QUANTUM
FUEL SYSTEMS

Virtual Pipeline Trailer
Owner's Manual

This manual is applicable to the VP Lite, VP-10' series trailers.

Rev B

Forward

This manual contains information for the use of Quantum Virtual Pipeline (VP) system. Read this manual from cover to cover and keep it for future reference.

Quantum's VP system must only be serviced by trained personnel who have read and understood this manual.

This manual contains Cautions and Notices that must always be observed to reduce the risk of personal injury during operation. Improper operation procedures may damage components or make the vehicle unsafe to operate. These Cautions and Notices are not all inclusive. Quantum Fuel Systems LLC cannot possibly warn of all the potentially hazardous consequences caused by a failure to follow these instructions.

If you need further information or have any questions, please contact:
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USA

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Tel: 949-399-4500

How to Use This Manual

This manual contains information pertaining to safe transport and use of the Quantum virtual pipeline system.

Please read this manual from beginning to end when you first receive your product. If you do this, it will help you learn about the special features of your virtual pipeline system. In this manual, you will find that words and pictures work together to make things easy to understand.

The information contained in this manual was originally authored in English.
Should a discrepancy exist between the English version of the manual and a translated version of the manual, in either the content or the intent of any portion of this manual, the English version is to be considered correct and shall take precedent.
If any questions arise related to the accuracy of the information contained in the translated version of this manual, please refer to the current English version of the manual available on the Quantum Fuel System LLC. Website at QTWW.com.
No liability is assumed by Quantum Fuel Systems LLC for any errors, omissions, or ambiguities that may exist in this translated manual.

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Introduction

Thank you for purchasing your Quantum Virtual Pipeline trailer. Quantum Fuel Systems has a series of high capacity trailers that are easily transportable domestically and globally. The standard 10' shipping container is equipped with Quantum's signature Q-Lite™ high-pressure cylinders.

Quantum offers the following Virtual Pipeline (VP) trailer configurations:

- VP Lite 10-8:
  - 3600 psi (248 bar) standard capacity trailer for CNG, Hydrogen, Nitrogen and other approved gases.

- VP Lite 10-6:
  - 3600 psi (248 bar) standard capacity trailer for CNG, Hydrogen, Nitrogen and other approved gases.

We are innovators in compressed natural gas technology

For over 20 years, Quantum has been supplying and producing the lightest and the highest capacity CNG Type IV tank in the world. Quantum's Q-Lite™ tanks are up to 30% lighter than other CNG tanks in the industry. These tanks are currently on thousands of CNG heavy-duty trucks today and are used by fuel system manufacturers across the country.

Our goal is to provide the highest storage density and capacity at the lowest possible weight.

Please read this manual cover to cover before using your Quantum VP gas storage trailer. This manual contains important information about the system specifications and safe usage of your VP system.

Safety Systems

The trailer is equipped with multiple devices to protect the system and operators in the event of a system malfunction or in the event of a fire in or around the trailer. The systems safety features are described in this section:

Cylinder PRD valves

Each storage cylinder is equipped with its own thermally activated pressure relief device. If a thermal event were to occur locally or globally the cylinder or cylinders will protect themselves depending on the level of heat to which they are subjected. These valves should only activate in the event of fire; ambient conditions should never cause activation of these valves.

Loading Pressure Relief Valve

A pressure relief valve on the loading side protects the system from excess pressure. In the event the system pressure exceeds the preset value, the pressure relief valve will discharge the excess pressure to atmosphere.

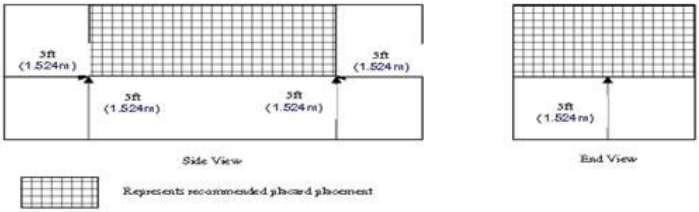
The PRV set pressures are:

- VP Lite, 4,900 psi (338 bar) for 3,600 psi (248 bar) systems.

Trailer Markings

A placard with the appropriate markings must identify the contents of the trailer before any type of transport occurs. For US transport, the Quantum VP is approved for over the road, rail car and cargo ship transport, the hazardous materials placards must be positioned to be visible on the left and right sides and front and rear ends of containers as shown below.
Do not place the placard over any container markings, or close to any advertising or other background that is of similar color (like red or orange).
For Canadian transport the Quantum VP trailer is only approved for over the road shipment. Follow placard placement guidelines defined for US shipments.

The illustration below shows the proper placement of the placards.

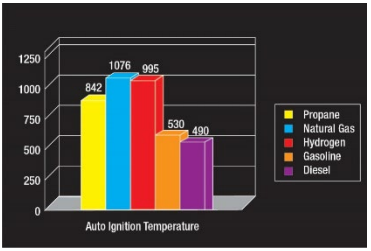


The Quantum VP Trailer is approved for transport of a number of gas and gas compounds and must be marked accordingly.
For a list of approved gases reference Approved Gases in this manual.

General Fuel Safety

About Compressed Natural Gas

Natural gas is lighter than air. If a leak were to develop, the gas would rise and disperse through the atmosphere giving little chance for ignition. Compare that to gasoline and diesel fuel, both of which are dense liquids that tend to pool and are easily ignitable.

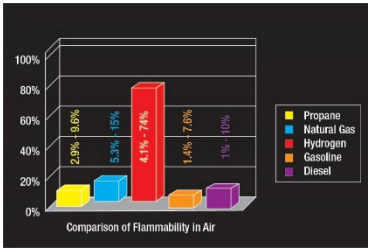


Raw natural gas is odorless; a distinctive odorant that smells like strong sulfur is added prior to distribution for your safety. This strong odor makes the presence of a leak very easy to detect. If an odor is detected, inspect the vehicle for the source of the concern, and repair as needed.

Natural gas itself is a safer fuel than either gasoline or diesel fuel. It has a limited range of flammability, meaning it requires the correct mixture of air and fuel to burn—somewhere in the 5 to 15 percent range, and an ignition temperature of approximately 1100°F (593°C). Compare that to gasoline and diesel fuel which both have lower concentrations of flammability and lower temperatures of ignition.

About Hydrogen Gas

Hydrogen is lighter than air. If a leak were to develop, the gas would rise and quickly disperse through the atmosphere giving little chance for ignition. Compare that to gasoline and diesel fuel, both of which are dense liquids that tend to pool and are easily ignitable.



Hydrogen in its raw form is odorless and unlike other gases no odorants can be added to hydrogen; hydrogen is an asphyxiant that is colorless, tasteless and is undetectable by human senses.

A pure hydrogen flame is nearly invisible in daylight and will not produce smoke. Hydrogen has low flame emissivity, because there is no carbon to burn, this results in lower radiant heat and may be difficult to feel until close to the flame.

Hydrogen has a wide range of flammable concentrations in air (between 4% to 74%) and an auto ignition temperature of approximately 995°F (535°C). Compare that to gasoline and diesel fuel which both have lower concentrations of flammability and lower temperatures of ignition.

Training in safe hydrogen handling practices is a key element for ensuring the safe transportation and use of hydrogen.

Trailer Options

The following options are available for installation when ordering:

Chassis Style: The 10' trailers come standard with a bumper pull, ball hitch chassis but can be ordered with a pintle eye.
There is also an option for a gooseneck style chassis for fifth wheel applications.

System Specifications

VP Lite 10 Series

Trailer Length: ..... See Note 2
Trailer Width: ..... 102 in (2.59 m)
Trailer Height, Approximate: ..... 137 in (3.48 m)
Approximate System Weights: ..... See Table 1 [1]
Approved Gases: ..... Contact your sales representative
Total System Water Volume: ..... See Table 1
Number of Cylinders: ..... See Table 1
Maximum System Gas Mass: ..... See Table 1
Maximum System Gas Volume: ..... See Table 1
Minimum System Pressure: ..... 200 psi (13.8 bar)
System Working Pressure: ..... 3,600 psi (248 bar)
Maximum System Pressure: ..... 4,500 psi (310 bar)
Minimum System Ambient Temperature: ..... -40°F. (-40°C.)
Maximum System Ambient Temperature: ..... 135°F. (57°C.)
Maximum Loading Flow Rate: ..... 47,500 SCFH
Maximum Unloading Flow Rate: ..... 24,000 SCFH
Minimum Cylinder Temperature (Loading): ..... -40°F. (-40°C.)
Minimum Cylinder Temperature (Unloading):..... -70°F. (-57°C.)
Maximum Cylinder Temperature: ..... 185°F (85°C)

Notes:

[1] Full system weight and capacity will vary based on chassis configuration, gas composition and density.

[2] Container length is ten feet, trailer length and total weight will vary depending on chassis configuration and options.

VP Lite 10 Series Cont

Table 1 CNG Base Weights and Capacity			
		Base Weight	
Cylinder Count	Chassis	Empty Weight	Full Weight [1]
6	Bumper Pull	8,349 lbs. (3787 kg)	11,247 lbs. (5102 kg)
6	Goose Neck	8,849 lbs. (4014 kg)	11,747 lbs. (5328 kg)
8	Bumper Pull	9,285 lbs. (4212 kg)	13,148 lbs. (5964 kg)
8	Goose Neck	9,785 lbs. (4438 kg)	13,648 lbs. (6191 kg)

System Capacities			
Cylinder Count	Water Volume	Maximum System Gas Mass [2]	Maximum System Gas Volume
6	1,572 Gal (5,952 L)	2,898 lbs. (1,314 kg)	63,243 SCF
8	2,096 Gal (7,936 L)	3,863 lbs. (1,752 kg)	84,324 SCF

[1] Base system assumes STD Kwik Chassis, standard landing gear and trailer content. Total system weight may vary with chassis manufacturer and build options.

[2] Maximum gas weights calculated using a gas density of 0.0458 lb./scf @ 59° F.

VP Lite 10 Series Cont

Table 1 Hydrogen Base Weights and Capacity			
		Base Weight	
Cylinder Count	**Chassis**	**Empty Weight**	**Full Weight [1]**
6	Bumper Pull	8,349 lbs. (3787 kg)	8,586 lbs. (3895 kg)
6	Goose Neck	8,849 lbs. (4014 kg)	9,086 lbs. (4121 kg)
8	Bumper Pull	9,285 lbs. (4212 kg)	9,601 lbs. (4355 kg)
8	Goose Neck	9,785 lbs. (4438 kg)	10,101 lbs. (4582 kg)

System Capacities			
Cylinder Count	**Water Volume**	**Maximum System Gas Mass**	**Maximum System Gas Volume**
6	1,572 Gal (5,952 L)	237 lbs. (108 kg)	45,525 SCF
8	2,096 Gal (7,936 L)	316 lbs. (143 kg)	60,700 SCF

[1] Base system assumes STD Kwik Chassis, standard landing gear and trailer content. Total system weight may vary with chassis manufacturer and build options.

Usage Restrictions

The Quantum VP trailer has been built and certified under the provisions of US DOT special permit SP-16524 and Transport Canada Equivalency Certificate SH 11921. Transport of Quantum VP trailers shall occur only on approved roads following any federal, state or local road usage restrictions that may exist.

Local Special Permits

In many locations when loaded, the Quantum VP trailer is required to have a special permit to allow operation of the truck trailer combination on the road. There may also be local restrictions as to the roads, bridges, and seasons where the vehicle may operate.

IMPORTANT: A current copy of the DOT special permit for this trailer MUST be carried aboard each cargo vessel or motor vehicle used to transport the trailer covered by this special permit.

Please note that federal, state, and local regulations may vary and change over time or from region to region. Always check with any applicable federal, state, or local authorities to identify all of the applicable rules, regulations and route restrictions that may apply to your situation before transport of any hazardous material.

