Structural Composites Industries

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Technical Bulletin:
Inspection and Re-qualification
of
DOT Exempted, Carbon Reinforced Composite Pressure Vessels

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Subject:

Inspection and requalification of DOT Exemption carbon composite cylinders manufactured by Structural Composite Industries, (SCI). SCI's DOT Exemption number for carbon cylinders is E 10945.

1.0 Introduction

Under NASA sponsorship, Structural Composites Industries developed the technology to produce fiber reinforced plastic (composite) high pressure gas cylinders and introduced the world's first commercial composite cylinders in 1976. Since this time composite cylinders have demonstrated their safety and durability in a wide variety of commercial, military and aerospace applications.

This technical bulletin describes the proper techniques and references for inspection and re-qualification of SCI's commercial carbon composite cylinders.

In the Untied States, inspection and re-qualification of DOT Exemption cylinders must be performed by a facility holding a current re-tester's identification number issued by the Research and Special Programs Administration of the DOT. The re-test facility must also comply with other administrative DOT requirements in order to re-test Exemption cylinders.

2.0 De-Valve

Safely vent the cylinder. Refer to CGA Pamphlet C-2, "Recommendations for Disposition of Unserviceable Compressed Gas Cylinders with Known Contents", for venting procedures.

Remove the valve using the proper tools and a holding fixture so that the cylinder's exterior and valve are not damaged. Do not use a pipe wrench on the cylinder neck. Do not use heat to loosen the valve.

3.0 Exterior Inspection

Both interior and exterior inspection should be performed before any cylinder is hydrostatically tested.

All of SCI's commercial carbon reinforced composite cylinders are fully over wrapped with a protective layer of fiberglass. This over wrap is intended to protect the carbon fiber from abrasion and other damage. Most of SCI's carbon cylinders will also have a layer of 'Flow Coat' applied over the fiberglass. 'Flow Coat' is a SCI proprietary coating that is UV and chemical resistant.

The cylinder should be clean and free from dirt and remove any attachment that would interfere with visual inspection. Soap and water, Windex or equivalent, may be used to remove oil and grease from the cylinder exterior.

Cylinders that have been exposed to high heat for short intervals may cause yellowing of the Flow Coat. This is a cosmetic issue only. Generally, the yellowing can be removed with the aid of a Scotch-Brite pad. If there is charring or an Arc burn on the exterior of the cylinder that is considered Level 3 damage and the cylinder shall be condemned.

Inspect for damage. Use as a reference CGA Pamphlet C-6.2-1996, "Guidelines for Visual Inspection and Re-qualification of Fiber Reinforced High Pressure Cylinders." Exceptions to CGA Pamphlet C-6.2-1996 are noted below.

NOTE: Any cylinder showing Level 2 damage should be internally examined for damage!

3.1 Abrasion and Cut Damage

Any cylinder that exhibits abrasion or cut damage through the glass overwrap layer and into the carbon layer has to be condemned. Cylinders with questionable damage should be returned to SCI for evaluation. Call SCI to obtain a return authorization number prior to returning the cylinder.

If required damaged paint can be refurbished by repainting the area with air drying paint.

DO NOT USE ABRASIVES OR CHEMICAL CLEANERS TO REMOVE PAINT.

3.1.1 Level One Damage

Level 1 damage is light cuts or abrasion that do not cause damage to the glass layer. This level is typical of cylinders used regularly and does not require any repair or immediate refurbishment.

3.1.2 Level Two Damage

Scuffs and abrasions that penetrate the glass layer but do not damage the carbon layer are considered Level 2 damage. Cylinders exhibiting this level of damage can be field refurbished. If the inspector is unsure if the carbon layer has been damaged, the cylinder should be returned to SCI for evaluation.

3.1.3 Level Three Damage

Damage that penetrates through the glass layer and into the carbon layer is considered Level 3 damage.

CAUTION: Cylinders that exhibit Level 3 damage are to be condemned!

