



LNG

**VEHICLE FUEL
TANK SYSTEM**

**OPERATIONS
MANUAL**



www.ChartLNG.com

INTRODUCTION



Vehicle Tank

Customer Service:

Phone: 1-800-838-0856

Fax: 952-758-8293

Fuel Station

Customer Service:

Phone: 952-882-5204

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This manual deals with LNG vehicular fuel tanks, the hazards and the safety precautions that are necessary when working with this type of equipment. The manual is designed to familiarize technicians and vehicle operators with the features, safety precautions, operating procedures and maintenance of the LNG Fuel Tanks and associated components provided by Chart. For more generalized information on LNG fuel systems, refer to the table below. If a technical drawing is needed, you can make a request from customer service.

For additional support, visit:

- www.chartlng.com
- www.chartparts.com

For technical service bulletins, visit:

- <http://literature.chart-ind.com/>

No attempt should be made to fill or maintain this equipment until this manual and its supplements have been read and fully understood.

Throughout this manual items appearing in **Bold Text** highlight conditions that can result in serious injury or death.

Underlined passages emphasize conditions that can damage the equipment.

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Region	Document	Title	Contact
USA	SAE J2343	Recommended Practices for LNG Powered Heavy-Duty Trucks	Phone: 724-776-4841 Web: www.sae.org
USA	NFPA 52	Vehicular Gaseous Fuel Systems Code	Phone: 617-770-3000 Web: www.nfpa.org
USA	NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas	Phone: 617-770-3000 Web: www.nfpa.org
USA	49 CFR 393.67	Liquid Fuel Tanks	Phone: 202-512-1800 Web: www.ecfr.gov
USA	CGA P-12	Safe Handling of Cryogenic Liquids	Phone: 703-788-2700 Web: www.cganet.com
EU	R110	Specific LNG Vehicle Components and LNG Vehicles	www.unece.org
EU	TPED	Transportable Pressure Equipment Directive	Osha.europa.eu
EU	RDW	Dutch Road Transport Directorate	Phone: 0900 0739 Web: www.rdw.nl
AU	AS1210	Australian Pressure Vessel Standard	Australia.gov.au

SAFETY I

Hazards of LNG

LNG is predominately methane gas (CH₄). It is cooled to very low temperatures (less than -200°F/-130°C) and stored as a cryogenic liquid under pressure (up to 230 psig/16 bar). Working with the equipment can expose you to the following hazards.

Flammable Gas: Although the liquid is not flammable it rapidly evaporates in air into large volumes of gas. The gas expands to 600 times its original liquid volume. So even small liquid leaks can pose a large fire hazard near the leak. The gas is flammable in concentrations of between 5% and 15% in air. **Although an LNG fire is unlikely to occur, do NOT use water or CO₂ to extinguish the fire. They will make the fire bigger by vaporizing the LNG.** Using a dry chemical is best when extinguishing an LNG fire.

Cryogenic Temperatures: The liquid LNG is below -200°F/-130°C. Since this liquid is stored under pressure you can be cryogenically burned very easily by coming in contact with a pressurized liquid stream. You can also be cryogenically burned by hard contact with a cryogenic temperature fuel line.

Large Expansion Ratio: Since LNG will expand to 600 times its original volume when warmed from a cryogenic liquid to a room temperature gas it will build extremely high pressures (over 3000 psig/200 bar) if trapped in lines. Pressures this high will cause lines and fittings to fail. **Care must be taken in the design of piping systems and during maintenance operations to assure that liquid cannot become trapped between two valves.**

Inert Gas: Although natural gas is non-toxic, it is an inert gas and can cause asphyxiation if present in large concentrations. Human senses cannot detect natural gas, as it is colorless, odorless, and tasteless. This is a minimal hazard with vehicle fuel systems as they simply don't contain enough product to displace large quantities of oxygen around the vehicle. Many vehicles have methane detection systems in place. Consult NFPA 52 for methane detection system guidelines.

Safety Precautions

Keep the equipment area well ventilated. This will prevent the buildup of methane gas if leaks are present. Use appropriate eye protection and cover exposed skin when working on LNG systems. If cryogenic liquid or cold boil-off gas contacts an operator's skin or eyes, the affected tissue should be flooded or soaked with tepid water (105-115°F/41-46°C). **DO NOT USE HOT WATER.** A physician should promptly examine cryogenic burns that result in blistering or deeper tissue freezing. Isolate the fuel tank and if necessary remove the pressure and liquid from the system prior to maintenance operations. Keep equipment away from open flames and sparks. Utilize leak detection equipment to locate small leaks.

Parking Safety

When parking your vehicle indoors, the tank could vent a combustible gas mixture. Ensure the parking facility or vehicle is equipped to handle an accumulation of gas in a combustible mixture. If not, the tank and the fuel lines will need to be drained of LNG and purged with inert gas or depressurized prior to venting.

As a guideline, the estimated hold-time for a full tank of LNG at various pressures is listed below.

Tank Pressure		Hold-Time
145 psi	10 bar	5 days
160 psi	11 bar	4 days
175 psi	12 bar	3 days
190 psi	13 bar	2 days
205 psi	14 bar	1 day

For reference, the auto-refrigeration system will maintain or reduce tank pressure when the fuel is sent to the engine; therefore, operating the engine can extend hold-time.

II LNG VALUE CHAIN

Cryogenics

The LNG fuel tank is a cryogenic container. This means that it stores the natural gas fuel as a highly refrigerated liquid at low pressure. Typically the fuel temperature is about -200°F/-130°C, and the fuel pressure is about 100 psig/6.9 bar. The reason for cryogenic storage is that natural gas is much more dense as a low temperature liquid than it is as a compressed gas. Typically you can get three times as much gas in the same space at about half the weight if it is stored as a cryogenic liquid instead of as a compressed gas.

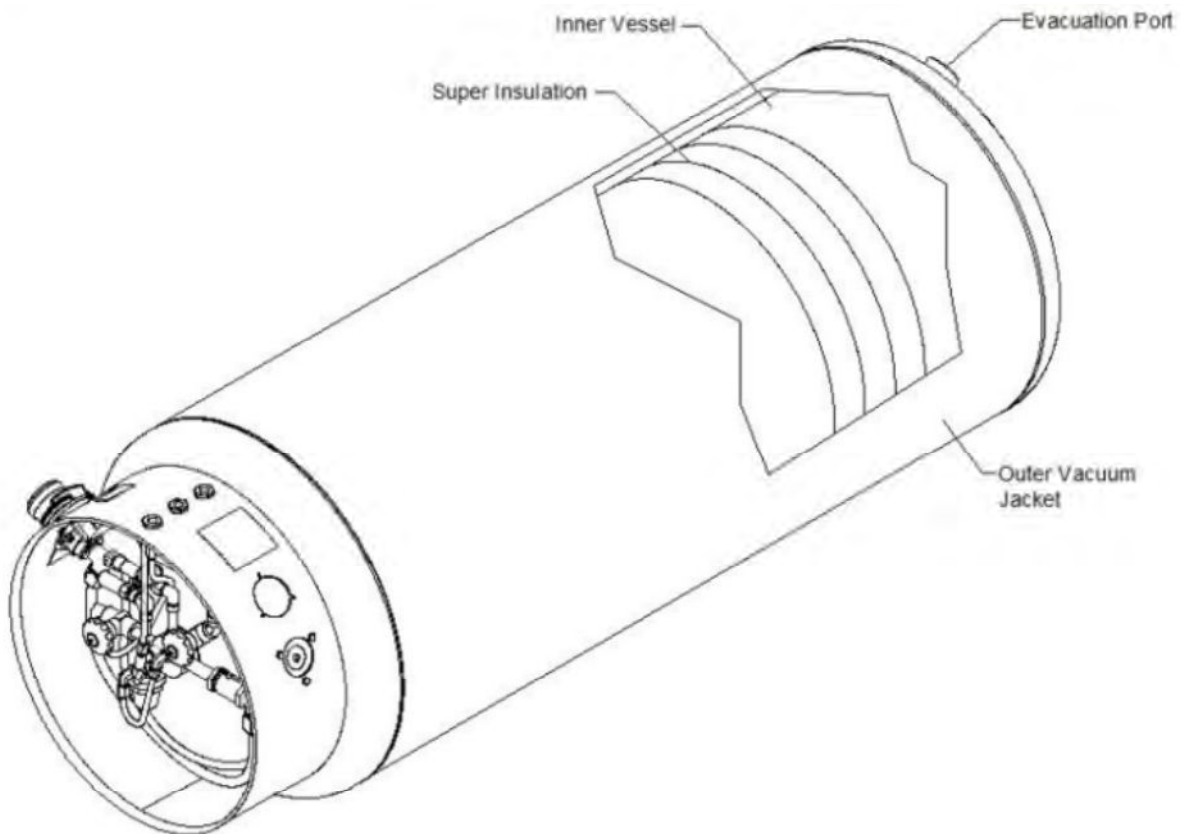
The Storage Tank

To contain this cryogenic fuel without the use of any outside source of refrigeration the tank has to be extremely well insulated. To achieve the high level of insulation efficiency needed the LNG pressure vessel is covered with insulation and enclosed by an outer vacuum vessel. A vacuum is pulled between the LNG tank and the outer shell. This combination of insulation and vacuum, called super-insulation, has the highest thermal efficiency known with an R value exceeding 5000. This type of insulation allows for standby times of over a week with no loss of

product. Both the inner pressure vessel and the outer vacuum vessel are constructed of stainless steel. Stainless has both the low temperature strength necessary to contain the cryogenic fuel and the high temperature toughness to allow the vacuum casing to armor the inner pressure vessel. With an all stainless vessel support structure as well, the LNG fuel tank can withstand years of vehicular service with no loss of performance.

Fuel Delivery System

The driving force for delivery of the fuel to the engine is provided by the fuel pressure. There are no pumps in a typical Chart system. When the engine demands fuel the pressurized liquid natural gas flows out of the tank toward the engine. The cold pressurized fuel then passes through a Heat Exchanger. The Heat Exchanger uses the heat from the engine coolant to vaporize the liquid and turn it into a gas. Once out of the Heat Exchanger the fuel is a warm gas, at tank pressure, ready to be burned by the engine. Tank pressure is maintained by a tank mounted Pressure Control Regulator that vents excess pressure into the fuel line during periods of engine operation.



PLUMBING COMPONENTS III

Integrated Heat Exchanger Tank

The Integrated Heat Exchanger Tank is an enhanced version of our standard Shrouded Tank. It incorporates most of the hardware normally installed outside of the tank and is moved to inside the shroud of the tank.

(1) Fill Check Valve

The fill line check valve is a bronze check with a soft seat. Its function is to prevent backflow through the fill line in the event of a fuel coupler failure or vehicle accident. It relies on tank pressure to seal and despite the soft seat should not be regarded as a positive shutoff valve. The Fill Check Valve connects to a top fill line inside of the tank.

(2) Fuel Shutoff Valve

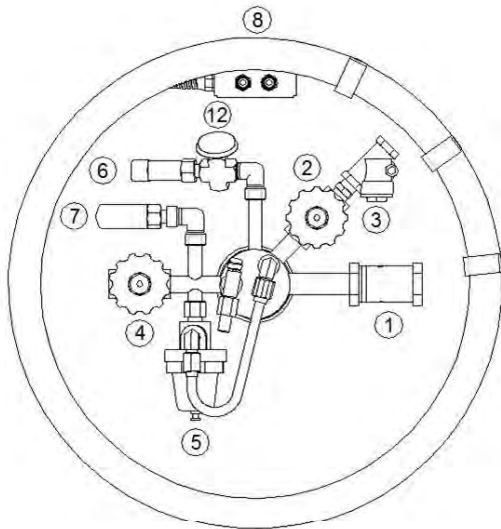
The Fuel Shutoff Valve (Liquid Valve) is a bronze globe manual valve with a soft seat. Its function is to provide a positive shutoff of the fuel line for service and maintenance operations. The fuel shutoff valve connects to the liquid withdrawal line at the bottom of the tank and to the vapor withdrawal line at the top of the tank through the Pressure Control Regulator. The fuel shutoff valve is open for normal vehicle operation.

(3) Excess Flow Valve

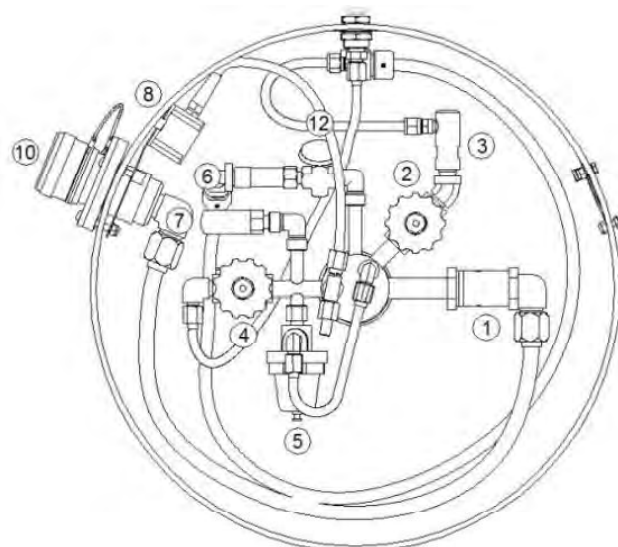
The Excess Flow Valve is a specialized check valve with a hard metal seat designed to cut off fuel flow if it exceeds a certain limit. Its function is to protect the fuel line between the tank and Heat Exchanger against uncontrolled fuel release in the event of a vehicle accident. It is not designed to protect piping downstream of the Heat Exchanger. This is the function of the Electronically Controlled Automatic Fuel Shutoff Valve. The Excess Flow Valve is not a positive shutoff valve. Its hard seat allows a small flow to pass by when it is in the closed position. For integrated tanks, the Automatic Valve is used in place of the excess flow valve.

(4) Vapor Shutoff Valve

The Vapor Shutoff Valve (Vent Valve) is a bronze globe manual valve with a soft seat. Its function is to provide a positive shutoff of the vapor withdrawal line for service and maintenance operations. The valve connects to the vapor withdrawal line at the top of the tank. The Vapor Shutoff Valve is closed for normal vehicle operation.

