



# **Luxfer Composite Repair Guide**

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GUIDANCE FOR THE REPAIR OF DELAMINATED COMPOSITE  
CYLINDERS MANUFACTURED IN THE UNITED STATES

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## 1. Guidelines

The information contained in these guidelines was obtained from sources believed to be reliable and is based on technical information, experience and regulations currently available from Luxfer Gas Cylinders.

The guidelines provided herein are not intended to be comprehensive and are intended to assist suitably trained personnel in the safe operation, inspection, periodic testing and valving of Luxfer Gas Cylinders composite cylinders. The use of these guidelines shall not create or give rise to any liability to Luxfer Gas Cylinders.

There may be situations, however, which may be outside the company's current experience and so are not included in this document. Luxfer Gas Cylinders, the national approval authority or a government approved retest agency should be contacted for guidance and if there is any doubt as to a cylinder's condition. If such consultation is not possible, the cylinder should be condemned.

It should be noted that these guidelines should not be used for inspecting composite cylinders from any other manufacturer.

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## 1. Introduction

**Delamination** is a phenomenon where the outer sacrificial layer of glass fiber, on a carbon fiber reinforced cylinder, is damaged from a cut or gouge and a strip or band of material peels up from the body of the cylinder. Depending on the depth and width of the initial damage that causes the delamination, the cylinder may be repaired. The Luxfer Care and Maintenance Manual shows the allowable depth/length levels for damage.

## 2. Cylinder Damage Criteria

The acceptance/rejection criteria given in this Luxfer manual are the manufacturer's recommendations and do not replace or supersede any criteria required by DOT-SP 10915, DOT-SP 10945, DOT-SP 14232, DOT-SP 15136, TC-SU 5134, TC-SU 10530. or CGA C-6.2.

First check the marking to ensure that the cylinder is within its working life. Working life is within 15 years from the date of manufacture as indicated on the cylinder label.

Luxfer carbon composite cylinders have an outer glass fiber layer that is additional to the structural strength of the carbon wrapping. As a rule, any damage to the glass layer is either acceptable or can be repaired. However, any damage that exposes the structural carbon fiber layers is sufficient to cause rejection of the cylinder.

Luxfer recommends the use of three categories of damage in accordance with CGA C-6.2 section 10 (note that in some of the cases specified below, only Levels 1 and 3 are used).

Level 1 damage is minor damage considered normal wear-and-tear and that has no adverse effects on the integrity or safety of a cylinder. Cylinders with Level 1 damage can continue in service.

Level 2 damage is greater than Level 1, but less than Level 3. Level 2 damage can be repaired.

Level 3 damage is sufficiently severe that the cylinder must be rejected. Level 3 damage cannot be repaired.

**It is important to be aware that under special permits granted by the US DOT, Transport Canada, and guidance for the CGA, a hydrostatic test must be performed on any repaired cylinder before being refilled and returned to service.**

## 3. Delamination

Delamination is a separation of composite overwrap layers or strands. It may also appear as a whitish patch, such as a blister or an air space beneath the surface. Delamination is usually a result of an impact, cut or exposure to temperatures of more than 200°F.

- **Level 1 damage:** Light damage, such as a small area where the fiberglass is frosted, does not require repair. The cylinder may be returned to service.
- **Level 2 damage:** If delamination is restricted to the glass-fiber layer only and any defect does not exceed a width of 2 inches (50 mm), the cylinder may be repaired and returned to service.
- **Level 3 damage:** Delamination damage greater than Level 2 requires the cylinder to be rejected.

## 4. Delamination Repair

If the cylinder has been determined to have Level 2, repairable damage, the cylinder should be repaired as soon as possible to avoid additional material from coming off the cylinder. The following procedure describes how to repair a delamination. Read all of these instructions before attempting to repair a delamination. Figure 1 below shows an example of repairable delamination beginning at a cut in the cylinder surface.



Figure 1: Example of delamination damage



## 5. Required Tools

To successfully repair delamination damage, the following tools and supplies, shown in Figure 2 below, are recommended to have available before beginning the repair:

- ☐ Caliper or Ruler
- ☐ Depth Gauge
- ☐ Scissors
- ☐ Knife
- ☐ Squeegee
- ☐ Nylon (heat-resistant) Tape
- ☐ 5-minute Epoxy
- ☐ Super Glue®
- ☐ Sandpaper or 3M Scotch-Brite® Pad
- ☐ Non-Powdered Disposable Gloves
- ☐ Paper Towels or Microfiber Cloth
- ☐ Isopropyl Alcohol



Figure 2: Tools and supplies needed for repairing delamination damage

The 5-minute epoxy can be any brand of two-part (A/B, hardener/resin), 5 minute curing, liquid based epoxy. Loctite® Epoxy as shown below is easy to work with and has a mixing tube to make application and mixing easier. Super Glue® is any ethyl cyanoacrylate adhesive for use with plastics. Loctite® 495 is an excellent adhesive and comes in an easy to apply bottle and is recommended for delamination repair.

