

G-Stor™

Carbon Composite Cylinder

User Manual

Alternative Fuel Cylinders



Guide to the use, maintenance and periodic inspection of Luxfer carbon composite AF cylinders



Table of Contents

1.0	<i>Introduction</i>	4
1.1	Distribution and proper use of this manual.....	4
1.2	Applicability	4
2.0	<i>Product description</i>	5
2.1	Cylinder identification and labels.....	6
3.0	<i>Operating conditions</i>	8
3.1	Gas composition	8
3.2	Service life.....	8
4.0	<i>Cylinder handling, storage and installation</i>	10
4.1	Handling.....	10
4.2	Storage.....	10
4.3	Preliminary inspection	10
4.4	Installation	11
4.4.1	Cylinder installation and protection	11
4.4.2	Mounting cylinders	11
4.4.3	Strap or band or “belly” mounting	12
4.4.4	Neck mounting	13
4.5	Valve and pressure-relief device (PRD) installation and removal.....	14
4.5.1	Valve and/or plug installation.....	14
4.5.2	Valve and/or plug removal	15
4.5.3	Pressure-relief device (PRD)	15
5.0	<i>Fueling (filling) and defueling (evacuating) cylinders</i>	18
5.1	Filling.....	18
5.1.1	Initial filling (fueling).....	18
5.1.2	Standard filling (refueling)	19
5.2	Defueling.....	20
6.0	<i>Inspection</i>	21
6.1	Mounting inspection	21
6.2	Fuel system inspection	21
6.3	Cylinder inspection	21
6.3.1	General system inspection	22
6.3.2	Periodic inspection	23
6.3.3	Inspection training	23
6.4	Recommended equipment	24
6.4.1	Inspection tools	24
6.4.2	Cut measurement	25
6.4.3	Abrasion measurement	26

6.5	Types of damage	28
6.5.1	Cuts, scratches and gouges.....	28
6.5.2	Fire and heat damage	30
6.5.3	Chemical attack	32
6.5.4	Weathering	33
6.5.5	Abrasion.....	33
6.5.6	Impact damage	35
6.5.7	Disbond and delamination.....	36
6.6	Leak Testing.....	37
6.5.7	Background Information on Gas Leakage and Permeation	37
6.6.2	Inspection guidelines for determining gas leakage	38
6.6.2.1	Using leak detection fluid	38
6.6.2.2	Using a flammable gas detector	38
6.7	Table of damage levels	39
7.0	Repair	41
7.1	Repair tools	41
7.2	Repair procedure.....	41
7.3	Repairing delamination	44
8.0	<i>Destruction of condemned or expired cylinders</i>	49
9.0	Summary.....	49
9.1	Care and maintenance	49

1.0 Introduction

Luxfer carbon composite fully wrapped (Type 3: aluminum-lined and Type 4: plastic-lined) and hoop-wrapped (Type 2: aluminum-lined) cylinders are among the lightest gas cylinders available for alternative fuel applications. These products, which meet the needs of many end users in alternative fuel (AF) applications, offer a lightweight storage solution for compressed natural gas (CNG).

High-pressure carbon composite cylinders are designed to be durable for the demanding usage they receive. Nevertheless, like all compressed gas equipment components, cylinders must be well maintained and properly used. This guide is intended to assist trained personnel in safely operating, valving, installing and inspecting Luxfer composite AF cylinders.

You must be familiar not only with Luxfer's instructions about properly and safely filling your Luxfer composite cylinders, but also with all applicable filling guidelines, regulations, requirements and laws of all appropriate local and/or national authorities and industry organizations.

1.1 Distribution and proper use of this manual

This document must be provided to all parties involved in distributing, handling, installing, inspecting and using Luxfer composite AF cylinders. The manual may be reproduced to provide sufficient copies for this purpose, but its contents must not be altered in any way. Luxfer accepts neither responsibility nor liability for consequences resulting from unauthorized alternations to this manual or for failure to follow the instructions herein.

1.2 Applicability

This manual applies to cylinders used in the storage of compressed natural gas (CNG) as *a vehicle fuel only* and does not address all unique requirements for cylinders used to store CNG for bulk transport in commerce.

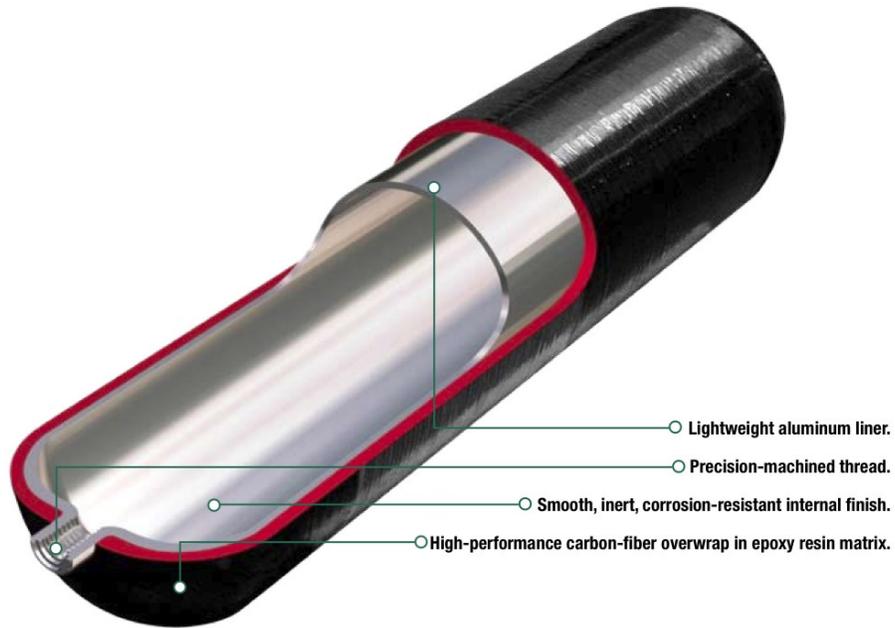
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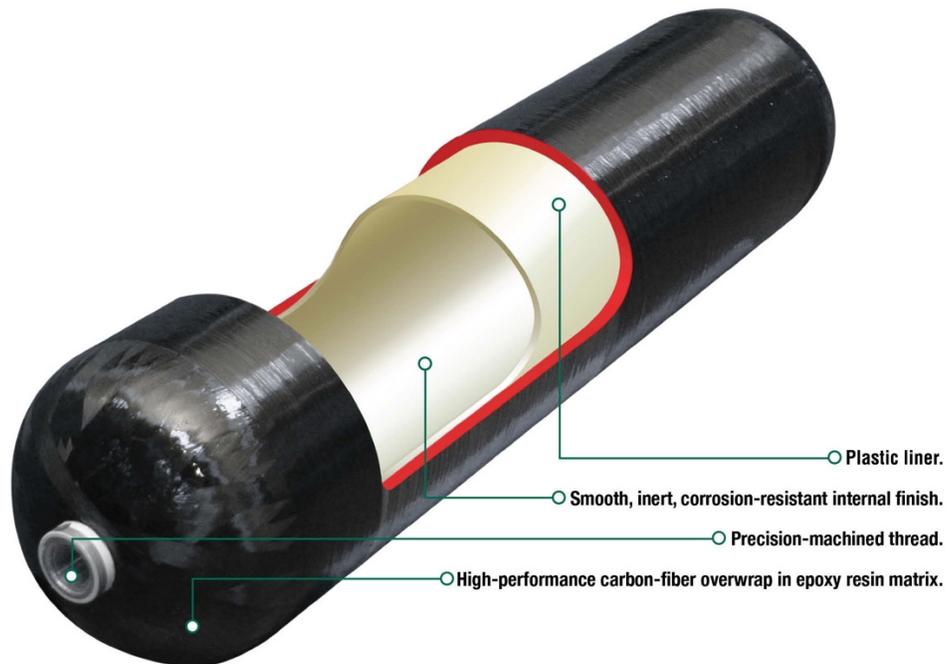
Luxfer Gas Cylinders is a member of Luxfer Group (NYSE:LXFR).

2.0 Product description

G-Stor™ Pro Type 3 AF cylinder ▼



G-Stor™ Go Type 4 AF cylinder ▼



2.1 Cylinder identification and labels

G-Stor Pro CNG ONLY G-Stor Pro

TYPE 3 CYLINDERS

Luxfer Part Number:	A1159D-301
Serial Number:	AIR [REDACTED]
Service Pressure:	24820 kPa (3600 psig) at 21°C (70°F)
Date of Manufacture:	10 A 2013
DO NOT USE AFTER:	10/2033
Capacity:	111 Liters [REDACTED]
Empty Weight:	100 lb. [REDACTED]

DOT FMVSS 304 / NGV2-07 / TYPE 3
FOR USE ONLY WITH THE CONTAINER
MANUFACTURER'S APPROVED PRD AND VALVES.

THE LUXFER USER MANUAL FOR ALTERNATIVE FUEL CYLINDERS IS AVAILABLE AT
<http://www.luxfercylinders.com/downloads/>
For more information, visit the Luxfer Gas Cylinders website at www.luxfercylinders.com or call Luxfer customer
service at (800) 764-0366, Fax (951) 781-6598.

WARNING

Improper handling, use, filling, storage or disposal of this container may result in personal injury, death and/or property damage!

Do not puncture or drop container. Do not modify container in any way. Never expose container to temperature exceeding 180°F (82°C).

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 and deterioration. For visual inspection after a motor vehicle accident or fire, contact Luxfer Gas Cylinders at (800) 764-0366.

If there is a question about proper use, installation, or maintenance of this container contact Luxfer Gas Cylinders, 3016 Kansas Ave., Riverside, CA 92507; call (800) 764-0366 or fax (951) 781-6598.



Example: NGV2/FMVSS 304 label. ▲

G-Stor Pro CNG ONLY G-Stor Pro

TYPE 3 CYLINDERS

DO NOT USE AFTER 2033/10

Luxfer Part Number:	A2173C-101
Serial Number:	AHF [REDACTED]
Service Pressure:	20.0 MPa / 15°C
Test Pressure:	30.0 MPa
Date of Manufacture:	2013/10
Capacity:	250 Liters [REDACTED]
Empty Weight:	90.3 Kg [REDACTED]

ECE R 110 CNG-3
110 R-000250 2009/11 
FOR USE ONLY WITH THE CONTAINER
MANUFACTURER'S APPROVED PRD AND VALVES.
EMER PRD200 / MARK SERIES - Torque: 217 ± 10 N-m
VTI PRD K905 / RV200 - Torque: 134 ± 4 N-m

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Example: ECE R110 label. ▲

G-Stor Go CNG ONLY G-Stor Go

TYPE 4 CYLINDERS

Luxfer Part Number: A2843D-101
Serial Number: AJB [REDACTED]
Service Pressure: 24820 kPa (3600 psig)
at 21°C (70°F)
Date of Manufacture: 11 ▲ 2012
DO NOT USE AFTER: 11/2015
Capacity: 282 Liters
Empty Weight: 165 lb.

DOT FMVSS 304 / TYPE 4
FOR USE ONLY WITH THE CONTAINER
MANUFACTURER'S APPROVED PRD AND VALVES.

THE LUXFER USER MANUAL FOR ALTERNATIVE FUEL CYLINDERS IS AVAILABLE AT
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LUXFER
GAS CYLINDERS

Example: FMVSS 304 ONLY label. ▲

3.0 Operating conditions

Operating conditions include the pressure, temperature, gas type and environment in which the cylinder is used. Various standards provide multiple cylinder operation pressures and temperatures for different applications and gas services. The best source of pressure and temperature limits is the cylinder label for each individual product. Please refer to those guidelines and contact Luxfer Gas Cylinders with any questions.



