Product Manual

Orca™ MicroBulk Delivery System

CO_2 Series

Designed and Built by:

Chart Inc.

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Part Number 21235568 Rev. D

Contents

Revision Log

Revision Level	Date	Description
A	2/21/2018	Original
B	3/8/2018	Added parts and specs update
C	6/18/2018	Specs change, added preventive maintenance log
D	10/15/2018	Inclusion of Trailer components

Preface

General

Chart's MicroBulk delivery system has revolutionized the gas industry by making on-site distribution for smaller accounts a profitable reality. The Orca CO_2 Series delivery unit has been designed to flow up to 500 pounds-per-minute with minimal pump cooling or product loss under normal conditions. Fill termination with Sure-Fill eliminates lost product associated with overfilling. In total, the Chart CO_2 MicroBulk system increases asset utilization, reduces labor costs and maximizes distribution efficiency.

Chart offers the complete MicroBulk CO_2 delivery system as a solution to reliably and effortlessly manage a diverse range of applications. The Orca CO_2 Series delivery unit offers fast, reliable and accurate on-site delivery to Perma-Max and Carbo Series storage vessels or small bulk tanks. The Perma-Max line offers the widest range of sizes and piping options and the greatest flexibility with accommodations for indoor and outdoor installation.

Product Highlights

- Fast on-site filling of the Perma-Max storage system
- Fast-filling of Carbo-Max and Carbo-Mizer
- Flowcom® Flow Meter System
- National Institute of Standards & Technology (NIST) and California Weights and Measures approved metering system
- Large cabinet with removable access panels for ease of maintenance and servicing
- Pressure transfer for small delivery
- Optional pump transfer for bulk deliveries; pump can also be used to fill Orca CO_2
- Calibrated meter system with no moving parts for minimal maintenance
- Vessel designed with robust inner support system for rugged road conditions
- Stainless steel plumbing with stainless steel and brass valves for long service life and reliability
- Stainless steel inner vessel eliminates damage due to icing

Product Manual

The CO_2 Series Product Manual is designed to be used in conjunction with Orca CO_2 Series models. It should be thoroughly read and understood by anyone who operates or is exposed to this equipment. If there are any questions regarding the operation of the tank, contact Chart's Technical Service division at 1-800-400-4683.

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

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

For detailed information on how to operate the Orca system, refer to the Operations section. Here are various filling, pressure dispense and pump dispense instructions.

The Components & Systems section contains photos and descriptions of all working parts of the Orca system.

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

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

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

Terms

Throughout this manual safety precautions will be designated as follows:

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

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

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

Acronyms / Abbreviations

The following acronyms / abbreviations are used throughout this manual:

ASME	American Society of Mechanical Engineers
BAR	Metric Unit of Pressure
BARG	Metric Unit of Gauge Pressure
CGA	Compressed Gas Association
CO_2	Carbon Dioxide
DOT	Department of Transportation
NER	Normal Evaporation Rate
GAWR	Gross Axle Weight Rating
GPM	Gallons Per Minute
GVWR	Gross Vehicle Weight Rating
LAR	Liquid Argon
LN_2/LIN	Liquid Nitrogen
LOX	Liquid Oxygen
LPM	Liters Per Minute
MAWP	Maximum Allowable Working Pressure
NIST	National Institute of Standards and Tech.
NPSH	Net Positive Suction Head
OEM	Original Equipment Manufacturer
PB	Pressure Builder
PN	Part Number
PSI	Pounds per Square Inch
PSIA	Pounds per Square Inch Absolute
PSIG	Pounds per Square Inch Gauge
PSID	Pounds per Square Inch Differential
PTO	Power Take-Off
RV	Relief Valve
RTD	Resistance Temperature Device
SS	Stainless Steel
VAC	Voltage - Alternating Current
VDC	Voltage - Direct Current
VFD	Variable Frequency Drive

Safety — General Orca

Safety Summary

While every possible safety precaution has been taken to ensure safe operation and maintenance of the Orca CO_2 Series delivery system, it is imperative that all persons having contact with the Orca delivery system become thoroughly familiar with all maintenance, safety precautions, and procedures contained in this product manual. If for any reason any part or parts of this manual become confusing or the information provided is not completely understood contact a Technical Service Representative at Chart Inc. 1-800-400-4683 before proceeding with the operation or repair of the vessel.

Compatibility and Cleaning

Always keep the Orca delivery system clean and free from grease and oil. Use care when cleaning with high-pressure water or steam cleaning equipment. DO NOT direct the cleaning nozzle into the electronic components. When replacing components, use only parts which are considered compatible with liquid oxygen. Do not use regulators, fittings, or hoses, which were previously used in compressed air or carbon dioxide environments. Use only oxygen compatible sealants on threaded connections. All new joints should be leak tested with an oxygen compatible leak test solution at a minimum of 35 psig. Failure to comply with these instructions may result in serious personal injury, death, or damage to the container.

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

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

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

Safety Bulletin

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

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

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

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

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

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

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

Oxygen Deficient Atmospheres

Warning! Nitrogen, argon and carbon dioxide vapors in air may dilute the concentration of oxygen necessary to support or sustain life. Exposure to such an oxygen deficient atmosphere can lead to unconsciousness and serious injury, including death. Nitrogen, argon and carbon dioxide are colorless and odorless and can replace the oxygen in the air when released in confined areas.

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

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

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

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

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

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

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

Oxygen Enriched Atmospheres

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

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

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

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

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

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

Nitrogen, Argon & Carbon Dioxide

Nitrogen, argon and carbon dioxide (inert gases) are simple asphyxiates. These gases will not support or sustain life and can produce immediate hazardous conditions through the displacement of oxygen. Under high pressure these gases may produce narcosis even though an adequate oxygen supply sufficient for life is present.

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

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

Personal Protective Equipment (PPE)

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

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

Safety — CO_2 Specific

General

The Orca CO_2 Series Tank consists of an inner pressure vessel encased within an outer carbon steel vacuum shell. The container operates under low-to-medium pressure. Safety relief devices are used to protect the pressure vessel and vacuum casing, sized and selected in accordance with ASME standards. They include a dual relieve valve system to protect the pressure vessel, and a lift plate to protect the vacuum casing (outer vessel). The Orca CO_2 Series is designed and engineered for safe, reliable operations and are durable enough to provide many years of trouble-free operation. Strict compliance with proper safety and handling practices is necessary when using an Orca CO_2. We recommend that all our customers re-emphasize safety and safe handling practices to all their employees and customers. While every possible safety feature has been designed into the unit and safe operations are anticipated, it is essential that every user of the Orca CO_2 carefully reads all WARNINGS and CAUTIONS listed and enumerated in this safety section and contained in the manual itself. Also read the information provided in the safety bulletins for Carbon Dioxide gas. Periodic review of this safety summary is recommended.

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

Warning! 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.

Warning! Accidental contact of liquid or solid CO_2 with the 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 CO_2 cold pipe and cold equipment, or cold gas exists. Safety goggles or a face shield should be worn if liquid ejection or splashing may occur or if cold gas may issue forcefully from equipment. Clean, insulated gloves that can easily be removed and long sleeves are recommended for arm protection. Cuffless trousers should be worn over the shoes to shed spilled liquid.

Caution! Do not use oxygen equipment that is marked "For Oxygen Use" in CO_2 service. Failure to comply with these instructions may result in serious damage to the container.

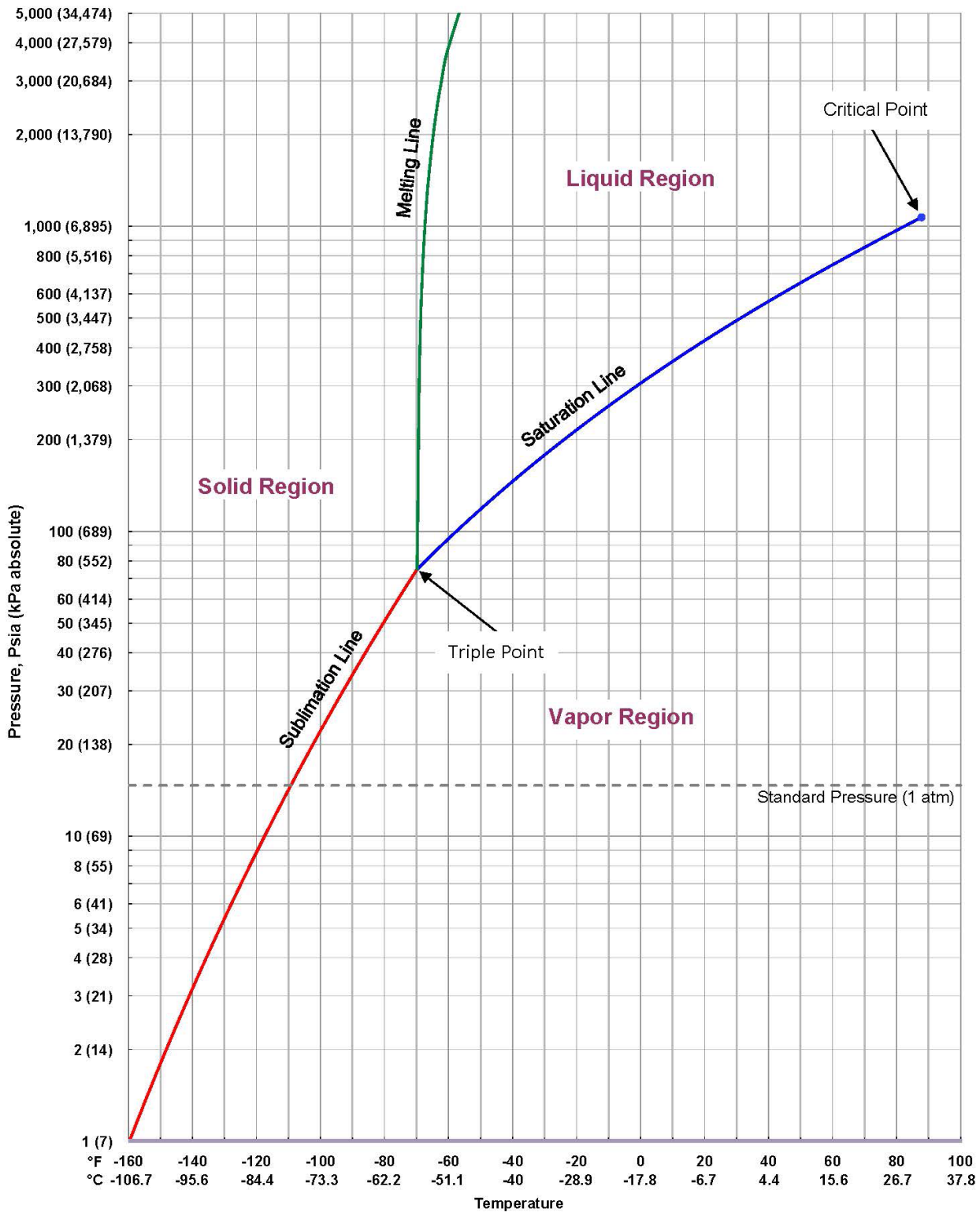
Carbon dioxide

Carbon dioxide is a compound formed by the combination of carbon and oxygen atoms in a 1:2 ratio expressed by the chemical symbol CO_2. The weight percentages of carbon and oxygen are 27.3% and 72.7%, respectively.

Carbon dioxide is a gas at normal atmospheric temperature and pressure. It is colorless and somewhat pungent, although essentially odorless and is about 1.5 times more dense than air.

Depending on the temperature and pressure to which it is subjected, carbon dioxide may exist in the form of a solid, liquid or gas. At a temperature of 69.9°F (56.6°C) and a pressure of 60.4 psig (417 kPa), CO_2 can exist simultaneously in all three phases. This condition is known as the triple point. The phase diagram for CO_2 is shown in Figure A.

Carbon Dioxide Phase Diagram - Figure A



Introduction

Theory of Operation

Although the Orca CO_2 Series system can have pressure or pump delivery options, all units have the same general functional operating characteristics. They have the ability to be filled with liquid CO_2 and deliver that product to the end customer safely and efficiently.

Terminology of Cryogenics

Cryogenic

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

Though liquid CO_2 is very cold, it cannot exist below -69.9°F. While it is technically not a cryogen, it is to be handled as such.

Cryogenic Temperatures

The Orca CO_2 Series delivery systems employ near-cryogenic temperatures to store the product in its liquid state. CO_2 can exist as a liquid down to -69.9°F (60.4 psig saturation). Below that, CO_2 becomes solid. CO_2 is typically transported and stored above -20°F (200 psig saturation).

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 (subcool) to maintain equilibrium. Gas and liquid can exist at a range of temperatures.

Saturation

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

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

Equilibrium

In a closed vessel the gas and liquid temperatures are the same. If there is a temperature difference between the gas and liquid (with the tank closed), the gas and liquid will change their temperatures until they are equal. In stationary tanks, stratification can take place, creating a temperature gradient across the liquid and vapor. However, the temperature at the liquid-vapor interface is the same for both.

Saturation Pressure

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

Subcool

Raising the vapor space pressure above the current boiling pressure of a saturated liquid is called subcool. This contributes to the Net Positive Suction Head (NPSH) to the pump. The higher the subcool, the less susceptible the liquid will be to two-phase flow and pump cavitation.

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 can damage the pump and cause meter inaccuracy.

Cavitation

Defined as the formation of vapor bubbles in a liquid, it manifests as partial or full loss of pump prime due to the lack of proper subcool. The pressure of the liquid flowing to the pump has dropped below the saturation pressure. Audible changes in the pump often are an indication of partial loss of prime. The pump will stop pumping during full loss of prime. Cryogenic pumps will be damaged by cavitation. Some CO_2 pumps can handle small amounts of cavitation, however, cavitation should always be avoided.

Vaporization

Changing liquid into vapor by warming the liquid for the purpose of subcooling or for gas use. The Orca CO_2 Series delivery system uses a pressure building coil inside of a propylene glycol/water bath heat exchanger in the cabinet.

Vapor Pressure

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

Condensation

The conversion of vapors into liquid by cooling the vapors. The Orca CO_2 Series storage vessel pressure during normal operation will rise above the saturation pressure of the liquid. This warmer gas will condense to the colder liquid pressure during transit. The liquid splashes into the gas space during normal movement of the truck/trailer. The splashing condenses the gas and drops the pressure. This is known as "splash-down."

Condensation and the Perma-Cyl® MicroBulk Storage System

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

Depressurization Flash Losses

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

Entrainment

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

Liquid Growth

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

Pressure Drop

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

Stratification

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

Operations

Modes of Operation

I. Orca CO_2 First Fill

The Orca CO_2 Series delivery system is shipped under pressure with a CO_2 atmosphere to keep out moisture. It must be purged prior to use.

1. Remove hoses from storage tubes, set in place and open cabinet doors.
2. Open Vapor Vent (V-5) valve and vent tank until empty.
3. Open Pump Inlet/Fill (V-1), Pressure Dispense (V-4), PB Force Feed (V-16), PB Liquid (V-28) valves.
   a. Vapor Balance/PB Isolation (V-13), Inner Vessel Gauge (V-14), Vapor Phase Isolation (V-31), Liquid Phase Isolation (V-32) valves should already be open, they are only closed for service.
4. From delivery tank connect vapor balance hose to Fill Line (DC-1) connection. Use size adapters as necessary.
5. Open Bottom Fill (V-17) supply tank vapor balance valve to pressurize to 50 psig. Close supply tank vapor balance valve.

Note: Cryogenic ball valves have a flow direction; the higher pressure must always be on the inlet side of the ball valve. If there is significantly higher pressure on the outlet side, product WILL leak past the ball valve.

6. Open Vapor Vent (V-5) and vent tank under 5 psig. Close Vapor Vent.
7. Open Bottom Fill (V-17) and pressurize to 250 psig.
8. Remove the cap from Vapor Balance (DC-5) connection. Slowly open Vapor Balance (V-44) valve and purge for 1-2 minutes. Close Vapor Balance (V-44) valve and replace cap.
9. Remove the cap from Dispense (DC-2) and Hose Reel Inlet (DC-3) connections. Connect Hose Reel Inlet (DC-3) to Dispense (DC-2) connection.
10. Slowly open Dispense (V-41), Delivery Flex Hose (V-47), Delivery Hose (V-46), and Hose Reel Line Drain (V-6) valves and purge for 1-2 minutes. Close Hose Reel Line Drain (V-6) valve and leave Hose Reel Inlet (DC-3) connected to Dispense (DC-2) connection for hose reel delivery.
11. Slowly open Vapor Vent (V-5) valve 1-2 turns and let purge 1-2 minutes. Close Vapor Vent (V-5) valve.
12. Crack open the compression fitting on the Inner Vessel Front of Tank (PI-3) gauge and allow leak for 1-2 minutes. Tighten fitting before line frosts. Leak check compression fitting.
13. Crack open the compression fittings on the Inner Vessel Level Indicator (LI-1) and Inner Vessel Pressure Indicator (PI-2) manifold gauges and allow leaks for up to 1 minute. Tighten fitting before line frosts. Leak check compression fittings.
14. Close Pump Inlet/Fill (V-1), Pressure Dispense (V-4), PB Force Feed (V-16), PB Liquid (V-28) and Bottom Fill (V-17) valves.
15. Open and close Fill Line Drain (V-9) valve to depressurize connection.
16. Disconnect supply tank vapor balance hose from Fill Line (DC-1) connection and connect to Vapor Balance (DC-5) connection.
17. Follow the rest of the instructions in “II. & III. Fill Orca CO_2”.

