Reviewers Note: Words/phrases in blue will be links to specific diagnostic procedures when this document is published in Freshdesk.

CNG Cylinder Inspection Manual

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Introduction

About this Manual

This manual contains specific information pertaining to the inspection of Type 4 cylinders designed and manufactured by Hexagon® Agility®.* It should not be applied to cylinders made by other manufacturers.

It is the responsibility of the vehicle OEM or third party installer to provide this manual to the appropriate personnel and to ensure its accessibility. Appropriate personnel includes, but is not limited to, those who are responsible for the inspection of cylinders.

A thorough understanding of the information provided in this manual is required for the safe and proper product inspection. If further information is needed or questions arise, contact Hexagon Agility.

Hexagon Agility endeavors to maintain a comprehensive and accurate product and service information. We reserve the right to make changes at any time to manuals and other materials. Please contact Customer Care and Technical Services to ensure you have the latest version.

*Applies to cylinders labeled under Agility Fuel Solutions, Hexagon Agility, Hexagon Lincoln, and Lincoln Composites

Inspection Types, Tools, and Supplies

Hexagon Agility cylinders must be inspected to ensure continued performance and safety. This manual should be read thoroughly prior to performing an inspection. Cylinder specifications, as noted in the design parameters (DP), should also be reviewed.

Pre-Delivery Visual Inspection

Hexagon Agility requires the fuel system OEM to perform a thorough inspection of the cylinder prior to the vehicle being put into service. The inspection should include the following checks:

Item	Description	Examples
1	signs of leaks	▪ rotten egg smell ▪ hissing sound
2	signs of cylinder damage	▪ abrasions ▪ chemical damage ▪ cuts ▪ debris around cylinder(s) ▪ dents ▪ dings ▪ excessive heat damage ▪ gouges ▪ loose fibers ▪ scrapes ▪ etc.
3	signs of cylinder mount damage	mounts, rubber pads, or hardware ▪ loose ▪ damaged ▪ missing
4	cylinder clearance	minimum distance from vehicle and other fuel system components *(refer to cylinder DP and fuel system OEM specifications)*

5	cylinder labels	▪ visible ▪ in place ▪ legible ▪ cylinder is within the OEM “do not use after” expiration date

Pre-Trip Visual Inspection

The driver should perform a cursory visual inspection before each trip. Look for the following items:

1. **signs of cylinder damage** – dents, dings, cuts, gouges, scrapes, etc.
2. **signs of leakage** – rotten egg smell or a hissing sound

WARNING

If damage is found, remove cylinder from service until a more in-depth inspection can be performed.

Inspection During Routine Maintenance

A trained technician should perform a general visual inspection during routine preventative maintenance such as oil and fuel filter changes. Hexagon Agility recommends that shields, covers, and panels be removed, where possible, to make the cylinder surface visible.

NOTICE

Use soap and water to clean cylinder and mount surfaces of road grime and grit before inspection.

Inspect for the following items:

Item	Description	Specifics
1	signs of leaks	▪ rotten egg smell ▪ hissing sound
2	signs of cylinder damage	▪ abrasions ▪ chemical damage ▪ cuts ▪ debris surrounding cylinder(s) ▪ dents ▪ dings ▪ excessive heat damage ▪ gouges ▪ loose fibers ▪ scrapes ▪ etc.
3	signs of cylinder mount damage	mounts, rubber pads, or hardware ▪ loose ▪ damaged ▪ missing
4	neck mount cylinders	signs of wear on bosses, mount blocks, and bushings
5	strap mount cylinders	shifting of rubber pads, cracking of rubber pads, or other damage to rubber
6	cylinder labels	▪ visible ▪ in place ▪ legible ▪ cylinder is within the OEM “do not use after” expiration date

WARNING

If damage is found, remove cylinder from service until an in-depth inspection can be performed.