3.2 Impact Damage

Carbon composite cylinders are more sensitive to this type of damage than glass or aramid designs. Internal inspection for dents is especially important. If damage is present as described in GCA C-6.2-1996, Section 6.5.3, the cylinder should be condemned.

4.0 Interior Inspection

Inspect the cylinder threads for nicks, cuts cracks and other damage. See CGA C-6 or C-6.1.

All SCI cylinders have straight threads with O-rings seals. Make sure the O-ring gland is clean and free of damage. See CGA C-6.1.

Inspect the interior with a high-intensity light. Normal interior inspection procedures are found n CGA 6-2 and C-6.1. Cylinders with visible dents on the interior surface shall <u>be condemned.</u>

5.0 Hydrostatic Testing

SCI's carbon composite cylinders have been hydrostatically tested in accordance with their DOT Exemption. SCI's DOT Exemptions for carbon cylinders have been updated as of 07/31/01. Cylinders re-tested prior to 07/01/01 must be re-tested within 36 months of the re-test date marked on the cylinder. Cylinders re-tested after 07/01/01 must be re-inspected and hydrostatically re-tested at least once every five years. Cylinders operating in Canada are not subject to the re-test period increase and will remain at their current three year requirement. A cylinder shall be condemned if the elastic expansion exceeds the marked rejection elastic expansion (REE number) as shown on the label. The exception is; Canada where the 5% Permanent to Total Ratio still applies

5.1 Hydrostatic Testing Procedure - UNITED STATES

Zero the burette/scale and observe the water level for thirty (30) seconds to ensure there are no temperature variations.

If the water level is constant pressurize to the test pressure at a rate not to exceed 3000 psig per minute and maintain pressure for 30 seconds or sufficiently longer to ensure complete expansion of the cylinder. Read and record the total expansion.

Depressurize the cylinder and adjust the burette to bring the water level to the zero reference point. Wait 60 seconds, or longer if the water level in the burette is still falling, once it is stabilized read and record the permanent expansion.

Calculate the Elastic Expansion (EE):

Total Expansion - Permanent Expansion = EE

If the EE exceeds the REE, the cylinder must be condemned.

NOTE: When using computer controlled test equipment, make sure that the 60 second wait period is entered into the software. Failure to do so will often result in a false high permanent reading.

Dry the internal surface of the cylinder with forced hot air for a minimum of 30 minutes or until completely dry. Verify dryness by using an internal drop-light. The temperature of the hot air should be from 120 to a maximum of 140°F (49 to 60°C).

5.2 Hydrostatic Testing Procedure - CANADA

The following hydrostatic test procedure is recommended in order to stabilize the cylinder and test equipment. The pre-test and test pressure for some common service pressures are shown in Table I.

Table I

Service Pressure (psig)	Pre-Test Pressure (psig)	Test Pressure (psig)
2216	3145	3693
2800	3974	4667
3000	4250	5000
3295	4668	5492
4500	6375	7500
5000	7083	8333

Zero the burette/scale and observe the water level for thirty (30) seconds to ensure there are no temperature variations. Apply the pre-test pressure to the cylinder at a rate not to exceed 3000 psig per minute, lock off and check for leaks. If the water level falls in the burette/weigh bowl, check the system for leaks. If the water level rises in the burette/weigh bowl, water is leaking into the jacket. Repair the system as necessary.

If the water level is constant, release the pressure and re-zero the burette. Pressurize to the test pressure at a rate not to exceed 3000 psig per minute and maintain pressure for 30 seconds or sufficiently longer to ensure complete expansion of the cylinder. Read and record the total expansion.

Depressurize the cylinder and adjust the burette to bring the water level to the zero reference point. Wait 60 seconds, or longer if the water level in the burette is still falling, once it is stabilized read and record the permanent expansion.

Calculate the Permanent to Total Expansion Ratio:

Permanent Expansion ÷ Total Expansion x 100 = %

If the ratio exceeds 5%, the cylinder must be condemned.