Operation

⚠ DANGER ***Some gases approved for use in these VP trailers are extremely flammable. Always be aware of the safe and proper handling procedures for the gas being transported. As a rule, the following precautions should always be followed:***

- ***When loading or unloading the system, keep all sparks, flames, and ignition sources a minimum of 16 feet (5 meters) from any gas.***
- ***Do not smoke near the virtual pipeline regardless of the gas being loaded or unloaded.***
- ***Verify any vehicles in the vicinity are turned OFF before transferring gas.***
- ***Always load and unload the virtual pipeline in a well-ventilated area.***
- ***Do not use a mobile phone within the immediate area.***

The gas storage cylinders may be damaged if overfilled. A cylinder must never be filled above 125% of the rated service pressure.

Failure to follow these instructions will result in death or serious injury.

Conditions of Use

⚠ DANGER ***Modification of the Quantum Virtual Pipeline (VP) trailer may affect the safe operation and use of this equipment.***

Use the Quantum VP trailer as built by Quantum Fuel Systems. Any changes to the VP trailer assembly, the chassis, containment, or its contents, may affect compliance with the special permit and must be approved by Quantum Fuel Systems. Failure to follow these instructions will result in death or serious injury.

The VP Trailer must be used on the supplied chassis or an equivalent chassis. Use of the containment separated from the chassis is not allowed and may violate the terms of the DOT special permit.

Also, if the containment is separated from the chassis for use, it is no longer considered portable equipment and may be subject to ASME regulations for permanent installations. The cylinders within the containment are not approved for ASME applications or any use outside what is defined in the DOT special permit.

Modifications of the containment, containment contents or the chassis may affect the safe use and operation of the VP trailer assembly. Modifications are not allowed unless approved in writing by Quantum Fuel Systems LLC.

⚠ WARNING ***This system must never be used in vacuum service. Do not continue unloading under 200 psi (13.8 bar). Failure to follow this instruction could result in death or personal injury.***

The system's minimum working pressure is 200 psi (13.8 bar).
Avoid operating the gas storage system below 200 psi (13.8 bar) as this may have an adverse effect on gas system components.

The Quantum virtual pipeline system must NEVER be exposed to a vacuum. If the system experiences a vacuum the gas storage cylinders will be damaged.

Conditions of Use (Cont.)

The system service pressure is indicated on the system label.

The typical VP Lite system working pressure is 3,600 psi (248 bar) at 70°F (21°C) but some systems may operate at pressures up to 5000 psi (350 bar). Consult the VP Trailer system label prior to filling the VP Lite trailer.

The system must never be filled above 125% of the rated service pressure.
The Quantum Virtual Pipeline system must only be filled with the gas indicated on the VP Trailer system label for your specific unit and approved for use by this manual.

Tow Vehicle Requirements

At this time there are no specific requirements for the vehicle being used to pull these trailers.

The tow vehicle must be rated for the capacity of a full trailer which will vary based on the trailer configuration.
It is the operator's responsibility to ensure the vehicle tow ratings are adequate for the full weight of the trailer being towed.

It is recommended that the tow vehicle be equipped with an ABS/ECS system and an electronic trailer brake controller.

Towing Your Trailer Safely

Before connecting the Quantum VP-10' trailer to a vehicle, verify the vehicle is properly equipped and rated to safely tow the VP trailer. Look up the specific model of your Quantum VP trailer in this manual and obtain the total full weight of your specific VP trailer. Verify the vehicle and hitch is capable to safely support the added capacity of your fully loaded VP trailer.

Things to consider are:

- Amount the tow vehicle may weigh when fully loaded, or Gross Vehicle Weight Rating (GVWR).
- Permissible combined weight of the tow vehicle, trailer, passengers, equipment, gas, etc., that the vehicle can handle, or Gross Combination Weight Rating (GCWR).
- Weight a single axle can carry, or Gross Axle Weight Rating (GAWR).

This information can be found in the tow vehicle owner's manual.

Before Each Trip

Perform a safety inspection before each trip. Make sure that:

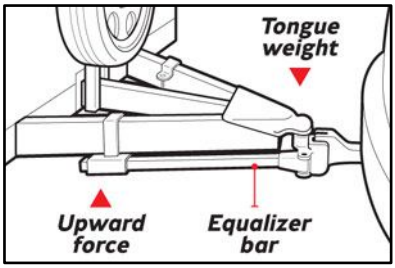
- The pin securing the ball mount to the receiver is intact (if used).
- The ball or pintle being used is properly rated for the weight of the trailer and is in good condition.
- The hitch coupler is secured and locked.
- If using a load equalizing or weight distributing hitch, verify the spring bar hinges are tight and the safety clips are in place.
- The vehicle and trailer are both riding level.
- Safety chains are properly attached.
- The electrical plug is properly installed.
- The emergency breakaway switch is properly connected and functioning.

Trailer Hitch Requirements

The hitch installed on the tow vehicle used to pull the VP-10' trailer shall be rated to accommodate both the total weight and tongue weight of the trailer being connected.

It is ultimately the responsibility of the vehicle operator to ensure the vehicle and towing components being used to pull the VP-10' trailer are properly rated and in good working order to safely pull the VP-10' trailer.

Depending on the vehicle being used, it may be necessary to use a weight or load distributing style trailer hitch to allow for proper tow vehicle axle loading and to ensure both the tow vehicle and trailer ride level.



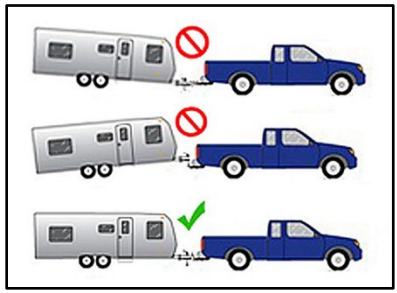
Verify the ball size and capacity of the ball installed on the tow vehicle. The trailer hitch size and the weight rating of the ball is stamped on the top of the ball. Make sure it is adequate for the trailer being pulled.

The weight rating of the ball should be clearly visible on the top of the trailer ball. If not, **do not assume** it is correctly sized and purchase a ball with the proper size and weight rating.

From the factory the trailer comes equipped with a 2 5/16", height adjustable, trailer receiver unless otherwise specified when ordered.

Hitch Height Adjustment

It's important that the loaded trailer be level to the ground when it's attached to the vehicle, and that you trim the trailer's flatness either with an adjustable drawbar or by finding one with the right offset. (If an offset drawbar is used, make sure it's rated to handle the trailer weight.)

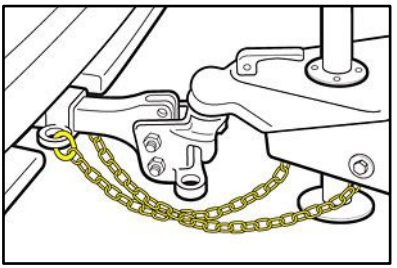


The hitch mounting on the trailer is also adjustable but it is recommended to adjust the drawbar height first if possible.

If the trailer rides level when empty but does not ride level when full you may need to use a weight distributing trailer hitch.

Safety Chains

The safety device or safety chains must be connected to the towed and towing vehicles and to the tow-bar in a manner which prevents the tow-bar from dropping to the ground in the event the coupling fails or becomes disconnected.



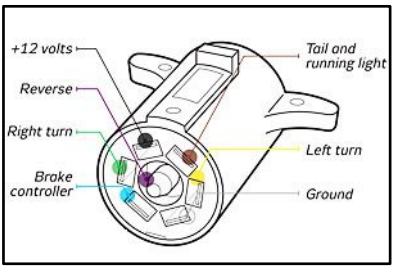
Safety chains or cables, when used as the safety device for that vehicle, may consist of either two chains or cables or a single chain or cable used alone;
A single safety device, including a single chain or cable used alone as the safety device, must be in line with the centerline of the trailer tongue.
When using two safety devices it is recommended to connect them in a crossing pattern as shown to create a cradle. If the coupling were to become disconnected, it will land on top of the crossed chains rather than hitting the pavement. An added benefit of crossing the chains is that the chains won't come up short in tight turns.

Whether using one or two safety devices, the ultimate breaking strength of the safety device must be equal to or greater than the gross weight of the towed vehicle. For additional information refer to §393.70(d). It should be noted that some States may have more stringent requirements for safety chains.

Inspect the safety devices before each use for damage or wear. If any part of the safety device is damaged or worn repair or replace the safety device as needed.

Trailer Electrical Connection

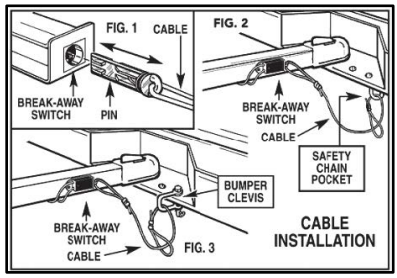
The trailer is equipped with an industry-standard electrical connector.
Connect the trailer plug to the tow vehicles and verify the proper operation of all the trailer lights.



Emergency Break Away Switch

Verify the breakaway switch cable is properly connected to the vehicle.

The breakaway switch cable should be secured to vehicle bumper or frame.
The breakaway switch cable should never hang lower than the safety chains and should not be so tight as to become inadvertently activated.



The breakaway switch cable can be attached many different ways. Two of the most common methods to connect the breakaway switch cable to the vehicle are:

- Pull the pin out of the Break-Away Switch (Fig. 1) and route through safety chain pocket (Fig. 2), then through cable loop and reconnect pin.
- Attach cable loop to a bumper clevis (Fig. 3). DO NOT loop cable over hitch ball, the cable may bounce off while vehicle is moving.

It **IS NOT** recommended to connect the breakaway switch cable to the safety chain hooks, should the safety chain hook become disconnected the emergency breakaway switch will not be activated in an emergency.

IMPORTANT: The plunger pin must be facing the rear of the vehicle directly behind where the cable is secured to the vehicle. Any other alignment may cause breakaway switch failure.

IMPORTANT: When routing the cable do not wrap excess cable around fixed objects or weave the cable through the safety chains. Any cable routing that may result in pinching the cable or preventing the cable from pulling the breakaway switch pin straight out of the breakaway switch in an emergency must be avoided.

Approved Gases

The following gases are approved for use in the Quantum VP trailer systems. Use of any gases not approved for use in these systems may damage the gas storage system components.
The Quantum VP trailers are currently only approved for storage and transport of the gases indicated below. If you would like to use a VP trailer for storage and transport of other gases, contact Quantum Fuel Systems for applicability.

⚠ DANGER ***Use of this system for storing media other than the approved gases indicated in this manual, may damage the cylinders or system components. Use the system for storage of the approved gases only, if there is a question about the proper use of this system, contact Quantum Fuel Systems.***
Failure to follow these instructions will result in death or serious injury.

Trailer design and construction may vary depending on the gas or gas composition being stored. Do not transport any gas not indicated for use in your specific Quantum VP trailer model.

Refer to the part number on the manufacturer's label and the product specifications in this manual to determine what gas your specific unit is approved to carry.

If there is a need to transport an approved gas other than what is identified on the manufacturer's label, contact Quantum Fuel Systems technical assistance.

The Quantum VP trailers are not intended to carry any type of liquid or cryogenically stored media. Compression and storage of any gas or gas mixture that results in a state change from gas to liquid is not approved.

List of Approved Gases

- Gases in Class 2.2 (Canada Only)
- Air, compressed, UN 1002 (U.S. and Canada)
- Argon, compressed, UN 1006 (U.S. and Canada)
- Carbon dioxide, UN 1013 (U.S. and Canada)
- Helium, compressed, UN 1046 (U.S. and Canada)
- Hydrogen, compressed, UN 1049 (U.S. and Canada)
- Krypton, compressed, UN 1056 (U.S. and Canada)
- Nitrogen, compressed, UN 1066 (U.S. and Canada)
- Compressed Gas, Flammable, N.O.S., UN 1954 (Canada Only)
- Compressed Hydrocarbon gas mixture, N.O.S., UN 1964 (Canada Only)
- Methane, compressed; or Compressed Natural Gas (CNG) with high methane content, UN 1971 (U.S. and Canada)

CNG Gas Quality

Quantum strongly recommends the use of CNG that meets the specifications of ISO 15403. These specifications place limits on particulate contamination and moisture content.
CNG that does not meet this specification may contaminate or cause damage to the gas storage system.

