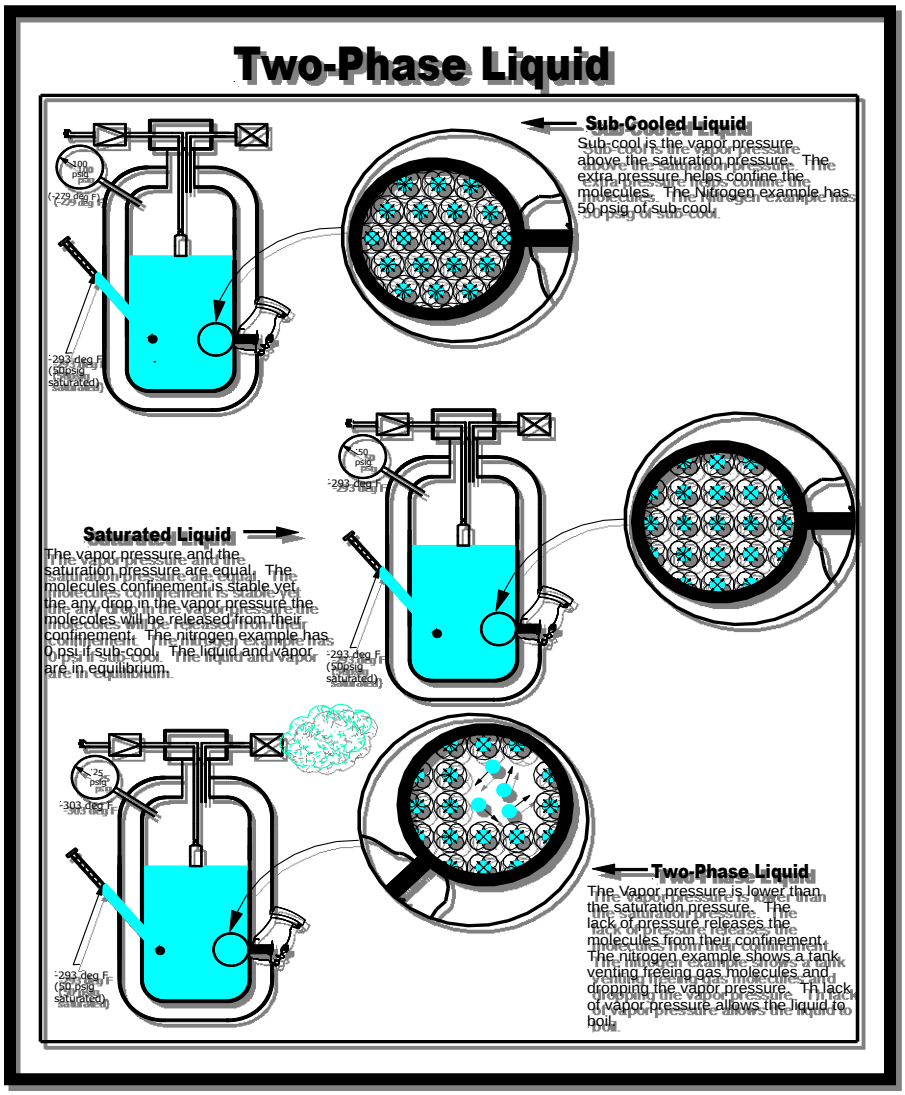
When transferring liquid from a vessel, sub-cool is important to maintain the liquid in the liquid state as it travels from the tank through the piping circuit (See figure 4).

In the case of the ORCA system, 5 psi of sub-cool is required for Nitrogen or Oxygen delivery and 7psi is required for Argon delivery to prevent two-phase liquid. Liquid leaving the pump must be replaced in the sump at the same rate. Liquid flowing creates pressure drop as it travels through the feed line. If the pressure drops below the saturation pressure of the liquid it will begin to boil.

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!** Figure 5 illustrates two-phase liquid.

Figure 5-Two Phase Liquid



Cavitation

Defined as partial or full loss of pump prime due to the lack of proper **SUB-COOL.** 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.**

Caution **Cavitation will cause damage to the pump. The Orca system pump requires a minimum of 5 PSI subcool for Nitrogen or Oxygen delivery and a minimum of 7 PSI for Argon delivery.**

Vaporization

Changing liquid into vapor by warming the liquid for the purpose of sub-cooling or for gas use. The Orca System uses a pressure building coil, shown in Figure 6, located on the roadside of the vessel to accomplish this.

Figure 6-Orca Pressure Building Coil

Vapor Pressure

Pressure of the vapor space within the tank. Measured by reading the tank pressure gauge.

Condensation

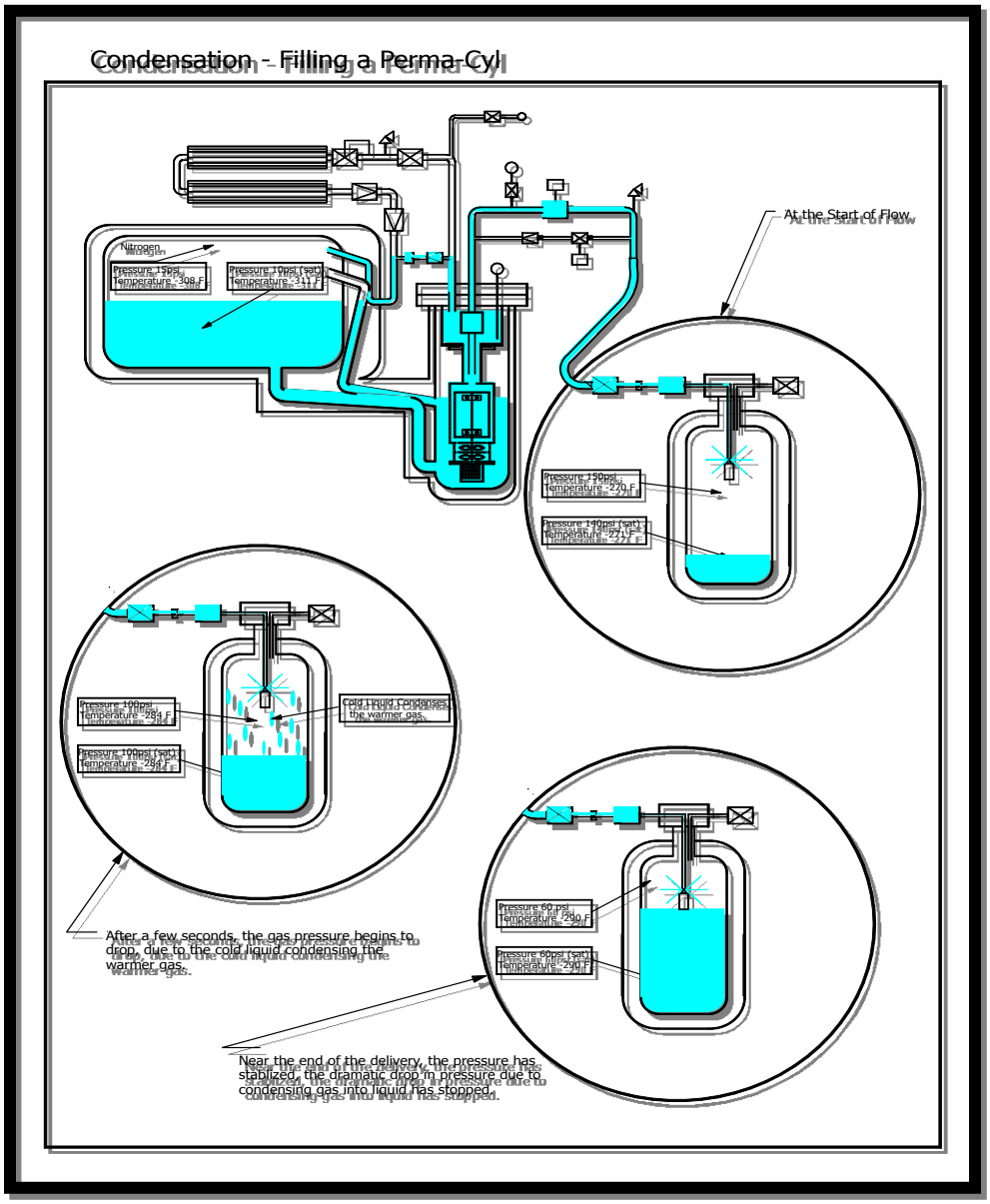
The conversion of vapors into liquid by cooling the vapors.

The ORCA 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. The splashing condenses the gas and drops the pressure. This is known as “splashdown.”

Condensation and the Perma-Cyl

An example of condensation can be seen in the filling theory of a Perma-Cyl. Top filling a Perma-Cyl without venting is possible due to condensing warmer gas into liquid. Figure 7 explains the filling of the Perma-Cyl and how condensation makes filling without venting possible.

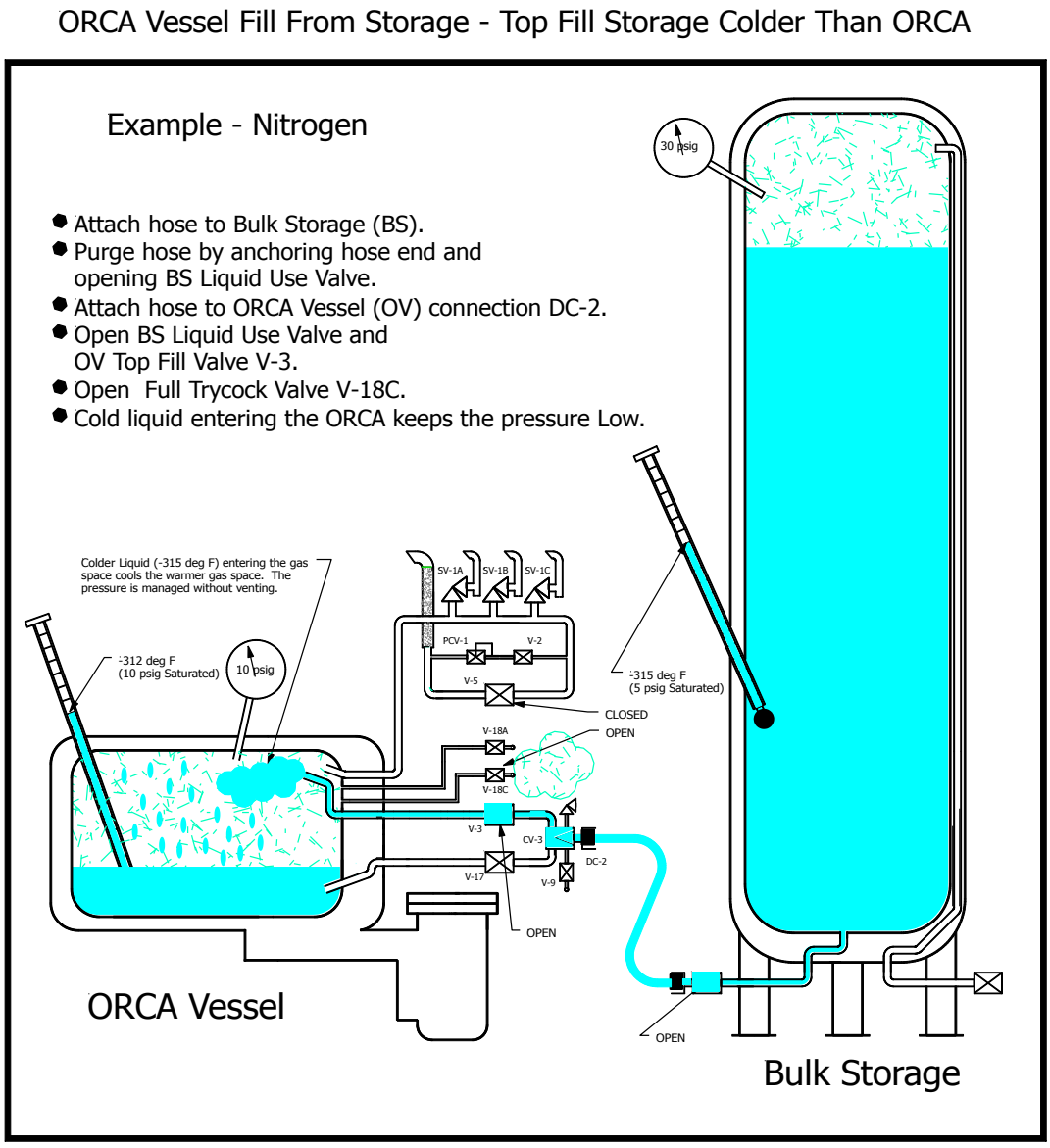
Figure 7 - Condensation top filling a Perma-Cyl



Condensation and the Orca

Just like Top filling of a Perma-Cyl, Top filling the ORCA vessel allows filling without venting. Figure 8 Describes the conditions at which the ORCA can be filled without venting using the condensation principle.

Figure 8 - Condensation top filling the ORCA Vessel

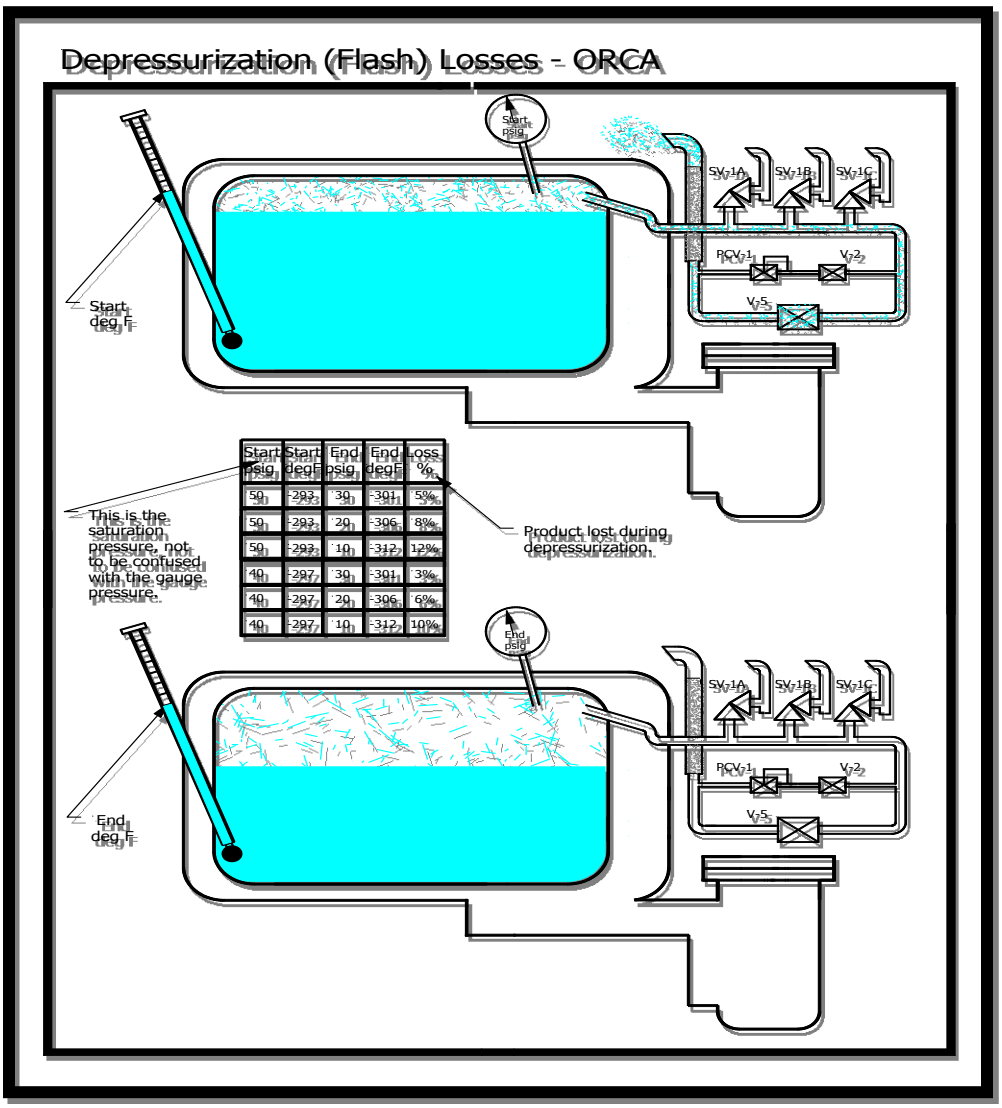


Depressurization Flash Losses

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 decreases, and the saturation pressure will drop.

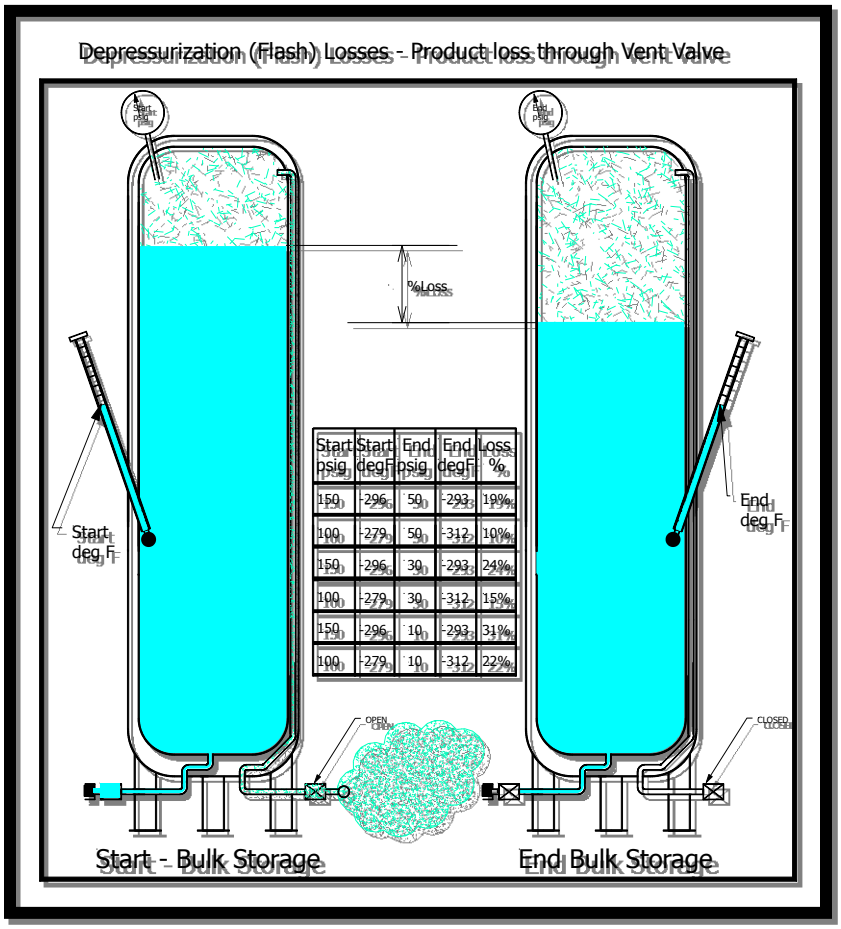
Product losses due to venting are summarized in the following figures (figure 9 and figure 10). The starting and ending pressures in the charts within the figures are saturation pressures not to be confused with vapor pressures. For example, if the ORCA has a starting pressure (saturation) of 40 psig and is vented down to 10 psig the product lost during venting is 10%.

Figure 9 - Flash Losses ORCA



Start psig	Start degF	End psig	End degF	Loss %
50	293	30	301	5%
50	293	20	306	8%
50	293	10	312	12%
40	297	30	301	3%
40	297	20	306	6%
40	297	10	312	10%

Figure 10 - Flash Losses Bulk Storage



Start psig	Start degF	End psig	End degF	Loss %
150	296	50	293	19%
100	279	50	312	10%
150	296	30	293	24%
100	279	30	312	15%
150	296	10	293	31%
100	279	10	312	22%

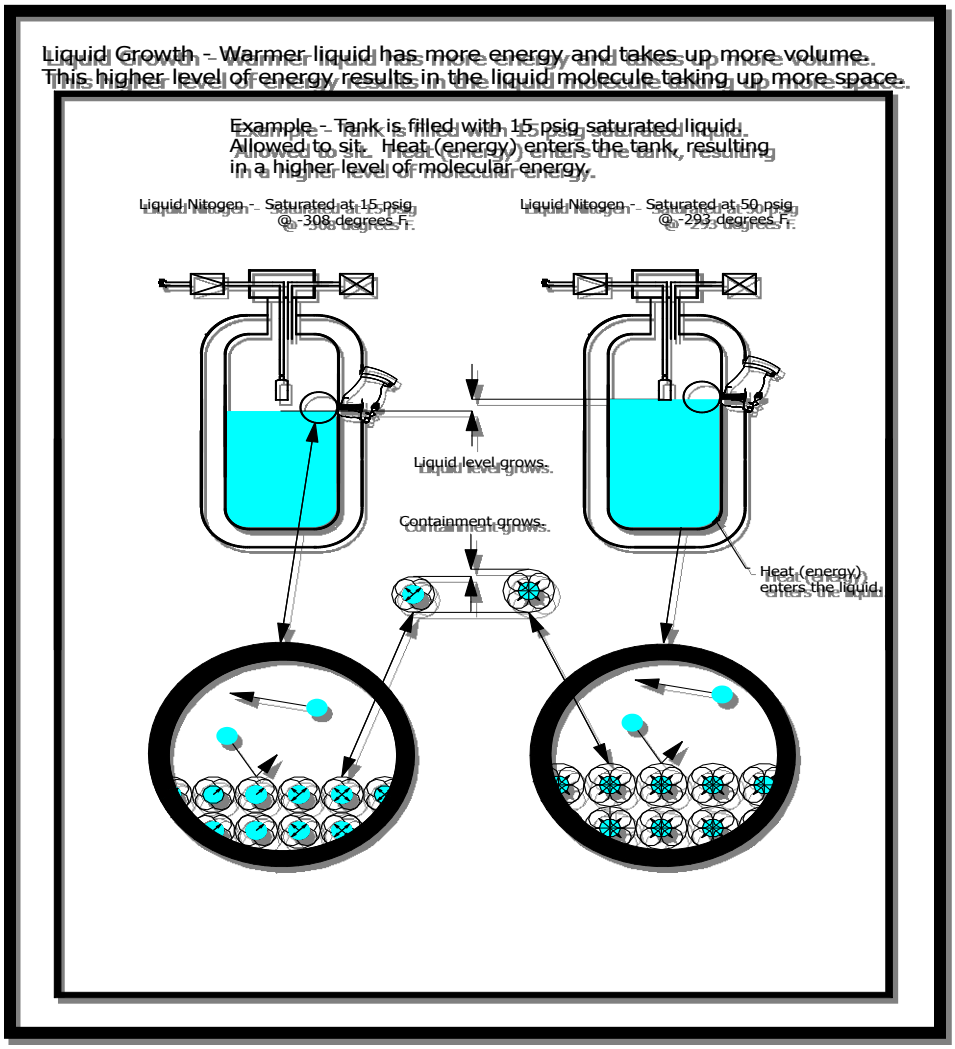
Entrainment

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. Figure 11 illustrates the growth of liquid at the molecular level.

Figure 11- Liquid Growth



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 change of temperature from top to bottom is called Stratification.

ORCA System Components/Terms

12-24 VDC Electrical System

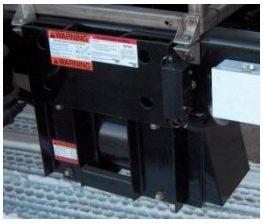
The 12-24 VDC (Low Voltage) Electrical System is powered by the 12 VDC Systems (Truck Mounted Orca) or from the battery (Trailer Mounted Orca) located inside the MQ Whisp att Generator cabinet.

480 VAC Electrical System

The 440-480 VAC (High Voltage) Electrical System is powered by the PTO/Alternator System (Truck Mounted Orca) or by the MQ WhisperWatt Generator (Trailer Mounted Orca).

