CP Industries

Operating Manual

Type IV Compressed Gas Cylinders

16 Inch Diameter Full Carbon 3600 psi Cylinder Design

Manufactured by:

CP Industries A Division of CP Industries Holding, Inc.

2214 Walnut St. McKeesport, PA 15132

1.412.664.6604

http://www.cp-industries.com

Table of Contents

1 General Information

1.1 General

This operating manual provides the instructions for safe installation, use, maintenance, and inspection procedures of CP Industries Type IV Composite Compressed Natural Gas (CNG) cylinder. These cylinders are designed, manufactured, and tested by CP Industries, a Division of CP Industries Holding, Inc.

The operating manual should be easily accessible. In addition to the operating manual, the valid legal and authoritative rules for accident prevention and environmental protection must be adhered to. In the event the Operating Manual is not available, a copy can be obtained from CP Industries upon request.

This composite gas cylinder should only be handled by employees that have read and understood the operation manual. In particular, the safety notes must be observed at all times to reduce the risk of personal injury.

Personal protective equipment must be used by every employee at a minimum according to prevailing regulations, without specific instructions being issued in the operating manual.

All possible risks, notices, cautions and warnings cannot be mentioned in this operation manual. CP Industries Inc. cannot possibly warn of every potential hazardous risk associated with the operation of this gas cylinder.

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

CP Industries A Division of CP Industries Holding, Inc.

2214 Walnut St. McKeesport, PA 15132

Tel: 1.412.664.6604

1.2 Requirements for Inspectors

Inspectors are required to pass an accredited high pressure CNG fuel system for motor vehicles training course before executing any kind of test. They must be familiar with natural gas and applicable regulations as well as applicable safety instructions for the handling of natural gas storage systems and they must have read and understood the Operating Manual for CNG Type IV cylinders.

1.3 Safety Sign Description

Prohibitory Signs

Unauthorized entry prohibited. Work is to be performed by authorized personnel only

No smoking

No fire or open flames

Warning Signs

Warning of a dangerous point or safety notice.

Warning of fire.

Warning of potential explosion.

Warning of cold surfaces.

Commandment signs

Be careful!

Use ear protection

Use protective gloves

1.4 Relevant Standards

In addition to the operating manual, the following regulations must be observed depending on the design specification of the specific cylinder (as indicated on the label):

1.4.1 ANSI NGV 2, FMVSS304, CSA B51

1.5 Definitions and Description of Terms

Axial Length

A measure used to quantify the size of material condition. The axial length is the length of the condition measured perpendicular to the fiber direction.

Abrasion

Damage to the cylinder or supports caused by wearing, grinding or rubbing away of material by friction. Abrasion can be the result of many cycles of something rubbing lightly on the surface of the cylinder or equipment, or due to a few cycles, perhaps only one, of heavy rubbing.

Material Condition

Material Condition refers to a range of anomalies that occur in the cylinder material. These conditions include for example cuts/scratches, abrasions, fractures, delamination and impact damage.

Acceptable Condition

Occurs when an anomaly associated with the cylinder material is within CP Industries acceptable range and does not affect the safe operation of the cylinder. These conditions do not require repair and the cylinder may remain in service, however, cosmetic repairs that minimize the risk of personal injury from stray fibres may be carried out at the operator's discretion.

Unacceptable Condition

Occurs when an anomaly associated with the cylinder material is outside of CP Industries acceptable range. When these conditions occur the cylinder must be removed from service and either returned to CP Industries for recertification or disposed of appropriately.

Impact

Forceful blow to the surface of the cylinder that can cut, gouge or significantly indent the surface. Impact can also induce such damage as delamination or subsurface cracking, which may not be readily apparent through visual examination.

Condemned

Cylinder or piece of equipment in a state no longer fit for service and for which repair is not allowed.

Crazing

Hairline cracking of the resin, giving it an opaque, frosty appearance.

Cut

Damage caused by a sharp object coming into contact with the surface of the cylinder.

Delamination

A form of composite damage where a separation develops within the composite material.

Discoloration

The change in resin color that occurs over time especially when exposed to ultraviolet radiation.

Domes

Curved end portions of the fuel cylinder

Fissure

A circumferential void in the final hoop layer that is caused by an overlap of twisted fiber bands.

Pure Resin Layer

The non-structural outermost surface of the cylinder which contains no fiber material.

Resin Flaking

Occurs when sections of the pure resin layer are dislodged from the final hoop layer leaving composite material exposed.

Fibre fracture

A break in the composite material where both fiber and resin fracture.

Final hoop layer.

The outermost composite layer (fibers in the hoop direction).

Helical layer

Winding in the longitudinal circumferential direction for both the cylindrical and dome regions of the cylinder.

Hoop Direction

Winding in the cylindrical region of the cylinder perpendicular to the longitudinal axis of the cylinder.

Circumferential Resin Fracture

A cracking of the pure resin layer parallel to final hoop layer fibers.

Axial Resin Fracture

A cracking of the pure resin layer perpendicular to the fibers of the final hoop layer.

Inspection Mark

Mark, label or tag placed by an inspector on the cylinder indicating acceptance/rejection of the cylinder,

Winding Termination Anomaly

At the end of the winding process, the last section of fiber can create a raised section on the surface of the cylinder. This surface anomaly is often confused for delamination but does not affect the safe operation of the cylinder.

2 Proper Use and Description of CP Industries Composite CNG cylinder

The cylinder is for storage of compressed natural gas (CNG). The cylinder is attached to a vehicle and has to remain attached to the vehicle during service, unless tests are to be conducted on the gas cylinder, or the gas cylinder has to be removed for other reasons.

2.1 Compressed Natural Gas (CNG)

Natural gas is a flammable gas which is lighter than air and rises upwards. The gas is invisible and can be only detected by odorizing (the addition of an odorous substance).

Smoking near gas cylinders is strictly prohibited!

