

## **LUXFER GAS CYLINDERS**

### **QUESTIONS AND ANSWERS FROM THE TECHNICAL SEMINARS HELD IN SOUTH ASIA - JAN/FEB 2002**

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#### **1. About Luxfer itself:**

In which countries does Luxfer have plants?	UK (1), France (1), USA (3), Australia (1)
When did Luxfer buy Gerzat?	Mid-2001.
What is Luxfer's global market share?	>90% of aluminum seamless high pressure cylinders, but <20% of all seamless high pressure cylinders.
Are Luxfer still associated with CIG Gas Cylinders?	CIG Gas Cylinders ceased to exist when BOC sold the business to Luxfer in 1996.

#### **2. About the alloys:**

What is alloy 6061?	Alloy 6061 is the international designation for the heat treatable alloy used to manufacture most Luxfer cylinders. The alloy is described as a balanced magnesium-silicon alloy of aluminium (nominally 1% magnesium and 0.6% silicon).
What is the difference between 6061 and 5283 alloys?	Alloy 5283 does not contain silicon as an alloying element. The strength of 5283 alloy is derived from the addition of 5% magnesium.
Does the manufacture of 5283 alloy require higher extrusion pressures?	Alloy 5283 is only hot extruded by the Gerzat plant in France. There is no data to compare the pressure for cold extrusion.
Is there any issue with beverage CO <sub>2</sub> in aluminium-zinc alloy cylinders?	No experience or testing to date, but no issues expected.
What are the comparative pressures between 6061 and 7000 series alloys?	There does not need to be any difference, however, most 7000 series designs have at least 200 bar fill pressure due to the lighter designs using the higher mechanical properties.
How do customers decide which alloy is appropriate?	Discuss the application with Luxfer. Alloy 6061 is suitable for the vast majority of uses.

### **3. About testing:**

What is a pulsation test?	In the pulsation test the cylinders are filled with water and then cycled between test pressure and zero pressure for 10,000 cycles. The frequency is around 12 cycles per minute. This is a metal fatigue test that requires the cylinder to not leak or show signs of failure during the test. The US DOT allows 100,000 cycles between service pressure and zero as an alternative test.
What is the sample size for pulsation and burst testing?	For all specifications, the tests require that three cylinders from initial production pass each of the pulsation and burst tests.
What is the burst pressure?	Specifications vary on the exact requirement, but the ratio of burst pressure to fill pressure is in the range 2.0:1 to 2.5:1. Cylinders from Luxfer Australia typically burst at 2.4 to 2.6 times fill pressure.
Where does the cylinder fail in the burst test?	In the middle of the side wall.
What is hydrostatic testing?	Hydrostatic testing is when the cylinder is filled with water and pressurised to the design test pressure. The pressure is held for 30 seconds. The pass criteria varies between specifications, but in general, the cylinder must not leak during the test or expand permanently to any significant extent.
What is the period between tests?	The period between hydrostatic testing varies according to the use of the cylinder and local regulations. It can be as little as one year for SCUBA diving cylinders and as long as ten years for dry permanent gases.
When inspecting the inside of a cylinder, what should be looked for?	Look for signs of corrosion (corrosion deposits and possible pitting underneath), signs of contamination (usually liquids), and smell for odours (but not for toxic gases!). Corroded or contaminated cylinders must be cleaned for final inspection.
What test pressures are common in aluminium cylinders?	The lowest is for CO <sub>2</sub> (carbon dioxide). The CO <sub>2</sub> test pressure is 207 bar (3,000 psi). Most industrial cylinders have a test pressure of 245 bar (3,550 psi). SCUBA diving cylinders have the highest test pressure at 360 bar (5,220 psi).
Does Luxfer have details of the steps that test stations should take?	There are published procedures that are available. Examples are AS2337.1 (from Australia Standards) and CGA Pamphlet C-1 for hydrostatic testing and Pamphlet C-6.1 for aluminium cylinder inspection (from the US Compressed Gas Association). Copyright laws prevent Luxfer from distributing these publications, but they can be purchased through Standards Australia and CGA websites.
Doesn't the stamping of cylinders damage the cylinders?	Stamping in the thickened section of the cylinder shoulder does not weaken the cylinder.
What are the CGA steel cylinder re-testing guidelines?	CGA Pamphlet C-1 covers methods for hydrostatic testing, and Pamphlet C-6 covers inspection for steel cylinders.
Is there a published standard procedure for the care and maintenance of special gas cylinders?	No. Luxfer has published care and maintenance guidelines for CO <sub>2</sub> cylinders only.