WARNING: An over-pressure condition can occur as a result of filling to service pressure in cold weather. As temperature increases, the pressure will increase and the settled condition could exceed the service pressure. Temperature must always be considered and compensated for during filling.

3.1 Gas composition

Luxfer carbon composite AF cylinders are designed and approved for storage of natural gas for use as a motor vehicle fuel. The natural gas used must comply with: *Recommended Practice for Compressed Natural Gas Vehicle Fuel*, SAE J1616; *Canadian General Standards Board Standard for Natural Gas for Vehicles*, CGSB 3.513; an equivalent national standard; and/or as shown below.

Dry Gas - Water vapor would normally be limited to less than 32 mg/m³ (2 lbs/MMscf), a pressure dewpoint of -9°C (16°F) at 20 700 kPa (3,000 psi). There would be no maximum constituent limits for dry gas, except for:

1. Hydrogen Sulfide	23 mg/m ³
2. Oxygen	1.0 percent by volume
3. Hydrogen	2.0 percent by volume

Wet Gas - Gas that contains 32 mg/m³ (2 lbs/MMscf) of water or more normally meets the following maximum constituent limits:

1. H ₂ S and other soluble sulfides	23 mg/m ³ (1 gr/100scf)
2. Total Sulfur	115 mg/m ³ (5 gr/MMscf)
3. Oxygen	1 percent by volume
4. CO ₂	3 percent by volume
5. Hydrogen	0.1 percent by volume

Under wet gas conditions, a minimum of 1 mg of compressor oil per kilogram of gas (0.007 grains of compressor oil per pound of gas) is necessary to protect metallic containers, liners and bosses.

3.2 Service life

Luxfer carbon composite AF cylinders have a maximum service life as defined by the country of use or the design standard to which they are built. The service life of a cylinder can be determined from the "Do not use after" designation on the cylinder label.



WARNING: NEVER use a cylinder past the “Do not use after” date. Personal injury or death may result.

If a label is unreadable, an inspector or user can determine the cylinder serial number from the end-plug label or stamping on the liner neck. Contact Luxfer Gas Cylinders and provide the serial number to learn the final date of use and to obtain replacement labels. When the service life stated on the label has been reached, the user must remove the cylinders from service. Cylinders removed from service must be disabled or destroyed in accordance with applicable regulations.

4.0 Cylinder handling, storage and installation

Use the following guidelines to install Luxfer AF cylinders into vehicles.

4.1 Handling

To prevent cylinder damage, Luxfer recommends the following:

- Only handle AF cylinders with appropriate lifting devices and equipment that will not cause damage.
- Do not walk on cylinders! Walking on cylinders can cause level 2 damage.
- Do not handle cylinders with internal pressure above 3 bar (40 psi).
- Do not drag, drop or roughly handle cylinders.
- Protect cylinder labels to ensure legibility.
- When transporting a valved cylinder, protect the valve and properly secure the cylinder. Never handle cylinders by their fittings, valves, pressure relief devices or piping.

4.2 Storage

Luxfer cylinders must be stored in a dry environment away from direct sunlight (UV radiation), chemicals, heat sources and corrosive environments. Prevent cylinders and/or assemblies from rolling or moving. Protect cylinders from any contaminants and damage. Luxfer recommends storing cylinders in their original shipping packaging.

Cylinders should not be stored completely unpressurized. If a cylinder is stored unpressurized at very low temperatures, moisture condensation and contamination could damage the cylinder. Install plugs and/or valves and O-rings intended for use according to the valve manufacturer's recommendations. Store cylinders with a small positive pressure (not less than 25 psi and not more than 40 psi) of a dry inert gas or natural gas.

4.3 Preliminary inspection

Before beginning any installation, visually inspect the cylinder for damage caused by shipping and handling. If no damage is found, proceed with installation. If damage is found or suspected, complete a thorough visual inspection (see Section 6) before installing the cylinder.

4.4 Installation

4.4.1 Cylinder installation and protection

When the cylinder is installed on a vehicle, use shielding to protect the cylinder from damage caused by road debris and contact with vehicle components and cargo. The preferred shielding is open mesh, which not only protects the cylinder, but also permits easy reading of cylinder labels.

To prevent cylinder damage:

- Avoid direct contact between the shielding and the cylinder.
- Avoid trapping solid debris or liquids between the shielding and the cylinder.
- Avoid cylinder contact with vehicle components (e.g., brake lines, etc.).
- Avoid exposure to vehicle heat.
- Avoid exposure to harmful liquids and gases.
- Avoid prolonged exposure to sunlight.

4.4.2 Mounting cylinders

Various mounting methods may be used with Luxfer cylinders. The mounting method and appropriate mounting hardware are often specified by the system manufacturer and may be supplied by Luxfer. While typical, the sample mounting methods and parts list shown below are provided for general information only and do not overrule or supersede requirements of system manufacturers or specific instructions provided either by system manufacturers or Luxfer for particular mounting configurations. Refer to applicable instructions and specifications provided by the system manufacturer before attempting to mount cylinders.

Cylinders used to store natural gas as vehicle fuel and bearing NGV2 or FMVSS304 markings should be installed in accordance with NFPA 52 requirements.

When installing a cylinder in an underbody configuration, give proper consideration to damage that could occur from impact with large objects. Luxfer carbon composite cylinders should be shielded not only from road debris, but also from impact with curbs, high traffic bumps, deep potholes, pavement protrusions and large objects in the road that could damage cylinders and cause hazardous situations.



CAUTION: During pressurizing and de-pressurizing of a composite cylinder, it is normal for the cylinder to expand and contract. The chosen mounting system must allow for this expansion and contraction; otherwise, damage to the cylinder and fuel storage system may occur.

4.4.3 Strap or band or “belly” mounting

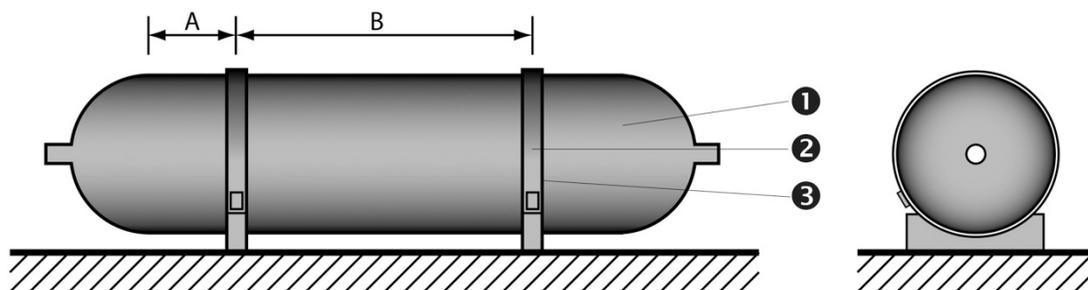


Figure 4.4.3a ▲

Minimum dimensions: A = 25mm (0.984”), B = 1/3 of cylinder length

PARTS LIST	
ITEM	DESCRIPTION
1	Composite cylinder
2	Belly mounting strap
3	Rubber strip†

If a cylinder is sufficiently long or heavy to require more than two brackets during installation, follow the bracket manufacturer’s installation guidelines. Brackets should be installed 6 to 8 inches apart near the cylinder ends. Do not use one bracket in the center and one on each end; this may lead to damage of brackets and/or the cylinder.

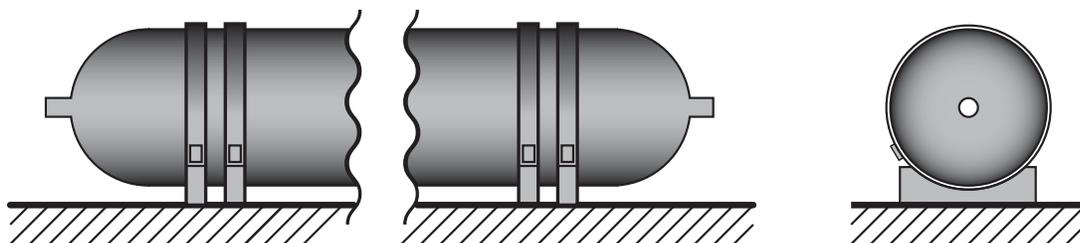


Figure 4.4.3b ▲

Vertical mounting of a cylinder with straps is not permitted. The cylinder may slide out of the straps due to gravity and vibration and cause damage to the fuel system components and/or the cylinder, which could cause personal injury or death.

Any straps or bands used to secure a cylinder must not induce a pressure on the outer surface of the cylinder greater than 3.45MPa (500 psi) at any cylinder fill pressure.



CAUTION: When using the strap or “belly” mounting method, a strip of rubber must be installed between the cylinder and metal straps to protect the carbon composite exterior of the cylinder. The mounting should also be sufficiently flexible to allow for longitudinal cylinder expansion and contraction.

NOTE: Optional Luxfer-approved straps are offered, for an additional charge, with all Luxfer G-Stor™ Go strap-mount cylinders. Luxfer-approved straps are specifically designed for use with Luxfer cylinder diameters to allow for hoop expansion during fill. Luxfer assumes no responsibility for any damage that occurs as a result of improper cylinder installation with non-approved straps.

4.4.4 Neck mounting

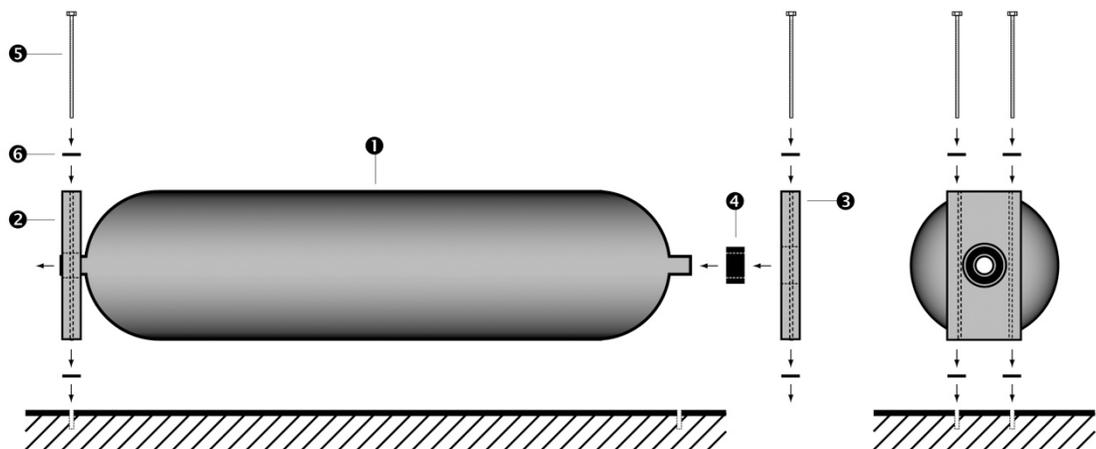


Figure 4.4.4 ▲

PARTS LIST	
ITEM	DESCRIPTION
1	Composite cylinder
2	Fixed neck block
3	Sliding neck block
4	Bearing
5	Bolt
6	Washer(s) (optional)

Visually inspect end-mounting blocks regularly for signs of corrosion and premature wear. When lubrication of the neck block is required, use an aluminum-compatible, silicon-based lubricant.