Physical Characteristics of Natural Gas

Explosions limits in air: 4 to 17 Vol%

Density at 20°C: 0.7 to 1.00 kg/m³

Ignition temperature: approx. 640°C

It must be ensured, that the natural gas is in accordance with local requirements and in accordance to regulations marked on the cylinder label.

2.2 Cylinder Description

CP Industries Type IV full carbon cylinders consist of a high density polyethylene liner, fully wrapped with a full carbon fiber / resin matrix, configured with dual neck ports and neck mounting brackets

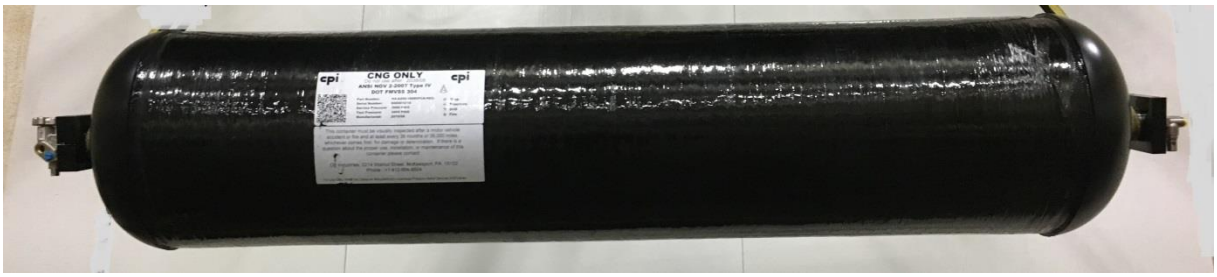


Figure 2.1: CPI Full Carbon Neck Mount Cylinder

2.3 General Technical Data

The technical information listed on the label must be observed. Additional detailed information can be found in the design standard associated with the cylinder

2.3.1 Service Life

The maximum cylinder service life as specified by the standard is 20 years. This is defined on the cylinder label as “DO NOT USE AFTER” with the date listed. The cylinder cannot be used beyond the “DO NOT USE AFTER” date and must be destroyed (refer to section 8).

2.3.2 Service Pressure

The maximum service pressure of the cylinder, as indicated on the cylinder label, is 3600 psi and must not be exceeded. The service pressure is reached when the uniform gas temperature is allowed to settle down to 21°C (70°F) after filling.

2.3.3 Filling Pressure

Maximum filling pressure must not exceed 125% of the service pressure.

2.3.4 Temperature Range

CP Industries gas cylinder are designed and tested for a settled gas temperature ranging from -40°C (-40°F) to 85°C (185°F).

2.4 Cylinder Marking

The information listed below is permanently attached to the gas cylinder as a sticker on the surface. This label must be visible and must not be removed. If the label becomes damaged or illegible, please contact **CP Industries Inc.**

Label example:

This container must be visually inspected after a motor vehicle accident or fire and at least every 36 months or 36,000 miles, whichever comes first, for damage or deterioration. Mounting shall be in accordance with the container manufacturer's instructions. If there is a question about the proper use, installation, or maintenance of this container please contact:

CP Industries, 2214 Walnut Street, McKeesport, PA 15132
Phone: +1 412-664-6604
For Use Only With The Container Manufacturer's Approved Pressure Relief Devices And Valves

CNG ONLY	Designed, manufactured and tested for compressed natural gas only
CPI Industries	Gas cylinder manufacturer
Do not use after	After exceeding the maximum lifetime, the gas cylinder has to be decommissioned. Date is shown in Year / Month
Type approval	Approval certificate issued to standard e.g. NGV 2-2016 by certified institute.
According to	The gas cylinder is approved according DOT FMVSS 304 by an independent technical inspection agency
Part Number	Part number of the cylinder
Serial Number	Individual continuous serial number of the cylinder
Service Pressure	As defined above
Test Pressure	Cylinders are tested by hydrostatic test to prove leak tightness and strength as defined in the standard associated with the cylinder
Manufactured	Date of cylinder manufacturing. Date is shown in Year / Month
Safety Signs	Do not DROP PUNCTURE DRILL or expose to FIRE

2.5 In the event of an accident or fire

2.5.1 Accident

Gas cylinders which have been involved in collisions, accidents or other events that may cause damage must be inspected by CP Industries or an authorized inspector. Continued use of the gas cylinder without expressed permission from the manufacturer is not allowed. Condemned cylinders must be removed from service and destroyed (refer to section 8).

2.5.2 Fire

Gas cylinders which have been exposed to a fire event must be removed from service and destroyed (refer to section 8).

3 Storage, Transport, Operation

Use proper personnel protective equipment during handling of cylinders. Minimum Steel-Toe Boots and protective gloves

If an uninstalled gas cylinder is transported, it must be verified that the cylinder is not pressurized. Exercise caution to guarantee that the cylinder is not damaged by mechanical or other means during handling and transport.

The cylinder can be lifted by using textile lifting slings, fixed to the cylinder cylindrical body or at the necks (bosses), but exercise caution not to damaging the valves and end plugs.

Do not handle the cylinders by their valves, fittings, piping, or pressure relief devices.

The cylinder should not be stored on concrete floors or other hard surfaces. Soft isolation materials, such as foam, rubber, or wood must be placed under the cylinder during transportation and storage to prevent damage to the external surface.

Verify that the cylinders are restrained from rolling or moving during transport and storage.

Cylinders should be stored in a clean and dry environment.

Protect cylinders from UV radiation at all times. If cylinders must be stored temporarily outside in the full sunlight, a tarp or other cover should be used to shield the cylinders from UV radiation.

Mechanical work near the cylinder such as drilling, grinding and sawing is prohibited.

Although cylinders are equipped with drop protection, a drop from any height greater than 12” can potentially cause damage that is difficult to quantify and as such must be reported to CP Industries.

If damage is detected CP Industries Inc. must be informed.

4 Installation

Work must be performed by authorized personnel only!