## 6. Verify Damage Depth

Before beginning any repair, be sure that the damage is repairable. Please see Luxfer user's manual and special permit for damage limits.

**Note: To decrease the risk of the original damage propagating, the repair should be done at or near the cylinder's marked service pressure. Although it is recommended to conduct the repair while the cylinder is charged, it is not required, and an effective repair can still be made when the cylinder is at zero pressure.**

## 7. Clean Affected Area

Using Isopropyl alcohol of at least 70% purity and a clean, lint free towel or microfiber cloth, gently wipe down the area under and on top of the delamination. Be very careful of loose fiber as the edges of the delamination can be very sharp and can cause cuts or slivers of material to become lodged in exposed skin.

**Note: Be sure that the cylinder has dried completely before proceeding to the next step or the repair could fail.**

## 8. Apply Super Glue®

**Note: Ethyl Cyanoacrylates bond to skin very easily and quickly, therefore gloves should be worn for this step of the repair.**

If the delamination is less than four (4) inches around the circumference of the cylinder in either direction from the original cut or gouge that caused the delamination, follow the steps immediately below.

Gently lift the material that has come up from the surface of the cylinder. At the base of the delamination where the material is still attached to the cylinder, gently squeeze some Super Glue® on the cylinder surface between the fiber that has delaminated and the cylinder. Only put enough Super Glue® to cover the width of the delamination and only about ¼ to ½ inch of the exposed cylinder from where the delaminated fiber is still attached to the cylinder. This step will arrest further delamination of the fiber.

If the delamination is longer than four (4) inches around the circumference of the cylinder in either direction from the original cut or gouge that caused the delamination, follow the steps immediately below.

**Note: Care must be exercised in this step to be sure that the fiber seats back into the area of the delamination fully. Once the Super Glue® has dried, any spot not adhered back to the cylinder may cause additional delaminations and remain raised like a "bridge" that is easy to damage with air pocket underneath.**

Gently lift the delamination up and away from the cylinder. Try to place the delamination back into the space in the cylinder where it came from. Be sure that the delamination will seat fully back down into the space on the cylinder. If it does not, trim or sand the area or piece of fiber

that is not allowing the delamination to seat back down fully. The next step should be done in one to two inch segments until the entire length of the delamination has been glued back down to the surface of the cylinder. Working with the Super Glue® bottle, squeeze some Super Glue® onto the surface of the cylinder in approximately 1 to 2 inch segments being careful not to apply too much so that it runs all over the cylinder when pressing the delamination back onto the cylinder. After application of the Super Glue® push the delaminated fiber back into place on the cylinder. Immediately wipe off any Super Glue® that squeezes out from the delamination. The Super Glue® will dry very quickly. As each section dries, repeat this process until the entire length of the delamination has been glued back into place. Allow the Super Glue® to cure for a minimum of one (1) hour before proceeding.

**Note: If the entire surface of the cylinder under the delamination is covered in Super Glue® and it is attempted to glue the entire delamination at once instead of working in sections, it is very easy to have a portion of the delamination not fit back onto the cylinder and either go back crooked or create a “bridge” that will then require further intervention and repair.**

## 9. Abrade the Area Over the Delamination

Using 220 grit, or higher sandpaper or a Scotch-Brite pad, carefully sand the area over the entire delamination and approximately ½ inch beyond the delamination on the cylinder sidewall. This step is necessary for adhesion of the epoxy resin applied in the next step. Once the “shine” has been removed from the delamination and the surrounding area, take a lint free cloth or microfiber cloth with some isopropyl alcohol on it and remove any dust or dirt from the abraded area.



Figure 3: Abrading the surface over the delamination

## 10. Apply Epoxy Resin

As some individuals can have an epoxy allergy, it is recommended to complete this step with disposable gloves that do not contain powder or other mold release agents.

If the delamination is less than 4 inches in either direction around the circumference of the cylinder and only the base of the delamination was glued, follow the steps immediately below.



Using a two-part, 5 minute cure time, epoxy resin dispensed from a tube with a syringe as shown below, squeeze some mixed epoxy under the entire section of material that has delaminated. There should be enough epoxy to cover the entire surface area under the delamination without having so much that it will prevent the delamination from fully seating back into the location it separated from. Carefully fit the delamination back onto the surface of the cylinder. Completely seat the delamination by applying some pressure over the affected area starting at the end farthest from the damage that caused the delamination and working towards the original damage, squeezing out any excess resin. Using a squeegee, smooth the resin over the edges of the delamination and be sure that the original cut or gouge is completely filled with epoxy resin.

If the entire length of the delamination was glued into place, follow the steps immediately below.

Using a two-part, 5-minute cure time, epoxy resin dispensed from a tube with a syringe as shown below, squeeze some mixed epoxy over the entire section of material that has delaminated and previously been abraded. Be sure not to apply too much excess resin or it could leave some “lumpy appearing resin” after completing the repair. Using a squeegee, smooth the resin over the edges of the delamination and be sure that the original cut or gouge is completely filled with epoxy resin. Remove any excess or runs with a cloth or lint free paper towel.