Vertical mounting of Luxfer cylinders is authorized only when neck mounts are used. Care should be taken in the design of the neck mount, because the weight of the cylinder will be completely on one block. If the cylinder is vertically mounted, ample room must be allowed for any valves, plugs, tubing or other components to ensure there is no rubbing or abrasion of the cylinder or components.

4.5 Valve and pressure-relief device (PRD) installation and removal

Use only approved valves and pressure-relief devices that comply with applicable standards and regulations (e.g., NGV 3.1 and PRD-1). Contact Luxfer for a list of approved valves and PRDs (or pressure-relief devices).



WARNING: Do not use valves or pressure-relief devices that have not been tested and approved by Luxfer.

4.5.1 Valve and/or plug installation

Inspect the valve in accordance with the valve manufacturer's recommendations prior to installation. Do not install any valve that has not passed such an inspection.



WARNING: Do not use valves or pressure-relief devices that have not been tested and approved by Luxfer.

Valve threads must be free from damage. Visually inspect threads to ensure that the mating surface of the valve is smooth and free from damage.

Not all O-ring materials are compatible with all gases. To ensure that the O-ring material being used is suitable for natural gas service, follow the recommendations of the valve manufacturer or use an O-ring supplied by the manufacturer. The natural gas industry generally recognizes Nitrile (also called Buna N), with a 70 – 90 Durometer hardness, as the standard O-ring material. If you have questions, please contact the system manufacturer, the valve manufacturer or Luxfer.

Check to make sure that the O-ring groove and threads in the cylinder are clean and free from debris and damage. Install a new O-ring on the valve or plug in accordance with the valve or plug manufacturer's recommendations. Luxfer recommends lubricating the O-ring prior to installation with a lubricant compatible with the O-ring and natural gas (unless the valve or plug manufacturer specifies otherwise). For any O-ring sold by Luxfer, or an O-ring on a Luxfer brand valve or plug, only use Krytox GPL 100 oil or Krytox GPL 200 grease. Never use Molykote 55 or other lubricant, which may cause O-ring failure.

For installation of a Luxfer brand valve, refer to the Luxfer operation manual S-OP-MPV for installation instructions and proper torque values. For installation of a Luxfer brand plug, follow the installation and torque guidelines as stated in this section.

Apply a small amount of aluminum-compatible, silicon-based lubricant to the bottom three valve threads, taking care not to apply lubricant to the bottom face of the valve body. Only a thin application of lubricant is necessary—too much lubricant can cause sealing problems.

Insert the valve into the cylinder neck and tighten it by hand to make sure threads are properly aligned. Then tighten the valve to the torque value recommended by the valve manufacturer.

Note: Some valve manufacturers may require special or specific tools for valve installation; if so, using a standard wrench could damage the valve or valve connections. Follow valve manufacturer instructions.

Note: Valve torque guidelines in the table below are provided for general information only and do not overrule or supersede valve manufacturers' torque-level recommendations, which should be used in preference to the values shown.

Table 1—Valve torque guidelines

PARTS LIST		
<i>Thread</i>	<i>Min. N-m (ft.lb.)</i>	<i>Max. N-m (ft.lb.)</i>
1.125 – 12 UNF	167 (123)	186 (137)

4.5.2 Valve and/or plug removal

Follow the system manufacturer's guidelines to depressurize the system. Following the recommendations of the system manufacturer or valve manufacturer, ensure that the cylinder is completely empty before attempting to remove the valve and/or plug. Luxfer recommends removal of the valve before attempting removal of any plugs. Removal of a plug while under pressure can lead to serious injury or death.



WARNING: If the valve is hard to remove, STOP! If you suspect for any reason that a valve may be defective, do not attempt to remove the valve—because a valve that is damaged or not functioning properly may cause you to think erroneously that the cylinder is empty when you do not hear gas being released. Handle all valved cylinders—even those you think are empty—as if they were under pressure! To check whether a hard-to-remove valve is functioning properly, add to the cylinder a small amount of the gas specified on the cylinder label to prove that gas actually goes in and out of the valve. If the valve works properly during this check, fully depressurize the cylinder and then carefully remove the valve. If you have questions about valve function or require further instructions, contact the valve manufacturer.

Once the valve and/or plug is removed, inspect it thoroughly if it will be reused in the installation or another installation. Check valve and/or plug threads for damage and inspect cylinder threads to verify that they are clean-cut and undamaged. Clean and inspect the cylinder O-ring gland (groove) to verify that there is no damage.



REJECT cylinders with damaged threads.



REJECT cylinders with O-ring gland damage that prevents an effective, safe seal.

4.5.3 Pressure-relief device (PRD)

Use only approved pressure-relief devices that comply with applicable standards and regulations (e.g., PRD-1). Contact Luxfer for a list of approved PRDs and PRD configurations.

Some PRDs are integrated into the valve, while others must be installed separately. If a vent line is required to vent gas away from the cylinder, take note that no valves or flow restrictions are allowed anywhere in the inlet or outlet flow path of a PRD. Below are sample PRDs installation methods.

Single PRD configuration—Where only a single PRD is required, use one of the following configurations approved by Luxfer for the specific cylinder model being considered:

CNG valve with an integrated PRD

Valve with a retrofitted PRD

Separate end-plug PRD

Double PRD configuration—There are three possible configurations for double PRDs:

(1) A valve either with an integrated PRD or an installed PRD plus a separate end-plug PRD. (2) A valve with a PRD that has been piped to the center of the cylinder plus a separate end-plug PRD. (3) Two PRDs piped from either the valve or the plug of the cylinder and centrally located along the length of the cylinder.

Multiple (more than two) PRD configuration—Figure 4.5.3 (below) is an example of a cylinder configured with three PRDs—one integrated in the valve, a second end-plug PRD in the opposite cylinder end and a third, L-shaped PRD piped from the valve to a central position. Additional T-shaped PRDs could also be installed in series along the pipe from the valve.

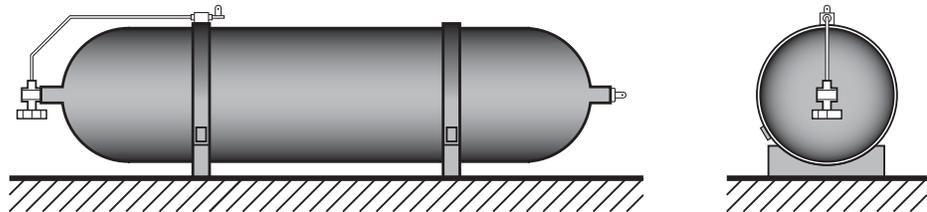


Figure 4.5.3 ▲

Shared PRDs—Some fuel systems can have multiple cylinders plumbed to a single PRD or set of PRDs; these are generally plumbed either from end plugs of multiple cylinders or from valves of multiple cylinders. Contact Luxfer for more information about approved configurations for shared PRDs.

General guidelines that apply to all PRD installations:

- Ensure that threads are undamaged.
- Clean threads thoroughly.
- Dry threads and ensure that the area is free from debris.
- Select the proper O-ring or copper-crush washer specified by the PRD manufacturer. Do not reuse copper-crush washers or O-rings. Always use a new copper-crush washer or O-ring; failure to do so may cause a leak.
- Remove the used copper-crush washer or O-ring before replacing the PRD. Do not double-stack copper-crush washers or O-rings.
- If recommended by the PRD manufacturer, apply lubricant to the O-ring or copper-crush washer.
- Place the O-ring or copper crush-washer properly on the fitting, being careful not to damage the O-ring or copper crush-washer.
- Thread the fitting into the mating surface.
- Apply the proper installation torque recommended by the PRD manufacturer.

5.0 Fueling (filling) and defueling (evacuating) cylinders

The following procedures apply for initial fueling (filling), re-fueling, and defueling (evacuation) of cylinders.

Note: During fueling (filling) and defueling, expansion or contraction of the cylinder sometimes causes snapping or popping noises. This is normal and is not a cause for concern.



WARNING: Rapid flow of gas can generate a static electrical charge, which can ignite escaping gas. Therefore, the cylinder, attached components (including the vent pipe used for defueling) and vehicle must be connected to a ground for purging, fueling (filling) and defueling (evacuating).

Prior to filling the cylinder, it is important to understand the characteristics and hazards of natural gas, including explosion, fire and asphyxiation.

Fuel (fill), defuel (evacuate) and purge all systems in a well-ventilated area that is free from possible ignition sources, including (but not limited to) open flames, electric sparks and static electricity.



WARNING: When working with flammable gases in a confined area, always use gas-monitoring equipment.

5.1 Filling



WARNING: Always remove all oxidants (including air) from a cylinder prior to filling the cylinder with flammable gas! Failure to remove oxygen or other oxidants from the cylinder before filling with natural gas can create a combustible mixture that can ignite and cause serious injury or death. Be alert to the fact that air may enter the cylinder whenever the cylinder has been vented or exposed to ambient pressure, including during initial filling, after valve installation or any time the system has been bled to zero pressure.

5.1.1 Initial filling (fueling)



WARNING: Failure to follow the fuel system manufacturer's instructions on filling may lead to serious injury or death!

An "initial fill" is the first pressurization that occurs after the cylinder has been vented or exposed to ambient pressure, including initial filling, after valve installation or any time the system has been bled to zero pressure. Before filling a cylinder with natural gas, the cylinder must be purged of any oxidants. Failure to purge any oxidants can create a combustible mixture that can ignite and lead to serious injury or death. Do not perform the purge operation or the initial filling of a Luxfer G-Stor Go cylinder if the cylinder has been stored in an environment at or below 0F (-18°C). Allow the cylinder to warm up to room temperature, 60°F or greater, before attempting to purge or fill an empty cylinder.

Follow the fuel system manufacturer's guidelines to purge the system before the initial fueling, if required, or use the following procedure to purge any oxidants

before filling the cylinder with CNG. The following is a guideline to safely remove or reduce any oxidants (including oxygen from air) in the cylinder.

Guideline:

1. Ensure that the cylinder is grounded and in a well-ventilated area.
2. Pressurize the cylinder or assembly to at least 5 bar (72.5 psi) with dry nitrogen.
3. The cylinder or assembly is now ready to be pressurized with CNG.

During the initial filling of a cylinder that has been purged of oxidants, fill with natural gas to a pressure of at least 50 psi. If the cylinder is filled to a pressure less than 50 psi with natural gas, there is still a potential to create a flammable mixture that could ignite.

During the initial filling of a Luxfer G-Stor Go cylinder, it is TYPICAL and NORMAL to experience AIR LEAKAGE through the composite reinforcement. During manufacture, air collects between the internal polymer liner and the carbon composite when it is unpressurized. During its first pressurization, the trapped air is forced out. Escaping air will be most noticeable where the metal end hardware meets with the composite. However, air leakage may be noticed in other locations as well. It usually takes between 10 to 45 minutes for trapped air to escape. This is not a defect or leak of the cylinder.

5.1.2 Standard filling (refueling)

If the residual pressure in the cylinder is less than 300 psi and the cylinder/vehicle has been stored in an environment that is 0°F (-18°C) or lower do not fill the cylinder. Bring the cylinder and/or vehicle inside and allow the cylinder to warm up to 60°F or higher before filling. If the residual pressure is higher than 300 psi, the cylinder may be filled as long as the temperature is above -40°F (-40°C).



WARNING: Fill the cylinder such that the settled pressure does not exceed the marked service (working) pressure at 21°C (70°F). Never fill the cylinder greater than 1.25 times the marked service pressure immediately after filling, regardless of the temperature.

5.2 Defueling



WARNING: When working with flammable gases in a confined area, always use gas-monitoring equipment and ground (earth) all equipment.