FIGURE 12 – TRUCK MOUNTED ORCA

480 VAC – PTO system (WEG Alternator)



12 VDC – Supplied by Truck 12 VDC System

FIGURE 13 – TRAILER MOUNTED ORCA

12 VDC – Supplied by Battery of MQ Whisperwatt

480 VAC – MQ Whisperwatt Generator

Inner Cylinder

The Inner Cylinder is the container in which the liquid product is stored. It is constructed of high quality alloy steel and its exterior is wrapped with a multi-layered insulation.

Outer Cylinder

The Outer Vessel houses the Inner Cylinder and serves as the chamber in which a vacuum is drawn to minimize the transfer of heat from the Outer Cylinder to the Inner Cylinder where the product is stored.

Annulus

The Annulus Volume of space is between the outer and inner cylinders that minimize the transfer of heat from the outer cylinder to the inner cylinder where the product is stored.

Plumbing Cabinet

The Plumbing Cabinet houses the Electronics and plumbing components for the ORCA. It is also referred to as the "Dog House."

Section 2 General Maintenance

Overview

Required maintenance usually becomes apparent during inspection, 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 should be fully familiar with cleanliness requirements for components. It is recommended that all parts be kept clean for oxygen service, even if being used with other cryogens.

Truck / Trailer Mount

As described earlier, the Orca vessel can be mounted on a truck chassis or trailer depending on the desire of the customer. The system function is the same; with the primary difference being that the trailer has an onboard MQ WhisperWatt Generator supplying the electrical power to the Orca control system while the truck mount has a PTO system driving a truck mounted Alternator. Figure 14 shows typical examples of Truck and Trailer mounts.

Figure 14– Typical Truck and Trailer Mounts

Typical Truck Mount (HL-2000)

Typical Trailer Mount (HL-3300)

Orca Vessel Mounting Brackets and Bolts

The mounting brackets from just in front of the suspension cross members to the rear most are rigged mounted. The mounts to the front are designed to flex. Periodic inspection of the brackets and bolt torque's is recommended. The bolts at the flex mounts should be tightened until they are in contact then tighten and compress the springs an additional 3/16" to 1/4".

Figure 15

CAUTION!

Before conducting maintenance or replacing parts on the ORCA system, release container pressure in a safe manner. Replacement of certain parts may require that the entire contents be completely emptied.

Orca Periodic Inspection

In order to maintain the Orca unit in good operating condition, certain system components must be inspected on a periodic basis. These components requiring periodic inspection are listed in Table 1 - Periodic Inspection.

ORCA PERIODIC INSPECTION

Inspection Item	Interval
Valves and fittings for leaks, malfunction etc.	**Monthly and during operation**
Control Wiring	**2 months**
Indicating gauges for malfunction	**6 months**
Relief valves to verify proper settings	**1 year**

Table 1 - Periodic Inspection

Pumping System

The system components are designed to give long trouble-free service. The long life of the components will be assured if a regular maintenance inspection schedule is followed.

Prior to Each Operation - Inspect for loose or damaged cabling, piping and connections, cooling obstructions, etc. Check for proper pre-start conditions.

Every Three Months - Visually inspect all components of the system. Clean and inspect all connections, electrical cabling and instrument console.

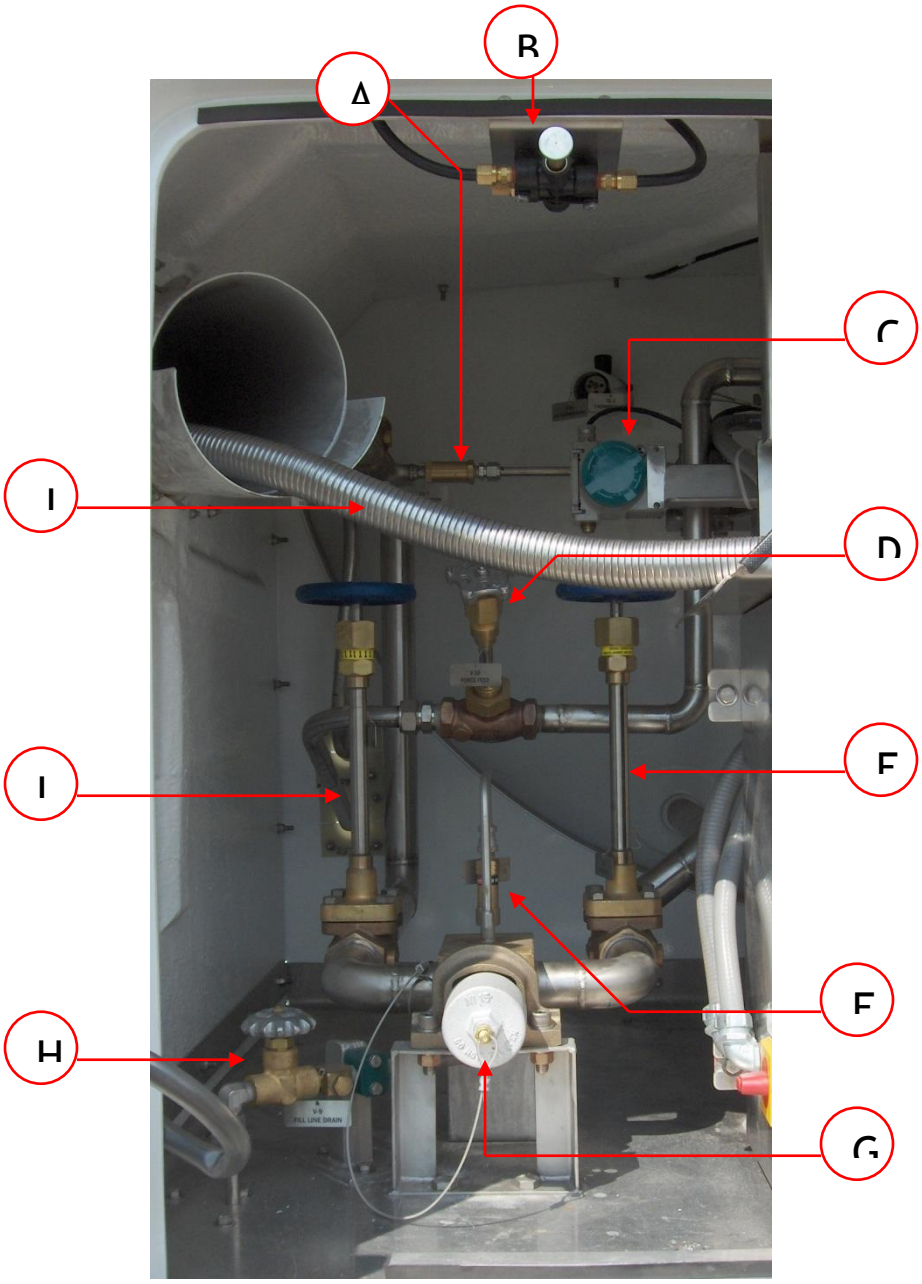
Every Twelve Months - Thoroughly check entire system. Inspect all parts for wear and replace as necessary. Clean and repair all electrical components as needed. Repair or replace worn or damaged cabling and connectors.

Section 3 Plumbing Cabinet Components & Systems

Roadside Center Curbside

This is a view of a Typical Orca plumbing Cabinet. In this section we will discuss in detail, Plumbing cabinet components and systems. To aid in this we will break the Cabinet into 3 areas. Roadside, Center (system control and monitoring), and Curbside.

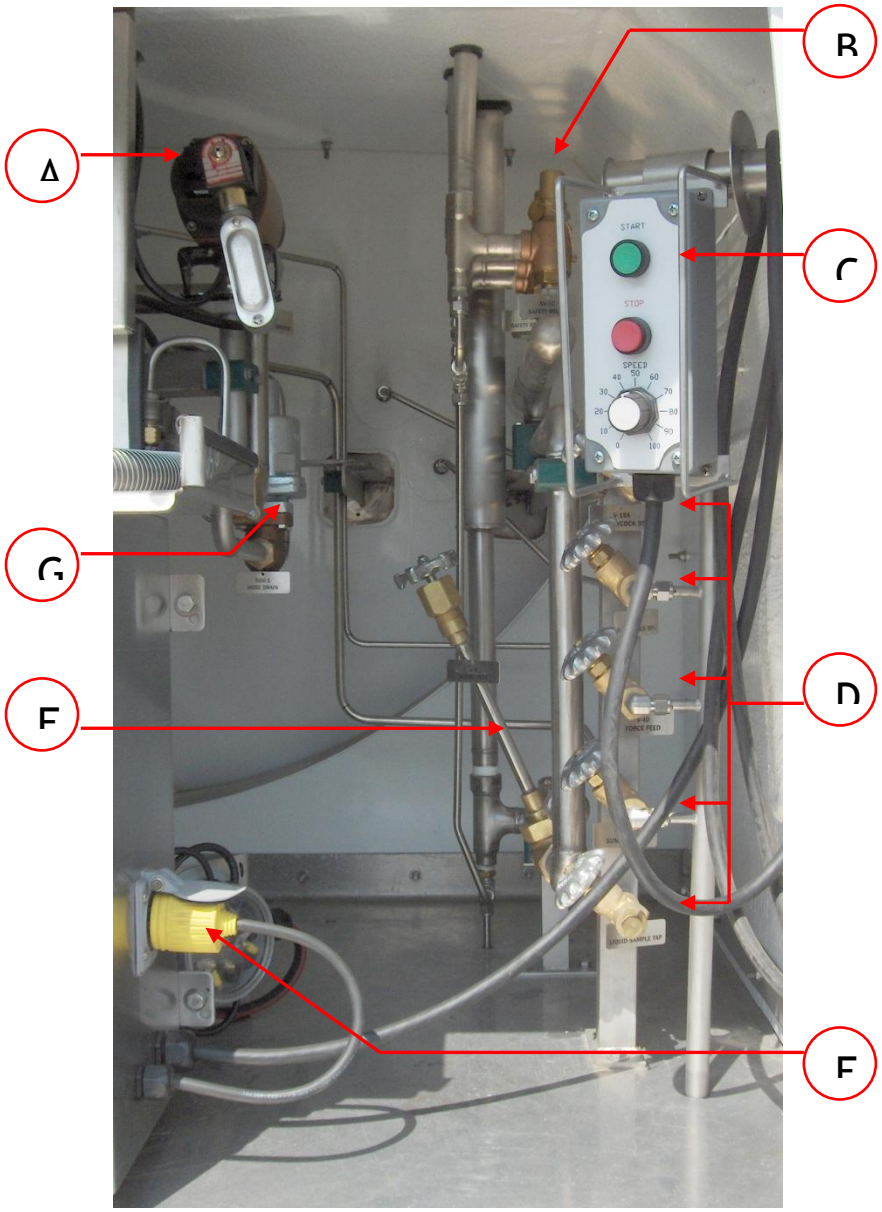
Plumbing Cabinet-Roadside



Plumbing Cabinet Roadside				
Item	Tag	Part No	Qty	Description
A	CV-7	11889589	1	Recirculation Check Valve
B		11707247	1	Anti-Tow Valve
C	DP-1	10945294	1	Differential Pressure Transmitter
D	V-16	1718772	1	Force Feed Valve
E	V-17	10927184	1	Bottom Fill Valve
F	SV-4	11670000	1	Safety Relief Valve, Fill Line

Plumbing Cabinet Roadside				
Item	Tag	Part No	Qty	Description
G	DC-1	*	1	Connection Fill Line
H	V-9	1713202	1	Fill Line Drain Valve
I	V-3	10927184	1	Top Fill Valve
J		11702585	1	Delivery Hose

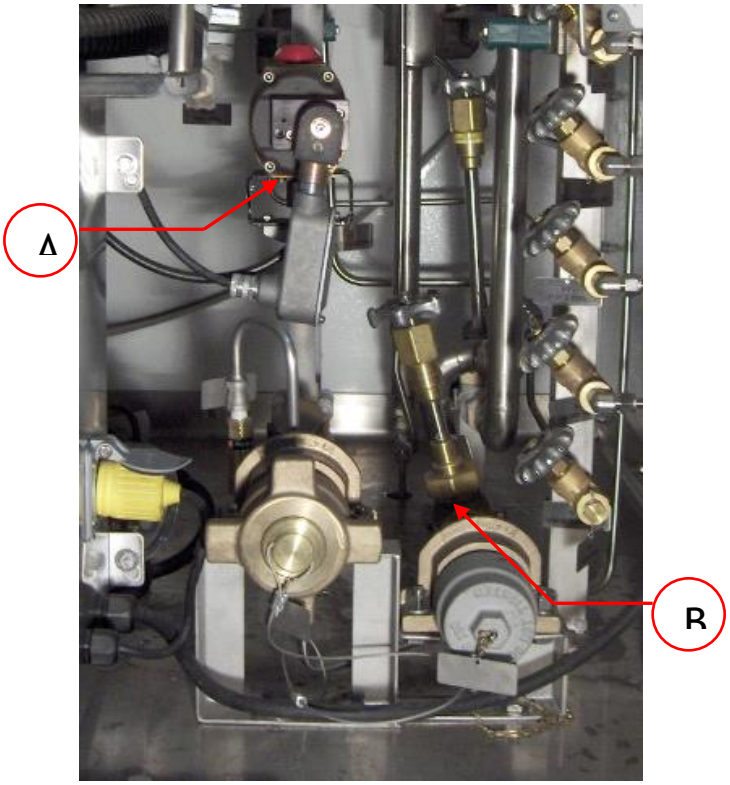
Plumbing Cabinet Curbside



* Contact Chart Inc. 1-800-400-4683

Plumbing Cabinet Curbside				
Item	**Tag**	**Part No**	**Qty**	**Description**
A	AOV-1	10917761	1	Air Operated Dispense Valve
B	SV-1A/1B	1810732	2	Relief Valve 50 PSI Spence
B-1	SV-1C	1811812	1	Relief Valve 70 PSI Spence
C		11694600	1	Remote Pendant
D-1	V-18a	1713202	1	95% Trycock Valve
D-2	V-18c	1713202	1	90% Trycock Valve
D-3	V-40	1713202	1	P.B. Force Feed Drain Valve
D-4	V-33	1713202	1	Sump Purge Valve
D-5	V-23	1713202	1	Liquid Sample Valve
E		11910958	1	Heater Plug 120VAC
F	V-5	10927192	1	Vapor Vent Valve
G	SOV-1	10856531	1	Hose Drain Solenoid Valve

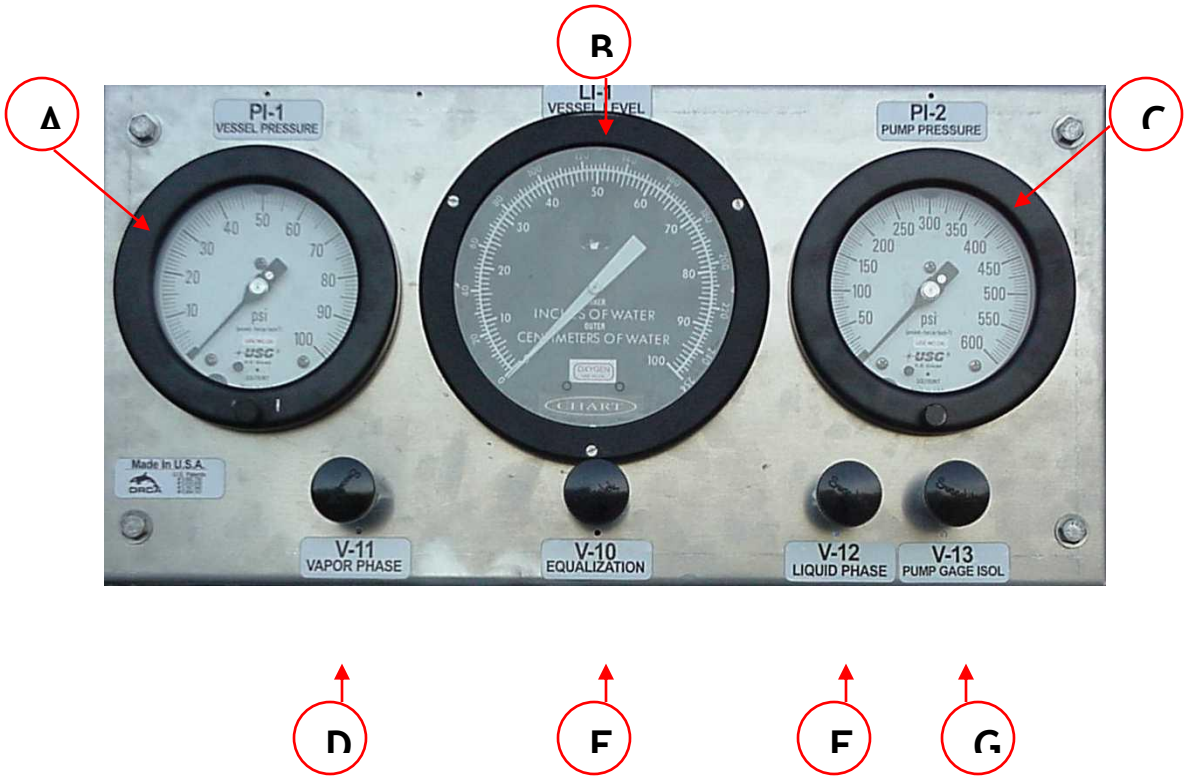
Curbside – Plumbing Cabinet (Optional Components)



Optional Components				
Item	Tag	Part No	Qty	Description
A		*	1	Air Operated Dispense Valve (High Flow)
A-1	AOV-2	11939460	1	Coil Only 12VDC
A-2	AOV-2	11879583	1	Actuator w/Solenoid & Coil 12VDC
A-3	AOV-2	11890061	1	Repair Kit, Actuator Coupling
B		*		Vapor Recovery Kit

* Contact Chart Inc. 1-800-400-4683

Control Gauge Panel



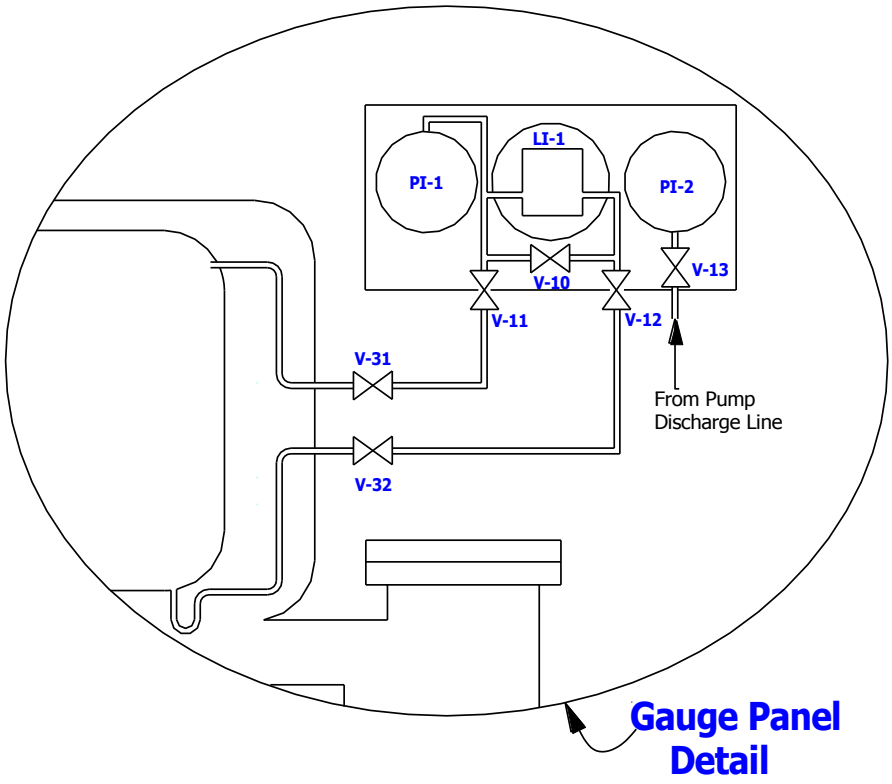
Gauge Panel				
Item	Tag	Part No	Qty	Description
A	PI-1	11707191	1	Inner Vessel Pressure Gauge
B	LI-1	11532088	1	Inner Vessel Liquid Level Gauge
C	PI-2	11702121	1	Pump Discharge Pressure Gauge

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

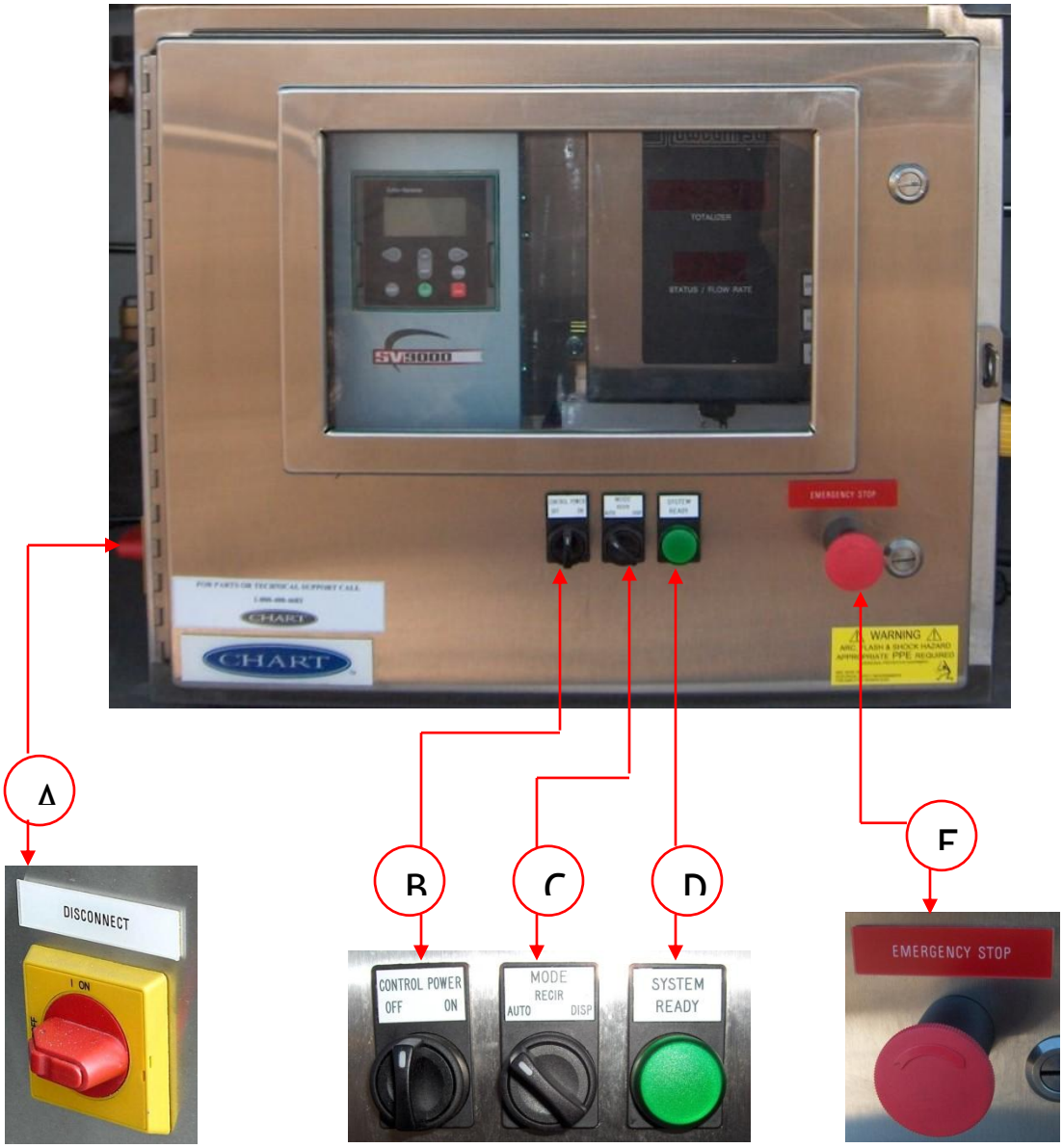
3. Open the vapor and liquid level valves.
4. Close the equalizer valve.