Inspection Tools and Supplies

Item	Description	Purpose
1	**shop light**	illuminate fuel system components
2	**inspection mirror**	visual access to back surfaces of cylinders
3	**hand tools**	remove / replace fuel system covers, mounts, plumbing
4	**depth gauge / micrometer / caliper**	measure cylinder surface and boss damage
5	**neck bushing go-no-go gauge,** p/n 24200183	measure cylinder neck mount to bushing gaps
6	**fuel receptacle go-no go tool**, p/n 10300140 or **coin**	perform tap test
7	**Swagelok® Snoop® or other leak detection fluid**	leak detection
8	**clean water and mild detergent**	clean grit and road grime from cylinders
9	**cleaning cloths** or **wipes**	clean grit and road grime from cylinders
10	**notepad**	record inspection findings
11	**camera**	document cylinder damage

When Inspections Must be Performed

WARNING

Always perform a Periodic Full Visual Inspection of the cylinder(s) immediately if:

1. **Cylinder or vehicle has been in an accident** involving collision, fire, or any event that may have caused external or internal damage, **or**
2. **Cylinder seems to be behaving oddly.** This includes but is not limited to, emission of CNG odor, unexpected loss of gas pressure, snapping or hissing sounds, rattling, and any indications of loose parts, **or**
3. **Cylinder is believed to have been pressurized above its maximum fill limit** as indicated on the label.
4. **Cylinder inspection is a required part of full CNG fuel system inspection which is required every 12 months or less per U.S. Department of Transportation and Canadian federal requirements**.

The Hexagon Agility Statement of Service document specifies the recommended inspection frequency for each cylinder according to its certifications.

Some areas have specific requirements for CNG cylinder inspections. Check with the local authority having jurisdiction (AHJ) for the most recent requirements.

NOTICE

If there is a difference between inspection intervals specified in this manual and the requirement of the authority having jurisdiction, the more stringent requirement applies.

For convenience, Hexagon Agility recommends other vehicle maintenance tasks, such as engine oil and fuel filter changes and the yearly DOT inspection, be matched with the cylinder periodic full visual inspection.

Inspection Preparation

Cylinder History

The inspector should question the owner / fleet manager and vehicle operator(s) about any known incidents that may have caused damage to the cylinder or any unusual observations. Additionally, the service history of the cylinder, including any rework or repair that may have been performed since its last inspection, should be supplied to and reviewed by the inspector.

Cylinder Access

Remove shields, covers, and panels, where possible, to make the cylinder surface visible.

Washing

The exterior surface of the cylinder should be washed prior to performing this inspection.

NOTICE

Hexagon Agility recommends washing the cylinder by hand with water or a mixture of water and a mild detergent. If using a detergent, ensure the cylinder and surrounding components are thoroughly rinsed with water.

Inspection Criteria

Composite Inspection

Visually inspect the composite for signs of damage including abrasion, impact, weathering, excessive heat, chemical attack, leakage, and unraveling.

Abrasion Damage

Abrasion damage may occur when an object contacts the surface of the composite. Light-load abrasion appears smooth and polished (**Figures 3** and **4**), while high-load abrasion appears as gouges or cuts (**Figures 5** and **6**).

The severity of the abrasion should be evaluated by the depth of the damage as shown in **Table 1**. High-load abrasion should also be evaluated for impact damage.

Table 1. Abrasion Damage Levels and Disposition

Damage Level	Abrasion Depth		Disposition
	inches	millimeters	
1	0.000 ≤ 0.010-in	0.00 ≤ 0.25 mm	field repair
2a	0.011 ≤ 0.035-in	0.26 ≤ 0.89 mm	field repair
2b	0.036 ≤ 0.050-in	0.90 ≤ 1.27 mm	contact CCTS
3	> 0.050-in	> 1.27 mm	decommission and dispose of cylinder

Figure 3. Surface scratches categorized as Level 1 abrasion damage.

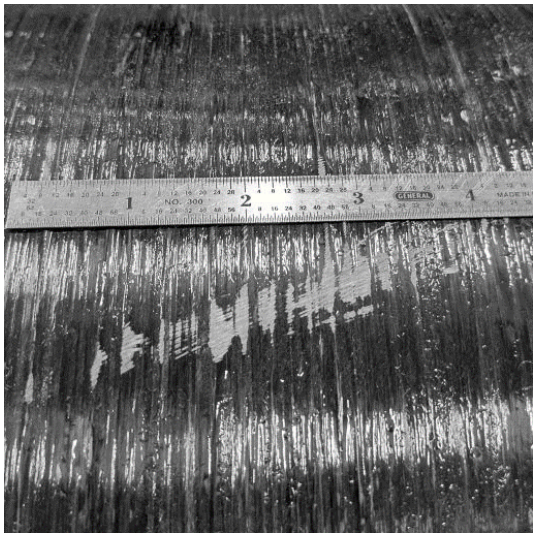

Figure 4. Matte surface texture from Level 2a abrasion damage.