For system operating in Canada, the following additional restrictions for CNG quality apply.

Methanol or glycol is not deliberately added to the natural gas and the composition of the natural gas meets one of the following conditions:
(i) for dry gas, the maximum gas contaminant limits apply:
- a) 32 mg/m3 of water vapor,
- b) 23 mg/m3 of hydrogen sulphide, and
- c) 1 % by volume of oxygen, or

(ii) for wet gas, the maximum gas contaminant limits apply:
- a) 23 mg/m3 of hydrogen sulphide and other soluble sulphides,
- b) 115 mg/m3 total Sulphur,
- c) 1 % by volume of oxygen,
- d) 3 % by volume of carbon dioxide, and
- e) 0.1 % by volume of hydrogen

Nitrogen Gas Quality

Use only clean, dry nitrogen in the VP storage system. Any liquid or particulate contamination transported in the gas could cause damage to the system.

All Other Gases

For all other gases, contact Quantum Fuel Systems for guidance regarding your specific application questions.

System Transport Preparation

DANGER ***Do not tow the trailer with cylinder storage valves open. Moving the trailer with the cylinder storage valves open may violate federal, state or local ordinances. Verify the cylinder storage valves are closed before transportation.***
Failure to follow these instructions will result in death or serious injury.

Before and after transporting, the operator should check and verify the condition of the trailer to ensure the trailer is in a proper and safe condition for use or transportation.

Before moving the trailer, complete the following procedure:

- Verify the station hoses are disconnected and properly stowed.
- Verify the earth ground connection has been disconnected.
- Verify the cylinder selection/isolation valves are in the closed position.
- Verify the rear doors on the trailer are fully and securely closed.
- Verify the container locks are still in place and secure
- After connection to the tow vehicle, verify the wheel chalk blocks have been removed.
- Walk around the trailer and inspect for any obvious physical damage.
- Verify you have the proper local permits for the route the trailer will travel.
- Verify a current copy of the Special Permit and Equivalency Certificate are present on the trailer and or in the vehicle AND at the facility where the trailer is offered for transport.

Trailer Transport

In the U.S. the Quantum VP trailer is approved for over the road transport, rail car transport and cargo ship transportation where regulations allow.
In Canada the Quantum VP trailer is only approved for over the road transport.

The restrictions noted below may not be all inclusive, before transporting your VP trailer, consult the carrier regarding any special considerations that may arise from the shipping method used.

If the trailer is charged with flammable gas it should NEVER be covered for any reason. Covering the trailer will inhibit system ventilation and may allow for the accumulation of a flammable mixture inside the container.

The Quantum VP trailer may be transported as cargo, but the following special provisions apply:

- Transportation of Division 2.1 (flammable gas) is not authorized aboard cargo vessel unless specifically authorized in the Hazardous Materials Table (§ 172.101).

- When transported by cargo vessel, the cylinders must be stowed on deck only and are prohibited from passenger ships (Stowage Category D).

- If being transported by rail certain restrictions may apply, the VP trailer or containment may be damaged by the shock loads encountered during rail transport.

If transporting the VP trailer or containment by rail car or cargo ship, please contact Quantum prior to transportation for any needed assistance. Contact Quantum technical assistance at 800.816.8691.

Special Container Chassis

The chassis supplied with the containment is specially designed for use with the equipment packaged in the containment. It is not recommended that the containment be separated from the chassis for transportation unless the containment is empty and purged of all flammable gasses and an equivalent chassis is available at the containment destination.

Stacking

DANGER ***Once filled with gas, never stack this container on top of other containers and do not stack other containers on top of this system. Any restriction of system ventilation through the top or bottom of the containment will affect operation of the fire protection systems. Failure to follow these instructions will result in death or serious injury.***

For U.S. transportation, when new and not pressurized, the container may be stacked within the labeled limitations without concern.
Once the trailer has been charged with gas, it cannot be stacked. Stacking another container on top of this system will inhibit ventilation of the system and will affect operation of the fire protection systems.

For Canadian transportation stacking or lifting of this container is prohibited.

Lifting

The Quantum VP trailer can be lifted like a conventional cargo container by using the anchor points at the top corners of the container. This container also has provisions to allow for lifting from the bottom using a forklift. You MUST use fork extensions that are long enough to go completely through the container.

DANGER ***Using a short fork will cause damage to the bottom of the container and possibly the cylinders within the container. Verify the forks go completely through the container before lifting. Failure to follow these instructions will result in death or serious injury.***

Shipping

The Quantum VP trailer assembly may be transported in the US as an assembly by rail car, consult the rail carrier for any special regulations that may apply.

It is not recommended that the container assembly alone be shipped by rail unless the system is empty and all the precautions outlined in this manual are observed.

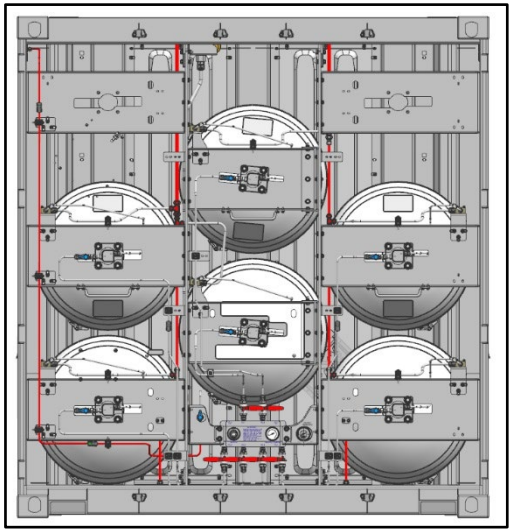
The Quantum VP Trailer is not approved for rail car shipment in Canada.

Trailer Parking Guidelines

The system should never be parked under a canopy or any type of cover that can accumulate and trap escaping gases. Additionally, any lighting in the immediate area that is higher than the trailer should be explosion proof lighting fixtures.

Never cover the trailer with any kind of tarp or breathable cloth cover. If the cover inhibits the escape of any gases present in the trailer, then a combustible mixture may be created. Even if the cover is easily permeable, the presence of the cover will change the movement of air and escaping gases in and around the trailer.

The trailer is equipped with multiple pressure relief devices. The majority of these devices will only discharge gas in the event of an emergency. However, there is also a discharge pipe located at the rear of the trailer that is used to vent and drain gas during system usage.



When positioning the trailer, you must verify that these pressure discharge pipes have a clear, unobstructed discharge path. See the illustration for the location of these discharge pipes.

After positioning the trailer for loading or unloading, the wheels must be chocked.

Trailer Hazard Classification

The standard Quantum VP Trailer does not have electrical devices or ignition sources, in addition it is a portable gas storage and transportation system and is not intended to be used in a permanent installation capacity. The Quantum VP Trailer does not fall under any typical zoning or classified area definitions for permanent installations.
The following information is developed using NFPA 52-23 as a guide and is provided as guidance only for site loading and unloading considerations.

- The area adjacent to the VP Trailer loading and unloading point should be treated as a Class 1, Division 2, Zone 1, area with a 5' (1.5m) radius.

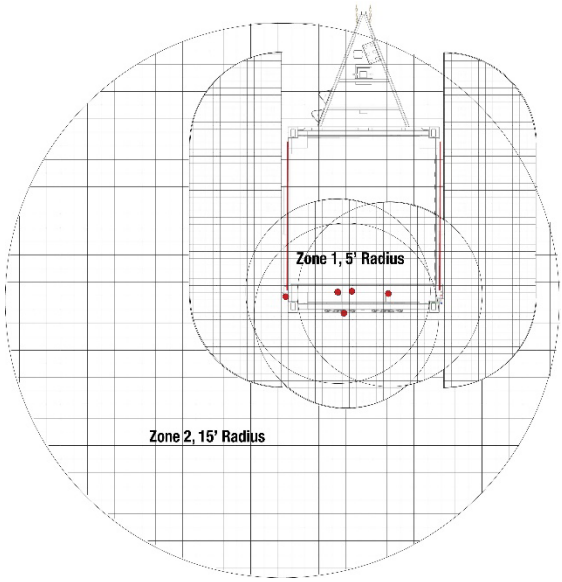
- The area adjacent to the VP Trailer containment vents should be treated as a Class 1, Division 2, Zone 1, area with a 5' (1.5m) radius.

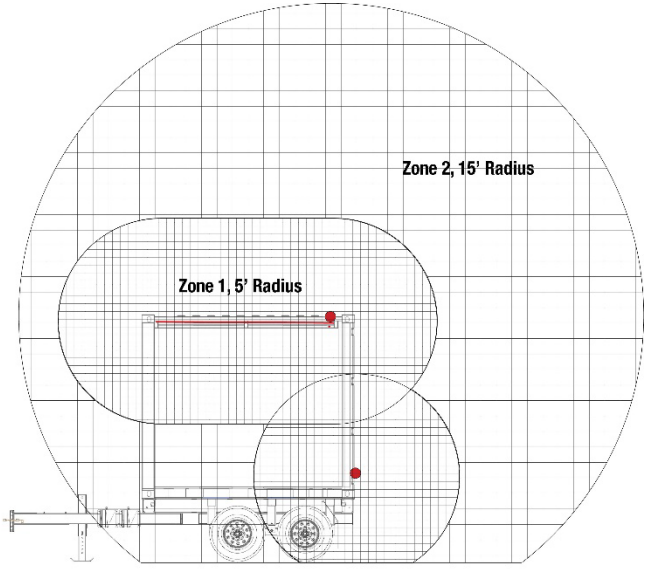
- The area adjacent to the VP Trailer vent, PRD and PRV discharge points should be treated as a Class 1, Division 2, Zone 1, area with a 5' (1.5m) radius.
  AND
  Class 1, Division 2, Zone 2, area with a 15' (4.5m) radius due to the presence of explosive or flammable gases for some of the time during normal operating conditions.

- The entire area inside the VP Trailer containment as well as the roof should be treated as a Class 1, Division 2, Zone 2, area with a 10' (3.0m) radius.

- Group B: if Hydrogen
  Group D: if CNG

Trailer Hazard Classification (Cont)





Trailer Parking

Failure to follow the trailer parking procedure below may result in damage to one or more components in the VP trailer system.

1. Verify there is adequate room to open the doors in the final parked position.

2. Verify the trailer is not parked under a canopy and that there are no electrical devices overhead.

3. Chock the wheels.

4. Disconnect the trailer electrical connection and breakaway switch, and then lower the trailer landing gear.

5. Disconnect the safety chains and unhitch the trailer from the vehicle.

IMPORTANT: NEVER LEAVE A VEHICLE CONNECTED TO THE TRAILER WHEN IN USE.
IF THE VEHICLE MUST REMAIN CONNECTED FOR SAFETY REASONS, SUCH AS PARKING ON AN INCLINE, IT IS STRONGLY RECOMMENDED TO LOCK OUT OR TAG OUT THE VEHICLE SO IT CANNOT BE DRIVEN AWAY INADVERTENTLY.

Parking in Severe Weather

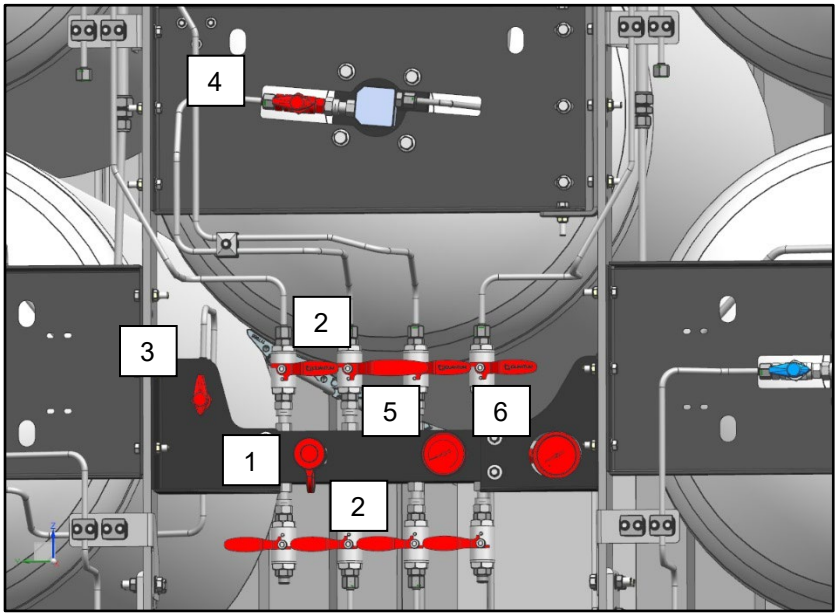
High wind events

Quantum VP trailers can withstand up to 150 mile per hour sustained wind speeds when parked and full, empty or partially filled trailers may tip at lower wind speeds.
When securing a trailer for a strong wind event, it is recommended that the VP trailer be parked as closely as possible to another trailer or next to a wall that is strong enough to withstand the wind event.

