Overview

The information contained in this bulletin is intended to provide general installation guidelines and recommended specifications. It will aid an up-fitter or OEM in system design and/or installation of an LNG vehicle tank and system components manufactured by Chart Industries. For further information refer to Chart Industries LNG Vehicle Tank Operation Manual. The LNG system should be designed by a professional fuel system designer with experience in LNG vehicle fuel systems.

Selection of System Components

Tank Selection

Proper tank sizing is one of the more critical elements of the installation process. This is dictated by information collected from the intended equipment fleet operator. Conditions such as expected fuel mileage, operating conditions, vehicle range, and diesel to LNG ratios must be considered to ensure the LNG vehicle contains sufficient on-board fuel capacity. An LNG powered vehicle will use a greater quantity of fuel than a diesel powered vehicle. The LNG to diesel ratio normally used is 1.7:1 – 2.0:1. A diesel powered vehicle that uses approximately 50 gallons of diesel on a route/day will need an LNG tank with a 100 gallon (or greater) net capacity.

Consideration also needs to be taken regarding available tank mounting space on the vehicle chassis. Listed below (page 2) are the most common tank sizes available, their weights (empty and full), length, and diameter, in overall dimensions. A shrouded type tank (one with the plumbing components completely enclosed and protected) should be used on a vehicle when the fuel tank(s) will be mounted outside the frame rail of the vehicle. Extra spacing (~12 inches or greater) must be made available at the tanks plumbing end to allow for accessibility of the tank shroud plumbing and hand valves.

Resource Information

The following publications are recommended resource materials to be used in conjunction with this document. Consult local, state and federal authorities to ensure all legal requirements are met.

SAE J2343

NFPA 57

California Title 13

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DOT 4L

Chart Industries LNG Vehicle Tank Operations and installation Manual (PN 3835849)

Economizer Regulator Pressure Specifications

When ordering a new LNG tank the purchaser will be asked what pressure they need to have the economizer regulator set at. This is the normal operating/delivery pressure of the tank. Charts LNG vehicle tanks operate best at low pressures. This maximizes the length of hold time of the LNG in the tank and allows for more complete fills and greater onboard fuel capacity. The goal is to maintain low pressures but not so low as to interfere with the normal operation of the engine.

All natural gas engine manufacturers publish specifications for normal delivery pressures; lower than specified delivery pressures will cause engine performance issues. Therefore a happy medium needs to be determined by the system up-fitter or OEM. System design characteristics can cause excessive pressure drop through the system, especially under peak torque/load conditions. Therefore a newly designed/installed system needs to be tested thoroughly prior to delivery to the customer to validate correct system operation.

Most Common Models	HLNG-119		HLNG-127		HLNG-150		HLNG-158	
Dimensions	in	cm	in	cm	in	cm	in	cm
Diameter	26	66	26	66	26	66	26	66
Length	76	192	76	192	91	230	90	229
Capacity	gal	ltr	gal	ltr	gal	ltr	gal	ltr
Net	108	409	115	435	135	511	141	534
Gross	119	450	127	481	150	568	158	594
Weight	lbs	kg	lbs	kg	lbs	kg	lbs	kg
Empty	525	238	540	245	635	288	650	295
Full	903	410	943	428	1108	503	1144	519

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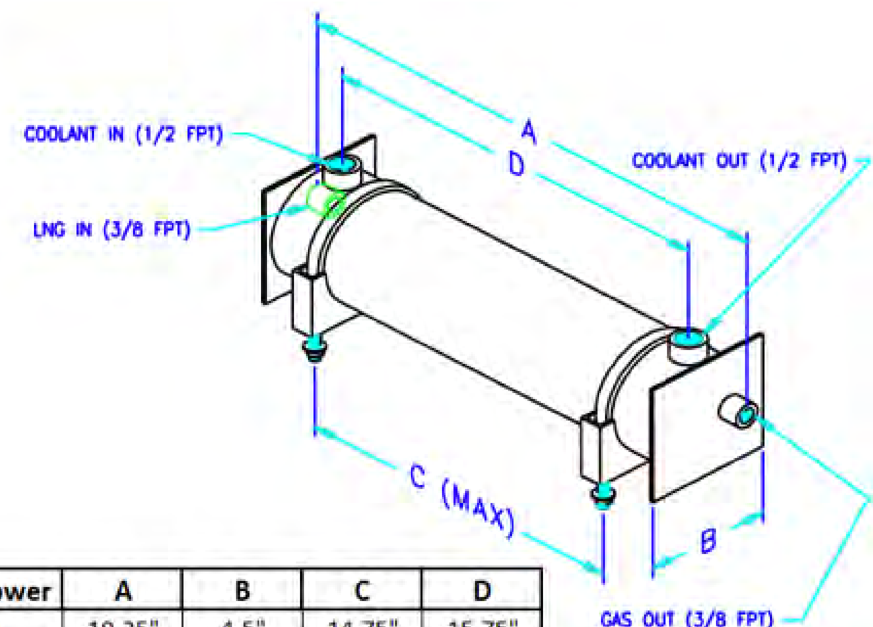
Heat Exchanger (vaporizer) Selection

