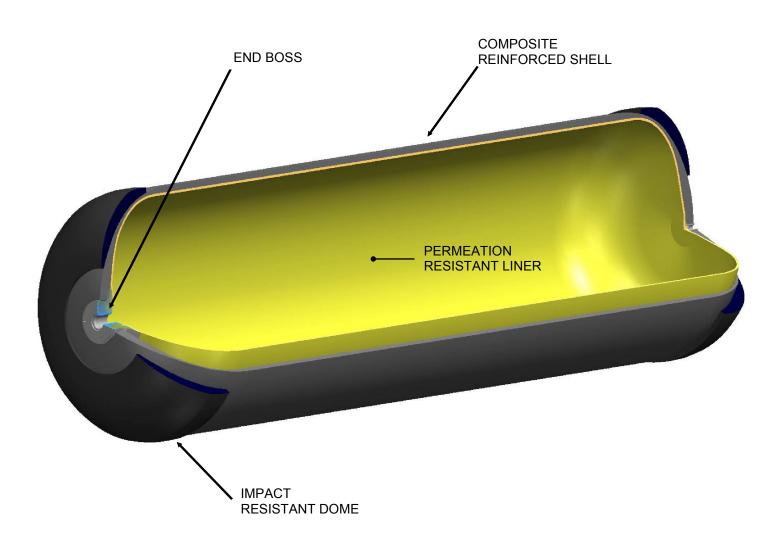


Type 4 Compressed Natural Gas (CNG) Cylinder Installation and Maintenance Manual





Foreword

This User Guide provides the information for the Quantum Type 4 composite Compressed Natural Gas (CNG) cylinder manufactured by Quantum Fuel System. and contains instructions for end user installation, maintenance, and self inspection of the cylinder in its installed environment. A thorough and complete understanding of the information contained in this publication is required for the continued safe use of this product. Read this manual in its entirety and keep it for future reference.

The CNG cylinder should only be installed by qualified personnel who have read this guide from cover to cover. Individual operator training is the responsibility of the company, firm, or organization performing the installation.

This manual contains Notices, Cautions, and Warnings that must be observed at all times to reduce the risk of personal injury during installation or maintenance. Improper installation or maintenance procedures may damage the cylinder or make the cylinder unsafe to operate. These Notices, Cautions and Warnings are not all inclusive. Quantum Fuel Systems 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:

Quantum Fuel Systems LLC 25372 Commercentre Drive Lake Forest, CA 92630 USA Tel: 949-930-3400 Fax: 949-930-3401 www.gtww.com

This guide also provides the criteria for regulatory inspection requirements. The following publications are required to achieve a full understanding of these requirements:

- CGA C-6.4 Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HV) Fuel Containers and Their Installation.
- NGV-2 American National Standard for Compressed Natural Gas Vehicle Fuel Containers.
- CSA B51 Part II, High Pressure Cylinders for the On-Board Storage of Natural Gas and Hydrogen as Fuels for Motor Vehicles.
- NFPA 52 Vehicular Gaseous Fuel Systems Code

All information, illustrations, and specifications contained in this guide are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

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How to Use This Manual

This manual contains information specific to the CNG cylinder. It does not explain everything you need to know about your vehicle installation. You must use this manual along with the information provided by the equipment manufacturer(s) for the remainder of the components used, and regulatory requirements applicable to your use of the cylinder. Only then will you be able to properly install and maintain your Quantum CNG cylinder.

Please read this manual from beginning to end when you first receive your product. If you do this, it will help you learn about any special features or installation considerations that may apply to your specific cylinder. 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.

Quantum Fuel Systems LLC assumes no liability for any errors, omissions, or ambiguities that may exist in this translated manual.



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Introduction

The Quantum CNG Cylinder is a rugged, state-of-the-art component of a CNG vehicle fuel system designed for permanent vehicle installation. The Quantum CNG cylinder utilizes aerospace-quality composite and metallic materials in the construction of a type 4 cylinder providing resistance to fatigue, environmental degradation, stress corrosion cracking and impact damage over its service life under normal conditions defined in this document. The corrosion-free inner-liner is resistant to CNG permeation, leaks and contaminants. The Quantum CNG cylinder is engineered to be lightweight, easy to handle and install, and is designed to meet or exceed the requirements of applicable U.S., Canadian, and European standards of burst strength, cyclic fatigue, extreme temperatures, impact and corrosion resistance, fire and gunfire safety, permeation and high temperature creep resistance.

Quantum offers a collar mounted option as part of its CNG family of cylinders.

Quantum manufactures CNG cylinders for use up to 34.5 MPa (5,000 psig) service pressure rating at 21° C (70° F).

Quantum builds CNG cylinders designed to meet the following standards:

- **NGV-2** "American National Standard for Compressed Natural Gas Vehicle Fuel Containers".
- **ISO 11439** "High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles"
- **CSA B51** Canadian Standards Association (CSA) "Boiler, Pressure Vessel and Pressure Piping Code", "Part 2, High pressure cylinders for the on-board storage of natural gas and hydrogen as fuels for automotive vehicles".
- ECE R110 "Uniform provisions concerning the approval of specific components of motor vehicles using compressed natural gas (CNG) in their propulsion system."

Quantum CNG cylinders may be designed, tested and manufactured to meet additional and/or different standards when required by customer requirements and specifications.

This document provides guidance to an installer for safely installing the Quantum CNG cylinder onboard a CNG-powered vehicle and provides important instruction for safe use and maintenance. Installation will vary according to the use or application of the CNG cylinder. The installer must ultimately ensure all local, state and federal regulations were followed when installing the CNG cylinder.

WARNING

Read this entire manual before proceeding with the installation. Installation of CNG cylinders should only be performed by competent CNG system installers, following applicable local, regional, and national codes and regulations. Failure to do so may result in serious injury or death.



Safety Information

CAUTION

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed:

Proper installation and maintenance of compressed natural gas (CNG) fuel cylinders is important to ensure the safe, reliable operation of CNG-fueled vehicles.

The procedures recommended and described in this guide are effective methods of performing maintenance, inspection, and repair. Some of the procedures require the use of tools specifically designed for this purpose.

Accordingly, anyone who intends to use a service/inspection/maintenance procedure or tool which is not recommended by the cylinder manufacturer, must first determine neither their safety nor the safe use of the cylinder will be jeopardized by the replacement procedure or tool selected.

It is important to note that this guide contains various "Dangers", "Warnings", Cautions", and "Notices" that must be carefully observed to reduce the risk of personal injury during the installation and maintenance, or the possibility that improper installation and maintenance may damage the cylinder or render it unsafe. It is also important to understand that these "Dangers", "Warnings", "Cautions" and "Notices" are not exhaustive, because it is impossible to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

The various symbols with accompanying definitions appear below:



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.



DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE is used to address practices not related to personal injury.

CAUTION, without the safety alert symbol, is used to address practices not related to personal injuries.



General Safety Information

DANGER

Never pressurize a CNG cylinder that is not restrained by approved brackets properly mounted or otherwise acceptably restrained to prevent movement while under pressure.

Installation of a valve or Pressure Relief Device (PRD) not approved for use in this cylinder can result in a cylinder rupture. Contact Quantum regarding valves and PRDs approved for use in your cylinder.

Use of this cylinder for storing media other than Compressed Natural Gas (CNG) or exceeding the cylinder rated pressure may damage the cylinder. Use the cylinder for storage of CNG only, if there is a question about the proper installation or use of this cylinder contact Quantum Fuel Systems.

The Pressure Relief Device (PRD) must not be shielded in any way. Shielding may prevent the PRD from functioning in the event of a fire resulting in cylinder failure.

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

WARNING

Installation of this cylinder must be performed by competent personnel in accordance with all Federal, State, and Local regulations applicable to the application.

When working with flammable gases in a confined area, always use gas-monitoring equipment and ground all equipment. If natural gas ignites, you could be severely burned.

A vehicle fire may damage the cylinder or valves. Immediately remove from service any CNG cylinder involved in a fire.

When servicing the CNG cylinder or valves, the proper tools must be used to avoid damage to the components being serviced.

Maintain the cylinder above the minimal working pressure. If not maintained, it may result in shortening the potential service life of the cylinder.

Failure to observe these warnings may result in death or serious injury.



CAUTION

Natural Gas is extremely flammable. If something ignites it, you could be severely burned. If you are refueling a vehicle, keep sparks, flames and ignition sources a minimum of five meters (16 feet) from natural gas. Do not use cell phones or other electronic equipment while refueling, defueling or servicing a vehicle.

Turn the vehicle OFF while refueling, defueling or servicing.

Refuel, defuel or service compressed natural gas fuel cylinders in a well-ventilated area.

Use the proper grounding procedure to an earth ground to prevent a build-up of static electricity, which can lead to an electrical discharge.

The compressed natural gas system must be purged and leak checked with inert gas:

- Before initial use.
- Before and after service.
- Before shipping.

Inspect the CNG cylinder and brackets every 3 years or 36,000 miles (60,000 km), whichever comes first. The frequency and level of inspection may vary based on state and local requirements.

Additional inspections may be necessary if the following conditions are present.

- The cylinder has been exposed to corrosive chemicals such as acid or alkali.
- Unusual or excessive vehicle corrosion is observed in the area near the cylinder.
- Obvious vehicle damage is observed in the area near the cylinder.
- The vehicle has been involved in a collision and damage is observed in the cylinder area.

The compressed natural gas cylinder and valves are designed for use only with dry compressed natural gas that meets SAE J1616 fuel quality. Do not use liquid natural gas, hydrogen, butane, LPG or other gaseous fuels as a fuel source.

A cylinder may be damaged if overfilled. A cylinder must never be filled above 125% of the rated service pressure, per ANSI/NFPA 52.

Failure to observe these cautions may result in injury or damage.

NOTICE

Do not remove, plug or tamper with any of the factory installed hardware or components or the system could be damaged.

Verify that all fuel cylinder labels are in place and legible. Contact Quantum if any of the following conditions exist:

- The cylinder label is illegible
- The cylinder label is peeling
- The cylinder label is missing

Verify that the "DO NOT USE AFTER DATE" indicated on the cylinder matches the fill area label. If needed, replace the fill area label so the "DO NOT USE AFTER DATE" matches the cylinder label.

NOTICE

Maintain the cylinder above the minimal working pressure. If not maintained, it may result in shortening the potential service life of the cylinder.



Definitions

Below are a few terms you should be familiar with when reading this manual.

Abrasion damage: Damage to a container caused by wearing, grinding, or rubbing away of the container material by friction.

Carbon fiber: Type of reinforcement fiber used in composite overwrap.

Composite: Structural material composed of load bearing fibers embedded in a protective resin matrix.

Crazing: Hairline cracking of the resin giving it an opaque "frosty" appearance.

Cut damage: Damage caused by a sharp object coming in contact with a composite surface.

External/exterior coating: Clear or colored surface treatment applied to the container for environmental protection and improved appearance.

Foam Dome: Protective impact absorbing component installed on each end of the CNG cylinder to protect the cylinder from handling and in use impact damage.

Helical wrap: Layers in the composite overwrap filament wound to provide primarily longitudinal strength and some hoop strength for the cylindrical region of the container. NOTE-The strands of reinforcing fibers are oriented at an angle to the longitudinal axis of the container.

Hoop wrap: Reinforcement by a composite material applied in a substantially circumferential pattern over the cylindrical portion of the liner so that the filament does not transmit any significant stresses in a direction parallel to the container longitudinal axis.

Impact damage: Damage caused by dropping or by a blow from another object. NOTE-Impact damage can be at the surface, internal to the structure, or both.

Inspection mark: Mark, label, or tag placed by an inspector on the container indicating acceptance of the container.

NOTE-The mark shall at least identify the inspecting agency and the date of inspection (month and year)

Liner: Internal component of the container that prevents leakage of gas through the composite container structure.

Over pressurization: Pressures exceeding those allowed during filling procedures specified in the standards referenced in this document.

Permeation: Penetration of a small amount of gas through the cylinder wall.

Pressure Relief Device (PRD): Device installed in the container or integrated with a valve that will release the contained gas in specific emergency conditions.

Resin: Plastic material in the composite overwrap that fills the space between individual reinforcing fibers and binds them together.

Scuff: Minor abrasion damage to the protective coating, paint, or resin-rich composite surface.

Service pressure: Authorized pressure marking indicated on the cylinder labeling.



Valve, manual: Device installed in one of the ports of the container used to regulate gas flow into and out of the container, which is turned on and off manually with a handle.

Valve, solenoid: Device installed in one of the ports of the container used to regulate gas flow into and out of the container, which is turned on and off electronically.

Vent line: High pressure line used to conduct gas from a PRD to a location away from the cylinder or outside the vehicle.



Receiving Inspection

Inspect all shipments for damage at time of receipt in the presence of carrier. If damage is suspected due to shipping package appearance, do not unpack product. Immediately notify your freight carrier and Quantum of the damage. Document condition concerns with photographs, if possible. Note condition on receiving document(s) and obtain driver's signature.

Contact Quantum for assistance in evaluating the damage and possible return of the damaged product.

Cylinder Storage

Quantum cylinders when shipped new, are at atmospheric pressure and can be stored with no special precautions or provisions.

However, if the cylinders are being stored with valves installed and in the closed position, there are some considerations.

If the cylinders will be stored for an extended period of time, it is reasonable to expect that the storage environment can experience significant temperature swings. These temperature swings can possibly result in negative pressure condition inside the cylinder. A negative pressure inside the cylinder can result in liner damage over time.

If the cylinders will be stored with closed valves for an extended period of time, in a variable temperature environment, you may want to charge the cylinders with 5-10 psi (345-689 mbar) of nitrogen as a precaution.

This small amount of pressure will ensure the cylinder does not experience a negative pressure condition and will protect the cylinder from any possible damaging conditions.

Storage in Direct Sunlight

While Quantum cylinders are not susceptible to sunlight and will not be damaged by extended UV exposure, over time the sunlight can result in fading where exposed to sunlight.

If the cylinder is partially covered by packaging, covers, etc., this can result in unusual patterns or perceived discoloration showing on the surface of the cylinder.

Even if the cylinder is not partially covered but is stored in direct sunlight, the color will fade on the top and remain unchanged on the bottom. These color transitions are often flagged by a fuel system inspector for further investigation.

If these color variances exist when the cylinder is installed new, it is recommended to make record the condition indicating the fade was a result of storage.

Cylinder Handling Instructions

Anytime the fuel cylinder(s) are not in the vehicle, store it in a dry and safe location that prevents damage from vehicles or other shop equipment. Protect all open ports and fittings with the appropriate plugs or caps in place. Do not store the fuel cylinders in direct sunlight or in close proximity to a heat source or open flame.