During hydrostatic testing, how is stretch measured?	In water jacket testing, the stretch is measured by the displacement of water from the jacket both during and after the test. The jacket is not pressurised, but sealed so that the expansion of the cylinder displaces water in a measurable way. In non-water jacket testing, only the permanent stretch after de-pressurisation is measured, by the additional water contained in the cylinder.
Is there any correlation between hardness test methods?	Yes, there are conversion charts available to correlate all types of hardness test method.
Where can CGA publications be obtained?	By the Internet. Either e-mail to <a href="mailto:CustomerService@cganet.com">CustomerService@cganet.com</a> or visit <a href="http://www.cganet.com">www.cganet.com</a>
Must a cylinder be tested every five years (in Singapore) even if not used in that period?	Yes.
Can aluminium cylinders be ultrasonically tested?	Yes.
Does the CO2 video and care and maintenance poster cover "rejection criteria"?	No, not in great detail. You will need to refer to one of the AS or CGA documents.

#### **4. About the design of aluminium cylinders:**

What are the wall thickness tolerances?	The wall thickness will never be below the minimum design thickness, but may be up to 10% above, depending on the cylinder size.
What is the wall thickness of the 48L cylinder?	The minimum is 12.25 mm, and the nominal is 13.5 mm.
Are weight and pressure relationships linear?	Cylinder weight is a function of diameter, pressure and water capacity. There is no simple relationship between weight and pressure.
Can Luxfer Australia manufacture 200 bar fill 48L cylinders?	Technically it is possible. The cylinder would have a diameter of 250 mm, a height of 1390 mm and weigh 47 kgs. Some adjustments would be required to the extrusion set-up.
Are 300 bar fill SCUBA cylinders available?	No, as there has been no commercial demand for SCUBA cylinders at this pressure.
What is meant by "high pressure" cylinders?	"High pressure" generally refers to seamless cylinders for fill pressures above 75 bar.
Is there recognition of DOT, BS and AS standards by each reciprocal group?	Unfortunately, not completely. Australia recognises all three. The USA only recognises DOT. UK accepts DOT but not AS. Throughout Asia, all standards are acceptable. Standardisation will only come with the universal adoption of ISO standards.
How long does an aluminium cylinder last?	Luxfer cylinders made over thirty years ago are still giving excellent service. Unlike some highly stressed designs like composites, standard aluminium cylinders in good repair have no life limit.
Can aluminium cylinders be filled slightly above the fill pressure?	This is not recommended. The fill pressure for AS1777 cylinders is $\frac{2}{3}$ x test pressure, and for DOT 3AL cylinders the fill pressure is stamped on the shoulder in psi units.
Is 10% overfill allowed in aluminium cylinders?	This is a US concept for some steel cylinders. However, 10% overfill in 3AL cylinders is not permitted in CFR Title 49 Clause 173.302(c).
Does the volume of the cylinder increase over time/pressure?	The volume will not increase over time. The internal volume will expand when pressurised to service

	pressure, but return to the original volume when empty of gas.
What is the water capacity tolerance?	Normally –0, +3%. The + tolerance is larger on small cylinders.
Is there a 50L aluminium cylinder?	No.
On 10L cylinders there has been a variation of height over time. How could this happen?	The main reason is tooling wear. This causes a gradual increase in wall thickness, resulting in a gradual increase in length to maintain the water capacity. There was also a reduction of the wall thickness tolerance late in the 1980s once confidence grew with control of the manufacturing process. This caused a step change when new tooling was purchased.
Why are the base profiles of aluminium and steel cylinders different?	The reason is the different forming processes used in the manufacturing process.
Does the weight advantage over steel reduce with increased pressure and volume?	Yes.
Do diving cylinders come in standards other than DOT, BS or AS?	Almost all Luxfer diving cylinders come in one of those three standards. Prior to DOT 3AL, Luxfer USA cylinders were made to an exemption (stamped as SP6498 or E6498). DOT exemption cylinders have always been acceptable in Asia. Other cylinder standards are used in Europe for particular countries, and these may appear in Asia.
How can a copy of an exemption be obtained?	For any Luxfer cylinders, ask Luxfer.
Does Luxfer stamp the specification on the cylinder, e.g. DOT 3AL and AS1777?	Yes, on the shoulder.
Can Luxfer stamp the thread on the cylinder?	Historically, Luxfer in Australia has not done this. The proposed ISO marking standard requires the thread to be stamped. Luxfer will begin with stamping on all new 25T cylinders.
Does the wall profile of the cylinder differ if the cylinder is repeatedly filled as opposed to one at constant fill?	No.