Use proper personal protective equipment during handling of cylinders. Minimum Steel-Toe Boots and protective gloves

This section describes the installation of a CP Industries full carbon dual port neck mount CNG cylinder and its components.

For this type of cylinder, the standard installation position is horizontal. Vertical installation is possible, but requires special mounting hardware and considerations and will not be addressed here.

4.1 Cylinder assembly

The “Cylinder Neck” bosses indicated in Figure 4.1. Pos. 2 and 3 are shipped fully assembled by CPI and should not be disassembled or otherwise tampered with by unauthorized personnel. Additionally, it is not possible to gain access to the O-ring or sealing surface via the one piece boss system.

CP Industries accepts no liability for damage resulting from improper installation.

4.2 Cylinder and Components Diagram

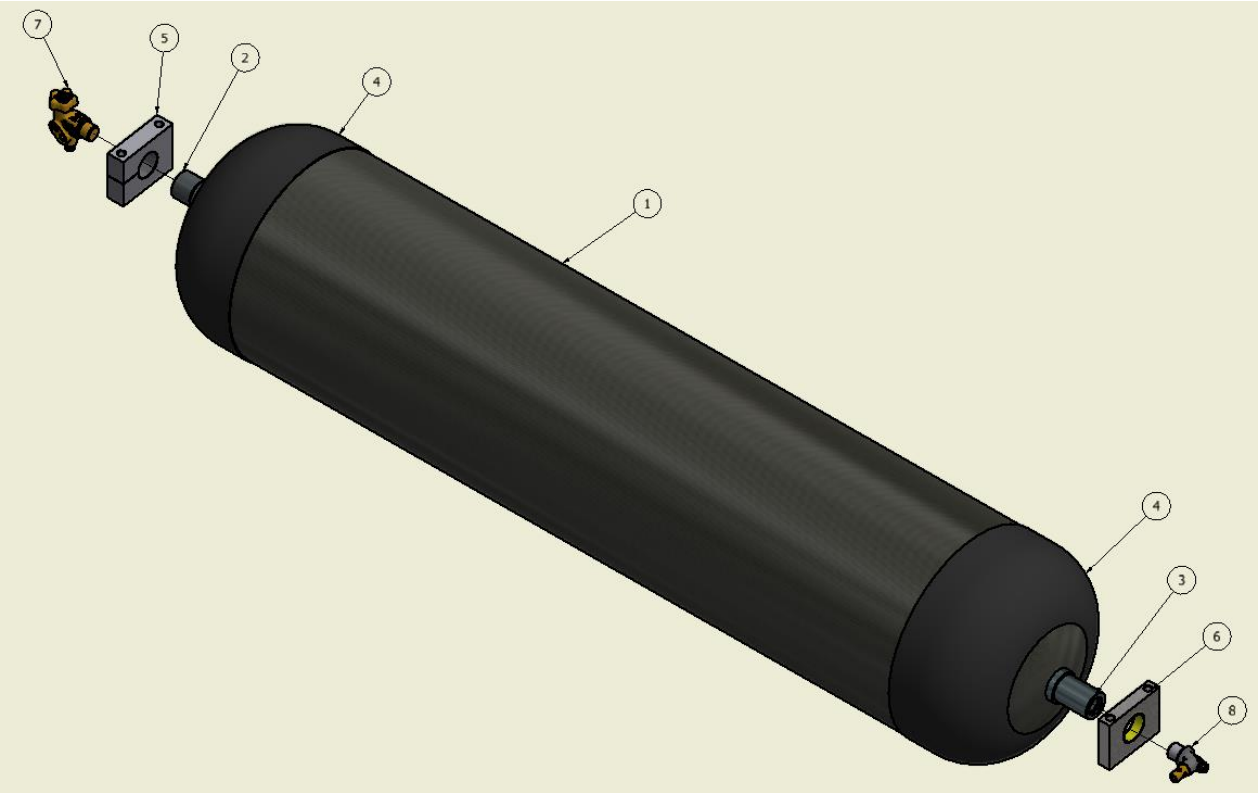


Figure: 4.1

Pos.	Description
1	CPI Cylinder
2	Cylinder Neck Fixed Side (Threaded)
3	Cylinder Neck Sliding Side
4	PUR Protection Cap
5	Fixed Neck Bracket (Threaded)
6	Sliding Neck Bracket
7	Cylinder Valve with PRD
8	Cylinder PRD

4.3 Neck Mounting

For this cylinder design, CP Industries relies on neck mounting brackets which create the mechanical connection between the necks, or bosses, of the cylinder and the supporting frame of the vehicle to which the cylinder is to be connected. Please note that there is a fixed bracket side and a sliding bracket side to secure the extended cylinder necks as indicated in Figure 4.2 below. The brackets are made of anodized aluminum. The valve must be installed at the fixed bracket side. The end plug PRD must be installed at the sliding bracket side. The sliding bracket side features a spherical plastic bearing, which allows for axial growth of the cylinder due to expansion during pressurization and the subsequent contraction of the cylinder during depressurization, and compensates for minor misalignment that may exist in the installation.

Fixed bracket side Sliding bracket side

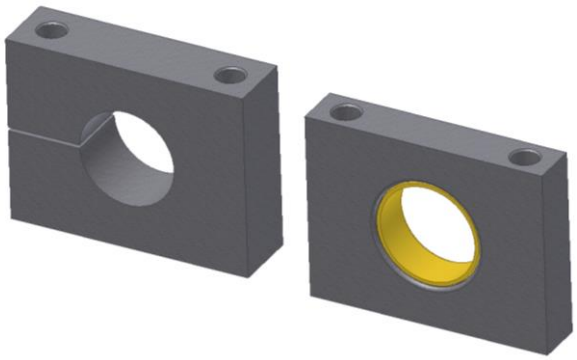


Figure 4.2

Each bracket must be installed with two ½" Grade 8 bolts, two washers, and two self-locking nuts. Clamping torque must be compatible to the screw material strength. For a ½"-20 Grade 8 Cap Screw, recommended torque is 65 lbf ft (88 Nm).