PI-1	Inner Vessel Pressure Indicator
LI-1	Inner Vessel Level Indicator
PI-2	Pump Discharge Pressure Indicator
V-10	Equalization Valve
V-11	Vapor Phase Valve
V-12	Liquid Phase Valve
V-13	Pump Discharge Gauge Isolation Valve
V-31	Vapor Phase Isolation Valve
V-32	Liquid Phase Isolation Valve

Control Panel

The Control Panel is protected against electrical sparking, is enclosed in a NEMA X4 Enclosure, and is UL Listed. Components include a Variable Frequency Drive (VFD), Flow Processor, and various Control Switches. The primary controls (440 Power Disconnect, Control Power, Emergency Stop, Mode Selection Switch and System Ready Light) are located on the face of the Control Panel.



Control Panel				
Item	**Part No**	**Tag**	**Qty**	**Description**
A	11910632		1	440 Pump Disconnect Switch
B	11910704		1	Control Power Switch 12VDC
C	11910691		1	Mode Selection Switch - 3 pos. Selector
D	119110616		1	System Ready Light - Green
E	11910712		1	E-Stop Push Button

Control panel Switches (Cont.)

Standard Orca

Generator Run switch for Trailer mounted Orca Unit with MQ Generator

Flow Selector Switch for (Optional) Dual Dispense Orca Unit

480 Disconnect Switch

When the 480 Disconnect switch is turned to the "ON" position, the 480VAC from the Alternator is supplied to the 480VAC Contact Block in the control cabinet. Will this switch in the "OFF" position, it is not possible to power the VFD or the Pump.

Emergency Stop Button

The Emergency Stop or "E-Stop" is located on the front of the control panel and provides an immediate way to stop the system from operating in the event should an emergency occur. When the Red Plunger is depressed, the system power will be shut off and all Air operated Valves will close. To de-activate the E-Stop button, turn the red plunger to the right until the plunger moves out.

Dome Light/Work Lights

Two features of the lighting system are a Dome Light to provide light to the Plumbing Cabinet and two work lights that can be directed while making a delivery. To operate the Dome Light and Work Lights, turn on the switch located on the Plumbing Cabinet Dome Light must be turned on.

Service Lights Switch (Interior Cabinet)

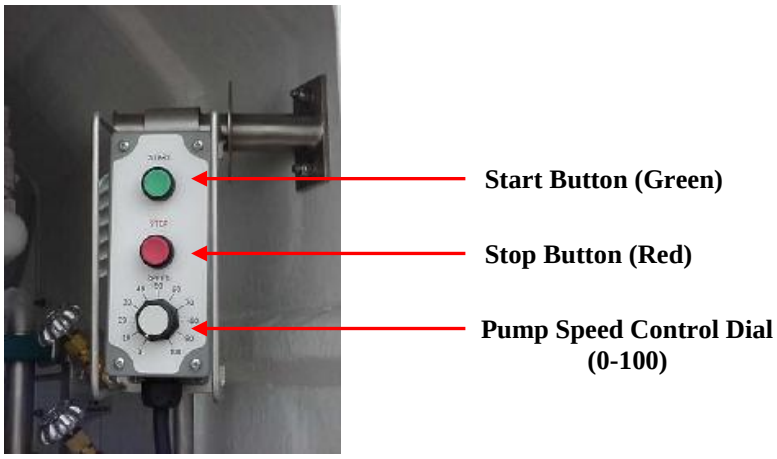
Service Lights
(Exterior Cabinet Road &Curbside)

Plumbing Cabinet Doors

The interior of the Plumbing Cabinet Doors have numerous labels which include FlowcomS8 Fault Code Chart, Variable Frequency Drive Fault Code Chart, Liquid Level Chart, Plumbing Schematic, Technical Service Data, General Troubleshooting Table, Printer, Sub-Cool Warning, and Standard Operating Procedures.

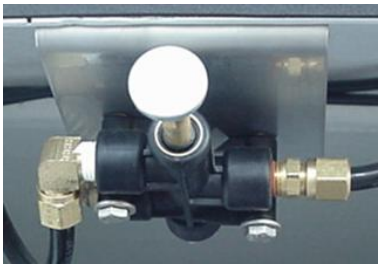
Remote Pendant

The Remote Pendant allows the operator the flexibility of system control up to 15 feet away. Loading docks and other site constraints make the Remote Pendant invaluable. The remote from the top down includes the following controls: **Start Button-Stop Button-Pump Speed Dial-15' Remote Cable**. Located inside the piping cabinet above the Remote Pendant is a hook to stow the Remote Pendant and cable. Stowing the cable in this location will minimize contact to any cryogens. This will keep the cable flexible and will prevent damage during removal.



Anti-Tow Valve

Located at the top of the piping cabinet and positioned to be operated when the doors close, is the Anti-Tow Valve. It is pneumatically connected to the air brakes and which 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. **This feature protects the equipment from damage in the event of a drive away accident due to the equipment not being properly stowed.** **Under no circumstances should the Anti-Tow Valve be disconnected or altered in any way!**



Heater/Inverter

The Cutler-Hammer Variable Frequency Drive (VFD) has internal temperature switches that do not allow the VFD to operate at temperatures **below 20° degrees F. It is recommended plugging the heater into the 120 VAC External Plug in on nights that drop below 32° degrees F. During the days deliveries the Power Inverter can be used to power the heater by utilizing the Power Inverter On/Off Switch. The Power Inverter can be left on during deliveries or in-transit due to the fact of the Panel Heater being thermostatically controlled.** The inverter can be used to power any 120 VAC device requiring less than 350 watts of power using the additional 120VAC Receptacles on the side of the Power Inverter.

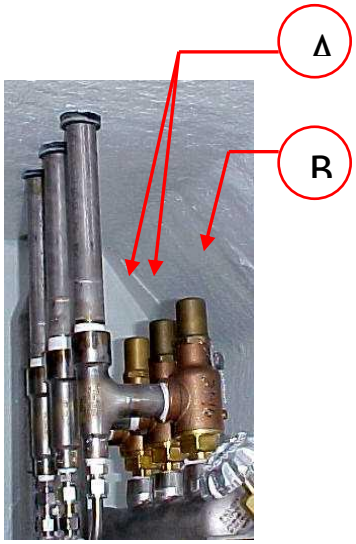
Control Panel Heater

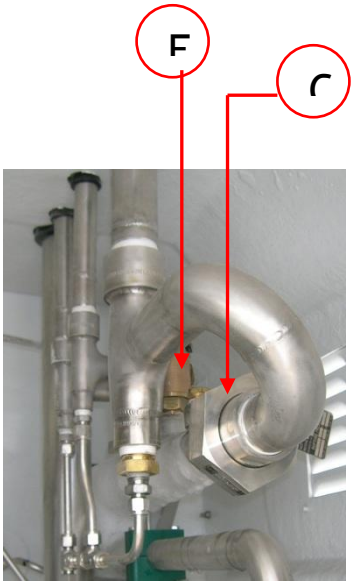
Power Inverter

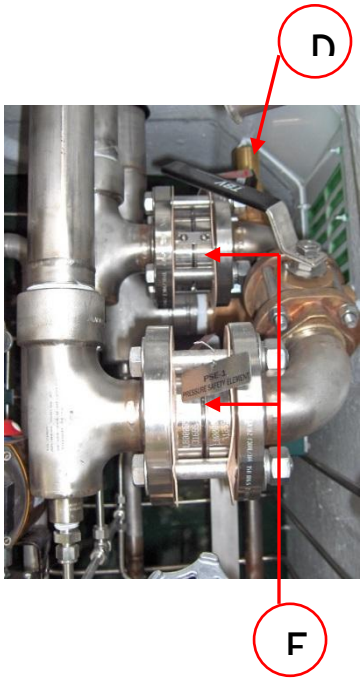
Heater Bypass Plug

Vent Circuit

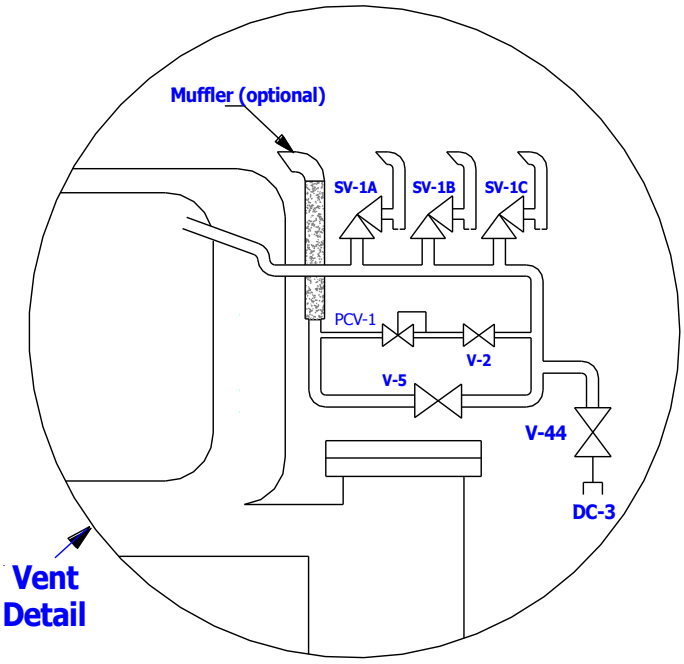
The Vapor Vent Valve (V-5), when open, relieves the vapor pressure in the ORCA Tank. The Vent Circuit includes a Primary Safety Relief Valve (SV-1), Secondary Relief Valve (SV-2) , and a third Safety Relief (SV-3) **The Primary relief valves (SV-1, SV-2) are set at the maximum allowable working pressure (MAWP), which is 50psi**. **The Third (SV-3) is set at 70 psi.** These valves are sized to safely relieve the tank during a loss of vacuum. The Main storage tank is coded **DOT MC-338** and the pressure limit in transit is the **MAWP (50-psi)**. The DOT fill level is based on this relief setting. **At a relief setting of 50 psi the ORCA can be filled to 90%.** Some Customers request variants in the relief system, such as Burst Discs. Below are pictures of different Relief circuit designs.







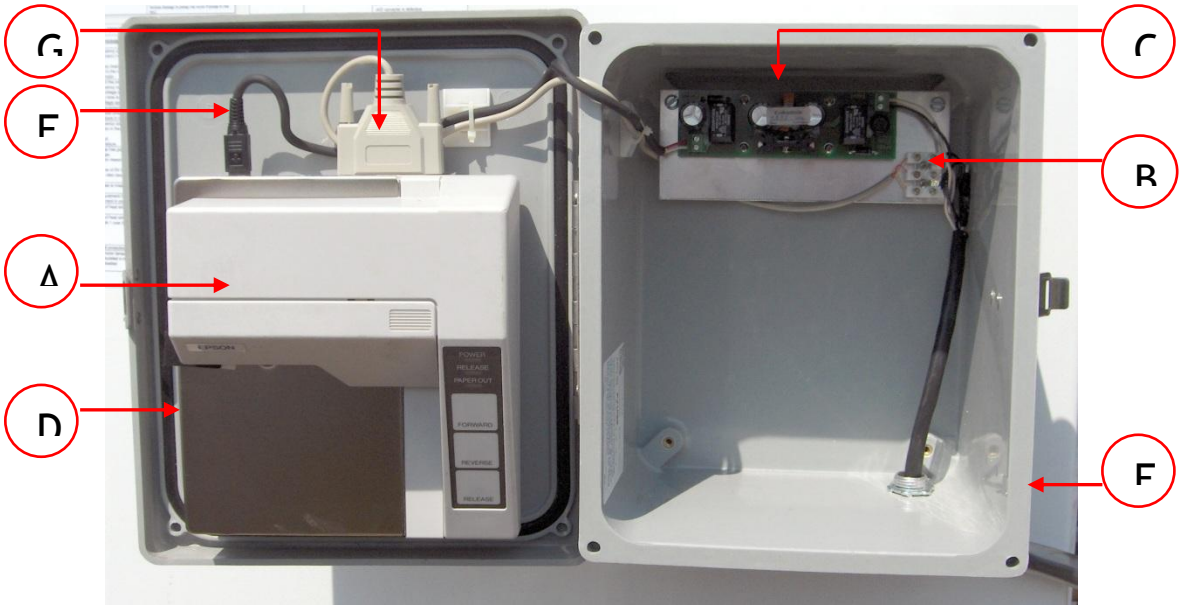
Safety Reliefs			
Item	Part No	Qty	Description
A	1810732	2	50 PSI RELIEF
B	1811812	1	70 PSI RELIEF
C	11899437	1	Burst Disc 1 ½" BS&B
D	12930310	1	RELIEF PRIMARY
E	12930133	2	Burst Disc 2" BS&B
F	14282707	1	RV 1-1/2MPT x 1-1/2FPT 50 PSI



SV-1A	Vent Circuit Safety Relief Valve (50 psi)
SV-1B	Vent Circuit Safety Relief Valve (50 psi)
SV-1C	Vent Circuit Safety Relief Valve (70 psi)
PCV-1	Road Relief Regulator (optional)
V-2	Road Relief Valve (optional)
V-5	Vapor Vent Valve
V-44	Vapor Recovery Valve (optional)
DC-3	Vapor Recovery Connection (optional)

Ticket Printer

The Ticket Printer (EPSON TM295) is directly connected to the flow processor via a serial data link. The printer requires a 24-volt power source. A DC/DC converter is supplied to convert the truck or trailer 12-volt power to 24 volts. The system allows printing in a customized ticket form as well as a standard ticket on a plain sheet of paper. Additionally, it can also be used to print the system's parameter and audit trail information.



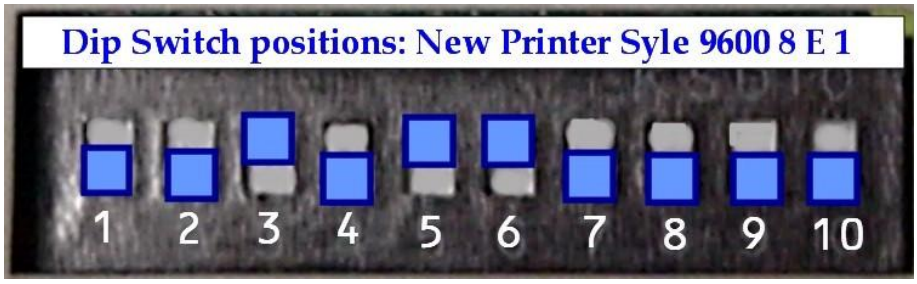
Printer and Components			
Item	**Description**	**Part Number**	**Qty**
A	Printer Ribbon	11693421	1
B	Terminal Block	outside supplier	1
C	DC/DC 12-24 VDC Converter	10963978	1
D	Printer - Epson	913700	1
E	Printer Box	11720142	1
F	Printer Power Cord 6'	11764428	1
G	Printer Data Cable	11764436	1

Printer Dip Switches

Due to a design change of the EPSON printer TM295, the so called FWD protocol is not available on the new style printer model. In order to use these printers in the same way with our flow meters, a software update in the Flowcom S8 may be necessary.
The new printer model can be identified by its serial number which starts with "F7…." These printers will be supported by the following software releases or a later version:

- V6.73.1 or later (runs on CPU02 and supports most applications) - works with both printer models.
- V2.78.1 or later for standard applications except Orca (runs on CPU01) - works with new printer style only.
- V2.08.2 or later for Orca (runs CPU01) - works with new style printer only.

The new printer model also requires different interface settings to be adjusted via DIP switches:



480 VAC System

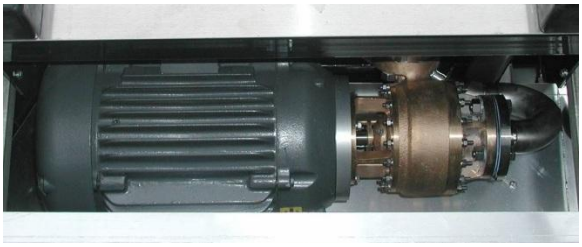
The Orca requires a 440 System to power the on-board submerged ACD Pump. The 440 system is made up of 3 main components, the Alternator/Generator, Variable Frequency Drive, and the Pump/Motor.

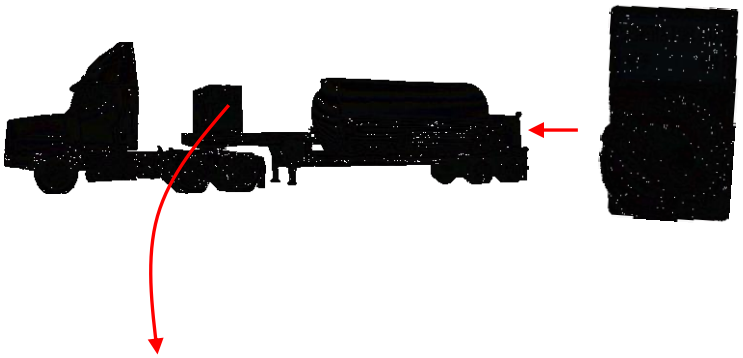
Generator / Alternator

MQ WhisperWatt

Weg Alternator

Variable Frequency Drive





To start the MQ WhisperWatt simply turn on the switch identified as “Generator Run.” This switch is located on the front of the control box in the Rear plumbing cabinet.

Located on the Road-Side of the MQ WhisperWatt is a control panel. When operating, the Circuit breaker must be ON, and the mode switch must be in AUTO.

WEG Alternator

The WEG Alternator is driven by a PTO shaft connected to the Truck engine. The PTO shaft spins at 1800 RPM producing 480 VAC. The WEG comes in a 26KVA or 38 KVA size depending on the Orca pump being driven.

SVX 9000 Variable Frequency Drive

SVX 9000 VFD

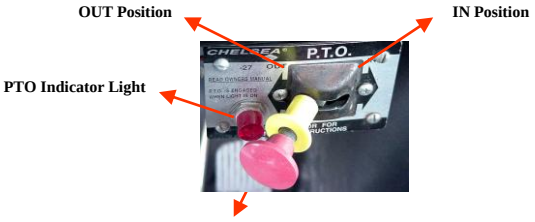
Pendant W/ Speed Control

The VFD when supplied with **480 VAC, Three-Phase Power** from the Alternator/Generator, provides an output of voltage and frequency that correspond to the pump speed selected on the Remote Pendant Pump Speed Dial. See the Troubleshooting section of this manual for programming of the VFD.

PTO/PTO Engagement Lever

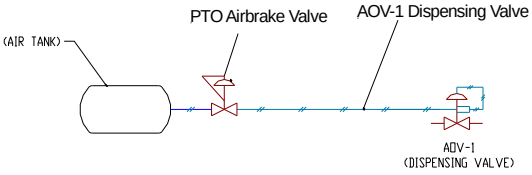
The PTO Engagement Lever is designed to engage/disengage the PTO. There are two positions-**OUT/IN**. In the **OUT Position the PTO is not engaged**, **IN Position the PTO is engaged**. Once the PTO is engaged the **Red Indicator Light** will illuminate. **The PTO will not engage unless the air brakes are set.** The type of PTO used (there are different ratios available) will determine the high idle speed (rpm). The high idle speed (rpm) is determined during the initial testing and is labeled in the cab of the truck (**common rpm speed is 1100 RPM**). **Exceeding the pre-determined High Idle Speed will result in the Alternator spinning to fast and generating excessive voltage. Over-spinning the Alternator can result in damage to the bearings or windings or damage to the Control Panel. It is recommended to disengage the PTO by manually disengaging the PTO lever to the off position and deactivating the PP-5 Valve before driving the vehicle.**

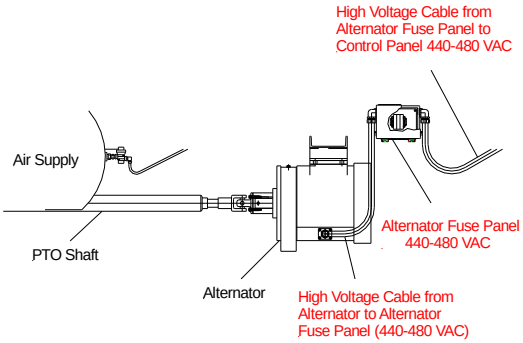
PTO Gearbox PTO Shaft



PTO Engagement Lever

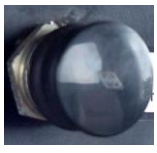
Pneumatic Schematic





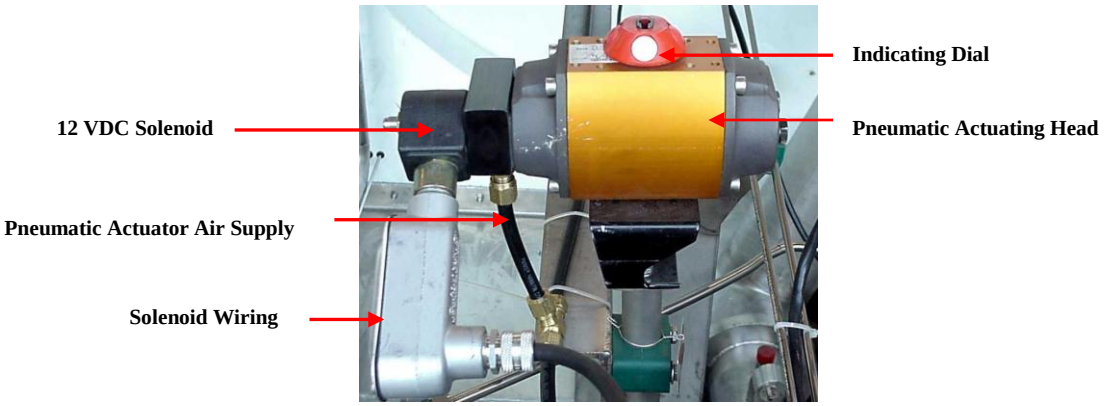
PP-5 Valve/High Idle Speed

This valve is designed to disengage the PTO in the event of driver error. The PP-5 Valve (located on the dashboard of the truck) is a piloted valve that is pneumatically tied into the air brakes. Any time the air brakes are released the piloted valve closes. This is to assure that the PTO is not engaged during transit. At the end of the delivery, the PTO will automatically disengage when the air brakes are released. **It is recommended to disengage the PTO by manually disengaging the PTO lever to the off position and deactivating the PP-5 Valve. Exceeding the pre-determined High Idle Speed will result in the Alternator spinning to fast and generating excessive voltage. Over-spinning the Alternator can result in damage to the bearings or windings or damage to the Control Panel.**



AOV-1 Air Operated Dispense Valve

AOV-1 is an air operated dispense valve that opens to allow liquid out the delivery hose. An additional AOV is used with Orca systems incorporating a High Flow Dispense circuit. The Air Operated Valves are connected into the truck/trailer air system and also has a low-voltage solenoid (12 VDC). It is imperative that there is an adequate air supply to this valve. **A minimum of 90 psi of air is required for this valve to function properly.**