II. Fill Orca CO_2 from Bulk Tank Pump

1. Remove hoses from storage tubes, set in place and open cabinet doors.
2. Connect supply tank vapor balance hose to Vapor Balance (DC-5) connection and connect fill hose from supply tank to Fill Line (DC-1) connection.
3. Open supply tank vapor balance and dispense valves.
   a. This assumes supply tank is at a lower pressure than Orca CO_2. If Orca CO_2 is at a higher pressure, swap Orca CO_2 and supply tank in steps 3 and 4.
4. Open and close Vapor Balance Line Drain (V-45) and Fill Line Drain (V-9) valve to purge air from hoses.
5. Slowly open Vapor Balance (V-44) valve to equalize pressure in tanks.
6. Open Bottom Fill (V-17) and Pump Inlet/Fill (V-1) valve.
7. Start supply tank pump filling and monitor liquid level.
8. When liquid level is getting close to full (3/4 of net capacity), open Vapor Balance Line Drain (V-45) valve.
   a. The vapor balance line serves as the 95% full trycock.
9. When liquid exits the Vapor Balance Line Drain (V-45), valve stop the pump and close the Bottom Fill (V-17) valve.
10. Close the Vapor Balance Line Drain (V-45), Pump Inlet/Fill (V-1), and Vapor Balance (V-44), supply tank dispense & vapor balance valves.
11. Open and close the Fill Line Drain (V-9) and Vapor Balance Line Drain (V-45) valves to drain and release all pressure.

Warning! Fast depressurization of liquid CO_2 can cause dry ice to form, holding in pressure that quickly releases when the dry ice melts. Follow proper safety procedures for draining and venting liquid CO_2 from hoses.

12. Disconnect hoses from Vapor Balance (DC-5) and Line (DC-1) connections.
13. Close cabinet doors and stow hoses. Replace all dust caps.

III. Fill Orca CO_2 from Onboard Pump

1. In order to minimize pump cavitation and surging:
   a. The liquid level in the supply tank must be above the Orca CO_2 pump inlet height. As such, supply tanks should be limited to vertical tanks or horizontal tanks located above the Orca CO_2 pump height.
   b. Additional subcool in the supply tank will be beneficial.
   c. If the Orca CO_2 tank pressure is significantly lower than the supply tank, causing the supply-tank pressure to drop below the saturation of the supply liquid when vapor balancing, pressure in the supply tank must be added to subcool the liquid.
2. Start truck and engage PTO, turn on cruise control and increase engage speed to set point.
   a. Engine must be at low idle speed to engage PTO.

Caution! Engage the PTO when not at low idle speed will damage the PTO.

   b. Engine will go to set speed with one push of the cruise control speed increase button.

Caution! Supply tank must have a vapor balance circuit for this functionality otherwise pump damage may occur.

3. Remove hoses from storage tubes, set in place and open cabinet doors.
4. From delivery tank connect vapor balance hose to Vapor Balance (DC-5) connection and connect fill hose from delivery tank to Fill Line (DC-1) connection.
5. Slowly open supply tank liquid valve to fill pump supply hose with liquid.
6. Open Fill Line Drain (V-9) valve until CO_2 snow comes out and close valve. This purges air and fills the hose with liquid.
7. Make sure Pump Inlet/Fill (V-1) valve is closed.
8. — **If supply tank is higher pressure than Orca CO_2:**
   a. Open Bottom Fill (V-17) valve.
   b. Start pump with Switch (SW-1).
   c. When supply tank pressure comes within 5 psig of Orca CO_2 tank pressure, open supply tank

vapor balance and Orca CO_2 Vapor Balance (V-44) valves.

— If Orca CO_2 is higher pressure than supply tank:

a. Open supply tank vapor balance and Orca CO_2 Vapor Balance (V-44) valves.

b. Open Bottom Fill (V-17) valve.

c. Start pump with Switch (SW-1).

9. Monitor for pump to catch prime.

   a. Pump discharge pressure should be 70 psig higher than tank pressure (bypass valve factory setting).

   b. In recirculation mode, if pump discharge pressure is less than 50 psig higher than Orca CO_2 tank, pump did not catch prime; stop pump and restart or open the Pressure Dispense (V-4) valve to help catch prime.

10. Open Pressure Dispense (V-4) valve and throttle to maintain pump discharge minimum 25 psig higher than Orca CO_2 tank pressure.

    a. This keeps the pump on the pump curve, maintaining prime.

    b. Too little pressure differential can cause pump cavitation.

    c. Too much pressure differential creates a low flow rate.

11. Monitor liquid level and pump pressure.

12. When liquid level is getting close to full (3/4 of net capacity), open Vapor Balance Line Drain (V-45) valve.

    a. The vapor balance line serves as the 95% full trycock.

Note: Do not pressure build with Orca CO_2 after filling has started. If the PB coil is overrun, liquid will enter the vapor balance/full trycock line, giving a false indication that Orca CO_2 is full.

13. When liquid exits the Vapor Balance Line Drain (V-45) valve stop the pump (SW-1) and close the Bottom Fill (V-17) valve.

14. Close the Pressure Dispense (V-4) valve.

15. Close the Vapor Balance Line Drain (V-45), Vapor Balance (V-44), supply tank dispense & vapor balance valves.

16. Open the Fill Line Drain (V-9) and Vapor Balance Line Drain (V-45) valves to drain and release all pressure.

    Close Fill Line Drain (V-9) and Vapor Balance Line Drain (V-45) valves.

Warning! Fast depressurization of liquid CO_2 can cause dry ice to form, holding in pressure that is quickly released when dry ice melts. Follow proper safety procedures for draining and venting liquid CO_2 from hoses.

17. Disconnect hoses from Vapor Balance (DC-5) and Line (DC-1) connections.

18. Close cabinet doors and stow hoses. Replace all dust caps.

19. Disengage engine speed control and disengage PTO.

Filling Levels - MC-338

The DOT regulations limit the fill levels based on the tank's pressure control valve settings. This volume assures that when the pressure control valve discharges the tank is not liquid full. This fill volume varies with the saturation pressure of the liquid. DOT fill levels are based on the weight of the liquid. Differential pressure liquid level gauges are an approximation of the pounds of liquid in the vessel. The true full liquid level should be determined by the full trycock. Both are dependent on the vessel being level.

Current Saturation of Liquid

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

IV. Pressure Build: Heater

Note: Instructions are specific to the standard heater and programmable controller. Other heaters and controllers may be used, refer to their respective manuals.

1. Review heater and heater controller manuals for additional operational information.

a. The timer can be set to turn on the heater at a specific time each day of the week. This normally won't be needed but can be used.

2. Press center button on timer to start heater. Heater will start regardless of ignition key switch position. **See section "Dash Controls" for further details.**

   a. In key ON position, heater will run indefinitely.

   b. In key OFF or ACC, heater will only run for a maximum of 120 minutes, which can be increased or decreased any time using the arrows. This will preserve the battery if left on.

   c. Note: the timer continues to decrement in any key position, so if the timer reaches zero when in the key ON position, the heater will shut off if the key is moved to OFF or ACC. Press the right arrow to increase time before moving key position or restart the heater with the middle button.

3. Start heater 20-40 minutes before delivery.

   a. ≈20 minutes if in 80°F ambient, 30 minutes in 30°F, longer for colder temperatures.

   b. Heater will run indefinitely with key in ON position. In OFF or ACC, heater will run as long as time is left on the timer.

Note: If heater fails to start, turn heater off and back on. Remove heater cover and listen for water pump to spin, followed by fuel pump clicks and burner lighting. See heater manual for additional details.

4. After delivery, decide if heater is to remain on or shut off based on outside temperature and time to next delivery.

   a. Keep running if next delivery is soon: <30 minutes, depending on ambient temperature.

   b. Or turn off if next delivery will be later: >30 minutes, depending on ambient temperature.

   c. Heater can be left on all day in between runs.

      i. The heater runs on high until coolant temperature reaches 176°F (80°C).

      ii. Cycles to low mode until coolant drops to 167°F (75°C).

      iii. This repeats until coolant reaches 185°F (85°C), at which heater shuts off.

      iv. Heater restarts when cooled down to 158°F (70°C).

V. Pressure Build: Operation

1. After the heater has been on for appropriate time, the Pressure Build Coil (PBC-1) has built sufficient heat into the 60/40 propylene glycol/water mixture (3 parts PG : 2 parts water).

   a. Propylene glycol is used for its non-toxic properties.

   b. A 60% mixture provides -70°F freeze protection from cold outside ambient temperature and cold liquid CO_2 temperature with factory installed DELO ELC PG Antifreeze/Coolant (other brands will vary in cold temperature protection).

2. Note the tank arrival pressure to determine how much pressure to build.

   a. More pressure will provide higher flow rate and reduce likelihood of pump cavitation.

   b. Exceeding the tank 350 psig MAWP will cause the main reliefs to vent.

   c. Exceeding the Pump (P-1) and Bypass (V-7) valve 400 psig MAWP will cause the Pump Discharge Relief (RV-11) valve to relieve.

      i. Bypass (V-7) valve is factor set to 70 psid. Exceeding 330 psig tank pressure will exceed 400 psig pump discharge when pump is started, causing Pump Discharge Relief (RV-11) to relieve.

      ii. If Orca CO_2 pressure exceeds 330 psig, either pressure transfer or vent until pressure is below 330 psig before starting the pump.

   d. Monitor the tank pressure during pressure building.

Caution! There is no automated method to stop pressure building. The only way to stop pressure building is to close the PB Liquid (V-28) and PB Force Feed (V-16) valves. Leaving these open or unattended can cause the tank main reliefs to vent!

3. Open one of two liquid supply valves. Both valves can be open concurrently.

   a. Open the Pressure Build Liquid (V-28) valve to gravity feed-pressure build.

      i. This will be used most of the time.

ii. The lower the liquid level, the lower the rate of pressure build.

iii. At low liquid levels (less than 1/4 full), the pressure build rate will be diminished and stop at some point, depending on truck pitch. Items to assist include:

1. Park with the truck front high.

2. Dump the truck air bags.

3. Use Pump Force Feed (V-16), item 'b' below.

b. Open the Pressure Build Force Feed (V-16) valve to build pressure while the Pump (P-1) is running.

i. This is needed when the liquid level in Orca CO_2 drops below 1/4 full during a pump delivery.

ii. This can be opened before starting the Pump (P-1); it will also assist in catching prime.

4. Pressure building is dependent on many factors: liquid level, vessel pressure, liquid temperature, truck angle, etc. This system was designed to pressure build via gravity flow (PB Liquid (V-28) valve) at low-liquid levels. The standard heater was selected for many factors and will perform well in most situations. Since the Pressure Build Coil (PBC-1) is sized larger than the heater can output, the pressure build rate will diminish from when either of the pressure build valves (V-28 or V-16) are open and eventually overrun in these two conditions:

a. High liquid level with the PB Liquid (V-28) valve fully open.

i. Small deliveries through the hose reel are not an issue and will not be noticed.

ii. Large-pressure transfers through bulk hose will eventually cause loss of subcool. If subcool drops under 5 psig meter accuracy will be compromised. It is recommended that large bulk transfers utilize pump delivery and vapor balance.

iii. The Pressure Build Coil (PBC-1) will continue to build pressure even when over-run.

iv. Throttling the PB Liquid (V-28) valve at high liquid levels will delay the time the coil takes to over-run. Throttling may have effects on PB rate and should be analyzed in each delivery scenario where needed.

b. Pump (P-1) delivery situations with the PB Force Feed (V-16) valve fully open.

i. Use the PB Force Feed (V-16) valve with low liquid levels when the PB Liquid (V-28) valve cannot build pressure and throttle as necessary.

ii. Pump recirculation through the Bypass (V-7) valve reduces tank pressure. Start delivery as soon as the pump catches prime to minimize this.

iii. High pump delivery rates will reduce the pressure in the Orca CO_2. This will not affect metering due to subcool added by the pump.

c. These situations are normal operation.

5. Close the Pressure Build Liquid (V-28) and/or the Pressure Build Force Feed (V-16) valve to stop pressure building.

VI. Pressure Delivery: Hose Reel

1. Start Pressure Build Heater with adequate time before delivery.

a. See **"IV. and V. Pressure Build"** instructions.

2. Turn truck key to ACC position. Flowcom has no power in key OFF position.

3. Open cabinet doors.

4. Note the Orca CO_2 vessel starting pressure. Open Pressure Build Liquid (V-28) valve. Build sufficient pressure for delivery.

a. Minimum 5 psi subcool needed for meter accuracy when pressure dispensing.

b. Higher pressure = faster delivery, but more heat input into the vessel.

c. Cycle PB Liquid (V-28) valve as needed to not exceed the tank MAWP. Exceeding the tank 350 psig MAWP will cause the main reliefs to vent.

5. Power on Flowcom and select DELIVERY mode. This also powers on the printer.

6. Two methods to pressure dispense through hose reel.

— **Purge Needed**: Hose Reel Delivery Flex Hose (DC-3) is not connected to Dispense (DC-2) connection from previous delivery and delivery flex hose purge is needed.

a. Connect Hose Reel Delivery Flex Hose (DC-3) to Dispense (DC-2).

b. Open Pressure Dispense (V-4) and Delivery Flex Hose (V-47) valves.

c. Connect Hose Reel Dispense (DC-4) to fill box.

d. Open Delivery Hose (V-46) valve. Open Dispense Line Drain (V-8) valve for 20-30 seconds to purge air from Hose Reel Flex Hose (TRAN-1).

i. This also aids in venting the receiving tank to an adequate receiving pressure.

Caution! Do not vent the receiving tank below acceptable levels.

e. Close Dispense Line Drain (V-8). Open Hose Reel Line Drain (V-6) valve for additional receiving tank venting as necessary.

— No Purge Needed: Hose Reel Delivery Flex Hose (DC-3) is still connected to Dispense (DC-2) connection from previous delivery.

a. Close Dispense (V-41) valve. Pressure Dispense (V-4) and Delivery Flex Hose (V-47) valves can remain open from previous delivery.

b. Connect Hose Reel Dispense (DC-4) to fill box.

c. Open and close Hose Reel Line Drain (V-6) valve to vent receiving tank as necessary.

d. Open Delivery Hose (V-46) valve.

7. Press START on Flowcom. Slowly open Dispense (V-41) valve to start delivery. Monitor flow rate to not exceed maximum flow rate allowed.

8. Monitor filling. If flow rate is too high, too low, or suddenly slows, the Flowcom may terminate totalizing.

a. The Totalizer has an approximately 5-second delay once delivery starts to account for hose volume. This is normal.

b. If the Totalizer fails to start or stops due to an error condition, close Dispense (V-41) valve and assess.

i. Receiving tank may be full. If not full, restart dispense.

ii. Differential pressure from Orca CO_2 to receiving tank may be too little. Pressure build Orca CO_2 or vent receiving tank as necessary.

c. Once the issue is addressed, open the closed Dispense (V-41) valve. There will be no delay in Totalizer now as the hose volume is already accounted for.

d. Do not exceed 100% flow rate on Flowcom. Use Dispense Valve (V-41) to throttle flow rate as necessary.

i. The Flowcom will not totalize with greater than 100% flow rate. Decrease flow rate or terminate dispensing.

ii. The Flowcom will not totalize with less than 3% flow rate. Increase flow rate or terminate dispensing.

iii. In both conditions, the delivery will continue until a Dispense valve is closed.

9. When the receiving tank is full (SureFill stops venting), close Delivery Hose Valve (V-46) and press STOP on the Flowcom.

10. Disconnect Hose Reel Dispense (DC-4) and open & close Hose Reel Line Drain (V-6) to relieve trapped liquid in fill gun assembly.

a. Flowcom will stop totalizing when a Dispense valve is closed.

11. Retract hose into Hose Reel (HR-1) and holster dispense gun.

12. Keep open Dispense (V-41) & Delivery Flex Hose (V-47) valves. This allows warming CO_2 to return to the tank.

13. Close Pressure Dispense (V-4) and Pressure Build Liquid (V-28) valves.

14. On Chart printer-equipped models:

a. Open printer box, press RELEASE to insert paper into printer, press FORWARD to lock paper in.

b. On Flowcom, press EXIT, PRINT. When printing is complete, press printer RELEASE, remove paper and close door.

15. On Flowcom press CLEAR, CLEAR, and DELIVERY to return to delivery screen.

Note: This prepares the Flowcom for the next delivery.

16. Power off Flowcom. This also powers off the printer.

17. Close cabinet doors and stow hoses. Replace all dust caps.

18. Keep Pressure Build Heater running or turn off as necessary.

Note: This procedure can also be used for pressure transferring through a bulk hose instead of the hose reel flex hose.

Note: To fully empty Orca CO_2, dump the truck air bags or park so the back of the Orca CO_2 is lower than the front.

VII. Pump Delivery: Bulk Hose

1. Start Pressure Build Heater with adequate time before delivery.

   a. See **"IV. and V. Pressure Build"** instructions.

2. Leave truck running. Engage PTO, turn on cruise control and increase engine speed to set point.

   a. Engine must be at low idle speed to engage PTO.

   b. Engine will go to set speed with one push of the cruise control speed increase button.