Figure 5. Gouge in the composite categorized as Level 2b abrasion damage.

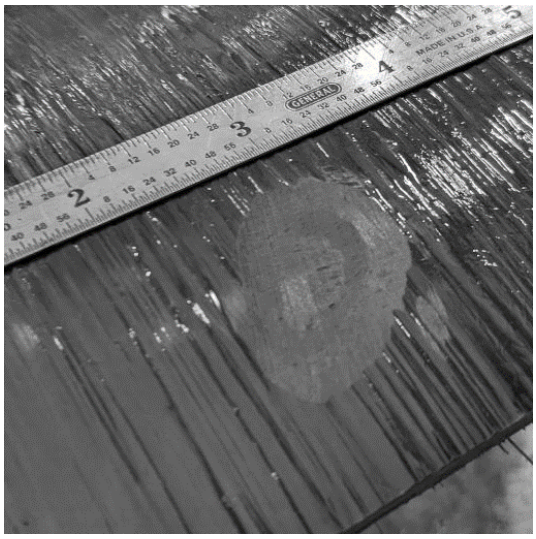

Figure 6. Level 3 abrasion damage where multiple layers of composite are visible.

Impact Damage

Severe structural damage can be caused from impacts. Impact damage may occur during shipping, installation, or while in service (e.g., vehicular accident).

Since composite cylinders tend to return to their original shape after an impact and typically do not dent like metal cylinders, a simple visual check is not enough. Damage may be hidden within the composite wall. This is particularly true if the object impacting the cylinder is blunt and relatively smooth. Impact damage types are delineated in **Table 2**.

Table 2. Impact Damage Types and Descriptions

Impact damage category	Description
surface damage	damage to composite shell including cuts, gouges, scrapes, scuffs, chips, punctures, and change in coloration or appearance. Surface cracks may appear circular or linear.
permanent deformation	depression of composite surface resembling a dent
softness or deflection	composite surface moves in response to pressure applied with hands
damage to cylinder end bosses and /or hardware	signs of physical scrapes and scuffs to cylinder components including valves, plumbing, fittings, pressure relief devices, and mount hardware
damage to dome protection	cracks in or loss to cylinder end dome caps

If signs of impact damage are observed, a tap test may be performed to help determine whether impact damage is present.

The tap test is a method to identify delamination within the composite and may be performed on areas of possible damage by tapping the surface with a quarter, or similarly size metal object, grasped between the fingers. Differences in sound are evidence of damage.

NOTICE

False indications may be heard if the tap test is performed on the dome (end) areas. The tap test should be limited to the main portion of the cylinder and not the dome ends.

WARNING

Decommission and dispose of the cylinder if a known impact has occurred, if signs of impact damage are present, or if there is any uncertainty in assessing damage.

Weathering Damage

The outside layer of resin will naturally yellow over time. This is normal and does not affect cylinder performance.

Weathering damage can occur when the cylinder has prolonged exposure to sunlight and weather. Weathering damage is evident by areas of resin degradation (chalking) and loose or broken fibers. **FIGURE 7**

NOTICE

Contact Hexagon Agility for evaluation of weathering damage.

FIGURE 7. a) cylinder not exposed to weathering, b) a weathered cylinder with yellowed resin and loose surface fibers, c) a macro of the weathered cylinder showing the visible fibers.

Excessive Heat Damage

Hexagon Agility cylinders have a maximum service temperature as noted in the Statement of Service.

Heat damage may occur if the cylinder is involved in a fire or is near a heat source such as an exhaust system. Evidence of heat damage includes discoloration, charring, soot, melted resin, loose fibers, melted labels, or activation of a T-PRD. **FIGURE 8**

WARNING

Cylinders exhibiting evidence of heat damage must be decommissioned and disposed of.