Be sure to complete this step as rapidly as possible. Although the epoxy is supposed to harden in 5 minutes, it could be less if the temperature is in excess of room temperature. If this step is not completed before the resin hardens it will cause additional issues that must be addressed.



**Figure 4: Application of two-part 5-minute epoxy under delamination**

## 11. Apply Heat Resistant Tape

Apply a piece of heat resistant nylon tape over the affected area to keep pressure on the repair while it is curing. Start the tape behind the affected area and pull the tape tight while applying it over the affected area. Be sure to end a good distance past the end of the original damage (at least several inches). If the tape is not wide enough to cover the delamination area in one pass, a second pass (or more if necessary) can be added, being sure that there is some overlap with an already applied pass of tape. Be sure that the tape does not wrinkle, or the resin will fill the void left by the wrinkle and appear lumpy when finished with the repair.

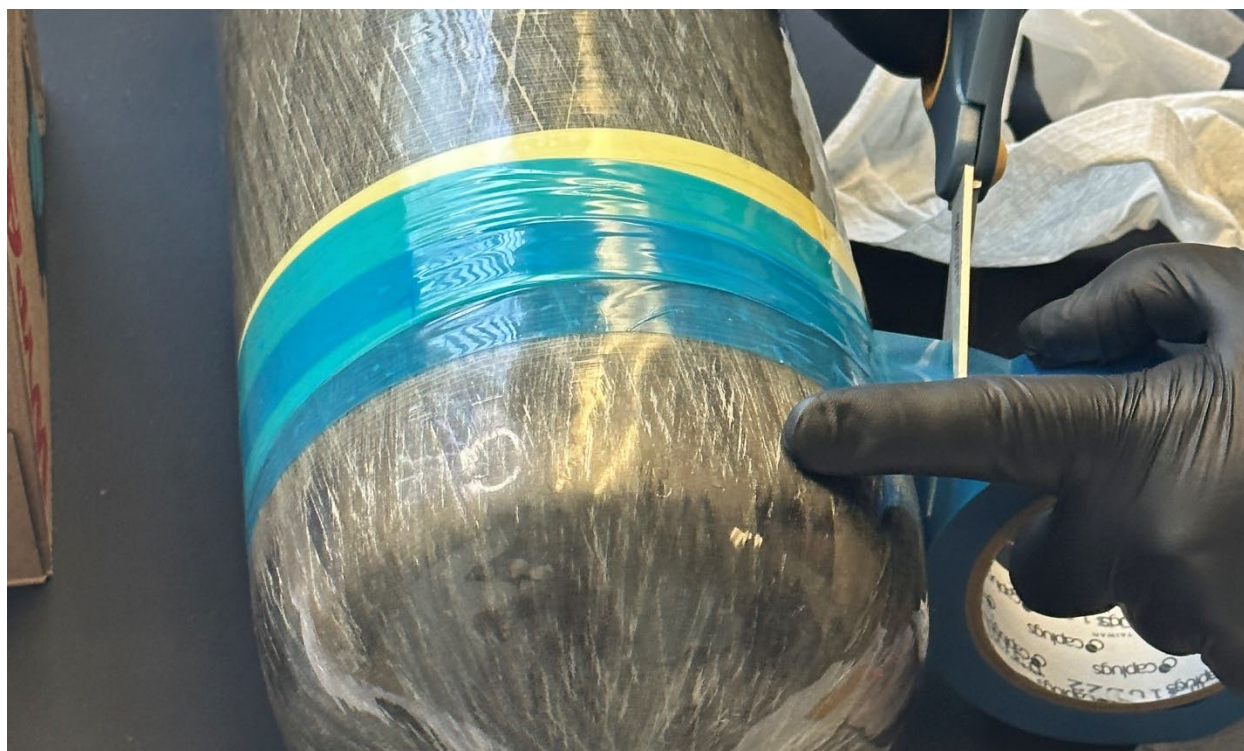


Figure 5: Application of nylon tape over repair area using the overlapping layer method

## 12. Cure

Although the epoxy may say it “cures” in 5 minutes, it actually requires 24 hours at room temperature to achieve its ultimate cure. Leave the heat resistant tape over the repaired area for a minimum of 24 hours before removing.

Once the 24 hours have elapsed, the tape can be removed. If the tape was applied carefully there should be no further action required. If excess epoxy has accumulated at the edges of the tape or in any location, it can be sanded down using a 180 grit or higher sandpaper.

## 13. Retest

Per the DOT requirements and the Luxfer special permits that the cylinder was made to, any repair to a carbon composite cylinder **MUST** be subjected to the hydrostatic test after the repair has been completed. If the repair holds and does not allow the delamination to peel up again, the cylinder can be returned to service after the retest is complete. **The cylinder must not be used or refilled prior to completing the hydrostatic retest.**

## 14. Completed Repair

Successful repair shown in Figure 6, will be indicated by cleanly-blended outer sacrificial glass layer.



**Figure 6: Repaired delamination**