3. Remove hoses from storage tubes, set in place and open cabinet doors.

4. Note the Orca CO_2 vessel starting pressure. Open Pressure Build Liquid (V-28) valve and monitor pressure build.

   a. Cycle PB Liquid (V-28) valve as needed to not exceed the tank MAWP. Exceeding the tank 350 psig MAWP will cause the main reliefs to vent.

   b. Exceeding the Pump (P-1) and Bypass (V-7) valve 400 psig MAWP will cause the Pump Discharge Relief (RV-11) valve to relieve.

      i. Bypass (V-7) valve is factory set to 70 psid. Exceeding 330 psig tank pressure will exceed 400 psig pump discharge, causing Pump Discharge Relief (RV-11) to relieve.

      ii. If Orca CO_2 pressure exceeds 330 psig, either pressure transfer or vent until pressure is below 330 psig before starting the pump.

   c. Should subcool become depleted during delivery, the pump will provide sufficient subcool for accurate metering.

5. Open Pump Inlet/Fill (V-1) valve.

6. Power on Flowcom and select DELIVERY mode. This also powers on the printer.

7A. If vapor balancing: Connect 1.0" vapor balance hose to Vapor Balance Connection (DC-5) and the receiving tank vapor balance connection.

Note: Some customers do not allow vapor balancing.

a. Slowly open vapor balance on the lower pressure tank first.

Note: Cryogenic ball valves have a flow direction; the higher pressure must always be on the inlet side of the ball valve. If there is significantly higher pressure on the outlet side, product WILL leak back past the ball valve.

b. Open and close the line drain at the higher pressure tank to purge the hose.

c. Slowly open the vapor balance valve on the higher pressure tank.

Example: Orca CO_2 is at 280 psig, receiving tank is at 265 psig.

i. Slowly open the receiving tank vapor balance valve.

ii. Open and close the Vapor Balance Line Drain (V-45) valve to purge air from hose.

iii. Slowly open Vapor Balance (V-44) valve to equalize the pressure in both tanks.

Note: If the receiving tank is at a much lower pressure than the pump discharge, the delivery can start without opening the vapor balance circuit to take advantage of the tanks' differential pressure. Once the Orca CO_2 tank and the receiving tank are within 5 psig of each other, then vapor balancing should take place.

Note: The flow rate will be high intially and will decrease as the tank pressures equalize. Once vapor balancing is initiated, the flow rate should significantly increase again.

7B If not vapor balancing:

a. Vent receiving tank as necessary before and during the delivery.

b. Orca CO_2 tank pressure may decrease over time if the pressure build rate cannot keep up with the dispense rate.

i. This is normal. Continue to keep the pressure build circuit open to keep subcool on the liquid.

ii. Adjusting the Bypass (V-7) valve for a higher pressure differential may increase pressure/flow rate for a specific condition, but may over-pressurize the dispense circuit when the Orca CO_2 vessel pressure is higher, causing the 400 psig relief to discharge. Adjusting the bypass is not recommended.

8. Close Dispense (V-41) & Delivery Flex Hose (V-47) valves, open Dispense Line Drain (V-8) and disconnect Hose Reel Delivery Flex Hose (DC-3).

9. Connect 1.0" to 1.5" CGA adapter to Dispense Connection (DC-2). Connect 1.5" bulk dispense hose to adapter and receiving tank fill connection.

10. Assess Orca CO_2 and receiving tank pressures. On the lower pressure tank, slowly open the valve(s) to pressurize the fill hose. Use the opposite tank's line drain to purge the hose.

Example: Orca CO_2 is at 250 psig, receiving tank is at 275 psig.

a. Slowly open Dispense (V-41) valve to pressurize hose. Opening too quickly can cause dry ice to form in hose.

b. Open and close receiving tank fill line drain to purge air from hose.

c. Close Dispense (V-41) valve.

11. Open receiving tank fill valve.

12. Note Orca CO_2 pressure and start pump with Switch (SW-1) in recirculation mode.

a. Bypass (V-7) valve is factory set to 70 psid. Starting the pump with vessel pressure greater than 330 psig WILL exceed 400 psig pump discharge, causing the 400 psig Pump Discharge Relief (RV-11) to relieve.

13. Monitor for Pump (P-1) to catch prime.

a. Exceeding 330 psig tank pressure will exceed 400 psig pump discharge when pump is started, causing Pump Discharge Relief (RV-11) to relieve.

i. Bypass (V-7) valve is factory set to 70 psid. The pump discharge pressure will be 70 psig greater than the vessel pressure when pump catches prime.

b. If pump discharge pressure is less than 50 psig higher than CO_2 Orca tank — and/or the gauge needle is erratically bouncing — the pump did not catch prime.

i. Stop pump and restart, or

ii. Open PB Force Feed (V-16) valve to assist in catching prime.

14. Press START on Flowcom to enable metering.

15. Slowly open Dispense (V-41) valve.

16. Monitor filling. If flow rate is too high, too low, or suddenly slows, the Flowcom may terminate totalizing.

a. The Totalizer has an approximately 5 second delay from when the delivery starts to account for hose volume. This is normal.

b. If the Totalizer fails to start or stops due to an error condition, close a delivery valve Delivery Hose (V-46), Delivery Flex Hose (V-47) or Dispense (V-41) and assess.

i. Receiving tank may be full. If not full, restart dispense.

ii. Differential pressure from Orca CO_2 to receiving tank may be too little. Pressure build Orca CO_2 or vent receiving tank as necessary.

c. Once the issue is addressed, open Dispense (V-41) valve. There will be no delay in Totalizer now as the hose volume is already accounted for.

d. Do not exceed 100% flow rate on Flowcom. Use Dispense Valve (V-41) to throttle flow rate as necessary.

i. The Flowcom will not totalize with greater than 100% flow rate. Decrease flow rate or terminate dispensing.

ii. The Flowcom will not totalize with less than 3% flow rate. Increase flow rate or terminate dispensing.

iii. In both conditions, the delivery will continue until a dispense valve is closed.

17. When delivery is complete close Dispense (V-41) valve and press STOP on the Flowcom.

a. Closing slowly reduces the chance of a pressure spike.

18. Stop pump with Switch (SW-1).

19. Close PB Liquid (V-28), PB Force Feed (V-16) and Pump Inlet/Fill (V-1) valves.

20. Close receiving tank fill valve and re-open Dispense (V-41) valve to allow liquid in hose to warm and travel back into Orca CO_2.

21. Close Vapor Balance (V-41) and receiving tank vapor balance valves. Open and close Vapor Balance Line Drain (V-45) valve to depressurize.

22. On Chart printer-equipped models.

    a. Open printer box, press RELEASE to insert paper into printer, press FORWARD to lock paper in.

    b. On Flowcom, press EXIT, PRINT. When printing is complete, press printer RELEASE, remove paper and close door.

23. On Flowcom press CLEAR, CLEAR, and DELIVERY to return to deliver screen.

Note: This prepares the Flowcom for the next delivery.

24. Power off Flowcom. This also powers off the printer.

25. Close Dispense (V-41) valve. Open line drain at receiving tank and shake hose to get all liquid out.

26. Once de-pressurized, open Dispense Line Drain (V-8) to ensure hose is empty and de-pressurized.

Caution! Use best practices to properly drain the liquid and keep from forming pressurized dry ice plugs.

27. Disconnect CGA size adapter, bulk delivery hose and stow.

    a. Reconnect Hose Reel Delivery Flex Hose (DC-3), open Dispense (V-41) & Delivery Flex Hose (V-47) valves.

    b. Optional: purge and pressurize per "**VI Pressure Delivery 6. a.**"

28. Close cabinet doors and stow hoses. Replace all dust caps.

29. Disengage engine speed control and disengage PTO.

30. Keep pressure build heater running or turn off as necessary.

Note: This procedure can also be used for pump transferring through the Hose Reel Flex Hose instead of the bulk hose.

Note: Use CGA fitting 1.0"-1.5" size adapters as necessary.

Note: To fully empty Orca CO_2, dump the truck air bags or park so the back of the Orca CO_2 is lower than the front.

VIII. Receiving Tank Commission: Hose Reel

— Follow steps 1-4 in **"VI. Pressure Delivery"** for pre-delivery instructions.

1. Connect Hose Reel Inlet (DC-3) to Vapor Balance (DC-5).

2. Open Vapor Balance (V-44) and Delivery Flex Hose (V-47) valves.

3. Connect Hose Reel Dispense (DC-4) to receiving tank fill.

4. Open Delivery Hose (V-46) valve and pressurize tank to 100 psig.

5. Close Delivery Hose (V-46), Vapor Balance (V-44) and Delivery Flex Hose (V-47) valves.

6. Open Vapor Balance Line Drain (V-45) valve and close when depressurized. Replace dust cap on Vapor Balance (DC-5).

7. Disconnect Hose Reel Inlet (DC-3).

8. Refer to **"VI. Pressure Delivery"** for further instructions.

IX. Tank Commission: Bulk Hose

— Follow Steps 1-4 in **"VII. Pump Delivery"** for pre-delivery instructions.

1. Connect Bulk Transfer Hose to Vapor Balance (DC-5) and receiving tank fill connection.

2. Open Vapor Balance (V-44) and receiving tank fill valves. Pressurize receiving tank to 100 psig.

3. Close Vapor Balance (V-44) and receiving tank fill valves.

4. Open Vapor Balance Line Drain (V-45) and close when depressurized.

5. Disconnect Bulk Transfer Hose from Vapor Balance (DC-5).
6. Refer to **"VII. Pump Delivery"** for delivery instructions.

Hydraulic Power Supply

With the Orca CO_2 securely positioned and ready for delivery, follow these steps to start and use the power take-off.

1. Engage PTO per heavy duty truck OEM's recommendation (if unknown, consult your local OEM truck dealership).
    a. Confirm provided instructions meet OEM truck recommendations and can be easily understood by all operators.

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

2. Set speed to desired operating speed.

Note: *Label in cab should determine the max engine speed.*

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

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

Methods to Stop Pump

Primary

- Switch on Gauge Panel
- Truck PTO Dash Switch
- Truck Key

Trailer Operating Instructions

Start Delivery

1. Check diesel fuel, hydraulic oil and engine oil levels. Periodically check engine coolant level.

   a. If pressure build heater fails to work or if pink liquid is seen leaking, check Pressure Build Coil (PBC-1) glycol level.

Note: *If Pressure Build Coil (PBC-1) is over-filled, once warmed up it will leak out the pressure cap, this is normal. At 70°F ambient temperature, the level should be about 2.5-3" below the top plate.*

   b. Check fuel supply and hose if pressure build heater fails to ignite.

2. Open engine control panel.

   a. Turn key to on position, wait for yellow glow plug light to turn off, then start engine.

      i. If engine fails to start, turn key off, wait a short period, then restart after glow plug light turns off.

   b. With engine running, one green light should be on, no other lights should be on.

3. Increase engine speed to about 1/3 throttle, then switch on pressure build heater.

   a. This gives the engine and hydraulic oil some time to warm up, especially in cold weather.

   b. The pressure build heater pulls a lot of current, so the engine must be run at high idle to keep battery charged.

Note: *Battery state of charge can be monitored in the Flowcom "Inputs/Outputs" screen, "Vs_Main_In".*

   c. The pressure build heater water pump will start circulating glycol first.

   d. The heater internal fan will start, followed by the furnace lighting.

Note: *If the heater shuts off or fails to start, verify battery voltage is greater than 11.5 volts.*

4. Open the plumbing cabinet doors and follow the Modes of Operation instructions as previously explained.

5. Differences from truck operation:

   a. Prior to operating CO_2 pump, increase engine to full speed.

      i. Typically, this is done after connecting and purging hoses, just before pump delivery is needed.

   b. If the CO_2 pump is not needed (pressure transferring), leave the engine at high idle.

End Delivery

1. Complete the delivery per the Modes of Operation instructions as previously explained.

2. Switch off the pressure build heater and return the engine speed to 1/3 throttle high idle.

   a. This allows the engine and hydraulic oil to cool down before being switched off.

3. Set engine to low idle, turn off and close the engine control panel.

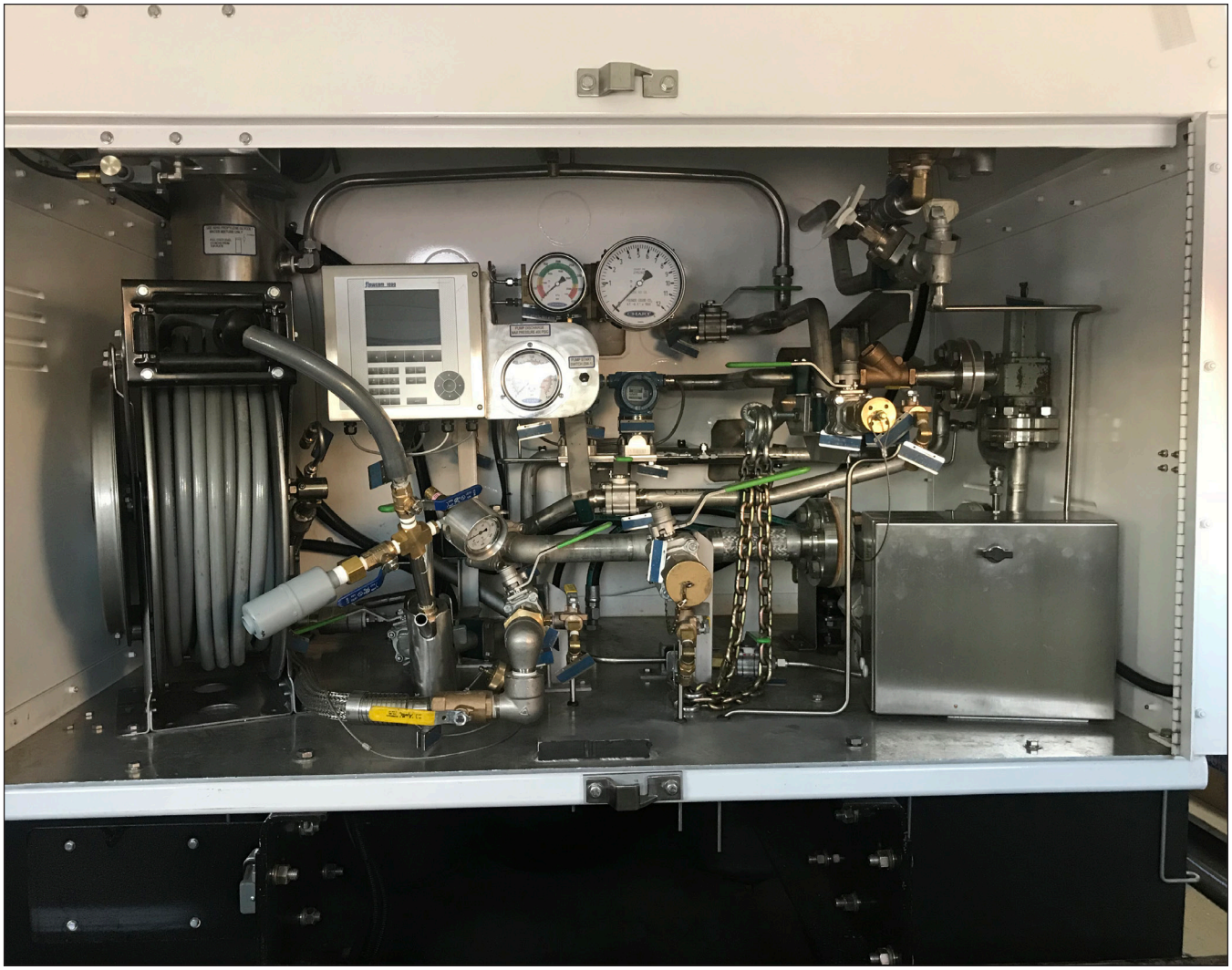
Methods to Stop Pump

- Switch on Gauge Panel
- Engine Key in Control Panel

Maintenance

Follow the maintenance protocols in this manual, per the engine manufacturer manual and per the heater manufacturer manual.