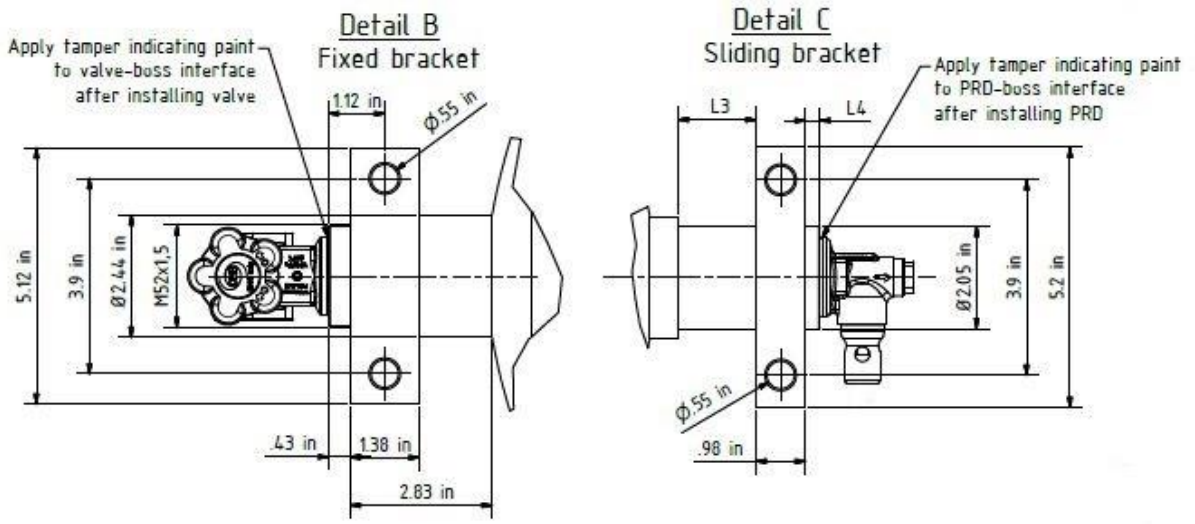


Figure 4.3

CP Industries neck mount cylinders are delivered with the fixed bracket and valve pre-installed. Therefore, for initial installation, removal of the valve is not necessary. Similarly, CP Industries neck mount cylinders are delivered with the sliding bracket and end plugs pre-installed. For initial installation, removal of the end plug/PRD is not necessary.

Depending on manufacturing process, the cylinders have a length tolerance of ±5mm. The sliding bracket compensates for this length variation and also allows for axial growth of the cylinder under pressure. Figure 4.3 shows the assembly condition with nominal cylinder length. In the assembled condition the bracket position can vary from L3=34.6 mm to L3=44.6 mm or L4=12.6 mm to L4=2.6 mm. Dimensions L3" and "L4" (Figure 4) should be verified during installation.

The cylinder must be installed in an unpressurized state.

4.4 Cylinder Installation Location

CP Industries cylinders must be protected from full exposure to the potentially harsh environmental conditions encountered on commercial vehicles, including direct sunlight, chemical attack from vehicle fluids, impact damage from road debris, and excessive exhaust heat. This is generally accomplished via a protective enclosure. Similar consideration must be given to cylinders in storage prior to deployment on a vehicle, these cylinders should be stored in a clean environment, protected from direct sunlight and weather.

4.5 Valve Installation

During installation of the valve, please follow precisely all the points listed below.

Please note that there is a fixed bracket side and a sliding bracket side for neck mount cylinders. The valve must be installed on the shorter fixed bracket side.

4.5.1 Installation valve with 1 1/8”-12 UNF thread

Only CPI authorized valves and relief devices are to be used. This cylinder configuration currently requires:

Component	Part No.	Description
Valve	696UULAVATH	OMB Beta New Manual Valve w Std TPRD
Valve	696UULYVALH	OMB Beta New Manual Valve w ESA TPRD
Valve	691A113B4C7H	OMB Lyra Automatic Valve w Live Port
End Plug	90520.0-S2	VTI SP 260 End Plug TPRD

Ensure that the thread of the valve is compatible to the cylinder threads. CP Industries cylinders have a connecting thread of 1 1/8”-12 UNF-2B with an O-ring seal.

Check all threads for damage and dirt. Pay especially close attention to the O-ring, it must be clean and free of any damage. Remove dirt with a clean cloth and solvent such as acetone. Damaged parts must be replaced.

Always use new O-rings, and lubricate for installation. The lubricant must comply with the requirements in the valid relevant standard and environmental conditions. CP Industries recommends OKS®1110 Multi-Silicone Grease.

Check the valve and the supporting brackets for damage. During preparation and assembly, the cylinders must be handled carefully. Any impact, drop damage or other visible damage (e.g. scratches or notches t > 0.5mm or surface damage) must be recorded and reported to CPI as soon as possible.

Additionally, to prevent damage to the O-ring, always position it at the top of the threads on the valve during installation (as opposed to in the O-ring groove of the cylinder boss).

Some valves, for example the OMB Beta, can be installed using an appropriately sized standard open end wrench attachment and a torque wrench (as shown on the left hand side of Figure 4.4. Other valves, such as the OMB Lyra, require a custom valve adapter provided by the valve manufacturer in combination with a torque wrench as shown on the right hand side of Figure 4.4. The appropriate installation torque for the OMB Beta and Lyra valves is 100 to 130 Nm. The cylinder must be held securely during valve installation and torque application. The PRD’s are fragile, exercise special care not to damage them during the installation process!

More detailed information specific to OMB manual and automatic valves can be found at www.omb-saleri.it/manuals/.

Figure 4.4

4.6 Cylinder Depressurization

This work must be performed by authorized personnel only.