Submerged Pump

Manufactured by ACD

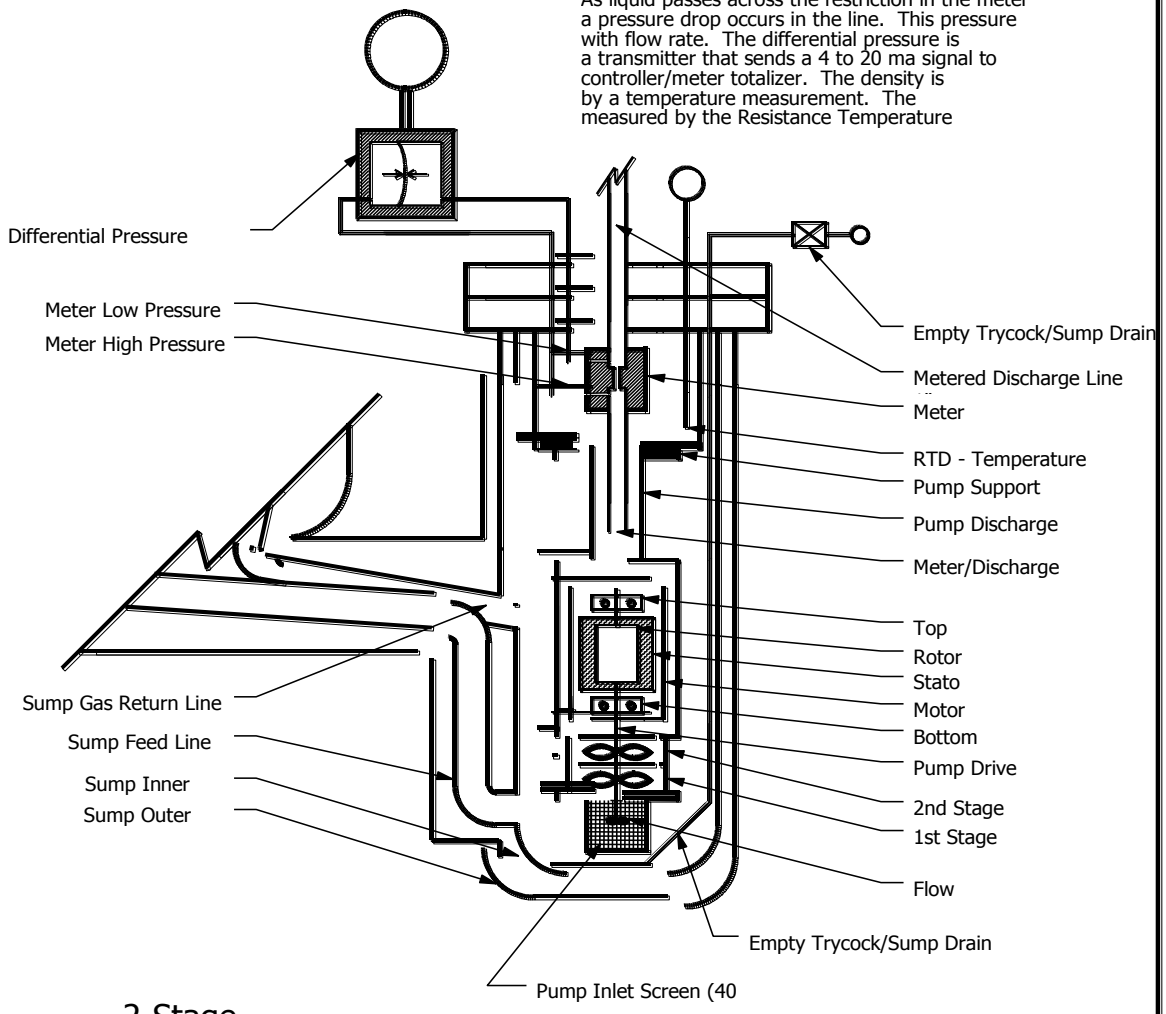
The Submerged Pump is a specifically designed variable two-speed centrifugal pump that is designed to operate while submerged in liquid nitrogen or argon. The pump is inside a flanged sump that is connected to the ORCA Vessel, and is always filled with cryogenic fluid during deliveries. This means that the pump is always cooled-down and can be used to deliver product to the Perma-Cyl or other Micro-Bulk vessels virtually instantaneously. Since the pump and motor are submerged, it is not equipped with mechanical shaft seals, has ceramic bearings and requires no cool-down prior to start-up. Depending on the particular model of ACD pump selected, pump output pressure can be as high as 400 PSI in Nitrogen/Argon Service. Centrifugal Pumps produce pressure and flow. The flow rate will depend on the pressure of the receiving tank and the pressure drop that results from the flow rate. The higher the flow rate the greater the pressure drop due to the restriction in the line to the receiving tank. The chart below shows each pump model and associated output performance.

TC-34 SUBMERGED	AC-34 SUBMERGED	KA-34 SUBMERGED
Up To 40 Gallons Per Minute Low Flow	Up To 40 Gallons Per Minute Low Flow	Up To 40 Gallons Per Minute Low Flow
Up To 60 Gallons Per Minute High Flow	Up To 80 Gallons Per Minute High Flow	Up To 100 Gallons per Minute High Flow
220 PSI Pump Pressure	275 PSI Pump Pressure	400 PSI Pump Pressure
15 HP Motor	23 HP Motor	36 HP Motor
Motor RPM 4400	Motor RPM 5300	Motor RPM 7200

Sump, Pump, and Meter

Meter

As liquid passes across the restriction in the meter a pressure drop occurs in the line. This pressure with flow rate. The differential pressure is a transmitter that sends a 4 to 20 ma signal to controller/meter totalizer. The density is by a temperature measurement. The measured by the Resistance Temperature

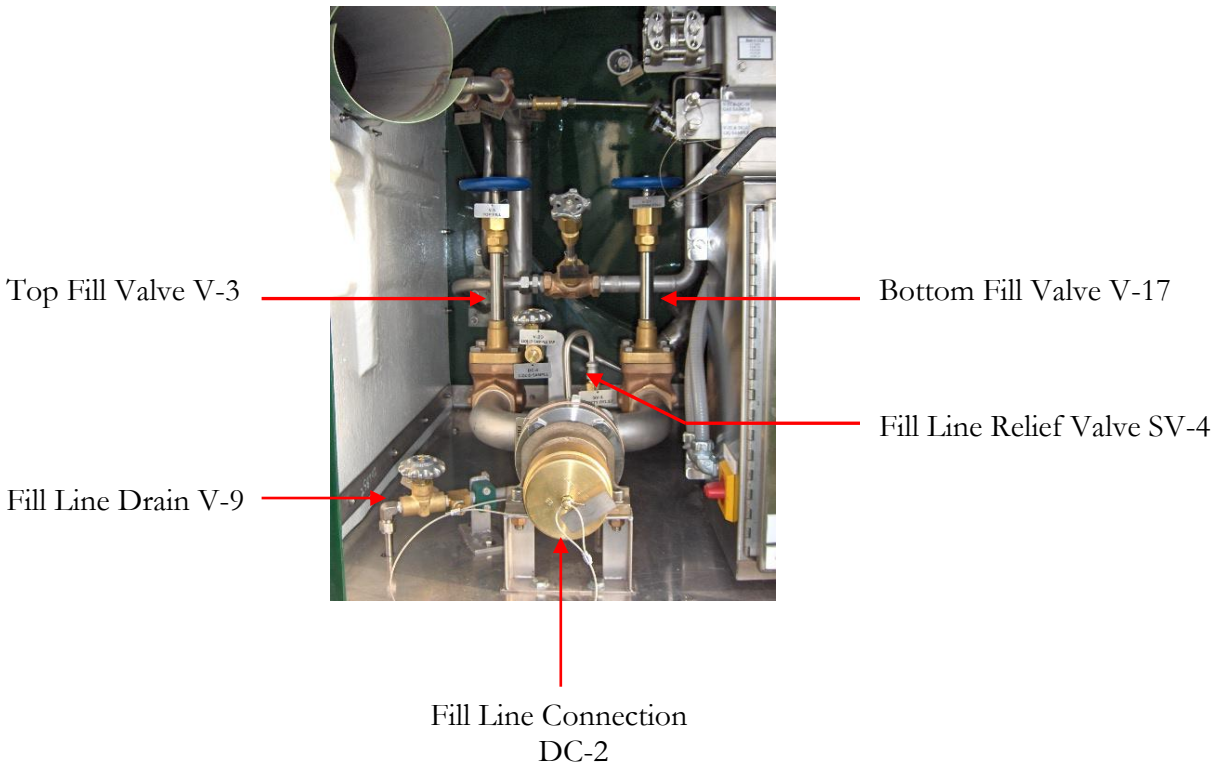


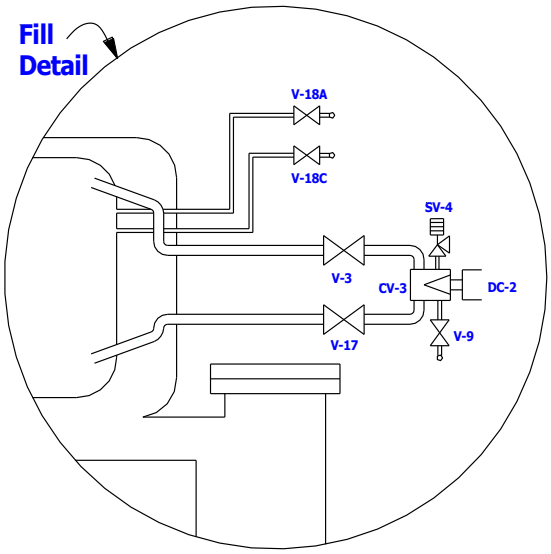
2-Stage

The pump hangs from the meter chamber in the sump. The sump is flooded with liquid. Liquid travels from the main tank to the sump through the 2"pipe size feed line. Any gas that gas side of the main tank. Liquid enters the pump through the 40 mesh screen that prevents the pump.

Fill Circuit

The ORCA is filled through the Top and Bottom Fill Circuit (DC-2). Using the Top and Bottom Fill Circuits properly will minimize vent losses during filling. The Fill Line Drain (V-9) should be used to vent the Fill Hose after filling to relieve any pressure. The check valve (CV-3) is designed to prevent the reverse of flow during filling. **The Full trycock (V-18C) is your DOT MC-338 fill level.**



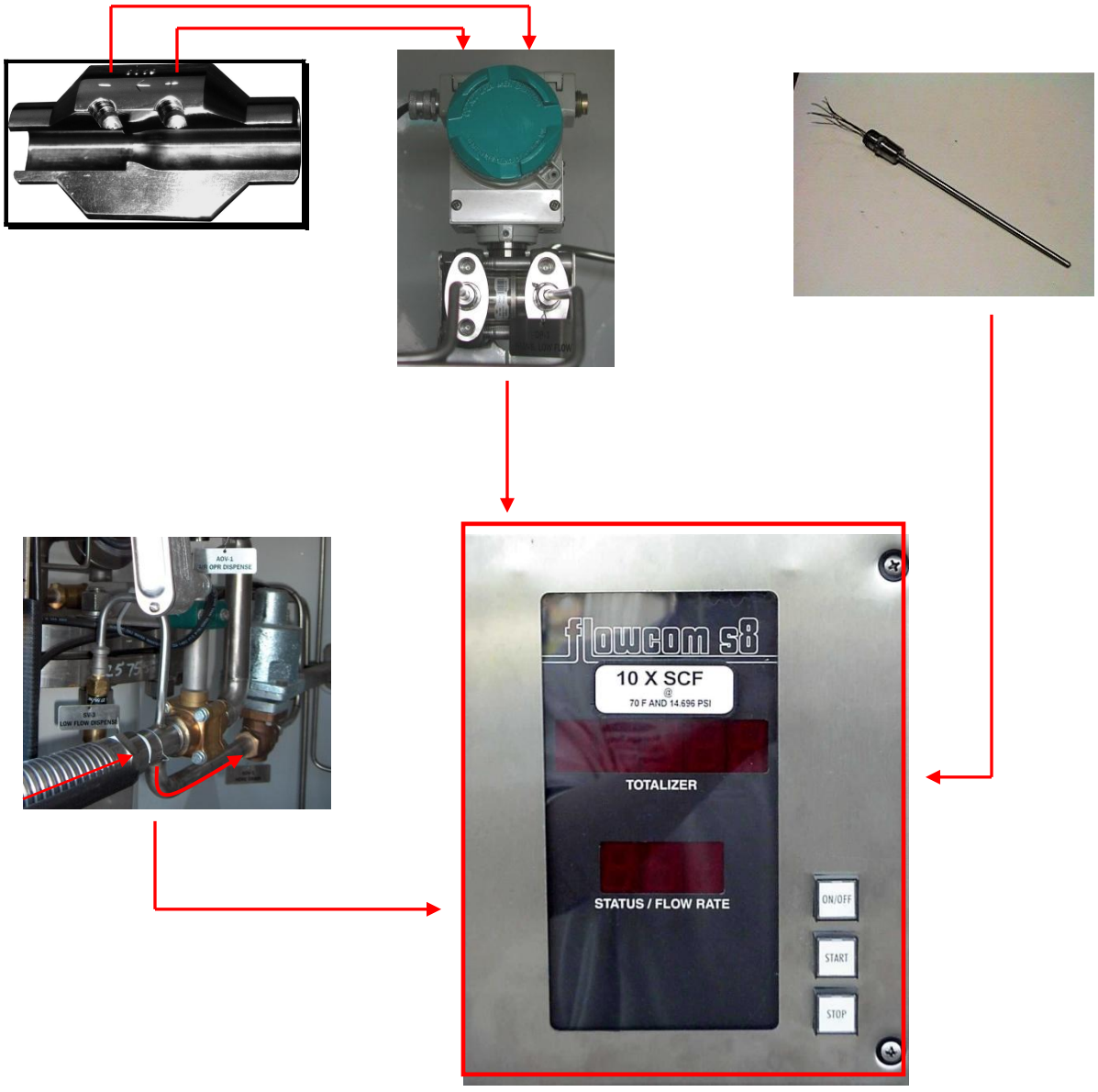


V-18A	95% Trycock Valve
V-18C	90% Trycock Valve
V-3	Top Fill Valve
V-17	Bottom Fill Valve
CV-3	Fill Line Check Valve
V-9	Fill Line Drain Valve
SV-4	Fill Line Safety Relief Valve
DC-2	Fill Line Connection

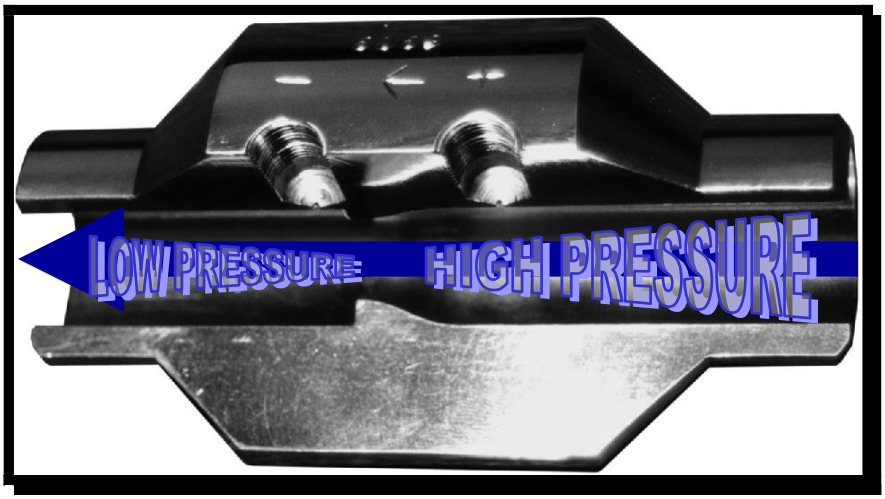
Metering System

The metering system provides an accurate and calibrated means for measuring the amount of product dispensed from the Orca vessel to the customer. The system is made up of 5 components. The Meter Section, Differential Pressure Transmitter, PT 100 Temperature probe, Hose Drain Solenoid, and the FlowComS8 Flow processor. Below we will go into each of these components in detail.

Metering Theory



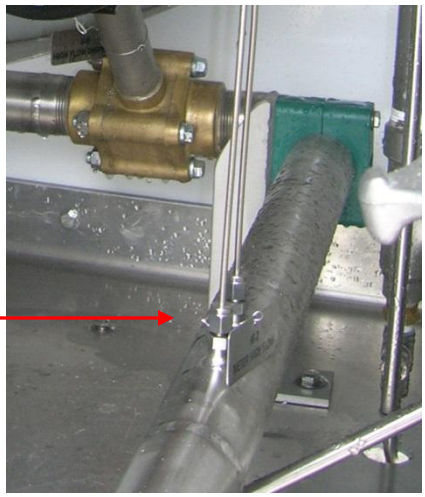
Meter Section



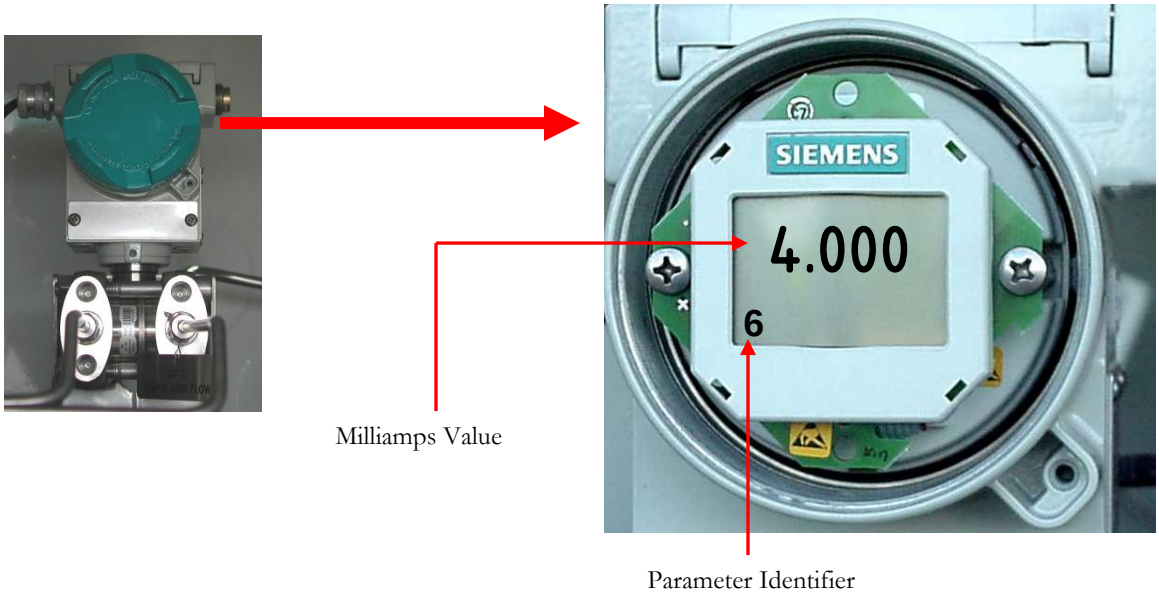
The Orca system incorporates an Orifice type Meter Section, which unlike turbine meters, has no moving parts to be damaged by gas. This Unique feature makes the Meter Section a low maintenance item. As the liquid flows to the tapered orifice, a high pressure zone is created. Once the liquid flows through 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 ¼" line is plumbed into each side of the Meter Section (one to the High Pressure side and one to the Low Pressure side). These two lines are then plumbed to the Differential Pressure Transmitter which makes this differential pressure an electronic signal.

The Primary Meter section of the Orca system (LIN/LAR) is located in the sump along with the Submerged Pump, however an auxiliary meter section can be located in the dispense line plumbing external to the sump, depending on the particular Orca model purchased. below is an example of an Auxiliary Meter Section, external of the sump.

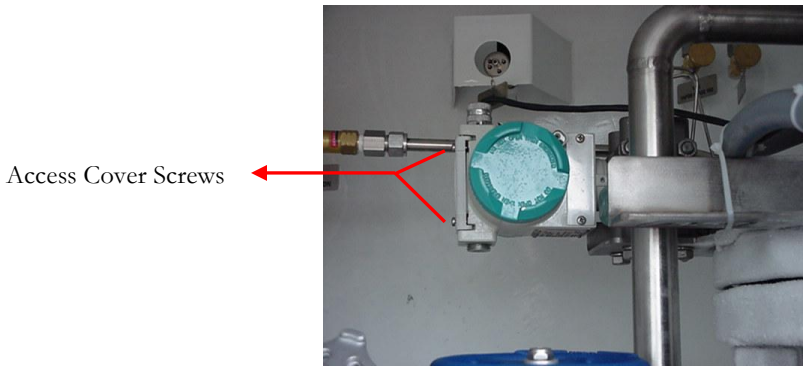
Auxiliary Meter Section
and Phase lines



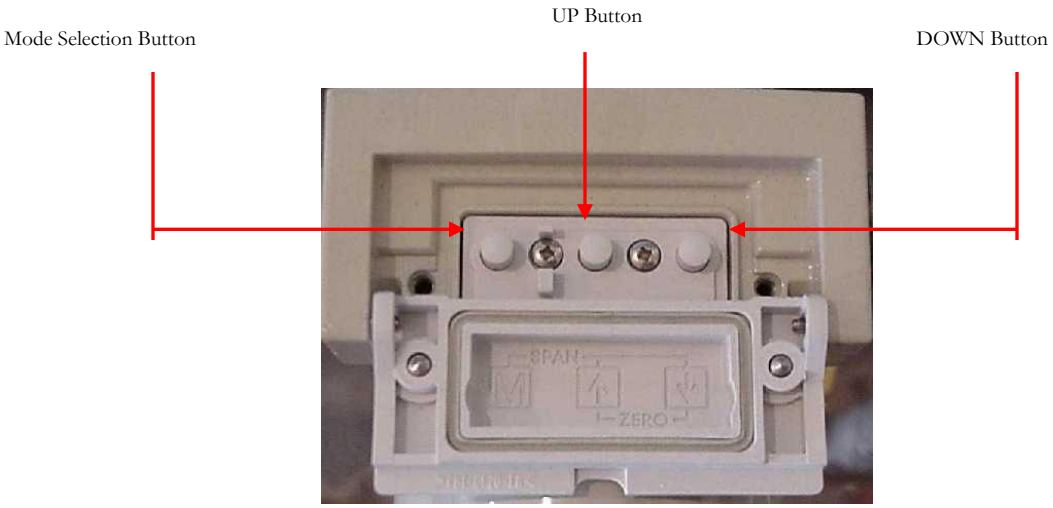
Differential Pressure Transmitter (DP Transmitter)



This is a SIEMENS Differential Pressure Transmitter used on the ORCA System. It is connected to the Meter Section, and the FlowcomS8 Flow processor. The DP Transmitter measures a change in pressure (pressure drop) across the meter section and relays this information to the Flow Processor in an electrical signal. The signal sent to the Flow processor is a **4-20 milliamp signal**. At an idle state the DP Transmitter should read approximately **4 milliamps**. At a maximum run state the DP Transmitter should read approximately **18 milliamps**. Connected to the DP Transmitter are two ¼" airlines (high/low flow) that are also plumbed to the Meter Section.

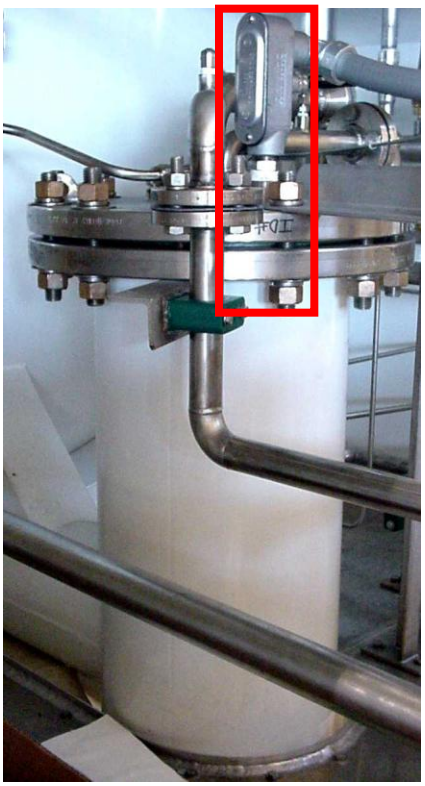


Differential Pressure Transmitter (Cont.)