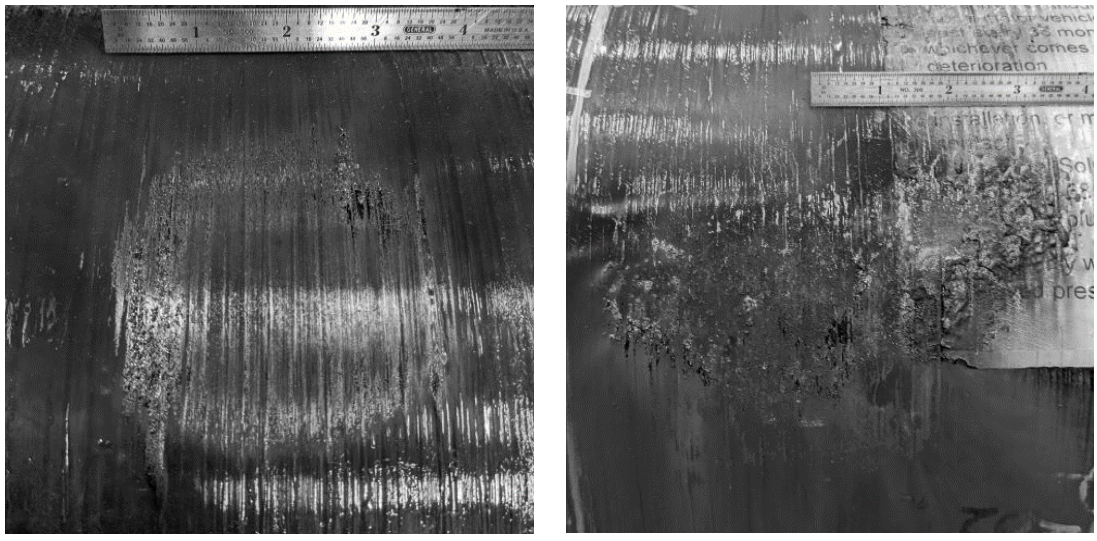

FIGURE 8. Cylinder exposed to excessive heat. *Left:* surface charring, melted resin; *right:* melted label and resin.

Chemical Damage

Hexagon Agility cylinders are resistant to common chemicals encountered in the typical fuel service environment. Chemical damage types are listed in **TABLE 3**.

TABLE 3. Chemical Damage Types

Chemical damage categories	
corrosion	**swelling**
discoloration	**softening**
pitting	**cracks**
blistering	**loose fiber**

WARNING

Cylinders exhibiting evidence of chemical damage must be decommissioned and disposed of.

Leakage

Prior to leaving a Hexagon Agility production facility, cylinders are leak tested with a trace gas detector. This testing method can detect extremely small amounts of gas and is more accurate than any possible leak check done in the field or at the installer. No cylinder leaves the factory without a passing leak test.

Signs of leakage include the following:

1. **an audible sound**—hissing—of a leak
2. **a strong smell** of CNG
3. **icing, frost, or condensation visible on fuel system fittings and lines**
4. **an inexplicable drop in fuel pressure** over time

When investigating a potential leak in the field or at the installer, Hexagon Agility recommends performing a bubble leak check. Using handheld electronic leak detectors often results in false-positive readings due to the sensitivity of the equipment. A bubble leak check is performed by simply applying a certified leak detecting solution (e.g., Swagelok Snoop®) to potential leak sources, waiting three minutes, and looking for bubbles.

WARNING

If a leak is found, remove cylinder / vehicle from service.

WARNING

If the leak source is in the plumbing or associated hardware, **defuel cylinder before tightening fitting / component connections or replace per OEM specifications, as necessary.**

If the source of the leak has been isolated to the cylinder, the procedure below may be used to confirm a cylinder leak.

False Indications of a Leak

Often, when a cylinder is filled for the first time, some amount of air will be present in the space between the liner and composite. With time and pressure cycling, the air will work its way out. If a bubble leak check is performed during this time, the escaping air can generate bubbles around the metallic end boss or on the surface of the composite. This is ***not*** a leak. The number of bubbles and how long it takes to dissipate depends on the size of the cylinder and variation in porosity of the composite. Normally, trapped air escapes within 24 hours. If bubbles are observed during the first fill, no action is necessary unless there is a strong smell of natural gas.

A similar condition can occur if a cylinder is at low pressure or defueled. In this case, permeated gas evolving from the liner can collect and mix with the air. When filled again, a handheld electronic leak detector may have the sensitivity to pick up low concentrations of gas. While gas is present, the source is ***not*** a leak. Like the first-fill scenario, trapped gas normally escapes within 24 hours. If bubbles are observed during this inspection scenario, no action is necessary unless there is a strong smell of natural gas.

Confirming a Cylinder Leak

If uncertain whether a cylinder has trapped gas or is leaking, first keep the cylinder at pressure for 24 hours, in a well-ventilated area (preferably outdoors), then repeat the bubble leak check.