Following a few simple safety precautions will prevent injuries resulting from the use of a damaged cylinder:

Failure to follow these precautions may cause damage to the cylinder assembly resulting in serious injury or death.

Do:

- Protect the cylinder from damage when the cylinder is not installed in the vehicle.
- Examine the cylinders for damage after any vehicle crash or grounding.
- Examine the cylinders and brackets for damage anytime there is evidence that the stone shield has been struck by a solid object (if equipped).
- Ensure that the compressed natural gas going into the vehicle is not contaminated.
- Perform regular leak inspections on high-pressure lines.
- Attach a tag or label to the cylinder valve indicating that the fuel cylinder is defueled and purged.
- Protect the cylinder from physical damage while removed from the vehicle.
- Inspect any fuel cylinder that has been removed from the vehicle for damage prior to installation.

Do Not:

- Drill holes in the cylinder or any of the components.
- Drop the fuel cylinder or fuel cylinder assembly.
- Block off or plug the thermal PRD vents except with the Quantum supplied dust caps.

Refer to Compressed Gas Association pamphlet CGA C-6.4 "Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders" for more detailed instructions and descriptive photographs of damages.

It should be noted however, that the recommendation in CGA C-6.4 must be used in conjunction with recommendations from Quantum Fuel Systems.

Service Conditions

WARNING

Vehicles or equipment undergoing repairs involving welding or the application of heat to any part within five feet of a filled cylinder must have the cylinder removed or shielded from the source of the heat. Failure to do so may result in serious injury or death.

CAUTION

A cylinder may be damaged if overfilled. A cylinder must never be filled above 125% of the rated service pressure, per ANSI/NFPA 52. Failure to observe this caution may result in injury and or damage to the vehicle.

Some Quantum cylinders are designed for permanent installation in vehicles for storage of CNG at ambient temperatures for use as a fuel for vehicles. The standard service conditions specified in the ANSI/AGA NGV-2 and CSA B51 Part II standard is the basis for the design, manufacture, inspection, testing and approval of these cylinders.

Some Quantum cylinders are built under DOT special permits for use in storage and transportation of bulk CNG, these cylinders must be used, serviced, and maintained according to any special provisions defined in those special permits.

The installer and or the operator must ensure that the cylinder service conditions are compatible with the following:

- Maximum fill pressure
- Service temperature range
- Natural gas quality (level of contaminants)
- Cylinder exposure to corrosive agents and physical damage, and gas permeation rate defined in the above standards and indicated on the cylinder label.
- The cylinder being installed is appropriate for the intended use or application.
- Contact Quantum, or visit our website at <u>www.qtww.com</u> for clarification if extraordinary service conditions are expected.

Preparing the CNG Cylinder for Installation

A DANGER

Install only approved valves and Pressure Relief Device (PRD) in your CNG cylinder, installation of the incorrect part may cause a cylinder to rupture. Contact Quantum for information regarding the proper components for your cylinder. Failure to follow this instruction will result in death or serious injury.

Only approved valves and PRD's can be installed in Quantum Type 4 cylinders. If you are not sure the valve, PRD or combination of the two components are approved for use in your cylinder, refer to the product data sheets available for your cylinder at <u>www.gtww.com</u> or contact Quantum.

The following steps performed in the order below are recommended as part of a proper installation of the CNG cylinder.

Note: Certain cylinders may not require all of the steps listed.

- 1. Verify the allowed CNG cylinder valves and PRD devices for your particular cylinder.
- 2. If the CNG cylinder was not equipped with these components at time of manufacture by Quantum Fuel Systems Install the CNG cylinder valve and/or PRD device. General instructions are provided in this document. Refer to <u>CNG Cylinder Valve/PRD Installation</u> in this manual.
- Perform the initial CNG cylinder pressurization and initial CNG cylinder valve interface leak test. Instructions are provided in this document. Refer to <u>CNG Cylinder Initial Pressurization/CNG</u> <u>Cylinder Valve Initial Interface Leak Test</u> in this manual.



Typical CNG Cylinder Valve Installation

NOTICE

QUANTUM

The following procedure applies to a Quantum CNG cylinder manufactured without factory-installed CNG cylinder valve and/or PRD(s). The procedure shown is a typical procedure; follow the manufacturer's installation guidelines for your specific components.

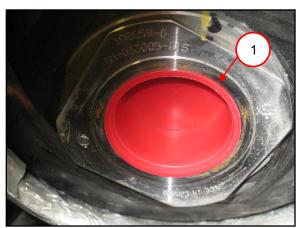
 Secure the CNG cylinder to a suitable workstation to prevent the CNG cylinder from rotating during CNG cylinder valve installation. The workstation must be capable of preventing CNG cylinder rotation while protecting the CNG cylinder from damage.



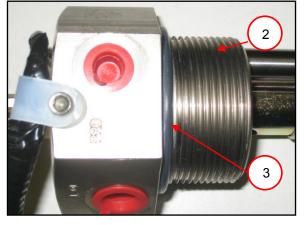
2. Remove the dust plug (1) from the boss adapter and verify the adapter bore and threads are undamaged and clean.

DANGER

Install only approved valves and Pressure Relief Device (PRD) in your CNG cylinder, installation of the incorrect part may cause a cylinder to rupture. Contact Quantum for information regarding the proper components for your cylinder. Failure to follow this instruction will result in death or serious injury.



- 3. Verify the CNG cylinder valve is correct for this application by verifying the following:
 - The part number is approved by Quantum Fuel Systems for installation in the specific part number CNG cylinder being assembled.
 - The thread pitch (2) and seal type (3) match the adapter boss.





WARNING

Use proper tools to install or remove cylinder valves or PRDs. Use of an incorrect tool may cause damage to the components resulting in fuel leakage. If ignited serious injury or death may result

- 4. Install the CNG cylinder valve per the valve manufacturers' instructions. During the installation, the following must be adhered to:
 - Lubricate the CNG valve O-ring seal just prior to installing in boss adapter. Use Parker® O-Ring Lube or other equivalent lubricant compatible with natural gas and seal material. Use just enough lubricant to apply a thin film to the entire seal surface.
 - Hand-install the CNG cylinder valve until fully seated in adapter boss. If valve cannot be seated by hand, remove and re-inspect valve and boss threads for damage, contaminants, etc. Clean interface components and re-install by hand.



NEVER use impact tools to install or remove cylinder valves. Use of an impact tool may cause damage to the components resulting in fuel leakage. If ignited serious injury or death may result

5. Tighten the CNG cylinder valve using a torque wrench with a current calibration certificate to the valve manufacturer's specifications. It is good practice to apply verification marks (paint pen, torque seal compound, etc.) to all connections handling pressurized gas after performing final tightening operations to indicate the status of these connections.

Note: The valve interface for most Quantum CNG cylinders is a 1 1/8" SAE fitting thread. The recommended torque for that interface is 100 lb.-ft (135 N.m). Consult the Quantum product data sheet for your specific cylinder or the valve manufacturers' documentation for the recommended installation torque.



Valve Boss Movement

The cylinder valve boss is keyed to the composite shell to allow for the cylinder valve to be installed and removed without the boss rotating.

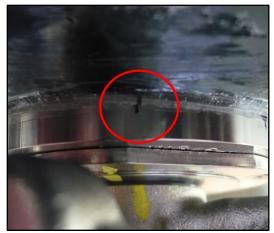
However, when the cylinder is not pressurized, it is not unusual to have rotational movement between the cylinder valve boss and the composite shell of the cylinder. On cylinders with a valve boss in one end of the cylinder, the cylinder liner will move with the valve boss, integrity of the cylinder will not be affected by this movement.

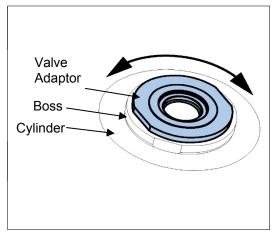
On single valve boss cylinders, there is no limit defined for the amount of rotational movement of the cylinder valve boss. If the cylinder valve boss turns and the valve cannot be tightened to specification, this does not indicate a problem. Contact Quantum Technical Assistance for a cylinder valve adaptor tool (701494).

The valve adaptor tool will secure the valve adaptor so that the valve can be tightened to specification.

On cylinders with a valve boss on both ends of the cylinder, rotational movement of the valve boss may result in damage to the cylinder liner and may cause a cylinder leak.

If movement of the cylinder valve boss is detected in excess of 0.100" (2.54 mm) during valve installation, you must immediately stop and secure the valve boss before proceeding.





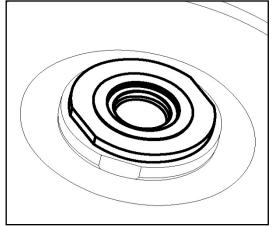


Valve Adaptor Movement

All Quantum type 4 cylinders use a valve adapter fitting that is threaded directly into the cylinder boss. This valve adapter fitting is locked in place using dowel pins and is not expected to move for the life of the cylinder.

Any technician servicing a Quantum type 4 CNG cylinder must observe the CNG cylinder valve adapter and note if any movement occurs. If the valve adapter is moving and the dowel pins are found to be missing, stop the service procedure and contact Quantum technical assistance.

If the CNG cylinder valve adapter rotates with the valve boss during installation of a CNG cylinder valve, no action is required. The CNG cylinder valve can be installed and tightened to the recommended value.



If the CNG cylinder valve adapter begins to move independently of the valve boss during a CNG cylinder valve installation or removal procedure, the technician must stop immediately.

If the valve adapter is moving with the valve boss, the technician must contact Quantum Technical Assistance to obtain the valve adaptor tool to hold the CNG cylinder valve adapter from rotating during the CNG cylinder valve installation or removal process.

PRD Installation – General Instructions

A DANGER

Install only approved valves and Pressure Relief Device (PRD) in your CNG cylinder, installation of the incorrect part may cause a cylinder to rupture. Contact Quantum for information regarding the proper components for your cylinder. Failure to follow this instruction will result in death or serious injury.

Only approved valves and PRD's can be installed in Quantum Type 4 cylinders. If you are not sure the valve, PRD or combination of the two components are approved for use in your cylinder, refer to the product data sheets available for you cylinder at <u>www.qtww.com</u> or contact Quantum.

Some CNG cylinders also use an auxiliary PRD installed at the opposing cylinder dome from the CNG cylinder valve. The use of a PRD at this location will be based on regulatory requirements or bonfire test performance.

If your installation requires PRD(s) to be installed, the following must be adhered to:

- Verify the correct components are used.
- Install the PRD devices according to the device manufacturers' instructions.
- If external PRD's are installed, follow the cylinder manufacturer's guidelines for construction and installation of the PRD system.
- Leak test all interface areas and the device(s) at initial pressurization and system operating pressure.



CNG Cylinder Installation

The cylinder must be mounted in a manner that adequately restrains but does not induce abnormal loads or cause damage to the cylinder.

The cylinder expands and contracts as the pressure in the cylinder increases and decreases. This causes the cylinder's diameter and length to vary depending on pressure. Quantum cylinders will typically expand when fully pressurized at the rates shown below.

For cylinders up to 25" diameter

- The cylinder length expansion at service pressure is approximately 0.30%.
- The cylinder diameter expansion at service pressure is approximately 0.54%.

For cylinders larger than 25" diameter

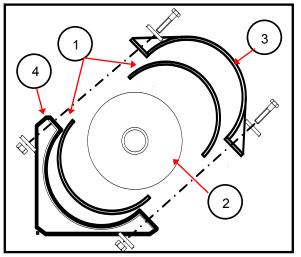
- The cylinder length expansion at service pressure is approximately TBD %.
- The cylinder diameter expansion at service pressure is approximately TBD %.

The cylinder mounting system shall be able to accommodate this expansion without inducing excessive loads in the cylinder, cylinder mounting system or causing abrasion of the cylinder. Brackets should be designed and installed in accordance with all applicable federal, state and local regulations.

Saddle Mount

The Quantum CNG cylinder is installed as part of an overall CNG vehicle fuel system. This section provides general information for the installation of the cylinder using a typical dual saddle mount approach, as an example only. The storage cylinder must be mounted in a safe location, following all applicable codes, regulations and crash worthiness requirements in effect at the time of installation.

- 1. Upper and Lower Isolator
- 2. Fuel Cylinder
- 3. Cylinder Strap
- Lower Cylinder Bracket (Attached to vehicle)

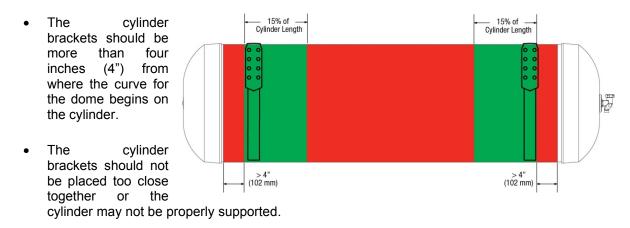




Saddle Mount (Cont.)

Quantum cylinders are not sensitive to mounting bracket position on the cylinder, a bracket may be secured at any point along the cylindrical portion of the cylinder. It is recommended that the brackets be mounted at least 4" (102mm) from the dome area of the cylinder.

The illustration below provides guidance for recommended bracket placement on the fuel cylinder.



Depending on your application the cylinder mounting brackets may need to move to accommodate a proper mounting surface on the vehicle frame.

The cylinder brackets must be properly aligned to each other so that the brackets can hold and support the cylinder properly without binding or causing any abnormal loads or stresses, or allowing contaminates to be introduced between the isolators and the cylinder.

The mounting bracket specifications must be defined by the bracket manufacturer as the bracket specifications will change based on the design and construction of the bracket as well as the cylinder being installed in the bracket.

The installer is ultimately responsible for determining proper cylinder bracket selection and installation requirements.



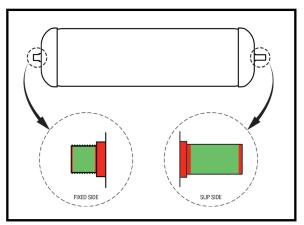
Collar Mount

Quantum produces cylinders that are designed to be mounted by the cylinder "collar".

Only cylinders specifically designed for collar mounting may be supported by the cylinder collar.

Collar mounting means that the cylinder is designed to be secured by the metal boss or collar on each end of the cylinder instead of a saddle bracket around the shell of the cylinder.

The collar mount bracket cylinder must follow and comply with the same applicable codes, regulations, and crash worthiness requirements as saddle mounted cylinders.



The cylinder collars are designed and tested to support the weight of the cylinder, for the life of the cylinder under normal operating conditions.