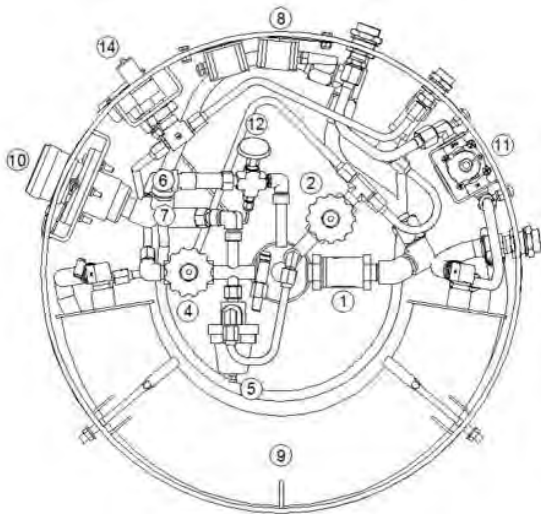


**Heading Tank
(Bus Style)**



**Shrouded Tank
(Truck Style)**

III PLUMBING COMPONENTS



**Integrated Tank
(Truck Style)**

(5) Auto Refrigeration Regulator

The Auto Refrigeration Regulator (Economizer) is a bronze pressure reducing valve that is open at pressure above its set point and closed at pressures below its set point. Its function is to allow vapor to flow into the fuel line during vehicle operation, re-refrigerating the liquid and reducing the tank pressure to its set point. It is assisted in its operation by an Internal Check Valve in the fuel pickup line providing a 2 psi/0.1 bar bias pressure to aide vapor flow. The set point of the regulator is set at the time of manufacture. Flow through the regulator is not directional it will be an open valve whenever the fuel line pressure is above its set point. Some LNG tanks will have a filtering system included in the pressure control regulator gas stream. The filters are incorporated into fittings on the inlet and outlet of the regulator. Their function allows for fuel laden debris to be captured prior to entering or damaging any downstream fuel system components.

(6) Primary Relief Valve

The Primary Relief Valve is a brass cryogenic relief valve set at the maximum allowable working pressure (MAWP) of the tank. Its function is to vent product to atmosphere if

the tank pressure exceeds the MAWP. It is connected to the top fill line thereby providing additional safety against over pressurizing the tank. The Primary Relief Valve is equipped with a pipe away adapter to permit piping the vent gasses to a safe location on the vehicle. Shrouded type tanks use a non-metallic primary relief valve pipe away tube inside the tank shroud. The pipe away tubing runs from the relief valve pipe away adapter to a bulk head connector installed in the tank shroud.

The pipe away tubing incorporates a 1/8" hole at the lower most point of the tube run. The hole will act as a moisture drain if rain or wash water accumulates in the tube. The pipe away with low point drain is a water prevention device to mitigate freezing of the Primary Relief Valve.

(7) Secondary Relief Valve

The Secondary Relief Valve is a brass cryogenic relief valve set at 1.5 times the maximum allowable working pressure of the tank. Its function is to vent product to atmosphere to prevent a catastrophic failure of the tank in the event of a malfunction of the Primary Relief Valve or line. It is connected to the vapor withdrawal line providing a secondary relief path to the tank. It is protected from debris and water intrusion by a red plastic cap and should never be piped away.

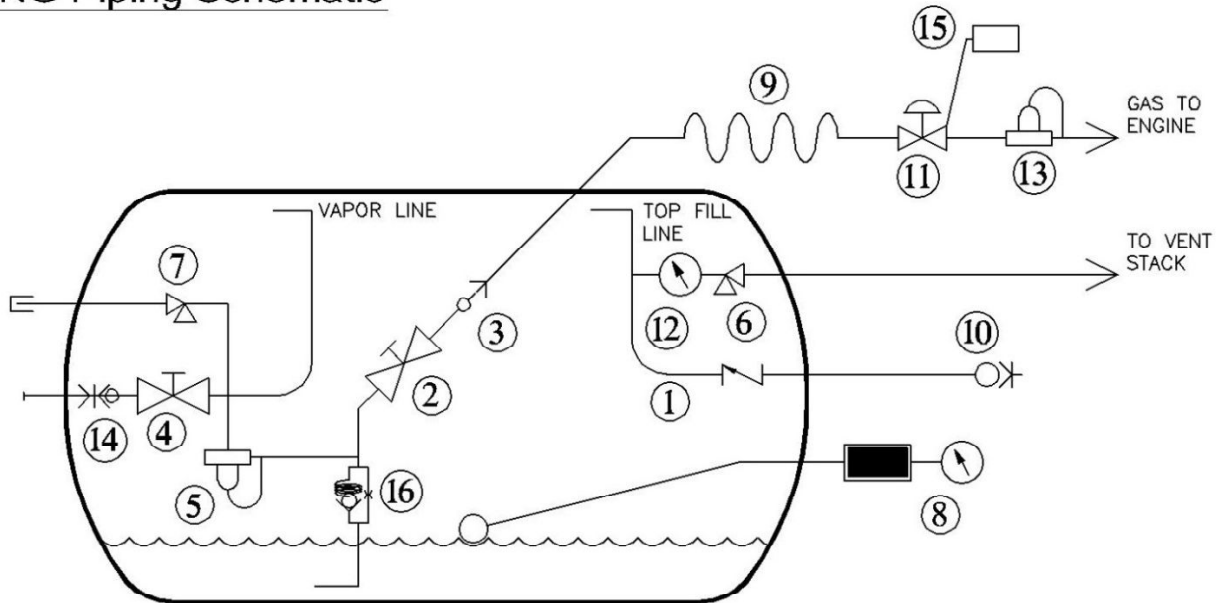
Since this is the last line of defense for the tank if the red plastic cap is ever missing the vehicle should be immediately removed from service and the primary relief system inspected. The red plastic cap is a water prevention device to mitigate freezing of the Secondary Relief Valve.

Evacuation Port

The Evacuation Port is located on the non-plumbing head of the tank. Its function is to provide a re-sealable connection for the evacuating the tank. Its secondary function is to provide a pressure relief path in the event of a product leak in the vacuum space. Do not remove the plug, not only will it cause the tank to lose vacuum, but it will void your warranty as well.

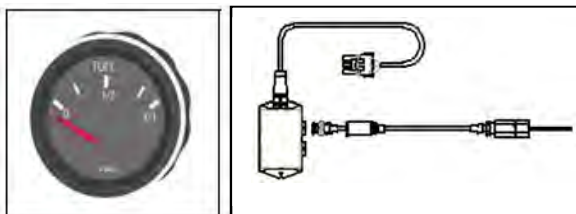
ACCESSORIES IV

LNG Piping Schematic



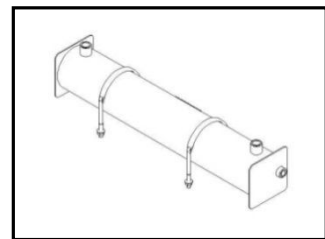
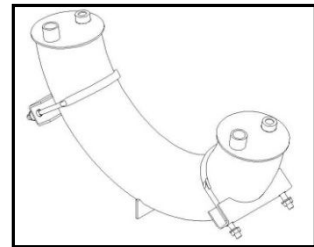
(8) Fuel Contents Gage

Each LNG fuel tank comes equipped with an electronic Fuel Contents Gage. The typical system consists of two parts: the fuel gage sender and a dash mount fuel gage. The fuel gage sender comes mounted to the fuel tank. Its function is to convert the electronic signal from the internal fuel level probe to a signal compatible with the dash mount gage. It is a solid state, sealed unit and no field adjustments are possible. The sender accurately reflects the actual mass of the product in the tank and is unaffected by product state, pressure or temperature. It is designed to dampen the effects of acceleration, braking, cornering and hills, although some variation will be seen on the gage under these transient conditions, similar to its gasoline or diesel counterpart. The fuel gage is a standard automotive type gage calibrated to the sender. It reads out empty to full and has an accuracy of $\pm 1/16$ th of a tank. Note: The gage, the sender and the cable connecting the sender to the fuel tank are calibrated as a system and must be replaced with identical parts to maintain gage accuracy.



(9) Heat Exchanger

Every LNG fuel system must contain a Heat Exchanger. The function of the Heat Exchanger is to vaporize the cryogenic liquid fuel and deliver it as a warm gas to the engine. The Heat Exchanger is mounted inside the shroud for integrated tanks (shown above). On non-integrated tanks, the Heat Exchanger is mounted external to the tank shroud (shown below). It gets its heat from the engine cooling system and connects to the engines water jacket through flexible coolant lines.

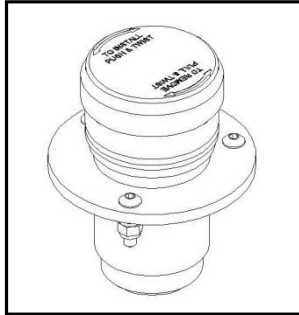


Note: The Heat Exchanger does not affect the fuel pressure it simply raises its temperature and turns the fuel from a liquid into a gas.

IV ACCESSORIES

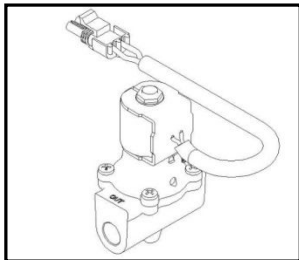
(10) Fill Fitting

Every fuel system must contain a cryogenic fill connection. The function of the fill connection is to provide a connecting point to the re-fuelling station that permits a cryogenic Liquid transfer to occur. The Fill Fitting incorporates a positive shutoff device to prevent fuel leakage when disconnected. Each fuel connection needs to be mounted to the vehicle at a location capable of withstanding a 250 lb/1,100 N load. This is necessary to assure that in the event of a drive away the breakaway devices on the fuel station will fail first. Each fuel fitting should be fitted with a sealed cap to prevent the introduction of water or debris into the fuel tank.



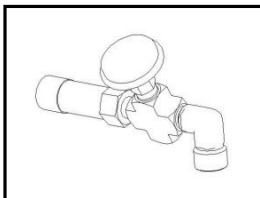
(11) Automatic Valve

Every LNG fuel system must contain an Automatic Fuel Shutoff Valve. Its function is to shut off fuel to the engine when the ignition is switched off or when activated by an out of limits sensor. Its recommended mounting location is at the warm gas outlet of the Heat Exchanger, this enables a wide selection of valves to be used. For integrated tanks, the automatic fuel shutoff valve is already installed within the shroud.



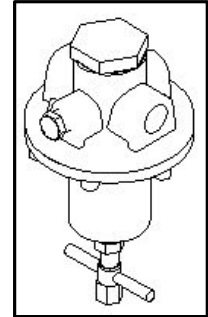
(12) Tank Pressure Gage

Standard on shrouded tanks, an optional mechanical pressure gage can be mounted to any LNG fuel tank. A 1/4" pipe size pressure gage port is located on the Primary Relief Valve tee at the 12 o'clock position on the plumbing manifold to allow for direct or remote mounting of a Tank Pressure Gage.



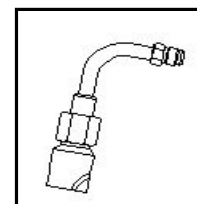
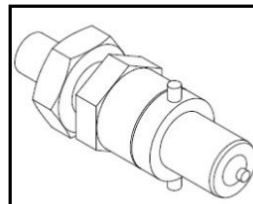
(13) Overpressure Regulator

Some natural gas engines are unable to accept pressure up to the MAWP of the fuel tank. The fuel systems on these engines need to be equipped with an Overpressure Regulator to keep the operating pressure window within acceptable limits for the engine. The Overpressure Regulator is mounted in engine fuel line downstream of the Heat Exchanger and automatic shutoff valve. It works in conjunction with the Pressure Control Regulator on the fuel tank to establish the fuel systems operating pressure window. The Pressure Control Regulator on the tank is set to the normal operating pressure of the engine. The Overpressure Regulator in the fuel line is set to the maximum operating pressure of the engine. The settings on these two regulators assure that the engine will always see pressures within its operating range. Note: If an Overpressure Regulator is used it must be set at least 25 psig/1.7 bar above the Pressure Control Regulator on the tank to avoid transient low pressure spikes on acceleration.



(14) Quick Disconnect Valve

Some refueling stations either require or have provision for venting the tank during re-fueling. Some tank systems will include a QDV to allow for venting of the tank system. The QDV incorporates a spring loaded poppet valve which will require the Female QDV assist handle (PN:10538867) to open the valve. The handle will lock into the male QDV on the tank by way of utilizing the guide pins on the QDV to guide the Female QDV assist handle into the male QDV on the tank by way of utilizing the guide pins on the QDV to guide the Female QDV assist handle by rotating it until it locks.



Note: Ensure that the Vent Valve on the tank is closed prior to locking the Female QDV assist handle to the QDV on the tank and that a long enough, cryogenically rated hose, is attached to the threaded side of the handle.

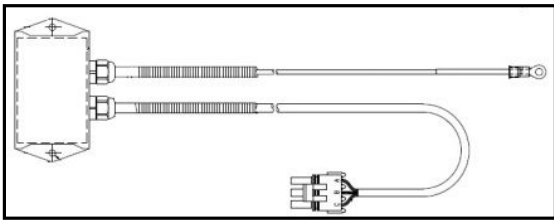
ACCESSORIES IV

(15) Low Temperature Signal Device (LTS)

If an engine cooling system malfunction occurs, the fuel exiting the heat exchanger can reach temperatures below the set point (-4°F/-20°C). It can be setup to provide a warning signal to dash light, ECU, etc. Once the fuel temperature rises above the set point, the system will reset itself. Also, the LTS incorporates a time delay on startup for the system in order to allow for engine warm-up under conditions of low ambient temperatures.

The time delays per temperature are as follows:

- 1.) 68°F/ 20°C = 20 seconds
- 2.) 32°F/0°C = 2 minutes
- 3.) -40°F/-40°C = 5 minutes



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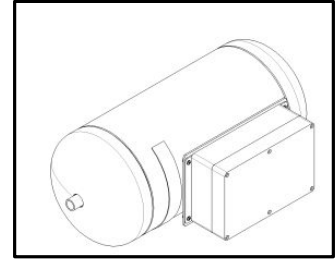
rated Tank systems are able to already incorporate the LTS mounted inside the shroud.