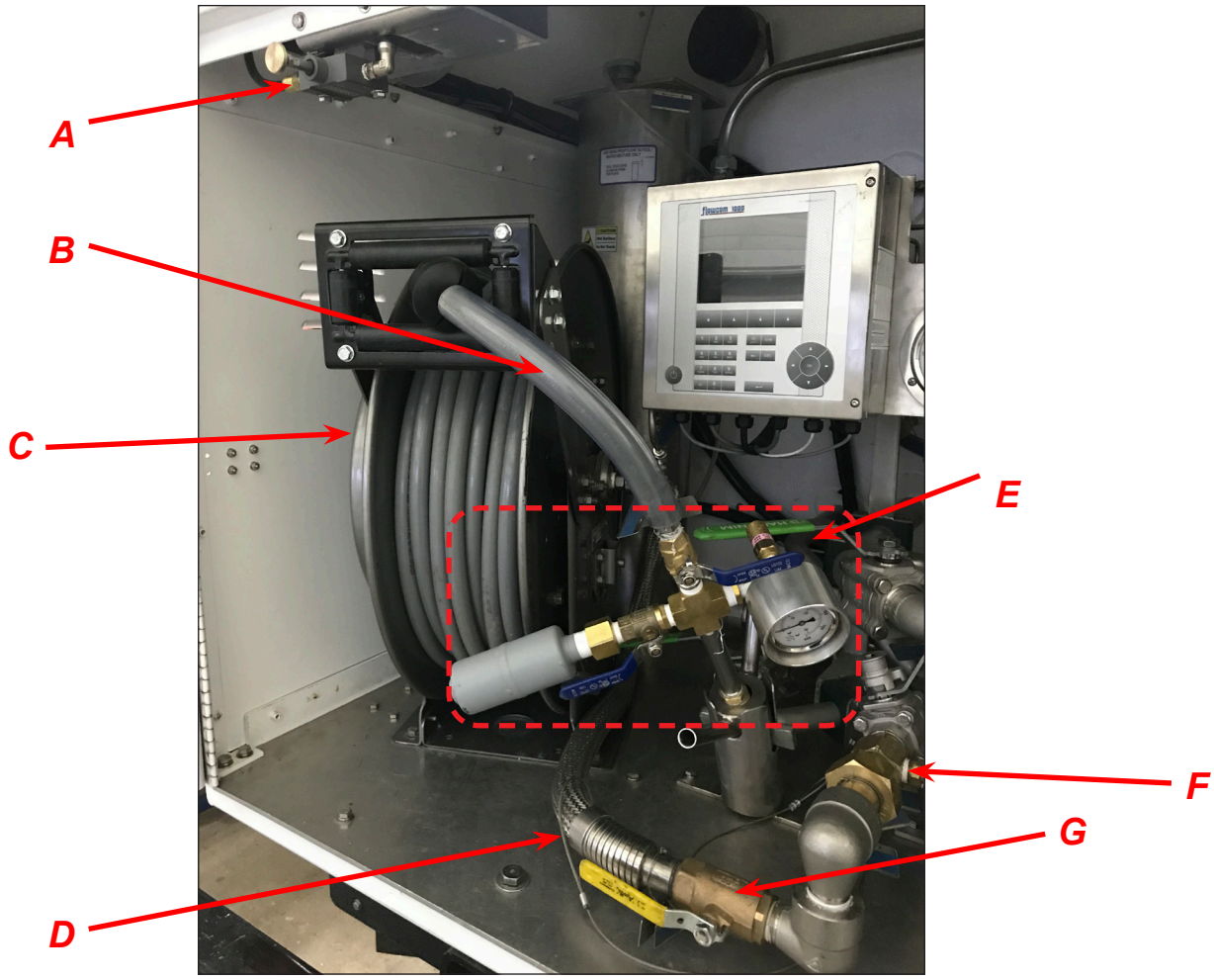
Components & Systems



Roadside **Center** **Curbside**

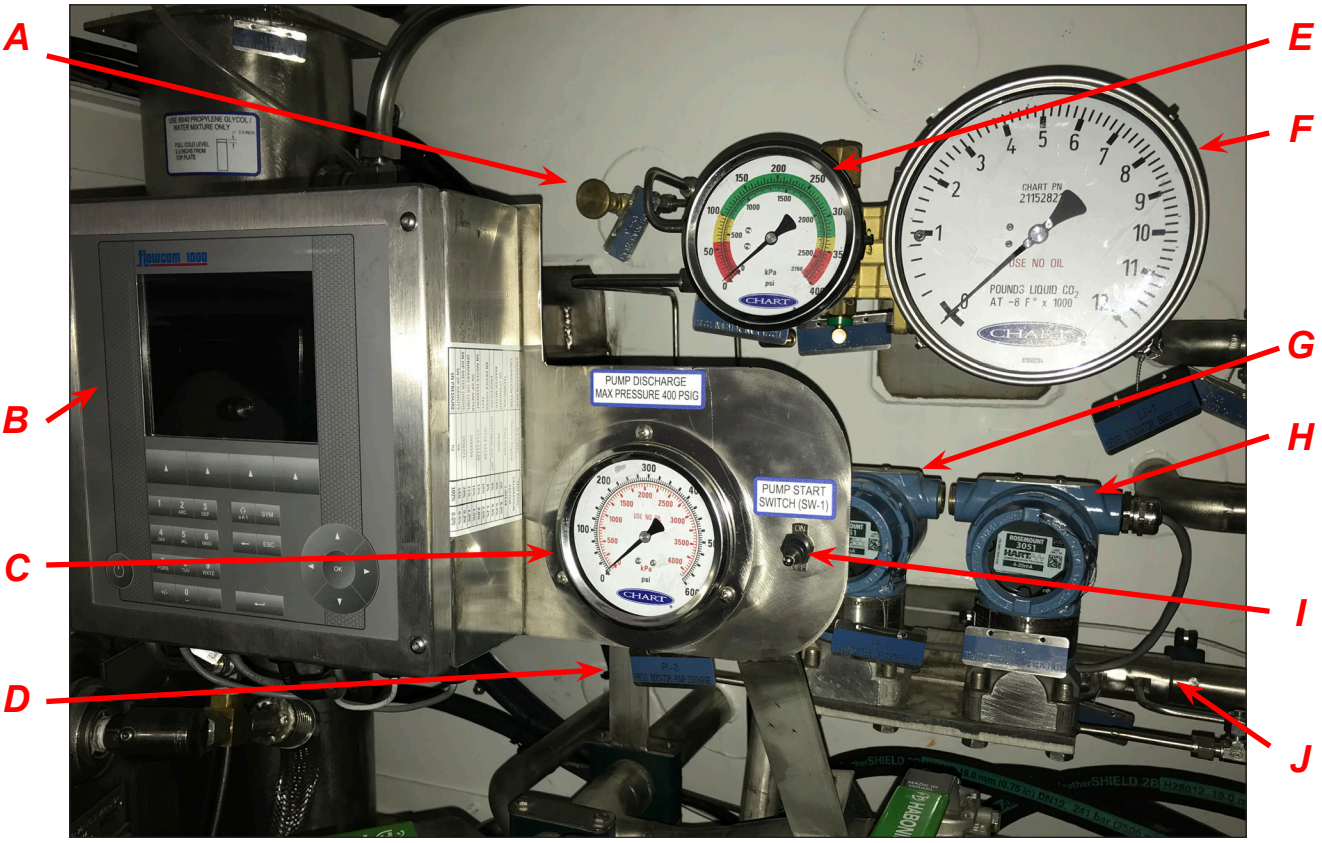
This is the view of the Orca CO_2 Series delivery system cabinet. This section will discuss in detail the plumbing cabinet components and systems.

Plumbing Cabinet - Roadside



Item	Tag	Description
A	AI-1	Anti-Tow Valve
B	TRAN-1	Hose Reel Flex Hose
C	HR-1	Hose Reel
D	TRAN-2	Delivery Flex Hose to Hose Reel
E		Fill-Gun Assembly
F	DC-3	Connection, Hose Reel Inlet
G	V-47	Valve, Delivery Flex Hose

Plumbing Cabinet - Top Center

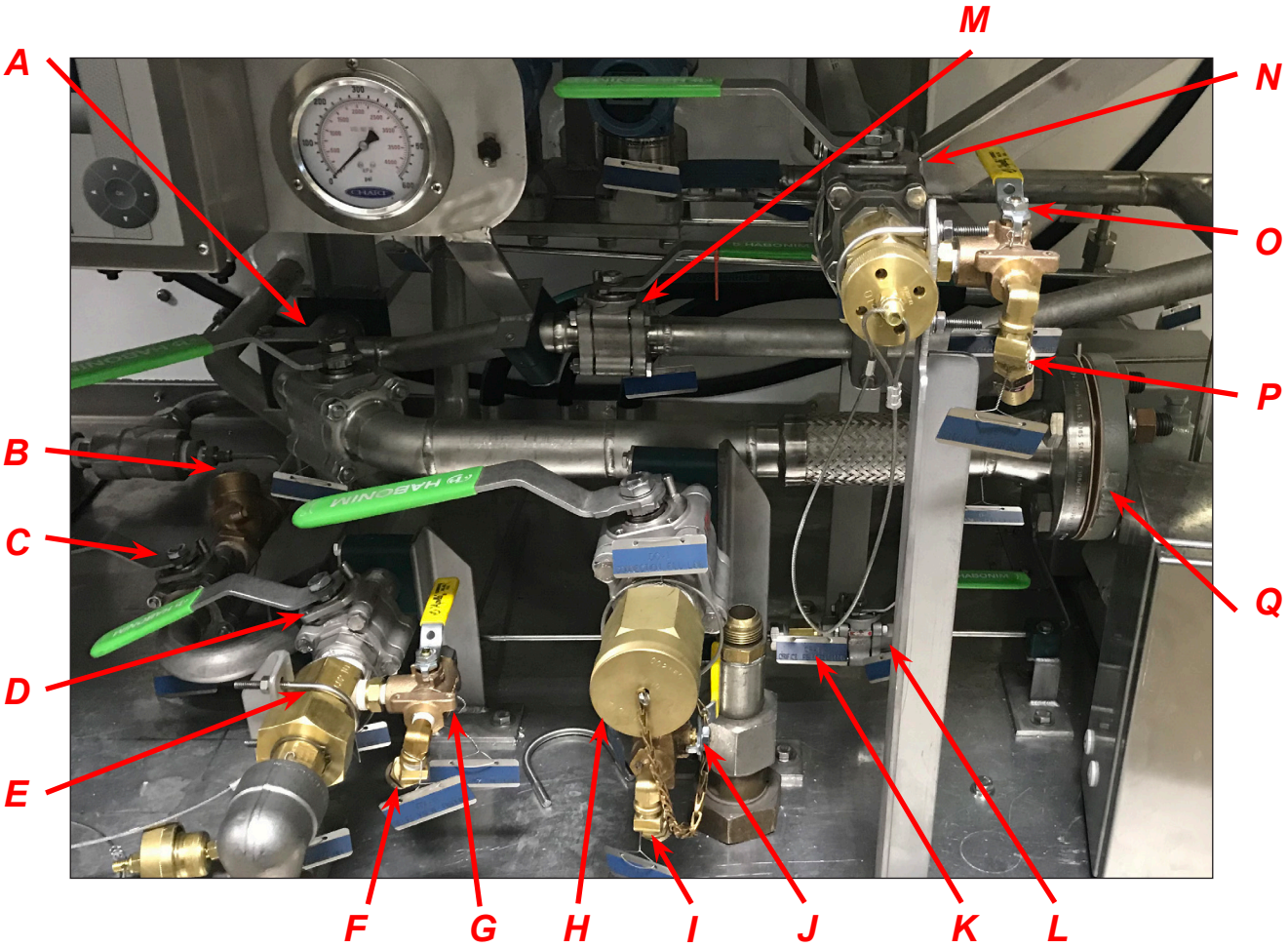


Item	Tag	Description
A	V-31	Valve, Vapor Phase Isolation
B		Flowcom® 1000 Flow Meter System
C	PI-2	Pressure Indicator, Pump Discharge
D	V-32	Valve, Liquid Phase Isolation
E	PI-1	Pressure Indicator, Inner Vessel
F	LI-1	Level Indicator, Inner Vessel
G	DP-1	Transmitter, DP Meter Low
H	DP-2	Transmitter, DP Meter High
I	SW-1	Switch, Pump Start
J	M-1	Flow Meter, Delivery
K	PI-3	Pressure Indicator, Inner Vessel

Liquid Level Gauge Chart

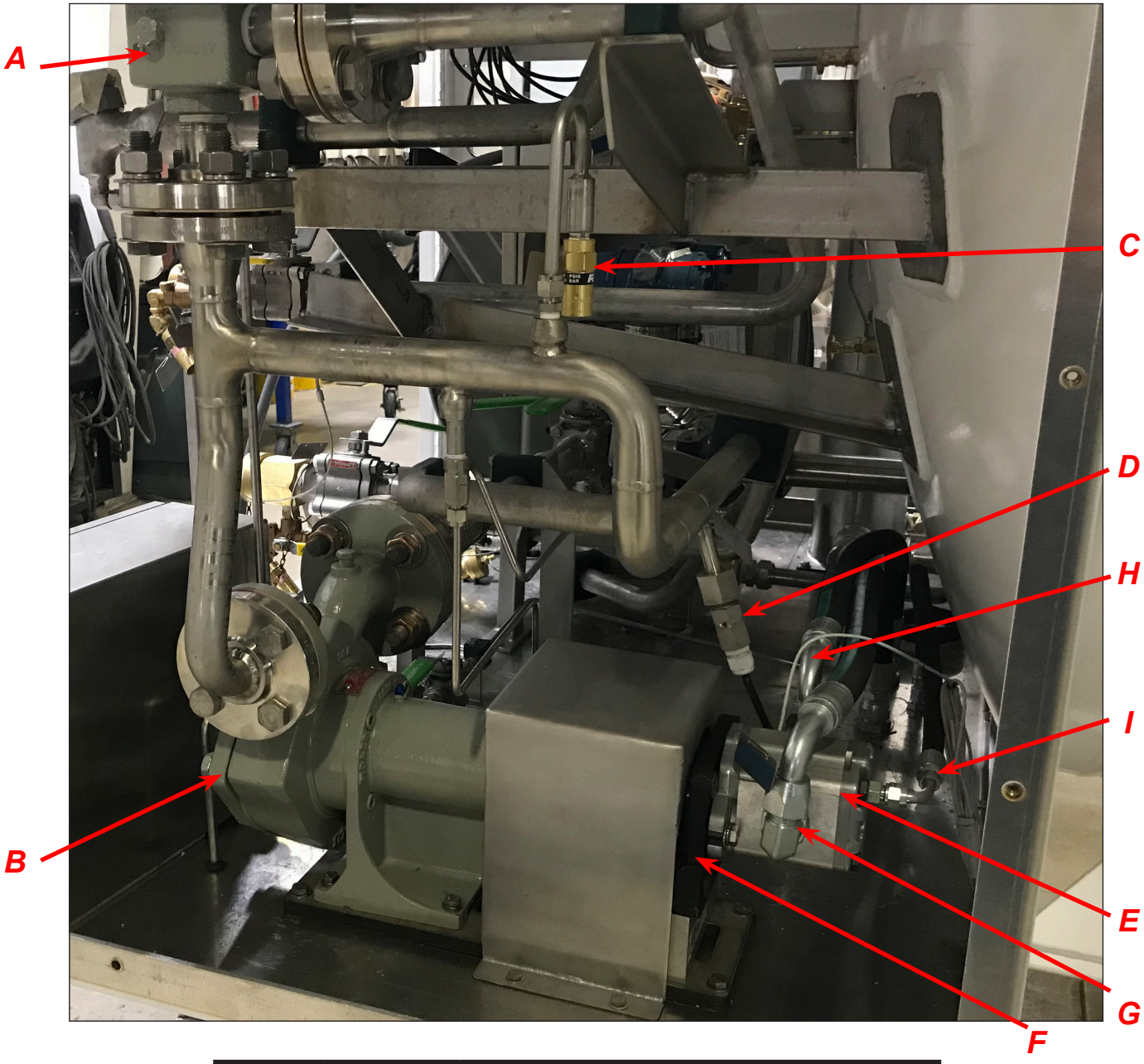
Size	Range
3.8	7,800
5.5	11,000
6.5	13,200
10.5	21,000

Plumbing Cabinet - Bottom Center



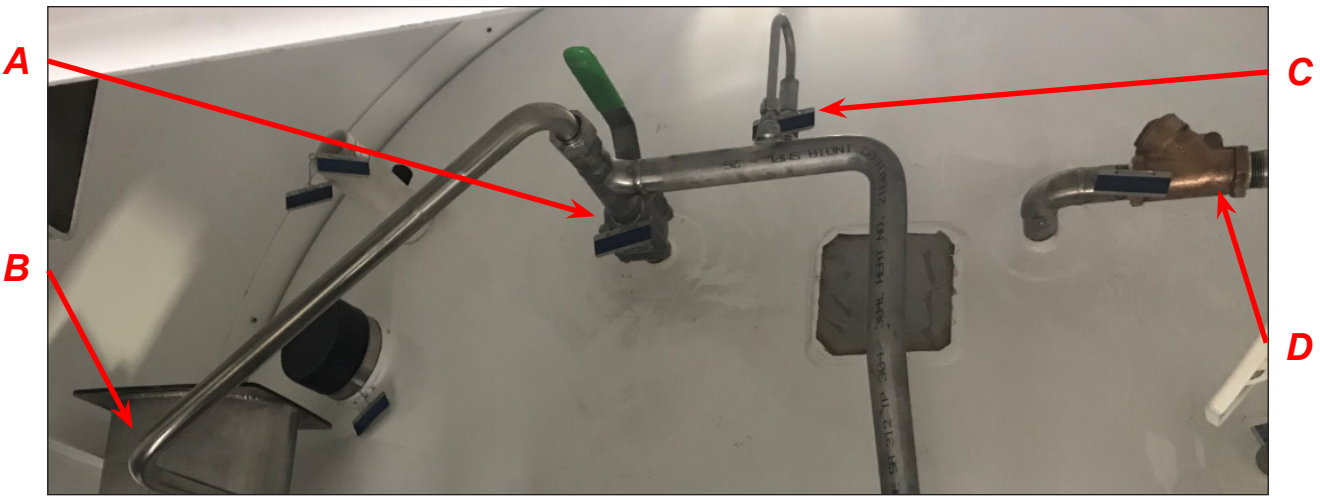
Item	Tag	Description
A	V-1	Valve, Pump Inlet/Fill
B	CV-2	Check Valve, PB Inlet
C	V-28	Valve, PB Liquid
D	V-41	Valve, Dispense
E	DC-2	Connection, Dispense
F	RV-6	Relief Valve, Dispense
G	V-8	Valve, Dispense Line Drain
H	DC-1	Connection, Fill Line
I	RV-10	Relief Valve, Fill
J	V-9	Valve, Fill Line Drain
K	OR-1	Orifice, Force Feed
L	V-16	Valve, PF Force Feed
M	V-4	Valve, Pressure Dispense
N	V-44	Valve, Vapor Balance
O	V-45	Valve, Vapor Balance Line Drain
P	RV-7	Relief Valve, Vapor Balance
Q	S-1	Strainer, Pump Inlet