## **5. About the internal surface:**

Is Super Clean standard, or must the customer request it at the time of order?	Standard and Super Clean cylinders are made in the same process. However, Super Clean cylinders are guaranteed to a high level of internal cleanliness. If essential, Super Clean must be ordered.
How do Luxfer guarantee Super Clean?	By individual inspection of each cylinder.
Is there an oil analysis conducted on Super Clean cylinders?	One in every 200 cylinders (or less for smaller lots) is tested. Super Clean cylinders have residual hydrocarbons of less than 10 mg/m <sup>2</sup> of internal surface.
Is there another internal preparation for oxidising gases?	Other than standard and Super Clean, no.
Are all Luxfer plants able to produce standard "clean" cylinders for oxidising gases?	Yes.

Which market would be interested in honed cylinders?	Semiconductor gases and ultra high purity mixed gases. A substantial premium is charged.
What is the benefit of acid washing?	Acid washing removes much of the oxide layer, and consequently the contaminants entrapped in the oxide layer. The thinner oxide layer that re-forms will hold less residual gas, retained moisture and chemical compounds.
Are the internal processes patented?	No.
Do any of the polishing processes weaken the cylinder?	No. The most aggressive Luxfer polishing process is honing. Even with honing, the minimum wall thickness is maintained.
What is the effect of caustic solutions on aluminium cylinders?	Caustic solutions are corrosive to aluminium and should be used with great care as a cleaning agent. Never store caustic solutions in aluminium cylinders.
Do Luxfer measure surface smoothness?	No, not as a routine quality check. The surface smoothness of standard cylinders from Australia is around 2µm RA.
What is the acid blend and concentration used in the acid wash process?	Luxfer will give limited information in confidence. A proprietary solution is purchased by Luxfer.
Can Luxfer provide a list of chemicals used in the process?	Luxfer will give limited information in confidence.
Does mercury attack aluminium cylinders?	Yes.
What happens to the honed finish when cylinders undergo the neck swaging process?	Wrinkling and micro folding occurs.
Is Spectra Seal the same as Super Clean?	No, Spectra Seal is BOC's proprietary special gas internal surface finish. Spectra Seal may start with a Super Clean cylinder.
What processes do Luxfer use for the final cylinder washing?	Mild detergent wash followed by a rinse, a mild acid etch and more rinsing. After hydro in clean tap water, the cylinders are hot water flushed and dried with dehumidified oil-free air.
How can internal surface be repaired if a chemical reaction has taken place?	It would be possible with some mild reactions, and each repair will be case specific. Luxfer is not knowledgeable in this area.
Does the washing during manufacturing sanitize the interior?	Yes.
How does Luxfer dry the cylinder?	With dehumidified oil-free compressed air.
What is the temperature of the hot water during cleaning?	80°C

## **6. About gas stability and reactions:**

What gases can be filled and stored in aluminium?	Almost all of the common gases. The main exception is chlorine, and compounds of chlorine. Hydrogen containing mercury must not be filled in aluminium cylinders. A comprehensive list has been published in BS5045 Part 3. If in doubt, ask Luxfer.
Are aluminium cylinders suitable for 1-2 ppm moisture in nitrogen?	Yes, based on customer catalogues.
Can Super Clean cylinders be used directly for reactive gases in low concentrations?	Luxfer believes that most customers condition the surface further before use.
Can hydrogen sulphide be stored in aluminium cylinders?	Yes.