(16) Internal Check Valve

The internal check valve is located inside of the plumbing manifold on the tank, behind the elbow connecting the manifold to the economizer U tube. This check valve provides 2 psi (0.14 bar) back pressure on liquid withdrawal line to assist the Pressure Control Regulator in rapidly reducing tank pressure

Cold Fuel Appliance

The Cold Fuel Appliance module option is a device which allows the vehicle tank to operate normally if filled with cold fuel. It provides adequate pressure to either a dedicated (spark ignition) engine or dual-fuel (compression ignition) engine. It detects and compensates for low fuel pressure automatically. Its pressure output is adjustable to the engine requirements. The unit utilizes the vehicle's electrical system (12V /24V) and can be retrofitted to an existing or new Chart HLNG vehicle fuel system. Refer to the Chart LNG CPB Manual for additional information.



V INSTALLATION - Materials

Many materials are unaffected by cryogenic temperatures. In general 300 series stainless steel, copper and brass, aluminum, fiberglass, wood, polyethylene, polypropylene, Teflon and epoxies can be safely used. Carbon steel, 400 series stainless steel, zinc, PVC, and rubber become brittle at low temperatures and will fail if flexed while cold. When running low temperature piping, care should be taken in its mounting to stand it off of the vehicle frame, electrical wiring, and brake or air lines that can embrittle and fail. Some paints, notably enamels, tend to de-bond and flake off at cryogenic temperatures.

Piping

All piping material must be able to withstand the effects of low temperatures without failure. On fuel lines that carry LNG liquid we recommend the use of rigid 300 series stainless steel tubing. Fill and fill crossover lines may be rigid or flexible metallic or non-metallic tubing rated for cryogenic service. Vent and relief pipe away lines may be constructed out of flexible tubing or hose suitable for natural gas service. The pipe away shall include a low point drain which is a water prevention device. Since liquid and vent lines repeatedly go from ambient to cryogenic temperature allowances for thermal expansion must be designed into the piping system. This is typically accomplished by incorporating S bends or expansion loops into rigid lines. In general if one end of the tube can be moved 1/2" (13mm) by hand while the other end is fixed it is flexible enough for low temperature service. If the tube is rigid it must be redesigned since it will move when it gets cold easily pulling itself from supports and fittings. Recommended tube sizes and wall thickness for rigid stainless tubing:

- 3/8"OD x 0.035" (10mm x 1.0mm)
- 1/2"OD x 0.049" (12mm x 1.0mm)
- 3/4"OD x 0.065" (20mm x 2.0mm)

Tube Fittings

Rigid tube fittings should be either a double ferrule type (Parker A-lok, Swagelok, or equivalent) or 3 piece 37° flare type (Parker Triple Lock or equivalent). Tubing wall thicknesses used should be per fitting manufacturer's specification for gas service.

Pipe Threads

All pipe fittings should be installed using thread seal tape. After the tape is applied to the fitting, it should only be tightened in the clockwise direction to its final position. If the fitting is tightened past its desired

position, do not turn it counterclockwise to reposition. Remove the fitting clean both surfaces and start over. Turning a pipe thread counterclockwise will cause tiny thread leaks to develop over time. If multiple pipe fittings are stacked up be sure to use two wrenches to keep the back fitting from breaking loose. There are many types of commercial pipe fittings available. Chart recommends the use of NPTF fittings for leak resistance. When stainless fittings are used, we recommend the use of stainless to brass fittings to prevent galling during installation. When maintenance is performed, replace the brass fittings with new if necessary. The use of stainless to stainless pipe threads is not recommended as thread galling may occur. Also, if maintenance is required, it is difficult, if not impossible, to get the fittings apart without destroying the threads. If a stainless to stainless thread/fitting arrangement is necessary, it is highly recommended to use an anti galling compound such as nickel impregnated thread tape which is designed to minimize the galling effects.

Pipe Thread Seal Tape

Chart has approved nickel Teflon tape as a sealant and anti-seize compound for pipe threads on vehicle tanks. Two types of nickel tape are available: nickel coated and nickel impregnated. Nickel impregnated tape is highly recommended as it provides better sealing characteristics. The tape is available on www.chartparts.com (PN: 11811511). When applying tape, ensure the threads are clean, close to ambient temperature, and dry. Tape applied to cold or wet threads will cause moisture to be retained under the tape, jeopardizing sealing capabilities. The tape may also slip and spin on the thread surface during the application and fitting installation process. Align the edge of the tape with the second thread so that the first thread is exposed. Hold the end of the tape on the threaded surface and gently pull the tape down into the threads, keeping the tape under tension so the tape molds itself into the root of the threads. When applying tape to right hand (NPT) threads, always wrap the tape in a clock wise direction only. Two wraps are sufficient for pipes and fittings 1/2" (13mm) and under. Three wraps for pipes and fittings between 5/8" (16mm) to 1" (25mm). Ensure the last section of tape is pulled down tight and there are no loose edges.

Pipe Support

Piping and tubing should be supported along its length to guard against vibration. A general guideline is one support

INSTALLATION - Components V

per two feet of tubing. A practical test is to “strum” the installed tube by hand. If it vibrates it is not supported well enough. Stainless P clamps, and polyethylene or polypropylene tube clamps are commonly used on cold lines. Care must be taken in support placement to allow for thermal expansion and contraction of the lines.

Vehicle Tank

Since the fuel pickup is located near the plumbing head the vehicle tank should be installed with the plumbing head of the tank facing the rear of the vehicle. Rear facing mounting assures that at low fuel levels that the fuel pickup will remain submerged during acceleration or when climbing hills.

The tank should be secured to the chassis with mounting brackets and steel straps located 2” minimum from any welds on the tank. The straps should incorporate rubber pads to prevent rotation or slippage of the installed tank. In accordance with NFPA 52 guidelines the mounting system should be sufficiently strong to hold 8 times the full weight of the tank. This will determine the number of brackets and straps required per tank. Also refer to the truck manufacturer’s recommendation for additional details.



(9) Heat Exchanger

To assure proper Excess Flow Valve function the Heat Exchanger should be mounted within 8 feet of the tank. The LNG inlet to the Heat Exchanger is piped to the tank using rigid 300 series stainless steel tubing. If the Heat Exchanger is less than 3 feet/1m from the tank 3/8”/10mm OD x 0.035”/0.9mm wall tubing can be used. If greater than 3 feet, 1/2” (1m 13mm) OD x 0.049”/1.2mm wall tubing is used. For integrated tanks, heat exchanger is already installed.

The recommended coolant flow to the Heat Exchanger is 1 gpm/3.8 lpm of 180°F/80°C coolant per 50 horsepower engine output. For coolant lines less than 10 feet/3m in length this flowrate can normally be achieved using 5/8”/16mm heater hose. For runs longer than 10 feet/3m use 3/4”/19mm heater hose.

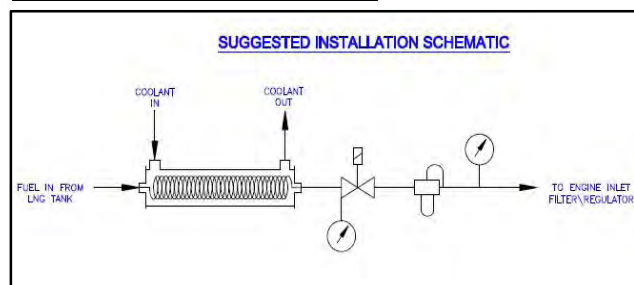
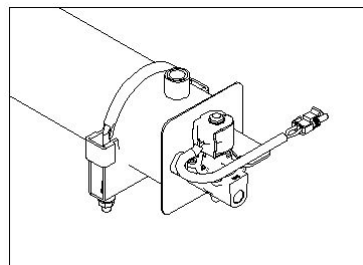
The Heat Exchanger should be piped so that the LNG inlet and the coolant inlet are on the same side. It can be mounted either vertically or horizontally. To prevent air from becoming trapped in the coolant side of the Heat Exchanger the coolant ports must be pointed up in horizontal mounts, the gas out and coolant out ports must be up on vertical mounts.

Note:

DO NOT PLUMB THE HEAT EXCHANGER COOLANT HOSES INTO CAB HEATER LINES.

(11) Automatic Valve

The Automatic Valve should be mounted to the warm gas outlet of the heat exchanger. Even though the valve is screwed directly into the heat exchanger, its weight should be supported by a mounting bracket. The valve should close when the vehicles ignition switch is placed in the off position. It also may be activated by out of limits sensors on the engine or fuel system. Chart recommends the inclusion of a low temperature limit signal device on the warm gas line to protect the valve and downstream components in the event of a cooling system malfunction. For integrated tanks, the Electronically Controlled Fuel Shutoff Valve is already installed inside the shroud.



V INSTALLATION - Components

Primary Relief Valve Vent Stack

The Primary Relief Valve should be piped to a safe point on the vehicle. Since methane gas rises it is typically piped to a vent stack that exhausts at the top of the vehicle with flow directed upwards. Since there is a possibility of relieving liquid through this line its discharge path should be away from persons, ignition sources or materials that could be damaged by exposure to cryogenic temperatures. To prevent the possibility of water accumulating and freezing in the relief valve line the vent stack should include provisions for excluding rain and wash water from the line and incorporate a low point water drain. The low point drain is a water prevention device to mitigate freezing of the Primary Relief Valve. The minimum recommended size for vent stack is 1/2" (12mm) tubing. The tubing connecting the Primary Relief Valve pipeaway to the vent stack can be either metallic or non-metallic tubing suitable for low temperature methane service.

Fill Line

Many vehicles have remote mounted fill connections and require a fill line to connect to the fuel tank. Since the fill line is handling pressurized, high flow cryogenic liquid Chart recommends metallic tubing be used. The minimum fill line size to be used will be 3/4" (20mm) tubing. If rigid tubing is used, it should incorporate at least one S bend between the fill connector and the fuel tank to allow for flexibility and collapsibility in the event of a vehicle accident.

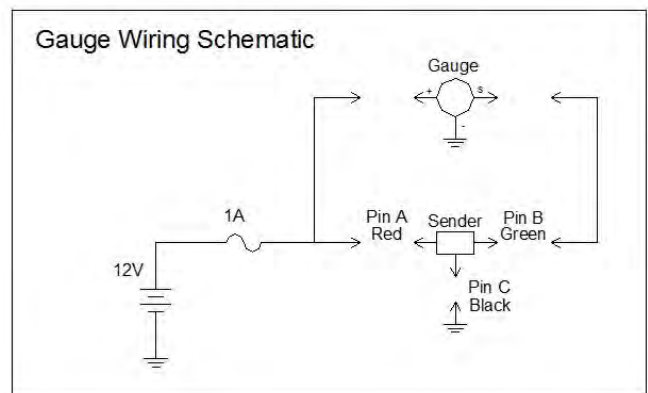
Engine Fuel Line

The fuel line from the automatic shutoff valve to the engine can be either metallic or non-metallic tubing suitable for natural gas service. If non-metallic tubing is used, a low temperature shutoff switch must be incorporated into the fuel system. The engine fuel line should be a minimum, 1/8" (3mm) larger in diameter than the LNG liquid line into the Heat Exchanger to prevent a flow restriction as the fuel expands when it is vaporized.

Note: In higher horsepower applications, larger diameter fuel lines may be required.

Fuel Contents Gage (8)

The Fuel Contents Gage consists of two parts: the sender and the gage. The sender is a sealed unit that comes mounted to the fuel tank. It is connected to the vehicle via 3 pin female Weatherpak connector. The pins are power (red) A, signal (green) B, and ground (black) C. The sender should be protected with a 1 amp fast blow automotive type fuse. The supplied VDO gage should be mounted on the dashboard inside of the vehicle. The power, signal, and ground wires should be common to the sender for proper gage function.



INSTALLATION – Multiple Tanks V

When available space on the vehicle won't accommodate the vehicles fuel requirement in a single tank it is easy to manifold multiple tanks together. The fill, liquid, vent, relief valve, and gage lines are simply connected in parallel in accordance with the following recommendations. The tanks will fill and supply product independently of one another, but act as a system, to the engine appearing as a single large tank. Note: During refueling it is common for the tanks to go full at different times. This causes the flow and pressure to change several times during multiple tank fills. The multiple pressure spikes can confuse the automatic shutoff system in some fuel stations into shutting down before all of the tanks are completely filled. Therefore, Chart does not recommend multiple tank systems of more than three tanks per vehicle.

Fill Crossover Line

The fill line size requirement is the same as a single tank system. To achieve reasonable fill times use 3/4" (20mm) minimum line size. On groups of tanks that are mounted side by side a fill manifold is generally the easiest solution to multiple tank fill lines.

Fuel Line (Conventional Dual Tank System)

On non-Integrated Tanks, the fuel lines to the engine are simply teed together before they enter the Heat Exchanger. Line sizes are the same as in single tank installations to assure proper Excess Flow Valve function. Note: Since the fuel lines are common to all of the tanks the fuel pressure will be the same in all tanks except immediately after filling.

Relief Valve Lines

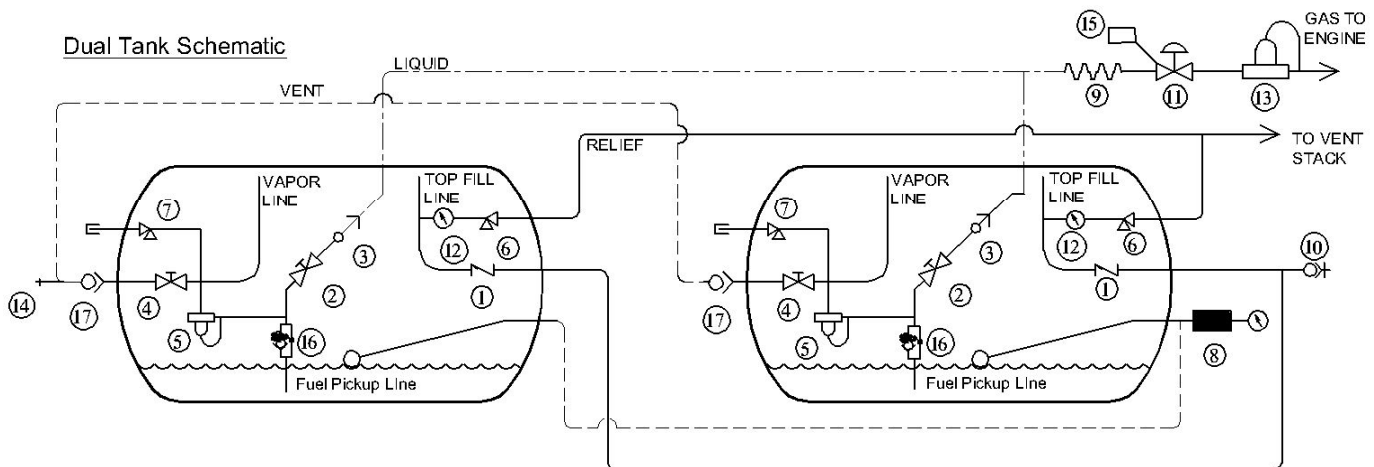
The Primary Relief Valve discharge lines may be piped together into a single vent stack. 1/2"/13mm minimum tubing should be used. The Relief Valve lines shall include low point drains which are water prevention devices.