If bubbling appears the same, reduce cylinder pressure to 500 psi (35 bar) to help lower the interface pressure between the liner and composite. This can sometimes help the trapped gas to escape more quickly. Hold at this pressure for 24 hours and then repeat the bubble leak check.

If there are noticeably fewer bubbles, this indicates the source is trapped gas and will work its way out naturally. The cylinder may return to service. If bubbling appears the same, contact Hexagon Agility.

WARNING

A cylinder with a confirmed gas leak must be decommissioned and disposed of.

Unraveling

Damage to cylinders can lead to unravelling when broken fiber progressively delaminates from the composite surface. **FIGURE 9**

If there is evidence of lifted fiber without unraveling, it may be repaired.

WARNING

If fiber has begun to unravel, cylinder must be decommissioned and disposed of. Refer to CNG Cylinder Decommissioning and Disposal Manual.

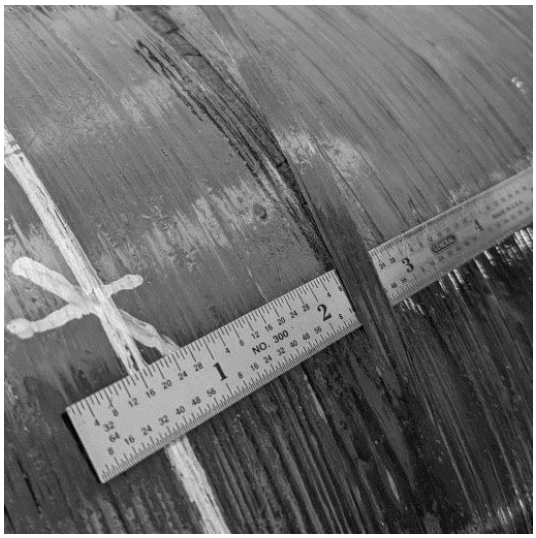

FIGURE 9. Fiber unraveling with a section of the composite lifted up

Composite Finish Imperfections

The method of manufacturing composite cylinders sometimes leaves surface characteristics which look like defects, but which are simply cosmetic and do not affect the performance or integrity of the cylinder. **TABLE 4**

TABLE 4. Composite Finish Imperfection Types and Descriptions

Imperfection category	Description	Image
crazing	hairline micro-cracking of the resin; common on composite cylinders.	**FIGURE 10**
resin bubbles or **pock marks**	formed as entrapped air works its way through the composite	**FIGURE 11**
resin and paint runs	formed when excess resin or paint drips down the composite surface	**FIGURE 12**
raised fiber	occurs when fiber is lifted from the surface of the composite creating a raised edge	**FIGURE 13**
tucked fiber	creates a bump where the cut fiber is tucked underneath the final layer at the end of the winding process	**FIGURE 14**
fiber gaps	appear around the dome; may be present on cylinders that utilize wound-in dome protection	**FIGURE 15**

NOTICE **If it is unclear whether a cylinder has a cosmetic defect or damage, contact Hexagon Agility.**

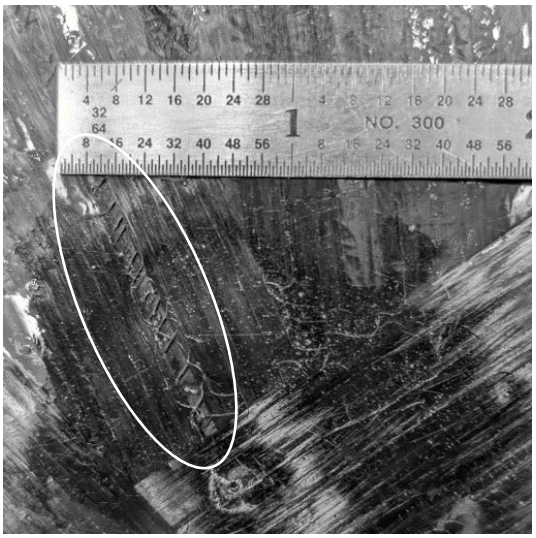

FIGURE 10. Resin crazing on the cylinder composite *(circled)*.