While the standard Orca System uses one Differential Pressure transmitter in its Metering system, a second transmitter is required for Dual flow Systems. It is also important to note that the D.P. Transmitters on your Orca system may not be interchangeable with each other. Systems with One Meter Section and Dual dispense capability utilize Transmitters with different internal spans. If you have questions regarding your system, call a Chart Representative for assistance at **1-800-400-4683**.

RTD – Resistance Temperature Device (P/N 10929382)



The Resistance Temperature Device (RTD) is located at the top of the Pump Flange. The Probe is threaded into the Pump 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. The temperature probe is a 4-wire Resistance Temperature Device (RTD). They are also referred to as PT 100.

Hose Drain Solenoid

The Hose Drain Solenoid, located behind the Low Flow dispense valve, is a Normally Open Solenoid. This allows a path for product left in the dispense hose following a delivery, to return to the sump. This solenoid becomes active and closes off the path in unison with the dispense valve opening when dispensing product. The Hose Drain Solenoid is part of the 12 Volt DC system and receives a power signal from the FlowcomS8.

FlowcomS8 Flow Processor

The Flow Processor 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 Processor 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 Processor 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**.

Section 4 FlowcomS8

FlowcomS8 – Modes of Operation

There are two modes in which the flowcomS8 can be operated, Automatic and Manual. In the "Automatic Mode" the flowcomS8 is given control over the system functions. It allows for "Automatic Shutoff" of the discharge process upon sensing an error condition as well as a drop in the flow rate. While in the "Manual/Dispense Mode" the flowcomS8 waits for commands from the operator. **It does not change states automatically.** Switching modes is accomplished by activating the Mode Selection Switch located on the face of the Control Panel.

Automatic Mode

This mode allows for using the flowcomS8 to control pump and recirculation functions, discharge, and drain valves. Once the operator activates the "START" Button on the Remote Pendant or the "START" Button on the face of the FlowcomS8, the pump starts running and performs the "RECIRCULATION" process where the pump catches prime, builds pump pressure, and cools down the Meter Section. The flowcomS8 indicates "GO" in the Flow rate/Status window and allows the operator to begin the delivery process without the need to operate any valves manually. During the delivery process, the flowcomS8 detects the change of the flow rate as the receiving tank gets full. This change in flow will increase as the receiving tank gets fuller and will raise the pressure. As the flowcomS8 detects this change in flow/pressure, it will automatically shut off the pump and close the discharge valve. Once the pump and corresponding valves are closed, the flowcomS8 will return to a "STANDBY" State.

Manual Mode/Recirculation

This mode allows the operator to have complete control of the system and its functions. The flowcomS8 does not control the pump and recirculation functions, discharge and drain valves (equipped with pneumatic actuators). To activate the pump, the operator must switch the Mode Selection Switch on the face of the Control Panel to the "RECIRC" (Recirculation) position. In addition, to activate the flowcomS8 to meter product, the operator must activate the "START" Button on the Remote Pendant or the "START" Button the face of the FlowcomS8 (a 10-0 Countdown will commence). Once the pump has caught prime and the flowcomS8 has been activated (10-0 Countdown, GO Status), the Mode Selection Switch should be moved the "DISPENSE" position. This will open the dispense valve and begin the delivery. The "START" Button should be pushed for a second time and the flowcomS8 will begin to meter the product.

IMPORTANT: Pushing the "STOP" Button will not stop the pump. In order to stop the pump the Mode Selection Switch must be put in the "AUTOMATIC" Mode position.

FlowcomS8 – States of Operation (Status)

-S- Standby Status (Automatic Mode)

Being is this state, the Orca system is powered up and waiting for the operator to initiate an action. The pump and discharge valve are in an idle state.

Recirculation (Automatic Mode)

Being in this state the flowcomS8 is in the "RECIRCULATION" Mode. The pump is running and the flowcomS8 is counting down (10-0) as the system cools. The discharge valves are closed.

Recirculation State (Manual Mode)

Being in this state the flowcomS8 is in the "RECIRCULATION" Mode. The pump is running and the FlowcomS8 is **NOT** counting down. In order to achieve the "COUNTDOWN" Status, the operator must push the "START" Button on the Remote Pendant or on the face of the FlowcomS8. The discharge valves are closed.

GO Status (Automatic Mode)

After the Recirculation (10-0 Countdown) has finished, the system is ready to "GO," or ready to discharge. The discharge can be accomplished by pushing the "START" Button on the Remote Pendant or the face of the FlowcomS8. The flowcomS8 is now metering product.

GO Status (Manual Mode)

After the Recirculation (10-0 Countdown) has finished, the system is ready to "GO," or ready to discharge. The discharge can be accomplished by pushing the "START" Button on the Remote Pendant or the face of the FlowcomS8.

IMPORTANT: In order to meter product with the flowcomS8, the operator must push the "START" Button a second time.

Start Discharge (Automatic Mode)

To start the discharge, the Meter must be in the "STANDBY" State indicated by a "-S-" in the Flow Rate/Status display on the FlowcomS8. Pressing the "START" button on the Remote Pendant or the face of the FlowcomS8 activates the FlowcomS8 to enter the "RECIRCULATION" Mode, from where an actual product delivery can be achieved. Once the countdown has elapsed and a "GO' is in the Status display of the FlowcomS8 indicating that the system is properly cooled and ready, a delivery can be initiated by depressing the "START" button.

Start Discharge (Manual Mode)

In this state, the Mode Selection Switch is in the "RECIRCULATION" position which activates the pump and cools down the Meter Section. A "GO" State can be achieved by the operator depressing the "START" Button on the Remote Pendant or the face of the FlowcomS8 after selecting "RECIRCULATION" on the Mode Selection Switch. This will activate the flowcomS8 to begin the 10-0 Countdown and eventually reach a "GO" Status once the Meter Section has reached the proper set temperature. Once a "GO" Status is achieved the operator simply depresses the "START" Button on the Remote Pendant or the face of the FlowomS8 to open the Dispense Valve and begin a delivery.

Resume Delivery after Interruption State (Automatic Mode)

If a discharge has been interrupted and needs to be resumed, follow the steps in **FlowcomS8 Modes of Operation-Automatic Mode**.

IMPORTANT: If a delivery has been terminated and the FlowcomS8 Flow Rate/Status Window is reading an "-E-"the delivery cannot be resumed.

Resume Delivery after Interruption State (Manual Mode)

If a discharge has been interrupted and needs to resumed, follow the steps in **FlowcomS8 Modes of Operation-Manual Mode**.

IMPORTANT: If a delivery has been terminated and the FlowcomS8 Flow rate/Status Window is reading an "-E-" the delivery cannot be resumed.

Stop Discharge State (Automatic Mode)

The discharge process can be terminated by simply pressing the "STOP" Button which stops the pump, and closes the dispense valves. Once this is done the FlowcomS8 enters the "STANDBY" State (-S). To resume a delivery follow steps in **Resume Delivery after Interruption State (Automatic Mode)**.

Stop Discharge State (Manual Mode)

The discharge process can be terminated by selecting "AUTOMATIC" with the Mode Selection Switch on the face of the Control Panel. Once this is done the FlowcomS8 enters the "STANDBY" State (-S). To resume a delivery follow steps in **Resume Delivery after Interruption State (Manual Mode)**.

Print Delivery Ticket State (Automatic/Manual Mode)

Once the delivery has been terminated, the FlowcomS8 can be put into the Print mode by depressing and holding the "STOP" button on the Remote Pendant until an "-E-" is indicated in the Status/Flow rate display on the FlowcomS8. A delivery ticket may be printed by simply loading paper into the printer and pressing the "START" Button on the Remote Pendant or on the face of the FlowcomS8. The first ticket is the original and any ticket printed subsequently is marked "Duplicate." The standard delivery ticket contains the following information:

1. Number of Starts if the delivery process has been interrupted

2. Transaction Number

3. Date/Time

4. Product

5. Quantity

Clear Total State (Automatic/Manual Mode)

In order to clear the Totalizer amount after printing a ticket, simply depress and hold the "STOP" button until the –E- leaves the Status Display and an –S- (STANDBY) appears." The previous delivery total is now cleared and ready for the next delivery.

Section 5 - Operation of the ORCA

Filling the ORCA-First use

Filling the ORCA-Warm Tank/Purge

The ORCA 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 ORCA Tank Pressure Indicating Gauge (PI-1). Make sure that the ORCA Tank Pressure does not go below 5 PSIG. Before making filling the ORCA, be sure that protective eyeglasses and gloves are being worn.

A Bottom Fill method is recommended the first time the ORCA System is filled and any other time the tank is "warm" (warmer than the boiling temperature of the product you will be dispensing). Pre-Cool 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 open the Vapor Vent Valve

(V-5) to manage ORCA Vessel Pressure. Important: Cooling the tank down 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 vessel.

1. Attach the source of liquid or gas purge product to the Top and Bottom Fill CGA Connection (DC-2) on the ORCA Vessel.
2. Open the source tank feed valve and the Bottom Fill Valve (V-17) on the ORCA allowing gas to flow slowly into the tank. Build the ORCA Tank Pressure to 40 psi.
3. Close the Bottom Fill Valve (V-17) on the ORCA and the close the source tank feed valve. Purge the trapped space by opening the Fill Line Drain (V-9) on the ORCA.
4. Crack the compression fittings on either side of the Liquid Level Gauge (L1-1), 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 (V-17) on the ORCA closed, open the Fill Line Drain (V-9) and the Top Fill valve (V-3). Purge for two minutes. Close the Top Fill Valve (V-3) and the Fill Line Drain (V-9).
6. Open the Bottom Fill Valve (V-17) and the Fill Line Drain (V-9). Purge for two minutes. Close the Bottom Fill Valve (V-17) and the Fill Line Drain (V-9). Note: **Build pressure by repeating steps 1 and 2, when the ORCA Tank Pressure drops below 20psi.**
7. Open the 90% (V-18C) and the 95% (V-18A) Trycocks. Purge for two minutes. Close Trycock Valves.

8. With the Re-circulation Valve (V-42) closed, crack the compression fitting at the outlet of the Pressure Building Coil and open the PB Gravity Force Feed Valve (V-16), and purge for two minutes. Tighten the compression fitting and leak check.
9. With the Mode Selection Switch on the Control Panel in the "DISPENSE" position, open the Low Flow Dispense Valve (V-41) on the end of the ORCA Delivery Hose.
10. Purge for two minutes. Close Low Flow Dispense Valve (V-41) and return the Mode Selection Switch on the face of the Control Panel to the "Auto" position.
11. Vent tank to 5 psi using the Vapor Vent Valve (V-5).
12. Repeat steps 7 and 8 three times.
13. After purge 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 Vessel are open:

    V-11 Vapor Phase Valve

    V-12 Liquid Phase Valve

    V-13 Pump Discharge Isolation Valve

Filling the ORCA-Normal Use

Filling the ORCA (after initial Fill/Purge)

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 ORCA, Bottom Filling is recommended. If filling the ORCA Tank with liquid saturated at a lower pressure (temperature) than what currently is in the ORCA Top Filling is recommended. This will minimize the tank pressure rise and minimize the venting required to manage the ORCA Tank Pressure. Filling the ORCA with liquid saturated at pressure at or above the tank pressure rating (50psi) 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 pounds 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 truck should be on a level surface when filling. If the vehicle is not level, instrument readings as well as the full trycock points may not be accurate. Wear gloves and protective goggles when working with any cryogenic material. Contact with cryogenic materials can result in severe frostbite and injuries similar to burns. Make sure that the Road Relief Valve (V-2) is closed prior to filling the ORCA Vessel.**

Purging the Fill Line

Connect the fill hose from the supply vessel to the ORCA Fill Connection (DC-2).

1. Open the Fill Line Drain Valve (V-9) on the ORCA.
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 and the bottom fill valve on the supply tank until the ready to commence filling of the ORCA Tank.

Top Filling the ORCA

If the source liquid is cold, Top Filling lowers the product losses during filling. The Top Fill Valve (V-3) on the ORCA Vessel 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 ORCA Vessel Tank Pressure. Check the ORCA Tank. If the ORCA Tank is cold, Top Filling is recommended. This will result in the pressure in the ORCA Tank being reduced.

1. If necessary, start the pressure-building device on the supply unit.
2. Check the chart on inside back door of ORCA Doghouse for specifications for each type of gas and the recommended filling levels for the product you are about to fill with. With the Supply Tank connected open the Top Fill Valve (V-3) on the ORCA 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 V-18) 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 Truck for five minutes.
6. Close the Top Fill Valve (V-3) on the ORCA Truck.
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) on the ORCA Vessel.
8. Replace the CGA Fill Fitting Cover onto the ORCA Fill Connection (DC-2) and stow the Delivery Hose.
9. Open Road Relief Valve (V-2) if applicable.
10. Close the Plumbing Cabinet Doors.

Filling Levels-CGA 341

The ORCA 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 vehicle axle rating (GVWR/GVAR). Tanks operating under CGA 341 must have a relief system that prevents the vessel pressure from exceeding 25.3psig. The ORCA is supplied with a Road Relief System that can be used to maintain the vessel pressure at or below 25.3psig.

Filling Levels-MCC 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 valves 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

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 in filling open dewars. Cold liquid will minimize vent losses, optimize fill times, and improves safety.
4. Collapsing of vapor space in Receiving Tank is achieved.
5.

Saturation Pressure psi	Liquid Nitrogen Temperature Deg F	Liquid Oxygen Temperature Deg F	Liquid Argon Temperature Deg F
0	-320	-297	-303
10	-311	-288	-293
15	-308	-284	-289

What is Cold Liquid

Cold liquid is liquid saturated at 15-psi or less.

How to Maintain Cold Liquid

The ORCA 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 Dewar's or low-pressure cylinders are to be filled. After filling the ORCA Storage Vessel, vent the contents to your desired pressure. During daily operation, keep the Road Relief Valve (V-2) open during transit. It is extremely important to close the Road Relief Valve before performing a delivery.

Current Saturation of Liquid:

Upon arriving at your delivery site, the ORCA Inner Vessel 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 vessel pressure will rise. This is not an increase in your saturation but an increase in your sub-cool. During normal deliveries your saturation pressure will remain the same as at arrival.

Engaging the PTO/Alternator

Engaging the PTO/Alternator Manual Transmission

To engage PTO/Alternator:

Push in the Clutch

Push in the PP-5 Valve (located on the dashboard of the truck)

Put the truck into gear

Slide the PTO Engagement Lever to the "IN" Position (located on the dashboard of the truck)

Take the truck out of gear

Slowly let out the Clutch (red indicator light will illuminate indicating engagement)

Set the Rpm's to the required value (1100 RPM) using the Cruise Control

To Disengage the PTO/Alternator:

Push in the Clutch

Slide the PTO Engagement Lever to the "Out" Position (located on the dashboard of the truck)

Pull out the PP-5 Valve (located on the dashboard of the truck)

Slowly let out the Clutch (red indicator light will go out indicating disengagement)

De-activate the Cruise Control

Engaging the PTO/Alternator Automatic Transmission

To engage the PTO/Alternator:

Have truck in Neutral and brakes set.

Activate the PTO Switch on dashboard of the truck (red indicator light will light up)

Set the Rpm's to the required value (1100RPM) using the Cruise Control

To disengage the PTO/Alternator:

Apply the Brake Pedal

De-activate the PTO Switch on dashboard of the truck (red indicator light will go out indicating disengagement)

De-activate the Cruise Control

Powering Up the ORCA

Control Panel-Standby State

The operator activates the power to the Control Panel by turning the 12VDC Control Power On/Off Switch and the Pump Disconnect Switch (440 VAC) on the side of the Control Panel to the "ON" Position. The Cutler Hammer VFD and the Flow processor will then power up and the System "Ready" Light on the Control Panel will illuminate. The pump and valves will remain in an Idle State as long as the Mode Selection Switch on the Control Panel is in the "AUTO" Mode Position. The VFD will display "Output Frequency 0.00 Hz". The Flow Processor will display "0.0" in the upper display (Totalizer Window) and "-S-" in the lower display (Status/Flow rate Window). The "-S-" stands for "Standby" Mode and ready to start. The "Frequency 0.00 Hz and –S- will be displayed after the required diagnostic checks are performed by the Flow Processor and VFD.

Automatic Mode

Automatic Mode-Recirculation

With the Mode Selection Switch in the "AUTO" position, the operator presses the "START" Button. The pump ramps up to speed and the Flow Processor Status Window displays the Countdown (10-0), then displays "GO" Status (lower display). If the Flow Processor Status Window does not display the "GO" Status (lower display), try opening V-16 (Force Feed Valve) until the "GO" appears. If the Flow Processor detects a problem while performing its diagnostic check it will display an Error Code (see Flow processor Troubleshooting Guide). The unit is now in the "Recirculation Mode" and liquid is being drawn into the pump and recirculated back into the ORCA Tank. During Recirculation, the operator can adjust the pump speed by using the Pump Speed Control Dial on the Remote Pendant. The operator should adjust the speed until the Pump Pressure (PI-1) is at least 50psi above the Receiving Tank Pressure.

Automatic Mode-adding Sub-Cool

Pumping boiling liquid will damage the pump! At least 5-psi of Sub-Cool is required to deliver liquid Nitrogen and 7 psi is required to deliver Liquid Argon from the storage tank to the sump. Upon arrival the operator must assess the liquid's current condition (Saturation Pressure). The arrival pressure is the Saturation Pressure of the liquid. The operator must maintain a minimum of 5-psi or 7psi respectively of Sub-Cool during the entire delivery. This is accomplished by opening the manual force feed valve V-16, which allows liquid to be pumped into the Pressure Building Coil, located Roadside of Orca Vessel. Liquid is routed into the PB Circuit, which is warmer than the cryogenic liquid. When the cold liquid enters the warmer PB Circuit it vaporizes and turns to gas and is routed back into the ORCA Tank and builds ORCA Vessel Pressure. For extended deliveries the PB Circuit can be used to add additional Sub-Cool during the filling process

Automatic Mode-Dispense (10-0/"GO")

At the completion of the Count Down (10-0), the Flow Processor confirms that the Temperature Probe (RTD-1) is indicating the required cryogenic temperatures, and the Flow Processor displays a "GO" in the Status display (lower display). If the Flow Processor senses the Temperature Probe (RTD-1) is not to the proper temperature, there will be no "GO" Status in the Flow Processor Window (lower display). Instead, three horizontal dashes will

appear in the Status display. Should this occur, Open V-16 (Force Feed Valve) until --the "GO" appears. If the problem persists call Technical Support at 1-800-400-4683. With the Transfer Hose attached to the Receiving Tank, the "V-41" valve at the end of the delivery hose open, and the "GO" indication in the status display, the operator simply presses the "Start" Button on the Remote Pendant to begin the delivery. The Control System opens the Air Operated Dispense Valve AOV-1 and product is directed out the Transfer Hose. The Flow Processor will totalize the delivery and will show the Flow Rate in the Flow Rate/Status display of the FlowcomS8. The VFD status will be "RUN" and show a Hertz Reading (this value will vary depending on the product being delivered and the setting of the Pump Speed Dial). The Flow Processor starts totaling once the Transfer Hose is filled with Product.

Automatic Mode-Fill Termination

The delivery can be stopped by pressing the "STOP" Button, by Auto Tank Shut-off while filling a Perma-Cyl, or by closing the Transfer Hose Dispense Valve (V-41). Upon completion of the delivery, the VFD will ramp the Pump down. The Pump continues to run but is "Decelerating". The Hose Drain Valve (SOV-1) remains closed until the Pump has finished its Deceleration. The FlowcomS8 displays the total amount of product delivered and an "-S-" in the Status Display Window. The FlowcomS8 is now in a "Standby Status" where additional product can be metered/delivered and added to this total.

After termination of the fill cycle, the SOV-1 (Hose Drain Valve) opens allowing pressure in the Transfer Hose to equalize with the storage tank. CV-4 is a 5-psi Check Valve. The Transfer Hose pressure will be 5-psi higher than the ORCA Vessel Pressure. The Transfer Hose Connection can be removed from the tank that has been filled and the hose may be stowed. When the hose is stored in the Hose Tube, the remaining liquid in the hose will drain into the Sump via the Hose drain solenoid.

Filling a Perma-Cyl-Automatic Mode *(Chart Inc. suggested procedure)*

The ORCA System has been specially engineered to make filling of a Perma-Cyl Container a quick, one-stop operation. In addition when filling containers other than Perma-Cyl's not all of the systems safety features are active. The operator must closely monitor the Receiving Tank Pressure, ORCA Pump Discharge Pressure (PI-1), and Receiving Tank Fill Level.

Filling a Perma-Cyl (First Fill/ Warm Tank):

Fill the Perma-Cyl until the tank pressure reaches 40 psi

Open the Main Vent Valve on the Perma-Cyl and vent the tank to 10 psi

Close the Main Vent Valve on the Perma-Cyl

Fill the Perma-Cyl until the tank pressure reaches 40 psi

Open the Main Vent Valve on the Perma-Cyl and vent the tank to 10 psi

Close the Main Vent Valve on the Perma-Cyl

Repeat this procedure a minimum of FOUR TIMES

The Perma-Cyl is now purged and cooled

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

Manual Mode

Manual Mode-Recirculation of the Liquid

In the Manual Mode the FlowcomS8 has to be initiated as a separate activity. With the Mode Selector Switch in the "RECIRC" position (starts the pump Recirculating), press the "START" Button. The meter will then count down (10-0) and check the temperature of the liquid. If the diagnostic checks are verified a "GO" Status will appear in the Status/Flow Rate Window of the FlowcomS8. If the FlowcomS8 Status Window does not display the "GO" (lower display) Status, push the "STOP" Button, which stops the Pump from Recirculating. If the FlowcomS8 detects a problem while performing its diagnostic check it will display an Error Code (see FlowcomS8Troubleshooting Guide). The unit is now in the "Recirculation Mode" and liquid is being drawn into the pump and recirculated back into the ORCA Tank. During the Recirculation, the operator can adjust the pump speed by using the Pump Speed Control Dial on the Remote Pendant. The operator should adjust the speed until the pump pressure (PI-1) is at least 50psi above the receiving tank pressure.

Manual Mode-adding Sub-Cool

Pumping boiling liquid will damage the pump! At least 5-psi of Sub-Cool is required to deliver liquid Nitrogen and 7 psi is required to deliver Liquid Argon from the storage tank to the sump. Upon arrival the operator must assess the liquid's current condition (Saturation Pressure). The arrival pressure is the Saturation Pressure of the liquid. The operator must maintain a minimum of 5-psi or 7psi respectively of Sub-Cool during the entire delivery. This is accomplished by opening the manual force feed valve V-16, which allows liquid to be pumped into the Pressure Building Coil, located Roadside of Orca Vessel. Liquid is routed into the PB Circuit, which is warmer than the cryogenic liquid. When the cold liquid enters the warmer PB Circuit it vaporizes and turns to gas and is routed back into the ORCA Tank and builds ORCA Vessel Pressure. For extended deliveries the PB Circuit can be used to add additional Sub-Cool during the filling process Initiate the FlowcomS8 by pressing the "START" Button on the Remote Pendant. The Flow Processor will display "L10". This status is a Low Flow Warning and is displayed at this time because there is no flow.

Manual Mode-Dispense (10-0, "GO")

The operator switches the Mode Selection Switch on the Control Panel to the "DISPENSE" position. This opens the Air Operated Dispense Valve (AOV-1) and allows liquid to flow out the Delivery Hose. The Flow Processor totalizes and displays the flow rate. During the Manual Mode many of the systems safety features are not active. The Auto Shut-Off feature is not active in the Manual Mode. The pump and valve controls are up to the operator and are completely controlled by the Mode Selection Switch on the Control Panel. To end the flow of liquid switch the Mode Selection Switch to the "RECIRC" position. The VFD will display "RUN" which means the pump will still be running. The Flow Processor Status Display will show the Low Flow warning "L10". Additional deliveries can be added to the total by connecting to the next tank and switching the Mode Selection Switch on the Control Panel to the "DISPENSE" Mode and then the "Automatic" Mode to completely terminate the delivery. At the end of the deliveries, turn the Mode Selection Switch to the "AUTO" position. The pump will ramp down with the VFD Display "DEC" (decelerating) and the Flow Processor status will be at standby ("-S-"). After the ramp down, the Hose Drain Valve SOV-1 will open equalizing the pressure in the hose with the ORCA and allowing the hose to drain. At this time the ticket printing procedure can be completed.