Adding additional components, covers, valves, etc. may introduce additional loads that may result in wear or damage to the cylinder collars or to the mounting system.

Most collar mounted cylinder are designed for horizontal mounting and are not approved for vertical mounting.

Refer to the specific cylinder product data sheet or contact Quantum regarding approval for vertical mounting of collar mounted cylinders.

A cylinder designed for collar mounting may also be mounted using saddle mount style brackets. But the installation should not mix collar mounting and strap style mounting brackets unless reviewed and approved by a professional engineer.

A DANGER

Failure to properly mount your collar mounted cylinder may result in damage to the cylinder, cylinder collar or cylinder mounting system.

Any collar mount cylinder mounting system should be reviewed and approved by a qualified engineer prior to use.

Quantum does not manufacture mounting brackets for collar mount cylinders.

The mounting bracket specifications and design are the responsibility of the installer. The mounting bracket design may change based on the application, placement, orientation, construction and operating conditions for where the cylinder will be installed.

The installer is ultimately responsible for determining proper cylinder bracket selection, construction and installation requirements.

Quantum does have a design for the collar mounting blocks used for the direct interface to the cylinder collars. Tolerances and measurements for the front and rear collar mount blocks should conform to the information contained in $\frac{#Appendix D - Drawings}{Provide Provide Pro$

The mounting blocks must be properly constructed, installed and aligned to each other so the cylinder mounting collars do not bind or transfer any abnormal loads or stresses into the mounting collars, brackets or the cylinder.



Introduction of loads due to any cylinder mounting bracket misalignment, cylinder mounting block misalignment, or general mounting system construction may result in damage to the cylinder.

Specifications for mounting block alignment tolerances are indicated in this manual.

The mounting criteria defined in this manual shall apply to the mounting system in both a static condition and a dynamic condition. Excessive movement, flexing or twisting of the mounting system can result in additional and or abnormal loads being applied to the cylinder collars.

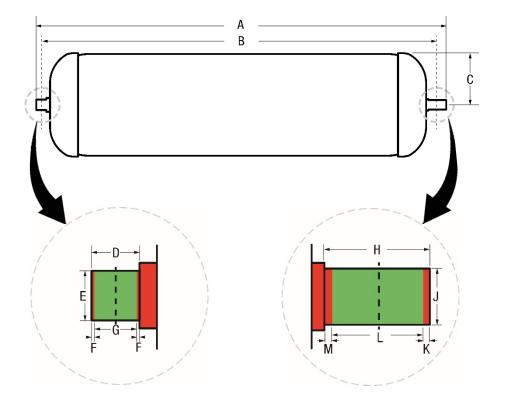
Some cylinders may have different tolerances, the tolerances indicated in this manual will apply if no other information is provided on the specific cylinder product data sheet.

Wear of the cylinder collar will not affect the structural integrity of the cylinder but may result in a concern with retention of the cylinder.

Any measurable wear on the fixed end collar is not allowed, the collar must be repaired before returning the cylinder to service. If the collar cannot be repaired to a state that will securely and properly retain the cylinder, the cylinder must be replaced.



Below are a few specifications that are typically defined for all collar mounted cylinders produced by Quantum Fuel Systems. Refer to the product data sheet for your specific cylinder specifications.



Minimum Saddle Width (B)	Refer to Product Data Sheet
Centerline to Sidewall Depth (C)	Refer to Product Data Sheet
Valve Collar Length (D)	Refer to Product Data Sheet
Valve Collar Diameter (E)	Refer to Product Data Sheet
Valve Collar Mounting Bracket Clearance (F)	Refer to Product Data Sheet
Recommended Mounting Area for the Valve Collar Mount (G)	Refer to Product Data Sheet
Rear Collar Length (H)	Refer to Product Data Sheet
Rear Collar Diameter (J)	Refer to Product Data Sheet
Rear Collar Mounting Bracket Clearance (K)	Refer to Product Data Sheet
Recommended Mounting Area for the Rear Collar Mount (L)	Refer to Product Data Sheet
Distance between Rear Collar Shoulder and Mount (M)	Refer to Product Data Sheet
Collar Material	Aluminum or 316L SS
Collar Mount Angular Alignment Tolerance	±2°
Collar Mount Alignment Offset	0.5" (13mm)
Cylinder Mount Orientation	Horizontal ±2° / Vertical ±2°
Slip Collar Bearing (Recommended)	Delrin*

* The Delrin bearing must have enough clearance to slide freely over the slip collar.

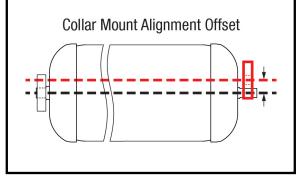
If a product data sheet is not available for your specific product contact Quantum for the needed information.



Collar Mount (Cont.)

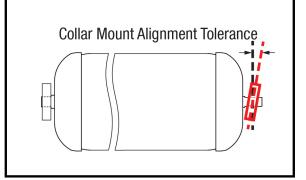
Collar Mount Alignment Offset

The maximum allowable offset between the front and rear mounting collars is 0.5" (13mm) unless otherwise stated in the specific product data sheet for the cylinder being installed.



Collar Mount Angular Alignment Tolerance

The cylinder collar mounting blocks must be both parallel to each other and perpendicular to the centerline of the cylinder. The maximum allowable misalignment tolerance is 0 ± 2 degrees unless otherwise stated in the specific product data sheet for the cylinder being installed.

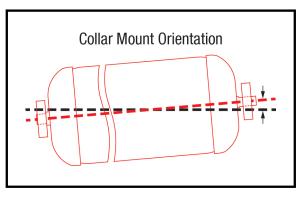


Cylinder Mount Orientation

The cylinder is designed to be installed and operated in either a horizontal or vertical mounting orientation unless otherwise specified in the specific product data sheet for the cylinder being installed.

Use of the cylinder outside of the recommended mounting angles may induce unknown loads on the cylinder or the mounting system.

Whether mounted on a horizontal or vertical axis the cylinder must not be off axis by more than 0 \pm



2 degrees. The cylinder has not been tested or approved for use beyond the angles indicated here.

General Installation Guidelines:

DANGER

The Pressure Relief Device (PRD) must not be shielded in any way. Shielding may prevent the PRD from functioning or activating properly, this can result in a cylinder failure resulting in death or serious injury.

WARNING

A minimum air gap of 0.5 inch (13mm) must be provided all around the cylinder. If relative movement is possible between cylinders or between a cylinder and any adjacent vehicle structure or components when the vehicle is loaded or operated, the clearance must be increased appropriately. Abrasion damage to the cylinder may lead to cylinder failure resulting in serious injury or death.

WARNING

The PRD vent line must allow for unrestricted gas release. Under no circumstances allow backpressure build-up in the PRD line. Backpressure in the PRD vent line will affect cylinder vent time and can lead to a rupture of the cylinder resulting in death or serious injury.

Brackets must be securely fastened to the vehicle at a location that provides sufficient strength to retain the cylinder in the event of collision. Single-wall sheet metal may not provide sufficient strength for the attachment of cylinder brackets. Refer to applicable regulations for anchorage strength requirements.

Improper installation may result in cylinder failure. Follow manufacturer instructions as well as all federal, state and local regulations for cylinder installation. Improper installation may result in serious injury or death.

Quantum saddle mounted CNG cylinders are designed for horizontal mounting only. Vertical mounting of cylinder requires special mounting provisions and considerations or the use of collar mounted cylinders. Improper mounting of the cylinder may result damage to the cylinder or valve resulting in serious injury or death. If considering vertical cylinder mounting, contact Quantum for further information.

NOTICE

Attachment brackets are designed to secure the cylinder in place and to prevent slippage, loosening or rotation. It is the installer's responsibility to confirm the installation complies with all applicable codes and regulations at the time of installation. Brackets must meet the minimum specifications defined in the latest updates of the following standards:

- ANSI/NFPA 52 Vehicular Fuel Systems Code
- CGA B149.4 M1991 NGV Installation Code
- FMVSS 304
- CSA B109 Natural Gas for Vehicles Installation Code



The following information is intended to provide general guidelines for the installation of the CNG Cylinder. Consult local regulatory standards for required installation requirements. A partial list of local regulatory standards is included in this document.

- The installer should use hardware appropriate for the installation location.
- Outside venting is required for CNG cylinders in enclosed areas.
- Do not allow any part of the CNG Cylinder or Fuel System to extend beyond the sides or top of the vehicle.
- A clearance of at least 6 inches (152mm) is recommended between the cylinder and the extremities of the vehicle to minimize damage due to collisions or overturning.
- Installer must provide sufficient impact resistant cages to side mounted cylinders unless specific impact tests are carried out to prove otherwise. Cylinders mounted below the vehicle body must be protected to minimize the possibility of foreign object damage or damage from stationary bodies.
- Installer must insure valves are protected from physical damage using the vehicle structure, valve protectors or a metal shield.
- If stone shields are necessary to protect the cylinder beneath the vehicle, the shield must not come in contact with, or trap solid or fluid matter against the cylinder surface.
- Do not mount the cylinder or Fuel System ahead of the vehicle front axle or behind the rear bumper mounting face, unless specifically approved by appropriate regulatory authorities.
- Install the cylinder with not less than the minimum ramp angle and road clearance of the vehicle when loaded to its gross vehicle weight rating.
- Secure the cylinder to the vehicle body, bed or frame using only approved installation brackets that prevent damage from road hazards, slippage, loosening or rotation.
- Installer must ensure cylinders located less than 8 inches (203mm) from the exhaust system are shielded against direct heat.
- Do not allow the cylinder and Fuel System installation to adversely affect the driving characteristics of the vehicle.

For collar mounted cylinders some additional guidelines must be considered.

Quantum does not manufacture and has not approved any mounting brackets for collar mounted cylinders. The mounting specifications defined in this manual are predicated on the use of the collar mounting blocks built to meet the specifications in the drawings provided in <u>#Appendix D – Drawings</u>. Quantum is not liable for mounting bracket adaptors that are not compliant to the drawings.

Selection and use of cylinder brackets is the sole responsibility of the installer to ensure the bracket selected will comply with all regulations applicable in the jurisdiction where the vehicle will be operated.



Cylinder Labeling

The cylinder label contains important information regarding the safe operation of the cylinder and must be visible. Your Quantum CNG cylinder has been supplied with two labels applied on opposite sides of the cylinder to ensure a label will always be visible when the cylinder is installed.

If it is not possible to install the cylinder with one of the original labels visible, an auxiliary label must be applied to the cylinder in a visible location or installed in a location as near as possible to the cylinder while maintaining visibility. Contact Quantum to request a new label.

Grounding

Externally mounted cylinders exposed to airflow must be grounded to prevent a static charge from accumulating in the composite as a result of airflow friction. In many cases the piping connected to the cylinder will provide an adequate static ground. If not, the grounding connection may be made to the valve if provisions are available or to the stainless steel fuel pipe connection adjacent to the valve using a 14-gauge multi stranded wire. Place 3 turns of copper strands around the pipe and secure with a stainless steel screw clamp of suitable size. Secure the other end of the ground wire to the vehicle body using a crimp-on eye lug and a self-tapping, stainless steel screw. Ensure ground is adequate, check for continuity and seal to prevent corrosion from damaging the contact points.

Venting Requirements

All CNG Fuel Cylinders installed in an enclosed area require venting to the outside of the vehicle. Venting systems must meet the requirements of all applicable venting codes or regulations.

Due to the design of Type 4 fuel cylinders there will always be low levels of permeation that may result in a fuel odor in the vehicle if mounted in a passenger compartment.

Quantum does not recommend mounting Type 4 cylinders in enclosed passenger compartments. Type 4 cylinders do have low levels of permeation and this permeating gas must be captured and controlled. If a type 4 cylinder will be mounted in a passenger compartment, the entire cylinder and valve connections should be covered with a vent "bag" or include a system to capture and route any gas that escapes from the cylinder to the outside of the passenger compartment.

Installation Verification

Perform the following verification immediately following the installation and also after three months of initial operation. Verify the cylinder installation for:

- Integrity of attachment to vehicle.
- Potential damage occurring during service.
- Leak tightness of the fuel-line connections.
- The installer should verify that the cylinder certification and installation meets all local jurisdictional requirements. If the cylinder has been in service before, verify the service history to ensure that the previous vehicle(s) has not been involved in any serious accidents or subjected to fire.



Integrity of Attachment to the Vehicle

Visually examine all bracket-to-bracket and bracket-to-vehicle connections. Verify that all connections are secured and that backing plates are in place at single wall anchorage points. Verify that the brackets are not worn, bent or damaged due to excessive tightening of fasteners.

Potential for Damage during Service

Check for minimum air gap around the cylinder. Ensure that the rubber gaskets are properly in place. Verify that the specified clearances are maintained between the cylinder body and the vehicle structure and moving cables even when the vehicle is fully loaded and the cylinders are filled. Verify that the cylinder is properly shielded from exhaust heat. For underbody mounted cylinders, ensure that the protective shield locations are adequate to protect the cylinder from damage during service. Visually examine the cylinder to ensure that it was not damaged during installation. Ensure that the PRD(s) are not shielded in any way.

Cylinders with Integrated Isolators

Some Quantum cylinders have been designed with integrated cylinder bracket and strap isolators built into the cylinder assembly.

Verify that the cylinder straps being used to retain these cylinders properly fit these isolators. These isolators are a permanent part of the cylinder assembly and cannot be easily replaced if worn or damaged.

Cylinder Initial Pressurization/CNG Cylinder Valve Initial Interface Leak Test

Never pressurize a CNG cylinder that is not restrained by approved brackets properly mounted or otherwise acceptably restrained to prevent movement while under pressure. Failure to follow this instruction may result in serious injury or death.

Failure to use an orifice in the venting system may subject the valve and cylinder to extremely low temperatures during venting resulting in severe damage to (or failure of) these components. Use an orifice specified by the valve or cylinder manufacturer when venting. Failure to follow this instruction may result in serious injury or death.

CAUTION

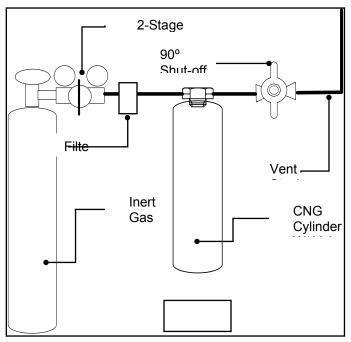
Verify all equipment used is rated for the highest pressure that can be generated during the procedure. Failure to do so may result in injury.

NOTICE

Quantum recommends the use of clean, dry, inert gas (Nitrogen, >99.5% purity) for this procedure. If it is necessary to use flammable gas, this procedure should be performed after the CNG cylinder vehicle installation is completed.