FIGURE 11. Solidified resin bubbles on the cylinder surface *(circled).*

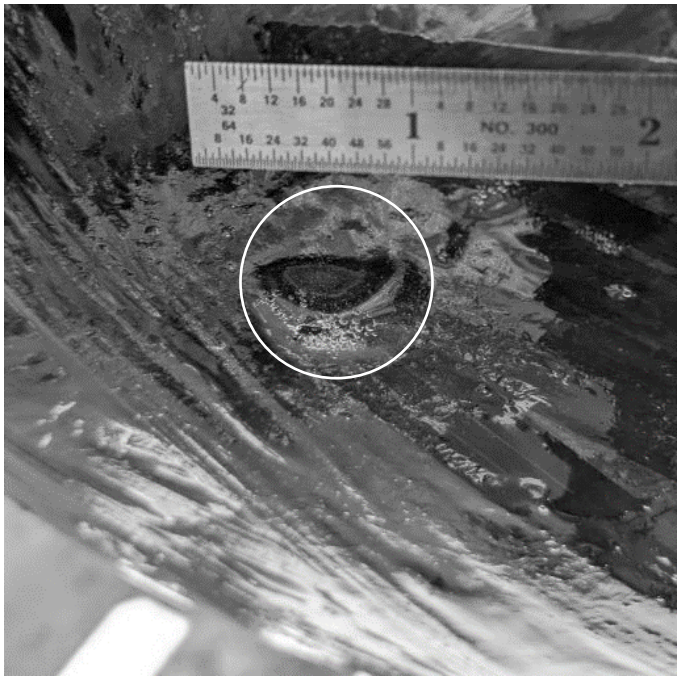

FIGURE 12. Resin run on the cylinder surface *(circled).*

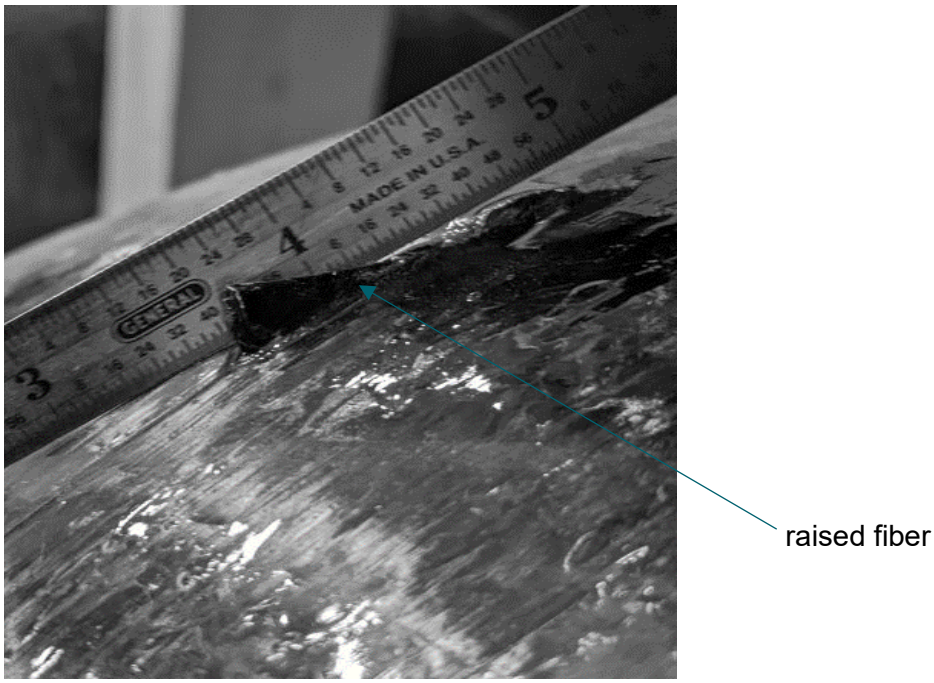

FIGURE 13. Raised fiber on the cylinder surface.