Ice storms or heavy snow accumulations

All the cylinder PRD vents discharge through the top of the trailer, any heavy snow or ice accumulation on top of the trailer may impede the ability of these vent devices to operate properly.
It is recommended to remove any heavy ice or snow accumulations from the top of the VP trailer as soon as it is safe.

Component Locator VP Lite



1	Load/Unload coupling
2	Cylinder selection/isolation valves
3	Blow down valve
4	Service manual shut off valves
5	Manifold pressure gauge
6	Manifold temperature gauge

Initial Pressurization or Repressurization of the Trailer

The following procedure must be followed when initially pressurizing or repressurizing the trailer when the system is empty (at atmospheric pressure) for any reason.

⚠CAUTION

Failure to follow the initial pressurization instructions may irreversibly damage the gas storage cylinder, leading to gas leakage. Gas leakage may result in personal injury or damage to the vehicle.

NOTICE

When a cylinder is initially pressurized from empty, a quantity of AIR (not fuel) is compressed out from between the liner and composite shell. This may cause bubbling around the surface of the shell and/or the end bosses during leak tests. This is a normal condition; most of the bubbling should subside typically within 30-60 minutes. The larger the cylinder the longer this process may take.
If the pressure is unchanged and the bubbling has been reduced or has completely subsided, this is considered to have been either the expulsion of entrapped air or normal permeation.

If the cylinder has been in use and has been vented for a service procedure, there will be gas between the liner and the cylinder shell instead of air or purge gases. When the cylinder is pressurized after repairs, whatever gases are present will be expelled; it is not uncommon to trigger a gas detector under these conditions.

Even after the cylinder has been in service for a period of time there may be a presence of bubbles randomly on the cylinder surface or around the cylinder bosses. This permeation is considered normal, contact Quantum if you have any questions.

You may also observe some cracking or popping sounds coming from the cylinder during the initial pressurization. If the liner has settled away from the shell during shipping, some cracking or popping noises may be heard during the initial fill; you may also be hearing the shell of the cylinder settling as it is pressurized. If there is no damage to the cylinder, and no gas leakage is observed, there should be no concern pressurizing the cylinder.

The recommended steps for initial pressurization are:

1. Inspect the system to ensure no physical damage has occurred to the system during transport. If this procedure is being performed after servicing, verify all serviced components and connections have been properly connected.

2. Following the steps outlined in the *System Loading* section of this manual, fill the system until the pressure is approximately 430 psig (30 bar) while listening for gross leakage.

3. If service work was just performed, test all connections and interfaces that were disturbed with a liquid leak test fluid. If bubbles are found, repair any leak(s) found before proceeding.

   If this is an initial system fill, observe the system pressure over a short period of time, any pressure drop may indicate the presence of a leak. If a leak is suspected, inspect the system using a liquid leak detection fluid and repair any leaks found before proceeding.

4. Once it is determined no leaks are present in the system, continue filling the system to its rated service pressure.
   Note: It is normal to see a decrease in system pressure after filling due to the gas cooling. The amount of pressure decrease will vary based on initial gas temperatures, ambient temperatures and fill rate.

System Loading

⚠CAUTION

If pressure in the gas storage cylinders falls below 200 psi (13.8 bar) and the ambient temperature is above 10°F (-12°C), the system can be filled normally.

If pressure in the gas storage cylinders falls below 200 psi (13.8 bar) and ambient temperature is below 10°F (-12°C), the operator must either:

- ***Allow the cylinder(s) to warm up to >61°F (16°C) and remain at that temperature for 8 hours. Once the cylinders have warmed up, the system can be filled normally.***

OR

- ***SLOWLY fill the system to approximately 450 psi (31 bar) and leave at this pressure level for approximately 1 hour to normalize the cylinder liners. After 1 hour the system can be filled normally.***

Failure to observe these cautions could result in minor or moderate injury and/or damage.

The following instructions are written assuming industry standard practices and connection devices are being used. It is strongly recommended that any operator loading or unloading the system be properly trained on the specific station equipment being used.

Loading Procedure VP 10

1. Connect earth ground to trailer.
2. Verify the BLUE blow down valve is in the OFF position.
3. Inspect the load/unload coupling for damage or wear and verify the seal is in place and in good condition, verify no debris is present in either side of the coupling.
4. Connect the gas transfer hose to trailer load/unload coupling.
5. Turn the RED cylinder selection/isolation valves to the open position.
6. Begin transferring gas into the trailer.
7. Monitor the system temperatures and pressures during the loading procedure, the gas transfer should be immediately aborted if:

- System pressure exceeds maximum system pressure.
- System temperatures exceed 180°F (82°C)
- Maximum system mass has been reached based on the fill pressure/temperature chart located on the door of the trailer.

8. Once the trailer is full, stop the gas transfer at the station.
9. Turn the RED cylinder selection/isolation valves to the closed position.
10. Turn the BLUE blow down valve to the VENT position and wait until the manifold is completely vented.
11. Disconnect the gas transfer hose.
12. Turn the BLUE blow down valve to the OFF position.
13. Disconnect the earth ground from the trailer.

Loading Pressure Relief Valve

The system is protected by a pressure relief valve on the loading side of the system. In the event the system pressure exceeds the set pressure, the pressure relief valve will activate and vent the excess pressure to atmosphere.
This valve is designed to protect the Quantum VP trailer storage system up to the published load flow rates. Exceeding these flow rates may create back pressure in the load pipes higher than the pressure being seen in the cylinders and cause premature activation of this valve.

The PRV set pressures are:

- VP Lite, 4,900 psi (338 bar) for 3,600 psi (248 bar) systems.
- VP Lite, 6,250 psi (431 bar) for 5,000 psi (350 bar) systems.

IMPORTANT: The pressure relief valve may not be able to vent at the flow rate that can be achieved during the loading process as this flow rate is determined by the loading station.

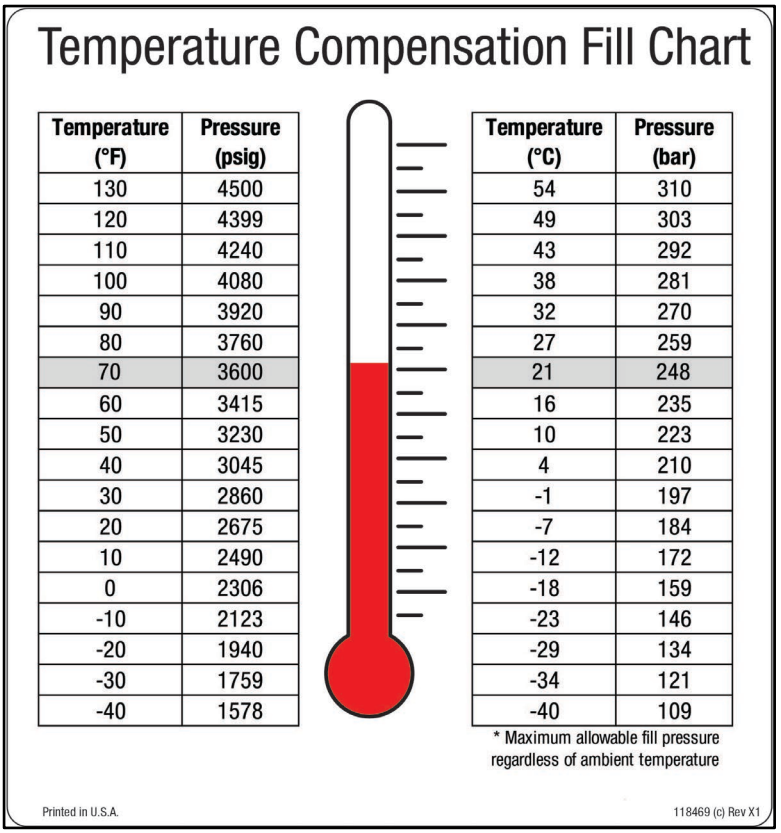
If the pressure relief is actively venting, the gas transfer must be stopped immediately. Even with the pressure relief device activated, the pressure in the gas storage system may continue to rise.

⚠DANGER ***Never leave the system unattended during loading. If the pressure relief is activated during the loading process the loading procedure must be stopped immediately. Failure to follow these instructions will result in death or serious injury.***

Temperature Compensated Loading

Use the tables below to help calculate the final temperatures and pressure you should see when the trailer is full. It is strongly recommended not to exceed the pressures associated to gas temperatures when filling the trailer.

VP Lite Temperature Compensation Chart



Temperature Compensation Fill Chart

Temperature (°F)	Pressure (psig)
130	4500
120	4399
110	4240
100	4080
90	3920
80	3760
70	3600
60	3415
50	3230
40	3045
30	2860
20	2675
10	2490
0	2306
-10	2123
-20	1940
-30	1759
-40	1578

Temperature (°C)	Pressure (bar)
54	310
49	303
43	292
38	281
32	270
27	259
21	248
16	235
10	223
4	210
-1	197
-7	184
-12	172
-18	159
-23	146
-29	134
-34	121
-40	109

* Maximum allowable fill pressure regardless of ambient temperature

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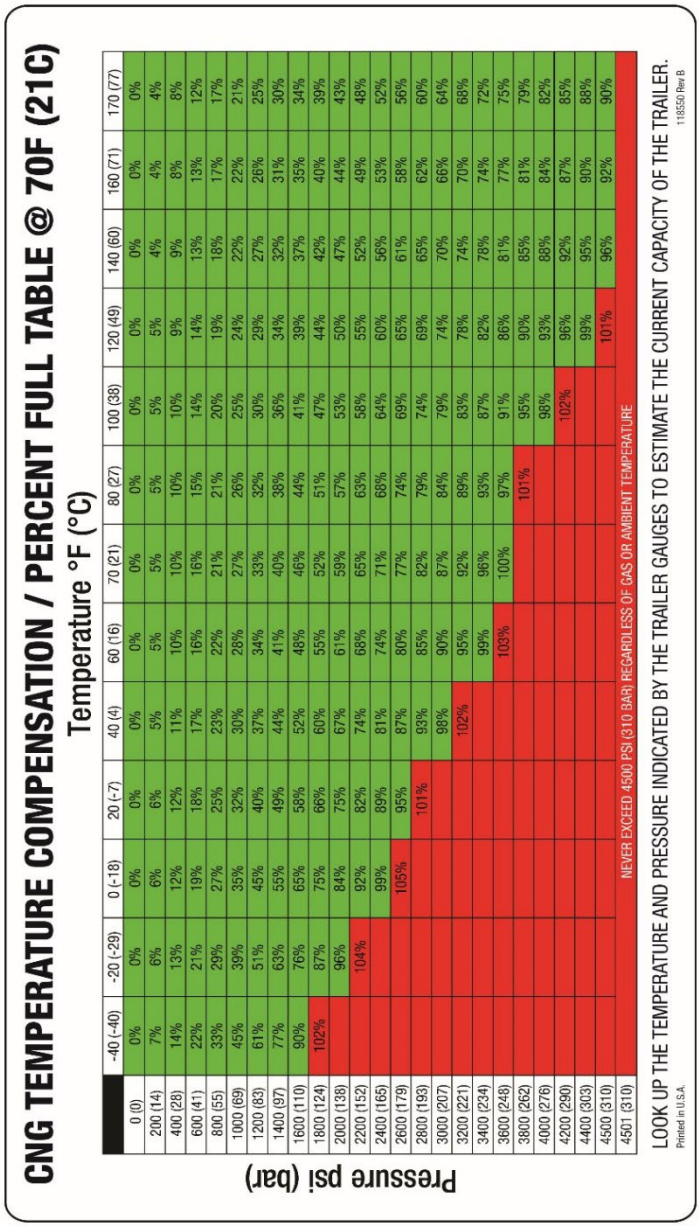
118469 (c) Rev X1