Follow the fuel system manufacturer's guidelines for venting CNG from the system. Otherwise, if possible, the preferred method of de-fueling is to run the engine. Note that some residual pressure will likely remain in cylinders and will need to be vented. During defueling, make sure pressure is sufficiently low that those performing the procedure will not be harmed if gas escapes due to a leak or broken seal. However, defueling pressure must be slightly higher than atmospheric pressure to stop air from entering the cylinder

if a seal is broken. Vent gas properly through a flue or flare stack to prevent contaminating the environment and to avoid a potentially hazardous gas accumulation. Always make sure that all equipment is properly grounded. Use caution and avoid any uncontrolled ignition sources during any defueling operation.

6.0 Inspection

Using proper equipment and safety apparatus, inspect cylinders routinely to determine whether damage has occurred. Before beginning any inspection, remove all dirt and debris from the cylinder. If necessary, you may use a mild soap-and-water solution. Do not use solvents, harsh cleaners or abrasives. Always carefully inspect cylinders if a vehicle has been involved in an accident.

6.1 Mounting inspection

Ensure that all mounting blocks, brackets and other components are in good condition and properly secured. If any mountings are loose, re-tightened them by following procedures specified by the fuel system manufacturer. If a mounting is damaged, you must conduct a re-certification inspection. If parts are missing or need replacement, please contact the fuel storage system manufacturer.

6.2 Fuel system inspection



CAUTION: Never allow air or debris to enter a cylinder. When disconnecting fittings (seals) during maintenance or inspection, make sure that air or debris do not enter through the opening.

Fuel system inspection includes checking all attached components, such as valves, tubing, end plugs, fittings and pressure-relief devices. During inspection, make sure that each device is securely attached. If any is loose, tighten it in accordance with the fuel system manufacturer's instructions. If any component is missing, contact the fuel storage system manufacturer and do not put the system back into service.

6.3 Cylinder inspection



IMPORTANT: The Luxfer-recommended “accept” and “reject” criteria provided in this manual do not replace or supersede any criteria established by regulatory authorities either now or in the future.

Alternative fuel cylinders are designed and manufactured for a limited design life, which is indicated on the cylinder label. Always check the label first to ensure that the cylinder has not exceeded its expiration date.



REJECT and remove from service any cylinder that either lacks a label containing mandatory information or has a label that has become illegible. If you can positively determine that Luxfer produced such a cylinder and you know the cylinder serial number, contact Luxfer for disposition instructions.

Inspect for the following conditions during periodic inspection:

- Cuts, scratches and gouges
- Fire and heat damage
- Chemical attack
- Debonding
- Delamination
- Weathering
- Abrasion
- Impact damage

Inspection Type	Inspection Description	Inspection Frequency	Qualification
General Inspection.	Performed by the operator, driver, maintenance personnel, or other service technician. It is primarily a visual inspection to ensure that the cylinder, mounting and plumbing are in good condition and remain secure.	Recommended every 3 months or at specified maintenance intervals depending on operating conditions.	Performed by the operator, driver, maintenance personnel, or other service technician. Review of this cylinder manual is recommended.
Detailed Visual Inspection.	Performed by trained personnel who are certified in accordance with local authority. It is a more in-depth examination of the cylinder, mounting and plumbing and evaluates system code compliance.	Check with local authority and cylinder label, but is most commonly performed immediately after installation, then every 3 years or 36,000mi (58,000km), whichever comes first.*	Luxfer or External Training Certificate in Fuel Storage System and Cylinder Inspection.

*Detailed Visual/Requalification inspection intervals specified by local authorities and standards may be more or less than 3 years. Recommended inspection intervals also vary with operating conditions.

6.3.1 General system inspection

This inspection, usually performed by a driver, maintenance person or service technician, is a basic visual inspection to ensure that the cylinder and mountings are in good condition. The inspection includes, as a minimum, examining the mounting system, cylinder and plumbing, as well as checking for gross leaks and damage.

Perform this inspection at least every three months under normal operating conditions and more frequently during more demanding conditions.

6.3.2 Periodic inspection

This is an in-depth examination of the cylinder, mounting system and plumbing for external damage and deterioration, including the cylinder surface under the support straps. A competent agency or person approved or recognized by applicable regulatory authorities must conduct the inspection in accordance with all applicable regulations and Luxfer specifications. Under normal operating conditions, perform the inspection every three years or 36,000 miles, whichever comes first. In addition, you must perform a recertification inspection following any accident or fire, as well as at the time of any reinstallation. (This recertification inspection is mandatory under most CNG cylinder and system standards; however, the prescribed frequency may vary from standard to standard.)



IMPORTANT: For the lifetime of a cylinder, records of all periodic recertification inspections and testing should be sent to Luxfer along with materials, test certificates and inspection reports relating to the manufacture of the cylinder. Such record-keeping is required by regulatory authorities.

6.3.3 Inspection training

Luxfer Gas Cylinders offers inspection training either at its AF facilities in Riverside, California, on site at customer locations or periodically at special training venues (watch www.luxfercylinders.com for announcements of upcoming training sessions).

6.4 Recommended equipment

6.4.1 Inspection tools



A mirror and a flashlight are helpful when you are inspecting hard-to-reach areas. Bubbling leak-detection fluid is also useful. (*Optional:* A digital camera can be used to document damaged areas.) Fill out an inspection report form (available from Luxfer.) If a cylinder is irreparably damaged, apply a “Danger: Failed Cylinder Inspection” label to cylinder. If the cylinder passes inspection, apply a label showing the date of the inspection.

6.4.2 Cut measurement



▲ **Cut measurement**—First calibrate the depth gauge to zero on the undamaged cylinder surface.

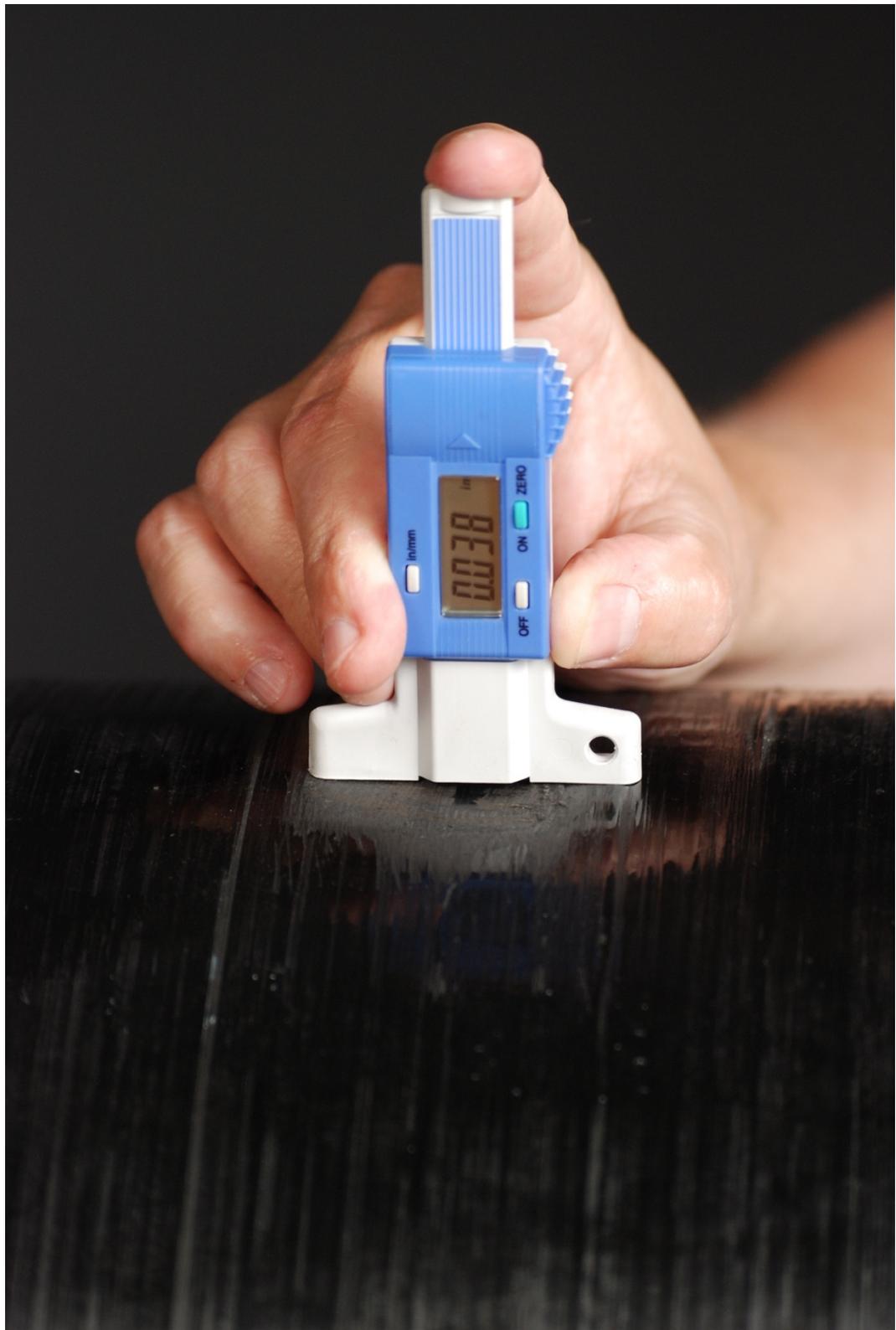


▲ Then measure the depth of the cut.

6.4.3 Abrasion measurement



▲ **Abrasion measurement**—Calibrate the depth gauge to zero on the undamaged cylinder surface (left), then measure the depth of the abrasion at the deepest point (right).



▲ You may also use a digital depth gauge.