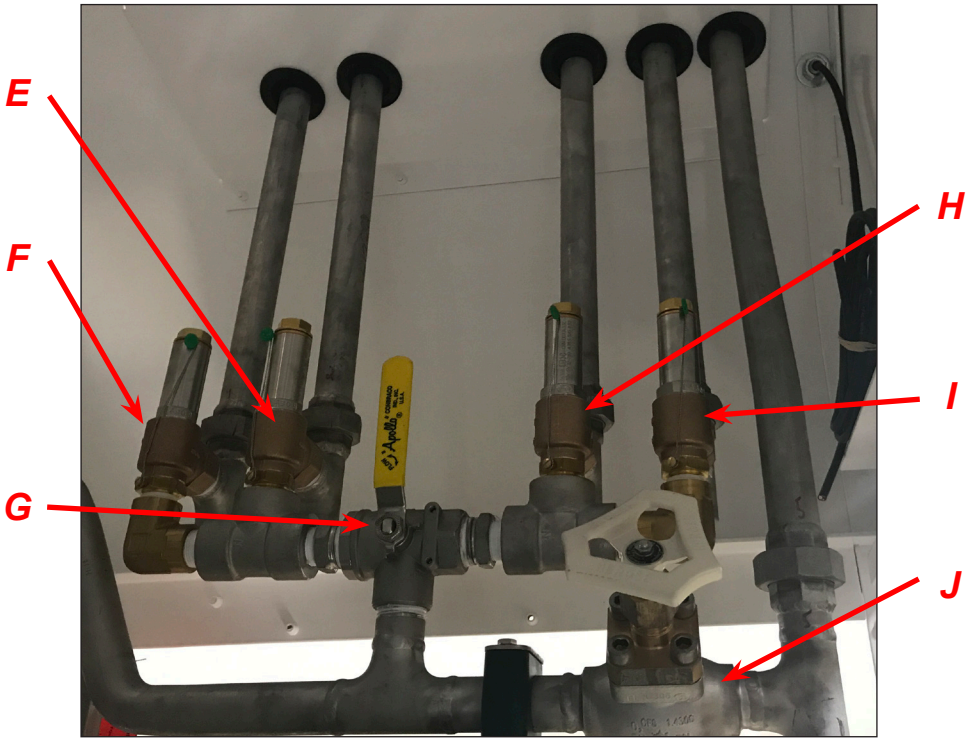
Plumbing Cabinet - Curb Side



Item	Tag	Description
A	V-7	Valve, Bypass
B	P-1	Pump
C	RV-11	Relief Valve, Pump Discharge
D	RTD-1	Resistance Temperature Device
E	MTR-1	Motor
F	CPL-1	Coupler, Motor to Pump
G		Motor High Pressure Side
H		Motor Low Pressure Side
I		Motor Case Drain

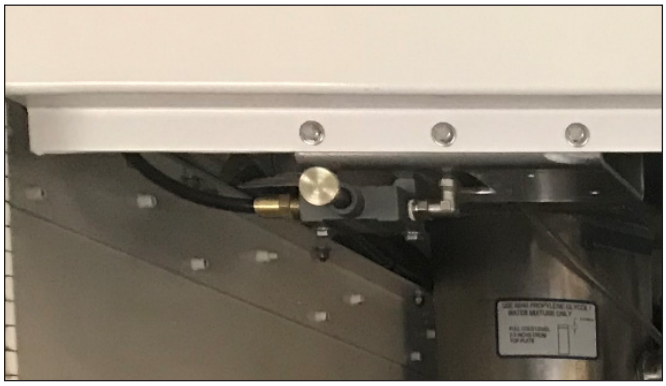
Plumbing Cabinet - Other Piping





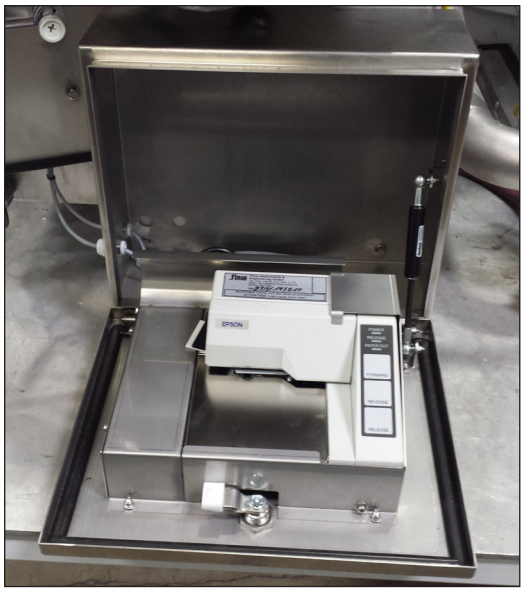
Item	Tag	Description
A	V-13	Valve, Vapor Balance/PB Isolation
B	PBC-1	Pressure Building Coil
C	RV-5	Relief Valve, Pressure Build
D	CV-5	Check Valve, Bypass
E	RV-1A	Safety Valve, Inner 350 psig
F	RV-1B	Safety Valve, Inner 375 psig
G	V-15	Valve, Safety Relief Selector
H	RV-2A	Safety Valve, Inner 350 psig
I	RV-2B	Safety Valve, Inner 375 psig
J	V-5	Valve, Vapor Vent

Anti-Tow Valve



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

Ticket Printer



Bluetooth Printing

Bluetooth printing is available via kit part number 21244207. For more information, see the following documents:

- FLOW_BTP-II - V2_0
- PR8000-V1_0-EN-PRINTER_ COMPATIBILITY_DATA_COMMUNICATION

Metering System

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

Meter Section

The Orca system incorporates an Orifice type meter section, which unlike turbine meters, has no moving parts to wear out or be damaged by gas. This unique feature makes the meter section a low maintenance item. As the liquid flows to the tapered orifice, a high pressure zone is created. Once the liquid flows through this restriction and reaches the larger “back side” of the restricted orifice, a drop in pressure occurs. This difference of pressure is the beginning of how product is metered. A 1/4” (6mm) line is plumbed into each side of the meter section. These two lines are then plumbed to the Differential Pressure Transmitters which make this differential pressure an electronic signal.

Differential Pressure Transmitter (DP Transmitter)

These are Rosemount Pre-Set Differential Pressure Transmitters used on the Orca system. They are connected to the meter section and the Flowcom meter system. The DP transmitters measure a change in pressure (pressure drop) across the meter section and relay this information to the Flowcom meter system in a 4-20 milliamp signal.

RTD - Resistance Temperature Device

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

Flowcom Flow Meter System

The Flowcom® Flow Meter System is used for calculating, integrating, system controlling, and displaying the mass flow.

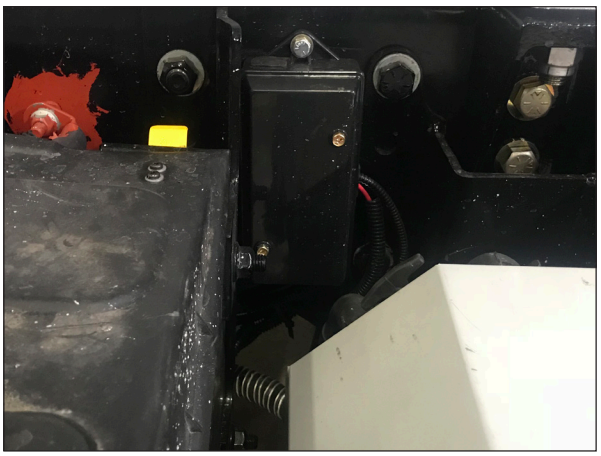
The push button controls allow the operator to start and stop the delivery, to view information, initiate the print out of the delivery ticket and to clear the total.

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

Note: *See the Flowcom manuals for preference changes such as date, time, units of measure, printing options, password settings, etc.*

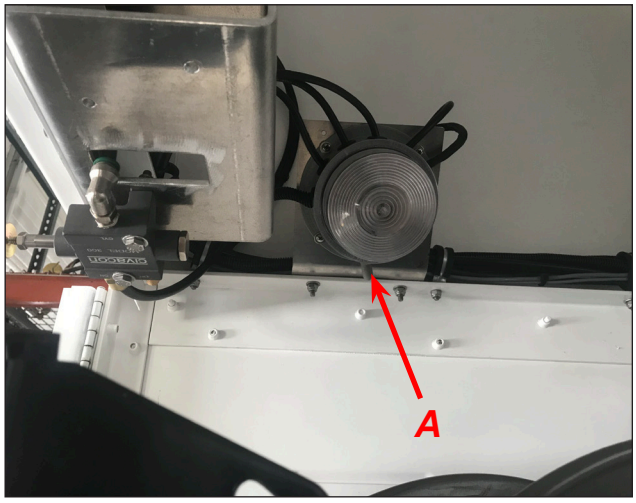
Cabinet Power - Truck

Power to the worklights and Flowcom comes from the 12 volt junction box near the battery box. Within the junction box is a relay that is energized with the truck key in the ON or ACC position, providing cabinet power. The 10-amp breaker protects the circuit.



Work Lights

Three LED work lights are located on the back of the Orca. The dome light in the cabinet has a switch (A) that powers all three. The dome light also acts as a junction box for 12-volt power into the cabinet.

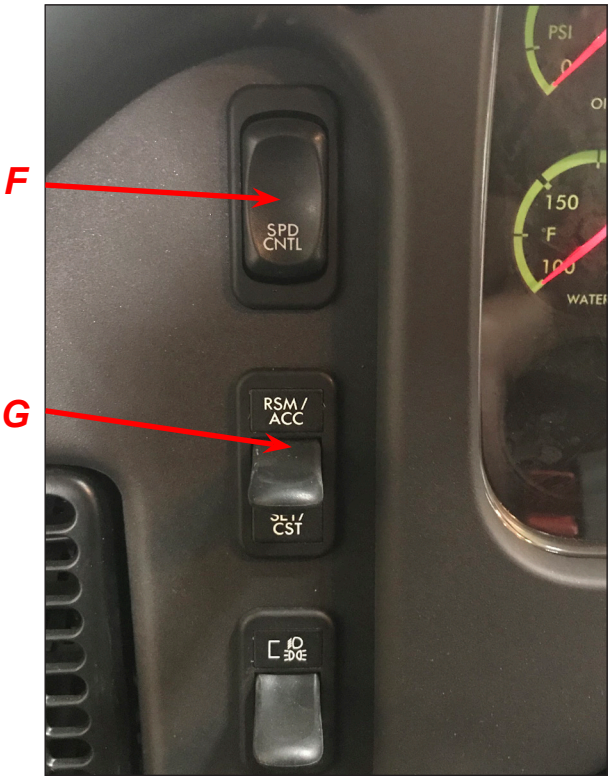


Dash Controls - Truck

Programmable timer Button (A) turns on and off the pressure build heater. Arrow Buttons (B) and (C) adjust heater on time with key in OFF or ACC positions. If the truck is equipped with two heaters, one for truck engine and one for pressure build, a second timer or switch (D) is used to turn on the pressure build heater. See OEM manual for more information.

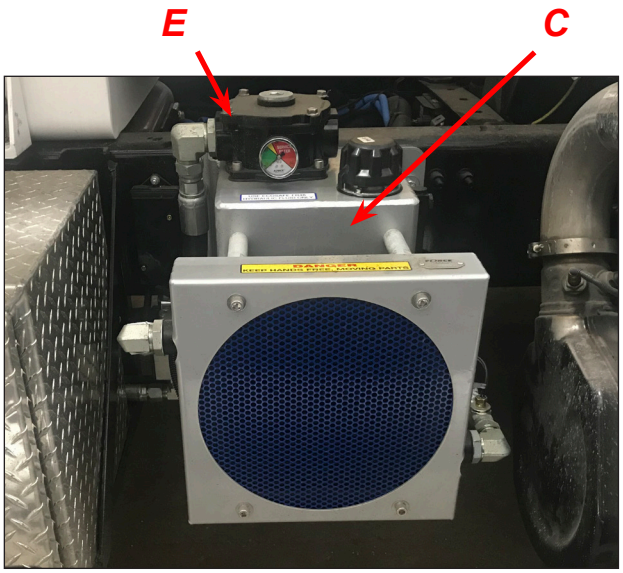
Switch (E) engages the PTO. Switch (F) turns on the cruise control and Switch (G) increases engine speed to set point.

Note: *With the specific PTO on this truck, the engine set point is 1,100 rpm. This will vary with other PTOs and may be as low as 950 rpm max engine speed.*



Hydraulic System - Truck

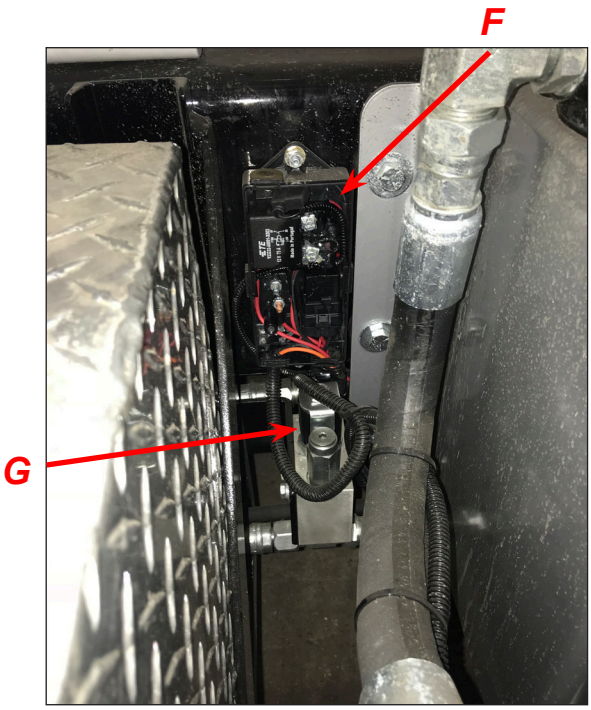
Power Take-Off (A) is connected to hydraulic pump (B). Ensure reservoir (C) is filled to proper height (D). Filter (E) is located in the reservoir.



Hydraulic System cont.

The hydraulic electrical junction box (F) contains a fuse and relays for powering solenoid block (G) and the cooling fan. When the cabinet switch (SW-1) is in the up position, recirculating flow is redirected to the motor (MTR-1) in the cabinet to power the CO_2 pump (Pl-1). Both the junction box and the solenoid block are located near the hydraulic oil cooling reservoir.

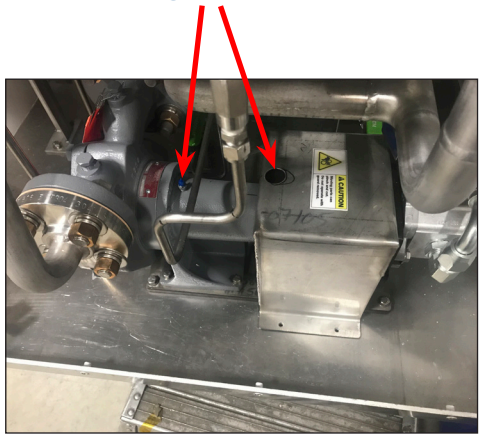
See OEM manuals for further information.



Motor and CO_2 Pump Rotation Direction

Cast onto the CO_2 Pump end cover is an arrow indicating the pump rotation. The rotation is counterclockwise as viewing this pump cover.

Grease Fitting Locations

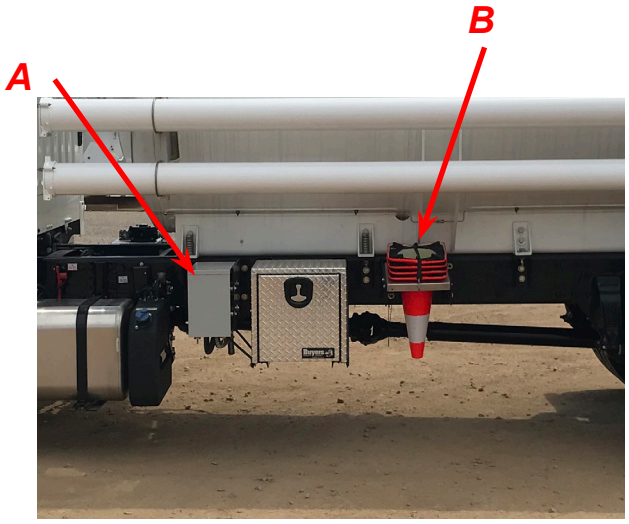


Pressure Build Heater and Safety Equipment

PB Heater (A) is located on the frame behind the fuel tank.

Safety cones (B) may be located anywhere on the truck frame. Wheel chocks (C) and safety flares (D) are in the tool box (E), which may be located anywhere on the frame.

The optional fire extinguisher (F) is located curb side at the cabinet.