The following equipment is necessary to conduct the initial fill and initial interface leak test:

- Compressed Nitrogen Source capable of charging the CNG cylinder to 1450 psi (100 bar).
- Dual stage pressure regulator fitted to nitrogen source capable of regulating down to 73.0 psi (5.0 bar).
- Inline filter >10 micron <50 micron upstream of CNG cylinder valve inlet port.
- Fuel transfer system from dual stage regulator outlet through the filter to the CNG cylinder valve inlet port.
- CNG cylinder outlet port connected to an approved CNG cylinder vent stack arrangement equipped with a ¼ turn valve between outlet port and vent stack in reach of operator. The valve must contain a 0.042" orifice.



• Liquid leak detection fluid or an electronic combustible gas detector.



CAUTION

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

CAUTION

Performing this procedure when the CNG cylinder temperature is less than 0° F (-18° C) may result in damage to the cylinder. Allow the CNG cylinder to warm to room temperature >60° F (13° C) for a minimum of 12 hours before pressurizing. If ambient conditions where test is performed are less than 0° F (-18° C), complete the procedure within $\frac{1}{2}$ hour after removing cylinder from room temperature environment. Failure to follow this requirement may result in injury.

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 there is any doubt leave the cylinder pressurized overnight. 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. Refer to <u>*Permeation*</u> in this manual for additional information.

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 fuel leakage is detected, there should be no concern pressurizing the cylinder.

The recommended steps for initial pressurization are outlined in order below:

- 1. Ensure the cylinder is properly installed in a vehicle or retained in an appropriate test fixture before proceeding.
- 2. Confirm the compressed gas supply is "OFF" and connect the gas supply from the regulator to the CNG cylinder valve inlet.
- 3. Connect the vent stack inlet to the CNG cylinder valve outlet port.
- 4. Install suitable port plugs in any remaining inlet/outlet ports.
- 5. Close the CNG cylinder valve (manual type valve) or close the cylinder isolation lock-off screw (automatic type valve).
- 6. Close the ¹/₄ turn valve at the vent system flow path.
- 7. Verify the nitrogen supply regulator is fully backed-off. Slowly open the nitrogen supply valve until the 1st stage pressure gauge indicates supply pressure.
- 8. Slowly increase the regulator outlet pressure to 430 psig (30 bar) while listening for gross leakage. Test all connections and interfaces in the circuit with a liquid leak test fluid. Observe all connections and interfaces for bubble formation over a two minute period. If no bubbles are present, continue with procedure. If bubbles are found, close the supply valve and vent the system by opening the vent circuit ¼ turn valve and repair any leak(s) before proceeding.
- 9. Increase the supply pressure to 1450 psig (100 bar) and close the supply valve. Re-test per step 7 and repair any leaks discovered. When leak test is successfully passed, vent the system through the vent circuit. These steps validate the equipment setup and operation for testing the CNG cylinder valve/PRD interface.
- 10. Reduce the gas supply regulator outlet pressure to a 0.0 psi (1.0 bar).
- 11. Open the CNG cylinder valve (manual valve) or the cylinder isolation lock-off screw (automatic valve).
- 12. Open the gas supply valve. Slowly increase the gas supply regulator output pressure to 34.5 bar (500 psig) and allow gas flow to stabilize. When gas flow stops, close the gas supply valve.
- 13. Apply liquid leak detection fluid to the CNG cylinder valve interface and any user-installed PRD interface(s). Observe interface(s) for two minutes. If bubbling present, depressurize cylinder and repair as necessary. See <u>Cylinder Depressurization</u> section of this document for proper procedure. If no bubbles present, continue the procedure.
- 14. Open the gas supply valve and slowly increase gas regulator outlet pressure to 1450 psig (100 bar) and repeat the liquid leak detection fluid application. Wait two minutes while observing interface connection(s) for bubbles. If no bubbles detected, initial test is passed. If bubbles detected, diagnose & correct cause of leak and re-perform this procedure.
- 15. Close the gas supply valve. Vent the CNG cylinder to nearly empty 14.5 45.0 psi (1.0–3.0 bar) residual pressure of inert gas remaining in cylinder. This will assist the CNG cylinder purge operation performed prior to initial fuel fill. Refer to <u>Cylinder Depressurization</u> in this manual.

Purge Instructions

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

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

Cylinder purging should also be performed to dilute the CNG concentrations within the cylinder any time a cylinder has been drained and will require service or shipping.

Do not allow atmosphere to enter the fuel storage cylinder during purging. The fuel 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.

Only perform the purge process when the ambient temperature is above 0^{0} F (-18^oC). If cylinder was stored at temperatures below 0^{0} F (-18^oC) allow cylinder to warm up to room temperature 60^{0} F (>15^oC) before proceeding.

Prior to the initial fill with CNG or any service, the cylinder should be purged.

If the <u>Cylinder Initial Pressurization</u> procedure defined in this manual has been previously performed, the cylinder was not opened to atmosphere after the initial pressurization, and the cylinder temperature criteria for filling an empty cylinder is within the temperature range defined in this manual, an additional cylinder purge using this procedure is not necessary.

If a CNG cylinder purge is required use the following recommended procedure:

- 1. Fill the fuel storage cylinder with a dry inert gas (nitrogen, argon, etc.) to 150 psi (10.3 bar). Selection of the inert gas should take into consideration what will be most compatible with the system. Refer to the fuel system component manufacturer for system compatible purge gas recommendation.
- 2. Drain the fuel storage cylinder to approximately 25 psi \pm 5 psi (1.7 bar \pm 0.35 bar).

CAUTION

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

3. You may now fill the fuel storage cylinder to service pressure with CNG per applicable codes. Fill the cylinder with CNG to greater than 40 psi on the initial fill.



Leak Testing

DANGER

The cylinder must be first purged with an inert gas to ensure that no explosive mix is formed at any point during the initial fill. Refer to <u>Purge Instructions</u> in this manual. Failure to follow this instruction will result in death or serious injury.

A DANGER

Never check for gas leaks with an open flame, use only approved leak detection methods. Use of an open flame may result in a fire or explosion, in case of a fuel leak. Failure to follow this instruction will result in death or serious injury.

NOTICE

When a new cylinder is pressurized from nearly empty to full, 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 and the bubbling should subside typically within 30-60 minutes. The larger the cylinder the longer this process may take.

On smaller cylinders (under 300L) an electronic gas detector can be used to confirm that the bubbling is due to normal permeation not a cylinder leak, there should not be a sufficient volume of gas to trigger the gas detector. On larger cylinders, if the permeation is escaping in a concentrated area, an electronic gas detector may be triggered. Refer to <u>Permeation</u> in this manual for additional information.

When a cylinder is fast filled for the first time to the service pressure, some minor cracking noises may be heard. This is due to differential movements within the cylinder, and is a normal condition for composite cylinders. The noises should stop within 5 to 10 fills.

Verify the leak-tightness of the connection between the cylinder shut off valve or in-cylinder regulator and the CNG cylinder by pressurizing the system to the rated service pressure of the cylinder. An inert gas such as nitrogen is preferable for the initial test. CNG cylinder mounted PRD's must be tested in the same manner.

Leak testing must be done in stages: an initial 500 psi (34.5 bar) fill and verification, followed by a fill to service pressure if no leak is detected at 500 psi (34.5 bar). Positively ensure there are no leaks prior to filling the cylinder to service pressure. Conduct another leak test at service pressure.

A non-corrosive, commercial-type leak test fluid that does not containing ammonia or harsh corrosives is recommended for leak testing (example: Snoop® or equivalent available from most tube fitting suppliers). An electronic combustible gas detector may also be used, if using CNG for the test medium. Be sure to follow the manufacturers' instructions to ensure proper equipment operation.

Testing must be conducted under adequately vented conditions and at least 25 feet away from any open flame or other sources of ignition. Ensure all safety procedures are observed when working with high pressure or flammable gases.



Action in Case of a Serious Leak

If a serious leak is encountered:

- Shut off all electrical equipment and sources of heat and flame in the immediate vicinity.
- Clear people at least 100 feet away, in an up-wind or cross wind direction until the source of leakage is detected and gas flow is stopped.
- In the event of an ignition contact the fire department immediately.
- If any leaks are detected in the body of the cylinder or around the end bosses or valve, the cylinder must be depressurized and taken out of service.
- Contact Quantum Fuel Systems or its agents for instructions at 1.800.816.8691 or 1.949.930.3400, dial "0" for Operator.

Cylinder Pressurization

Failure to follow the fill conditions may irreversibly damage the fuel storage cylinder, leading to fuel leakage. The fuel storage cylinder must be handled in a safe and responsible manner. Failure to do so may result in serious injury or death.

- Under normal operating conditions, a residual pressure of 300-350 psig (20.7-24.1 bar) is maintained in the fuel storage cylinder and may be filled normally following all applicable state, local, and fire codes, to a temperature compensated 70°F (21°C) service pressure.
- If pressure in the fuel storage cylinder falls below 300 psig (20.7 bar) the cylinder can be filled normally if the ambient temperature is above 0°F (-18°C).
- If pressure in the fuel storage cylinder falls below 300 psig (20.7 bar) and ambient temperature is below 0°F (-18°C), please let the vehicle/cylinder warm up to room temperature >60°F (15.5°C) in a heated garage. Once the vehicle/cylinder has warmed up, the vehicle can be driven to a fill station, but must be filled within ½ hour after leaving the heated garage.

WARNING

Maintain the cylinder above the minimal working pressure. Repeated cycling below the minimum working pressure will affect cylinder life. Do not cycle the cylinder below minimum working pressure. Failure to do so may result in death or serious injury.

Cylinder Venting

WARNING

Failure to follow these instructions when venting the system may subject the valve and cylinder to extremely low temperatures during venting resulting in severe damage to (or failure of) these components. Use an orifice specified by the valve or cylinder manufacturer when venting. Failure to follow this instruction may result in serious injury or death.

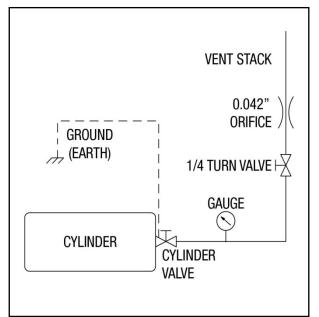
WARNING

During the venting process static may build up in the cylinder or vent system, if this static creates a spark the fuel may be ignited. The cylinder and vent system must be properly grounded to an earth ground. Failure to follow this instruction may result serious injury or death.

The venting operation should be performed by qualified personnel and in a manner that meets all federal, state and local regulatory requirements. The main considerations for safe venting are listed below:

- The release of gas to the atmosphere must be done in a manner that complies with all applicable codes concerning release of gas to atmosphere.
- Must be performed outdoors in an open area.
- Must be a minimum of 100 feet away from a source of ignition.
- Must use a venting system that meets the valve or cylinder manufacturer's specifications for the vent rate.

The illustration to the right shows a typical vent system layout.



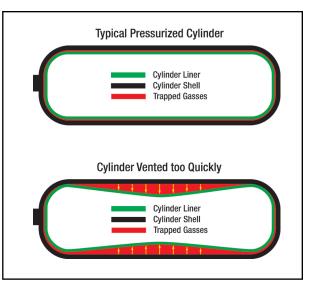
In the absence of another specification Quantum recommends the use of a 0.042" orifice in the vent system.



Cylinder Venting Instructions

There is always a small amount of gas trapped between the cylinder liner and shell, this gas is at cylinder pressure. If the cylinder is vented to atmospheric pressure too quickly, before this trapped gas is able to escape, it may cause the cylinder liner to collapse.

- If cylinder pressure is greater than 200 psi (14 bar) connect the cylinder directly to the vent stack.
- While monitoring the valve and cylinder temperature, vent the cylinder at as high a rate as possible without causing the cylinder boss or cylinder valve to drop below -40°F(-40°C). Stop venting once the cylinder pressure is approximately 200 psi or the low temperature limit has been reached.



IMPORTANT: Do not continue to vent at this flow rate under 200 PSI (14 bar) or permanent cylinder damage may occur.

 Connect the cylinder through a 0.042" (1mm) orifice and continue the venting process until the cylinder is empty. Always reference the pressure gauge



JUANTUM

Quantum cylinders are designed for low maintenance and dependable operation for the duration of the service life specified on the cylinder label. Quantum recommends that the cylinders be visually inspected periodically to ensure that the cylinders have not been damaged and made unfit for continued service. The cylinders may also require periodic inspection and re-qualification as required by applicable regulatory authorities. No maintenance measures are required, other than those arising from self inspection. The owner must maintain inspection records during the cylinder life.

At a minimum, Federal Motor Vehicle Safety Standard 304, Compressed Natural Gas Fuel Container Integrity, requires that the CNG fuel cylinder be visually inspected after a motor vehicle accident or fire, and at least every 36 months or 36,000 miles driven, whichever comes first, for damage and deterioration.

Some cylinders used in heavy duty service may be marked with an inspection interval of every 12 months or 100,000 miles driven, whichever comes first, for damage and deterioration.

The surface of the cylinder should be clean and free of dirt or other debris that can impede the inspection of the external surface of the cylinder. Shields or covers should be removed where possible to provide access to the cylinder surface area for a thorough inspection

The information in this section can be used as a guide to determine whether the fuel cylinder can continue to be used, may be repaired and put back into service, or must be removed from service, decommissioned, and destroyed.

Cylinder Inspection

A DANGER

In order for a complete and through cylinder inspection to be completed, any accessible covers must be removed and the cylinders must be properly cleaned prior to inspection. Failure to properly inspect and detect any cylinder damaged will result in severe injury or death.

Periodic inspection of the FSM cylinders is required to ensure the safe and reliable operation of the fuel storage module. There are a number of documents commonly used in the industry as guidelines to ensure that a complete and thorough cylinder and fuel storage module inspection is performed. Quantum recommends that any technician responsible for performing cylinder inspections follow these guidelines. At a minimum, the documents listed below should be used and followed when performing cylinder inspections along with the *Quantum CNG Type 4 Cylinder Installation and Maintenance Manual*.

- CGA C-6.4 Methods for External Visual Inspection of Natural Gas Vehicle
- ISO 19078 Inspection of the cylinder installation, and requalification of high pressure cylinders for the on- board storage of natural gas as a fuel for automotive vehicles
- ISO 11623 Gas Cylinders- Composite Construction- Periodic inspection and testing

Any recommendations from Quantum that exceed the requirements outlined in the CGA or ISO documents should be followed and are considered to supersede those requirements. If there is a case where any Federal, State, or Local regulation is found to contradict or are more stringent than the inspection or maintenance requirements set forth by Quantum, then the Federal, State, or Local regulations should be followed without exception.