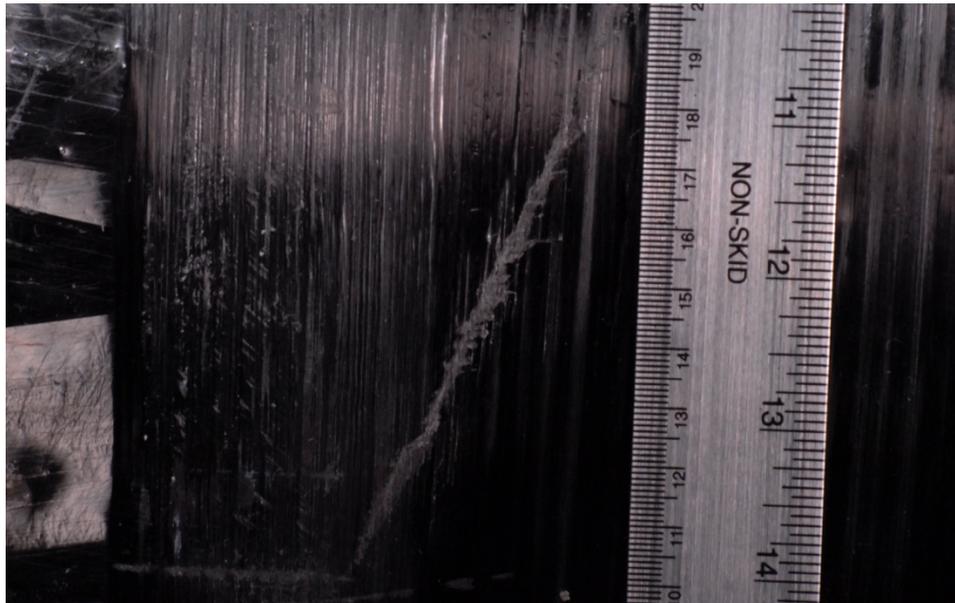
6.5 Types of damage

6.5.1 Cuts, scratches and gouges

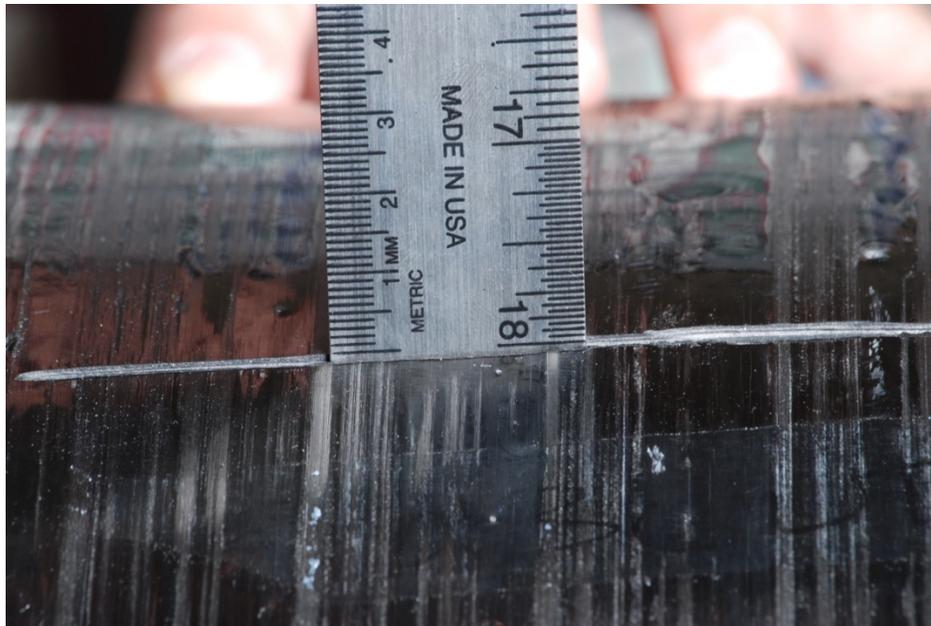
These are easily spotted on carbon composite cylinders. Watch for fiber lifting and unraveling caused by cuts transverse to the direction of the fiber wrapping.



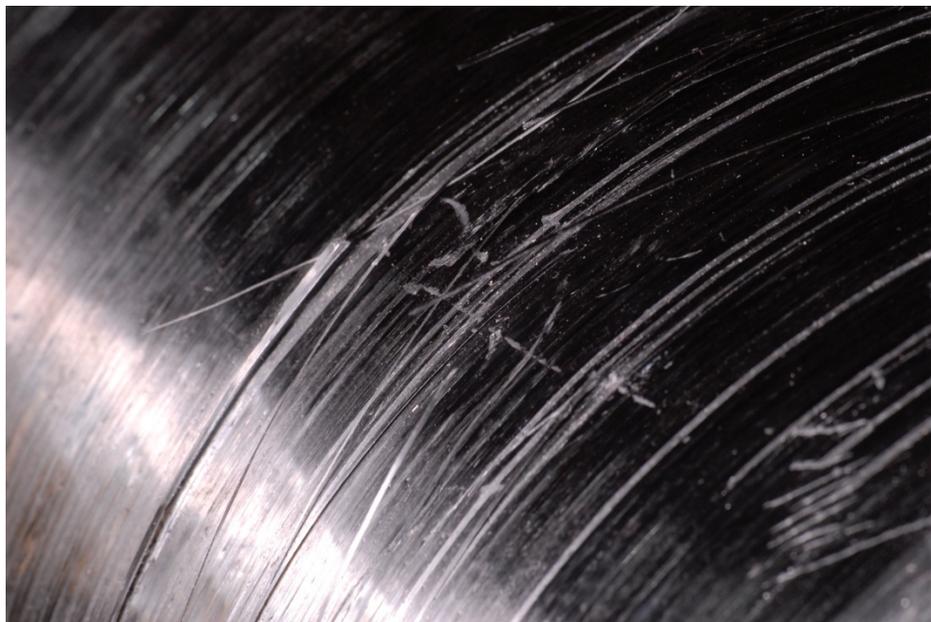
▲ Level 1 cut



▲ Level 2 cut



▲ Level 3 cut



▲ Fiber lifting and unraveling

Inspection method—Inspect cuts, scratches and gouges for depth and length. Measure depth either with a dial indicator-type depth gage or depth caliper. Measure length with a graduated scale or ruler.

Reference: Table and repair method.

The maximum allowable depth and length for this type of damage is found in the table of damage levels in Section 6.6; immediately remove from service and

Usually the degree and depth of resin discoloration are dependent on the temperature, the duration of exposure or a combination of both. The higher the temperature, or the longer the duration of exposure to a lower temperature, the darker the resin system will become.

If you are uncertain about the cause of resin discoloration, contact Luxfer for guidance.

Fire damage—Charring or melting of the composite material, decals, valves or other attachments is evidence of fire damage. Full or partial activation of the PRD is also evidence of fire or excessive heat. Flame impingement may result in the resin burning away from the cylinder exterior, leaving loose carbon fibers.



▲ Fire Damage

Inspection method—Visually inspect the entire surface of the cylinder for evidence of burnt or charred composite material. Also inspect any valves and attachments for evidence of extreme heat.

Reference: Table and repair method.

Cylinders showing light discoloration of the resin, but not showing evidence of extreme heat exposure (e.g., melting of decals, charring or heat damage to mounting attachments or PRD activation), may be returned to service without repair. If you are not sure whether cylinder discoloration is the result of elevated temperature exposure or harmless natural aging, contact Luxfer for guidance.



WARNING: Immediately remove from service any cylinder involved in a motor vehicle collision or fire.

Immediately **REJECT** and **CONDEMN** any cylinder showing melting or charring of composite material or attachments. No repair is possible for this condition. See Section 7.0 for procedures on condemning the cylinder.

6.5.3 Chemical attack

Chemicals, including battery acid (to which AF cylinders may be exposed), may dissolve, corrode, soften, remove or ruin cylinder materials; they may also cause bubbling, pitting or extreme dulling of the resin or create multiple fractures transverse to the direction of the fiber. When solvents are involved, the cylinder surface may become sticky when touched.



▲ Chemical attack

Inspection method—Visually inspect the entire surface of the cylinder for this condition.

Immediately **REJECT** and **CONDEMN** any cylinder with such damage.

6.5.4 Weathering

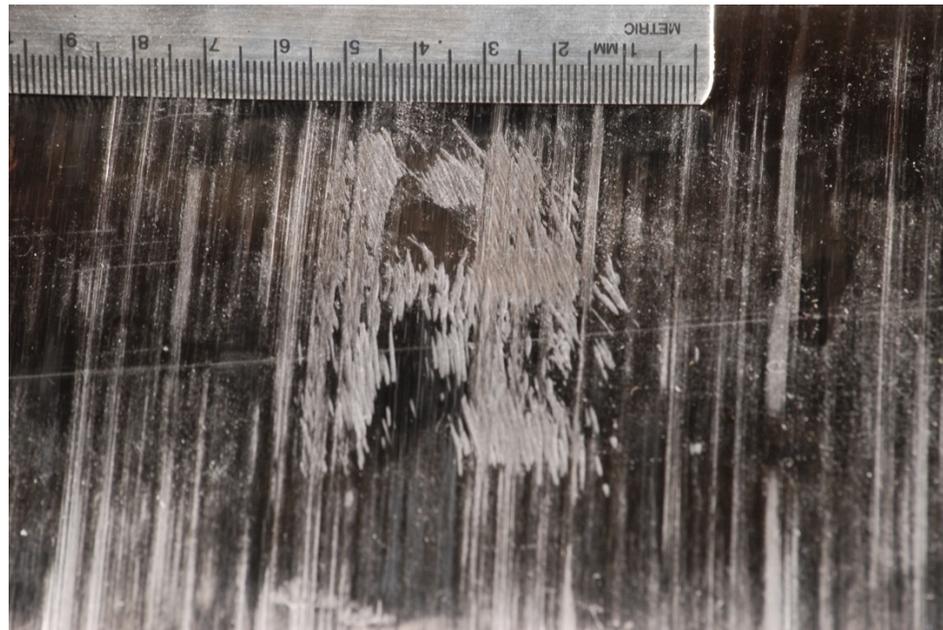
Weathering is a change in the surface appearance of composite material or exposed aluminum surfaces resulting from environmental exposure to sunlight, road salts and extreme heat and cold. Exposure to sunlight can discolor the composite over time; this is usually characterized by a yellowish color in the exposed area (see “Heat and fire damage,” Section 5.5.2). Road salts may corrode exposed aluminum, but this does not usually cause damage to composite material. Extreme heat or cold may cause mild discoloration of the composite or craze-cracking of the surface resin.

Inspection method—Visually inspect the entire surface of the cylinder for weathering. Discoloration or craze cracking of the resin is classified as Level 1 damage and does not require repair. If corrosion of exposed aluminum is found, contact Luxfer.

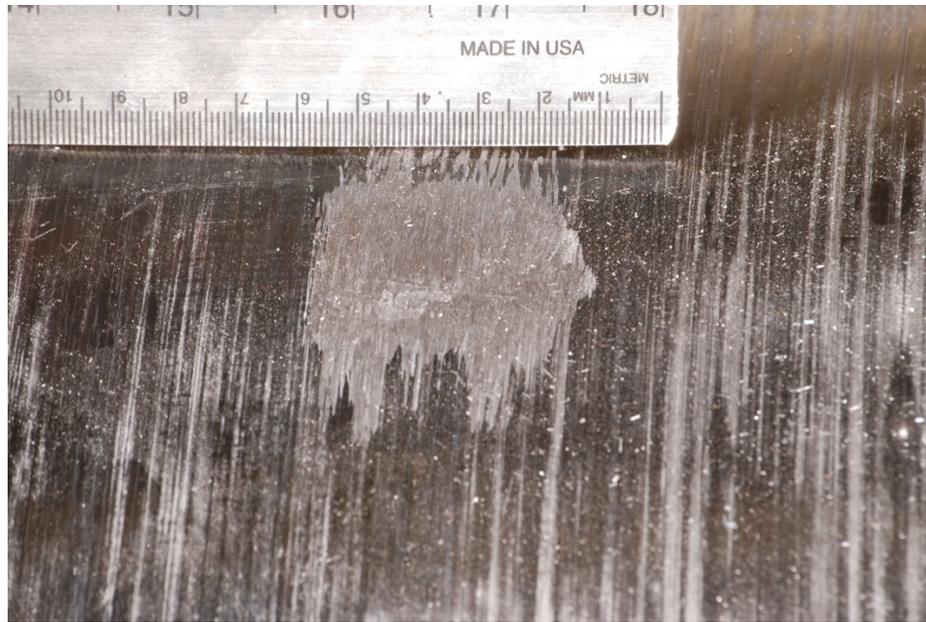
Reference: Table and repair method.