Trailer System Components

Top Deck

Diesel Fuel Tank

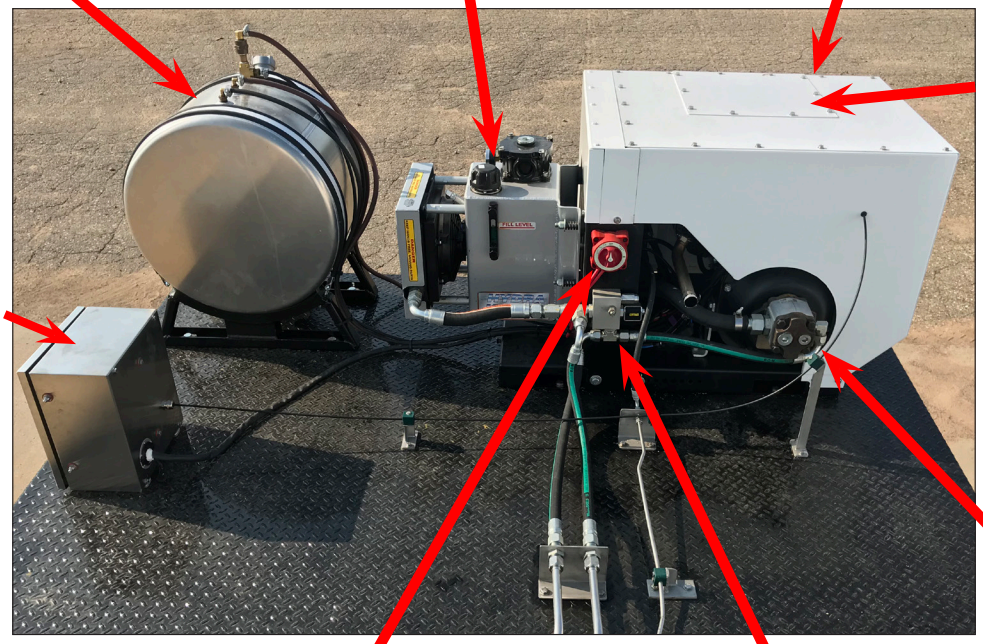
Supply to engine and pressure build heater

Hydraulic Reservoir/ Cooler/Filter

Same as on truck system

Engine and Battery

Battery supplies power to the engine, cabinet and pressure build heater.



Access Panel

In order to check coolant and add engine oil.

Control Panel

Hydraulic Pump

Same type as truck system but with a different displacement.

Battery Disconnect

Hydraulic Solenoid Valve

Same as on truck system.

Control Panel

Roadside Frame Rail

Troubleshooting

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

Symptom	*Probable Cause*	*Remedy*
No Flowcom or worklight power	Breaker tripped in 12 volt control circuit. 12 volt circuit open. Truck key in OFF position	Allow breaker to reset or replace breaker in junction box. Verify current draw is less than breaker rating. Verify connector is plugged in at front of tank. Also inspect wires from connector to control panel for break, cuts, etc. Repair if necessary. Turn to ACC or ON
Unstable flow of product.	Depletion of subcool. Vessel transmitter fault. Manual valves closed. Liquid level low. Two-phase flow. This occurs when a combination of liquid and gas flows through the pump.	Add subcool by opening pressure building coil. Ensure all valves are open. Check liquid level gauge. Pump delivery of product should not be attempted at low liquid levels. ***Caution! Serious damage to pump can occur if pump is run dry!*** Increase subcool. If the saturation pressure is high, the vessel may have to be blown down, then subcool added.
Paper out. (Print/Exit)	Add paper, check cables	Verify that the cables to the printer are plugged in, that the printer is turned on and that there is paper in the printer.
Flowcom parameters cannot be changed.	Improper Flowcom password entered.	Factory passwords are set to 1000 for the Flowcom 1000 and 3000 for the Flowcom 3000 Customers are expected to change the passwords for the three levels of security as they see fit. Refer to the Flowcom manual for more information. Do NOT forget what the password is changed to.

Overview of Operation Error Codes

Symptom	Possible Cause	Remedy
Flowcom® Flow Meter System does not power up.	Breaker tripped in 12 volt control circuit.	Check breaker in fuseblock in truck.
Flowcom® Flow Meter System cycling screens on startup.	12V supply voltage low.	Check 12V supply.
Message “Flowrate < Q...min” flashing red on screen.	Leak in DP Transmitter high line or pressure transmitter pump psi = 0, pump shutdown. Low Flow transmitter failure. High Flow transmitter failure. Warm hose.	Repair leak. Flowcom meter connector 5 and 6 disconnected, wire cut/disconnected, transmitter bad. Flowcom meter connector 7 and 8 disconnected, wire cut/disconnected, transmitter bad. Cool hose.
Message “Flowrate > Q... max” flashing red on screen.	Leak in the DP Transmitter low line, pump shutdown. Temporary extreme high-flow rate.	Repair leak. Use dispense valve to throttle.
Audible change in pump.	Liquid level low. Worn components 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!*** Rebuild or replace pump
Pump not catching prime.	Bypass valve not venting vapor or allowing recirculation. Liquid level low.	See pump supplier manuals for proper operation and adjustment. Temporarily open and close a dispense valve to introduce liquid to the 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!***
Pump will not start.	PTO not on. Solenoid valve not actuating. Oil level too low.	Start PTO. Verify 12 volts to/from switch (SW-1) to solenoid block. Add oil.
Printer error	Power loss. Data loss. Flowcom not set up. Paper not inserted.	Check power cable, DC converter bad, check connector 46, 47. Broken cable, check connector 17-19. Complete setup per Flowcom manual. Insert paper.

Symptom	*Possible Cause*	*Remedy*
Tank builds excess pressure or builds pressure too fast	Low usage Tank is over-filled	If daily usage is less than the NER, the tank will build pressure. If the tank is filled past the vent trycock or past the DOT specified fill weight, the pressure may rise rapidly after a fill
Tank pressure is too low or does not build pressure at a sufficient rate	Tank is leaking.	Check for frost anywhere on the plumbing or near the pressure reliefs. Spray soap solution on joints to test for leaks. Repair leaks if possible otherwise call Chart for assistance.
	Tank is contaminated with moisture or CO_2 byproducts.	Contaminants such as water will freeze in solution with liquid CO_2 preventing adequate flow of product into the pressure building coil. After the tank has been emptied, purge the tank with 50°C - 100°C nitrogen for 12 hours or more. Purge CO_2 byproducts out through the liquid fill line. After donning safety glasses and gloves, place a rag over the fill line outlet and open the valve briefly. Inspect the cloth for discoloration or impurities. Repeat until all impurities are removed.
	Carbon dioxide ice in tank	If the pressure in the tank drops below 61 psi, dry ice slush will form in the tank which will restrict liquid CO_2 from entering the pressure building coil. To liquefy solid CO_2, pressurize the tank using an outside source to 300 psi. Each pound of frozen CO_2 will consume one pound of dry CO_2 gas. For example, if the unit had 50 pounds of solid CO_2, it would consume the contents of one 50 lb high-pressure cylinder. Liquefaction is a slow process. It takes 30 minutes to liquefy each pound of solid CO_2.
Frost occurs around the plumbing	Tank is being used Frost is residual from last fill or earlier use	This is normal if the tank is receiving or delivering CO_2. This is normal. Frost may remain on the plumbing for hours after a fill or heavy use.
Frost occurs on hose or hose reel	Residual frost from last fill or recent use	This is normal. Ice may remain for hours after a fill or heavy use.
Flow meter not working	Water ice in phase lines to transmitters Carbon dioxide ice in phase lines to transmitters	If any moisture is found in the CO_2 supply, it will make its way to the DP transmitter phase lines and immediately block them. To purge the moisture, remove each phase line and force warm nitrogen through them. To avoid dry ice forming in the DP transmitter phase lines, pressurize the metering section with CO_2 gas above 70 psi before introducing liquid CO_2.

Error Codes & Warnings

During the switch-on phase, the Flowcom® Flow Meter System checks the important system functions and the data integrity. The differentiation is made between errors and warnings. Warnings and errors that can be addressed can be confirmed. The device can then be operated further. In the event of errors that cannot be addressed, the “DELIVERY” function is blocked. Errors and warnings are displayed during the switch-on phase.

Sections referenced below refer to the Flowcom 3000 Service Manual. See the Service Manual for more information.

Overview of Error Codes

Error	Cause	Task
E001	Hardware calibration not yet carried out. Checksum error identified when reading the calibration data.	Perform hardware calibration. (See section 3.2.8, “Hardware calibration”). The calibration seal needs to be broken.
E002	Parameters for configuration of the meter system have not been entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters. Settings.” The calibration seal needs to be broken.
E003	Parameters for calibration of the meter system have not been entered yet. Checksum error identified when reading the corresponding settings.	Calibrate metering system or enter calibration data. See section 6 “Parameters/Settings.” The calibration seal needs to be broken.
E004	User settings #1 of the meter system have not been entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters/ Settings.” The calibration seal does not need to be broken.
E005 - E007	A new mother board has been installed	Confirm error.
E009 - E010	Measured temperature is too low. PT 100 low signal voltage. PT 100 excitation current out of range. Broken cable.	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.
Boot-up errors E011 - E015	-Liquid flow through meter section before meter is turned on. -DP Transmitter defective -Wiring defective -Leak in DP lines	-Press “STOP” button on control pendant -Verify transmitter is plugged into junction box JB1, and that wires are not broken. -Voltage across contacts 1 & 2 on block X7 should measure between 18 & 26 VDC. If not, front board needs to be replaced. -Tighten fittings.
E030	User settings #2 of the meter system have not been entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters/ Settings.” The calibration seal does not need to be broken.
E031	PumpSmart settings of the meter system have not been entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters/ Settings.” The calibration seal does not need to be broken.

Error	Cause	Task
E032	Meter System serial numbers have not been entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters/Settings.” The calibration seal does not need to be broken.
E033	General settings of the meter system have not bee entered yet. Checksum error identified when reading the corresponding settings.	Configure device. See also section 6 “Parameters/Settings.” The calibration seal does not need to be broken.
E034	The License Key for the selected application has not been entered yet.	Enter License Key.
E035	Expansion module not connected or defective.	Check connection cable (ribbon cable) and/or replace. Expansion module.
E040	Battery Voltage lower than 1.82V (Nominal value is 3.0V).	Replace battery. Check date and time of internal clock and set if necessary.
E041 - E047	Main supply voltage too low.	Address fault in main voltage supply. Replacement of mother board (needs recalibration).
E048	Environmental temperature too low.	Address fault in main voltage supply. Replacement of mother board (needs recalibration).

Overview of Warnings

Warning Code	Cause	Task
W040	Battery voltage lower than 2.5V (Nominal value is 3.0V).	Replace battery. Confirm warning (device can be operated further). Check date and time of internal clock and set if necessary.
W041 - W047	Main supply voltage too low.	Confirm warning.
W048	Environmental temperature too low.	Confirm warning.
Circuit boards A, B or C do not pass on power up.	Circuit board is bad or lost program.	Replace board or reload program.

Preventive Maintenance

General

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

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

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

Note: During first-ever load, it's recommended to check mounting hardward once loaded.

Daily Observation Checks by Operator

Beginning of the Day Checks

1. Observe pressure in tank, pressure should not rise much in tank without the delivery systems operating (5-8 psi is typical).
2. Ensure safety reliefs are not leaking (frost on safety vent pipes is an indicator of a leak).
3. If ice forms around valves, ensure the valves are fully operational. If not, defrost with water.
4. Check for loose hardware, hydraulic oil leaks, glycol system leaks, and in general, items out of place.

During PTO (Power Take Off) Operation

1. Verify engine speed meets desired speed based on PTO type.
2. Check that there is no vibration from PTO driveline.

Caution: *If there is any vibration, the unit must be reviewed by a mechanic prior to making another delivery. Major damage may occur to equipment.*

During Deliveries

1. Review all plumbing and PB for any possible leaks.
2. Valves should open and close freely.
3. Check for pump noise or lack of building pressure.

Note: *If loud grinding noise is observed, contact Chart for proper diagnosis.*

4. Check that printer is operational (if equipped).
5. Check that the Flowcom® Flow Meter System has correct units, service, product type and no fault codes (this should not change, but could if service work has been performed).

Weekly Preventive Maintenance

Plumbing Inspection

1. Check that valves and piping are not leaking.
2. Tighten nuts, bolts, seals and gaskets.

Note: *Ice balls may be a sign of a possible issue.*

Power Take Off & Hydraulic System Inspection

1. Check hydraulic oil level.Top off with ECOSafe FR-46 oil as needed.
2. Ensure that transmission has no leaks around PTO housing.
3. Run PTO, ensure a smooth engagement (no grinding/clunking).
4. Inspect hydraulic lines for leaks or damage.

Every Three Months Preventive Maintenance

Electrical Connection Inspection (12v)

1. Check voltage at the batteries.
2. Check voltage at the relay box.
3. Check voltage on the junction box, located in the dome light
4. Check electrical connections at the Flowcom® Flow Meter System and electrical control box.

Every Six Months Preventive Maintenance

Tank-to-Frame Mounting Hardware

1. Bolts/nuts present and torqued.

Note: *Check within first month of use. If nuts continue to loosen replace the set. After 5-7 years, it is recommended to replace washer set and nuts.*

2. Springs not cracked and present forward of rear tandem.
3. Inspect all hardware and replace or tighten as needed.
4. Torque all PTO housing bolts (connection from PTO to transmission)

Note: See original equipment manufacturer (OEM) for maintenance and torque requirements.

Carbon Dioxide Pump

1. Lubricate the two bearings via grease gun with a MIL-G-10924 C ball bearing grease rating of -50°F. Follow maintenance procedures in pump manual.

Yearly Preventive Maintenance

1. Ensure proper service in all programmable settings.
2. Drain the air tank(s) every year before the winter months.
3. Perform a DOT inspection.
4. Test anti-tow system.
5. Get on-site meter calibration verification.
6. Change Hydraulic System filter per OEM. Verify fan turns on at 120°F.
7. Torque all PTO housing bolts (connection form PTO to transmission).

Note: *See original equpment manufacturer (OEM) for maintenance and torque requirements.*

8. Inspect line safety and main tank relief valves. Replace if leaking.
9. Top off with 60/40 propylene glycol/distilled water as needed (1.5 quarts PG : 1.0 quart water).

Every Five Years Preventive Maintenance

1. Replace main tank safety relief valves.
2. Replace line safety valves.

Vacuum Integrity Check (as required)