Inspections must be completed in accordance with CGA C–6.4 and ISO 19078 standards. The inspection should include thorough examinations of the fuel storage module structure, brackets, and cylinder(s).

Any observations regarding damaged and/or replaced fuel and vent lines or loose fittings must be recorded.

In order to ensure that the cylinders are fit for continued safe use, the inspection shall be carried out by persons who have the appropriate experience and or training needed to perform a thorough cylinder inspection. The inspector shall have available and within easy access during the inspection, the equipment and the documentation needed to properly complete the inspection.

The vehicle to be inspected shall be positioned in such a way that the inspector has unimpeded access to the surface of the cylinder.

If specific inspection criteria are required and cannot be found in this document, reference the *Quantum CNG Type 4 Cylinder Installation and Maintenance Manual* or ISO 19078 in that order. In the event a conflict exists between the Quantum documents and ISO 19078, the inspection criteria defined in the Quantum documents should take precedent.

For detailed information about fuel cylinder inspection refer to the specific inspection sections as needed in this manual.

Fuel Cylinder and Bracket Inspection

CNG fuel cylinders are designed and manufactured with a specified design life which is displayed on the label on the CNG cylinder. When inspecting a CNG cylinder always check the label first to make sure the fuel cylinder has not exceeded its expiration date.

The fuel cylinder inspection should be conducted according to CGA C-6.4, Methods for external visual inspection of natural gas vehicle (NGV) and hydrogen vehicle (HV) fuel containers and their installations, and any other applicable federal, state, and local requirements.

Where a conflict may exist between this document and a published, applicable regulatory requirement, the regulatory requirement must be observed.

Inspect the CNG fuel cylinder, brackets and cylinder isolators as determined by the maintenance schedule, after any vehicle accident or fire or after the CNG cylinder has been removed from the vehicle and reinstalled. A sample of a generic cylinder inspection form has been provided in <u>Appendix B</u>. Record the inspection information in the vehicle's permanent file and in the cylinder inspection record. A sample of a cylinder inspection record can be found in <u>Appendix C</u>.

See <u>Appendix A</u> for typical tools and materials for measuring and repairing fiber damage.

The fuel cylinder and mountings should be inspected promptly if:

- The fuel cylinder, or the vehicle it is installed in, has been involved in a collision or fire.
- The fuel cylinder was dropped or subjected to impact.
- The fuel cylinder has been exposed to excessive heat.
- The fuel cylinder is believed to have been damaged by cargo, the vehicle or components, and/or environmental chemicals.
- The fuel cylinder is transferred to another vehicle.
- Significant alterations are made to the fuel cylinder installation.
- The fuel cylinder has been re-installed after removal from the vehicle.
- The fuel cylinder is believed to have been pressurized above the design standard.
- The mounting brackets show evidence of damage.
- The valve or PRD show evidence of damage.



NOTICE

Do not remove the cylinder from the vehicle for general inspections. Cylinder removal is only necessary if the following conditions are present:

- The cylinder has been exposed to corrosive chemicals such as strong acid or alkali.
- Unusual or excessive corrosion is observed in the cylinder area.
- Obvious damage is observed in the cylinder area.
- The cylinder straps are loose or damaged.
- The vehicle has been involved in a collision and damage is observed in the cylinder area.
- The vehicle has been involved in a fire (the PRD may or may not have activated).

If the cylinder is replaced, perform the following steps:

- Obtain a new fill area, cylinder expiration label.
- Record the new cylinder's "DO NOT USE AFTER DATE" onto the label. This date is permanently printed on the face of the cylinder label.

Cylinder Label Inspection Procedure

The CNG cylinder is marked with the label indicating the critical cylinder information as well as a safety label, if either of these labels are missing or illegible contact Quantum for assistance.

Verify that all fuel cylinder labels are in place and legible.

Contact Quantum if any of the following conditions exist:

- The label is illegible
- The label is peeling.
- The label is missing.

Verify that the "DO NOT USE AFTER DATE" indicated on the cylinder matches the fill area label. If needed, replace the fill area label so the "DO NOT USE AFTER DATE" matches the cylinder label.

Cylinder Wrap Inspection Procedure

Important: Gaps of the fiber wrap around the dome area of the cylinder may occur during manufacture. Also, resin and paint runs may appear as a hard circle or spot on the cylinder surface. This is normal. Cylinder strength is not affected and does not require repair.

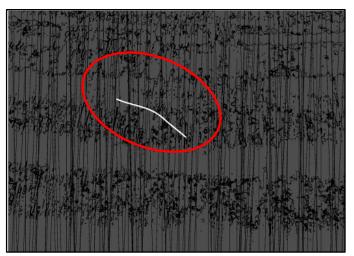
The following section provides a description of some types of damage that can occur with CNG cylinders. As it is not possible to address every possible damage scenario, these are the most common types of damage that your cylinder may experience. If the concern is localized over an integrated isolator configuration, then proceed to the *Integrated Isolator Inspection* section within this manual. The inspection criteria is the same for the dome area and the cylindrical portion of the cylinder unless specifically noted.

Inspect the surface of your Quantum Type 4 cylinder as follows:

How to Measure the Depth of Damage

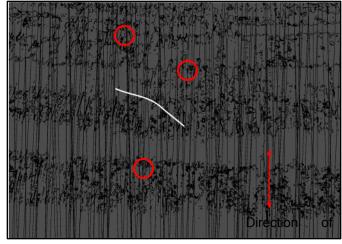
Due to the way the Quantum Type 4 cylinder is made there are variations in the height of the individual fibers in the hoop wrap, this uneven surface can complicate the measurement of a damaged area on your cylinder. The following process is recommended to provide the most accurate and consistent results when measuring any damaged area on your cylinder.

1. Identify the damaged area that needs to be measured.





2. Identify a number of areas in line with the wrap direction of the fiber, adjacent to the damaged area but where the damaged area will not interfere with a depth measurement.

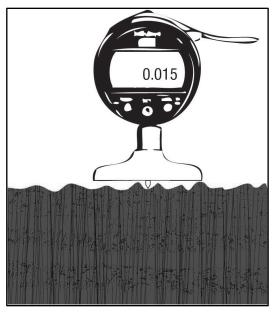


- 3. Using a depth gauge measure the depth of the lowest point in the wrap in the areas selected adjacent to the damage.
 - Record the largest reading observed when making these measurements.
- 4. Using a depth gauge measure the depth of the lowest point in the damaged area being inspected.
 - Record the largest reading observed when making these measurements.
- 5. Subtract the reading obtained in step 3 from the reading obtained in step 4. The result of this calculation will indicate the depth of the damaged area being measured.

EXAMPLE:

The maximum reading in Step 3 was 0.015" The maximum reading in Step 4 was 0.022"

0.022" - 0.015" = 0.007" damage depth





Level 1 Cut or Abrasion:

Level 1 cut, scratch or abrasions are minor cuts or abrasions that are less than 0.010° (0.25 mm) deep.

It is not necessary to resurface Level 1 abrasions.



Level 2a Cut or Abrasions:

Level 2a cuts or abrasions have some exposed fibers or have flat spots with a depth between 0.011-0.035" (0.26-0.89 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

Resurface Level 2a cuts or abrasions before returning the cylinder to service by following the procedures in <u>Cylinder Repair Procedures</u> in this manual.





Level 2b Cut or Abrasions:

Important: Cylinders with cuts or abrasions that meet or exceed Level 2b specifications must be removed from service.

Level 2b cuts or abrasions have some exposed fibers or have flat spots with a depth between 0.036-0.050" (0.90-1.27 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

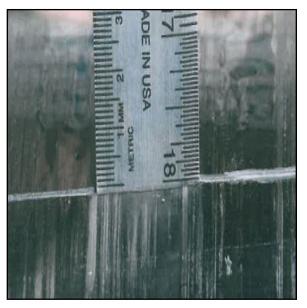
The final disposition of the cylinder will depend on the severity, location and direction of the damage to the cylinder. Contact Quantum for assistance in dispositioning a cylinder with level 2b damage.



Level 3 Cut or Abrasions:

Level 3 cuts or abrasions have some exposed fibers or have flat spots with a depth greater than 0.050" (1.27 mm). It may be necessary to remove loose fibers in order to accurately gage the depth of the cut or abrasion.

Any cylinder that has sustained level 3 damage must be removed from service. Refer to <u>Removing</u> <u>Cylinders from Service</u> in this manual.



Specialty Cylinders

Quantum does make specialty cylinders that may have features that could affect the results of a cylinder inspection. These special features must be identified and considered during the inspection process to allow for an accurate and proper evaluation.

When inspecting cylinders that incorporate any kind of special feature, these additional features may require additional inspection steps or have specific specifications associated to them that must be considered to ensure continued safe operation and use of the cylinder.

The damage criteria indicated in this manual may not apply to certain portions of specialty cylinders; the additional information needed to inspect these specialty cylinders is outlined in this section. Use the information in this section in conjunction with the damage inspection criteria defined in this manual to properly inspect specialty cylinders and evaluate any damage that may be present.

Contact Quantum Technical Assistance for any questions or concerns.



Fiberglass Wrapped Cylinders

Some cylinders will have an extra layer of fiber and resin to help protect the cylinder. This layer is composed of fiberglass resin and fibers. This layer will always have a white or opaque appearance. The pictures to the right both show cylinders with a fiberglass layer, the top picture has a white pigment in the resin to give it a pure white appearance.

The bottom picture has natural fiberglass resin with white fibers visible in the resin.

The fiberglass layer is only present over the hoop wrap or flat portion of the cylinder, there is not an extra layer of material present over the dome areas of the cylinder. There is no additional criterion for measuring or considering damage o the dome area of a fiberglass wrapped cylinder.

The fiberglass layer is a non structural layer; any damage to the fiberglass is considered cosmetic damage.

The fiberglass layer over these cylinders is 0.022" (0.56mm) thick.

Use the existing damage criteria defined in this manual when inspecting these cylinders, if any damage is present over the fiberglass wrapped portion of the cylinder, add the 0.022" (0.56mm) to the existing damage criteria.



EXAMPLE:

The damage criteria for a level 1 cut, scratch or abrasions is less than 0.010" (0.25 mm) deep. For damage in the fiberglass wrapped section of a cylinder, the level 1 damage criteria would be 0.032" (0.81 mm) deep.

Over time this fiberglass layer, if exposed to direct sunlight, may begin to yellow and may even become flaky. This is a normal condition for the fiberglass layer and does not indicate a problem.

It is strongly recommended that these cylinder be protected from direct sunlight to prevent this from occurring. If the cylinder has experienced UV damage, it may be painted to protect it from further damage.

Following the instruction in this manual for painting cylinders <u>Cylinder Repair Procedures</u>, paint the cylinder with white paint to ensure it is properly identified as a fiberglass wrapped cylinder.



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Cylinders with Integrated Isolators

Integrated Isolator Over-Wrap Inspection

Some cylinders have been constructed with the isolator integrated directly with the cylinder. The isolator is made of rubber and is fixed to the cylinder using wings that extend from the sides of the isolator groove. The wings are held in place under numerous layers of carbon fiber and resin called the over-wrap (1).

The carbon fiber used to retain the integrated isolator to the cylinder is not a structural component of the cylinder. Damage to the fiber added to the cylinder over the rubber wing of the isolator is not evaluated using the same criteria as the <u>Cylinder Wrap Inspection Procedure</u> mentioned in this manual.

The additional inspection items and criteria needed for

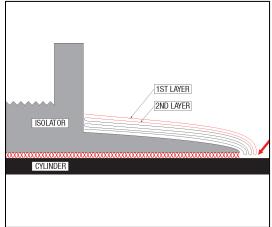
inspecting cylinders with integrated isolators is identified in this section.

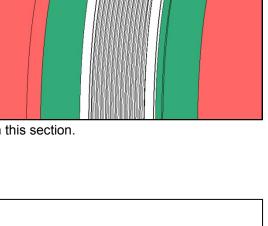
Edge Inspection

As part of the integrated isolator inspection, check for any damage or path that may allow for debris, water, or any contaminant intrusion under the isolator. Inspect for damage that may allow for intrusion at the point where the edge of the isolator wing meets the cylinder (See the red arrow in the illustration on the right).

Debris may cause abrasive damage to the resin and fiber under the integrated isolator. Debris is any abrasive or particulate, such as sand, that will work itself into an exposed opening or cavity.

Other contaminants such as chemicals, water, fuel, oils, etc., may attack the cylinder and/or the integrated isolators. If a breach or potential leak path is observed in the area shown, then the suspect area may be covered with a flexible sealer (such as silicone).





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End Inspection

Inspect the end joints of the integrated isolator. Search for paths where debris, liquids, or contaminants may intrude under the isolater (See photos to the right).

The photo to the right is showing possible intrusion paths. If the cavity appears to have contaminants, then take pictures and contact Quantum Technical Assistance.

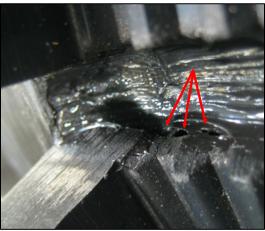
Repair any openings or leak paths observed before returning the cylinder into service.

The photo to the right has a tight seal between the integrated isolator and the cylinder. This tight seal passes inspection.

If damage is suspected at the edge or ends of the integrated isolator, take pictures and contact Quantum Technical Assistance for further direction.

The gap between the ends of the isolator may vary significantly. The distance within the gap does not indicate a problem.





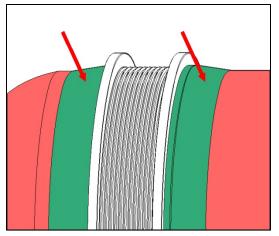




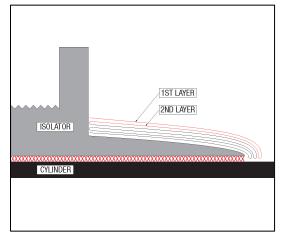
Over-Wrap Delamination Inspection

WARNING

The over-wrap delamination inspection is only for the fiber applied above the rubber wings of the integrated isolator (green area in the illustration to the right). Inspecting the fiber beyond the designated areas (red area in the illustration to the right) is not relevant to the integrated isolator delamination inspection and is not permitted. Performing the delamination repair procedure beyond the designated area is strictly prohibited and could result death or serious injury.



Delamination can be identified when the carbon fiber wrap lifts from the surface of the cylinder. The maximum number of layers that can delaminate and be repaired over the rubber wing of the isolator is two. A layer is defined as one winding of the carbon fiber wrap over the entire width of the isolator wing.