VP Lite Percent Full Table (3600 psi @ 70°F)



CNG TEMPERATURE COMPENSATION / PERCENT FULL TABLE @ 70F (21C)

Temperature °F (°C)

Pressure psi (bar)

	-40 (-40)	-20 (-29)	0 (-18)	20 (-7)	40 (4)	60 (16)	70 (21)	80 (27)	100 (38)	120 (49)	140 (60)	160 (71)	170 (77)
0 (0)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
200 (14)	7%	6%	6%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%
400 (28)	14%	13%	12%	12%	11%	10%	10%	10%	10%	9%	9%	8%	8%
600 (41)	22%	21%	19%	18%	17%	16%	16%	15%	14%	14%	13%	13%	12%
800 (55)	33%	29%	27%	25%	23%	22%	21%	21%	20%	19%	18%	17%	17%
1000 (69)	45%	39%	35%	32%	30%	28%	27%	26%	25%	24%	22%	22%	21%
1200 (83)	61%	51%	45%	40%	37%	34%	33%	32%	30%	29%	27%	26%	25%
1400 (97)	77%	63%	55%	49%	44%	41%	40%	38%	36%	34%	32%	31%	30%
1600 (110)	90%	76%	65%	58%	52%	48%	46%	44%	41%	39%	37%	35%	34%
1800 (124)	102%	87%	75%	66%	60%	55%	52%	51%	47%	44%	42%	40%	39%
2000 (138)		96%	84%	75%	67%	61%	59%	57%	53%	50%	47%	44%	43%
2200 (152)		104%	92%	82%	74%	68%	65%	63%	58%	55%	52%	49%	48%
2400 (165)			99%	89%	81%	74%	71%	68%	64%	60%	56%	53%	52%
2600 (179)			105%	95%	87%	80%	77%	74%	69%	65%	61%	58%	56%
2800 (193)				101%	93%	85%	82%	79%	74%	69%	65%	62%	60%
3000 (207)					98%	90%	87%	84%	79%	74%	70%	66%	64%
3200 (221)					102%	95%	92%	89%	83%	78%	74%	70%	68%
3400 (234)						99%	96%	93%	87%	82%	78%	74%	72%
3600 (248)						103%	100%	97%	91%	86%	81%	77%	75%
3800 (262)								101%	95%	90%	85%	81%	79%
4000 (276)									98%	93%	88%	84%	82%
4200 (290)									102%	96%	92%	87%	85%
4400 (303)										99%	95%	90%	88%
4500 (310)										101%	96%	92%	90%
4501 (310)	NEVER EXCEED 4500 PSI (310 BAR) REGARDLESS OF GAS OR AMBIENT TEMPERATURE												

LOOK UP THE TEMPERATURE AND PRESSURE INDICATED BY THE TRAILER GAUGES TO ESTIMATE THE CURRENT CAPACITY OF THE TRAILER.

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H2 TEMPERATURE COMPENSATION / PERCENT FULL TABLE @ 70F (21C)

Temperature °F (°C)

Pressure psi (bar)

	-40 (-40)	-20 (-29)	0 (-18)	20 (-7)	40 (4)	60 (16)	70 (21)	80 (27)	100 (38)	120 (49)	140 (60)	160 (71)	170 (77)
0 (0)	0	0	0	0	0	0	0	0	0	0	0	0	0
200 (14)	6%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%
400 (28)	17%	16%	16%	15%	14%	14%	14%	13%	13%	12%	12%	12%	11%
600 (41)	23%	22%	21%	20%	19%	18%	18%	18%	17%	17%	16%	15%	15%
800 (55)	34%	32%	31%	29%	28%	27%	27%	26%	25%	25%	24%	23%	23%
1000 (69)	39%	37%	36%	34%	33%	32%	31%	30%	29%	28%	28%	27%	26%
1200 (83)	44%	42%	41%	38%	37%	36%	35%	35%	33%	32%	31%	30%	30%
1400 (97)	55%	52%	50%	47%	46%	45%	44%	43%	41%	40%	39%	38%	37%
1600 (110)	60%	57%	55%	52%	51%	49%	48%	47%	45%	44%	42%	41%	40%
1800 (124)	65%	62%	59%	56%	55%	53%	52%	51%	49%	47%	46%	45%	44%
2000 (138)	74%	71%	68%	65%	63%	61%	60%	59%	57%	55%	53%	51%	51%
2200 (152)	79%	76%	73%	69%	67%	65%	64%	62%	60%	58%	57%	55%	54%
2400 (165)	88%	85%	81%	77%	75%	73%	71%	70%	68%	65%	63%	62%	61%
2600 (179)	93%	89%	85%	81%	79%	76%	75%	74%	71%	69%	67%	65%	64%
2800 (193)	97%	94%	90%	85%	83%	80%	79%	77%	75%	72%	70%	68%	67%
3000 (207)	106%	102%	98%	93%	91%	88%	86%	84%	82%	79%	77%	74%	73%
3200 (221)			102%	97%	94%	91%	90%	88%	85%	82%	80%	78%	76%
3400 (234)				100%	98%	95%	93%	91%	88%	86%	83%	81%	80%
3600 (248)					105%	102%	100%	98%	95%	92%	89%	87%	86%
3800 (262)								102%	98%	95%	93%	90%	89%
4000 (276)									105%	102%	99%	96%	94%
4200 (290)											102%	99%	97%
4400 (303)												102%	100%
4500 (310)													
4501 (310)	NEVER EXCEED 4500 PSI (310 BAR) REGARDLESS OF GAS OR AMBIENT TEMPERATURE												

LOOK UP THE TEMPERATURE AND PRESSURE INDICATED BY THE TRAILER GAUGES TO ESTIMATE THE CURRENT CAPACITY OF THE TRAILER.

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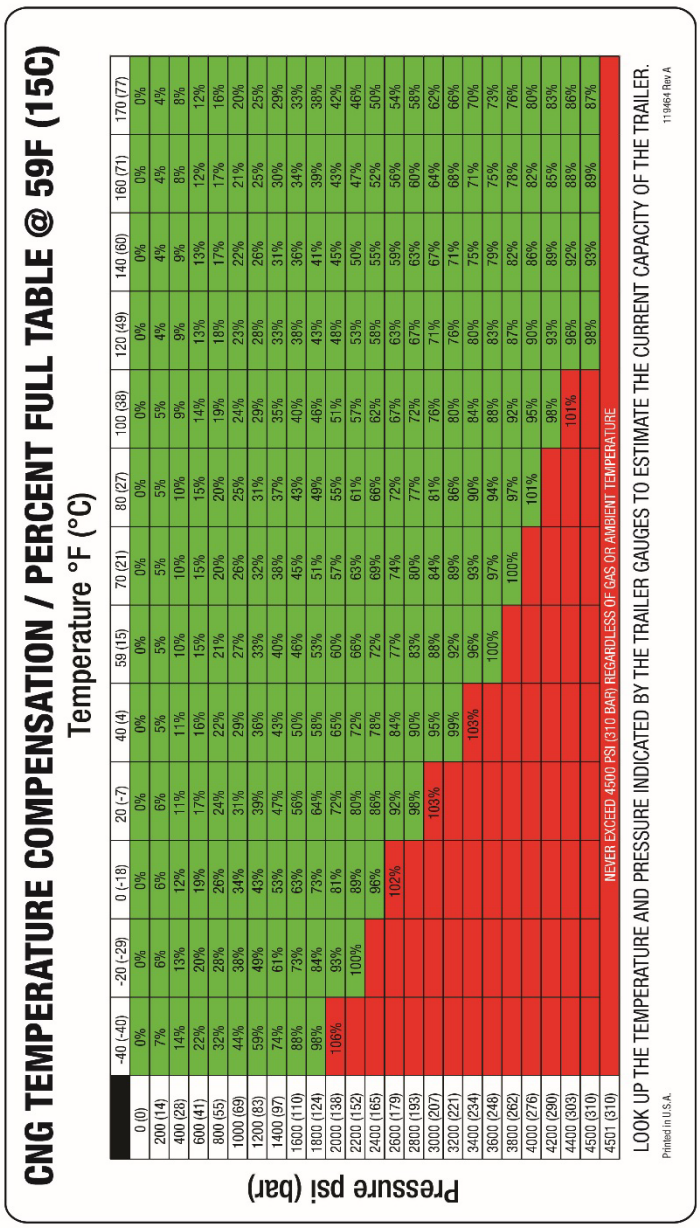
121233 Rev A

VP Lite Percent Full Table (3600 psi @ 59°F)



CNG TEMPERATURE COMPENSATION / PERCENT FULL TABLE @ 59F (15C)

Temperature °F (°C)

Pressure psi (bar)

	-40 (-40)	-20 (-29)	0 (-18)	20 (-7)	40 (4)	59 (15)	70 (21)	80 (27)	100 (38)	120 (49)	140 (60)	160 (71)	170 (77)
0 (0)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
200 (14)	7%	6%	6%	6%	5%	5%	5%	5%	5%	4%	4%	4%	4%
400 (28)	14%	13%	12%	11%	11%	10%	10%	10%	9%	9%	9%	8%	8%
600 (41)	22%	20%	19%	17%	16%	15%	15%	15%	14%	13%	13%	12%	12%
800 (55)	32%	28%	26%	24%	22%	21%	20%	20%	19%	18%	17%	17%	16%
1000 (69)	44%	38%	34%	31%	29%	27%	26%	25%	24%	23%	22%	21%	20%
1200 (83)	59%	49%	43%	39%	36%	33%	32%	31%	29%	28%	26%	25%	25%
1400 (97)	74%	61%	53%	47%	43%	40%	38%	37%	35%	33%	31%	30%	29%
1600 (110)	88%	73%	63%	56%	50%	46%	45%	43%	40%	38%	36%	34%	33%
1800 (124)	98%	84%	73%	64%	58%	53%	51%	49%	46%	43%	41%	39%	38%
2000 (138)	106%	93%	81%	72%	65%	60%	57%	55%	51%	48%	45%	43%	42%
2200 (152)		100%	89%	80%	72%	66%	63%	61%	57%	53%	50%	47%	46%
2400 (165)			96%	86%	78%	72%	69%	66%	62%	58%	55%	52%	50%
2600 (179)			102%	92%	84%	77%	74%	72%	67%	63%	59%	56%	54%
2800 (193)				98%	90%	83%	80%	77%	72%	67%	63%	60%	58%
3000 (207)				103%	95%	88%	84%	81%	76%	71%	67%	64%	62%
3200 (221)					99%	92%	89%	86%	80%	76%	71%	68%	66%
3400 (234)					103%	96%	93%	90%	84%	80%	75%	71%	70%
3600 (248)						100%	97%	94%	88%	83%	79%	75%	73%
3800 (262)							100%	97%	92%	87%	82%	78%	76%
4000 (276)								101%	95%	90%	86%	82%	80%
4200 (290)									98%	93%	89%	85%	83%
4400 (303)									101%	96%	92%	88%	86%
4500 (310)										98%	93%	89%	87%
4501 (310)	NEVER EXCEED 4500 PSI (310 BAR) REGARDLESS OF GAS OR AMBIENT TEMPERATURE												

LOOK UP THE TEMPERATURE AND PRESSURE INDICATED BY THE TRAILER GAUGES TO ESTIMATE THE CURRENT CAPACITY OF THE TRAILER.