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

Preventive Maintenance Log

Date	Preventive Maintenance Performed	Notes

Date	Preventive Maintenance Performed	Notes

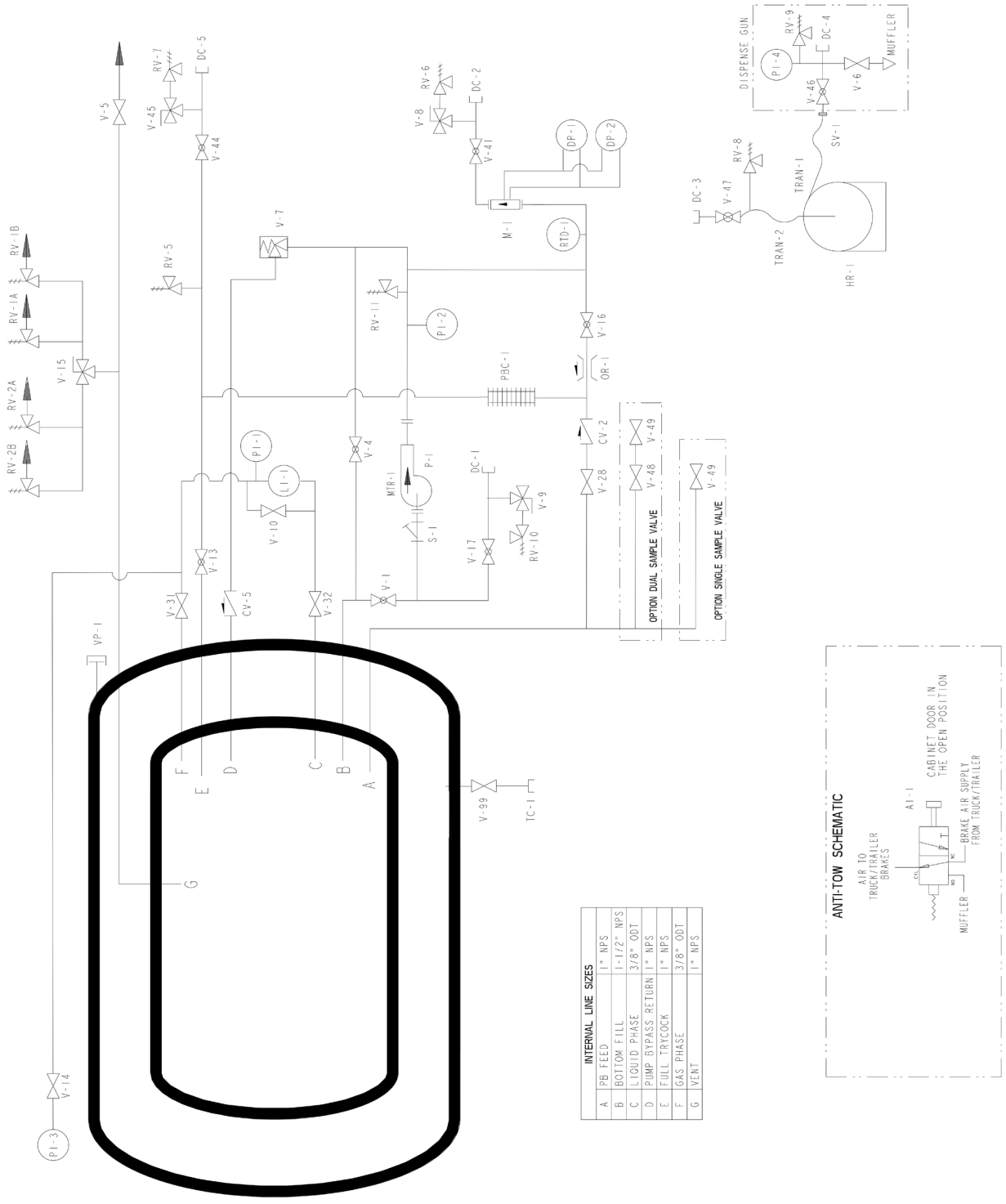
Specifications

Model	***3.8 Ton***	***5.5 Ton***	***6.5 Ton***	***10.5 Ton***	***13 Ton***
Type	Truck				Trailer
Real Axle	Single		Tandem		
Over 33,000# FET	No		Yes		
Design Code	DOT MC-338				
Flow Meter Type	Flowcom® Flow Meter System				
Pressure Build Type	ThermaFired™ or ThermaFired XL™				
Specifications	***3.8 Ton***	***5.5 Ton***	***6.5 Ton***	***10.5 Ton***	***13 Ton***
Gross Capacity (gal/L)	903 / 3,418	1,293 / 4,895	1,556 / 5,890	2,463 / 9,323	3,116 / 11,795
MC-338 Capacity (gal/L)	857 / 3,244	1,225 / 4,637	1,480 / 5,602	2,340 / 8,858	2,961 / 11,209
MAWP psig/bar	350 / 24.1				
Overall Length (in/cm)	146 / 371	181 / 460	205 / 521	253 / 643	346 / 879
Overall Height (in/cm)	68 / 173				
Overall Width (in/cm)	85 / 216				
Tank Diameter (in/cm)	66 / 168				
Tare Weight (lbs/kg)	6,900 / 3,136	8,600 / 3,909	9,700 / 4,409	13,700 / 6,227	16,700 / 7,575
Performance	***3.8 Ton***	***5.5 Ton***	***6.5 Ton***	***10.5 Ton***	***13 Ton***
Pressure Transfer	Standard				
100’ Hose on Reel	Standard				
Pump Transfer	Standard				
Min Dispense Rate* (lb/min, kg/min)	50 / 22.7				
Max Dispense Rate* (lb/min, kg/min)	500 / 227				
Max Dispense Pressure (psig/barg)	Pressure: 350 / 24.1 Pump: 400 / 27.6				

**** Min and Max Dispense Rates are based on NTEP approval and dependant on many variables: Orca pressure, receiver pressure, liquid temperature, flow circuit restriction, etc.***
*****Tare weights are estimated, and calculations will be confirmed when each size is built.***

Full Trycock Weight of Lading by Model based on Saturation Pressure												
Saturation Pressure (PSI)	***Density (#/gal)***	***Temp. (°C/°F)***	***3.8 Ton***		***5.5 Ton***		***6.5 Ton***		***10.5 Ton***		***13 Ton***	
			lbs.	***kg.***	***lbs.***	***kg.***	***lbs.***	***kg.***	***lbs.***	***kg.***	***lbs.***	***kg.***
350	8.28	-13.23/8.2	7,096	3,225	10,143	4,610	12,254	5,570	19,375	8,806	24,517	11,144
300	8.49	-18.41/-1.13	7,276	3,307	10,400	4,727	12,565	5,711	19,867	9,030	25,139	11,426
250	8.70	-24.24/-11.63	7,456	3,389	10,658	4,844	12,876	5,852	20,358	9,253	25,761	11,709
200	8.94	-31.04/-23.87	7,662	3,482	10,952	4,978	13,231	6,014	20,920	9,509	26,471	12,032
150	9.20	-39.23/-38.61	7,884	3,583	11,270	5,122	13,616	6,189	21,528	9,785	27,241	12,382
100	9.52	-49.75/-57.55	8,159	3,708	11,662	5,300	14,090	6,404	22,277	10,125	28,189	12,813
70	9.75	-64.95/-84.91	8,356	3,798	11,944	5,429	14,430	6,559	22,815	10,370	28,870	13,122

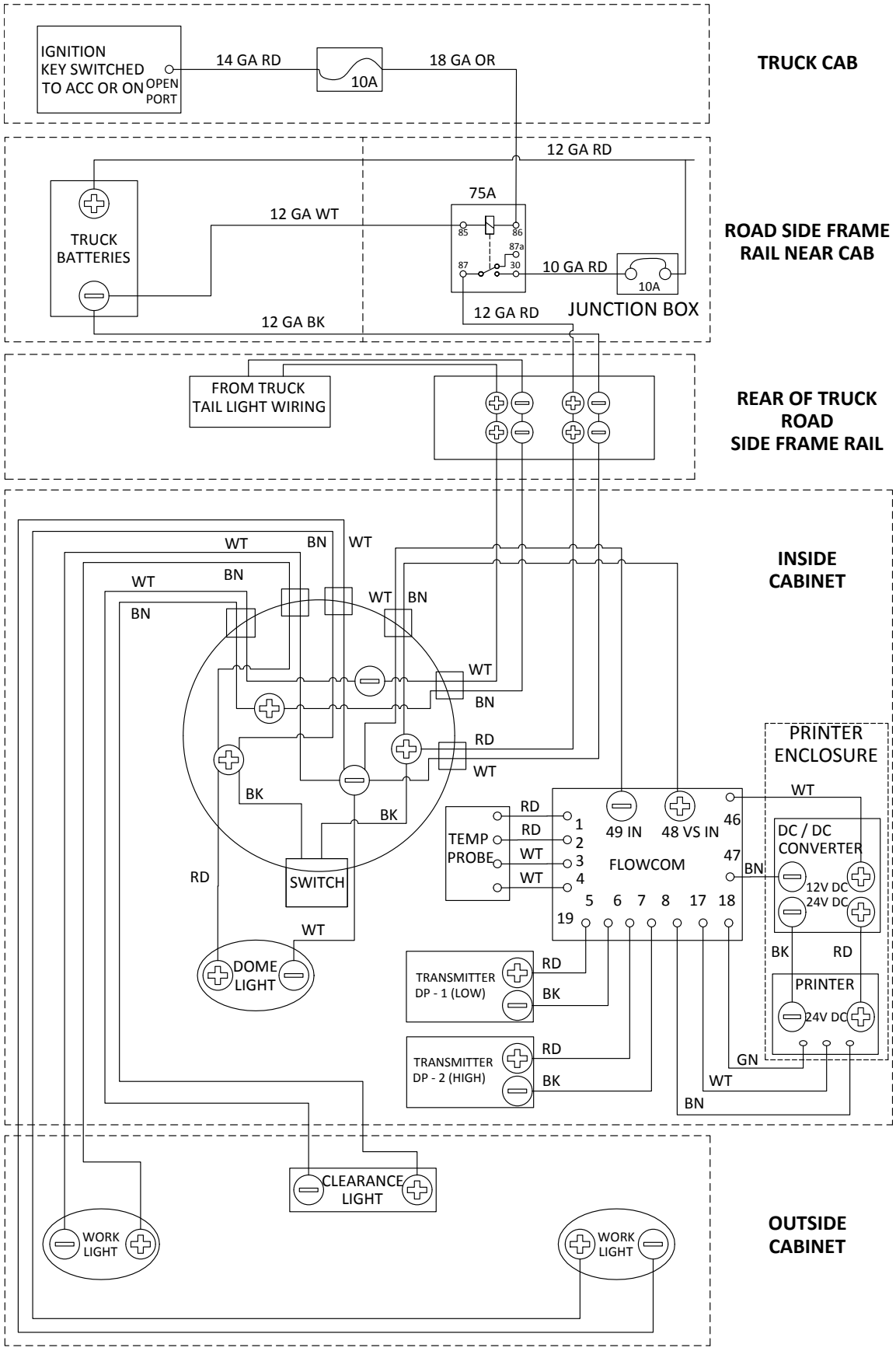
Piping Schematic



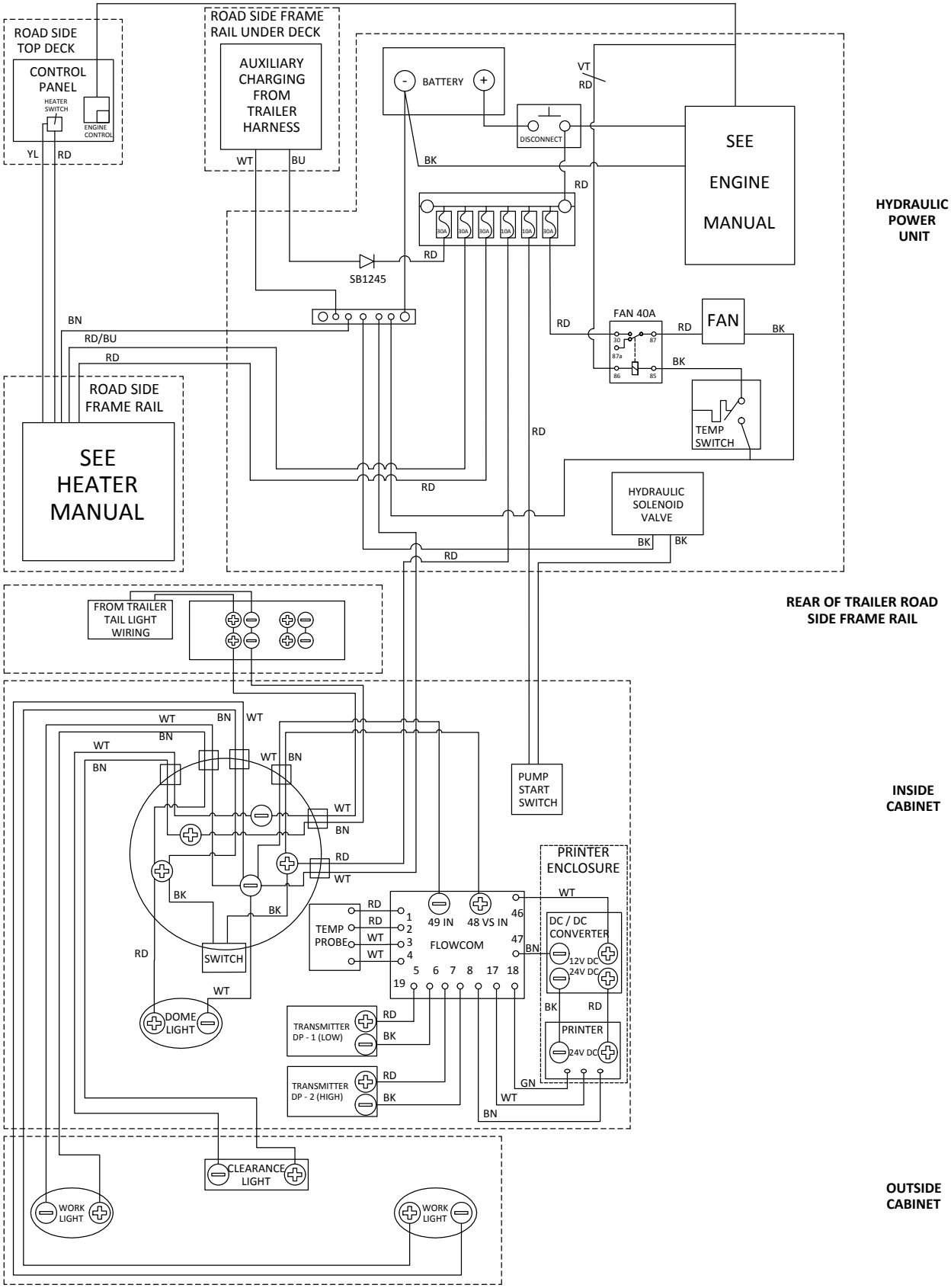
Nomenclature

TAG	DEFINITION	CHART NO	SIZE
CV-2	CHECK VALVE, PB INLET	11656072	1" FPT
CV-5	CHECK VALVE, BYPASS	11656072	1" FPT
DC-1	CONNECTION, FILL LINE	10715026	1.5" CGA
DC-2	CONNECTION, DISPENSE	20858964	1.0" CGA
DC-3	CONNECTION, HOSE REEL INLET	21162648	1" MPT
DC-4	CONNECTION, HOSE REEL DISPENSE	20679772	
DC-5	CONNECTION, VAPOR BALANCE	20858964	1.0" CGA
DP-1	TRANSMITTER, DP METER LOW	21272600	
DP-2	TRANSMITTER, DP METER HIGH	21272601	
V-1	VALVE, PUMP INLET/FILL	21078926	1-1/2" PS
V-4	VALVE, PRESSURE DISPENSE	20958013	1" PS
V-5	VALVE, VAPOR VENT	20569537	1" PS
V-6	VALVE, HOSE REEL LINE DRAIN	1716182	1/4" FPT
V-7	VALVE, BYPASS	21152731	1" FPT
V-8	VALVE, DISPENSE LINE DRAIN	11809868	1/4" FPT
V-9	VALVE, FILL LINE DRAIN	11809868	1/4" FPT
V-10	VALVE, LI-1 EQUALIZATION	21152821	1/4" MPT
V-13	VALVE, VAPOR BALANCE/PB ISO	20958013	1" PS
V-14	VALVE, INNER VESSEL GAUGE ISO	11701435	1/4" ODT
V-15	VALVE, SAFETY RELIEF SELECTOR	21152717	1" FPT
V-16	VALVE, PB FORCE FEED	21078927	1/2" FPT
V-17	VALVE, BOTTOM FILL	21078925	1-1/2PSX1-1/2FPT
V-28	VALVE, PB LIQUID	20569537	1" PS
V-31	VALVE, VAPOR PHASE ISO	10907239	1/4" MPT
V-32	VALVE, LIQUID PHASE ISO	10907239	1/4" MPT
V-41	VALVE, DISPENSE	21153268	1PSX1FPT
V-44	VALVE, VAPOR BALANCE	21153268	1PSX1FPT
V-45	VALVE, VAPOR BALANCE LINE DRAIN	11809868	1/4" FPT
V-46	VALVE, DELIVERY HOSE	20679772	1/2" FPT
V-47	VALVE, DELIVERY FLEX HOSE	11538754	1" FPT
V-48	VALVE, ISO SAMPLE	21078927	1/2" FPT
V-49	VALVE, SAMPLE	21078927	1/2" FPT
V-99	VALVE, TC ISOLATION	10482381	1/8" NPT
HR-1	HOSE REEL	10875652	100'
M-1	FLOW METER, DELIVERY	FL0800390	1" NPS
MTR-1	MOTOR	21208971	
OR-1	ORIFICE, FORCE FEED	21320341	1/2" MPT
P-1	PUMP	21152730	1-1/2"FLG 300#
PBC-1	PRESSURE BUILDING COIL	21217499	-
PI-2	PRESS INDICATOR, PUMP DISCHARGE	20860869	1/4" MPT
PI-3	PRESS INDICATOR, INNER VESSEL FRONT OF TANK	21152830	1/4" MPT
PI-4	PRESS INDICATOR FILL GUN	20679772	1/4" MPT
RTD-1	RESISTANCE TEMPERATURE DEVICE	FL1145110	
RV-1A	SAFETY VALVE, INNER	20724650	3/4"MPTX1"FPT
RV-1B	SAFETY VALVE, INNER	21152718	3/4"MPTX1"FPT
RV-2A	SAFETY VALVE, INNER	20724650	3/4"MPTX1"FPT
RV-2B	SAFETY VALVE, INNER	21152718	3/4"MPTX1"FPT
RV-5	RELIEF VALVE, PRESSURE BUILD	1811472	1/4" MPT
RV-6	RELIEF VALVE, DISPENSE	1811472	1/4" MPT
RV-7	RELIEF VALVE, VAPOR BALANCE	1811472	1/4" MPT
RV-8	RELIEF VALVE, DISPENSE FLEX HOSE	1811472	1/4" MPT
RV-9	RELIEF VALVE, FILL GUN	20679772	1/2" FPT
RV-10	RELIEF VALVE, FILL	1811472	1/4" MPT
RV-11	RELIEF VALVE, PUMP DISCHARGE	1810802	1/4" MPT
S-1	STRAINER, PUMP INLET	21152950	1-1/2 PS FLG
SV-1	SWIVEL JOINT	21297690	1/2" NPT
TC-1	VACUUM THERMOCOUPLE	4210049	1/8" MPT
TRAN-1	HOSE REEL FLEX HOSE	21180164	1/2"MPT X 1/2"MPT
TRAN-2	DELIVERY FLEX HOSE TO HOSE REEL	21163838	1/2" MPT X 1"MPT
VP-1	VACCUM PORT	10826172	
	PNEUMATIC & 12VDC POWER		
A1-1	ANTI-TOW VLV E BRAKE	10469961	1/4" FPT
CPL-1	COUPLER, MOTOR TO PUMP	21208975	1" SHAFT - 5/8" SHAFT
	LIQUID LEVEL GAUGE FOR TANK PER SIZE		
LI-1/PI-1	PRESS INDICATOR, INNER VESSEL (3.8TON)	21230028	
LI-1/PI-1	PRESS INDICATOR, INNER VESSEL (5.5TON)	21230029	
LI-1/PI-1	PRESS INDICATOR, INNER VESSEL (6.5TON)	21230030	
LI-1/PI-1	PRESS INDICATOR, INNER VESSEL (10.5TON)	21230031	
LI-1/PI-1	PRESS INDICATOR, INNER VESSEL (13TON)	21249112	
	OPTIONAL INNER SAFETY VALVE		
RV-1A	SAFETY VALVE, INNER	21194921	3/4"MPTX1"MPT
RV-1B	SAFETY VALVE, INNER	21194920	3/4"MPTX1"MPT
RV-2A	SAFETY VALVE, INNER	21194921	3/4"MPTX1"MPT
RV-2B	SAFETY VALVE, INNER	21194920	3/4"MPTX1"MPT