No fire or open flames

In the event it becomes necessary to fully depressurize a cylinder, caution must be exercised to guarantee that the process is completed safely. Additionally, any legal or environmental requirements for the jurisdiction where the depressurization is to take place must be adhered to. It is advantageous whenever possible to transfer the CNG into another storage container to reduce the pressure. When venting the compressed gas directly to the atmosphere, do so in an open area with plenty of ventilation, completely free of personnel and all ignition sources. Use of additional tubing to direct the compressed gas up and into the atmosphere away from building structures is required. During the depressurization process, the cylinder / vent tubing must be grounded to prevent the potential buildup / discharge of static electricity. The depressurization process should be performed gradually to avoid unnecessary and avoidable stress and potential damage to the plastic liner of the Type 4 cylinder. CP Industries recommends a maximum rate of 200 kg per hour. Cylinders must be fully restrained to prevent potential unintended movement during the depressurization process.

4.7 Valve Removal

The cylinder must be completely depressurized prior to removal of the valve!

This work must be performed by authorized personnel only.

No fire or open flames

Double check that the cylinder is completely depressurized and securely held in position. Use the custom manufacturer-supplied valve tool (if required) to turn the valve counterclockwise to remove. Exercise caution to avoid damage to the PRD.

4.8 End Plug Installation / Removal

Please note that there is a fixed bracket side and a sliding bracket side for neck mount cylinders. The end plug must be installed on the longer sliding bracket side.

Only CPI authorized end plugs and relief devices are to be used. For a listing of approved end plugs/relief devices, please refer to section 4.5.1 above. For this particular cylinder, only one option is currently available, the VTI SP 260 as indicated.

Ensure that the thread of the end plug is compatible to the cylinder threads. CP Industries cylinders have a connecting thread of 1 1/8”-12 UNF-2B with an O-ring compression seal.

Check all threads for damage and dirt. Pay especially close attention to the O-ring, it must be clean and free of any damage. Remove dirt with a clean cloth and solvent such as acetone. Damaged parts must be replaced.

Specialized tooling may be required to make the adaptation from a torque wrench to the VTI SP260 end plug, as shown in Figure 4.5. The appropriate installation torque for the VTI SP 260 end plug PRD is 130 Nm + 8 Nm. The cylinder must be held securely during valve installation and torque application. Refer to section 4.7 Valve removal, follow same process and precautions for end plug removal. More detailed information specific to VTI end plug PRD’s can be found at www.vti.de/en/products/automotive.

Figure 4.5

5 Service, Maintenance and Inspection

5.1 Safety Notes

Please be aware of the important safety notices listed below when working on the cylinder and its components.

- Always use the proper personnel protective equipment. Steel-toe boots, gloves, glasses and helmet.
- Do not release gas from the cylinder in the vicinity of other people.
- When depressurizing the cylinder by releasing the gas to the atmosphere, be sure to perform this operation in well-ventilated areas only. Transfer of the excess gas into another storage system is recommended.
- Never allow a cylinder to drop to the ground or impact any surface. Refer to section 3.
-  No fire, exposed flames, or smoking allowed.
- Clear the working area of any potential ignition sources.
- Treat every fitting and port as if it is fully pressurized, open slowly and carefully.
- Cylinder inspection and maintenance must be performed by qualified technicians experienced at working with pressurized gas systems.
- During depressurization, the cylinder must be grounded.

5.2 Cylinder Inspection Guidelines

Documents and guidelines relevant to the operation and inspection of CNG cylinders and fuel systems include (but are not limited to) the following:

- NFPA 52 Vehicular Natural Gas Fuel System Code
- Federal Motor Vehicle Safety Standards FMVSS 304
- CSA/ANSI NGV 2 Compressed Natural Gas Vehicle Fuel Containers
- Compressed Gas Association CGA C-6.4 Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations
- The cylinder manufacturer guidelines and instructions

CPI guidelines and instructions (this operating manual) should be afforded top priority. In the event of a conflict, the most stringent recommendations/requirements apply. Anything not specifically addressed in the CPI manual should defer to CGA-6.4.

5.3 Types of Inspection

Four types, or levels of inspection should be employed for the operation and maintenance of CNG vehicles:

1. Pre-Service Visual Inspection: This is the first level of inspection on the entire CNG system that should be completed before the vehicle is put into service. Consists of a thorough inspection of all components performed by a qualified inspector. Enclosure covers/panels are removed to gain full access.
2. Cursory Visual Inspection: This is the second level of inspection, typically performed on a daily basis by the operator of the vehicle. For this inspection, enclosure covers/panels are typically not removed as the inspection is focused on the exposed surfaces of the CNG fuel system. This inspection is identifying anything at the surface that could be indicative of damage that has occurred to the CNG fuel system as a result of daily operation.
3. General Visual Inspection: This is the third level of inspection, which would coincide with normal preventative maintenance activities. This inspection, could be performed by the operator of the vehicle or other maintenance personnel, consists of a more detailed visual examination of the exposed surfaces of the CNG system, without removal of enclosure covers and panels.
4. Detailed Visual Inspection: This is the fourth level of inspection, also referred to as periodic inspection, which consists of a thorough inspection of the entire CNG system. This inspection, which is performed by a certified/qualified inspector, will require removal of all enclosure covers and panels to gain full access to the cylinder(s) and CNG system. In this case, the inspector will identify any type of damage, including cuts, abrasions, dents, gouges, thermal/chemical attack, etc.

5.4 Periodic Cylinder inspection

The installed gas cylinder must be visually inspected every 36 months or 36,000 miles, whichever comes first, as indicated on the cylinder label. The test intervals and procedures are defined in the appropriate standards associated with the cylinder (ANSI NGV 2, FMVSS 304), and any national regulations which may apply. For additional questions, please contact CP Industries.

In addition to the required periodic cylinder inspection, it is recommended that the cylinder be visually inspected every 1 to 3 months, to ensure that the cylinder itself and the mounting brackets are secure and in good condition. After reading and understanding this manual, this type of intermediate inspection can be performed by the operator, maintenance personal or other technical workers.