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H2 TEMPERATURE COMPENSATION / PERCENT FULL TABLE @ 59F (15C)

Temperature °F (°C)

Pressure psi (bar)

	-40 (-40)	-20 (-29)	0 (-18)	20 (-7)	40 (4)	59 (15)	70 (21)	80 (27)	100 (38)	120 (49)	140 (60)	160 (71)	170 (77)
0 (0)	0	0	0	0	0	0	0	0	0	0	0	0	0
200 (14)	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	4%
400 (28)	17%	16%	15%	15%	14%	14%	13%	13%	13%	12%	12%	11%	11%
600 (41)	22%	21%	20%	19%	19%	18%	18%	17%	17%	16%	16%	15%	15%
800 (55)	33%	32%	30%	29%	28%	27%	26%	26%	26%	24%	23%	23%	22%
1000 (69)	38%	37%	35%	33%	32%	31%	31%	30%	30%	28%	27%	26%	26%
1200 (83)	43%	42%	40%	38%	37%	35%	35%	34%	34%	32%	31%	30%	29%
1400 (97)	54%	51%	49%	47%	45%	44%	43%	42%	42%	39%	38%	37%	36%
1600 (110)	59%	56%	54%	51%	50%	48%	47%	46%	46%	43%	42%	40%	40%
1800 (124)	63%	61%	58%	55%	54%	52%	51%	50%	49%	47%	45%	44%	43%
2000 (138)	73%	70%	67%	64%	62%	60%	59%	57%	57%	54%	52%	51%	50%
2200 (152)	78%	74%	71%	68%	66%	64%	62%	61%	61%	57%	56%	54%	53%
2400 (165)	87%	83%	80%	76%	74%	71%	70%	69%	68%	64%	62%	60%	59%
2600 (179)	91%	87%	84%	80%	78%	75%	74%	72%	72%	68%	66%	64%	63%
2800 (193)	96%	92%	88%	84%	82%	79%	77%	76%	75%	71%	69%	67%	66%
3000 (207)	104%	100%	96%	91%	89%	86%	84%	83%	82%	78%	75%	73%	72%
3200 (221)			100%	95%	93%	90%	88%	86%	86%	81%	79%	76%	75%
3400 (234)				99%	96%	93%	91%	90%	89%	84%	82%	79%	78%
3600 (248)				106%	104%	100%	98%	96%	96%	91%	88%	85%	84%
3800 (262)							102%	100%	99%	94%	91%	88%	87%
4000 (276)									105%	100%	97%	94%	93%
4200 (290)											100%	97%	96%
4400 (303)												100%	98%
4500 (310)													101%
4501 (310)	NEVER EXCEED 4500 PSI (310 BAR) REGARDLESS OF GAS OR AMBIENT TEMPERATURE												

LOOK UP THE TEMPERATURE AND PRESSURE INDICATED BY THE TRAILER GAUGES TO ESTIMATE THE CURRENT CAPACITY OF THE TRAILER.

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121234 Rev A

Loading Problems

If the system cannot be refueled, check for the following:

- Gas transfer hoses may not be properly engaged on the loading couplings.
  - Verify couplings are fully engaged.
- System is already full.
  - Verify the gas level in the cylinders using the instrument panel.
- Cylinder manual shut off valves may be closed.
  - Open the cylinder manual shut off valves.
- Cylinder selection valves may be closed.
  - Open the cylinder selection valves.

If the items above have been checked and the system still will not receive gas, the system may require service. Contact your fleet administrator or your local repair facility.

If at any time during the refueling process it is suspected that the gas may be leaking, immediately stop the loading process and contact your local repair facility.

System Unloading

Before unloading the trailer, ensure the trailer is parked and positioned following the guidelines described in *Trailer Parking Guidelines* contained in this manual

Unloading Procedure

1. Connect earth ground to trailer.
2. Verify the BLUE blow down valve is in the OFF position.
3. Inspect the load/unload coupling for damage or wear and verify the seal is in place and in good condition, verify no debris is present in either side of the coupling.
4. Connect gas transfer hose to trailer load/unload coupling.
5. Verify the station is ready to receive gas.
6. Turn the RED cylinder selection/isolation valve(s) to the open position.
7. The manifold pressure gauge will indicate the gas pressure present in cylinder(s) the trailer.

   ⚠WARNING ***This system must never be used in vacuum service. Do not continue unloading under 200 psi (13.8 bar). Failure to follow this instruction could result in death or personal injury.***

8. Monitor the system temperatures and pressures during the unloading procedure, the fill must be immediately aborted if:
   - System pressure drops below 200 psi (14 bar)
   - System temperatures drop below -70°F (-57°C)
9. Once the trailer pressure has reached 200 psi (14 bar), stop the gas transfer at the station.
10. Turn the RED cylinder selection/isolation valve(s) to the closed position.

Unloading Procedure (Cont)

11. Turn the BLUE blow down valve to the VENT position.
12. Disconnect the gas transfer hose.
13. Turn the BLUE blow down valve to the OFF position.
14. Disconnect the earth ground from the trailer.

Purging the System

The purge process dilutes the contents of the system or specific cylinder to a level that significantly limits the potential flammability range of any gases present.

Purging the complete system or a selected cylinder is an important step that should be performed before a cylinder is filled and or any time the cylinder has been open to atmosphere.

System or cylinder purging should also be performed to dilute the gas concentrations within the system or individual cylinder any time the system or a cylinder has been drained and will require service or intermodal shipping.

⚠WARNING ***Do not allow atmosphere to enter the gas storage system or cylinder during purging. The gas storage cylinder pressure should remain higher than atmospheric pressure during the purging process. Introduction of atmosphere (oxygen) in the cylinder may create a combustible mixture that if ignited, may result in death or serious injury.***

If the *Initial Pressurization or Repressurization of the Trailer* procedure defined in this manual has been previously performed, and the system or cylinder(s) were not opened to atmosphere after the initial purge and pressurization, an additional system or cylinder purge using this procedure should not be necessary.

If only selected cylinder(s) require a purge, close the manual shut off valves on all the cylinders that will not be purged.
If the complete system requires a purge, ensure all the manual shut off valves are open.
Once the system has been configured to purge the selected areas of the system, follow the procedure below.

The following procedure outlines are intended to reduce the oxygen level system and other atmospheric gases to a point to reduce the potential for a flammable mixture to be present inside the system during the first fill with a flammable gas.

If a purge is being completed to ensure gas purity levels, the pressure levels and number of cycles will need to be adjusted until the desired sample dilution in the system is achieved.

Purging the System (Cont)

For CNG systems the following procedure is recommended as a minimum requirement for purging.

Important: *This procedure will not lower the atmospheric gas concentrations within a system designed for hydrogen use to safe levels.*

1. Fill the portion of the system to be purged with an appropriate purge gas compatible with the gas being stored.
   Fill to a pressure greater than 150 psi (10.3 bar).

2. Vent the purge gas from the system until the remaining pressure is approximately 25 psi ± 5 psi (1.7 bar ± 0.35 bar).

⚠CAUTION ***The system must be filled to greater than 40 psi (2.8 bar) on the initial cylinder fill with gas. Not filling the cylinder to 40 psi (2.8 bar) may result in a flammable mixture within the cylinder. Failure to follow these instructions may result in personal injury and or system damage.***

3. You may now fill the system with the approved gas to service pressure, following the *Initial Pressurization or Repressurization of the Trailer* procedure as well as any applicable codes.

   Fill the system with gas to greater than 40 psi (2.8 bar) on the initial fill to dilute any remaining oxygen in the system beyond the flammability range.

Purging the System (Cont)

For hydrogen systems the following procedure is recommended as a minimum requirement for purging prior to use.

1. Fill the portion of the system to be purged with an appropriate purge gas compatible with the gas being stored.
   Fill to a pressure greater than 1100 psi (76 bar).

2. Vent the purge gas from the system until the remaining pressure is approximately 25 psi ± 5 psi (1.7 bar ± 0.35 bar).

3. Fill the portion of the system to be purged with an appropriate purge gas compatible with the gas being stored for a second purge cycle.
   Fill to a pressure greater than 1100 psi (76 bar).

4. Vent the purge gas from the system until the remaining pressure is approximately 25 psi ± 5 psi (1.7 bar ± 0.35 bar).

5. You may now fill the system with the approved gas to service pressure, following the Initial Pressurization or Repressurization of the Trailer procedure as well as any applicable codes.

Roadside Emergency

For additional information regarding emergency response procedures refer to the First Responders Guide available at http://www.qtww.com/service/product-documentation/

In The Event of a Gas System Leak

⚠WARNING

Some approved gases are extremely flammable. If something ignites it, you could be severely burned and cause injury or damage. Keep sparks, flames, and ignition sources a minimum of 16 Feet (5 meters) from the trailer.

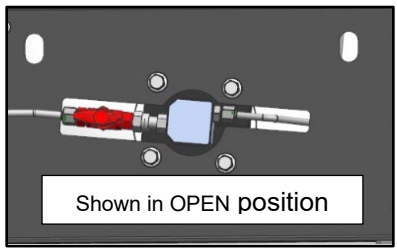
Steps:

1. Make sure there are no ignition sources near the gas cylinder.

2. If safe, ensure all the cylinder selection/isolation valves are closed.

3. If the leak persists, remove the cylinder inspection covers with a brisk pull and close the service manual shut off valves under the covers.

4. If the leak continues, move a safe distance from the vehicle, call your local service provider and have the trailer serviced.



In The Event of an Accident

If the trailer is involved in any type of accident, vehicle collision, experiences a drive away, roll over, an uncontrolled release of product that creates a hazard, or is exposed to severe weather of any kind, must be removed from service until a complete and thorough inspection can be completed by a qualified inspector.

For trailers operating in Canada that have been involved in a vehicle collision and removed from service, the trailer must be inspected for damage and determined to be in good working order by the equivalency certificate holder (Quantum Fuel Systems) before being returned to service.

For units operating in the U.S. under the DOT special permit SP-16524, no cylinder is permitted to be returned to service after a collision or crash.

For purposes of the DOT special permit, Quantum defines "collision/crash" as it relates to this clause in the special permit as follows:

- Any incident that has created a condition that results in a direct impact to any cylinder is considered a collision/crash.

- Any incident that has created a condition that has caused damage to a cylinder that results in a loss of cylinder containment.

- Even if no direct impact has occurred to any cylinder, Quantum must be supplied sufficient information to evaluate the stresses and loads that may have been applied to the cylinders after any type of collision, impact or incident. Cylinder condition and status will be evaluated by Quantum on a case-by-case basis as justified by the supplied information.

Additionally, any event similar to those described above shall be reported to the grantee of the special permit (Quantum) in writing to QTService@qtww.com before the unit is returned to service.
If required, any information supplied to Quantum may be supplied to PHMSA to satisfy Quantum's reporting requirements under the special permit.

In The Event of an Accident (Cont)

Reporting

For units operating in the U.S., any information submitted to Quantum regarding this event will in turn be submitted to specialpermits@dot.gov to satisfy Quantum's DOT reporting requirements as defined by the DOT special permit.

For units operating in Canada, any information submitted to Quantum regarding this event will be submitted to the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada to satisfy Quantum's Transport Canada's reporting requirements as defined by the equivalency certificate.

For units operating in other countries or jurisdictions not specifically addressed in this manual, Quantum will report any incidents as required by the Authority Having Jurisdiction (AHJ) as required by any local or national requirements.

IMPORTANT

The information supplied to Quantum and or the act of reporting the event to Quantum by the owner/operator of the equipment, does not satisfy the owner/operator reporting requirements required under U.S. 49 CFR, Transport Canada or any other AHJ.

In The Event of an Equipment Fire

⚠ WARNING

A vehicle or trailer fire may damage the cylinder or valves. Immediately remove from service any cylinder involved in a fire. Failure to follow this warning could result in death or serious personal injury.

Every individual cylinder in the containment is equipped with a Thermal Pressure Relief Device (TPRD). If a fire should occur near the containment or one of the cylinders the TPRD's located on the cylinders may activate. If any of the TPRD's are activated, VERY rapid venting of gas will occur.