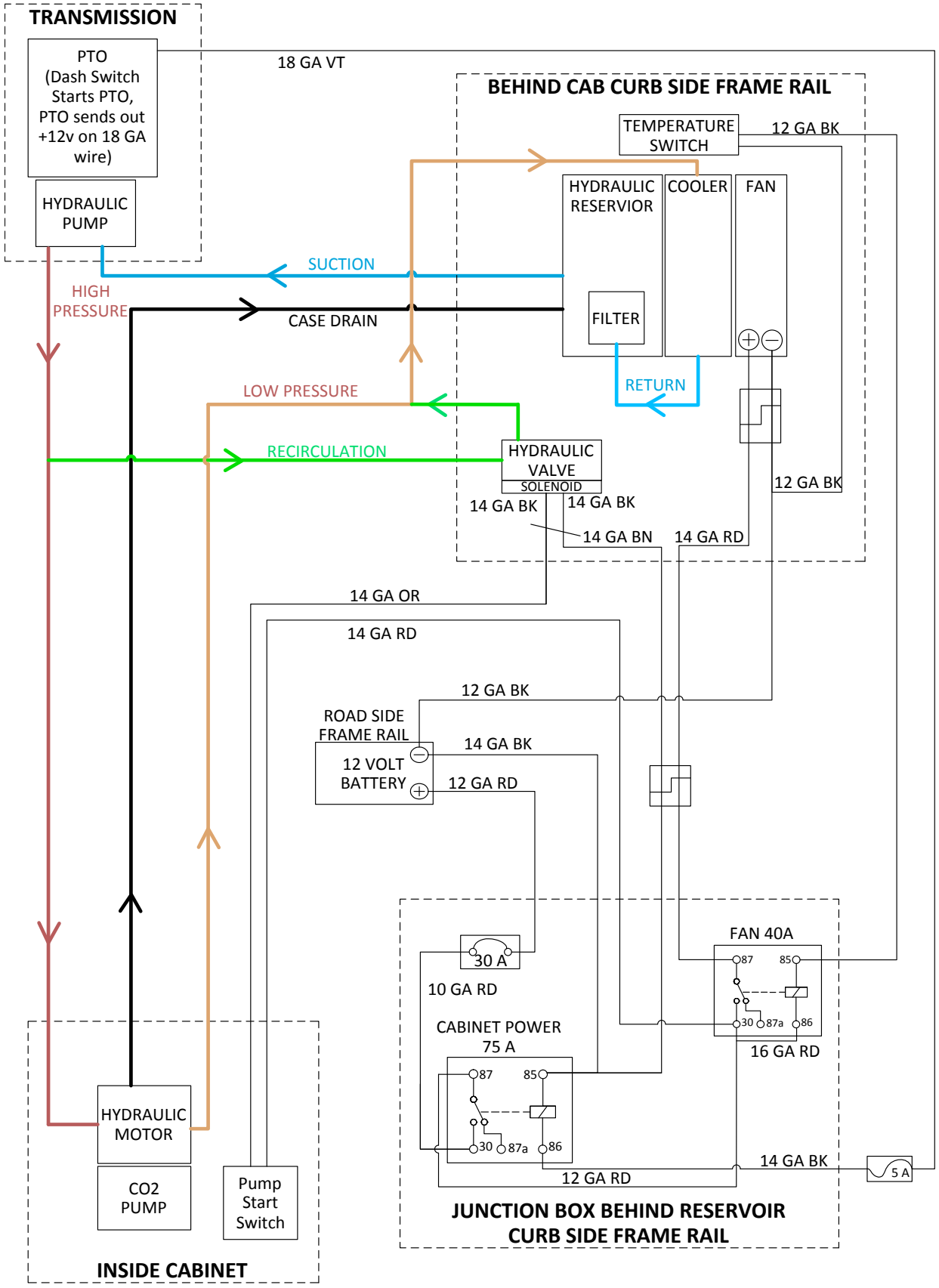
Truck Electrical System Diagram



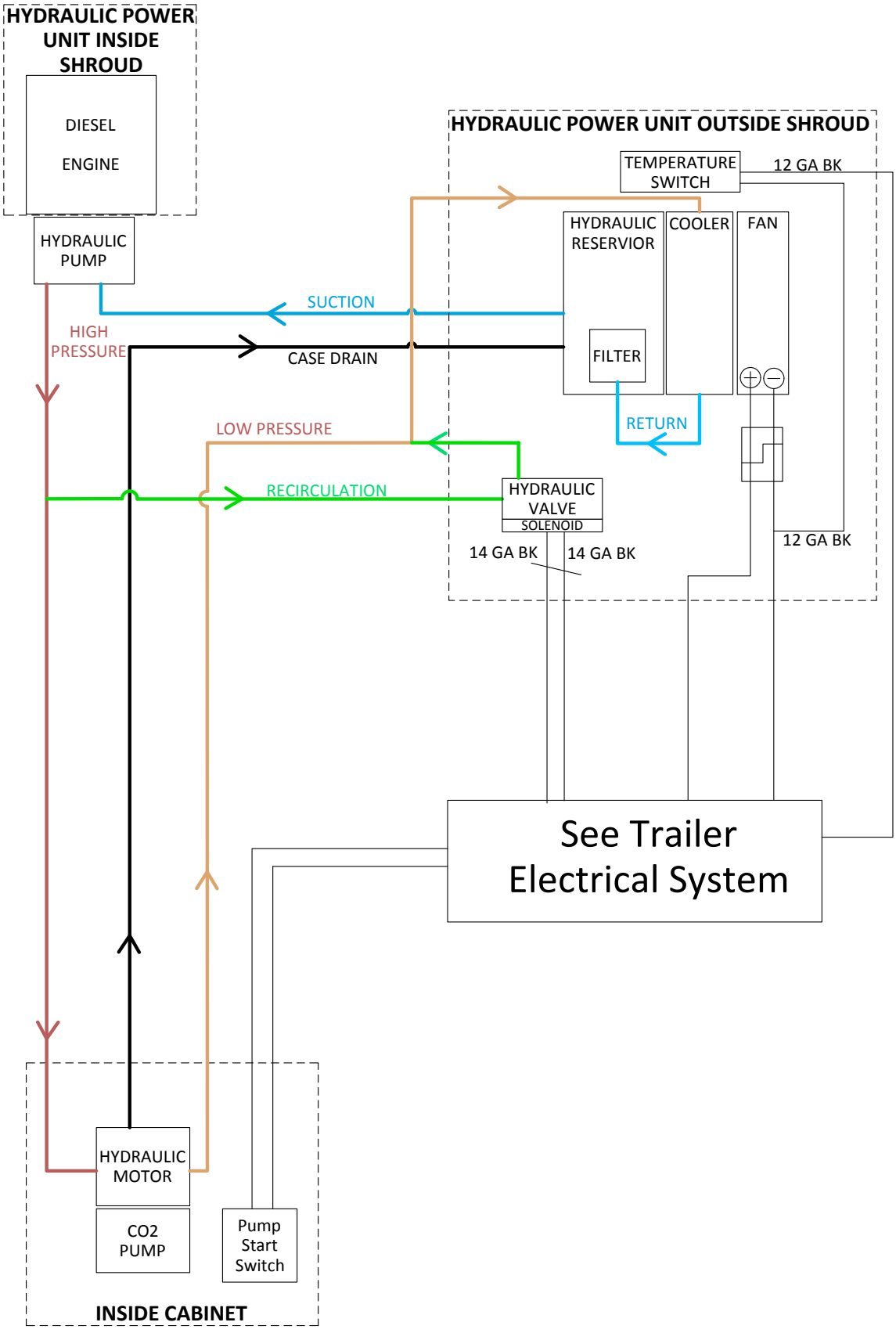
Trailer Electrical System



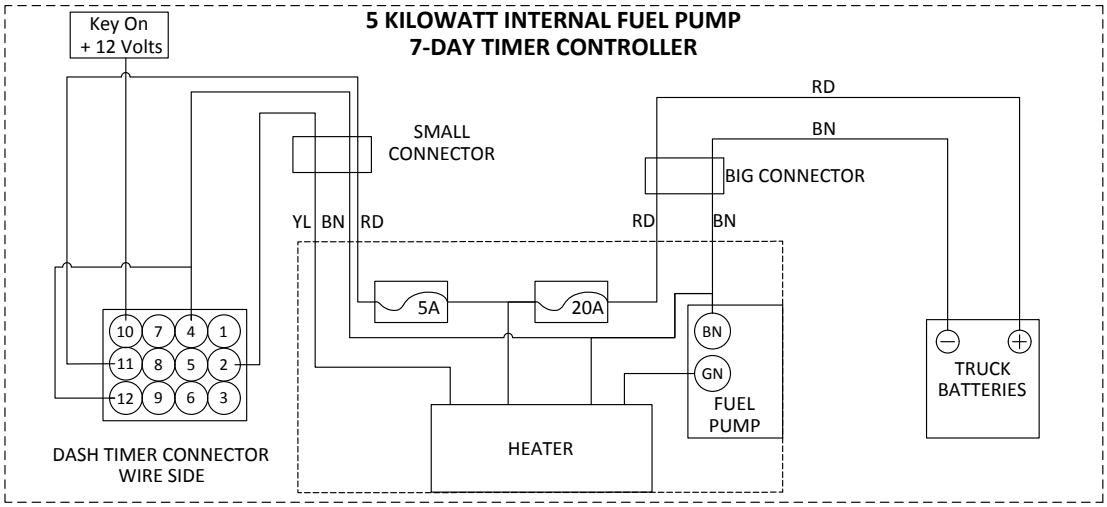
Truck Hydraulic System



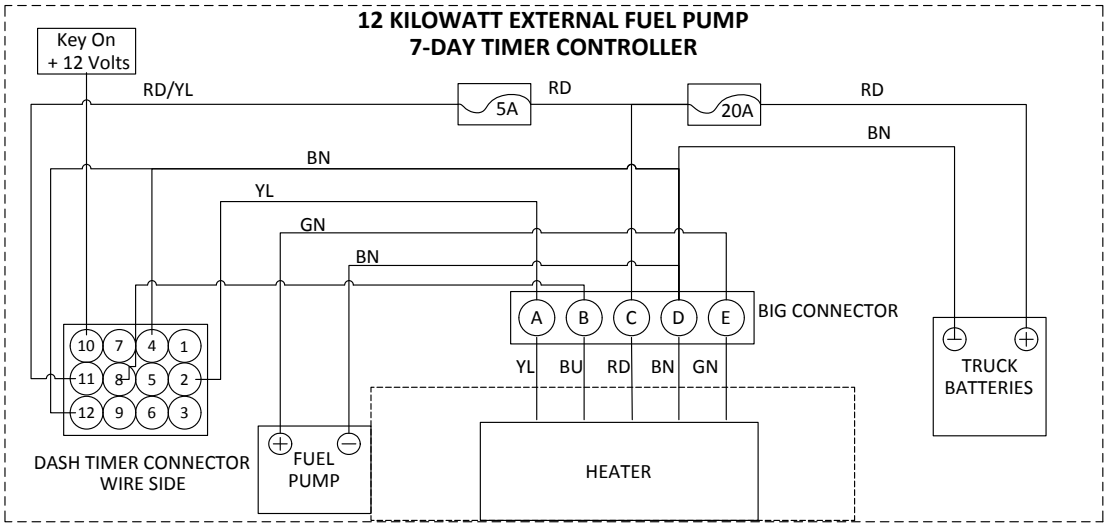
Trailer Hydraulic System

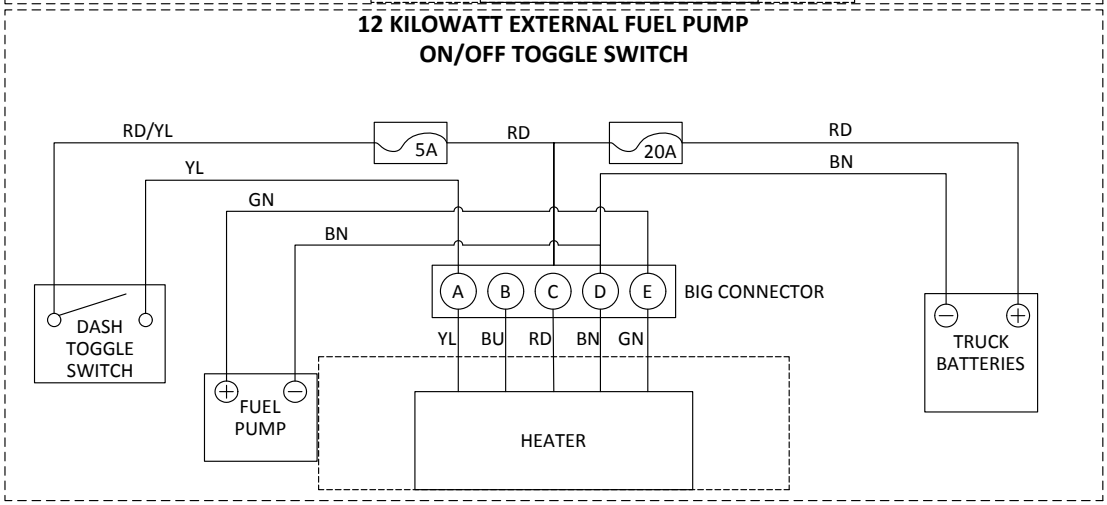


Pessure Build Heater Electrical



Terminal 1 – Power from vehicle dash lights
Terminal 2 – Heater switch wire (yellow wire).
Terminal 3 – Not used.
Terminal 4 – Heater brown "B-"
Terminal 5 – Not used.
Terminal 6 – Temperature setting "+" (air only).
Terminal 7 – Not used.
Terminal 8 – Heater diagnostic lead (blue wire).
Terminal 9 – Temperature setting "-" (air only).
Terminal 10 – Key "On" for continuous use, and for unlocking ECU.
Terminal 11 – Positive power from heater red "B+".
Terminal 12 – Heater brown "B-"





30 KILOWATT: SEE TRAILER ELECTRICAL SYSTEM

Warranty Statement

Chart Standard Warranty

Chart Purchased Parts

Chart Inc. will pass on all warranties offered to us by our vendors. This is for those items which Chart Inc. purchases from them directly. Below is a list of the major items with their warranty periods. For the items not listed below, Chart Inc. will warranty the replacement period for a time frame of 90 days after the ship date of the Orca CO_2 Series unit. If warranty replacement of part is required, the Orca CO_2 Series unit will be repaired at the nearest Chart Inc. Authorized Service Provider, by the Purchaser, or Chart Inc. personnel in the field. This warranty is subject to the exclusions above.

Major Components

Component	Time Frame*
Resistance Temperature Device (RTD)	1 Year
Differential Pressure Transmitter (DP Transmitter)	1 Year
Spin-on Connections	6 Months
Meter Element	Life of Orca System
Differential Pressure Gauge	1 Year
Orca CO_2 Series Delivery Hose	1 Year
Flowcom Flow Processor	1 Year
Printer	6 Months
Pump CO_2 Service	Mfg Warranty
Hydraulic Package	Mfg Warranty
Check Valves	1 Year
Safety Relief Valves, Vent	1 Year
Vacuum	3 Years

*From shipment of Orca CO_2 Series unit.

Workmanship and Vacuum

Chart Inc. warrants all Orca CO_2 Series units manufactured to be free from defects in material and workmanship for three years after shipment, subject to the exclusions listed below and statements on the preceding and following pages. Provided neither the evacuation valve nor the vacuum gauge valve has been tampered or disturbed so as to bleed gas into the annulus, and that no other misuse or abuse of the equipment has caused the excessive pressure. If warranty repair is required, the Orca CO_2 Series unit will be repaired at the nearest Chart Authorized Service Provider, by the Purchaser, or Chart Inc personnel in the field, or at Chart Inc. at the discretion of Chart Inc. and in accordance with the attached Warranty Claims Procedure.

Exclusions

1. Chart Inc. accepts no liability for any work performed or cost incurred by the customer, or others, without Chart Inc. express prior written approval.
2. Chart Inc.'s obligations under this warranty are expressly limited to repair or replacement of any Chart Inc. manufactured component found to be defective within ONE YEAR after ship date of Orca CO_2 Series unit.
3. Chart Inc. is not liable for any other losses, damages, product losses, cost of delays, freight charges, or excess costs for repairs made outside the 48 adjacent United States, including incidental or consequential damages.
4. For Warranty Claims please call Chart Inc. Customer Service Center at 1-800-400-4683.