After any accident or exposure, the cylinder must be removed from the vehicle and tested/evaluated prior to reinstallation. Examples of accidents include collision, unusual corrosion, and exposure to fire or chemicals such as strong acids or bases. Additionally, in the event that a cylinder or cylinders are removed from one vehicle and transferred to another, a periodic cylinder inspection is required.

The cylinder owner must maintain inspection reports for the life of the cylinder.

5.4.1 Types of Cylinder Damage

Cylinder damage can be categorized into five general areas based on the source of the damage:

1. Damage caused by cuts, scratches, and abrasions
2. Damage caused by impact
3. Damage caused by excessive heat or fire
4. Damage caused by exposure to chemical attack
5. Damage caused by weathering or UV light

5.4.2 Damage Levels

There are four damage levels, 1, 2a, 2b, and 3 (listed in order of increasing severity). The damage level due to scratch, cut, or abrasion is quantified by depth of the damage. Therefore, the depth of the damage must be measured to determine the damage level and appropriate course of action. Other types of damage, such as impact damage, or damage by fire or chemical attack, are more difficult to quantify and are therefore assigned serious damage levels. A table summarizing damage levels and the corresponding damage types associated with them is shown below.

Damage Levels	Damage Types	Damage Depth (for cuts, scratches, abrasions, gouges)	Appropriate Action
Level 1	Minor abrasion or scratch, fiber gaps	0 ≤ 0.25 mm	Customer rework, sand rough edges, paint w polyurethane paint
Level 2a	Scratches and cuts, loose fiber, fiber gaps or unraveling	0.26 ≤ 0.89 mm	Customer rework, remove loose fiber, sand rough edges, paint w polyurethane paint
Level 2b	More significant cuts/scratches, fiber damage	0.90 ≤ 1.27 mm	Remove cylinder from service, factory inspection and possible repair
Level 3	Deep gouge, impact damage, fire exposure, chemical attack	> 1.27 mm	Remove cylinder from service, condemn

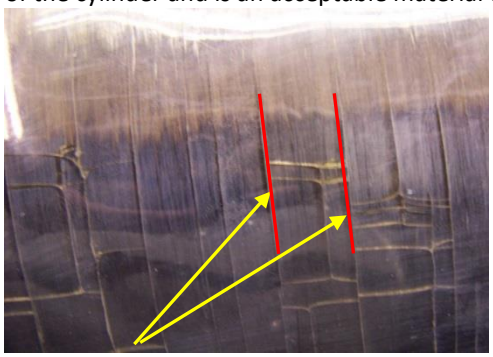
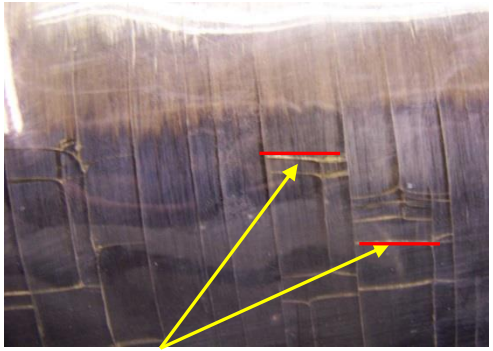
5.4.3 Visual Inspection of cylinder surface

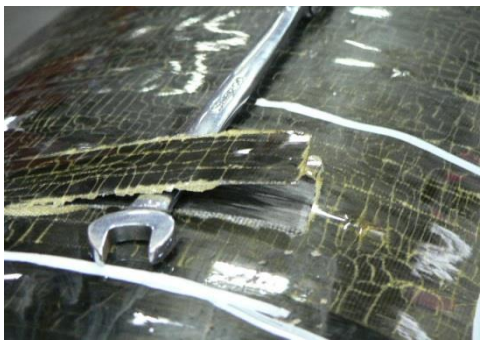
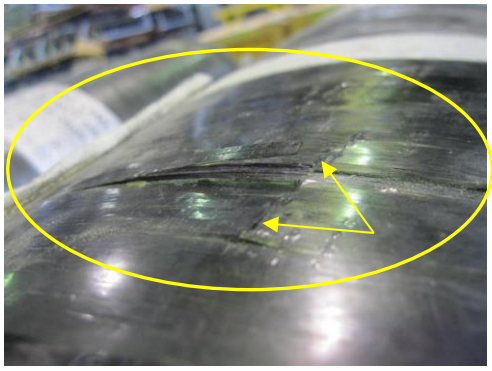
The following table describes the various composite material conditions that may be encountered during visual inspections, and provides guidance on classifying such conditions as acceptable or unacceptable.

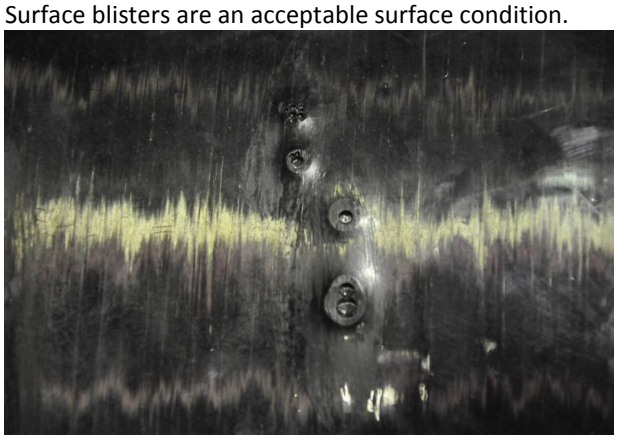
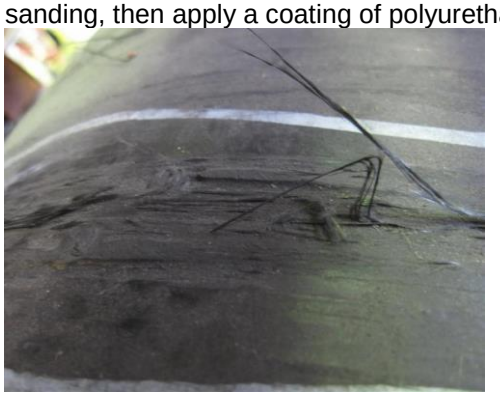
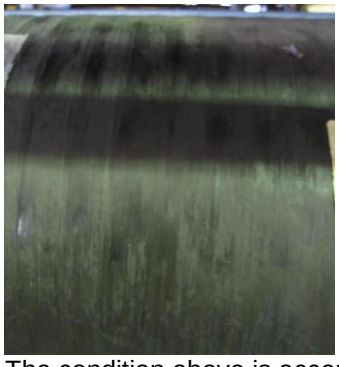
If any part of the cylinder label is not legible, missing, or peeling, please contact CP Industries.