If a fire caused the activation of the TPRD and the cylinder is full of flammable gas, it is possible that the gas exiting the pressure relief line will ignite and can be very dangerous. Even if the compressed natural gas does not ignite, debris blown about by the gas jet could be dangerous and the loud noise caused by the rapid venting could cause hearing damage.

If any of the TPRD's activate, evacuate the area immediately and call the appropriate authorities. Once a cylinder pressure relief device(s) has been activated for any reason, the cylinder and or system must be thoroughly inspected by qualified personnel before being returned to service.

Please visit www.qtww.com for more information.

For additional information refer to the First Responders Guide available at http://www.qtww.com/service/product-documentation/

Maintenance Schedule

The services shown in this schedule are specifically for the gas transfer and storage equipment and the container.

The inspections indicated below must be performed IN ADDITION TO any federal, state or locally required maintenance that is required for the chassis of the trailer.

The services shown should be performed at the listed intervals and repeated at the same intervals, for the life of the trailer.

Check at every load or unload

- ❑ Walk around the system and inspect for any system damage due to collision or impact from road debris.
- ❑ Inspect the load/unload coupling for damage or wear.

Check every 3 months

- ❑ Inspect the load/unload couplings for damage or wear.
- ❑ Check trailer battery condition.
- ❑ Test the emergency breakaway switch.

Check 12 months or 36,000 miles (57936 km)

- ❑ Inspect the cylinder and cylinder mounting brackets. [1]
- ❑ Inspect for gas system leakage.
- ❑ Inspect the PRD vent caps.
- ❑ Inspect the cylinder TPRD assemblies.
- ❑ Inspect the Load protection PRV.

Check every 30 months

- ❑ Have the container inspected by a certified CSC inspector. [2]

Check every 60 months

- ❑ Perform cylinder recertification testing. [3]

1 For additional information regarding cylinder inspections, refer to the *CNG Cylinder Installation and Maintenance Manual* at www.qtww.com.

2 Only for intermodal transport. The first container inspection is due 60 months from the date of manufacture and then at 30 month intervals thereafter.

3 For additional information regarding cylinder recertification, refer to *#Cylinder Recertification* in this manual or the DOT special permit SP-16524.

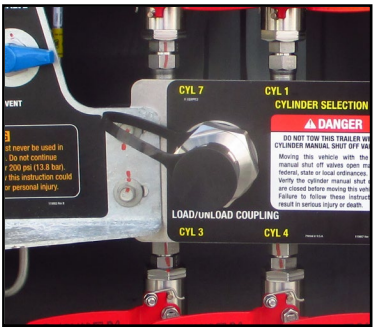
System Maintenance

Inspect the Load/Unload Coupling

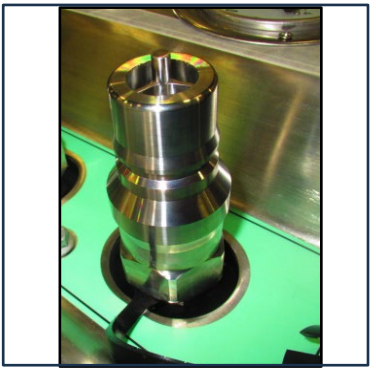
The load / unload coupling should be inspected prior to every use for signs of damage, wear or contamination.

1. Verify the cap is present and installed on the coupling.

2. Inspect the coupling for signs of water or debris present in the coupling. Do not use the coupling if it is contaminated.



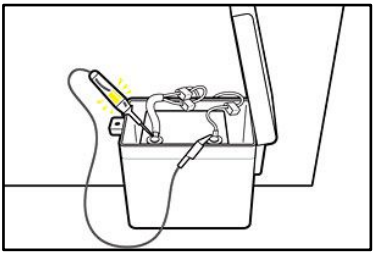
3. Inspect the coupling for any signs of wear or damage that may inhibit a proper and safe coupling connection.



4. Inspect the coupling and the coupling seals on the station hoses for signs of wear or damage.

If during any of these inspections, an observation is made that may indicate a problem or concern with making and maintaining a positive connection during a gas transfer, do not use the suspect coupling.

Inspect the Battery



Trailers with electric brakes rely on a small battery to initiate stopping when the breakaway switch is activated. Normally, the battery charges whenever the trailer is connected to a vehicle.

This battery should be checked periodically to ensure it retains a charge when not connected to a vehicle and can pass a battery load test.
If for some reason the battery is not charged by the vehicle when connected, it will be necessary to correct the condition before use to ensure proper brake and stability control system operation.

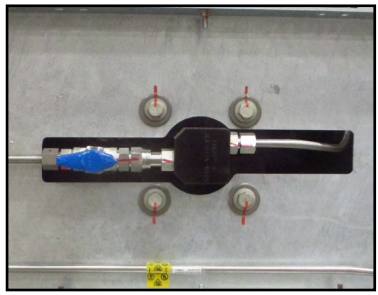
Cylinder and Cylinder Mounting Bracket Inspection

The following items must be inspected to ensure continued safe and reliable operation of the trailer.

The cylinders should be visually inspected following the criteria defined in the Quantum *Type 4 CNG Cylinder Installation and Maintenance Manual*.
Inspect all mounting system brackets for signs of fatigue, cracks, wear, abrasion, deformation, damage, excessive corrosion, loose or missing fasteners.

Document and address any damage or wear that is observed according to the severity and location of the condition.

Inspect all cylinder mounting collars, bolts and brackets for wear or damage.



Inspect the rear cylinder mounting blocks for any signs of wear or degradation. Any wear or damage that may allow for any cylinder movement should be addressed immediately.

Check the torque of the collar mounting bolts.

For systems with collar mounting bolts threaded directly into the aluminum collar mounting block and no safety wire, tighten the bolts to:

Torque specification: 63 lb.ft. (85 N.m.)

Note: If the mounting bolts are safety wired a torque check is not required as part of the periodic maintenance.

These safety wired collar mounting bolts are inserted through the aluminum block and into steel nuts and have an increased torque. If a torque check is required, tighten the bolts to:

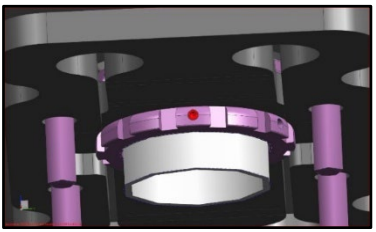
Torque specification: 80 lb.ft. (108 N.m.)

Inspect the front cylinder mounting plates for any signs of wear or degradation. Any wear or damage that may allow for a cylinder to move more than ¼" (6.3 mm) should be addressed immediately.

Inspect the flex plate for any signs corrosion, fatigue or wear. Replace any worn or damaged flex plates.

Inspect the fasteners securing the flex plate to the container and to the cylinder collar. Verify all mounting points are tight and secure.

Torque specification: 120 N.m. (89 lb.ft.)



Loosen the set screw securing the outer flex plate spanner nut.

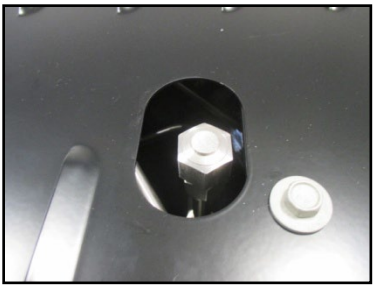
Verify the torque on the outer flex plate spanner nut.

Torque Specification: 148 lb.ft. (200 N.m.)

Tighten the set screw in the outer flex plate spanner nut.

Torque Specification: 14 lb.in. (16 dN.m.)

Inspect PRD Vent Cap



The PRD vent cap should be inspected whenever the cylinder is being inspected or serviced.

The following instructions are intended as a starting point for these inspections but may not be all inclusive to detect all potential concerns.

1. Inspect and verify that the PRD vent cap is accessible and not covered by vehicle panels or debris.

2. Check the PRD vent cap for any external damage, including corrosion or mechanical damage to the body.

3. Using pliers, lift the poppet on the cylindrical portion. Verify the presence of the O-ring and for a normal feel to the spring. A damaged spring will not behave as a normal spring.

4. Inspect the O-ring for any signs of cracking, contamination or other failure.

5. Inspect the chamfer on the body where the O-ring sits for any signs of damage.

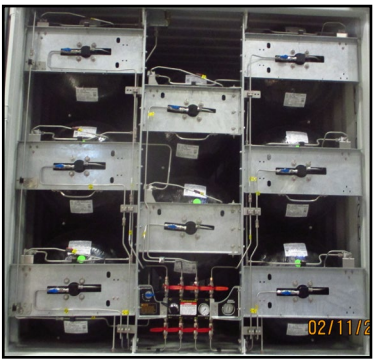
6. Inspect the vent line and verify it is undamaged.

Gas Storage System Leak Check

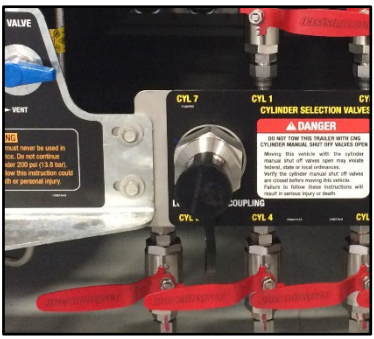
The gas storage system and all high pressure piping must be leak checked any time a leak is suspected or periodically to ensure continued safe and reliable operation.

1. Using a liquid leak detection fluid check all high pressure gas connections.
   In colder climates, it may be necessary to use a leak detection fluid specially formulated to prevent freezing.

2. Allow the leak detection fluid to rest for 3 minutes after application and check for the presence of bubbles. In warmer or windy climates the leak detection fluid may dry before 3 minutes has elapsed, adjust your wait times to accommodate any environmental restrictions.



3. Check the load/unload coupler as well as any valve accessible at the rear of the trailer for leakage.



4. Repair any leaks found before returning the unit to service. **Note:** It is normal for the cylinders to permeate and for there to be sporadic bubble generation from the surface of the cylinder.

5. Reinstall any removed access panels or covers.

Inspect TPRD Valve Assemblies

The TPRD assembly should be inspected whenever the cylinder is being inspected or serviced.
The following instructions are intended as a starting point for these inspections but may not be all inclusive to detect all potential concerns.

1. Check the TPRD for any external damage, including corrosion or mechanical damage to the body.

2. Inspect the trigger tube for wear or damage, check for bends or kinks beyond intentional installation bends.

3. Ensure mounting bolts on the body are tight.

4. Verify the condition of the trigger tube mounts.

5. Inspect the vent line to ensure there is no evidence of water accumulation or dirt.

6. Ensure there is a functioning method of relieving normal pressure build-up while keeping water out of the vent lines. If vent line closures or caps are missing or compromised, the TPRD and vent line must be inspected for any signs of the presence of water. Any evidence of water in the TPRD system may result in a requirement to replace the TPRD assemblies. Contact Quantum for assistance if water is found in the TPRD system.

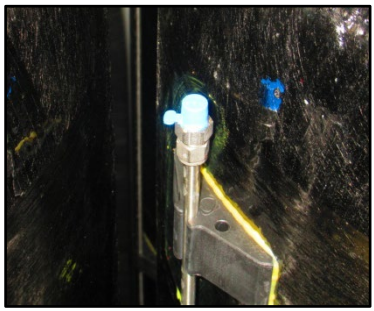
7. Verify that the TPRD supply lines are not kinked or damaged.

8. Leak check all pressurized TPRD connections.

Inspect TPRD Valve Assemblies (Cont)

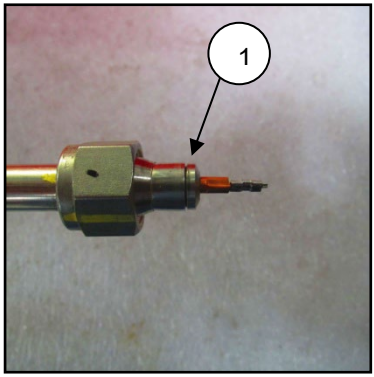
⚠CAUTION ***Exerting excessive force during this test may cause a TPRD activation. Do not exceed the force specified in the test step. Failure to follow this instruction may result in minor to moderate injury.***

1. Prior to disassembly, mark the position of the fitting to the fitting nut with a permanent marker.
2. Remove the cap from the end of the TPRD trigger tube.