Vapor Shutoff Valves (17)

The Vapor Shutoff Valves (Vent Valves) can be piped to a common connection, but they must have Check Valves placed in series with them only allowing flow out of the tanks. This will prevent de-pressurizing the system if the vent valves are accidentally left open during vehicle operation.

Fuel Contents Gage

The Fuel Contents Gage can be configured to have one gage read out the multiple tanks contents as if it were a single tank. In this configuration a capacitance cable is run between the tanks and the sender simply sums the tanks contents and displays them on a single gage. The connecting cable is part of the gage calibration and must be replaced with an identical part if damaged to assure proper gage operation. Alternatively each tank can have its own sender and display its contents on a separate gage. Note: On multiple tank systems, the tanks fill and drain independently from one another. It is unusual, except after a fill, for all of the tanks to have the same liquid level. It has no effect on engine operation, range or system re-fuelling.



FUELING VI

Fueling Safety

Accidental contact of LNG with skin or eyes may cause a freezing injury similar to a burn. Protect your eyes and cover skin wherever the possibility of contact with liquid, cold equipment, or cold gas exists. Personnel must wear proper clothing



and make use of protective gear while fueling. Make use of the following items whenever fueling: safety glasses, clean insulated gloves, face shield, apron, long sleeved shirt, cuff-less trousers, and appropriate shoes.

Before fueling, shut off the vehicle, electrically ground the LNG vehicle fuel tank to the fuel station, and ensure the vehicle will remain stationary while fueling.

Fuel Station Requirements

Your LNG fuel tank is designed to be filled from any LNG fuel source. The only requirements on the station are filtration and delivery pressure. Since LNG, like any liquid fuel, can pick up and transport debris that can cause fuel system problems a 250 micron or finer fuel filter is mandatory on all fuel station fill lines. The LNG fuel tank has a 230 psig/16 bar Primary Relief Valve on its inlet line therefore the delivery pressure of the fuel station should be 225 psig/15.5 bar or less.

Normal Fueling

The LNG fuel tank is designed to be top filled through a single fill hose with no vent return. This is accomplished by spraying subcooled LNG into the vapor space of the tank. The cold liquid condenses the vapor and creates space for itself inside of the tank eliminating the need to vent product. Since this will result in a 100% fill a small tank (ullage tank) inside of the main tank guards against overfilling.

A typical fill sequence would involve connecting the fill hose to the tanks fill coupler. Open the stations fill valve and monitor the flow or line pressure as the fill progresses. Initially at the start of the fill there is a brief pressure spike as the fill piping cools down. The flow and pressure then remain stable during the remainder of the fill. When the tank becomes full the pressure rapidly spikes up to the station's

delivery pressure and the flow rate falls off dramatically. The reason the flow doesn't immediately go to zero is because of the ullage tank. The ullage tank has a small opening (relative to the main fill line). Once the main tank goes full there will still be a small flow (typically 1-2 gpm/4-8 lpm) into the ullage tank. When the rapid pressure rise or flow drop is observed the tank is full and the station fill valve should be shut. Even though it is still possible to put more liquid into the tank by continuing to fill the ullage tank, the ullage tank is there to allow for fuel expansion and standby time. If the ullage tank is completely filled the hold time will be zero and the *Primary Relief Valve* will open almost immediately after the fill. If the fill is stopped at the onset of the rapid pressure rise/ flow decay, when the ullage tank is empty, the tank will have about a week of standby time even if the vehicle isn't driven. Most permanent fuel stations automatically monitor and perform these functions so the fueler's only duty is to connect and disconnect the fuel hose and push the Start button.

Vent Filling

Although the preferred method of fuelling is via a single hose top fill it is possible to vent fill the tank. This procedure is usually used when pressure transferring fuel out of a temporary fuelling facility or portable fuel tank. Since this normally is a manual procedure it requires more operator knowledge of the system. The vehicle tank should only be vented back to the fuel station or a separate tank or device designed to recover methane. The preferred method of venting is to connect the stations vent nozzle to the vehicle tank(s) vent receptacle, then slowly open the vent valve on the vehicle tank. Allow the tank to vent down to the desired pressure then close the vent valve. Slowly disconnect the vent nozzle from the tank receptacle and stow the nozzle. The tank can now be single hose filled per the normal fueling procedure.

Note: Unless a maintenance procedure is required, do not vent the tank down below the normal operating (economizer set) pressure, venting below the normal operating pressure can cause poor engine performance. The vehicle tank must be vented slowly if it is above it's normal operating pressure so that liquid isn't drawn out of the Pressure Control Regulator into the vent gas stream. Care must also be taken to monitor vehicle tank pressure during a fill so that at the end of the fill it arrives at its normal operating pressure.

VI FUELING

Vent Filling from a High Saturation Source

If the fuel station's saturation pressure is above the vehicle operating pressure and the station has no pressure building system a vent fill should be performed as follows. Vent the vehicle tank down to 30 psig (2 bar) below the vehicle tanks Pressure Control Regulator setting (vehicle operating pressure). Connect the fill line from the station. Open the station's fill valve and the vehicles Vapor Shutoff Valve. Throttle the vehicle tank's Vapor Shutoff Valve (and station's fill valve if necessary) during the fill to maintain the vehicle tank pressure between 10 (0.7 bar) and 20 psig (1.4 bar) below the vehicle operating pressure during the fill. When the tank reaches 3/4 full, close the Vapor Shutoff Valve and continue filling until the pressures equalize and flow stops.

Fueling a Warm Tank

An LNG fuel tank that has been idle for a long period of time, still has fuel, and is at its relief valve pressure is considered to be a warm tank. This tank must be vented down below the fuel station delivery pressure prior to filling.

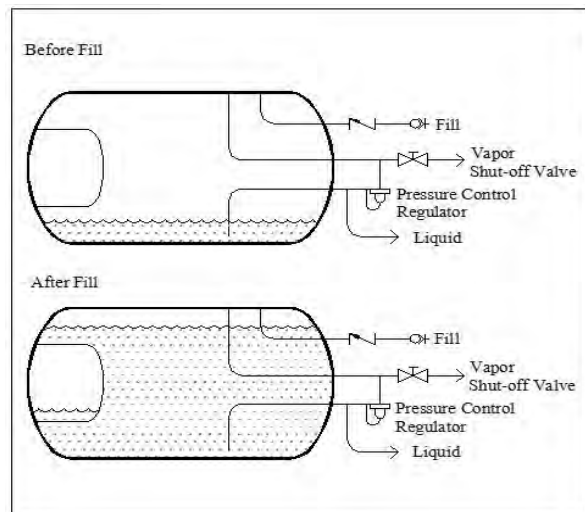
First Fill or Hot Tank Fill

An LNG tank when first installed is considered to be a hot tank. Hot tanks will build pressure rapidly during the fill as the pressure vessel cools down, on many stations this will prematurely stop the fill. The recommended first fill procedure is to put 5-10 gallons (40-80 L) of LNG into the tank. Check the plumbing for leaks. Drive the vehicle for 10–15 minutes, this will pull the pressure down to normal and cool down the tank. Re-check for leaks and fill normally. This same procedure is recommended for tanks that have been empty and out of service for more than ten days. Alternatively put 5-10 gallons (40-80 L) of LNG into the tank and fuel like a warm tank.

Vent Filling from a Station with a P/B

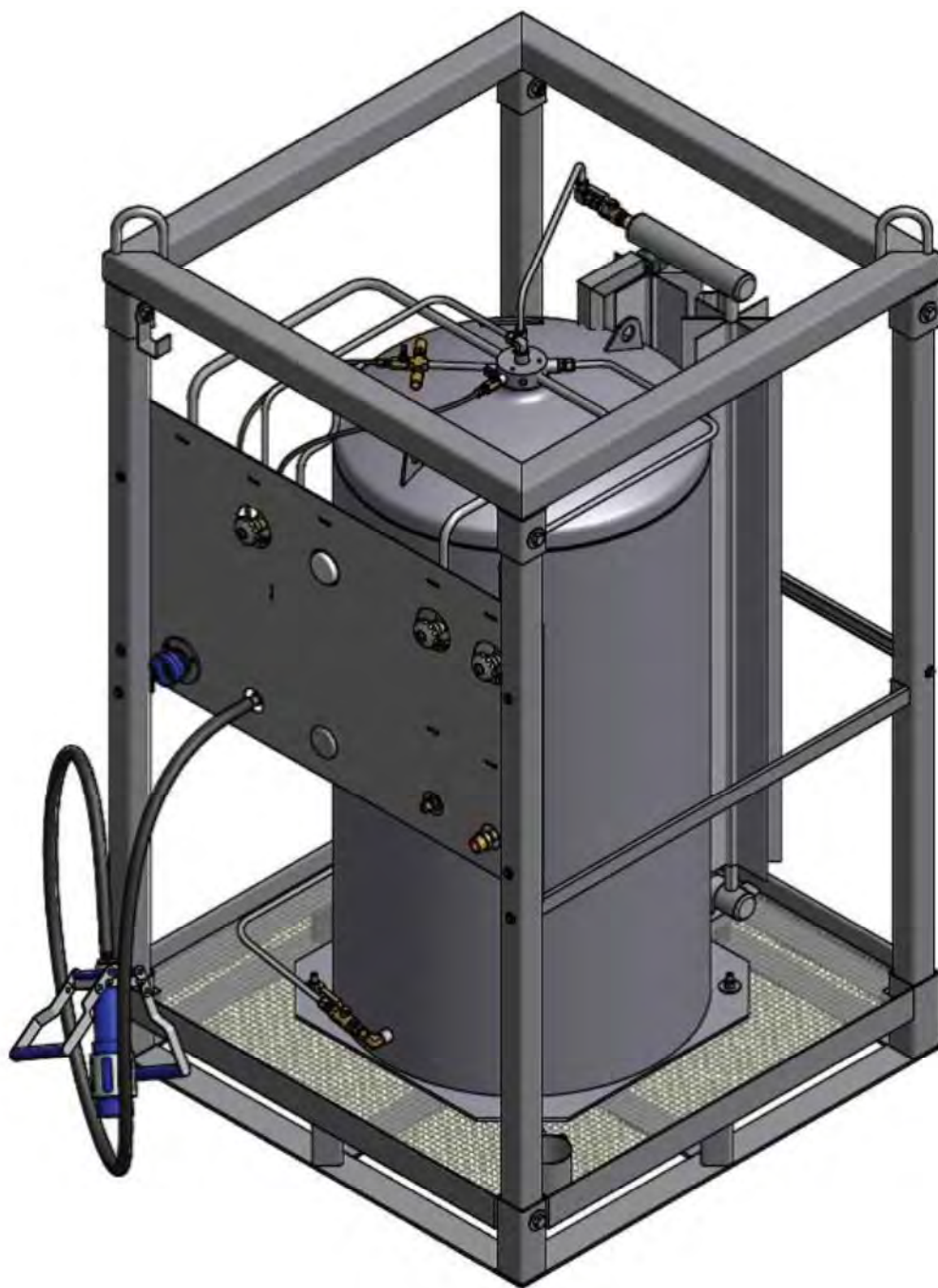
When Vent Filling from fuel station with a pressure building system the LNG in the station should be saturated to within 10 psig (0.7 bar) of the vehicle tanks Pressure Control Regulator setting (vehicle operating pressure). The fuel station should be pressurized to at least 50 psig (3.4 bar) above the vehicle operating pressure. The vehicle fuel tank's pressure should be vented to 20 psig (1.4 bar) below the vehicle operating pressure. Connect the fill line from the station. Open the station's fill valve and the vehicles Vapor Shutoff Valve. Once liquid starts flowing into the vehicle tank, close the Vapor Shutoff Valve. Filling should now

proceed much like a single hose fill. Once the flow stops or the pressure on the vehicle tank rapidly rises shut off the station's fill valve. Confirm the tank is full using the Fuel Contents Gage on the dash. If the filling tank loses pressure before the vehicle tank is completely filled vent the vehicle tank pressure down, this time only to the vehicle operating pressure, allow the filling tank to re-pressurize and repeat the process.



Defueling

If the vehicle tank needs to be serviced, the tank may need to be defueled. The LNG Defueler is designed to aid in the fueling and de-fueling of LNG vehicle tanks. It consists of a 119 gallon (450 liter) vacuum jacketed pressure vessel mounted inside a protective steel pallet frame. This frame makes it possible to transport the unit when needed. In addition to the Defueler, there will need to be a source of high-pressure gas to ensure the optimal performance of the system. Since the Maximum Allowable Working Pressure (MAWP) of the LNG Defueler is 350 psi, be sure to provide a means of regulating the high-pressure gas in order to avoid over-pressurization of the rest of the system. Refer to the Chart LNG Defueler Manual (PN: 20727341) for specific instructions for defueling.



LNG Defueler

VII TROUBLESHOOTING - Components

Rapid Pressure Rise

There are two main causes of rapid pressure rise on LNG fuel systems. They are overfilling or vacuum degradation resulting in a need for maintenance. A properly functioning, properly filled LNG fuel system should build less than 15 psig/1 bar per day. Any system that builds more than 40 psig/3 bar per day needs troubleshooting to discover the cause.