6.5.5 Abrasion

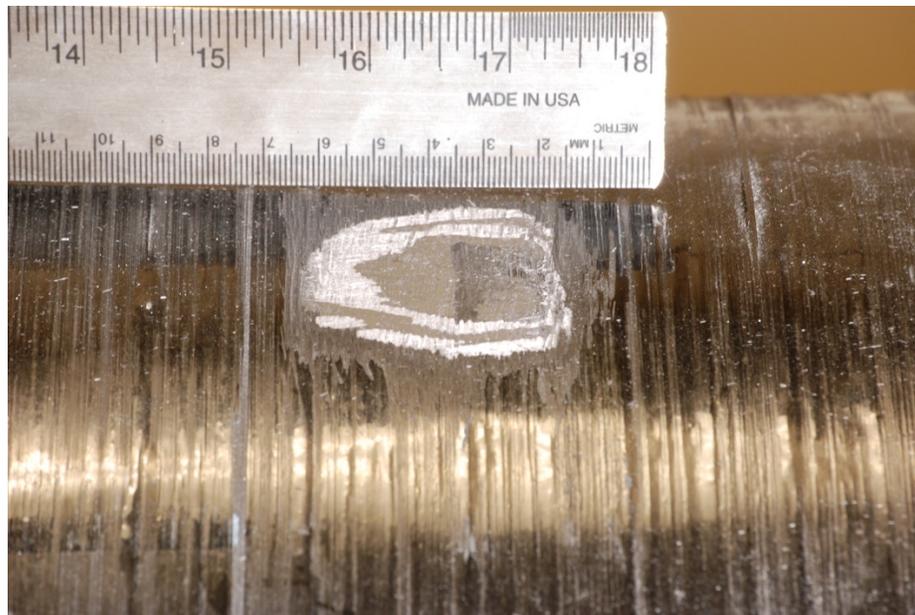
Abrasion, or localized wearing away of composite material, occurs when a cylinder rubs against other components such as mounting brackets, the vehicle structure, shielding, etc.



▲ Level 1 abrasion



▲ Level 2 abrasion



▲ Level 3 abrasion

Inspection method—Visually inspect the entire surface of the cylinder for evidence of abrasion. Pay close attention to areas around mounting straps or other attachments.

Reference: Table and repair method.

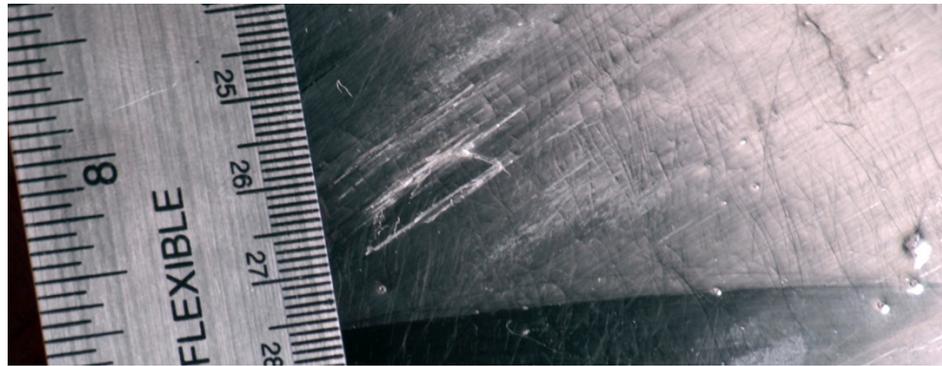
Refer to Table 6.6 for damage limits for abrasion. Immediately **REJECT** and **CONDEMN** any cylinders with unacceptable damage according to this table. The

appropriate repair method is found in Section 7 for cylinders that are capable of being repaired.

6.5.6 Impact damage

Impact damage may appear as hairline cracks in the exterior resin, cuts, abrasion and indentation of the surface of the aluminum liner.

Inspection method—Visually inspect the entire surface of the cylinder for evidence of impact damage. Carefully evaluate all impact sites according to the following criteria:



▲ **LEVEL 1:** Light impact damage that does not require repair. It usually consists of a small area where the composite is frosted. Where impact results in cuts or abrasion, evaluate these features according to the table of damage levels in Section 6.6 for the maximum area allowed for Level 1 damage. Cylinders with Level 1 damage can usually be returned to service.



▲ **LEVEL 3:** Severe damage in which impact has caused a large area of frosting (including cuts or abrasion), damage to fibers in the cylinder dome, liner denting

or other major structural damage. REJECT and CONDEMN a cylinder exhibiting such damage. Refer to table of damage levels in Section 6.6 for Level 3 impact, cut or abrasion damage limits.

Reference: See table of damage levels in Section 6.6.

6.5.7 Disbond and delamination

Disbond is physical separation between composite layers (most often a separation between glass and carbon layers). Usually caused by impact, disbond appears as a whitish region.

Delamination is the separation of composite layers, but it differs from disbond in that cut fibers are evident. Delamination is usually caused by severe impact.

Reference: See table of damage levels in Section 6.6. The appropriate repair method is found in Section 7 for cylinders that are capable of being repaired.

6.6 Leak Testing

6.5.7 Background Information on Gas Leakage and Permeation

Prior to inspecting Luxfer G-Stor Go cylinders for leakage, it is important to understand the difference between leaks, permeation and trapped air escaping from the composite.

The following definitions and inspection procedure will help inspectors distinguish between normal permeation levels and rejectable leaks.

Trapped air: Cylinders that are filled when new or after being vented may expel air that is trapped between the liner and the composite overwrap. While this may appear as leakage, this is normal and will stop after several minutes. Trapped air may be expelled from the composite or around the outer surface of the neck, or both.

Do not continue to fill cylinders if gas escaping is audible. See Fueling Cylinders in Section 5.1

Permeation: Permeation can occur with Type 4 cylinders. This is normal and often will result in a detectable level of natural gas. Permeation may escape through the composite in one or more locations.

Luxfer designs, manufactures and tests our cylinders in accordance with industry standards. Allowable limits for permeation are defined in these standards and are verified during testing. Permeation limits are based on a cylinder's volume. As a result, larger cylinders may show more evidence of detectable gas than smaller ones.

Leakage: Each G-Stor Go cylinder Luxfer produces is checked for leakage prior to being packed for shipment. Leakage will not occur under normal service conditions, however damage or abuse from extreme service conditions could cause a leak to form.

Verify leakage using the inspection procedure that follows. Leakage can be distinguished from permeation by:

- Audible hissing – usually from the cylinder dome area
- Vigorous and sustained bubbling of leak detection fluid forming a raised foam on the cylinder surface. (Note this can also happen when a cylinder is filled from zero or near-zero pressure. See Trapped Air note above.)
- Rapid reaction of flammable gas detector when held several inches away from the area. See leak detection procedure below.

If you suspect a leak, vent the cylinder using the procedure in Section 5.2. Do not defuel the system by running the engine! Contact Luxfer for further instructions.

6.6.2 Inspection guidelines for determining gas leakage

6.6.2.1 Using leak detection fluid

Before proceeding with the leak test, verify that all inspection preparation steps are completed. Perform the leak test in a well-ventilated area. For cylinder leak test perform the following steps:

- Ground the cylinders (refer to section 5.0)
- Ensure cylinder is filled to full operating pressure
- Spray leak detection fluid on cylinder surface. Check both sidewall and domes.
- Allow to sit for 5 minutes
- Visually check for any surface bubbling. Sites showing vigorous, sustained bubble formation may indicate a leak site. Small bubble trails that form slowly are likely from permeation.
 - Mark any areas that bubble (with a sharpie, paint marker) for later inspection (i.e. with a flammable gas detector)
 - If no bubbling is observed after five minutes, then the cylinder is acceptable
- Remove leak detection fluid from cylinder surface (wash off, wipe off)

6.6.2.2 Using a flammable gas detector

Use of a flammable gas detector can be used to verify gas leakage. If a flammable gas detector is used, follow the instructions below.

- When using a flammable gas detector, first perform the test in 6.6.2.1.
- Calibrate leak detector according to manufacturer's instructions.
- Verify any marked locations with methane/gas detector.
- Hold detector probe 1/8" from cylinder surface
- Note areas where indicated concentration is >200 ppm within 10 seconds (this depends on sampling rate of detector).
 - Sites with <200ppm should not be counted
 - Less than 100 sites at >200 ppm is within allowable permeation limits and should not be considered a leak
 - More than 100 sites at >200 ppm is cause for rejection.
 - Sites with vigorous, sustained bubbling fluid forming a raised foam on the cylinder surface should be considered cause for rejection.



WARNING: Do not perform inspection in extreme heat or cold, or if the cylinder temperature is increasing. Cylinder temperature and pressure should be stable before conducting test

NOTE: permeation can occur with Type 4 cylinders. This is normal and will result in a detectable level of natural gas. Permeation may escape through the composite in one or more locations. Determining the amount of gas using the procedure above will allow the inspector to distinguish between normal permeation levels and rejectable leaks.

6.7 Table of damage levels

Abrasion	Level 1	Any size area of abrasion less than 0.01" (0.254mm) deep.
	Level 2	Any abrasion between 0.01" (0.254mm) and 0.03" (0.762mm) deep and less than 1.0 sq.in. (645.16mm ²) in area.
	Level 3	Any abrasion exceeding level 2.

Cut / Gouge	Level 1	Any number of flaws of any length less than 0.01" (0.254mm) deep.
	Level 2	Any number of flaws of any length between 0.01" (0.254mm) and 0.03" (0.762mm) deep. OR one single flaw between 0.03" (0.76mm) and 0.05" (1.27mm) deep and less than 1.0" (25.4mm) long.
	Level 3	Any flaw greater than 0.03" (0.762mm) deep and greater than 1.0" (25.4mm) long. OR multiple flaws between 0.03" (0.762mm) and 0.05" (1.27mm) deep and less than 1.0" (25.4mm) long. OR any flaw greater than 0.05" (1.27mm) deep.

Impact	Level 1	A small, frosted and whitish area less than 1.5 sq.in. (967.74sqmm) in area.
	Level 2	N/A.
	Level 3	Any impact damage exceeding level 1 (liner indentation, fiber delamination in dome area, major structural damage).

Disbond	Level 1	Disbonding is allowed between the outer glass wrap and the carbon, since the glass wrap is for protection only. All disbonding needs to be checked to ensure that it is not caused by impact.
	Level 2	N/A.
	Level 3	N/A (see impact).

Disbond	Level 1	N/A.
	Level 2	Limited to outer hoop only. Width of delamination may not be wider than original damage from cut, gouge or abrasion.
	Level 3	Any delamination exceeding level 2.

Delamination	Level 1	N/A.
	Level 2	Limited to outer hoop only. Width of delamination may not be wider than original damage from cut, gouge or abrasion.
	Level 3	Any delamination exceeding level 2.

Fire / Heat	Level 1	Light discoloration.
	Level 2	N/A.
	Level 3	Evidence of burnt or charred resin.

7.0 Repair

Note: It is not possible to repair cylinders showing evidence of chemical attack, fire and heat damage. Refer to Section 7.0 for instructions on condemning cylinders with these conditions.