The photo on the right shows the fiber delaminating from the surface of the cylinder.

Inspect the cylinder thoroughly for damage locations. Mark and note the number of locations to be repaired (use masking tape if helpful).

If the cylinder can be repaired, then photograph and document the repair. Once the repair has been completed, store the photographs and documentation for future cylinder inspections. Keep a copy of the repairs with the vehicle if the vehicle is serviced at multiple locations.



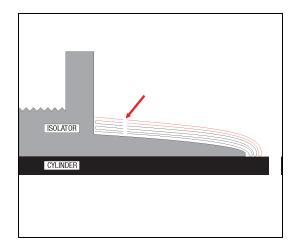


Separation Inspection

The CNG cylinder is a finished product that is structurally sound prior to the application of the rubber isolator and the carbon fiber over-wrap used to retain it. The flexible rubber isolator is then retained to the cylinder. Separation may occur in the carbon fiber overwrap due to normal movement between the cylinder and the rubber isolator.

Since the over-wrap is a non-structural component of the cylinder, no action or repair is required. The separation within the over-wrap is cosmetic and not a cause for concern. The separation may be covered with a flexible sealer (such as silicone) for appearances if desired.







General Damage Inspection

Damage Inspection (Scratch/Cut/Abrasion)

Damage that is contained or limited to the first two layers of fiber applied over the rubber wing of the integrated isolator may not be a cause for concern.

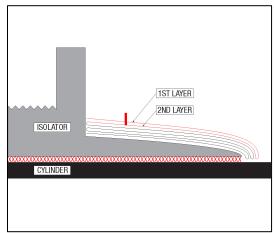
When damage to the fiber applied above the rubber wings of the integrated isolator has been observed, document the damage and determine the cause or source of the damage. If the damage does not cause fiber delamination or create a potential leak path where contamination may be allowed to penetrate under the rubber isolator, then no action is required. If delamination has occurred, refer to the <u>Delamination</u> <u>Inspection</u> section of this manual.

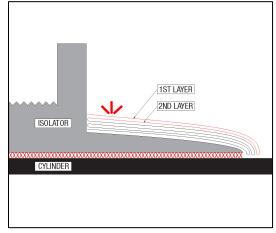
Always take pictures of the concern, measure the depth of the damage (if applicable), and keep a copy of the repairs with the vehicle if the vehicle is serviced at multiple locations. Contact Quantum Technical Assistance if you have any questions or concerns.

Damage Inspection (Impact/Heat/Chemical)

Other forms of damage may be caused by impact, chemical exposure, or other influences. This damage may affect the surrounding area or fiber (and cylinder in general). If the damage was caused by an impact, refer to the <u>Cylinder Impact Inspection</u> section in this manual, then contact Quantum Technical Assistance for further support if needed.

If the damage is caused by heat or chemical exposure, refer to the <u>Heat or Chemical Exposure</u> section in this manual.



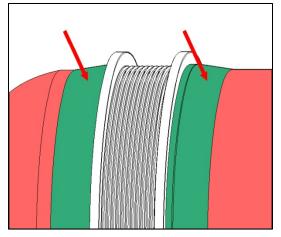




Over-Wrap Delamination Repair

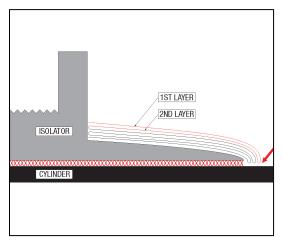
A DANGER

This over-wrap delamination repair procedure is only for the fiber applied above the rubber wings of the integrated isolator (green area in the illustration to the right). Repairs to the fiber beyond the designated areas (red area in the illustration to the right) are not permitted. Use of the delamination repair procedure on any other portion of the cylinder is strictly prohibited and will result death or serious injury.



Delamination repair procedure for fiber over integrated isolators (only):

- 1. If the delamination of the fiber wrap extends beyond 120 degrees around the cylinder, then trim off the excess delaminated fiber so that the loose fiber is 120 degrees around the cylinder or less.
- Document the amount of fiber removed. If the repair goes beyond 2 layers, do not proceed with the repair and contact Quantum Technical Assistance.



 Using lint free cloth soaked with isopropyl alcohol, thoroughly clean the surface of the cylinder at the delaminated location and the bottom side of the loose plies as far back as possible, without causing further delamination.





4. Prepare the surface area with a light sand using a 200-400 grit sandpaper. A light sand will remove contaminants and residue from the fiber as well as rough the surface for greater bond for the adhesive.



5. Clean the area again using isopropyl alcohol and a lint-free cloth. Allow time for the alcohol to dry. Any remaining residue, oils, or dirt will affect the repair and the adhesive's bond to the cylinder. Multiple repair attempts may be required if the surface area is not thoroughly cleaned.

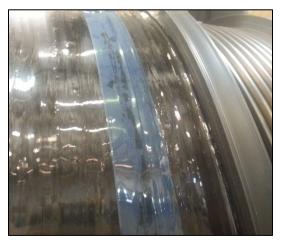
6. Apply Pliogrip[®] 7779 following the manufacturer instructions.





- Open the Pliogrip[®] application gun and insert the Pliogrip[®] adhesive cartridge. Remove the protective cap from the adhesive cartridge and install the mixing applicator.
- 8. Slowly squeeze the trigger on the application gun to prime the mixing applicator. Discard the first inch of material until the adhesive is uniform.
- Apply thin layer of adhesive underneath the delaminated plies and press down the plies. Apply a thin coat of adhesive on top of the delaminated plies.
- 10. Wrap repaired plies with polyester non-stick tape (such as D574-A from De-Comp Composites) to hold the plies in place during the cure cycle. Wrap the tape around the cylinder at least 1.5 times.
- 11. Allow 24 hour setting / curing time at room temperature.
- 12. Carefully remove the polyester film / tape.
- 13. Paint the area as specified in the <u>Cylinder Repair</u> <u>Procedures</u> section of this manual.





The materials needed for this repair are not typically available from local sources. Below is contact information where these products may be obtained.

Supplies	
Pliogrip 7779 (24 Pack)	Ellsworth Adhesives 877-454-9224
Polyester Non-Stick Tape D574-A	De-Comp Composites, Inc. 918-358-5881



General Cylinder Inspection

Heat or Chemical Exposure

Any indication that the vehicle has been involved in an accident or fire requires careful examination of the cylinders. Generally, if Type 4 cylinders are exposed to excessive heat, or any discoloration occurs that does not wash off, it is considered Level 3 damage.

The Quantum Type 4 cylinders are resistant to most acids and chemicals but some acids and chemicals can severely damage the cylinder. Cylinders suspected of being damaged by exposure to acids or chemicals should be depressurized as soon as possible to prevent rupture and be immediately removed from service.

Chemical damage can appear in the form of an alteration to the cylinder surface (e.g. corrosion, discoloration, etching, pitting, blistering and swelling). Chemical damage can also include softening, stress corrosion cracks and resin loss. In extreme cases, the composite can exhibit fractures and broken or loose fibers.

Exposure to excessive heat can not only affect the shell of the cylinder and compromise its strength, high heat levels can cause the liner of the cylinder to degrade or fail.

The allowable temperature range for these cylinders is -40° F (-40° C) to 185° F (85° C)

Fire or heat damage can be evident on exposed cylinder surfaces (e.g. burning, discoloration, darkening, charring or sooting of the surface, melted or deformed attachments or materials), severe exposure can result in resin removal and loose fibers.



Other indications of heat or fire exposure include burning; charring; discoloration of the coating, label or cylinder; and evidence of connection distortion, such as melted or deformed attachments or installation materials.

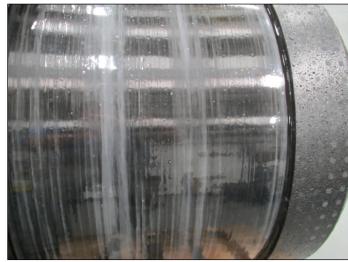
- Inspect the cylinder for heat exposure such as darkening or charring/sooting of the surface.
- Inspect for the following evidence chemical exposure:
 - Blistering of the external surface.
 - Localized swelling of the surface.
 - Softening of the surface finish.
 - Resin removal or loss by any means not attributed to mechanical action.
- Fracturing of the external sacrificial fibers by any means not attributed to mechanical action.
- Any cylinder with indications of heat or chemical exposure must be immediately removed from service. Refer to <u>Removing Cylinders from Service</u> in this manual.



Hazing

A hazy appearance in the resin may be normal due to the manufacturing process and does not indicate a potential problem or concern.

However, if the resin is hazy and is also rough or has a matte finish, then the discoloration or surface texture may be due to chemical exposure. Contact Quantum to determine if the cylinder surface is hazy from the manufacturing process or if the cylinder surface has been damaged due to chemical exposure.





Weathering Exposure

Quantum recommends that cylinders either in use or in storage are protected from road hazards, exhaust heat, vehicle use, and direct sunlight. However, Quantum's cylinders are designed to withstand exposure to direct sunlight for the life of the cylinder.

Inspect for excessive weathering exposure such as discoloration or, in very severe cases, light flaking of the surface coating. Repair weathering exposure by performing the procedures in <u>Cylinder Repair</u> <u>Procedures</u> in this manual.

Cylinders with a fiberglass layer are more susceptible to weathering damage and should not be exposed to direct sunlight in use or in storage. Excessive UV exposure will degrade the fiberglass layer resulting in a yellowing of the fiberglass layer and in severe cases flaking and loss of the fiberglass material.

Important: Any repair process should not remove surface material in excess of level 2a damage or the cylinder must be removed from service.

Blind Boss

In some tank designs a metal "blind boss" may be incorporated into the end of the cylinder opposite of the cylinder valve, to facilitate production.

This boss should be inspected as it can be a cause of concern if it becomes exposed and begins to corrode.

These blind bosses may be made of steel or aluminum so the corrosion may appear as red or white corrosion.

Repair Procedure

If the blind boss has become exposed and is showing visible corrosion:

- Clean any visible corrosion or contaminants from the area.
- Apply a zinc rich primer to the exposed metal and allow to dry.
- Paint the exposed metal with Rustoleum® black paint.
- After the paint has dried, fill and cover the blind boss with black RTV silicone.





Permeation

Permeation is a normal condition and does not indicate a problem with the cylinder.

It is normal to see bubbles or foam after liquid leak detection fluid is used over the surface of the cylinder.

All Type 4 cylinders are permeable. This means that the fuel molecules will pass through the cylinder liner material in small amounts. Due to the construction and materials used to build the cylinders, there will always be a small amount of gas that passes through the cylinder liner and escapes into the atmosphere.

As gas permeates the liner, it must escape from beneath or through the carbon fiber and resin. The gas will always follow the path of least resistance



and may result in gas escaping in concentrated areas or over the surface of the cylinder.

Maximum permeation rates are defined by industry standards as indicated on the cylinder certification label. All Quantum cylinders meet these requirements.

It is important to note that as Type 4 cylinders continue to grow in size, the total volume of acceptable permeation is increasing. While the allowable permeation rate is not changing, the increase in cylinder volumes is resulting in increased volumes of gas that may permeate from the cylinder.

The amount of permeation and how it is detected will vary based on cylinder size and other variables from manufacture. The cylinder permeation rates can only be accurately measured at the factory.

Loss of fuel from the cylinder due to leakage will exhibit a pressure loss observable on the pressure gauge in a period of time. If you suspect a cylinder leak, refer to <u>Cylinder Leakage</u> in this manual.

Handheld electronic gas detectors may trigger randomly over the surface of the cylinder due to normal levels of permeation and should not be used to determine if a cylinder leak exists.

If you have any questions or concerns regarding the information contained here, please contact our technical assistance department for clarification

If you are unsure about the condition of your cylinder, send a video to Quantum Technical Assistance at <u>QTService@qtww.com</u> and we will aid you in the assessment of the cylinder condition.



Cylinder Leakage

It is possible for a cylinder leak to occur if the liner is damaged on a Type 4 cylinder. A number of indicators may be used to determine if your cylinder is leaking:

- Excessive localized bubbling similar to the picture to the right or bubbling over a large area may indicate a cylinder leak is present.
- Gas visibly blowing leak detection fluid from the cylinder surface.
- Audible leak or persistent hissing is present.

If you believe any of the conditions above exist and may indicate a cylinder leak is present it is recommended that the cylinder pressure be monitored to confirm the existence of a leak.



Cylinder Pressure Drop Test

A pressure drop test will not provide accurate information if the test is being started less than 4 hours after a vehicle fill or if the starting temperature varies by more than approximately 20°F (11°C) at the end of the test.

- 1. If a system gauge is not present, install a test gauge in the system with a small enough scale to be capable of reading the pressure drop.
- 2. Note the system pressure, time and ambient temperature.
- 3. Isolate all the cylinders on the vehicle from each other by turning off the manual shut off valves.
- 4. Let the system stand for a 24 hour period.
- 5. Open one cylinder valve and record the cylinder pressure.
- 6. Close the cylinder valve.
- 7. Repeat steps 5-6 for the remaining suspect cylinders on the vehicle or system.
- 8. Any cylinder that has experienced a detectable pressure drop over a 24 hour period should be carefully inspected for any external source of a leak. It is important to note that significant temperature changes will result in significant pressure changes, if possible the temperature of the cylinder and gas should remain constant during this evaluation.
 - If a leak is indicated by the pressure drop test verify the cylinder valve connection and or PRD valves are not leaking before removing the cylinder from service.

Any cylinder that exhibits signs of gas leakage must be removed from service. Refer to <u>Removing</u> <u>Cylinders from Service</u> in this manual.

If you have any questions or concerns regarding the information contained here please contact our technical assistance department for clarification

If you are unsure about the condition of your cylinder, send a video to Quantum Technical Assistance at <u>QTService@qtww.com</u> and we will aid you in the assessment of the cylinder condition.



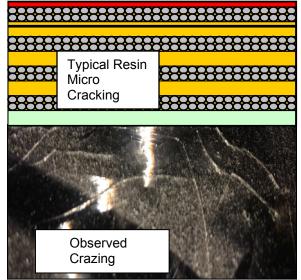
Crazing

Crazing is defined as micro-fracture of the resin coating or as "apparent fine cracks at or under the surface of an organic matrix". Crazing is common in fiber-reinforced composites, typically in a direction parallel to the fiber direction.

Crazing is a common occurrence in Type 4 pressure vessels. Quite often crazing is accompanied by audible noises as the strain is relieved in the resin. Occasionally crazing in fiber-reinforced structures may sound like a metallic object striking the pressure vessel or like a dull crack.