Overfilling

If the fuel tank is overfilled there will be little or no space for the fuel to expand as it picks up heat through the insulation. The most common cause of overfilling is not shutting off a single hose fill at the onset of the rapid pressure rise at the end of a fill. (See Fueling Section)

Vacuum Loss

Total loss of vacuum is an unusual event for an LNG tank (resulting in frosting of the entire outer shell) however with time the vacuum system will require maintenance as gasses diffuse out of the tank materials. This will show up over time as more and more rapid pressure rise times, eventually exceeding 60 psi (2.8 bar) per day. Once the pressure rise has reached this point the tank will need to be re-evacuated by a competent maintenance facility. While the vacuum life varies with tank service conditions, the vacuum life should last for several years before maintenance may be required. For maintenance procedure, refer to the Chart Parts website (www.chartparts.com).

Pressure Rise Test

To establish the pressure rise of an LNG fuel system the following test should be performed. Fill the tank to between 1/2 and 3/4 full. Drive the vehicle for about 10 minutes to stabilize the tank pressure and temperature. Park the vehicle. After 15 minutes, record the tank pressure. After a prescribed period of time (at least 8 hours) record the pressure again. Check to see that the plumbing is thawed, if so this is the pressure rise for the fuel system. **Refer to Chart service bulletin VT-0019 for details and specifications.**

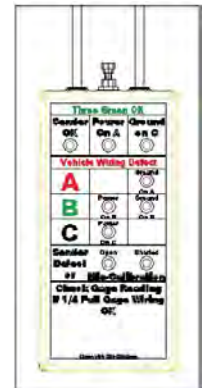
Fuel Contents Gaging System

Problems with the fuel contents gauging system can be diagnosed by the use of the Fuel System Tester. The 12 volt tester is PN 11656419 the 24 volt tester is PN

13107430. The tester enables diagnosis of both tank and vehicle wiring system problems with the gage circuit. This tester is to be used with systems that utilize a VDO dash mounted gauge.

The Fuel System Tester plugs into the Weatherpak connector between the fuel gage sender and vehicle wiring harness. It gets its power from the vehicle itself. To use the tester simply connect the Weatherpak plugs, turn on the power to the gage circuit and read the lights on the front panel. If the gage circuit is functioning properly all three green lights will be lit and the fuel gage will read 1/4 full.

Fault conditions on the fuel tank or with the vehicle wiring will be displayed on the tester. If an intermittent problem is present wiggle the wiring connectors with the tester connected, an open or shorted connector will cause the fault lights to flash. The fuel tank can be tested off of the vehicle. Simply connect the tester to the Weatherpak connector on the tank and push the test button on the top of the unit. On multi tank systems both tanks need to be connected since the connecting cable is an active part of the circuit.



Debris in Components

Debris commonly enters the tank in two ways:

- It is carried into the tank during refueling, from either dirty fill connectors or unfiltered fuel.
- Parts that aren't properly cleaned prior to reassembly during maintenance operations.

Either way the end result is the same, the debris can become lodged in a tank component and interfere with their function.

Debris In Relief Valves

Debris in the Primary Relief Valve will typically lodge underneath the valve seat and cause the relief valve to remain open well below its 230 psig (16 bar) set point.

TROUBLESHOOTING - Components VII

If the Primary Relief Valve becomes plugged the tank pressure could rise above 230 psig (16 bar) up to the Secondary Relief Valve setting of 350 psig (24 bar).

If tank pressures of over 250 psig (17 bar) are observed or if the red vinyl cap is missing from the Secondary Relief Valve the vehicle should be immediately removed from service, depressurized and monitored.

FAILURE TO REMOVE THE VEHICLE FROM SERVICE AND MONITOR THE TANK PRESSURE CAN RESULT IN TANK OVER PRESSURIZATION AND/OR RUPTURE.

Refer to Service Bulletin VT-0035 for further diagnostic procedure.

Pressure Control Regulator Test Procedure

The Pressure Control Regulator and internal check valve can be checked for proper function without removing them from the tank utilizing the following procedure. Chart offers a Pressure Control Regulator Test Kit (PN: 20837106) upon request. Refer to service bulletin VT-0044 for test procedure.

Vent the tank pressure to at least 25 psig (17 bar) below the Pressure Control Regulator setting. This in all cases should be less than 100 psig (7 bar).

Note: It is recommended, but not imperative, to empty the LNG from the tank for this test.

1. Connect a nitrogen gas cylinder with an adjustable non-relieving pressure regulator (0-150 psig/10 bar) and a 0-100 scfh (3 m³/h) flowmeter rated for at least 150 psig (10 bar) (Dwyer VFB-53 or eq.) to the outlet of the Excess Flow Valve on the cylinder. Minimum line sizes should be 1/4"/6mm to maintain adequate flow for the test.

Do not use air for this test. This will result in a flammable (explosive) gas mixture inside the tank.

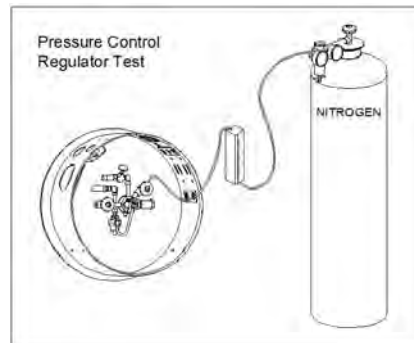
2. Open the Fuel Shutoff Valve on the tank. Adjust the nitrogen gas pressure until it is slightly ~5 psig (0.3 bar) above the tank pressure and nitrogen gas begins to flow into the tank. The flow should be in the 10-20 scfh (0.3-0.6 m³/h) range. If the flow pegs the meter, either the Pressure Control

Regulator is fully open or the internal check is open, generally the sound will reveal which.

3. Slowly increase the pressure, opening the Pressure Control Regulator, until the flow rapidly increases to the 60-80 scfh (1.7-2.3 m³/h) range.
4. Decrease the pressure observing the flowmeter as you do. The point at which the flow stops rapidly falling with decreasing pressure is the Pressure Control Regulator setting.

Never exceed 150 psig (10 bar) during this test or you could rupture the flowmeter.

5. Close the Fuel Shutoff Valve before you remove the test equipment.
Preventative maintenance activities on LNG fuel systems should include a program to detect and repair leaks.



VII TROUBLESHOOTING - Leaks

Small Leaks (Bubble Testing)

Leaks smaller than 100 cc/min are most easily pinpointed via commercially available bubble test solutions. It should be noted that this is not soap. Most soap contains high levels of chlorine and surfactants. While it is true that soap solutions will find the leaks, like bubble test solutions, it is also true that they will cause leaks by breaking down sealants and corroding fittings. Proper bubble test solution will not only pinpoint the source of small leaks but will also classify them by size. One caution on the use of bubble test solutions: leaks larger than 100 cc/min blow out the bubbles so fast and dry themselves out so quickly that they might be missed in a piping check, relying only on bubble testing. It is recommended that general leak surveys be done with an ultrasonic leak detector or flammable gas detector before pinpointing small leaks with bubble test solutions

Small Flammable Leaks

Leaks between 25 cc/min and 100 cc/min are flammable in still air. If ignited the flame ranges in size from less than 1/16" tall, sustainable only in dead calm conditions to a flame the size of a normal cigarette lighter flame. This size of leak is characterized by bubbles that grow and burst at the site of the leak before they can flow away from it. These leaks pose no hazard in moving air, or in well ventilated compartments, but could accumulate inside of small, poorly ventilated enclosed spaces. These leaks are typically caused by improper piping assembly or support that puts cyclic strain on the joints.

Non Flammable Leaks

Leaks smaller than 25 cc/min. are not flammable in air. They are characterized by a stream of bubbles that grow in size and foam off of the leak. Typically the bubbles range in size from 1/8" to 3/8" (3mm to 10mm) in diameter. The bubbles don't burst at the site of the leak, rather they flow away from the leak and burst downstream as they dry out. In a ventilated environment, even in still air they pose no flammability hazard and are mainly an economic nuisance.



Insignificant Leaks (Diffusion)

Leaks smaller than 1/2 cc/min are small and diffuse rapidly. They are characterized by a series of uniform size tiny (smaller than a pinhead) bubbles that emerge from the leak. This might show up immediately as a chain of tiny bubbles on leaks near the 1/2 cc/min size or appear as foam around the fitting up to 5 minutes after the fitting is sprayed with bubble test solution for the smallest ones. In either case the leaks are not flammable and will not accumulate inside of vehicle compartments. Normally there will be more of a negative economic impact created by repairing this size of leak than will be gained.



Flammable Gas Detectors

Handheld flammable gas detectors are available in a wide variety of configurations and sensitivities. The sensitive ones are good at detecting the presence of minute quantities of flammable substances, but are difficult to use to pinpoint the source. The less sensitive ones can more easily pinpoint leaks, but have to be held quite close and are difficult to use around most vehicle plumbing. They are useful for surveying for leaks, but not good at identifying the source.

COMPONENT REPLACEMENT VIII

Tank Mounted Components

Prior to starting any work on tank mounted plumbing components that cannot be isolated by closing the *Liquid Shutoff Valve* and *Vapor Shutoff Valve*, defuel the tank and release all pressure from the fuel tank. To avoid contamination do not leave the tank open to air any longer than it takes to replace the defective part.

Piping Components

For plumbing components that can be isolated from the tank by closing the *Liquid Shutoff Valve* or *Vapor Shutoff Valve*.

Close the *Liquid* and *Vapor Shutoff Valves*.

De-pressurize the plumbing line to 0 psig. This can be achieved by operating the vehicle or venting the line.

General

When removing components, use a backup wrench on pipe fittings so as not to disturb downstream plumbing. Clean all traces of pipe thread tape from pipe threads.

This will require the use of a hand brass wire brush. On female threads the tape must be blown out of the fitting with nitrogen gas, this may require purging out the entire tank with nitrogen gas.

Note: Do not use shop air to purge out LNG tanks - this can result in a flammable (explosive) gas mixture inside of the tank. Air also introduces large quantities of water into the tank which can freeze and plug lines.

It is recommended to replace brass pipe fittings with new ones.

Pressure test the plumbing with nitrogen gas after all new parts are installed and re-check system for leaks.

Pressure Relief Valves

The inner pressure vessel used in an LNG fuel tank is designed and rated for a maximum operating pressure. The maximum operating pressure for the vessel is stamped on the data plate located on the plumbing end of each tank. **Do not replace a relief valve with a higher pressure one. Do not attempt to repair or reset a relief valve. Only replace with Chart approved replacement parts. For Primary Relief Valve, be sure to reconnect pipe away with low point drain which is a water prevention device. For Secondary Relief Valve, be**

sure to replace Red Vinyl Cap which is a water prevention device.

NOTE: If the Red Cap is ever found to be missing from the 350 psi Relief Valve, the vehicle must be immediately placed out of service and a follow up investigation performed to determine root cause for the missing Red Cap.

Failure to remove the vehicle from service, depressurize and monitor the tank pressure can result in tank over pressurization and/or rupture.

Product Isolation Valves

The Liquid and Vapor Shutoff Valves have spring loaded valve packings. This automatically compensates for thermal shrinkage and wear. If a valve packing does become damaged or wear out the valve stem assembly can be replaced by following the instructions that comes with the valve kit.

Pressure Control Regulator Replacement

To install the pressure control regulator, first apply Nickel thread tape to the stainless pipe nipple on the tank then thread the regulator on the pipe.

Note: If the Economizer is required to be replaced, it is recommended the filters are to be replaced as well. Older tanks can be retrofitted per VT-0043.

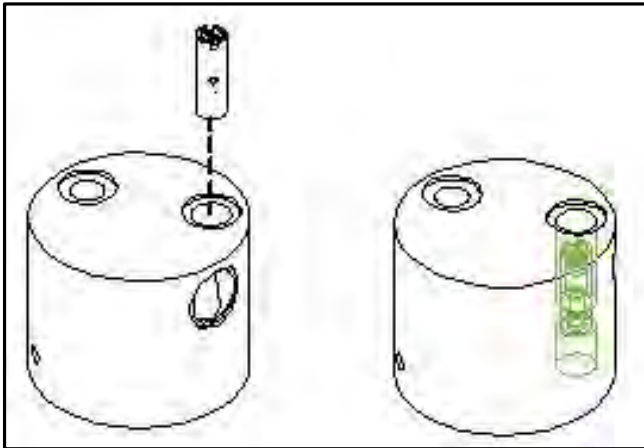
Internal Check Valve Replacement

The internal check valve is located inside of the plumbing manifold on the tank, behind the elbow connecting the manifold to the economizer U tube. The tank must be empty and purged with nitrogen gas prior to starting this procedure. It is a best practice to allow or cause the tank knuckle and components to warm up above freezing prior to attempting to remove the knuckle check valve.

1. To remove the check valve, remove the economizer U-tube and the elbow in the manifold. Insert the check valve wrench (PN 11188766) into the valve and unscrew.
2. Flow nitrogen gas at ~20 scfm/0.5 m³/h through the tank and clean out the internal 1/8"/3mm pipe thread and the pipe coupling on the manifold with an internal brass wire brush.
3. Apply only one drop of red thread lock liquid onto the threads to create a light coating.

VIII COMPONENT REPLACEMENT

4. Install the check valve using the check valve wrench. The check valve will only go in approximately two turns.
5. Snug the check valve but be cautious to not over tighten it.
6. Install thread sealant tape onto the elbow threads.
7. Install a new elbow, taking care to stop at the proper orientation to mate with the economizer U-tube.
8. Install new Flaretite (11751555) seals onto flared portion of fitting.
9. Re-install the U tube and tighten the U tube nuts.
10. Perform leak test.



- Unlatch and pull apart the Weatherpak connector.
- Remove the mounting clips and pry off the old sender.
- Scrape off remnants of the old tape.
- Peel off the backing from the double sided tape on the new sender and press it securely onto its mounting plate.
- Install the mounting clips with the hooks onto the plastic box and the smooth side on the stainless plate.
- Reconnect the Weatherpak connector.
- Slide heat shrink up over sender cable and reconnect sender cable to BNC nipple.
- Position heat shrink over the BNC connection.
- Apply heat evenly using a heat gun, starting from the center to the ends, all the way around the heat shrink circumference until the encapsulating glue oozes from both ends.