Pressure Transfer Mode

As a backup to the pump transfer method, liquid can be transferred from the ORCA Vessel by the Pressure Transfer method. This is accomplished by building pressure in the ORCA Vessel and minimizing pressure in the receiving tank. The vessel to be filled will have to be vented to less than 5 psi with the ORCA Saturation Pressure at 10 psi and ORCA Vessel Vapor Pressure raised to 40-45psi. The standard ORCA Vessel has a MAWP of 50psi. The Flow Processor has a metering range of 4 to 40 gallons per minute so it is important to create the maximum amount of pressure difference between the ORCA Tank and the receiving tank. If the Saturation Pressure of the liquid in the ORCA Vessel is above 10psi the Vapor Vent Valve (V-5) should be opened and the ORCA Tank De-Saturated to 10psi. The receiving tank must be at less than 5 psi and the receiving tank vent must be left open during the delivery.

Pressure Transfer-Standby Mode

The 440VAC Pump Disconnect switch should be switched to the "OFF" position. In the "OFF" position the pump cannot accidentally be started. The operator manually opens the Gravity Force Feed Valve (V-16 located on the trycock tree) drawing liquid into the Pressure Building Coil. The PB Regulator (PCV-2) is set just below 50 psi and will limit the pressure building in the ORCA Vessel. The PB Force Feed Valve (V-16) should be left open during the Pressure Transfer delivery to maintain a high ORCA Vessel Pressure (40-45 psi). To improve the Pressure Transfer, it is recommended that the ORCA Pump is operated in the Recirculation Mode and the PB Force Feed (V-16) is opened to help boost the ORCA Tank Pressure to 40-45 psi. Once the optimum pressure is achieved the pump should be turned off before the Pressure Transfer is initiated.

Pressure Transfer-Dispensing Mode

With 12VDC Control Power Switch on the Control Panel in the "ON" position, the FlowcomS8 will power up and begin its self-diagnostic check. If the FlowcomS8 completes the diagnostic check a –S- will appear in the Status/Flow Rate Window (lower window) indicating a "STANDBY" mode. To initiate the FlowcomS8 to meter the product being delivered, push the "START" Button on the Remote Pendant. The FlowcomS8 will indicate the "Count Down" (10-0) in the Status display. Once a "GO" Status is achieved in the FlowcomS8 Status display the delivery can be initiated by activating the Air Operated Dispensing Valve (AOV-1). Selecting "DISPENSE" with Mode Selection Switch on the Control Panel opens AOV-1. As the liquid flows from the ORCA Vessel, the vapor space increases and the pressure decreases in the ORCA Tank. To maintain the ORCA Vessel Pressure, keep the PB Force Feed Valve (V-16) open until the delivery is completed. The delivery is terminated by: moving the Mode Selection Switch on the Control Panel to the "AUTO" position, closing the PB Force Feed Valve (V-16) on the ORCA Vessel, closing the receiving tank vent valve, closing the Dispense Valve (V-41) on the ORCA Delivery Hose, switching "OFF" the 12 VDC Control Power Switch on the Control Panel, and removing the Delivery Hose. Stow the Delivery Hose, close the Plumbing Cabinet Doors, and proceed to the next stop.

Section 6 Systems Troubleshooting

Trouble Shooting Guide

Use the Troubleshooting table as a guideline to diagnose your ORCA system should problems develop. The table consists of the Trouble, Probable Cause and Remedy columns. This table cannot replace the knowledge that an experienced operator or cryogenic maintenance technician has, and should be considered as a guide only. Note that 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.

Vacuum Integrity

Since all ORCA vessels are super-insulated, any deterioration or loss of vacuum will be apparent by cold spots or frost on the outer shell, or abnormally rapid pressure build up. Unless one of these conditions is evidenced, the vacuum level should not be suspect.

The ORCA vessel is factory equipped with a Hastings DV-6R vacuum probe. In the event that the vacuum becomes suspect, measure the vacuum with the compatible Hastings meter. The cold vacuum level should be under 25 microns of mercury.

Note: Early morning condensation or dew on the tank is normal and may be irregularly distributed on the outer shell.

ORCA Troubleshooting

Symptom	Possible Cause	Remedy
Control panel does not light up.	Fuse blown in 12 volt control circuit. 12 volt circuit open.	Replace fuse in fuse block in truck. Verify connector is plugged in at front of tank. Also inspect wires from connector to control panel for breaks, cuts, etc. Repair if necessary.
Low voltage or high voltage error messages on VFD.	Alternator spinning too fast or too slow.	Adjust truck engine speed accordingly.
Over current error message on VFD.	Pump drawing too much current. Worn bearings in pump.	Slow pump speed down using control on pendant. Remove and replace pump.
Dispense valve does not open.	No air supply to the valve. No 12 volt power to the solenoid. Valve is frozen.	Verify that there is sufficient air in air tanks. Valve requires 100psi 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!!**
Flowcom flow meter cycles through boot-up repeatedly.	Defective front board in Flowcom.	Obtain replacement front board from factory and replace.
E 12/13 error code on Flowcom.	Liquid flow through meter section before meter is turned on. DP transmitter defective. Wiring defective. Leak in D.P. 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	Possible Cause	Remedy
Unstable flow of product.	Depletion of sub-cool.	Add sub-cool by opening pressure building coil. 5 to 7 psi above saturation pressure is required. **Caution: Venting during delivery will cause depletion of sub-cool, 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!**
Unstable flow of product (cont.)	Two-phase flow. This occurs when a combination of liquid and gas flows through the pump.	Increase sub-cool. If the saturation pressure is high, the vessel may have to be blown down, then sub-cool added.
Audible change in 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!**
	Worn bearings in pump.	Remove and replace pump.
Pump not catching prime.	Insufficient sub-cool.	Add sub-cool by opening pressure building coil. 5 to 7 psi above saturation pressure is required. **Caution: Venting during delivery will cause depletion of sub-cool, 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!**
No "Go" indication on Flowcom. (Flashing "0.0" after countdown.)	Meter section not cooling down.	Open the P.B. Gravity Feed valve located on the valve stand to the right of the control panel, third valve from the top. Leave open until "Go" indication appears.
E01 appears on Flowcom.	Printer error.	Verify that the cables to the printer are plugged in, that the printer is turned on, and that there is paper in the printer.

Meter Troubleshooting Guide

Reference Summary of Meter Error Messages

Screen Display	Status	Description
"-S-"	Stand by mode	System is ready for delivery. In the automatic mode, start the delivery pressing start
"-E-"	End of Delivery	Metering is completed. Ticket can be printed at this time.
"LLL"	Low temperature	The liquid temperature has exceeded the lower limit of the current temperature setup. Verify that the temperature limits and that the current product matches parameter settings
"HHH"	High temperature	The liquid temperature has exceeded the upper limit of the current temperature setup. Verify that the temperature limits and that the current product matches parameter settings
"L10"	Metered flow rate below meterable range.	Metering is stopped if "L10" is displayed. In the automatic mode L10 only appears during the start up time out. In the manual mode, "L10" appears any time the flow drops below the meterable range.
"H99"	Metered flow rate above meterable range.	Metering is stopped if flow rate exceeds the meterable range. In the automatic mode the delivery will be terminated and "H99" will be displayed. In the manual mode if the flow rate exceeds the meterable range the totalizing of the delivery is stop until the flow rate is lowered to the acceptable range.
"E01"	Printer Error	If the printer is off, the paper is out or data transfer is interrupted, this message will appear for 5 seconds. Resolve the printer error and press start the ticket will be printed (original).
"E11"	Measured temperature is too low.	This 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.

		-A/D converter is defective
"E12/E13"	DP Transmitter Fault	The controller reads a 4 to 20 ma signal from the DP transmitter. If the signal is less than 3.8 ma or higher than 19.9 ma when the system is powered up, "E12" will be displayed. Check the following: -Leaks in the sensor lines to the DP transmitter. -Dispensing during start up. -Defective DP transmitter. -Defective power supply to DP transmitter.
"E16"	Calibration/Configuration mode	During calibration and configuration, the security switch is removed to allow communication. If the switch is not replaced (delivery position) and a delivery is attempted "E16" is displayed. During this error no metering is possible.
"E20"	Main Setup Fault	The main setup data is lost or not correct due to one of the following: -main setup parameters not entered or entered incorrectly. -EEPROM defective -EEPROM cannot be addressed
"E21"	Ram-Check Fault	RAM data lost. Normal with first operation. This fault can be cleared by pressing the "Stop" button. If this fault occurs with each system power up, the CPU may need to be exchanged.
"E24"	Non-Critical (Public) Data Fault	
"E28"	Time out Fault	Data could not be stored properly in the EEPROM. The EEPROM may be defective.
"E30"	A/D Converter Fault	The program is stopped. The A/D converter may be defective.
"E31"	PT100 Temperature Sensor Fault	The Temperature Sensor is defective or not connected properly. The current is out of tolerance.
"E32"	EEPROM Fault	The memory of the EEPROM could not be read.
"PE 01"	Calculation Fault	General division error
"PE 02"	Calculation Fault	Division of a long variable by zero
"PE 03"	Calculation Fault	Division of a floating variable by zero
"PE 04"	Calculation Fault	Overflow of a floating variable by zero

"PE 05"	Calculation Fault	Underflow of a floating variable by zero

Description of Error Messages and how solve the problem

E01 Printer Error

This error message occurs when the handshake between the Flowcom S8 and the printer does not occur. The message occurs when attempting to print a ticket.

Reasons:

1. Paper not properly inserted (paper out)
2. Printer power off
3. RS232 connection problem
4. Printer DIP switch settings are not correct.

Fixing the Problem:

1. Make sure the printer has power (lights on printer should be lite).
2. Confirm that the paper is properly installed.
3. Check cable which connects flow processor and printer.
4. Check the DIP switches on the printer.

E11 Measured Temperature is too Low

This error message occurs when the calculated temperature is below the preset range determined by the product parameter. At atmospheric pressure the lowest possible temperature (LIN,LOX,and LAR) is predictable.

Reasons:

1. Temperature Parameters are wrong for the product being metered.
2. Current Product Parameter does not match actual product being metered.
3. Wiring Problem in the connection of the Temperature Probe (also refer to as PT100 or RTD).
4. FLOWCOM S8 defective
    - Temperature Range Switching is defective.
    - Constant current source is defective
    - A/D converter is defective

Fixing the Problem:

1. Confirm the temperature parameter settings
2. Confirm that the current product parameter matches actual product (check ticket print out or boot up display)
3. Check wiring connections to the RTD.
4. With the above confirmed, determine if the RTD is defective by: Disconnect the RTD wiring to the Flowcom S8 and measure current. If current matches expected values the RTD is OK.
5. If 1-4 are confirmed and do not resolve the problem the Flowcom S8 is defective. Call Chart for a replacement.

E12/E13 Zero Point Error of D.P. Transmitter

This error message occurs when the signal current of the differential pressure transmitter is higher than 4.2 mA or less than 3.8 mA during test mode of
FLOWCOMS8 (for 4 seconds after power on). The signal current at a flow rate of 0 percent is supposed to be 4.00 mA.

Reasons:

1. Product flowing through metering section before the meter has been switched on or when a power fail occurred during delivery and the power has come up again.
2. DP-Transmitter defective
3. Wiring Problem
4. FLOWCOM S8 defective

Fixing the Problem:

1. Check for leaks n D.P. Transmitter lines.
2. Zero out D.P. Transmitter (Page 77 of this manual)

E16 Calibration/Configuration Mode

This error message occurs when a delivery is attempted with the security switch removed. During this error no metering is possible.

Reasons:

1. Security switch is removed.

Fixing the Problem:

1. Confirm settings, power down the system, replace the security switch, power up and restart the delivery.

E20 Checksum Error of Parameters

This error message occurs when the check sum of the set-up parameters has become invalid or parameter are lost.

Reasons:

1. exchanging set-up memory or main PC-board (EEPROM) without entering new data
2. carried out the FORMAT EEPROM instruction (terminal and password required)
3. FLOWCOM defective

Fixing the Problem:

1. Configure the flow processor by reentering all parameters .
2. Configure the flow processor by reentering all parameters.
3. If the flow processor does not allow to be reconfigured the main board needs to be replaced. It is located on the back of the front door.

E21 RAM Supply Error

This error indicates that the quantity variable in the meter´s memory may contain an invalid value when first energized. It may also occur when the FLOWCOM S8 is switched off for more than 7 days. The memory (RAM) is supplied by a large capacitor which discharges after 1 week. This buffering prevents loss of the measured quantities if a power failure has occurred during operation. It does not affect the non resettable totalizer.

Fixing the Problem:

To reset the error message, press and hold STOP

E24 Checksum Error of Public Data

It occurs when the check sum of the general non-critical data has become invalid or data are lost. This could either be the totalizer or the transaction counter. Other data or parameter are not affected.

Fixing the Problem:

To reset the error message, press and hold the STOP button which initializes the internal variables and stores them in the non volatile memory.

E28 Checksum Error of Config Data

This error message occurs when data is not stored properly on the EEPROM.

Fixing the Problem:

1. Reset the error message, press and hold STOP.
2. If the error message does not clear the Flowcom S8 is defective. Call Chart for a replacement.

E30 A/D Converter Fault

This error message occurs when the Flowcom S8 internal diagnostics determines that there A/D converter is malfunctioning.

Fixing the Problem:

1. Reset the error message, press and hold STOP.
2. If the error message does not clear the Flowcom S8 is defective. Call Chart for a replacement.

E31 Temperature Probe is Malfunctioning

This error message occurs when the resistance between the combinations of the 4 wire leads exceed proper values. Measuring resistance only requires 2 wires. 4 wire RTD use duplicate wires.

Reasons:

Resistance between the wires in the pairs varies outside spec.

Measured resistance from pair to pair exceeds spec.

RTD was missed wired.

The Flowcom S8 was damaged such that it can not interpret the resistance.

Fixing the Problem:

Power down the system, open the Flowcom S8, remove the RTD quick connect terminal block, measure resistance between 1 and 2 then 3 and 4. The resistance should be less than 1 ohm. The wires are paired wrong or the RTD has failed. Change pairing by finding pairs with less than 1 ohm resistance (2 sets).

Using the procedure in 1, confirm that the resistance between 1 and 3 then 2 and 4 matches the expected current temperature.

If 1 or 2 fails than the RTD is defective. Call Chart for a replacement.

If 1 and 2 are confirmed than the Flowcom S8 is defective. Call Chart for a replacement.

E32 EEPROM Fault

This error message occurs when the memory of the EEPROM can not be read

Fixing the Problem:

Reset the error message, press and hold STOP.

If the error message does not clear the EEPROM is defective. Call Chart for a replacement.

H99 Flow Rate higher than 99%

The message H99 is displayed during discharge when the flow rate exceeds its maximum.

The meter is not counting any liquid being transferred during this condition (Under-registering) and in the automatic mode the system terminates the delivery. H99 will continue to be displayed, clear by holding the stop button. Slow the pump speed down and restart the delivery. The flow range of the meter will only be exceed when the tank being delivered to is at low pressures and has minimal pressure drop in the fill circuit.

Fixing the Problem:

Clear H99 by holding the Stop Button.

Decrease pump speed

Dark Display

Check fuses inside the flow processor. If both the printer and the flow processor is not powered start with the fuse on the bottom board (NT06/NT06A) otherwise the one on the main board (FCLC).

If both fuses are good, check polarity of the power supply and whether the relay, located in the left upper corner of the bottom board, is properly plugged into its socket.

Printer is not working

1. Lamps on the printer are illuminated

   If you have just finished installation, check the wiring of the serial communication port between flow processor and printer. The printer does not work when two or more wires are confused . If the printer has become faulty after it had been working properly, also check the serial communication cable for a broken wire or disruption.

2. Lamps on the Printer are dark

Check if the printer has a power switch on its left side and if it is in on position (the older version TM290 does not have a switch). It can be always left on. Open the flow processor and check if the green lamp, located in the right upper corner of the bottom board, is illuminated while the meter is switched on. It indicates that the printer supply voltage is higher than 20 V. If the lamp is off while the display of the flow processor is working, unplug the printer connector X6, switch the meter off and then on again. If the lamp does not go on check the power supply voltage of the meter across the contacts of connector X5. It must be between 9 VDC and 30 VDC. If the supply voltage is within specs the bottom board needs to be replaced. If the lamp has been illuminated after switching off and on again, check the power supply voltage of the printer. It can be measured on the connector X6 between contacts 5 (positive) and 6 (negative). The multi-meter should read a voltage between 20 VDC and 26 VDC. If the voltage is outside this range the bottom board needs to be replaced. If found within the allowed range, plug in X5 and check the voltage again. In case of the lamp goes out when the X5 is plugged in, check the wiring for a short circuit. If the voltage is found within its range, the green lamp inside the flow processor is illuminated and the wiring is correct check the fuse inside the printer. For example, it burns out if the polarity has been confused.

VFD Troubleshooting Guide

When a fault trip occurs, the fault indicator is illuminated and the fault code and its description are displayed. The fault can be cleared with the Reset button or via an I/O terminal. The faults are stored to the fault history from where they can be viewed. The fault codes are explained in Appendix B, B-1/B-4 **SVX9000** Manual.

Fault codes	Fault	Possible cause	Checking
F1	Over current	SVX9000 frequency converter has measured too high a current (>4*In) in the motor output: - sudden heavy load increase - short circuit in the motor cables unsuitable motor	Check load Check motor size Check cables
F2	Over voltage	The voltage of the internal DC-link of the SVX9000 frequency converter has exceeded the nominal voltage by 35% - deceleration time is too fast - high over voltage spikes at utility	Adjust the deceleration time
F3	Ground fault	Current measurement detected that the sum of the motor phase current is not zero - insulation failure in the motor or the cables	Check the motor cables
F4	Inverter fault	SVX9000 frequency converter has detected faulty operation in the gate drivers or IGBT bridge - interference fault - component failure	Reset the fault and restart again. If the fault occurs again contact your Cutler Hammer distributor.
F5	Charging switch	Charging switch open when START command active - interference fault - component failure	Reset the fault and restart again. If the fault occurs again contact your Cutler Hammer distributor.
F9	Under voltage	DC-bus voltage has gone below 65% of the nominal voltage - most common reason is failure of the utility supply - internal failure of the SVX9000 frequency converter can also cause an under voltage trip	In case of temporary supply voltage break, reset the fault and start again. Check utility input. If utility supply is correct an internal failure has occurred. Contact your Cutler Hammer distributor.
F10	Input line supervision	Input line phase is missing	Check the utility connection
F11	Output phase supervision	Current measurement has detected that there is no current in one motor phase	Check motor cables
F12	Brake chopper supervision	- brake resistor not installed - brake resistor broken - brake chopper broken	Check brake resistor If resistor is OK the chopper is broken. Contact your Cutler Hammer distributor
F13	under temperature	Temperature of heat sink below -10ºC	

Fault codes	Fault	Possible cause	Checking
F14	over temperature	Temperature of heat sink over 75^0C For Compact NEMA 1 over 80^0C	Check the cooling air flow Check that the heat sink is clean Check the ambient temperature Check that the switching frequency is not too high for the ambient temperature and load.
F15	Motor stalled	The motor stall protection has tripped	Check the motor
F16	Motor over temperature	The SVX9000 motor temperature calculating model has calculated a motor over temperature	Decrease motor load Check the temperature model parameters if the motor wasn't too hot.
F17	Motor under load	The motor under load protection has tripped	Check motor and possible belts etc.
F18	Analog input hardware fault	Component failure on the control card	Contact your Cutler Hammer distributor
F19	Option board identification	Reading of the option board has failed	Check the installation of the board. If the installation is OK, contact your Cutler Hammer distributor.
F20	10 V voltage reference	+ 10 V reference shorted on the control card or on an option board	Check the wiring connected to the + 10 V reference
F21	24 V supply	+ 24 V supply shorted on the control card or on an option board	Check the wiring connected to the + 24 V reference
F22 F23	EEPROM Checksum failure	Parameter restoring error – interference – component failure	On resetting this fault, the drive will automatically load the parameter default settings. Check all parameters before restarting the drive. If the fault occurs again, contact your Cutler Hammer distributor
F25	Microprocessor watchdog	– interference – component failure	Reset the fault and restart. If the fault occurs again, contact your Cutler Hammer distributor
F26	Panel communication error	The connection between the drive and the panel doesn't work	Check the panel cable and connectors. If the fault occurs again, contact your Cutler Hammer distributor
F29	Thermistor protection	The thermistor input on the I/O boards has detected a motor temperature increase.	Check the motor load and cooling. Check the thermistor connection. If there are no thermistors, make sure the inputs are short-circuited.
F36	Analog input Im< 4 mA (signal range 4-20 mA selected)	The analog input current is below 4 mA – signal source failed – control cable broken.	Check the current loop circuitry
F41	External fault	An external fault has been detected at the digital input	Check the external fault source.

Flow processor Troubleshooting Table

Flow Meter Status Display and Error Messages - Software Version P.2.08.0		
Screen Display	**Status**	**Description**
"-S-"	Stand by mode	System is ready for delivery. In the automatic mode, start the delivery pressing start
"-E-"	End of Delivery	Metering is completed. Ticket can be printed at this time.
"LLL"	Low temperature	The liquid temperature has exceeded the lower limit of the current temperature setup. Verify that the temperature limits and that the current product matches parameter settings
"HHH"	High temperature	The liquid temperature has exceeded the upper limit of the current temperature setup. Verify that the temperature limits and that the current product matches parameter settings
"L10"	Metered flow rate below meterable range.	Metering is stopped if "L10" is displayed. In the automatic mode L10 only appears during the start up time out. In the manual mode, "L10" appears any time the flow drops below the meterable range.
"H99"	Metered flow rate above meterable range.	Metering is stopped if flow rate exceeds the meterable range. In the automatic mode the delivery will be terminated and "H99" will be displayed. In the manual mode if the flow rate exceeds the meterable range the totalizing of the delivery is stop until the flow rate is lowered to the acceptable range.
"E01"	Printer Error	If the printer is off, the paper is out or data transfer is interrupted, this message will appear for 5 seconds. Resolve the printer error and press start the ticket will be printed (original).
"E11"	Measured temperature is too low.	This 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. -A/D converter is defective
"E12"	Low Flow DP Transmitter Fault	The controller reads a 4 to 20 ma signal from the Low Flow DP transmitter. If the signal is less than 3.8 ma or higher than 19.9 ma when the system is powered up, "E12" will be displayed. Check the following: -Leaks in the sensor lines to the Low Flow DP transmitter. -Dispensing during start up. -Defective MAIN DP transmitter. -Defective power supply to MAIN DP transmitter.
"E13"	High Flow DP Transmitter Fault	The controller reads a 4 to 20 ma signal from the High Flow DP transmitter. If the signal is less than 3.8 ma or higher than 19.9 ma when the system is powered up, "E13" will be displayed. Check the following:-Leaks in the sensor lines to the High Flow DP transmitter. -Dispensing during start up. -Defective AUX. DP transmitter. -Defective power supply to AUX. DP transmitter.
"E16"	Calibration/Configuration mode	During calibration and configuration, the security switch is removed to allow

		communication. If the switch is not replaced (delivery position) and a delivery is attempted "E16" is displayed. During this error no metering is possible.
"E20"	Main Setup Fault	The main setup data is lost or not correct due to one of the following: -main setup parameters not entered or entered incorrectly. -EEPROM defective -EEPROM cannot be addressed
"E21"	Ram-Check Fault	RAM data lost. Normal with first operation. This fault can be cleared by pressing the "Stop" button. If this fault occurs with each system power up, the CPU may need to be exchanged.
"E23"	Configuration Data Error	"Public Data Are Missing or Checksum found incorrect during startup.
"E24"	Non-Critical (Public) Data Fault	
"E31"	PT100 Temperature Sensor Fault	The Temperature Sensor is defective or not connected properly. The current is out of tolerance.
"PE 01"	Calculation Fault	General division error
"PE 02"	Calculation Fault	Division of a long variable by zero
"PE 03"	Calculation Fault	Division of a floating variable by zero
"PE 04"	Calculation Fault	Overflow of a floating variable by zero
"PE 05"	Calculation Fault	Underflow of a floating variable by zero

Note: Error messages can be cleared by holding "Stop Button" for 5 seconds. If Error messages do not clear then consult the manual.