Crazing of the matrix material has no influence on the pressure vessel performance since the fiber material is mainly responsible for support of the pressure load. In a composite shell involving multiple layers of fiber at different angles, microfractures are often confined to a layer and do not propagate to the next layer of a different angle.

If crazing is observed on your Quantum Type 4 cylinder no repair is necessary. If you are uncertain if the suspect area being inspected is affected by crazing or another type of defect, contact Quantum for assistance.



Cylinder Resin Surface Defects

During the manufacturing process it is possible for bubbles to form and pop in the resin during the curing process. This can leave a crater type impression on the surface of the cylinder. This is a normal condition that does not require any action unless:

- Loose fiber is observed in the defect.
- The fiber is discolored in or around the defect.
- The resin is cracked or cut, allowing contamination into the area beneath the bubble.

This is considered Level 2A damage and should be repaired following the guidelines in <u>Cylinder Repair</u> <u>Procedures</u>.





Repaired Cylinders

For cylinders that have been repaired by Quantum for delamination, each will have an additional layer of resin and fiber. The thickness of the layers will range from 0.019-0.031" (0.5--0.8mm) of additional material.

The added reinforcement layers to the cylinder may affect how the cylinder fits within the cylinder mounting brackets. Longer length bolts may be required in order for the bracket to fit properly. If a Quantum cylinder mounting bracket is being used, adjust the spring height as specified in the instructions.



Cylinders that have had a delamination repair may exhibit another condition, due to the expansion of the cylinder the resin may separate from the original layer of resin and become opaque.

The cylinder in the picture to the right is exhibiting this condition; this is not a condition that needs to be corrected.

Cylinder delamination repairs performed before September 21, 2015 may appear to have this opaque appearance; cylinders repaired after September 21, 2015, have a black dye in the resin to alleviate this concern.

Contact Quantum Technical Assistance toll-free at 800.816.8691 for additional support.





Cylinder Dome Inspection

Foam end caps or domes are installed on some Quantum Type IV cylinders to protect the ends of the cylinder from damage during shipping and handling.

As a general rule, any cylinder installed in an Over The Road (OTR) application should have cylinder foam domes installed.

Select cylinders are not required to have cylinder foam domes installed, these are typically cylinders built under DOT special permits.

Blunt impact damage on Type IV cylinders is very hard to evaluate and can be dangerous. Extreme care must be taken to determine if any impact has occurred to the cylinder.

If the dome is damaged in any way it must be assumed that the cylinder has been impacted, the



impact damage would be concealed by the dome. In addition to the impact damage, there is also a concern of contaminant intrusion beneath the dome. If the outer covering of the dome is damaged this would allow for contaminants to be introduced and held between the cylinder and the dome.

Any damage to the dome on either end of the cylinder must be treated as level 2B damage.

At the time of publication, the only recommended service procedure for a damaged dome is return of the cylinder to Quantum for dome removal, inspection, testing and installation of a new dome.

If during a periodic inspection you find that a cylinder foam dome is missing, the cylinder must be thoroughly and carefully inspected to determine the cause of the foam dome loss. Inspect the end of the cylinder for evidence of mechanical damage, heat damage or chemical attack.

In the case of a missing foam dome, ANY evidence of damage of any kind in or around the foam dome area must automatically be treated as 2B damage. The final disposition of the cylinder will depend on the severity, location and direction of the damage to the cylinder. Contact Quantum for assistance dispositioning a cylinder with level 2b damage.

If no evidence of cylinder damage is found the cylinder may remain in service on the vehicle with no restrictions. If at any time the cylinder is removed from the vehicle, the cylinder must be returned to Quantum for installation of a new foam dome. Handling and installation of a CNG cylinder on a vehicle that is missing a foam dome is illegal, the cylinder must be repaired before use or installation.

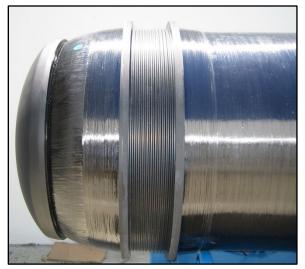
Cylinder Isolator Inspection

This inspection is only intended for Quantum cylinders that have been built with bracket isolators as part of the cylinder assembly.

It is not recommended to remove the straps from the cylinder to inspect the isolators unless there is reason to suspect that the isolator may be damaged or worn.

Inspect the isolator for evidence of contamination, this may be observed as bulging or softening of the isolator material, physical abnormalities or damage.

If possible, inspect the seam where the two ends of the isolator meet. While there will be a gap between the two ends of the isolator, this area should be sealed so as not to allow contaminants between the isolator and the cylinder. If there is



evidence of contaminant intrusion under the isolator, the cylinder should be removed for further inspection.

At this time if the isolator becomes damaged, worn or non serviceable in any way, there is no field repair or replacement procedure. The cylinder isolators can be replaced, but the cylinder must be sent to the factory for this repair.

Note: an extra layer of fiber has been applied to retain the isolators to the cylinder; damage to this layer of fiber may be evaluated differently than stated in the fiber inspection criteria in this manual. Any level 2B or level 3 damage to this area may be acceptable to repair. Contact Quantum for assistance in determining if a repair can be performed.

Refer to Cylinders with Integrated Isolators in this manual for additional information.



Cylinder Collar Inspection

Inspect the cylinder collar and mounting blocks for any signs of wear or degradation.

The fixed side block and mounting may be more susceptible to fatigue type failures where the slip side block may exhibit wear on the block and the collar.

Any movement or wear observed on the fixed end mounting collar or block should be addressed immediately.

Any movement of the cylinder boss or collar adapter in relation to the cylinder shell should be thoroughly inspected before returning the cylinder to service.

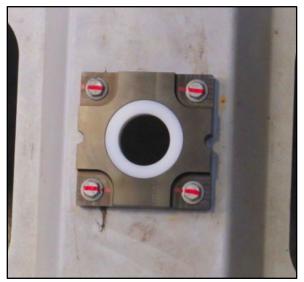


Inspect the slip side cylinder mounting pillow block collar and bushing for any signs of wear or degradation. Any wear or damage that may allow for a cylinder to move more than the specified amount should be addressed immediately.

Inspect for uneven wear of the ID of the pillow block bushing and verify it is still tight in the retaining block. Inspect the bushing for chips, cracks or any other physical damage to the bushing.

The tolerance for movement on the slip collar end of the cylinder is 0.250" (6 mm) of movement. Any movement beyond that amount should be corrected before returning the cylinder to service.

If wear is observed on the collar of the cylinder itself in excess of 0.125" (3 mm) the collar should be repaired.



Quantum makes cylinders with stainless steel and aluminum collars. When inspecting aluminum collars, any damage that has penetrated the anodize finish on the collar should be repaired to prevent corrosion.

Some cylinders may have different criteria for the collar wear, contact Quantum for any clarification that may be needed.

Cylinder Impact Inspection

WARNING

While all cylinder inspection items are somewhat subjective, the following inspections require an inspector with a higher level of experience. If there is any doubt as to the severity of the damage, return the cylinder to Quantum for a thorough inspection and test. Failure to properly identify cylinder damage may result in serious injury or death.

Impact damage differs from cuts or abrasions. More severe damage may occur within the wall of the cylinder and may not be readily apparent on the surface.

Blunt impact damage on Type 4 cylinders is very hard to evaluate and can be dangerous. Extreme care must be taken to determine if any deformation of the cylinder is present indicating fiber damage. A cylinder with any visible surface deformation must be immediately removed from service.

Return the cylinder to Quantum for a thorough inspection and test if there is any doubt as to the level of damage

Cylinder damage can be determined by the following methods:

- There is any visible deformation of the cylinder surface resembling denting.
- Softness or deflection of the cylinder wall. The cylinder wall should be rigid and not easily deformable.
- Localized areas of surface cracking. The cracks may have a localized circular, oval, or linear pattern.

If exposure to impact damage is suspected and cylinder condition cannot be determined, the cylinder must be removed from service. The "Tap Test" outlined below can be an aid in determining cylinder condition:

1. Tap the surface of the cylinder with a small metal object such as a large coin.

Important: The tap test is a subjective test and should only be performed by qualified personnel. The sound emitted in the cylindrical area of the cylinder will be different than the sound on the domes. The sound emitted by one area of the dome should be compared to a similar location of the opposing side of the dome

- 2. Compare the sound emitted in the suspect area to the sound emitted in an area where impact is not suspected.
- 3. Damage is present when the suspect area emits a sound that is different than other portions of the cylinder.
- 4. Remove from service any cylinder with suspected impact damage. Refer to <u>Removing Cylinders</u> <u>from Service</u> in this manual.

Cylinder Repair Procedures

Inspection and maintenance of this cylinder must be performed by competent personnel in accordance with all Federal, State, and Local regulations applicable to the application. Failure to properly identify and repair cylinder damage may result in serious injury or death.

Important: Only hand tools should be used during the repair process. Never exceed Level 2 specifications in making a repair. It is not required that the cylinder be removed from the vehicle during the repair process. The repair procedure shown below can be performed while the cylinder is pressurized.

Use the following procedures to repair Level 2 cuts or abrasions.

Resurface Level 2 cuts or abrasions before returning the cylinder to service by performing the following: 1. Remove any loose fibers.

- 2. Sand or hand-file the defect in order to remove any high spots and or taper the affected area.
- 3. Thoroughly clean the affected area with isopropyl alcohol and allow to dry.
- 4. Fill any low spots created with five-minute, fast-cure epoxy.
- 5. Paint small areas or scratches with touch-up paint. If painting the entire cylinder or large areas, use Sherwin Williams Polane HS Plus polyurethane paint or equivalent. Ensure the cylinder label(s) remain legible.

A DANGER

When painting cylinders, always paint them the same color as the original finish. All cylinders should be painted black except for fiberglass wrapped cylinders which should be painted white. Painting a standard cylinder white may cause an inspector to misidentify a cylinder which could result in a misclassification of damage. Failure to properly classify damage will result in death or serious injury.

Cylinder Collar Repair

At this time any wear observed on the cylinder collar should be reported to Quantum for evaluation and recommended corrective action if any.

Send pictures of any collar damage to <u>QTService@qtww.com</u>



Mounting Bracket Inspection Procedure

UANTUM

- Verify that the rubber isolator is properly seated on the cylinder brackets and straps.
- Inspect the rubber isolator for cracks, deterioration, or other damage.

Important: As a general rule do not verify the cylinder strap nut torque on a pressurized cylinder unless approved by the bracket manufacturer. A composite cylinder will expand and contract as the internal pressure increases and decreases. In order to compensate for expansion and contraction the cylinder strap rubber isolator is designed to deform slightly. The rubber isolators will eventually settle somewhat causing cylinder strap nut torque to vary from factory installed torque.

- Replace the rubber isolators whenever the cylinder straps are removed or loosened.
- Inspect the cylinder brackets, straps, mounting frame, and mounting hardware for cracks, corrosion, deformation, or other damage.
- Replace any parts that are suspect or found to be damaged or defective.

Regulatory Inspection and Requalification

Some cylinders built under DOT special permits require periodic requalification:

• A cylinder built under DOT SP-16524 is required to be requalified every 5 years, refer to the conditions and procedures noted in the special permit for details.

Certain regulations require that the cylinders be periodically re-qualified through visual inspection:

- In the US, every three years or 36,000 miles. (DOT FMVSS304)
- In Canada, every 36 months (CSA B51-4.1.4.1, 2009)

In addition, re-qualification is recommended when:

- A cylinder without test records is to be transferred to a vehicle
- A cylinder is transferred from one vehicle to another vehicle. (Example: OEM to retrofit vehicle)
- A cylinder is involved in a motor vehicle accident or fire.

Cylinder requalification or regulatory inspection can be satisfied by visual inspection of the cylinder using the guidelines defined in this manual.

In order to ensure that the cylinders are fit for continued safe use, the inspection shall be carried out exclusively by persons competent to do so. The inspector shall have available and within easy access during the inspection, the equipment and the documentation needed to complete the task.

The vehicle to be inspected shall be positioned in such a way that the inspector has unimpeded access to the surface of the cylinder.

If specific inspection criteria are required and cannot be found in this document, reference ISO 19078. In the event a conflict exists between this document and ISO 19078, the inspection criteria defined in this document should take precedent.



Cylinder Cleaning Procedures

Exterior Cylinder Cleaning

Cylinder cleaning is necessary to properly inspect for any cylinder damage that may have occurred since the last inspection.

In general, it would be safe to assume that anything that you would use to wash the painted surface of your vehicle should be safe for the cylinder if used in the same concentrations.

The exterior of the cylinder can be cleaned using water alone or water and a mild detergent such as Simple Green®. If a detergent is used, rinse the cylinder thoroughly with clean water.

DO NOT use a pressure washer or steam cleaner as the label or dome on the cylinder may be damaged.

Interior Cylinder Cleaning

Over time the CNG cylinder may accumulate water and oils, the interior of the cylinder can be cleaned using water alone or water and a mild detergent such as Simple Green®. If a detergent is used, rinse the cylinder thoroughly with clean water.

CAUTION

The cylinder may be damaged if solvents or chemicals are used to clean the interior of the cylinder. Do not use pressure washing or steam cleaning equipment to clean the interior of the cylinder.

Do not use sharp instruments or tools to clean inside the CNG cylinder or the cylinder liner may be damaged. Failure to follow this instruction may result in personal injury or damage.

Important: CNG cylinder cleaning is only necessary when a CNG system component has failed due to fuel contamination or when excess water and oil accumulation, that may reduce fuel capacity, is suspected within the cylinder.

Allow the cylinder to dry thoroughly before reassembly. Do not apply heat. If compressed air is used to help clean or dry the interior of the cylinder, use clean, dry air regulated to approximately 40 psi.



Collision Repairs

If the fuel storage system has been involved in an accident the fuel storage system and all fuel carrying components must be inspected for damage. The energy from the accident could be transferred to any component within the fuel storage system. Use a leak detection device or Snoop[®] to check for any leakage.

A DANGER

If vehicle paint repairs are required, the cylinder cannot be subjected to temperatures over 185°F (85°C) or the fuel cylinder liner may be damaged. The cylinder may also be equipped with over pressure relief devices. Heating the fuel will cause an increase in system pressure. If the fuel storage system is full when subjected to extreme temperatures, the pressure relief devices may be activated. Subjecting the cylinder to temperatures over 185°F will result in death or serious injury.

Do not use paint ovens to accelerate the paint curing process on equipment with CNG storage systems.