BNC Connector Replacement

Older LNG vehicle tanks manufactured by Chart used a fuel gage system which contained a BNC type feed through connector. The connector is located at what is called the feed through. Newer tanks use a solid capacitance wire which eliminates the BNC connector. Removing the connector from the system will eliminate the likelihood of loose or intermittent connections. Refer to service bulletin VT-0041 for changing a BNC type sender to a newer continuous wire sender.

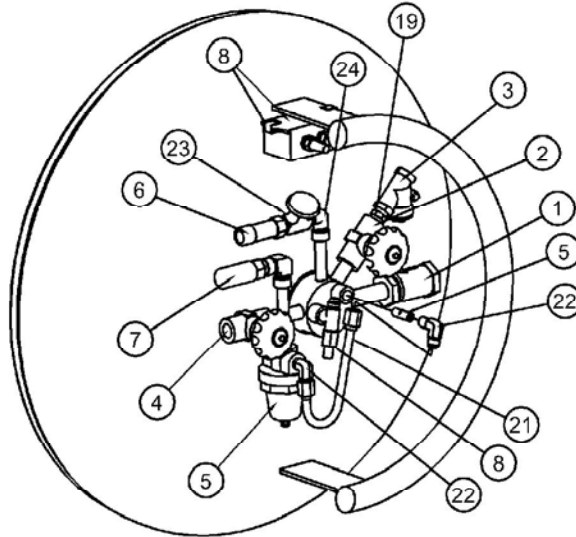
Fuel Gage Sender Replacement (BNC Connector Only)

This is a non-pressure component and can be replaced without de-pressurizing the tank, however before using a heat gun around the plumbing shut off the product isolation valves and check for leaks.

- Follow instructions for BNC Connector Replacement.
- Inspect the BNC connector on the tank for corrosion.

PARTS LIST IX

Heading Tank (Bus Style)



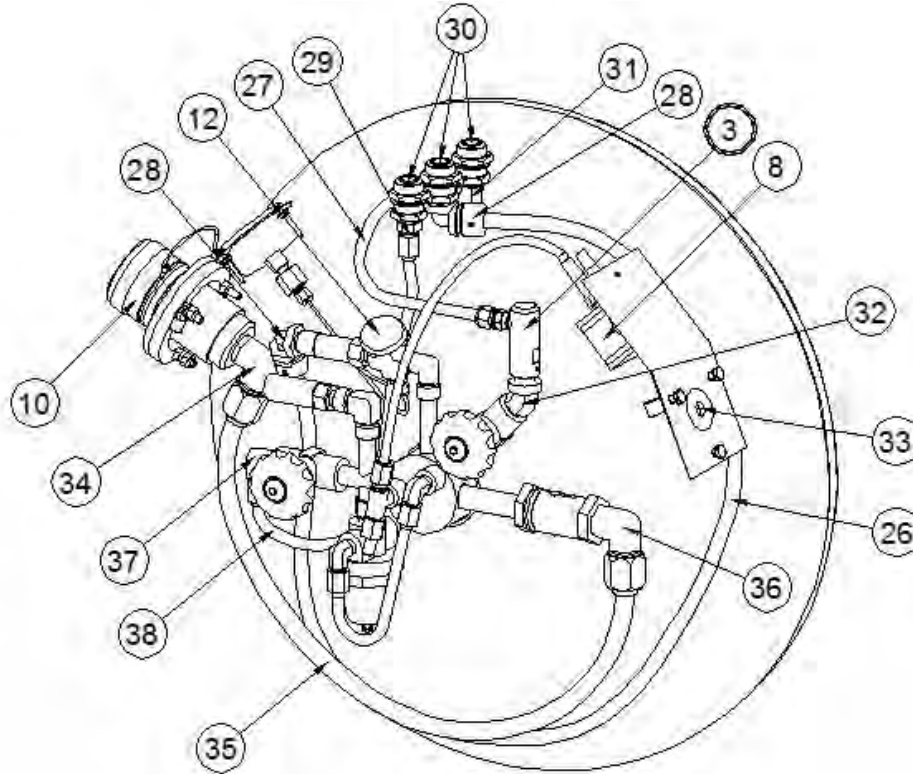
Item No.	Part No.	Description
1	11556768	Fill Check Valve 1/2" (Tanks > 50 gallons)
	11556733	Fill Check Valve 3/8" (Tanks > 50 gallons)
	20845025	Fill Check Valve 1/2" (Tanks > 50 gallons)(R110)
2	11673278	Fuel Shutoff Valve Rebuild Kit (Red Handle)
	13500901	Fuel Shutoff Repair Kit (R110)
3	11556741	ExcessFlow Valve 3/8" Bronze (Heading Tank)
	10614840	ExcessFlow Valve 3/8" Stainless (Shrouded Tank)
4	11673251	Vapor Shutoff Valve Rebuild Kit (Silver Handle)
	9715759	Rego Valve Rebuild Kit (R110)
5	11055541	Pressure Control Regulator (Economizer)
	10524262	Internal Check Valve 2 psi
* 6	11208974	Primary Relief Valve (230 psi)
	20537970	Primary Relief Valve (16 Bar)(R110)
* 7	11209011	Secondary Relief Valve (350 psi)
	13904869	Red Vinyl Cap
	13907496	Secondary Relief Valve (24 Bar)(R110)
8	11718341	Fuel Gage Sender 12 Volt Single Tank 30" Lead
	11718309	Fuel Gage Sender 12 Volt Dual Tank 30" Lead
	13870865	Fuel Contents Gage 12 Volt (Dash Mount 2-1/16")
	10484900	BNC Connector Kit (Obsolete)
	11718552	New BNC Connector Kit
	10692071	Sender Mounting Clip Stainless
	10692101	Male Weatherpak Kit
	11055867	Fuel Gage Sender 12 Volts 15" Lead (Obsolete)
	20725775	15" Cord Patch w/ Boot
	14431987	36" Cord Patch
	20723690	11' Coax Cross-Over Cable
	14706805	Fuel Gage Sender 12 Volt Single Bulkhead - CE
	14707672	Fuel Gage Sender 12 Volt Dual Bulkhead - CE
	14707728	Fuel Gage Sender 24 Volt Single Bulkhead - CE
	20622530	Fuel Gage Sender 24 Volt Dual Bulkhead - CE

Item No.	Part No.	Description
9	10682851	Heat Exchanger 150 Horsepower
	9722999	Heat Exchanger 300 Horsepower
	10668725	Heat Exchanger 450 Horsepower
10	11488232	Fill Fitting (Parker)
	10492678	Dustcap (Parker)
	10797447	Fill Fitting (JC Carter)
	14102067	Dustcap (JC Carter)
	10557574	Fill Fitting & Dustcap Tanks < 50 Gallons (NexGen)
	14636392	Fill Fitting (Parker-R110)
	11787970	Fill Fitting (Macro-Tech-R110)
11	10798239	Automatic Fuel Shutoff Valve 12 Volt 3/8"
	14322001	Automatic Fuel Shutoff Valve 12 Volt 1/2"(R110)
	11710999	Automatic Fuel Shutoff Valve 24 Volt 1/2"(R110)
12	10624239	Tank Pressure Gage 300 psi 1/8" (not used on R110 tanks)
	10924101	Bushing 1/4" Male X 1/8" Female
13	10644942	Overpressure Regulator 30-100 psi (Red)
	10586834	Overpressure Regulator 100-200 psi (Brown)
	20696072	Overpressure Regulator 125-225 psi
	10586834-145	Overpressure Regulator Pre-Set to 145 psi
14	11674262	Vent Connector and Dustcap (45 Flare Elbow 3/8")
	13843015	Quick Disconnect Valve (R110)
15	11732240	Low Temperature Signal Device
16	10524262	Internal Check Valve 2psi
17	11548178	Vent Check Valve 3/8"
18	1211102	Plug 1/4" Brass
19	11708178	Hex Nipple 3/8" Stainless
20	1210402	Elbow 1/4" Brass
21	11646202	U Tube Assembly 37° Flare Copper
	11502559	U Tube Assembly Stainless (Obsolete)
22	1111632	37° Flare elbow 1/4" Brass
23	13450730	Tee 1/4" Brass
24	11359158	Street Elbow 1/4" Brass

*The Red Vinyl Cap is a water prevention device. Pipe away with a low point drain is a water prevention device and must be added to the Primary Relief Valve (6 & 7).

IX PARTS LIST

Shrouded Tank (Truck Style)



Item No.	Part No.	Description
25	11658975	Sender Mounting Bracket Stainless
	2913921	Bolt 1/4-20 X 1-1/2" Stainless
	2914071	Lock Nut 1/4-20 Stainless
*26	2811726	Tube 1/2" OD Nylon
27	2710131	Tube 3/8" OD Stainless
*28	1013356	Elbow 1/2" OD X 3.8" Male Nylon
29	1111602	Connector 3/8ODT X 3/8MPT Brass
30	10888656	Bulkhead Connector 3/8" Brass
*31	10502004	Compression Elbow 3/8" Stainless
32	10790982	45° Street Elbow 3/8" Brass
33a	11647862	Cover Plate Stainless - Single Tank
33b	11672742	Cover Plate Stainless - Dual Tank
33c	10923765	Cover Plate Stainless - Blank
	11384505	Grommet
	2913701	Bolt 1/4-20 X 1-1/2" Stainless
	2914071	Lock Nut 1/4-20 Stainless

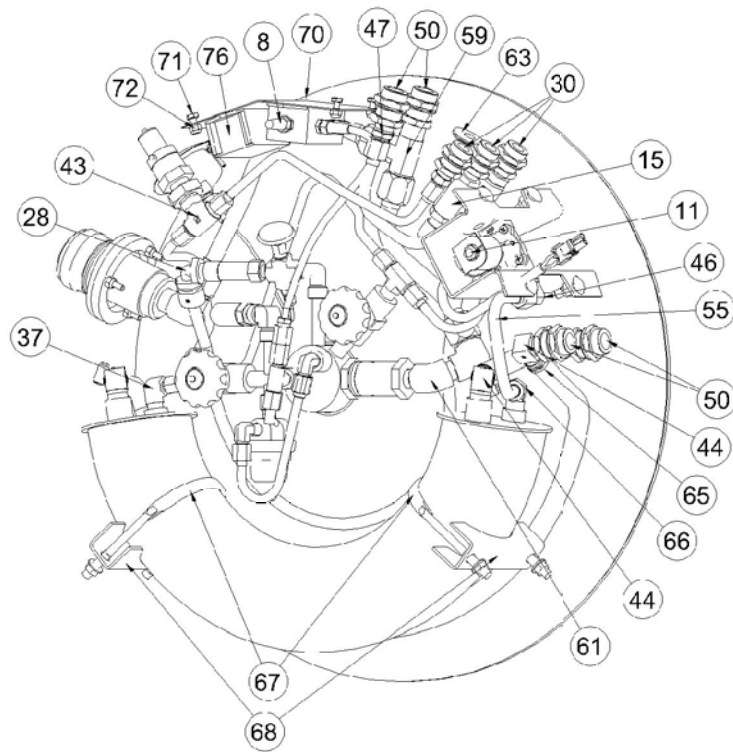
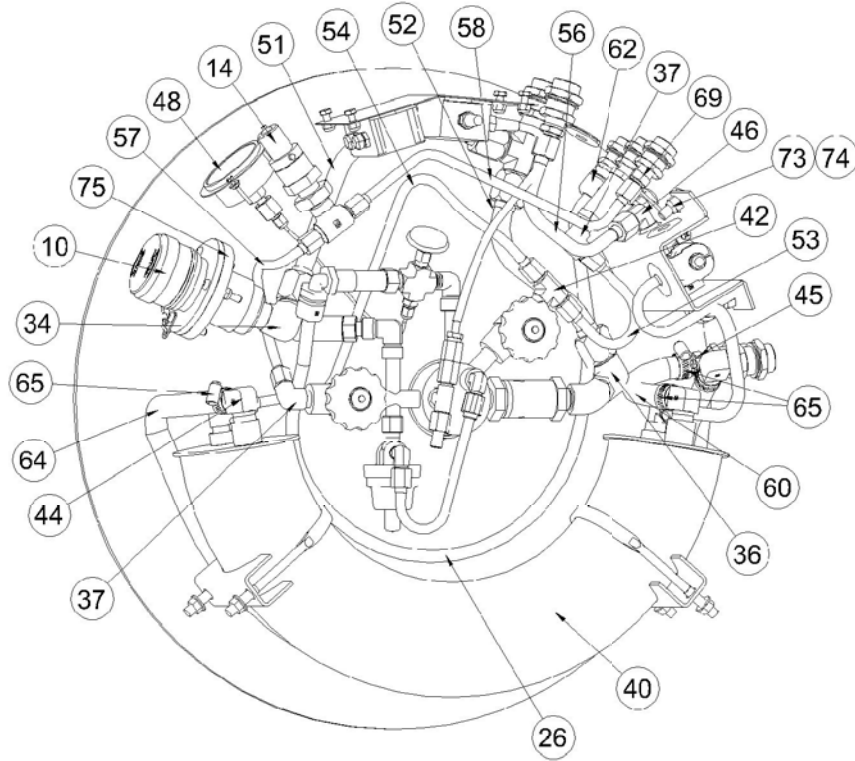
Item No.	Part No.	Description
34	11377751	37° F flare Elbow 3/4" Brass
35a	11647846	Fill Tube Sub Assembly (Driver)
35b	11649227	Fill Tube Sub Assembly (Passenger)
36a	11377823	37° F flare Elbow 1/2" Brass
36b	11658596	37° F flare Elbow 1/2" Stainless - Dual Tank
37	11377778	37° F flare Elbow 3/8" Brass
38	11647871	Vent Tube Sub Assembly
39	10928902	BNC Patch Cord 3'
	10746359	BNC Patch Cord 8'
	11015144	BNC Patch Cord 10'

*Pipe away with low point drain is a water prevention device (26, 28 & 31)

NOTE: If required refer to Chart Parts website for up to date Part Numbers.