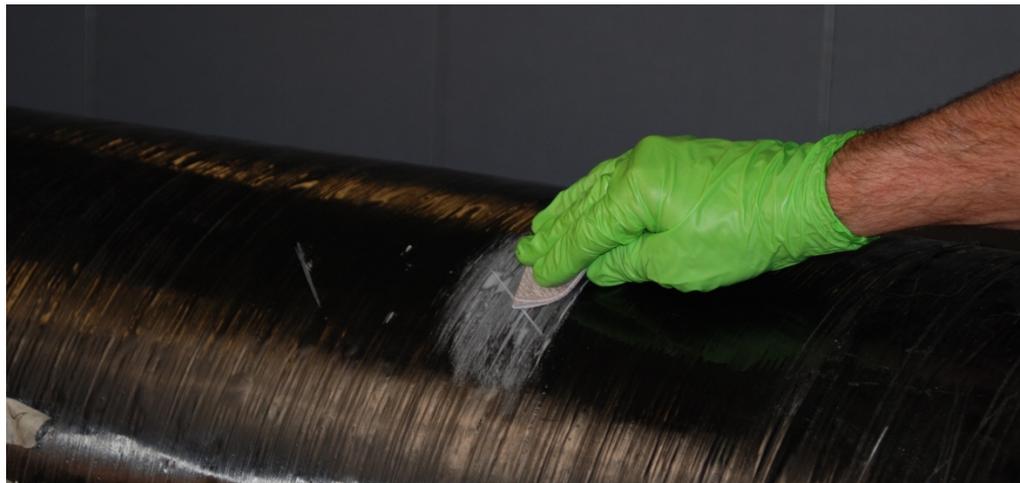
7.1 Repair tools



These tools are needed to repair Level 2 damage (left to right): 120-grit (fine) sandpaper, a receptacle for mixing epoxy resin, a resin applicator, two-part epoxy resin (resin plus cure) and a brush that may be needed for removing dust and debris. Clean shop rags or heavy-duty paper towels are also useful.

7.2 Repair procedure

For any cylinder with Level 2 damage, use the following repair procedure.



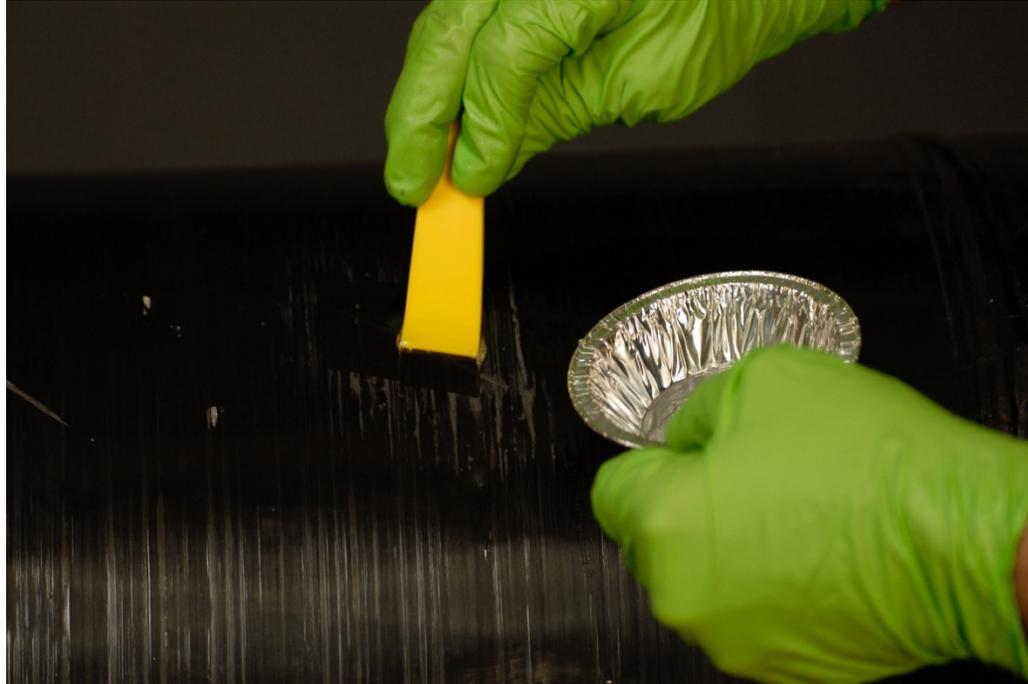
▲ Clean and sand damaged area with 120-grit (fine) sandpaper.



▲ Wipe off sanding dust.



▲ Mix epoxy resin, following manufacturer's instructions.



▲ Apply resin to damaged area, ensuring that resin is worked fully into any damage. Allow to dry, following manufacturer's instructions.

Optional steps to improve cylinder appearance:



▲ **Optional:** When the epoxy is fully cured and dried, sand the surface again.

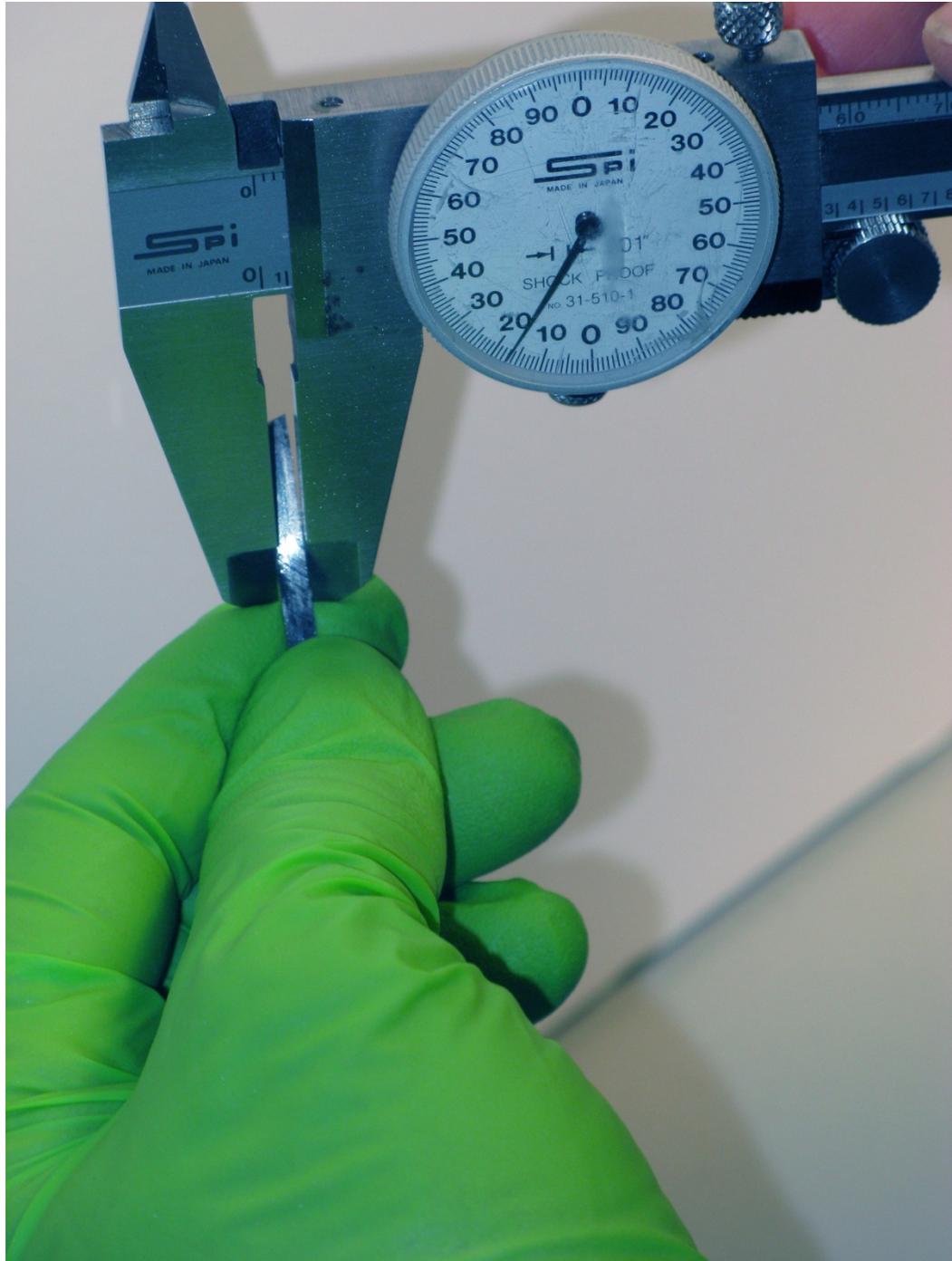


▲ **Optional:** Apply clear gloss air-dry acrylic enamel to the repaired area.

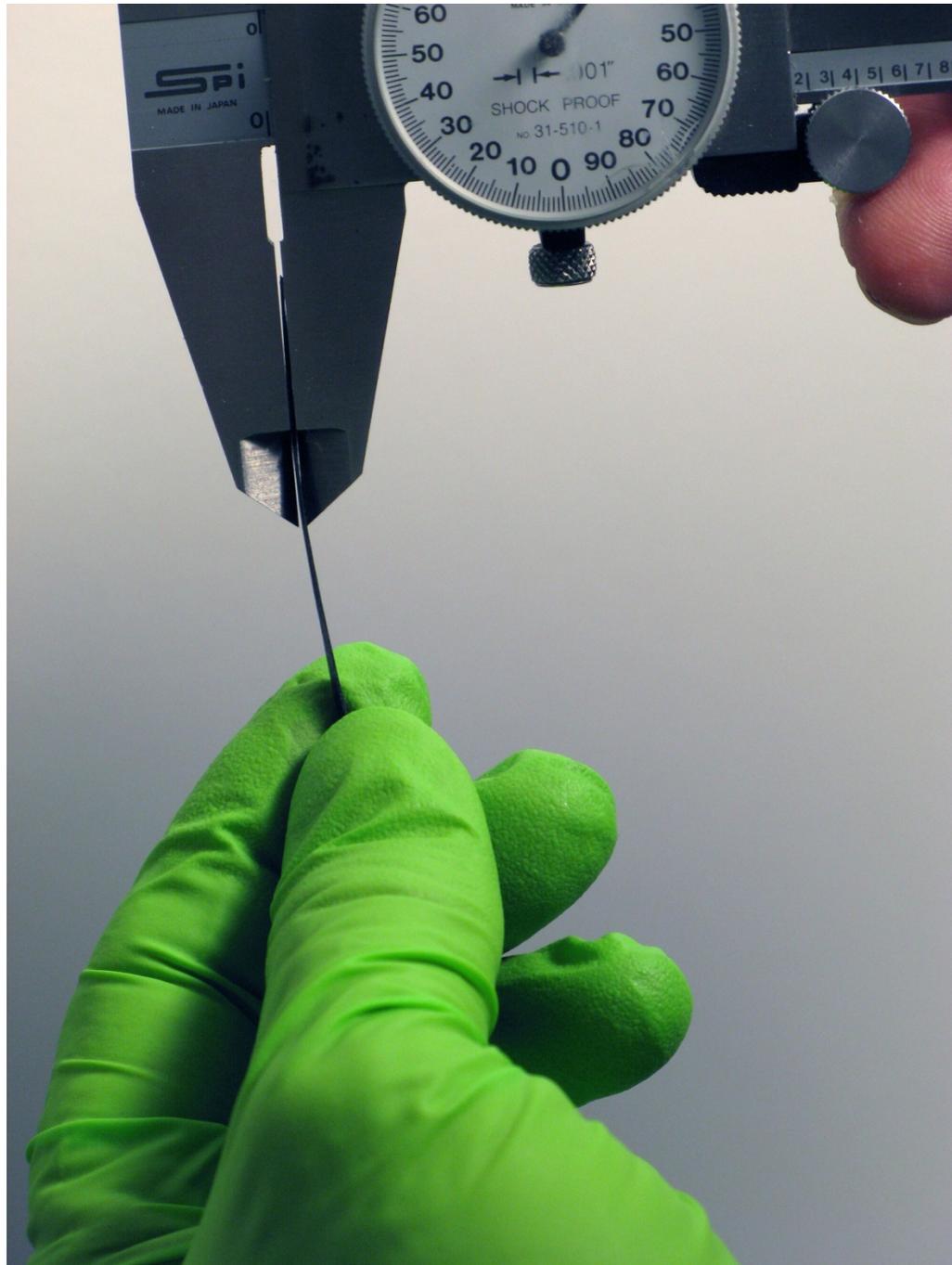
7.3 Repairing delamination



▲ Trim off delaminated fiber at the widest and deepest point. **Note:** Only delamination of the outer hoop wrapping may be repaired. The width of the delamination may not be any wider than the original area of damage from cuts, gouges or abrasion (see Section 6.6, above).