WARNING

If the fuel storage system is involved in a collision where the cylinder was directly impacted or an air bag deployment occurred, the cylinder should be removed from service. The fuel storage system must not be operated until it has been thoroughly inspected by a qualified CNG technician. Failure to inspect the fuel storage system could result in death or serious injury.

An impact from a collision may transfer inertial energy to components on the fuel storage system. In addition to inspecting the cylinder for damage and checking for leaks, it is important to check the cylinder mounting brackets. Check the alignment and condition of the cylinder mounting brackets and isolators.

National Fire Protection Association NFPA 52-2019 (16.3.5.2.1) states, "Where a vehicle is involved in an accident or fire causing damage to any part of the CNG fuel system, the system shall be repaired and retested (see Section 16.3.8) before being returned to service."

Canadian Gas Association CSA-B51 (4.1.4.2) states, "Cylinders that have been involved in a vehicular collision shall be re-inspected by an agency authorized by the manufacturer and, if required, by the authority having jurisdiction. A cylinder that has not experienced impact damage from a collision may be returned to service; otherwise, it shall be returned to the manufacturer for evaluation."



Valve/PRD Replacement

A DANGER

A malfunctioning valve may result in incomplete depressurization of the cylinder. Removing a valve or PRD from a pressurized cylinder may propel the valve being removed. Verify that there is no pressure present in the cylinder before removing the valve or PRD. Failure to do so may result in death or serious injury.

Failure to use approved valve and PRD may cause cylinder rupture. Only use valves and PRDs that are approved for use in your cylinder. Failure to do so may result in serious injury or death.

CAUTION

Do not remove or replace factory-installed valves without prior approval from Quantum Fuel Systems. Failure to do so may result in damage to cylinder.

NOTICE

Unauthorized removal of the valve and/or the regulator will void the warranty.

Certain models of the Quantum cylinders are supplied with factory-installed valves.

Regulatory approvals require that valve/PRD/cylinder combinations be tested in standard bonfire tests. It is critical that each cylinder be fitted with the tested and approved valve and PRD (Pressure Relief Device).

For cylinders supplied without a valve, follow the valve manufacturer's instructions for installation.

Only install Quantum-approved valves and PRD(s). Contact Quantum for a list of approved components for your cylinder(s).



Removing Cylinders from Service

Failure to remove traces of flammable vapor or gas may lead to dangerous explosions of disposed cylinders. Cylinders must be purged of flammable vapors before disposal. Failure to do so may result in serious injury or death.

Cylinders that have been damaged, or exceed the lifespan indicated on the cylinder label, may be at risk of gas leakage. These cylinders must be removed from service and disposed of according to applicable laws and regulations. Failure to do so may result in serious injury or death.

Decommissioning Procedure

The CNG fuel cylinder has a predetermined service life from the date of manufacture. The fuel cylinder "DO NOT USE AFTER DATE" appears on a label on the cylinder. The fuel cylinder expiration date is also located on the fill area label.

Any fuel cylinder in service beyond the date indicated on the cylinder label or that exhibits level 3 damage or greater must be removed from service with the following procedure:

- 1. Vent and purge the cylinder. Refer to *Purge Instructions* in this manual.
- 2. Clearly mark the cylinder as "CONDEMNED".
- 3. Disconnect the vent hose.
- 4. Remove the cylinder from the vehicle. Refer to the latest service procedures.
- 5. Place the cylinder outside in a well ventilated area.
- 6. Allow the cylinder to stand for 24 hours with the cylinder valve manually held open.
- 7. With a non-electric drill and with the cylinder valve removed, drill a hole with a 1/2 inch diameter or greater completely through the cylinder wall and inner liner at the end of the cylinder serial number. Do not drill through and destroy the serial number.
- 8. Dispose of the cylinder in a safe and approved manner. A properly decommissioned cylinder is considered solid waste by most authorities. If in doubt, contact your local disposal regulatory agency for disposal requirements.

Other Available Specifications and Information

ANSI/NFPA 52 Compressed Natural Gas Vehicular Fuel Systems

Canadian Gas Association CGA B146.4 - M1991-NGV Installation Code

FMVSS/CMVSS 303/304

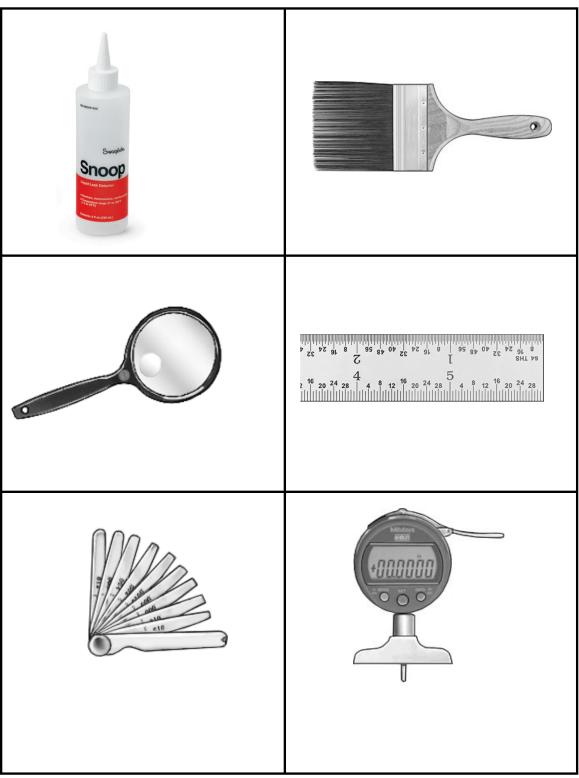
NGV-2

Limited Warranty for Composite Cylinders

For information regarding your cylinder warranty coverage, refer to our limited warranty statement available at www.com/warranty

You may also contact our technical assistance department with any questions or concerns at 800.816.8691 or visit <u>www.qtww.com</u>.





Appendix A – Typical Inspection and Repair Equipment







Appendix B - Sample Inspection Form

Vehicle Year:

Vehicle Make: _____

Vehicle Model:

Mileage: _____

Cylinder #	1	2	3	4
Manufacturer				
Serial Number				
Location (position)				

P = Pass X = Fail C = Correction made (see notes)

Cylinder Inspection Point	1	2	3	4
Verify cylinder installation is compliant with NFPA and MVSS regulations.				
Verify cylinder and mounting bracket are clean.				
Verify cylinder strap isolators are in place and in good condition.				
Verify cylinder mounting bracket and attachment points are in good condition.				
Verify cylinder labeling is in place and legible.				
Verify cylinder expiration dates have not been exceeded.				
Inspect for any signs of fire or extreme heat exposure are evident.				
Inspect for signs of physical damage to the cylinder bracket or adjacent				
area.				
Inspect for signs of corrosion or chemical damage to the cylinder bracket.				
Inspect for signs of chemical or physical damage to the cylinder.				
Verify the correct PRD and Valve are installed in the cylinder.				
Inspect for wear or damage to the PRD or cylinder valve assemblies.				
Inspect any vent system for proper installation or damage				
Check the cylinder boss, valve and lines for leakage.				

Inspection results:

Cylinder(s) returned to service

Cylinder(s) repaired or removed from service. Explain Below

Explanation of cylinder repairs or disposition (use back if more space is needed)

Date:

name

Inspector (print): Inspector Signature:

Appendix C - Sample Cylinder Inspection Record Form



Fuel Cylinder Inspection Record

Tank Serial Number _____

Tank Expiration Date _____

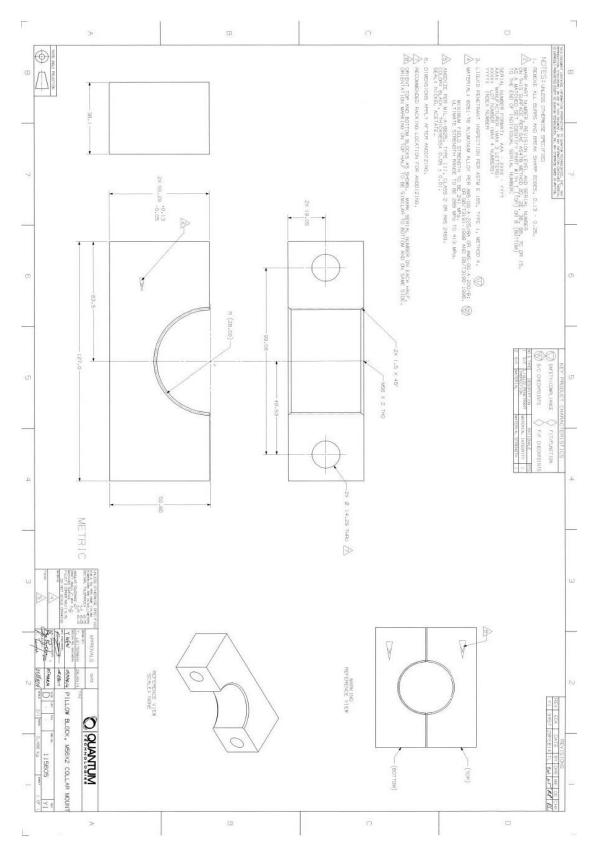
Vehicle VIN

Inspection Interval (Mileage or Years)	Inspection Date	Inspector	Inspector Initials	Type of Repair*

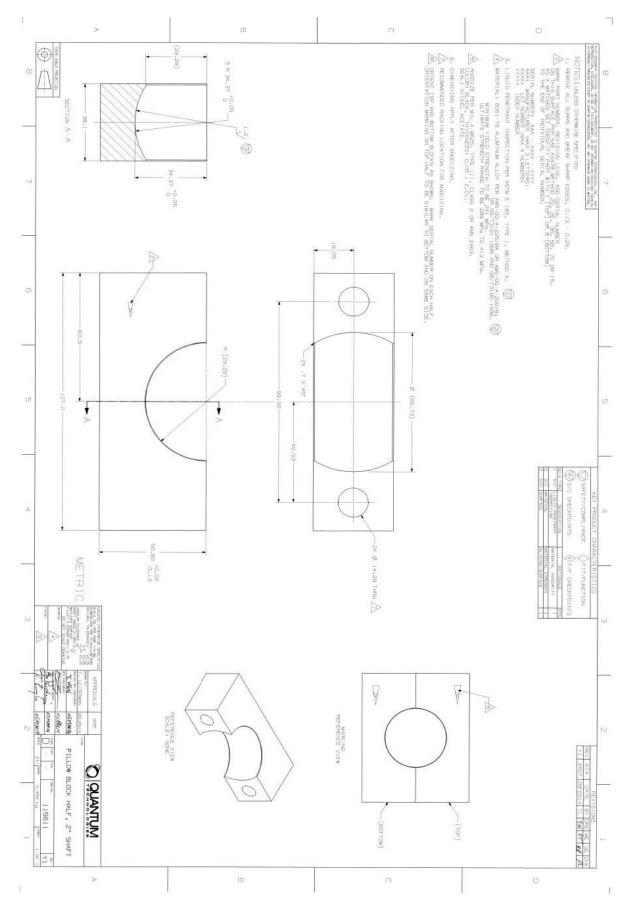
*Record the type of repair as None, Level1, Level2, or Exchanged. See "Cylinder Inspection" in the *Type 4 Cylinder* Installation and Maintenance Guide applicable to your cylinder (available at WWW.QTWW.COMQUALITY) for the inspection criteria.



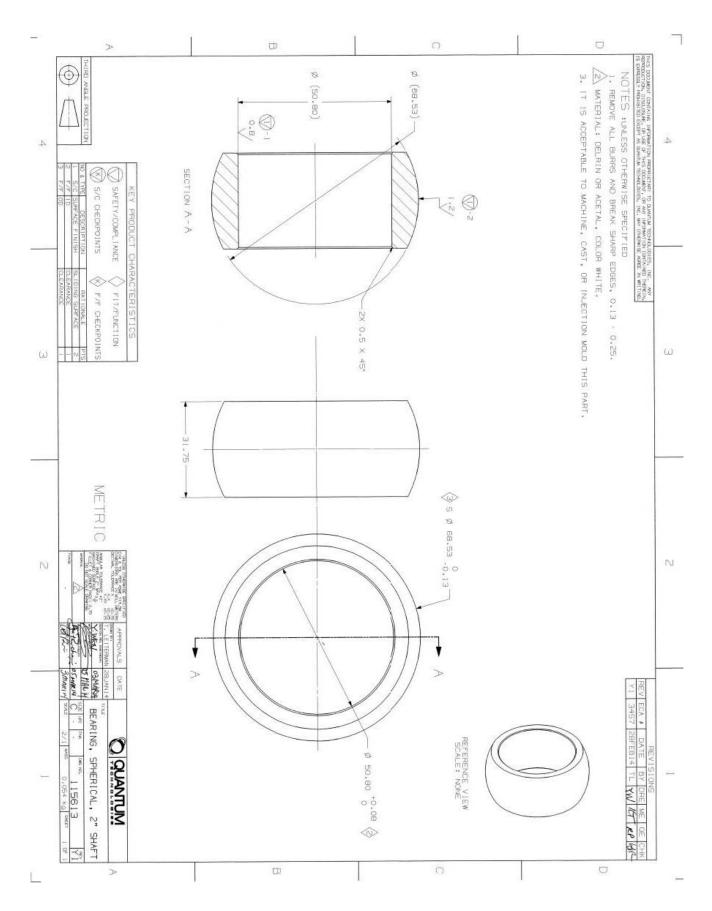
Appendix D – Drawings







CNG Cylinder Installation and Maintenance Guide



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Notes



Notes



Revision History

Revision A, 10/4/2011 Initial Release

Revision B 4/12/13

Add inspection criteria for domes, amend UV warnings, update inspection pictures, add repair procedures for damage and blind boss, add cleaning procedures, change company information, add integrated isolator information, add valve boss rotation statement, correct various typographical errors, add inspection instructions, update warranty statement, clarify heat and chemical damage, clarify inspection and requalification of cylinders.

Revision C 7/2/13

Updated purging data, updated cylinder bracket location graphics and text, typographical errors, and updated logos throughout the guide. Added disclaimer to the back of the guide.

Revision D 10/7/13

Updated hyperlinks, added repaired cylinder section, photos, caution formatting, and text.

Revision E

Revision F

Revision G

Revision H

Revision J 5/24/16

Revised Initial fill and Leak testing sections to comprehend permeation issues. Revised cylinder leak section for clarification. Added basic information for collar mounted cylinders. Added Permeation section. Remove warranty statements.

Revision K 2/28/17

Updated all references from Quantum Technologies to Quantum Fuel Systems. Revised Cylinder leakage section, revised cylinder venting section.

Added information for fiberglass wrapped cylinders as needed throughout manual.

Revision L 5/2021

Update to include special permit cylinders and collar mount content.



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