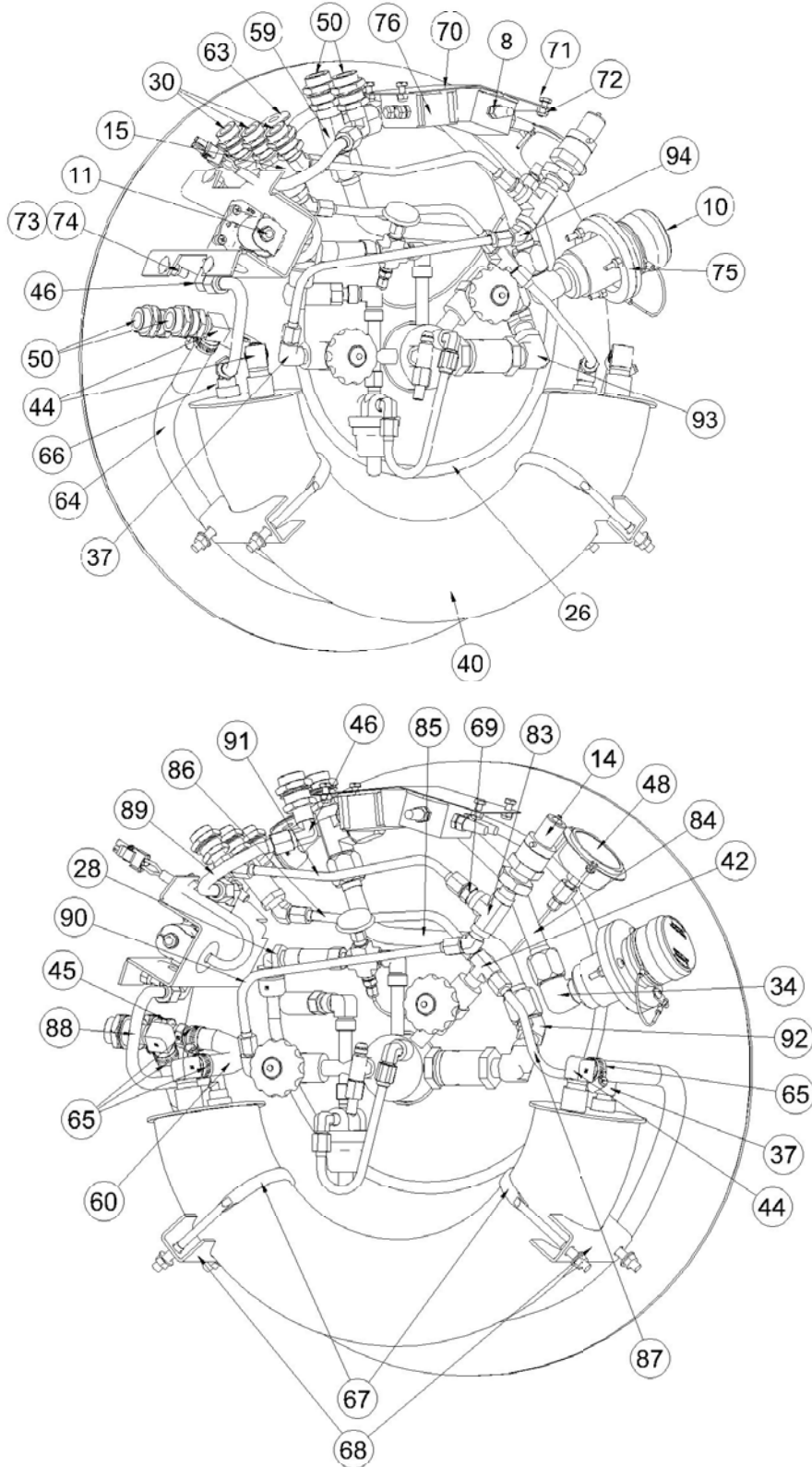
APPENDIX - Connections X

Integrated Tank (LH Dual - STD)



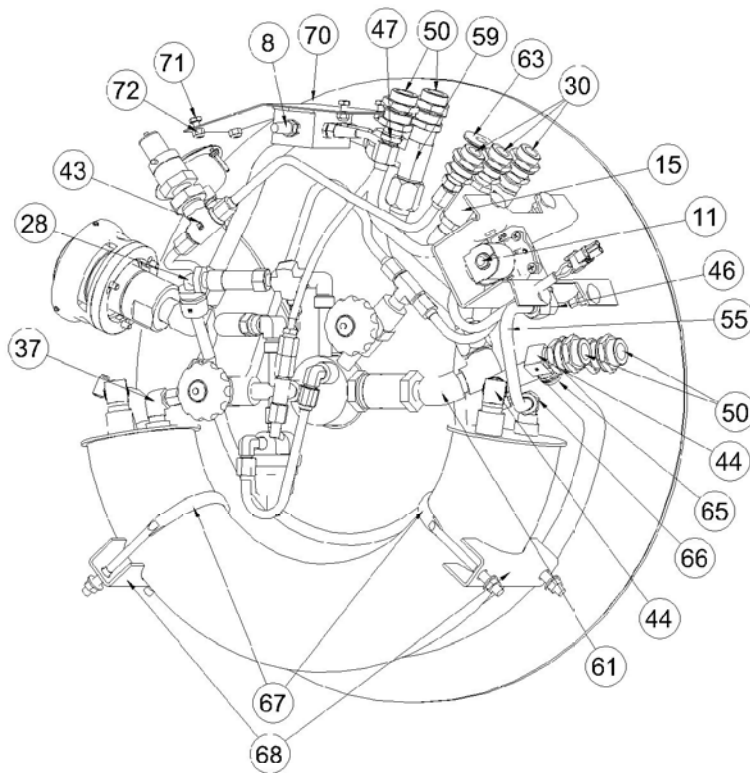
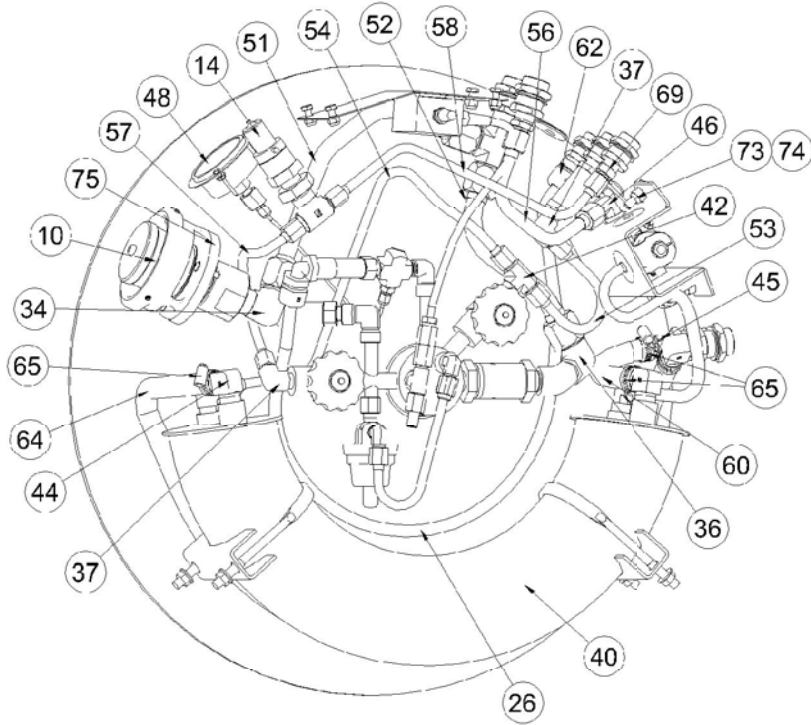
IX PARTS LIST

Integrated Tank (RH Dual - STD)



APPENDIX - Connections X

Integrated Tank (LH Dual – R1110)



IX PARTS LIST

ITEM NO.	PART NO.	DESCRIPTION
40	20615331	HEAT EXCHANGER IN-SHROUD S/A
42	20619615	ELBOW BRASS 90D 3/4" MPT X 3/4" FL
43	20643801	TEE STREET BRASS 3/8" NPT
44	20619616	HOSE BEAD BRASS 90D 1/2" MPT X 3/4" ID
45	20619617	HOSE BEAD BRASS CON 1/2" MPT X 3/4" ID
46	20619632	ELBOW BRASS 90D 1/2" MPT X 1/2" FL
47	1110092	CONN BRASS 1/2" ODT X 1/2" MPT
48	20813355	SHROUD MOUNTED PRESSURE GAUGE
50	10653187	BULKHEAD CONNECTOR 1/2"
51	20623354	3/4" COPPER FILL TUBE 1 DUAL LH
52	20623355	3/4" COPPER FILL TUBE 2 DUAL LH
53	20623356	3/8" SS LIQUID TUBE 1 DUAL LH
54	20623357	3/8" SS LIQUID TUBE 2 LH
55	20623358	1/2" SS SOLENOID INLET TUBE LH
56	20623359	1/2" SS SOLENOID EXIT TUBE LH
57	20623362	3/8" COPPER VENT TUBE 1 LH
58	20643802	3/8" COPPER VENT TUBE 2 DUAL LH
59	20619614	SS TEE 3/4" ODT X 1/2" MPT DUAL LH
60	20698805	90D COOLANT HOSE
61	1214802	45D BRASS ELBOW 1/2" FPT X 1/2" MPT
* 62	12893571	NYLON WHITE CONNECTOR 1/2" OD X 3/8"
63	11384505	RUBBER GROMMET 1/2" ID
64	20619634	COOLANT HOSE 3/4" ID
65	10958597	5/8" HOSE CLAMP
66	11674271	90D BRASS ELBOW 1/2" FL X 3/8" MPT
67	10691722	4-1/2" CLAMP

ITEM NO.	PART NO.	DESCRIPTION
68	20643804	H.E. SUPPORT
69	1111602	BRASS CONNECTOR 3/8"
70	20643806	FGS/LTS BRACKET
71	2910501	HEX HEAD METRIC SCREW 1/4" X 5/8"
72	2914071	SS LOCKNUT 1/4-20 WITH NYLON INSERT
73	2910641	HEX NUT SS 10-32 18-8
74	2913751	CRG SS BOLT .375-16 X 1"
75	11736515	ALUMINUM FILL RECEPTACLE SPACER
76	11732240	LOW TEMPERATURE SWITCH
79	20597530	90D BRASS ELBOW 3/8" SINGLE LH
80	20705957	3/4" COPPER FILL TUBE 1 SINGLE LH
81	20732476	PLASTIC PLUG 1-1/8"
82	20732477	PLASTIC PLUG 1-1/4"
83	20751007	TEE FITTING 3/8" NPT
84	20750999	3/4" COPPER FILL TUBE 1 DUAL RH
85	20751000	3/4" COPPER FILL TUBE 2 DUAL RH
86	20751001	3/8" SS LIQUID TUBE 1 DUAL RH
87	20751002	3/8" SS LIQUID TUBE 2 RH
88	20751003	1/2" SS SOLENOID INLET TUBE RH
89	20751004	1/2" SS SOLENOID EXIT TUBE RH
90	20751005	3/8" COPPER VENT TUBE 1 RH
91	20751006	3/8" COPPER VENT TUBE 2 DUAL RH
92	11377760	BRASS 45D ELBOW 1/2" X 3/4" RH
93	10791820	BRASS 90D ELBOW 1/2" X 1/2"
94	20751008	BRASS 45D ELBOW 3/8"
95	20753208	3/4" COPPER FILL TUBE 1 SINGLE RH
96	1212972	BRASS PLUS 3/8" MPT SINGLE RH

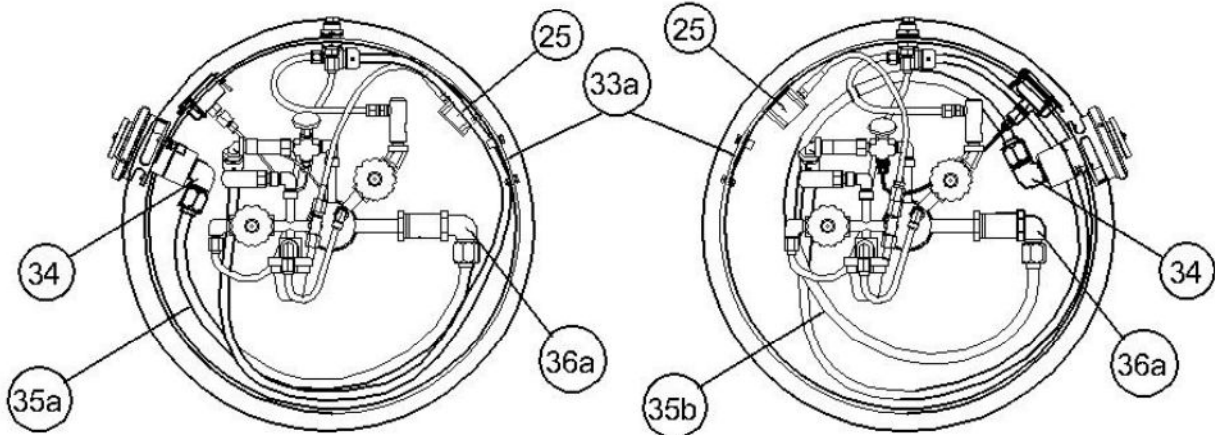
*Pipe away with low point drain is a water prevention device (26, 28 & 62)

NOTE: Refer to Chart Parts website for up to date Part Numbers.

Parts specific to Single Tank Plumbing Kits are listed in the table above and identified on page 29 of this Operations Manual.