Variable Frequency Drive (VFD) Troubleshooting Table

VFD Troubleshooting Table

Fault codes	Fault	Possible cause	Checking
F1	Over current	SV9000 frequency converter has measured too high a current (>4*In) in the motor output: - sudden heavy load increase - short circuit in the motor cables unsuitable motor	Check load Check motor size Check cables
F2	Over voltage	The voltage of the internal DC-link of the SV9000 frequency converter has exceeded the nominal voltage by 35% - deceleration time is too fast - high over voltage spikes at utility	Adjust the deceleration time
F3	Ground fault	Current measurement detected that the sum of the motor phase current is not zero - insulation failure in the motor or the cables	Check the motor cables
F4	Inverter fault	SV9000 frequency converter has detected faulty operation in the gate drivers or IGBT bridge - interference fault - component failure	Reset the fault and restart again. If the fault occurs again contact your Cutler Hammer distributor.
F5	Charging switch	Charging switch open when START command active - interference fault - component failure	Reset the fault and restart again. If the fault occurs again contact your Cutler Hammer distributor.
F9	Under voltage	DC-bus voltage has gone below 65% of the nominal voltage - most common reason is failure of the utility supply - internal failure of the SV9000 frequency converter can also cause an under voltage trip	In case of temporary supply voltage break, reset the fault and start again. Check utility input. If utility supply is correct an internal failure has occurred. Contact your Cutler Hammer distributor.
F10	Input line supervision	Input line phase is missing	Check the utility connection
F11	Output phase supervision	Current measurement has detected that there is no current in one motor phase	Check motor cables
F12	Brake chopper supervision	- brake resistor not installed - brake resistor broken - brake chopper broken	Check brake resistor If resistor is OK the chopper is broken. Contact your Cutler Hammer distributor
F13	SV9000 under temperature	Temperature of heat sink below -10ºC	
F14	SV9000 over temperature	Temperature of heat sink over 75^{0}C For Compact NEMA 1 over 80^{0}C	Check the cooling air flow Check that the heat sink is clean Check the ambient temperature Check that the switching frequency is not too high for the ambient temperature and load.
F15	Motor stalled	The motor stall protection has tripped	Check the motor
F16	Motor over temperature	The SV9000 motor temperature calculating model has calculated a motor over temperature	Decrease motor load Check the temperature model parameters if the motor wasn't too hot.
F17	Motor under load	The motor under load protection has tripped	Check motor and possible belts etc.
F18	Analog input hardware fault	Component failure on the control card	Contact your Cutler Hammer distributor
F19	Option board identification	Reading of the option board has failed	Check the installation of the board. If the installation is OK, contact your Cutler Hammer distributor.
F20	10 V voltage reference	+ 10 V reference shorted on the control card or on an option board	Check the wiring connected to the + 10 V reference
F21	24 V supply	+ 24 V supply shorted on the control card or on an option board	Check the wiring connected to the + 24 V reference
F22 F23	EEPROM Checksum failure	Parameter restoring error – interference – component failure	On resetting this fault, the drive will automatically load the parameter default settings. Check all parameters before restarting the drive. If the fault occurs again, contact your Cutler Hammer distributor
F25	Microprocessor watchdog	– interference – component failure	Reset the fault and restart. If the fault occurs again, contact your Cutler Hammer distributor
F26	Panel communication error	The connection between the drive and the panel doesn't work	Check the panel cable and connectors. If the fault occurs again, contact your Cutler Hammer distributor
F29	Thermistor protection	The thermistor input on the I/O boards has detected a motor temperature increase.	Check the motor load and cooling. Check the thermistor connection. If there are no thermistors, make sure the inputs are short-circuited.
F36	Analog input Im< 4 mA (signal range 4-20 mA selected)	The analog input current is below 4 mA – signal source failed – control cable broken.	Check the current loop circuitry
F41	External fault	An external fault has been detected at the digital input	Check the external fault source.

General Troubleshooting Table

ORCA General Troubleshooting Table

Symptom	Possible Cause	Remedy
Control panel does not light up.	Fuse blown in 12-volt control circuit. 12-volt circuit open.	Replace fuse in fuse panel in truck. Verify connector is plugged in at front of tank. Also inspect wires from connector to control panel for breaks, cuts, etc. Repair if necessary.
Low voltage or high voltage error messages on VFD.	Alternator spinning too fast or too slow.	Adjust truck engine speed accordingly.
Over current error message on VFD.	Pump drawing too much current. Worn bearings in pump.	Slow pump speed down using control on pendant. Remove and replace pump.
Dispense valve does not open.	No air supply to the valve. No 12-volt power to the solenoid. Valve is frozen.	Verify that there is sufficient air in air tanks. Valve requires 100psi to operate. Verify solenoid is plugged into junction box, and that the wires are not broken. Thaw out valve. **Caution: Do NOT use fire or flame to thaw valve on an oxygen unit!!**
Flowcom flow meter cycles through boot-up repeatedly.	Defective front board in Flowcom.	Obtain replacement front board from factory and replace.
E 12 error code on Flowcom.	Liquid flow through meter section before meter is turned on. DP transmitter defective. Wiring defective. Flowcom S8 defective.	Press STOP button on control pendant. Verify transmitter is plugged into junction box JB1, and that the 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.
Unstable flow of product.	Depletion of sub-cool. Liquid level low.	Add sub-cool by opening pressure building coil. 5 to 7 psi above saturation pressure is required. **Caution: Venting during delivery will cause depletion of sub-cool, and may also cause damage to pump!** 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	Possible Cause	Remedy
Unstable flow of product (cont.)	Two-phase flow. This occurs when a combination of liquid and gas flows through the pump.	Increase sub-cool. If the saturation pressure is high, the vessel may have to be blown down, then sub-cool added.
Audible change in pump.	Liquid level low. Worn bearings in pump.	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!** Remove and replace pump.
Pump not catching prime.	Insufficient sub-cool. Liquid level low.	Add sub-cool by opening pressure building coil. 5 to 7 psi above saturation pressure is required. **Caution: Venting during delivery will cause depletion of sub-cool, and may also cause damage to pump!** 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!**
No "Go" indication on Flowcom. (Flashing "0.0" after countdown.)	Meter section not cooling down.	Open the P.B. Gravity Feed valve located on the valve stand to the right of the control panel, third valve from the top. Leave open until "Go" indication appears.
E01 appears on Flowcom.	Printer error.	Verify that the cables to the printer are plugged in, that the printer is turned on, and that there is paper in the printer.

Section 8 Parts & Accessories

Suppliers

The components of the ORCA cryogenic system are available directly from the supplier or from Chart. The following listing of parts indicates the part name, number and manufacturer.

For replacement parts listed or not listed in this manual, contact Chart at
1-800-400-46(M)8(V)3(E)

PERMA-CYL®

ON-SITE STORAGE SYSTEM - MICROBULK SOLUTIONS

The Perma-Cyl® storage system allows users to enjoy the benefits of on-site gas delivery. Gone are the hassels, waste, and expense of full-for-empty gas cylinders. Using Perma-Cyls, there are no cylinders to change, no residual gas losses, no back, hand or foot injuries from handling cylinders, and no lost or damaged cylinders.

Perma-Cyls are reliable, efficient, and more economical than comparable transportable cylinders. Designed for a higher level of thermal efficiency, Perma-Cyls can hold their gas contents longer with lower pressure rise than other similar vessels. Their extraordinary thermal quality limits product losses during extended periods of little gas use.

The innovative Perma-Cyl storage system incorporates a top fill float designed to allow single-hose filling without losses. It automatically shuts off the ORCA delivery unit for a safe and reliable fill.

PRODUCT BENEFITS

- The first fill-at-site solution for packaged or cylinder gas users
- Fast filling capable
- Single hose no-loss/low-loss filling
- Automatic fill shutoff when used with ORCA
- Extended holding times
- Telemetry ready with Cyl-Tel® gauge

PRODUCT ADVANTAGES

- Sizes, pressures and configurations to meet most applications
- Capacities from 230 liters to 2,000 liters (60.8 gal to 528.3 gal)
- Pressures from 235 psi to 500 psi (16.2 bar to 34.5 bar)
- Patented automatic fill shut-off feature with optional fill box allows for remote filling from outside the building or compound when a Perma-Cyl is installed indoors
- ORCA automatically safely stops the fill process when Perma-Cyl is full
- Patented Cyl-Tel gauge supports remote alarms or telemetry communications
- High-pressure high flow models for laser assist applications
- Combination pressure control regulators with micrometer adjustment knob or screw
- Outdoor or indoor installation and operation

CHART®

Innovation. Experience. Performance.

PERMA-CYL®

ON-SITE STORAGE SYSTEM - MICROBULK SOLUTIONS

SPECIFICATIONS

DESCRIPTION	230L MP, LCCM Sq/Rnd Base w/Casters	230L HP, LCCM Sq/Rnd Base w/Casters	265L MP, LCCM Sq/Rnd Base w/Casters	265L HP, LCCM Sq/Rnd Base w/Casters	300L MP Plate Base	450L HP Plate Base	450L MP Plate Base	450L HP Plate Base	450L VHP Plate Base	700L HP Plate Base	1000L HP Plate Base	1000L VHP Plate Base	1500L HP Pallet Base	1500L VHP Pallet Base	2000L HP Pallet Base	2000 L VHP Pallet Base
CAPACITY (Liters)																
Gross	240	240	276	276	330	450	450	450	450	688	1,056	1,056	1,550	1,550	2,042	2,042
Net	230	230	265	265	300	420	420	420	420	645	950	950	1,455	1,455	1,945	1,945
CAPACITY (Gallons)																
Gross	63.4	63.4	72.9	72.9	81.2	118.9	118.9	118.9	118.9	181.8	279.0	279.0	409.5	409.5	539.5	539.5
Net	60.8	60.8	70.0	70.0	79.3	111.0	111.0	111.0	111.0	170.4	251.0	251.0	384.4	384.4	513.9	513.9
MAWP																
psig	230	350	230	350	300	350	250	350	500	350	350	500	350	500	350	500
bar	15.9	24.1	15.9	24.1	20.7	24.1	17.2	24.1	34.5	24.1	24.1	34.5	24.1	34.5	24.1	34.5
MAXIMUM PRE-SET OPERATING PRESSURE																
psig	125	300	125	300	250	300	125	300	450	300	300	450	300	450	300	450
bar	8.6	20.7	8.6	20.7	17.2	20.7	8.6	20.7	31.0	20.7	20.7	31.0	20.7	31.0	20.7	31.0
DESIGN SPECIFICATIONS																
	DOT	DOT	DOT	DOT	ASME	DOT	ASME	ASME	ASME	ASME	ASME	ASME	ASME	ASME	ASME	ASME
STORAGE CAPACITY (1)																
Nitrogen																
SCF	5,024	4,734	5,769	5,769	7,380	8,875	10,332	10,332	10,332	15,860	24,350	24,350	35,790	35,790	47,847	47,847
Nm^3	142	134	152	152	193	271	272	272	272	449	689	689	1,013	1,013	1,257	1,257
Oxygen																
SCF	6,244	5,930	7,186	7,186	9,100	11,124	12,760	12,760	12,760	19,600	30,070	30,070	44,220	44,220	59,089	59,089
Nm^3	177	168	189	189	184	315	336	336	336	554	850	850	1,250	1,250	1,553	1,553
Argon																
SCF	6,073	5,763	6,982	6,982	8,850	10,812	12,478	12,478	12,478	19,160	29,400	29,400	43,220	43,220	57,786	57,786
Nm^3	172	163	183	183	234	306	328	328	328	542	832	832	1,223	1,223	1,519	1,519
CO_2																
SCF	N/A	4,500	N/A	N/A	N/A	8,312	N/A	8,200	8,200	12,608	19,960	19,960	29,340	29,340	38,048	38,048
Nm^3	N/A	N/A	N/A	N/A	N/A	235	N/A	232	232	357	564	564	830	830	1,000	1,000
THERMAL PERFORMANCE (2) (NER%/Day)																
N_2	1.8%	1.8%	2%	2%	1.2%	1.9%	1.6%	1.6%	1.6%	1%	1%	1%	1%	1%	1%	1%
O_2-Ar	1.12%	1.12%	1.4%	1.4%	.74%	1.2%	1%	1%	1%	.62%	.62%	.62%	.62%	.62%	.62%	.62%
CO_2	.6%	.6%	N/A	N/A	.4%	.6%	.5%	.5%	.5%	.3%	.3%	.3%	.3%	.3%	.3%	.3%
GAS DELIVERY RATE (LIN/LAR/LOX)																
SCF/H	400	400	400	400	500	575	575	575	575	660	960	960	1,350	1,350	1,350	2,000[3]
Nm^3h	10.5	10.5	10.5	10.5	14.1	15.1	15.1	15.1	15.1	18.6	25.2	25.2	35.4	35.4	35.4	52.4
GAS DELIVERY RATE (CO_2)																
SCF/H	N/A	133	N/A	N/A	N/A	192	192	192	192	220	320	320	450	450	450	667
Nm^3h	N/A	3.8	N/A	N/A	N/A	5.4	5.4	5.4	5.4	6.2	9.0	9.0	12.7	12.7	12.7	17.5
DIMENSIONS																
Diameter																
in	26	26	26	26	26	30	30	30	30	42	42	42	48	48	48	48
mm	660	660	660	660	660	762	762	762	762	1,067	1,067	1,067	1,219	1,219	1,219	1,219
Height																
in	61.8/62	61.8/62	64.6/64.8	64.6/64.8	68	68	68	68	68	60	81	81	91	91	117	117
mm	1,570/1,575	1,570/1,575	1,641/1,646	1,641/1,646	1,727	1,727	1,727	1,727	1,727	1,524	2,058	2,058	2,311	2,311	2,970	2,970
Tare Weight																
lbs	300	340	340	340	450	688	605	688	812	1,065	1,750	2,250	3,080	3,350	3,860	3,860
kg	136	154	154	154	204	312	274	312	368	483	794	1,020	1,395	1,518	1,751	1,751

All specifications are subject to change without prior notice.
1) Values are based on net capacity at 0 psig (0 bar) for ASME vessels. CO_2 vessels are based on net capacity at 300 psi (20.7 bar). DOT vessels are per code.
2) Values are based on gross capacity.
3) Optional 3,500 SCF/H (92 Nm^3h) model available.
All dimensions are measured from the floor to the top of the handling ring. All of the plumbing components fit under the handling ring.

Patents: 5,787,942 • 5,954,101 • 5,136,852 • 6,542,848 - Other Patents Pending
DOT- Department of Transportation, 4L Code
ASME- American Society of Mechanical Engineers, Section VIII, Division 1
Contact Factory for Canadian and New York City Approvals.

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PN 11000938

CYL-TEL®

DIGITAL ELECTRONIC LIQUID LEVEL GAUGE

Cyl-Tel Gauge Specifications

Physical

- Approximately 4.75"w x 3.25"h x 3.75"d
- Mounting compatible with current differential pressure gauges used on Chart/MVE products
- Gauge is in a water-resistant enclosure (NEMA 4)
- Range - 0-160" H_2O
- Pressure - 500 psig maximum
- Differential Pressure - 30 psig maximum
- CE Listed

Electrical Inputs

- 12VDC at 500mA (AC Adapter)
- Optional battery powered, 9VDC *(level only, inactive Telemetry)*

Outputs

- Two independent programmable alert levels, programmable in 5% increments up to 100% for phone transmitter or local alert relay
- Electronic pulse output connection for interface board, satellite and cellular telemetry systems
- Low battery indicator
- Unit of measure indicator *(See Programmable Features)*
- Large 5 character x 0.4" High LCD Display

Sensor Accuracy

± 2.5% of Full Scale

Operator Interface

Keypad

Operating Temperature

-30°C to +70°C

Display Resolution

% Full = 5%

Gal = 1

L = 1

Lbs = 1

Kg = 1

SCF = 10

NM = 1

Programmable Features

- Product Type: LN_2, N_2O, LAr, O_2, CO_2

Unit of Measure

Gallons (Gal)
Liters (L)
Pounds (Lbs)
Kilograms (Kg)
Standard Cubic Feet (SCF)
Normal Cubic Meters (NM^3)
Inches H_2O (no light indicator)
Percent Full (% Full)

Alert Programmability

- Alert 1 programmable from 0% to 100% in 5% increments
- Alert 2 programmable from 0% to 100% in 5% increments

Interface Board (optional)

- Voltage output
  1-5VDC
- Current output
  4-20mA

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 PN 11083315

Section 9 Spare Parts

ORCA Spare Parts-Inert Service

Description:	Part Number:
HL-2000 Inert	11667628
HL-2800 Inert	11708101
HL-3300 Inert	11759670
Fire Extinguisher	11826377
Control Panel (new)	11694589
Fill, Hose Bulk 1 ½" to 1 ½" CGA 15' LIN	11705866
Fill, Hose Bulk 1 ½" to 1 ½" CGA 15' LAR	11705840
Extension Hose Flare Inert 16'	11732303
Extension Hose Quick Connect LIN 16'	11712361
Extension Hose Quick Connect LAR 16'	11709963
PP-5 Valve	10601580
PP-5 Button	11720951
PP-5 Pin	11720943
Truck Wiring Harness Low Voltage 12 VDC	11925797
Variable Frequency Drive LIN (new)	11758925
Variable Frequency Drive LIN (rebuilt)	11758925R
Variable Frequency Drive LAR (new)	11664881
Variable Frequency Drive LAR (rebuilt)	11664881R
Printer-Epson	913700
Printer DC/DC 12-24 VDC Converter	10963978
Printer Box	11720142
Printer Ribbon	11693421
Printer Power Cord 6'	11764428
Printer Data Cable	11764436
Flowcom	10918561
Flowcom CPU Board	913679
Flowcom Main Backboard	913677
Flowcom Display Board	913678
Heater Kit Assy.	11498676
Heater Power Inverter	11510241
Heater Strip	11510225
Heater Plug Receptacle	11910966
Heater Plug Receptacle Cover	11910974
Heater Plug 120VAC	11910958
Heater Cord 120 VAC 16-3	11910982
Heater Cord Locknut	11910991
Heater Cord Strain relief	11911002
Remote Pendant	11694600
Remote Pendant Enclosure	11911213
Remote Pendant Cord-16'	11911248
Start Button Green	11911256
Start Button Contact Block-NO	11912339
Stop Button-Red	11911281
Stop Button Contact Block-NO	11912399
Pump Speed Control Dial	11911301
Remote Pendant Locknut	11911088
Control Power Switch-12 VDC	11910704
Control Power Switch Contact Block-NC	11912321
Control Power Switch Contact Block-NO	11912339
Door Interlock Switch	119010510
Door Interlock Switch Bracket	11901608
Printer Locknut	11910991
Printer Strain Relief	11911002
Printer Power Cord	11911133
RTD Locknut	11910991
RTD Strain Relief	11911002
RTD Power Cord	11911109
P/I 209 Locknut	11911176
P/I 209 Strain Relief	11911168
P/I 209 Power Cord	11911168
Power In Locknut	11911088
Power In Strain Relief	11911096

Highlighted items are commonly used spare parts or wear items. To order, contact a Chart Inc. Representative for assistance at: 1-800-400-4683

ORCA Spare Parts-Inert Service

Description:	Part Number:
Power In Power Cord	11911133
SV 125 Locknut	11910991
SV 125 Strain Relief	11910002
SV 125 Power Cord	11910982
SV 128 Locknut	11910991
SV 128 Strain Relief	11911002
SV 128 Power Cord	11910982
Main Contactor 440 VAC	11910763
Contact Relay CR104	11910801
Contact Relay Socket	11910819
Contact Relay Hold Down Spring	11910827
Contact Relay CR105	11910801
Contact Relay Socket	11910819
Contact Relay Hold Down Spring	11910827
Contact Relay CR209	11910801
Contact Relay Socket	11910819
Contact Relay Hold Down Spring	11910827
Contact Relay CR211	11910801
Contact Relay Socket	11910891
Contact Relay Hold Down Spring	11910827
Contact Relay CR112	11910923
Contact Relay Socket	11910931
Contact Relay Hold Down Spring	11910827
Fuse 10 amp 32 VDC	11910780
Fuse Terminal	11910798
TB-1Terminal Block Numbered Tags	11912283
TB-1Terminal Block	11910747
TB-1 Terminal Block End Clamp	11910755
TB-1 Terminal Block Jumpers	11926298
TB-1 Terminal Block Mounting Rail	11926301
TB-2 Terminal Block Numbered Tags	11912283
TB-2 Terminal Block	11910747
TB-2 Terminal Block End Clamp	11910755
TB-2 Terminal Block Mounting Rail	11916301
Pump, Submerged-Inert (new)	10757648
Pump, Submerged-Inert (rebuilt)	10757648R
Pump, Kit Rebuild-Inert	11036068
Pump, Gasket-Inert	10804491
Pump, Grease Halocarbon	10684661
Pump, Lock wire-Inert	29N0022
Pump, Screen Assy.-Inert	11034724
Alternator, 10KW Marathon (new)	913515
Alternator, 10KW Marathon (rebuilt)	913515R
Alternator Link Board	11708952
Temperature Interlock Kit-complete without Red Loin Set Point Output Card	11801938
Temperature Interlock Box-complete without Thermocouple	11898274
Temperature Interlock Thermocouple	11798193
Temperature Interlock Set Point Output Card (Red Loin)	
Tool Box Assy.	11709795
Service Valve Pneumatic 4-way	1711312
Service Valve Pneumatic 4-way Muffler	9097553
Belleville Spring Washer	10809268
Label, Door Kit HL-3300-Inert	11926731
Label, Door Kit HL-2800-Inert	11926749
Label, Door Kit HL-2000-Inert	11926731
Label, Door Kit HL-2800-LOX	11926749
Label, Door Kit HL-2000-LOX	11926482
Label, Door Kit HL-1650-LOX Spanish	11913147
Label, Door Liquid Level Chart HL-3300-LOX	11926693
Label, Door Liquid Level Chart HL-2000-LOX	11926685
Label, Door PTO/Alternator	11926757
Label, Door Automatic Mode	11926491
Label, Door Manual Mode	11926626
Label, Door Pressure Transfer	11926634
Label, Door Ticket Printing	11926642
Label, Door VFD Fault Codes	11926503
Label, Door Flowcom Fault Codes	11926651

Highlighted items are commonly used spare parts or wear items. To order, contact a Chart Inc. Representative for assistance at: 1-800-400-4683