Chart manufactures different models of heat exchangers of various sizes based on the engine horsepower. The horsepower ratings shown in the table below are shown as maximum rated horsepower for that heat exchanger. As an example a 280 HP engine would use a 300 HP exchanger. See heat exchanger sizing illustration at bottom of page. The heat exchanger displayed below is an external version, Chart also offers a version integrated into the plumbing area of the LNG fuel tank.

System Design

A new system is best designed by an OEM or other facility that is able to determine the exact specifications and needs of the vehicle, engine and LNG system. Attempting to design the system as it is installed on the vehicle will most likely result in unnecessary re-engineering after testing and run in is completed. It is also difficult to duplicate such a custom designed system on future vehicles during installation. Chart highly recommends in depth research be conducted into federal and local laws and guidelines prior to inception of a new system.



Part Number	Horsepower	A	B	C	D
9722999	300	19.25"	4.5"	14.75"	15.75"
10668725	450	27.25"	5"	21.5"	22.5"

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Component Installation

Tank Mounting

The tank should be secured to the vehicle chassis with an appropriate number of steel brackets. The outer most brackets/straps must be located just inboard of the head to shell welds of the tank. The brackets must be mounted securely to the vehicle chassis. The straps should incorporate rubber pads to prevent rotation or slippage of the tank.

In accordance with NFPA guidelines the mounting system must be sufficiently strong to hold 8 times the full weight of the tank. The tank mounting system must incorporate the appropriate amount of mounting brackets to meet this standard. See the chart above (at bottom of page 2) to calculate anticipated full tank weights. The tank should be mounted with the plumbing end of the tank facing toward the rear of the vehicle whenever possible.

Fuel Gauge and Wiring

The fuel gauge level readings are controlled by a rectangular box mounted to the inside of the vehicle tanks shroud or protective ring support. This box is called the sender. A three conductor male weather pack is connected to the sender vehicle wiring lead. A female three conductor weather pack connector is supplied in the parts/ manual kit inside the shroud of the new tank when purchased. The parts kit will also contain the fuel gauge; **the supplied gauge must be used in the system.**

The sender and gauge are specified at time of ordering, according to vehicle system voltage, size, type and number of tanks in the system, and system operating pressure (economizer regulator pressure, see page 2). Three wires (preferably of the same coloring scheme as the sender wires) will need to be installed into to the supplied female weather pack connector, and then all wiring should be installed into a protective wire loom.

The loom/wiring should be run in parallel with the chassis harness into the cab and to the instrument cluster (or wherever the liquid level gauge will be located) and connected to the appropriate terminals at the rear of the gauge via spade terminals. (See photo on page 5 for correct wiring configuration).