The surface of the cylinder should be clean and free of any dirt or residue, anything which could interfere with or prevent a proper visual inspection. Additionally, enclosure covers and access panels should be removed to support a complete visual inspection. In some cases, improved lighting, mirrors, or even a borescope or camera may be necessary to inspect the entire surface of the cylinder.

CP Industries cylinders are individually produced, so visual differences between the cylinders may be observed on occasion. Minor aesthetic flaws may be present on the surface of the cylinder, examples of which are listed in the table below. These aesthetic flaws are a normal result of the manufacturing process and have no impact on the mechanical integrity, functionality, or performance of the cylinder. As a result, no modification or repair is necessary.

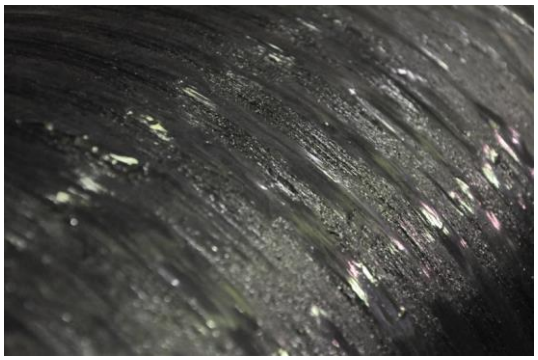
Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.1 Circumferential Resin Fracture	Circumferential resin fractures only occur in the pure resin layer. This type of fracture does not affect the safe operation of the cylinder and is an acceptable material condition.  Circumferential resin fracture	None
5.4.3.2 Axial Resin Fracture	Axial resin fracture only occurs in the pure resin layer. This type of fracture does not affect the safe operation of the cylinder and is an acceptable material condition.  Axial resin fracture	None.
5.4.3.3 Micro Cracking / Crazing	Micro cracking / crazing can occur occasionally in the pure resin layer following hydrostatic testing. This type of fracture does not affect the safe operation of the cylinder and is an acceptable material condition. 	None.

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.4 Fiber Fracture and Consequential Delamination	Acceptable limits for fiber fracture are as follows: Local fractures no longer than 200mm in axial length within the final hoop layer are acceptable provided the associated delamination area does not exceed 24,000mm^2.  The above photograph illustrates delamination, however in this case it is caused not by fiber fracture but as a result of the winding termination anomaly.  The above photograph illustrates delamination as a result of fiber fracture. The fibers of the final hoop layer were fractured as a result of a cut.	Any fiber fracture exceeding the acceptable limits.

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.5 Blisters	Surface blisters are conditions which exist in the pure resin layer and do not affect the safe operation of the cylinder. Surface blisters are an acceptable surface condition. 	None.
5.4.3.6 Borderline resin impregnation of the final hoop layer ("Hairy appearance")	It may occur that less than adequate resin impregnation can lead to conditions where fibers of the final hoop layer are not fully impregnated with resin. In this case the fibers will not be rigid. (i.e. fibers are flexible and appear "hairy"). Loose fiber should be removed by sanding, then apply a coating of polyurethane paint.  If this condition is present on less than 50% of the cylinder surface, the condition is acceptable.  The condition above is acceptable.	Where the borderline resin impregnation (hairy) condition is present on more than 50% of the cylinder surface.

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.7 Abrasion	Damage Level 1: Abrasion damage to the final hoop layer is acceptable provided it is less than 0.25mm, not longer than 200mm in axial length and the associated area does not exceed 24,000mm^2 	Level 2: Abrasion depth is greater than 0,25mm (0,01in) and less than 0,75mm (0,03in). It is necessary to repair the cylinder. This has to be done by hand, no machines allowed. First, the loose fiber has to be removed. Sand and deburr the abrasion in order to reducing the affected area. Fill any lower areas with ambient temperature fast curing epoxy resin. Level 3: Abrasion deeper than the final hoop layer, exceeding 24mm^2 in area or deeper than 0,75mm, remove cylinder from service. See chapter “8 Cylinder Destruction”

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.8 Cut / Scratch / Gouge	Cuts/scratches/gouges in the pure resin layer are acceptable regardless of length. Cuts/scratches/gouges within the final hoop layer are acceptable provided they are no longer than 200mm in axial length and are no deeper than the final hoop layer. 	Any Cuts / scratches / gouges exceeding the acceptable limits
		None.

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.9 Resin Discoloration	Changes in resin color from near clear to a darker brown is a normal process.  Discoloration of resin does not affect the safe operation of the cylinder and is an acceptable material condition.	None.
5.4.3.10 Chemical Attack	None. 	Any permanent signs of chemical attack. The cylinder shall be removed from service.
5.4.3.11 Fire Damage	None	Any permanent signs of fire damage. The cylinder shall be removed from service.

Material Condition	Acceptable Condition	Unacceptable Condition
5.4.3.12 Winding Termination Anomaly	The point on the cylinder surface where the winding terminates can often be seen as a raised section resembling delamination. This raised section of the cylinder is a result of the manufacturing process. This anomaly can result in delamination which must remain within acceptable delamination limits. 	None.