ORCA Spare Parts-Inert Service

Description:	Part Number:
Label, Door Troubleshooting Guide	11926669
Label, Door Sub-Cool Warning	11926511
Label, Door Emergency Discharge	11926677
Label, Valve Tags	11926520
Label, Door Technical Service	11926925
Label, Service Valve	11819661
Label DOT OXYGEN REFRIGERATED LIQUID	11713049
Label DOT OXYGEN REFRIGERATED LIQUID UN1073	11713006
AOV-1 Dispensing Air Operated Valve (Worcester #CRK44PM-1, 1" Ball Valve)	10800108
AOV-1 Ball Valve Repair Kit	10802445
AOV-2 Pump Flood Air Operated Valve (CVI#V1070-200-J, 2" Globe Valve w/Acct.)	11750069
AOV-2 Globe Valve Repair Kit	
AOV-3 Pump Block Air Operated Ball Valve (Worcester #CRK44PM, 1" Ball Valve)	10800108
AOV-3 Ball Valve Repair Kit	10802445
V-3 Top Fill Valve (REGO #BKA9412, 1 ½" Globe Valve)	10927184
V-3 Globe Valve Seat Kit	10997861
V-3 Globe Valve Packing Kit	10997852
V-3 Globe Valve Hand Wheel	10997801
V-5 Vapor Vent Valve (REGO #BKY8408, 1" Globe Valve)	10927192
V-5 Globe Valve Packing Kit	10997810
V-5 Globe Valve O-Ring Kit	10997844
V-5 Globe Valve Seat Kit	10997895
V-9 Fill Line Drain Valve (REGO #T9453, 3/8")	1713202
V-10 LI-1 Equalization Valve (Whitey #SS-1VS4-SC-11, ¼")	11701435
V-11 LI-1 Vapor Phase Valve (Whitey #SS-1VS4-A-SC-11, ¼")	11701443
V-12 LI-1 Liquid Phase Valve (Whitey #SS-1VS4-A-SC-11, ¼")	11710443
V-13 Pump Discharge Isolation Valve (Whitey #SS-1VS4-A-SC-11, ¼")	11710443
V-16 PB Force Feed Valve (REGO #BK8408T, 1" Globe Valve)	1718772
V-16 Globe Valve Seat Kit	10997895
V-16 Globe Valve Top Works Kit	10997924
V-17 Bottom Fill Valve (REGO #BKA9412, 1 ½" Globe Valve)	10927184
V-17 Globe Valve Seat Kit	10997861
V-17 Globe Valve Seat Kit	10997861
V-17 Globe Valve Packing Kit	10997852
V-17 Globe Valve Hand Wheel	10997801
V-18a 95% Trycock Valve (REGO #T9453, 3/8")	1713202
V-18c 90% Trycock Valve (REGO #T9453, 3/8")	1713202
V-23 Liquid Sample Valve (REGO #T9453, 3/8")	1713202
V-30 Dispense Line Drain Valve (REGO #T9453, 3/8")	1713202
V-31 LI-1 Vapor Phase Isolation Valve	1711862
V-32 LI-1 Liquid Phase Isolation Valve	1711862
V-40 PB Gravity Force Feed Valve	1713202
V-41 Transfer Hose Valve	11007881
V-41 Transfer Hose Valve Handle	259098
V-42 Recirculation Valve (REGO #BK8400-80BJ, 1")	1718772
V-42 Globe Valve Seat Kit	10997895
V-42 Globe Valve Top Works Kit	10997924
V-43 Vapor Return Assist Valve	1718772
V-43 Globe Valve Seat Kit	10997895
V-43 Globe Valve Top Works Kit	10997924
V-45 Pumpout Isolation Valve	10562120
V-99 Vacuum/TC Isolation Valve	10482381
DC-1 Dispensing Connection	11751424
DC-2 Fill Line Connection Service Assy LOX (1 ½" CGA)	10889448
DC-2 Fill Line Connection Service Assy LOX (2" CGA)	11708776
DC-2 Fill Line Connection Service Assy LOX (3" CGA)	11704572
DC-5 Pumpout Connection	1211571
LI-1 Inner Vessel Level Indicator	11532088
PI-1 Inner Vessel Pressure Indicator	11707191
PI-2 Pump Discharge Pressure Indicator	11702121
PBC-1 Pressure Building Coil	11739450
PCV-1 Road Relief Regulator	
SD-2 Outer Vessel Pressure Safety Element (Vacuum Tube Lift-6")	4410621
SD-2 Outer Vessel Pressure Safety Element (Vacuum Lift Plate-6")	4410611
SD-2 Outer Vessel Pressure Safety Element (Safety Chain No. 2-6")	9025782
SD-2 Outer Vessel Pressure Safety Element (O-Ring Viton 5.25ID x 5.75OD)	2324314
RTD-1 Resistance Temperature Device	11783362

Highlighted items are commonly used spare parts or wear items. To order, contact a Chart Inc. Representative for assistance at: 1-800-400-4683

ORCA Spare Parts-Inert Service

Description:	Part Number
SOV-1 Hose Drain Solenoid Operated Valve (MAGNATROL #E29LR62Z, ½")	10856531
SOV-1 Repair Kit (Coil, Gasket)	11879815
SV-1a Vent Circuit Safety Relief Valve (56 psi)	1810732
SV-1b Vent Circuit Safety Relief Valve (56 psi)	1810732
SV-1c Vent Circuit Safety Relief Valve (70 psi)	11815951
SV-3 Dispensing Thermal Relief Valve	11670000
SV-4 Fill Line Thermal Relief Valve	11670000
SV-7 Recirculation Thermal Relief Valve	
TC-1 Thermocouple/Vacuum Connection	4210049
Anti-tow Valve	10469961
Pump Flood Valve	10469961
Anti-Tow Muffler	909755

Highlighted items are commonly used spare parts or wear items. To order, contact a Chart Inc. Representative for assistance at: 1-800-400-4683

Section 10 Liquid Level Charts

Liquid Level Chart 2000 Gallon-Inert Service (LIN/LAR)

LIQUID LEVEL							
Argon				Nitrogen			
In H_20	Liquid (Gallons)	Weight (Pounds)	Gas (CU FT)	In H_20	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				

CHART

Orca 2000 LIN/LAR

(0 psig Saturation Pressure)

Liquid Level Chart 2800 Gallon-Inert Service (LIN/LAR)

LIQUID LEVEL							
Argon				Nitrogen			
In H_20	Liquid (Gallons)	Weight (Pounds)	Gas (CU FT)	In H_20	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				

CHART

Orca 2800

(0 psig Saturation Pressure)

Liquid Level Chart 3300 Gallon-Inert Service (LIN/LAR)

LIQUID LEVEL

Argon				Nitrogen			
In H_20	Liquid (Gallons)	Weight (Pounds)	Gas (CU FT)	In H_20	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				

CHART

HL-3300

(0 psig Saturation Pressure)

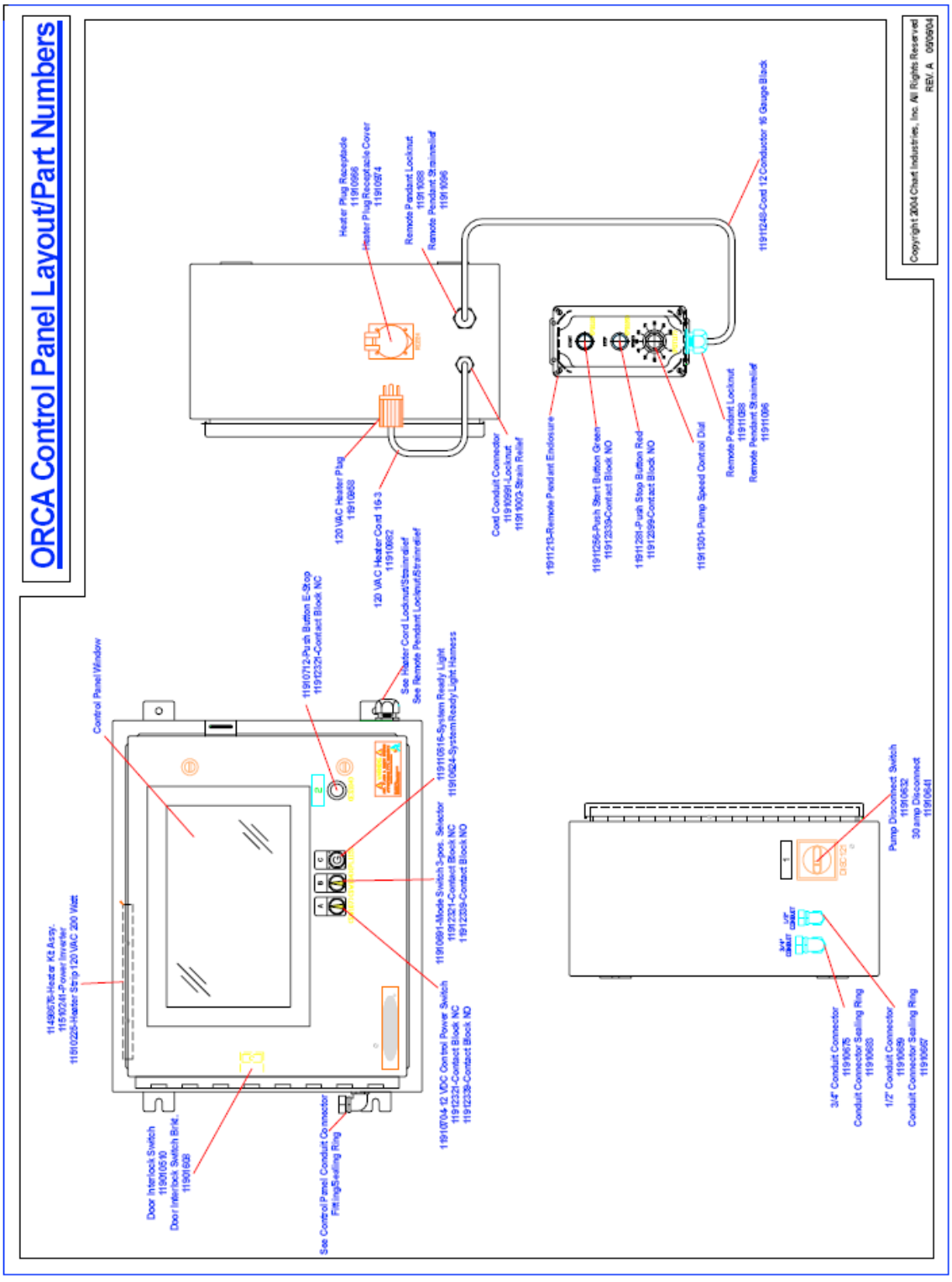
Liquid Level Chart 4200 Gallon-Inert Service (LIN/LAR)

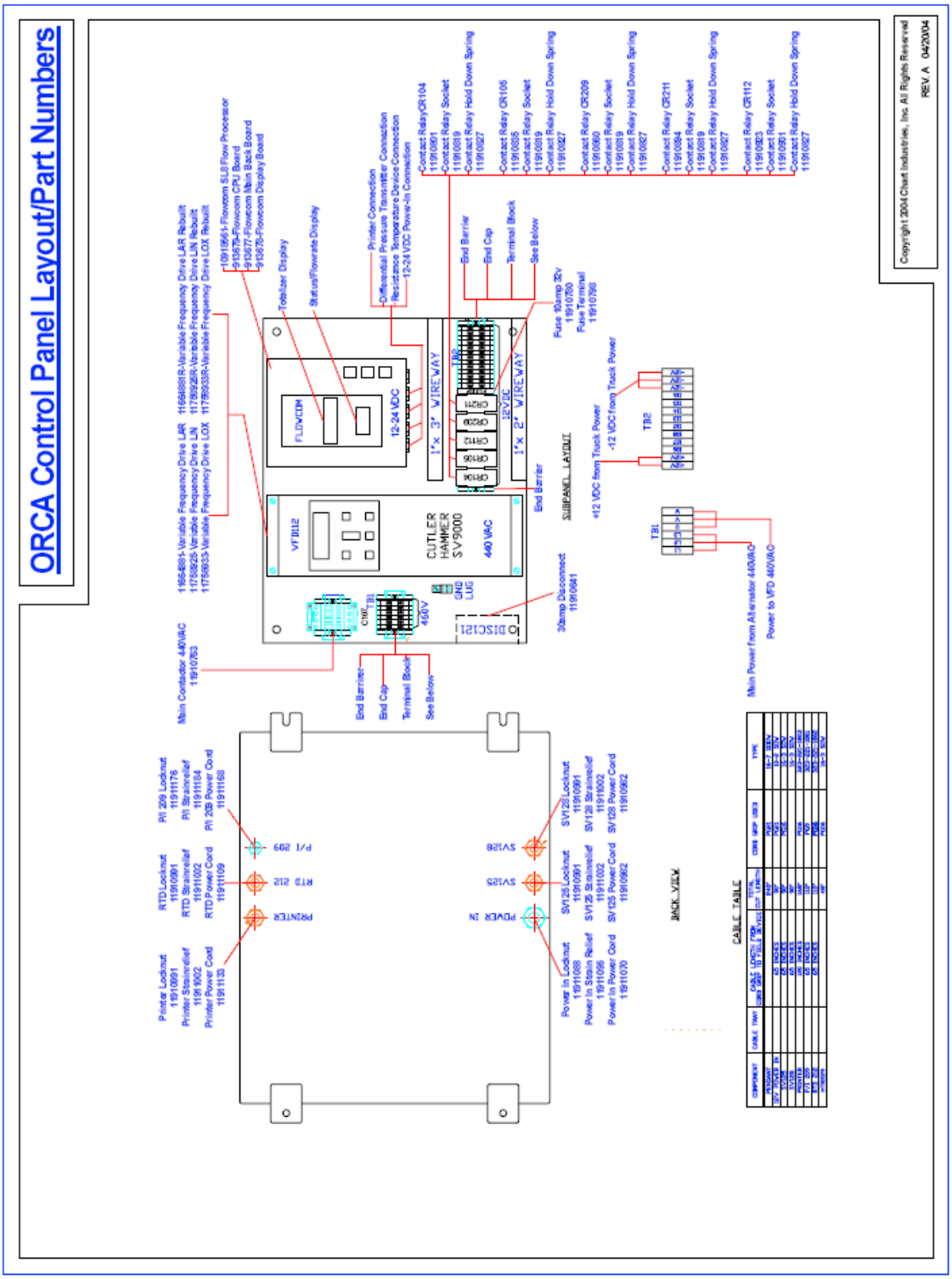
LIQUID LEVEL							
Inches of Water	Volume (Gallons)	Nitrogen Weight (lb)	Gas (SCF)	Inches of Water	Volume (Gallons)	Nitrogen Weight (lb)	Gas (SCF)
0	0	0	0	36	3,046	20,557	283,252
1	10	67	931	37	3,147	21,238	293,144
2	38	254	3,499	38	3,247	21,912	302,440
3	75	507	6,995	39	3,346	22,577	311,617
4	120	812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

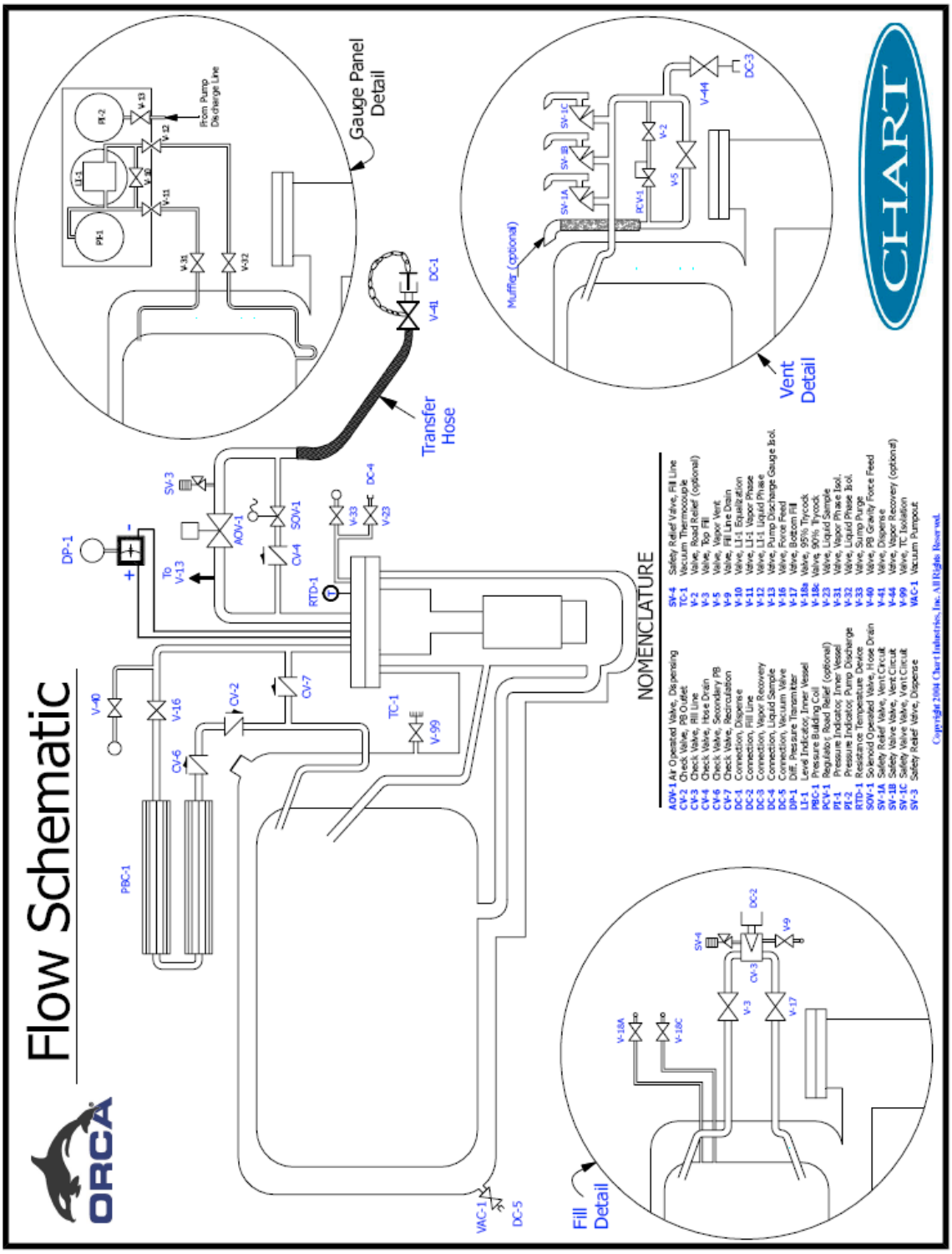
ORCA 4200

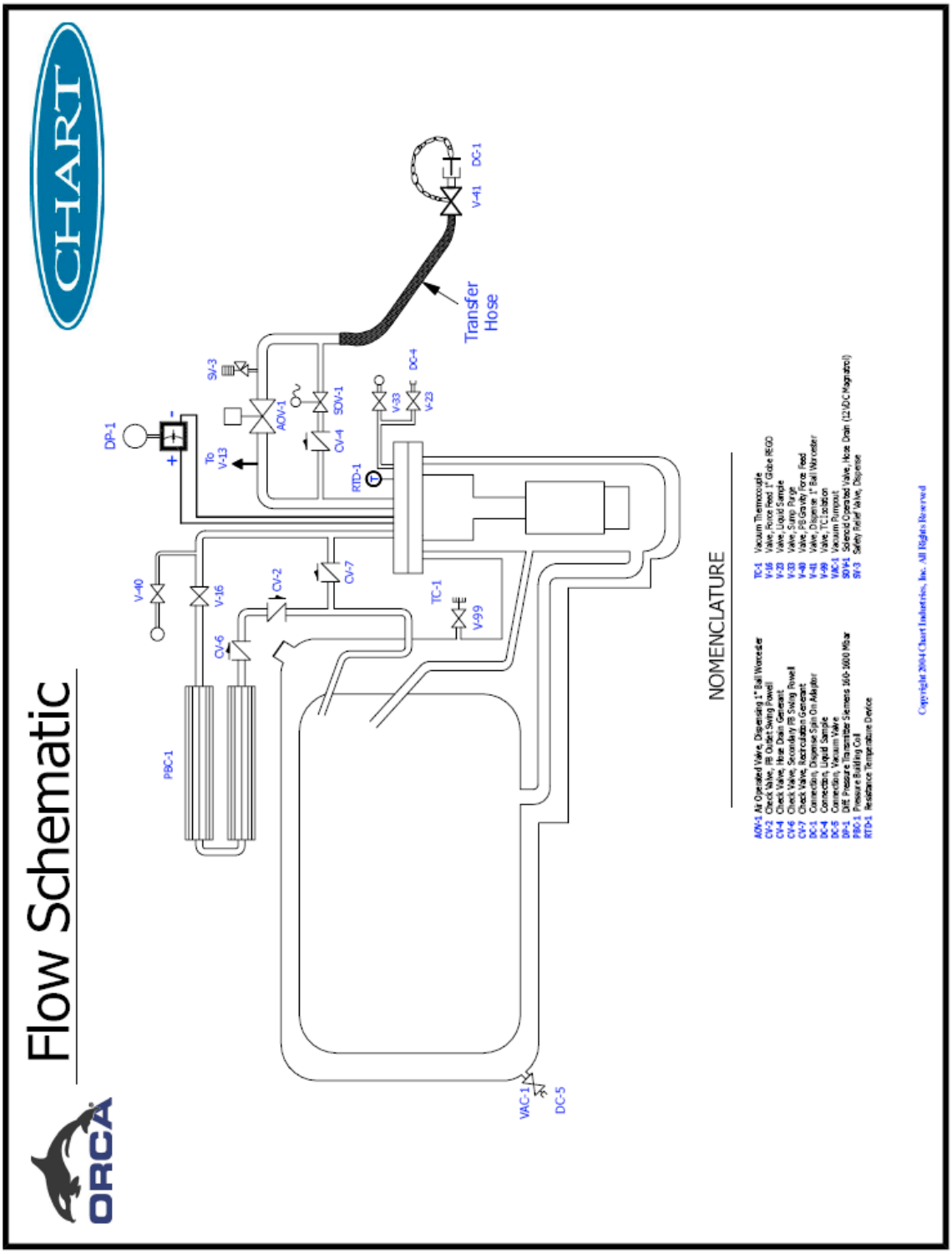
(0 psig Saturation Pressure)

Section 11 Drawings









Section 12 ORCA Warranty

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 Unit. If warranty replacement of part is required, the ORCA 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

Resistance Temperature Device (RTD)	1 Year from shipment of ORCA
Differential Pressure Transmitter (DP Transmitter)	1.5 Year from shipment of ORCA
Spin-On Connector	6 Months from date of shipment of ORCA
Meter Element 1"	Life of ORCA
Differential Pressure Gauge 0-100" H20	1 Year from Shipment of ORCA
AOV-1	1 Year form Shipment of ORCA
AOV-2	1 Year from Shipment of ORCA
AOV-3	1 Year from Shipment of ORCA
ORCA Delivery Hose	1 Year from Shipment of ORCA
Flowcom Flow Processor	6 Months from date of shipment of ORCA
Printer	6 Months from date of shipment of ORCA
Alternator	1 Year from shipment of ORCA
Generator	1 Year from shipment of ORCA
Pump Submersible LIN/LAR Service	1 Year from date of shipment of ORCA
Pump External LOX Service	1 Year from date of shipment of ORCA
Composite Face Seal (CFS)	9 Months from date of shipment
Variable Frequency Drive (VFD)	2 Years from date of shipment
Control Panel (440 VAC)	6 Months from date of shipment of ORCA

Standard Warranty

Workmanship and Vacuum

Chart Inc. warrants all ORCA Delivery Tanks 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. We also guarantee that the Annular Space Pressure will not exceed 20 Microns, when the Inner Vessel is cold, within ONE YEAR of the date of shipment of the ORCA Unit. 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 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 part or workmanship that Chart Inc. manufactured and found to be defective within ONE YEAR after ship date of ORCA 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.**

Chart Standard Warranty

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 Northwest
   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 a 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 the 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 warrant 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.**