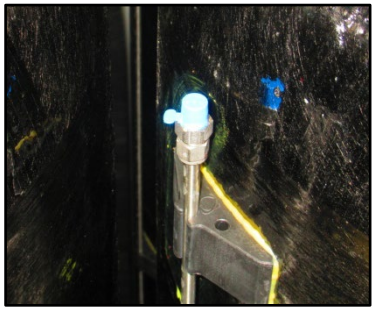
Ensure you are clear of the TPRD discharge port in case the device is activated during the next step.

3. Using your fingers, gently pull on the sensing wire inside the tubing. The pull direction must be parallel to the tube and the pull force MUST NOT exceed 2.5 lbs. or the TPRD valve may be activated.



4. While pulling, verify the seat (1) does not separate from the tube. If any TPRD valve is found to have a loose sensing wire the TPRD assembly must be replaced immediately.

5. Reinstall the TPRD trigger tube cap and tighten until the marks on the fitting and tube nut are aligned.



Cylinder Recertification

Each gas storage cylinder in the trailer must be re-qualified once every 5 years by a qualified person holding a valid Department Of Transportation (DOT) Requalifier Identification Number (RIN) in accordance with CFR § 107.805.

As part of this recertification process, the cylinders must pass a visual inspection of each cylinder as defined by the Quantum *Type 4 CNG Cylinder Installation and Maintenance Manual*. The cylinder inspection should also include any additional inspection criteria as defined by CSA B341-15.
In the event of a conflict of any of the inspection criteria, the more stringent criteria must be met.

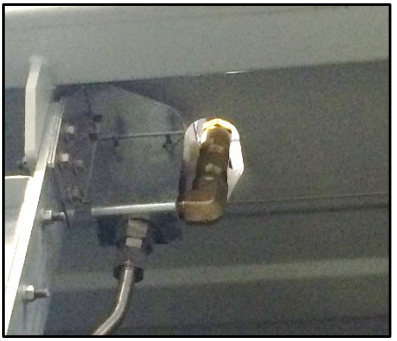
In addition to the visual inspections a Non-Destructive Examination (NDE) or hydrostatic test of each cylinder must be performed. Any test method used must be approved by the cylinder manufacturer and by the Office of Hazardous Materials Safety Approvals and Permits Division (OHMSAPD).

Note that ANY requalification test must be performed and approved by a qualified person holding a valid DOT RIN and a special permit for inspecting cylinders built under special permit SP-16524.

If the trailer is also approved to operate in Canada under Equivalency Certificate SH-11921, the entity completing the 5-year recertification testing must also hold a valid Equivalency Certificate for completing the required testing.

Please contact Quantum Fuel Systems LLC to verify the approved method of testing and confirm setup and criteria prior to testing.

Inspect Load PRV valve



The system is protected by a pressure relief valve connected to the load/unload manifold. In the event the system pressure exceeds a predetermined pressure, the pressure relief valve will begin to discharge the excess pressure to atmosphere.

This valve should be inspected and the set pressure verified annually to ensure it is not leaking, functional and that the pressure setting is correct.

The PRV set pressures are:

- 4,900 psi (338 bar) for 3,600 psi (248 bar) systems.
- 6,250 psi (431 bar) for 5,000 psi (350 bar) systems.

Cylinder Draining

Procedure not available at time of publication, Contact Quantum Fuel Systems.

Fitting Service

General Tube and Fitting Service Guidelines

Never attempt to tighten or adjust any high pressure tube or fitting when the system is pressurized. If a fitting or joint is exhibiting a leak, disassembly the joint, inspect the fitting and tube for damage or wear, install a new O-ring if used and tighten to specifications. Never attempt to stop a leak by over tightening a fitting.

Whenever leak checking high pressure tubes and fittings, it is recommended to check for leaks at various pressure levels. It is not uncommon for leaks to exist only within certain pressure ranges and to seal and be bubble tight above and below these ranges.

When servicing any high pressure tube or fitting joint that requires the use of an O-ring, the O-ring must be replaced when disturbed.

When installing or assembling any tube or fitting joint that uses O-rings, the O-ring must be lubricated with an appropriate lubricant. Failure to lubricate the O-ring may result in damage to the O-ring during assembly or may result in premature failure or leakage of the joint.

Fitting Service (Continued)
O–Ring Face Seal (ORFS)

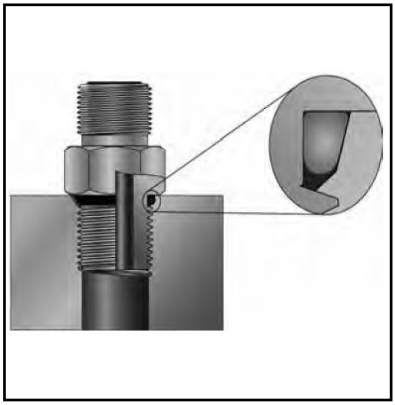
Always use a new o–ring when reassembling a fitting.

Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign matter.

SAE (J1926)– Straight Thread
Non–Adjustable Port End Fitting

Always use a new o–ring when reassembling a fitting.

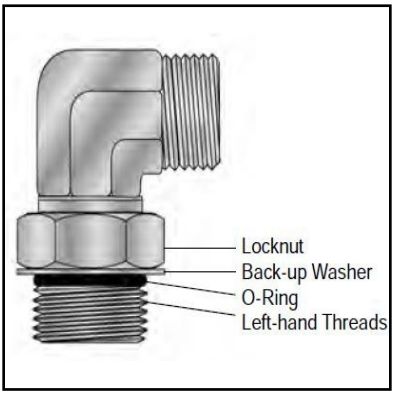
Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign matter.



Adjustable Port End Fitting

Always use a new o–ring when reassembling a fitting.

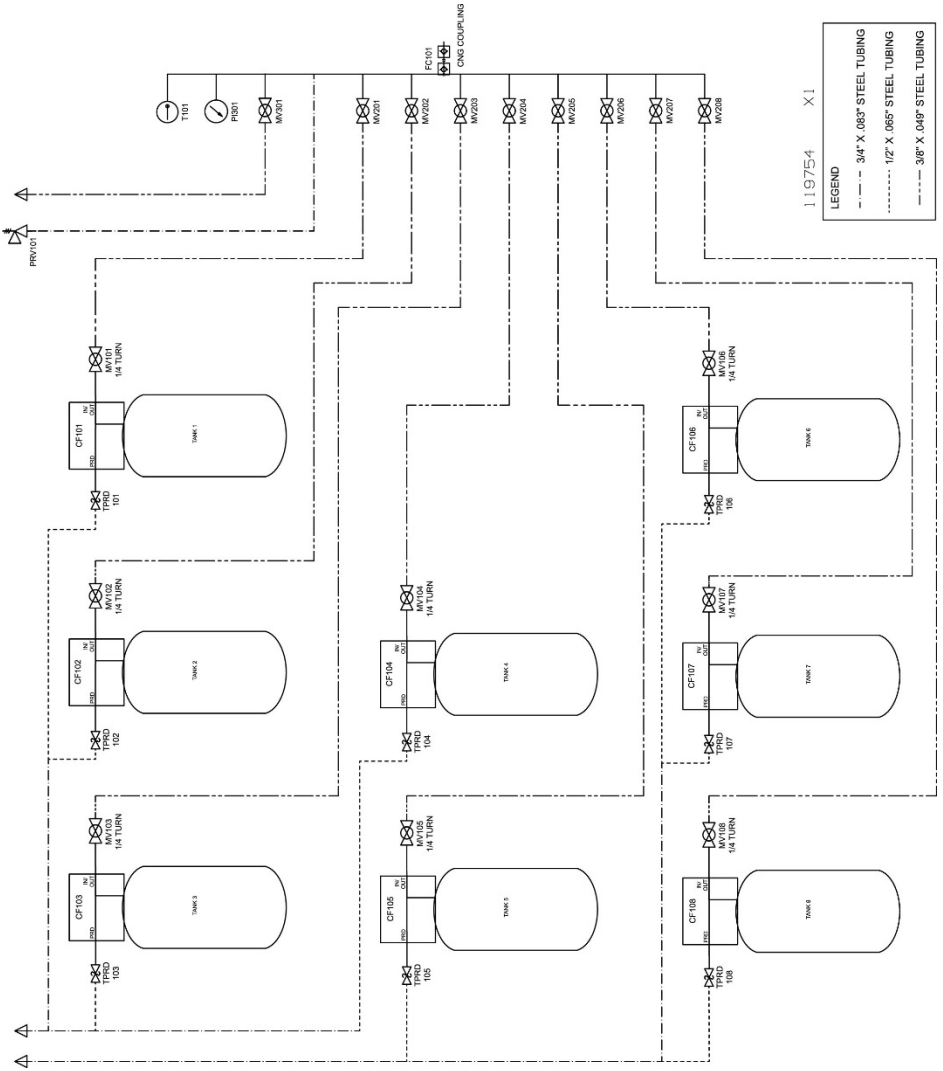
Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign matter.



General Fitting Torque Specifications

-8, 1/2" SAE ..... 65 Ft lbs. (88 N.m)
-6, 3/8" ORFS ..... 31 Ft lbs. (42 N.m)
-8, 1/2" ORFS ..... 43 Ft lbs. (58 N.m)
-12, 3/4" ORFS ..... 89 Ft lbs. (121 N.m)

System Mechanization



Addendum

Post Incident inspection

VP Trailer Post Crash Inspection Plan

The intent of this inspection plan is to determine the inspection process that should be followed after any VP trailer has been in any kind of accident.
Before continuing with this inspection, the assumption is that the trailer has been righted, secured and transported to an appropriate inspection facility.

Verify Trailer is Safe:

- ❑ If there is any reason to believe there may be cylinder damage immediately vent the contents of the trailer.

- ❑ If the trailer is still pressurized, ensure there are no significant leaks. Significant leaks may be detected either audibly or identified by the presence of ice or localized freezing. Any leaks detected should be addressed by repair, isolation or venting as required before proceeding.

General inspection:

- ❑ Inspect the outside of the container for any obvious damage to any of the sides and note the location and type of any damage.
- ❑ Open the rear doors and note if the doors do not open or close properly.
- ❑ Inspect the latches that secure the container to the chassis for any damage or wear.
- ❑ Inspect the hitch and hitch mounting for any signs of damage or fatigue.
- ❑ Have the chassis inspected by a qualified technician.
- ❑ Carefully inspect the plumbing and plumbing mounting points on the outside of the trailer for any damaged or missing components.

Check for leakage:

- ❑ Close all the cylinder manual shut off valves.
- ❑ Monitor for pressure degradation over time, if possible, it is recommended to leave the system sitting for 12 hours.
- ❑ Document the pressure reading on the pressure gauge. If pressure is present, mark the needle location on the face of the gauge and write the time and date.

Initial Pressure_____ Time/Date _____

Final Pressure_____ Time/Date _____

Internal Inspection:

- ❑ Remove front panels. When removing panels inspect for the presence of any debris or material that may indicate damaged or broken parts.

- ❑ As needed, clean the inside of the container to allow for a thorough visual inspection.

- ❑ Inspect all rear cylinder mounting collars for signs of damage or fatigue.

- ❑ Inspect all cross members for signs of stress, fatigue, cracks or broken or missing bolts.

- ❑ Inspect the front cylinder support plates for signs of damage or fatigue.

- ❑ Wherever there was damage to the outside of the container, carefully inspect for any evidence of contact between the container and the cylinder.

- ❑ Wherever there was damage to the outside of the container, carefully inspect for any damaged or missing gas lines or gas line retainers.

Notes:

Revision History

Revision A – 7/9/19 Initial release
Revision B – 10/5/23 Added Content for SP clarification, clarified component names, remove tow vehicle restrictions, update illustrations to more representative images, add fitting service information, added content for hydrogen, commonization of service and maintenance procedures.

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