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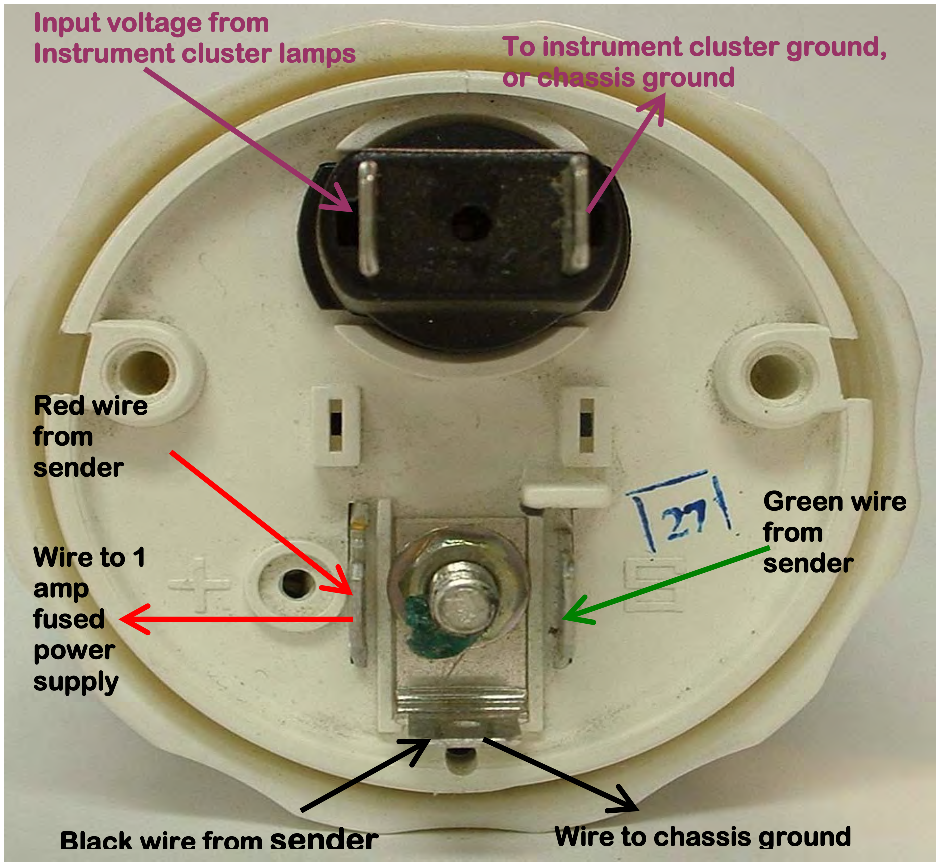

The three wires are to be connected to the following tabs on the back of the gauge.

- Red - connects to the positive (+) spade terminal on the rear of the gauge, a separate wire will be connected in series to the spade and run to a 1 amp fuse at the fuse panel.
- Black – connects to the negative (-) spade terminal on the rear of the gauge, a separate wire will be connected in series to the spade connector and run to a chassis ground.
- Green – Connects to (S) spade terminal on rear of gauge.

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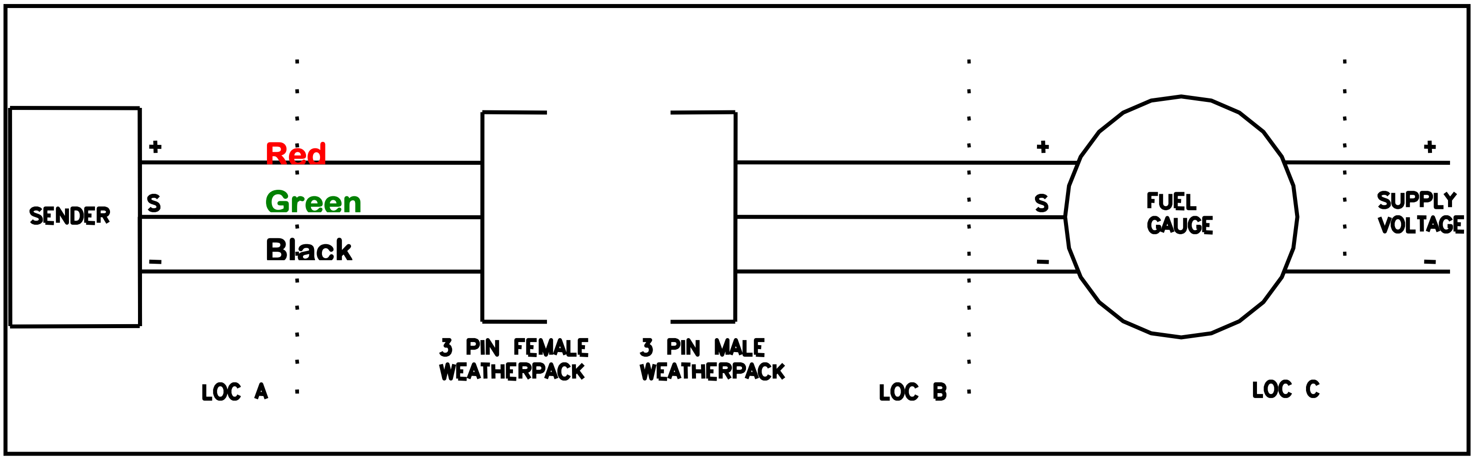

Two other wires need to be run to illuminate the gauge as shown in the gauge photo above (See photo page 5). One wire should be run from the instrument cluster lamps so the gauge illuminates only when the instrument cluster lights are illuminated. The other wire is simply a ground, and can return to the instrument cluster ground circuit or chassis ground.

The gauge is an automotive type and is not a sealed unit; it should be mounted inside of the vehicle or in a weather proof environment to protect it from the elements.