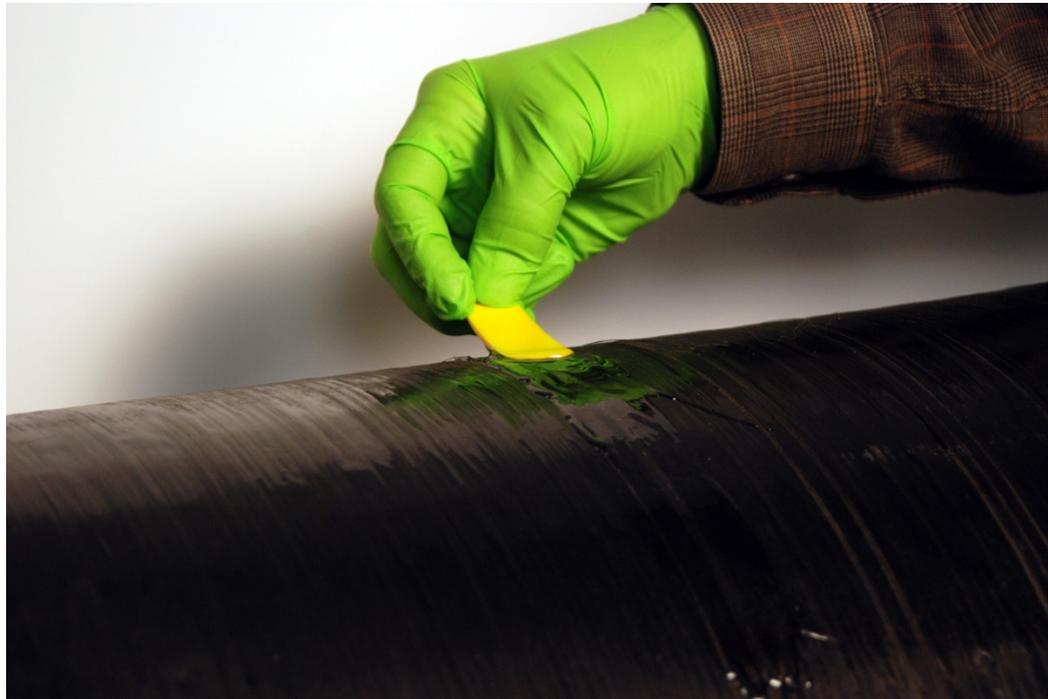
▲ Measure the width of the clipped segment to make sure that the delaminated area is within acceptable limits for repair.



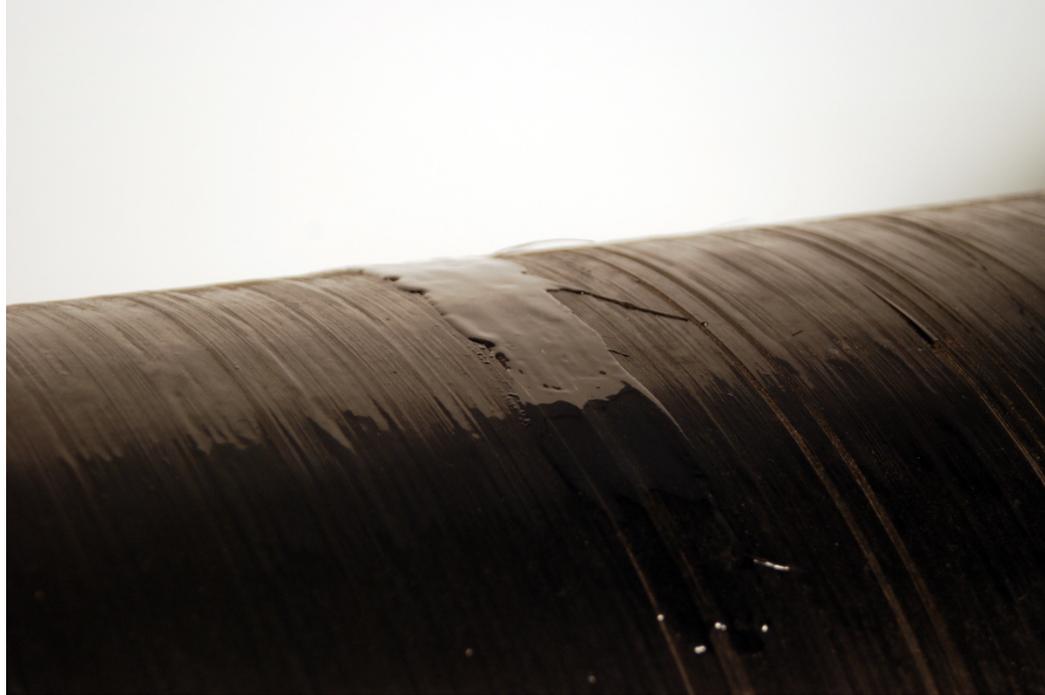
▲ Also measure the thickness of the clipped segment to ensure that it meets the criteria for repair shown in table 5.6, above.



▲ Follow the procedures shown previously above to mix epoxy resin. Generously apply resin to the gap left when delaminated fiber was removed from the outer hoop-wrapping.



▲ Continue applying resin until the gap left by delamination is completely filled. Allow to dry, following manufacturer's instructions.



▲ There should be no indentations or low spots in the repaired area, which should extend slightly above the original surface of the cylinder.

8.0 Destruction of condemned or expired cylinders

To destroy condemned or expired cylinders, drill a minimum 1/2-inch (13mm) hole all the way through the cylinder wrapping and liner so that the cylinder cannot hold gas.



WARNING: Even if completely vented, the cylinder will contain a significant amount of residual flammable gas that could ignite! Completely purge the cylinder with an inert gas (such as nitrogen) before destroying it. Do not use compressed air to purge the cylinder!

Always dispose of condemned or expired cylinders in accordance with current NGV-2 guidelines.

9.0 Summary

9.1 Care and maintenance

ALWAYS:

Always be alert for leaks with each fill.

Always keep the threads and cylinder interior dry and free from oil, dirt and other contaminants.

Always fill cylinders with the proper gas.

Always follow inspection recommendations.

Always follow the fuel system manufacturer's procedures and recommendations.

Always follow the valve manufacturer's installation procedures and recommendations.

Always maintain all accessory equipment in accordance with the manufacturer's recommendations.



NEVER:

Never fill a cylinder if it leaks.

Never fill a cylinder with a defect.

Never completely discharge a cylinder (except when you're planning to remove the valve), since this can cause moist air to seep into the cylinder.

Never fill or partially fill a cylinder with any gas not identified on the label.

Never artificially heat your cylinder.

Never fill a cylinder that is past its required periodic recertification inspection date.

Never fill a composite cylinder past its allowable life.

Never over-torque a valve.

Never remove, obscure or alter a manufacturer's labels or stamped markings.

Never use a cylinder after it has been exposed to an extremely corrosive atmosphere or environment, without having it pass the periodic recertification inspection.

Never use a cylinder that has been involved in a traffic accident or a fire.

Appendix 1: AF cylinder sample label.



CNG ONLY



Luxfer Part Number: A2085C-001

Serial Number: ADJ 12345

**Service Pressure: 24820 kPa (3600 psig)
at 21°C (70°F)**

Date of Manufacture: 7  2007

DO NOT USE AFTER: 07/2027

Capacity: 200 Liters

Empty Weight: 170 lb.

DOT FMVSS 304 / NGV2-00 / TYPE 3

**FOR USE ONLY WITH THE CONTAINER
MANUFACTURER'S APPROVED PRD
AND VALVES.**

For more information, visit the Luxfer Gas Cylinders website at www.luxfercylinders.com
or call Luxfer customer service at (800) 764-0366, Fax (951) 781-6598.

WARNING: Improper handling, use, filling, storage or disposal of this container may result in personal injury, death and/or property damage!

WARNING: Do not puncture or drop container. Do not modify container in any way. Never expose container to temperature exceeding 180°F (82°C).

WARNING: 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 and deterioration. For visual inspection after a motor vehicle accident or fire, contact Luxfer Gas Cylinders at (800) 764-0366.

If there is a question about proper use, installation, or maintenance of this container contact Luxfer Gas Cylinders, 3016 Kansas Ave., Riverside, CA 92507; call (800) 764-0366 or fax (951) 781-6598.

Appendix 2: AF cylinder inspection form (see next page)

The AF Cylinder Inspection Form may be used as a master for copying additional forms.

ALTERNATIVE FUEL CYLINDER INSPECTION FORM



Date: _____

Vehicle make	Model	VIN #	Year	Mileage
--------------	-------	-------	------	---------

Cylinder No:	1	2	3	4
Manufacturer				
Serial #				
Location				
Label Serial # (Applied)				

P = Pass F = Fail

NFPA 52 sect.	GRI pg.	ALTERNATIVE FUEL CYLINDER EXAMINATION	1	2	3	4
3-3	6-12	Cylinder and mounting brackets are clean.				
3-3	6-13	Cylinder installation complies with NFPA-52.				
3-3	4-4	Minimum 1/2-inch clearance exists around cylinder and 3/8-inch clearance from shields.				
3-3	6-14	Rubber mounting pads are in place and in good condition.				
3-3	6-6	Cylinder is firmly restrained by brackets (no looseness, rocking or cracks).				
3-3	6-14	All bracket securing bolts are present and tight.				
3-3	6-7	All bracket and strap bolts are torqued to proper specifications.				
3-3	6-7	Mounting brackets are in good condition and free from bends, deformations or damage.				
3-3	6-14	Mounting bracket area is undamaged.				
3-3	6-14	Bracket-to-vehicle mounting shows no signs of stress.				
3-3	6-14	Brackets and straps are free from corrosion.				
-	6-19	Cuts, gouges and abrasions on the cylinder are less than 0.010 inch in depth.				
-	7-8	No signs of cylinder exposure to fire or extreme heat.				
-	6-8	No signs of cylinder damage from an accident.				
-	Sect - 7	Cylinder is free from impact damage and shows no signs of surface discoloration, cracked resin, chipping or loose fibers.				
3-3	6-13	Cylinder service pressure markings are not less than vehicle service pressure.				
2-5	6-13	Cylinder has not exceeded its service life.				
3-4	-	Cylinder is properly externally vented (this applies only to cylinders enclosed in vehicle).				
-	7-2	Cylinder is free from rust, corrosion or etching of the outer surface.				
-	Sect - 7	External paint, composite layer and metal surfaces are free from bubbles or bulges.				
2-8	6-16	Valves, lines and/or pressure-relief devices (PRD) are damage free.				
3-5	-	Fuel and vent lines are properly attached to the vehicle.				
		Vehicle history shows no incidents that may possibly have damaged the cylinder.				
		New inspection sticker has been applied.				

Summary of examination and description of damage and/or other adverse findings:

Repaired or replaced brackets or other components as follows:

CYLINDER INSPECTION RESULTS (check only one)

Return cylinder(s) to service.

Repair cylinder(s) as follows:

Send cylinder(s) to manufacturer for further inspection as follows:

REMOVE CYLINDER(S) FROM SERVICE AND DESTROY.

Certificate No. _____ Inspector's signature _____