5.4.3.13 Mounting Inspection

Make sure connected parts do not yield to axial compression, are not damaged or bent, show no signs of corrosion and do not have any metal on metal contact. Check all connected parts (e.g. tank/storage fittings and/or gas bearing conduits).

For neck mounted cylinders verify that the plastic bushing on the floating cylinder side is not experiencing excessive wear. If the bushing is worn out or damaged, it must be replaced. Check the torque of the bracket screws, if necessary re-tighten the screw to the required torque.

5.4.3.14 Valve / End Plug PRD Inspection

The cylinder valves and end plug PRD's must be in perfect condition to operate properly. Damaged parts must be replaced immediately.

5.4.3.15 Protection Cap inspection

Protection caps must not exhibit any signs of damage such as cuts or abrasions. In this event the polyurethane cap must be replaced and reapplied using an RTV-based adhesive.

Verify that the adherence of the protection caps is sufficient to prevent loss of contact with the cylinder within the next inspection period. If the protection cap is not sufficiently secured, re-apply it using an RTV-based adhesive.

Protection cap is detached and must be re-secured.

Protection cap remains attached to the dome although the edge is starting to lift. Acceptable

The protection caps are an integral part of the cylinder design and must be installed properly. Alteration or removal of the protection caps is strictly prohibited.

5.4.3.16 Gas Leakage

Leaking cylinders must be removed from service and condemned. If potential gas leakage is suspected, perhaps by an audible indication or the distinct odor of natural gas, move the cylinder and compressed fuel system to an outdoor location with plenty of ventilation and contact CP Industries for additional information.

6 Sample-checklist for CP Industries Cylinder and individual inspections

CP INDUSTRIES
A Division of CP Industries Holdings, Inc.

2214 Walnut Street
McKeesport, PA 15132-7098
Tel: 412-664-6604

CYLINDER INSPECTION REPORT	
Date of Inspection:	
Inspector Name:	
Cylinder Manufacturer:	
Cylinder Model Number:	
Cylinder Serial Number:	
Cylinder Mounting Configuration:	
Vehicle Make and Model:	
Vehicle Mileage:	

	INSPECTION POINTS	ACCEPT	REJECT	COMMENTS
1	Cylinder/brackets are clean			
2	Brackets/attachment points are in good condition			
3	Condition of strap mounting pads/neck mount bushings			
4	Cylinder label is in place and legible			
5	Cylinder service life not exceeded			
6	Valve condition			
7	TPRD condition			
8	End plug condition			
9	Protection cap condition			
10	Fuel line condition			
11	Vent line condition, free of debris?			
12	Indication of fire, extreme heat?			
13	Indication of corrosion or chemical attack?			
14	Indication of weathering damage?			
15	Indication of cut, scratch, or abrasion?			
16	Indication of impact damage?			

Inspection Results:		Return to service
		Repair or remove from service
Disposition Explanation:		
Inspector Name (print):		
Inspector Signature:		

The leader in pressure vessel technology since 1897

All inspection criteria must be met for the cylinder to pass inspection. The check list must be filled in again after completing any necessary repairs.

Passing the entire inspection is only possible if all vessels of the gas storage system have passed their individual inspections.

7 Cylinder Decommissioning / Destruction

Composite cylinders which have failed leak testing, exhibit Level 3 damage, or have exceeded the lifespan indicated on the cylinder label, must be destroyed such that there is no possibility they can be reused. Additionally, the cylinder failing testing or inspection should immediately be clearly marked as “CONDEMNED” and be prepared for proper disposal and removal from service.

Before destroying the cylinder, it must be safely depressurized and the tank must be purged with nitrogen a minimum of three times. This is extremely important to prevent the potential formation of a combustible gas mixture. Caution must be exercised to guarantee that the depressurization process is completed safely. Additionally, any legal or environmental requirements for the jurisdiction where the depressurization is to take place must be adhered to. It is advantageous whenever possible to transfer the CNG into another storage container to reduce the pressure. When venting the compressed gas directly to the atmosphere, do so in an open area with plenty of ventilation, completely free of personnel and all ignition sources. Use of additional tubing to direct the compressed gas up and into the atmosphere away from building structures is required. During the depressurization process, the cylinder / vent tubing must be grounded to prevent the potential buildup / discharge of static electricity. Cylinders must be fully restrained to prevent potential unintended movement during the depressurization process.

Once the cylinder has been properly purged and completely depressurized, the cylinder valve and end plug PRD must be carefully removed. The cylinder must be held securely in place during valve / end plug removal. Specialized tooling may be required to make the adaptation to the valve and end plug. Turn the valve / end plug counterclockwise to remove.

Once the cylinder has been completely depressurized, purged, and the valve and end plug PRD have been carefully removed, the decommissioning / destruction process can be completed. Two holes must be drilled completely through the wall (composite fiber wrapping and HDPE liner) of the cylinder with a minimum diameter of 12mm or 1/2 in (refer to Figure 7.1 below).

Figure 7.1: Destruction of the cylinder by drilling two 12mm holes through the label.

Prior to drilling the holes, put on the appropriate personal protective equipment. At a minimum, the PPE for this operation must include safety glasses/face shield, dust mask, lab coat, and gloves as shown in Figure 7.1. The holes should be drilled directly through the cylinder label, as indicated in Figures 7.1 and 7.2, to emphasize that the cylinder has been decommissioned / condemned.

Additionally, “Condemned” along with the date of decommissioning must be written legibly across the cylinder label using an indelible marker or paint pen as shown in Figure 7.2. Finally, “Condemned” and the date of decommissioning should also be written on the body of the cylinder using a paint pen or an indelible marker to guarantee that it is fully understood that the cylinder has been decommissioned. A cylinder destroyed and decommissioned in this fashion is considered solid waste by most municipalities and can be disposed of safely.

Figure 7.2: Destroyed cylinder with two 12mm holes through the label, marked as “CONDEMNED” on the label and the cylinder body