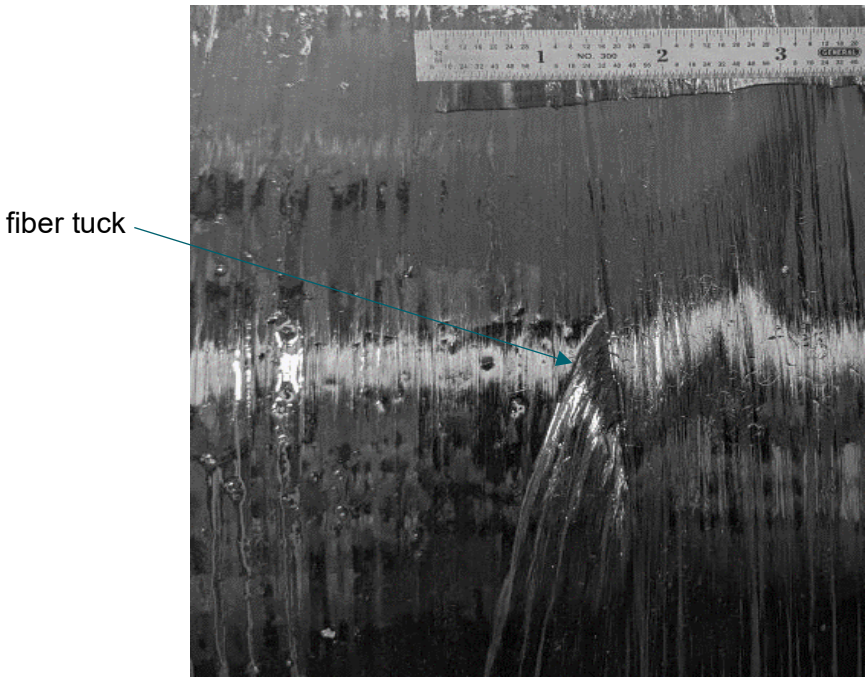

FIGURE 14. Fiber tuck on the cylinder surface.

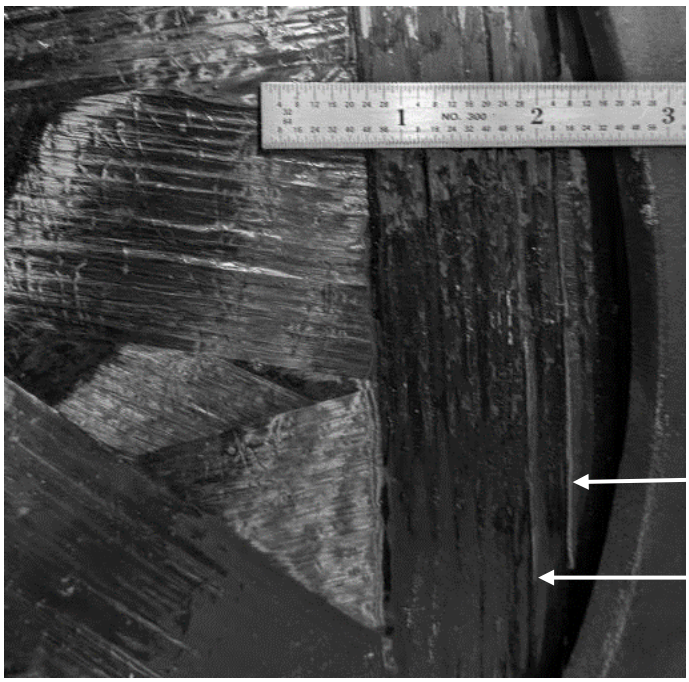

FIGURE 15. Dome end of cylinder displaying gaps in a fiber band *(arrows)* showing the band underneath.

End Mounted Cylinders

Visually inspect cylinder bosses, mount blocks, and hardware for damage and loosening.

Fixed End Inspection

Inspect the fixed end to ensure the cylinder is properly secured.

Signs of wear or a loose mount include the following:

- block or cylinder movement
- metallic dust around the boss/block interface.

WARNING

If damage is present, remove vehicle from service.

Disassemble loose mounts and inspect for damage (e.g., missing nuts, worn threads, broken bolts). Contact Hexagon Agility for replacement components.

Sliding End Inspection

Inspect the sliding boss surface, block, and bushing for wear. Signs of wear include the following:

- exposed aluminum **FIGURE 16**
- variation in diameter along the length of the boss **FIGURE 16**
- plastic shavings
- contact between the boss and block.
- a gap between the bushing and boss **FIGURE 17**

Wear severity and associated disposition for each sliding boss end component is shown in **TABLE 5**.

TABLE 5. Sliding Boss Wear Damage Severity and Disposition

Component	Wear Depth		Disposition
	inches	millimeters	
sliding boss	≤ 0.050 in	≤ 1.27 mm	note in inspection record
	0.051 ≤ 0.125 in	1.30 ≤ 3.18 mm	refer to “Resurfacing Sliding Boss Wear” in CNG Cylinder Repair Procedure
	> 0.125 in	> 3.18 mm	decommission and dispose of cylinder
block	≤ 0.050 in	≤ 1.27 mm	note in inspection record
	> 0.050 in	> 1.27 mm	replace
bushing	≤ 0.050 in	≤ 1.27 mm	note in inspection record
	> 0.050 in	> 1.27 mm	replace

WARNING

Inspect block bolts and nuts for signs of loosening. Tighten or replace hardware as necessary. Contact Hexagon Agility for replacement components.