Heat Exchanger (vaporizer)

The heat exchanger (HE), if not an integrated version, is normally mounted in a horizontal position however vertical mounting is also a viable solution when necessary. The heat exchanger should be mounted inside of the frame rail of the vehicle. If mounted horizontally the ½" coolant port outlets should point in the upward direction. The HE clamps should be mounted to a secure location. When mounted with in 3 ft of the tank 3/8" OD X .035 wall stainless tubing can be used to plumb the LNG outlet of the tank to the LNG inlet on the HE. If the HE is mounted greater than 3' from the tank ½" OD X .049 stainless tubing should be used instead of 3/8" tube.

Engine coolant will pass through to the ½" coolant ports and into the heat exchanger body to vaporize the LNG. The recommended flow rate through the heat exchanger is 1 gallon per minute of 180˚F coolant per 50 horsepower.

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For coolant hose runs of less than 10 feet in length (between engine block and HE coolant port inlet) this flow rate can usually be achieved using 5/8" hose. On runs longer than 10 feet the use of ¾" hose may be necessary. Consult the engine manufacturer for the correct coolant port plumbing configuration into the engine block.

Do not tee the hoses into the cab heater hoses, this can cause reduced coolant flow to the heat exchanger (especially when the cab heater is operated). The heat exchanger should be plumbed so the coolant and the LNG enter on the same end of the HE.

On a horizontally mounted HE the coolant ports must point upward to reduce the chances of air becoming trapped in the HE. Vertical mounted HE's must have the coolant and LNG inlet plumbed to the bottom ports and the outlets plumbed to the top ports of the HE. A 50/50 mix of antifreeze (or equivalent freeze inhibitor) and water is recommended to keep the engine coolant from freezing and damaging the HE.

Electric Solenoid

The electric fuel shut off solenoid should be mounted at or within close proximity to the 3/8" heat exchanger outlet port. The solenoids are available in 12 and 24 volt models. The valve is direction specific and the inlet and outlet ports are marked on top of the valve body. The valve can also be ordered with a left or right hand pre-installed mounting bracket on the solenoid.

The solenoid and bracket assembly must be securely mounted to avoid heat exchanger damage due to vibration. The solenoid is a normally closed switch with two wires. It is usually controlled by the vehicle ignition switch; however it can also be wired to the engine control module, shutdown circuits, methane detection equipment, or low temperature switch.

Chart recommends the use of a low temperature limit switch on the warm gas (HE outlet) tubing to protect the valve and downstream components in the event of a cooling system or other related malfunction.

Low Temperature Switch

A low temperature switch should be incorporated into the heat exchanger warm gas/outlet tubing, it can protect the electric solenoid and downstream components in the event of a coolant system malfunction. It should be wired to illuminate a warning light in the drivers' compartment.

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Overpressure Regulator

The overpressure regulator is plumbed into the warm gas tubing downstream of the electric fuel shutoff solenoid and prior to the engine OEM supplied tubing inlet. It should be mounted to a rigid bracket (the bracket is not supplied by Chart) bolted to the OP regulator body. It is direction specific, the inlet and outlet ports are marked on the regulator body. The regulator also has two gauge ports identified as "GA". A pressure gauge can be installed into either "GA" port; the second "GA" port should remain plugged.

The gauge is useful as an aid in setting the OP regulator pressure; it is also useful as a downstream pressure monitoring device. The OP regulator will need to be set and/or adjusted when testing the system (see page 10 below). See Chart Service Bulletin VT-0031 for specific instructions on setting the OP regulator.

Tubing Sizing and Support

Stainless tubing (rigid 300 series) should be used between the tank and heat exchanger. Stainless tubing is also recommended between the heat exchanger and engine, however cryogenic rated flexible hose is also acceptable for use between the HE and engine. Tubing carrying LNG will repeatedly go from ambient to cryogenic temperatures; therefore allowances for thermal expansion must be designed into the piping system. This is typically accomplished by incorporating S bends or expansion loops into the rigid tubing.

When the heat exchanger is mounted within 3 ft of the tank 3/8" OD X .035 wall stainless tubing may be used to plumb the two together. If the HE is mounted greater than 3' from the tank ½" OD X .049 stainless tubing should be used. **The warm gas tubing to the engine must be sized a minimum of 1/8" larger than the size of the tubing used on the liquid line inlet at the heat exchanger.**

All tubing and hoses must be supported; a general guideline is one support for every 2 ft of tubing. Supports for tubing carrying cryogenic liquid should incorporate cryogenic rated insulation material between the tubing and support bracket. All tubing and hoses should be routed to ensure they do not contact other vehicle components causing them to rub.