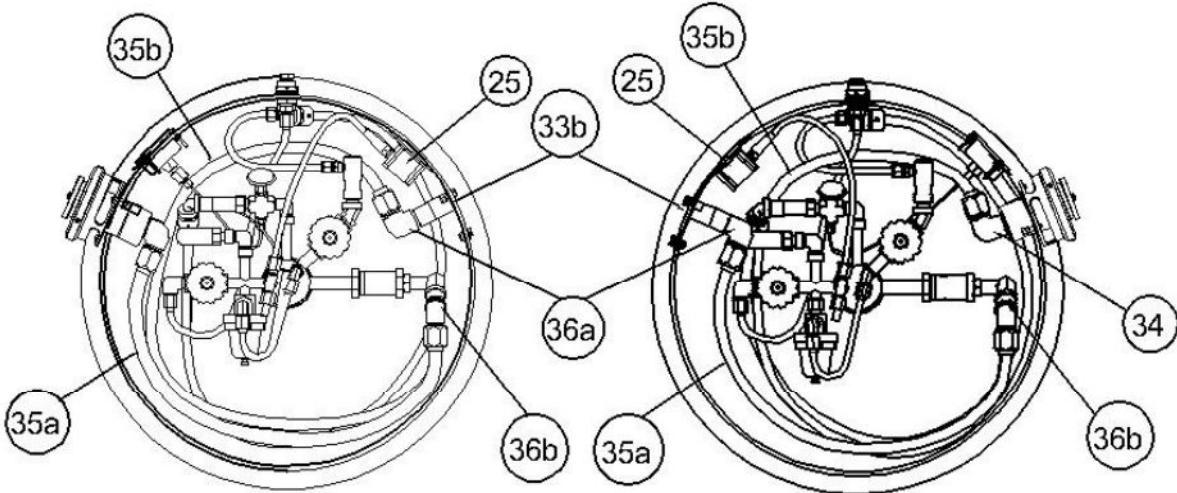
APPENDIX - Connections X

Shrouded Tank Configurations



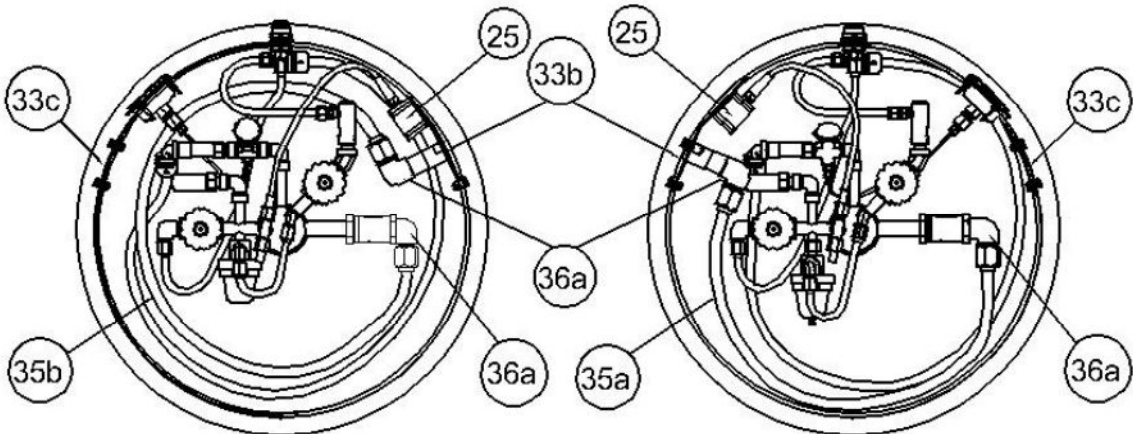
DRIVER SINGLE

PASSENGER SINGLE



DRIVER DUAL

PASSENGER DUAL

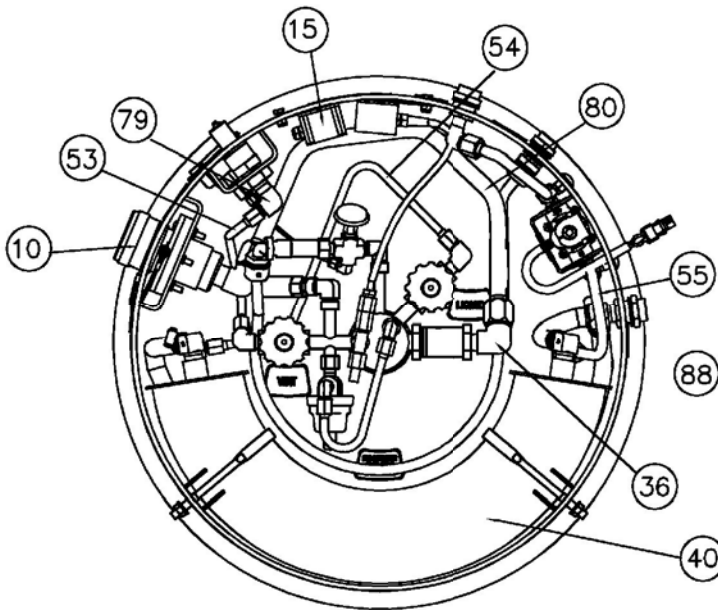


DRIVER DUAL
REMOTE FILL

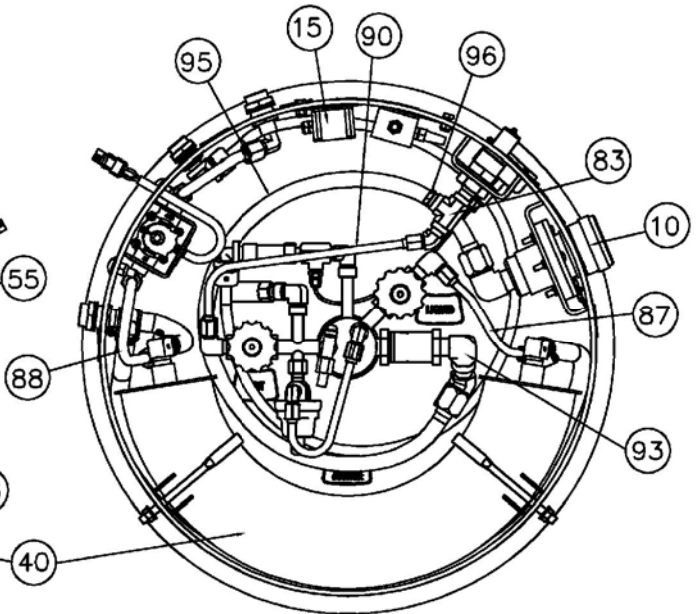
PASSENGER DUAL
REMOTE FILL

IX PARTS LIST

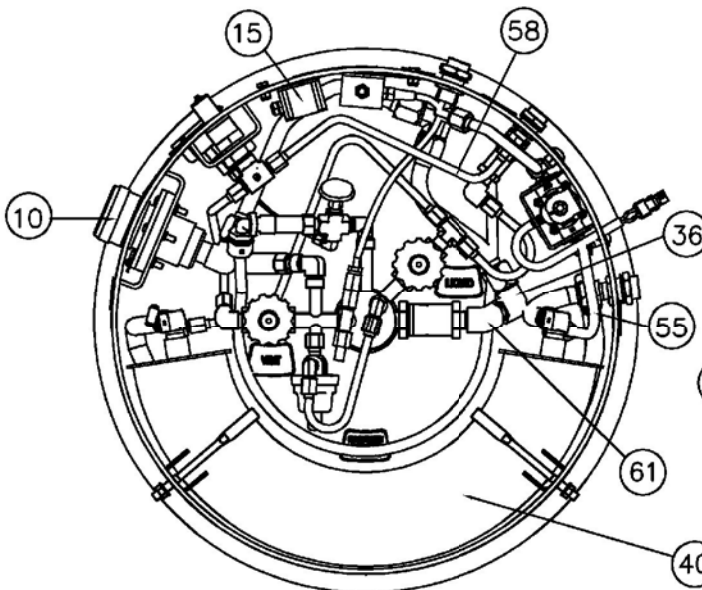
Integrated Tank Configurations



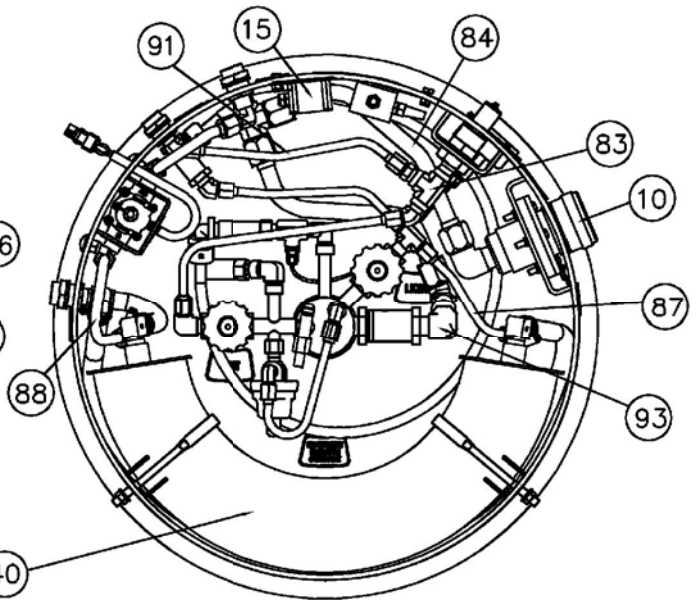
LEFT SINGLE



RIGHT SINGLE



LEFT DUAL



RIGHT DUAL

APPENDIX - Connections X

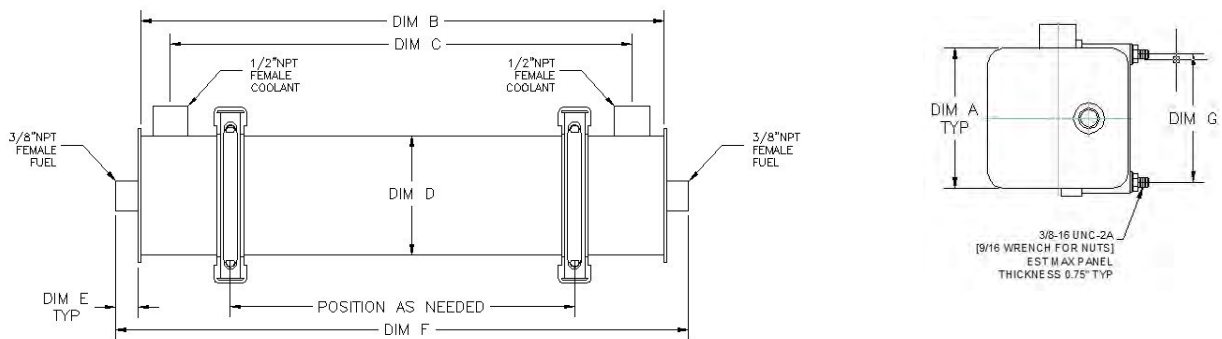
Heat Exchanger

CHART P/N	DESCRIPTION	DIM A IN [MM]	DIM B IN [MM]	DIM C IN [MM]	DIM D IN [MM]	DIM E IN [MM]	DIM F IN [MM]	DIM G IN [MM]
10682851	HEAT EXCHANGER ASSY 150 HP	4 1/2 [114]	9 1/2 [241]	7 1/2 [191]	4 [102]	3/4 [19]	12 3/16 [310]	4 1/2 [114]
9722999	HEAT EXCHANGER ASSY 300 HP	4 1/2 [114]	17 1/2 [445]	15 1/2 [394]	4 [102]	3/4 [19]	19 1/4 [489]	4 1/2 [114]
10668725	HEAT EXCHANGER ASSY 450 HP	5 [127]	25 1/2 [648]	22 1/2 [572]	4 1/2 [114]	1/2 [13]	26 1/2 [673]	5 [127]

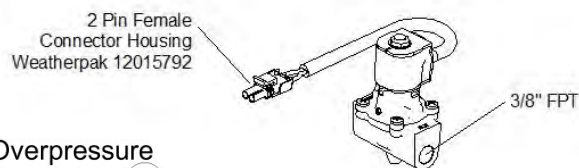
Specifications:

Max Operating Pressure (LNG): 300 psig (20 bar)

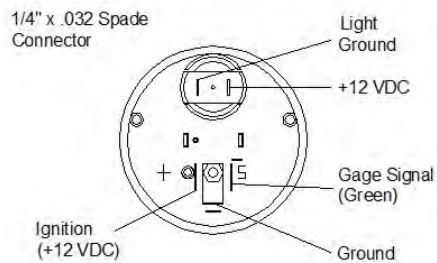
Max Coolant Pressure: 20 psig (1 bar)



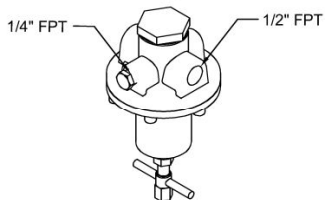
Automatic Fuel Shut Off Valve (11)



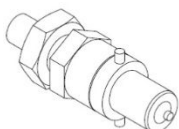
Contents Gage (8)



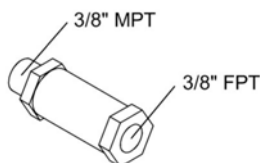
Overpressure Regulator (13)



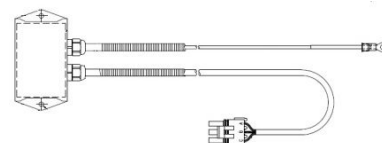
Quick Disconnect Valve (14)



Vent Check Valve (17)



Low Temperature Signal Device (15)



XI APPENDIX - LABELS

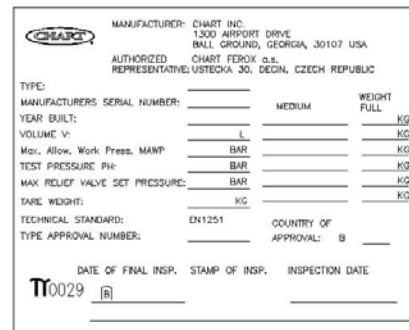


LNG 230 PSI/16 BAR Max – P/N10647617 (230PSI) or 20575668 (16Bar): **This label must be mounted in plain sight near the fill connector.** It is the most important label from a safety standpoint since it notifies the fuel station operator of the pressure limit of the vehicle tank.



LNG (Diamond) – P/N 10586412 or 20822444 (R110): Place these labels on the right rear and left front of the vehicle. It identifies the vehicle as an alternative fuelled vehicle that runs on LNG.

Data Plate: Permanently affixed to the tank this label gives the model number, serial number, date of manufacture, volumetric capacity and working pressure information about the tank. It also identifies the manufacturer and plant where built. Below are some examples of different versions of Data Plate used on LNG tanks.



UN 1972 – P/N 3835959: This label identifies the LNG by its HAZMAT identification number. Although not required, many safety, and emergency response organizations use this number to identify hazards and formulate suitable responses to accident situations.



P/N 3835959



P/N 3830599



P/N 3830619



P/N 3830709



P/N 11808048

LNG Tank Length — Volume