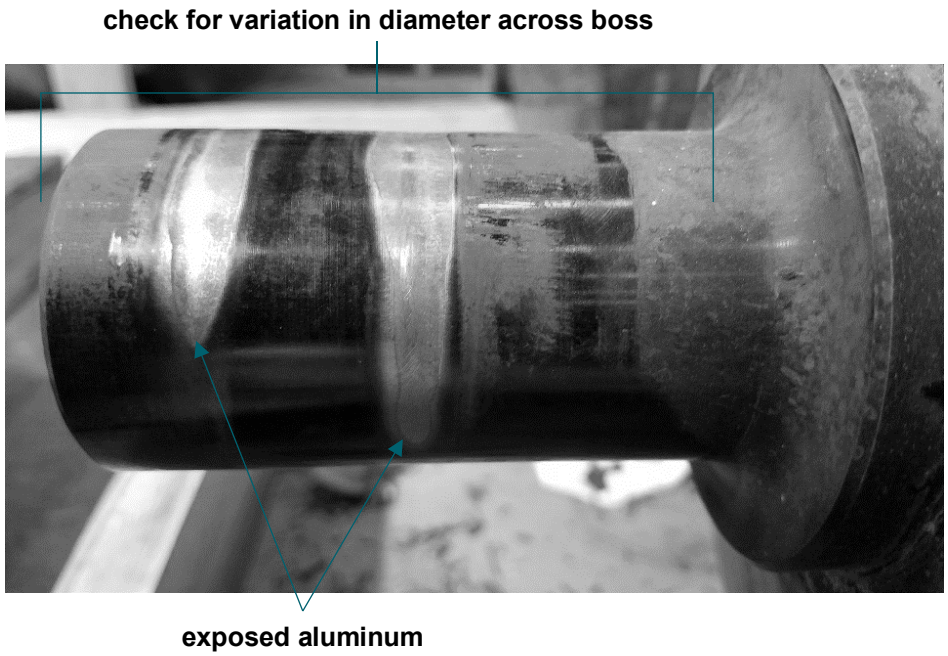

FIGURE 16. Indicators of sliding end cylinder boss wear.

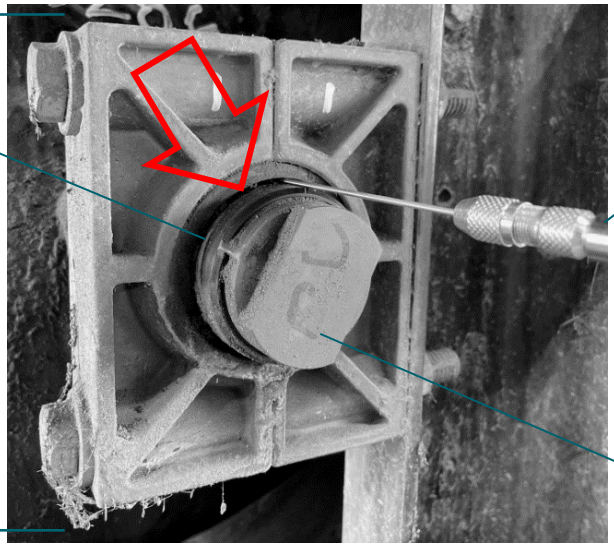

FIGURE 17. Gap indicative of bushing wear.

Strap Mounted Cylinders

Strap mount cylinders should be inspected for signs of movement relative to the strap and cracked or displaced rubber.

WARNING

If signs of movement are present, or the rubber is cracked or displaced it must be inspected and possibly replaced. Contact Hexagon Agility for replacement.

Inspect straps for signs of damage including corrosion, cracks, deformations, breakages, and broken bolts.

- Do not torque strap bolts.
- If straps are disassembled or loosened, replace rubber pads.

WARNING **If damage is present, remove vehicle from service and contact Hexagon Agility.**

Labels

Check OEM cylinder labels for signs of damage including tears and weathering.

WARNING **If label is missing or illegible, remove vehicle from service and contact Hexagon Agility.**

NOTICE **Contact Hexagon Agility for replacement.**