Tubing carrying liquid will frost up during normal operation and must not be routed within close proximity of other vehicle components, wiring or hoses. All tubing and hoses should be routed in a manner so they do not contain any sharp bends. Sharp bends can cause a hose to collapse; sharp bends can also cause reduced flow in tubing. Keep the number of bends in the system to a minimum whenever possible and avoid sharp bends whenever possible.

Pipe Fittings

Rigid tube fittings should be either a double ferrule type (Parker A-lok, Swagelok or equivalent). Tubing wall thicknesses used should be per fitting manufacturer's specification for cryogenic liquid and gas service.

Sealants

Nickel Teflon Tape is recommended for use on Chart LNG vehicle tanks.

Refer to bulletin VT-0030 for proper use of thread sealant tape.

Leak Testing – The entire system should be pressurized to the maximum operating pressure (230 psig), then leak tested. Use regulated compressed nitrogen through the tanks vent connection to pressurize the tank and entire LNG piping system, then check for leaks at all fittings and connections. Use a liquid (bubble) type leak tester such as snoop leak tester (Chart PN 10583211). This is also a good time to re-confirm the proper operation and pressure setting of the overpressure regulator.

Filling the Tank

First 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 heat from inside the tank is transferred to the cold LNG. On many stations this will stop the filling process leaving the tank only partially filled. Recommended first fill procedure is to install 5-10 gallons of cold liquid into the tank. Drive the vehicle for 15 minutes or longer to pull the pressure down in the tank. Once the tank pressure has approached the normal tank operating pressure (economizer regulator setting) the tank may be filled to its normal capacity. Check for leaks in the tank and chassis plumbing.

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LNG System Testing

A newly designed LNG fuel system must be tested to ensure it will meet or exceed OEM engine manufacturer's specifications and requirements.

Setting The Overpressure Regulator – The OP regulator must be set to the correct operating pressure prior to running the engine. The OP regulator can be set while leak testing the LNG system at 230 psi (see Leak testing on page 9).

First determine the economizer regulator pressure setting per VT-0014. The economizer is a gold colored regulator mounted on the tank within the tank plumbing arrangement. The economizer setting will be scribed or written on the upper economizer body.

The OP regulator will be set a minimum of 25 psig above the economizer pressure but not to exceed 150 psig. With system at or near 230 psi loosen jam nut on top of OP regulator body at adjusting screw. Watch the gauge on the regulator and either turn the adjusting screw T handle in or out to adjust to the correct pressure. Do not exceed 150 psig.

Heat Exchanger Coolant Flow Test – Test the engine coolant flow to ensure proper heat exchanger operation. Plumb a coolant flow gauge such as a Dwyer VFC 142 (or equivalent) in series into the coolant inlet hose at the heat exchanger. The Dwyer flow meter must be positioned in a vertical position with the meter inlet and outlet ports plumbed appropriately. The recommended coolant flow rate is 1 gallon of 180˚F coolant per minute per 50 HP engine output.

Coolant flow rate will usually vary based upon engine RPM and load. While the flow rate will be lower than the desired specification at idle keep in mind that the engine does not generate rated HP at idle.

As an example an engine rated at 300 HP would require ~6 gallons per minute of 180˚F coolant flow.

System Performance Test – The LNG plumbing system must be performance tested to check for improper flow characteristics within the LNG piping system. Road test the vehicle under various operating conditions and engine loads. Note any abnormal conditions such as engine stumbling,

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stalling, hesitation, low power, abnormal noises or engine fault codes logged during the road test. Note tank economizer set pressure.

Ensure the tank pressure gauge reads the same psi as the pressure setting of the economizer; ensure the engine is at its normal operating temperature. Install a pressure (psig) gauge into the warm gas tubing between the engines fuel filter housing and the engines warm gas inlet. The engines OEM diagnostic monitoring software may also be used if applicable.

Road test the vehicle once again under similar various operating and full load conditions. Note pressure deltas between tank pressure and engine inlet pressure and record. Optimum pressure variance is ~10 psig, greater than a 20 psig variance may indicate improper size tubing, excessive, or sharp bends in tubing and system.

The vehicle is ready for release to the customer only after proper system testing and operating parameters have been confirmed with LNG in the tank. Failure to complete a system performance test could result in costly breakdowns, rework of the system, and unnecessary vehicle downtime.

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