NOTE: When using computer controlled test equipment, make sure that the 60 second wait period is entered into the software. Failure to do so will often result in a false high permanent reading.

Dry the internal surface of the cylinder with forced hot air for a minimum of 30 minutes or until completely dry. Verify dryness by using an internal drop-light. The temperature of the hot air should be from 120 to a maximum of 140°F (49 to 60°C).

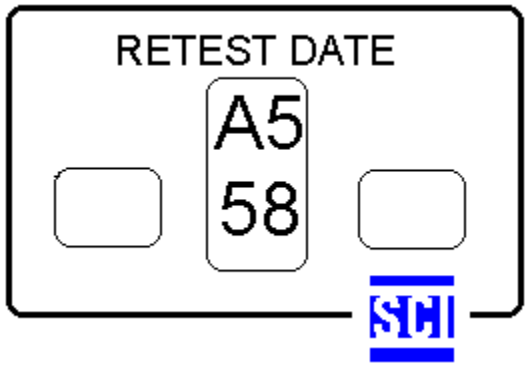
6.0 Re-Test Markings

CAUTION: Do not attempt to stamp re-test markings in the composite.

ANY CYLINDER WITH STAMPED MARKINGS IN THE COMPOSITE SHALL BE CONDEMNED!

SCI recommends use of an aluminum foil label, (covered with a 5 minute epoxy), as shown in Figure 1. The labels may be ordered through SCI.

Figure 1



Title 49 CFR, Chapter 1, Paragraph 173.34 (e) (6) requires as of April 15, 1986 that the re-tester's identification number be set between the month and year of the re-test date. The re-test date and the re-tester's identification number may be typewritten or metal stamped on the foil label. For example the re-tester's number shown above is A585.

NOTE: The numbers are read in a clockwise direction).

6.1 Re-Test Label Attachment

The re-test label shall be attached near the manufacture's label. First clean the surface where the label is to be attached.

Ammoniated water, "Windex" or equivalent window cleaner may be used. Dry the surface thoroughly before applying the label.

Mark the re-test label with the month, year and re-tester's identification number using either a typewriter or metal stamp. If you ordered the re-testers label through SCI, only the month and year will need to be marked on the label.

Peel the label from the paper backing. The label has a pressure sensitive adhesive surface on the back.

Over coat the label and edges with a thin epoxy coating. Use any commercial epoxy such as Devcon five minute clear epoxy or equivalent. Air dry.

7.0 Re-Valving

Use new O-rings compatible with the cylinder contents.

CAUTION: Only O-ring materials compatible with high pressure oxygen should be used on cylinders in oxygen service.

Make sure O-ring and cylinder gland are clean.

Make sure cylinder and valve threads are clean.

Lubricate O-ring with a light coat of Dow Corning M-55 grease.

CAUTION: For oxygen cylinders use no lubricants, sealant, grease, anti-seize compounds or Teflon tape on threads or O-rings.

Recommended O-ring sizes are shown in Table II

Table II

MS 33649 Dash No.	Cylinder Threads	Parker O-ring Size No.
4	.4375-20 UNF-2B	3-904
5	.5000-20 UNF-2B	3-905
7	.6250-20 UNF-2B	3-907
8	.7500-16 UNF-2B	3-908
10	.8750-14 UNF-28	3-910
11	1.000-12UNF-2B	3-911
12	1.0625-12UN-2B	3-912
14	1.1875-12UN-2B	3-914
16	1.3125-12UN-2B	3-916
18	1.5000-12UN-2B	3-918
20	1.6250-12UN-2B	3-920
24	1.8750-12UN-2B	3-924
28	2.2500-12UN-2B	3-928
32	2.5000-12UN-2B	3-932

NOTE: A number of SCI cylinders do not have the MS 33649 type port. For these units the following O-rings are recommended.

.6250-18 UNF-2B	2-208
.7500-16 UNF-2B	2-210
.8750-14 UNF-2B	2-212