Can aluminium cylinders be used for carbon monoxide?	Yes.
What is the Takachiho internal finishing process?	Absolutely no details have been given to Luxfer.
Why were Japanese companies chosen for the internal surface study?	Their close contact with Luxfer over many years, and the world class ranking of these companies in their field.
Will the results be published?	Yes, with all analysis details.
How can it be determined whether ppm concentrations are acceptable for gases such as SO <sub>2</sub> and NO?	Luxfer refers to published catalogues from the major gas companies. Experience has shown that very few gases in ppm concentrations are unstable in aluminium cylinders.
Will there be steel cylinders in the Takachiho study?	No, because for the mixtures involved the aluminium cylinder is clearly superior.
Are the issues with hydrogen embrittlement relevant in aluminium cylinders?	No.
400 ppm in hydrogen chloride – how to prepare the cylinder?	Luxfer is not knowledgeable in this area.

## **7. About cylinder cleaning:**

What concentration of bicarbonate soda (baking soda) and vinegar should be used for cleaning beverage cylinders?	Rinse the cylinder with a mix of one cup of bicarbonate soda with 4 litres of water. Rinse with fresh water. Then rinse with a mix of ½ cup of vinegar with 4 litres of water. Finally rinse several times with fresh water and dry.
What concentrations of caustic solutions should be used with aluminium cylinders?	Use only a mild soapy solution. Mix one tablespoon of liquid hydrocarbon-free or solid hydrocarbon-free detergent with 4 litres of water. Always finally rinse several times with fresh water.
Can acid be used on aluminium?	Use only chemical brighteners labeled as suitable for use with aluminium.
Is a detailed cylinder cleaning procedure available?	Ask Luxfer, but the cleaning solutions are those recommended above.
How can water get into the cylinder?	Through open valves when empty awaiting refilling, or filling with wet carbon dioxide, or poor dispensing equipment cleaning practices.
If water or residual beverage is found in the cylinder, should it be re-tested?	No. The cylinder needs to be emptied completely of the liquid and tested for odour before re-filling.
Should all remaining CO <sub>2</sub> be blown down before filling?	Yes. This is the only way to check for residual liquid in the cylinder.

## **8. About temperature effects:**

Is there potential for a cylinder to reach the burst pressure due to exposure to high sunlight?	No, the reference temperatures for design calculations ensure that developed pressures, even in tropics, will be less than the test pressure.
What temperatures cause damage to aluminium cylinders?	The absolute limit under controlled conditions is 120°C for a maximum of 24 hours accumulated.
Will heat degradation be the same for 1x24 hr period or 24x1 hr periods?	Yes, the effect is accumulative and non-reversible.
Is the temperature/time exposure chart available in any published standards?	No.

Do Luxfer have heat sensitive paints available, or do customers normally add this?	No, Luxfer does not apply heat sensitive paints.
Can the whole cylinder be painted with heat sensitive paint?	Yes, if desired. Multiple strips running from shoulder to base would give adequate indication of heat exposure.
Are plastic heat tags available from Luxfer?	No, they have always been supplied by the major gas company customers.
Can a heating rod or reflector be used to dry a cylinder?	Yes, so long as the metal temperature does not exceed 120°C.
What is the optimum temperature and time for drying a cylinder?	This will depend on the desired degree of dryness. A starting point would be 1 hour at 90°C.
How is aluminium affected by low temperatures?	Aluminium is an excellent cryogenic structural material. Aluminium can be used at temperatures as low as -400°F (-240°C) without significant loss of mechanical properties.
For CO <sub>2</sub> , is the chart of over-fill vs pressure with increasing temperature available?	Yes, ask Luxfer.
What temperature will cause the CO <sub>2</sub> to attain the burst disc release pressure?	65°C (150°F)

## **9. About valves and valving:**

Is there a published standard on the fitting of valves?	Yes, ISO 13341-1997 is an excellent reference document.
What is meant by "careless valving"?	A combination of incorrect preparation of the threads (dirty or damaged), no teflon tape on tapered threads, and/or excessive torque.
Does Luxfer recommend a limit to how many times a valve should be inserted-removed-reinserted?	No. Parallel threads are particularly reliable for multiple uses. Also, in practice, well maintained taper threads with the correct torque are not damaging cylinders after ten or more insertions.
Can molybdenum disulphide be used instead of Teflon tape?	Molybdenum disulphide paste is not recommended as a substitute for Teflon tape. It can be used in conjunction with Teflon tape.
What grade of molybdenum disulphide is used?	Molybond 122L Dry Film Lubricant is recommended. The carrier solvents must be allowed to evaporate.
How widespread are parallel threads?	All SCUBA, SCBA life support, beverage carbon dioxide and carbon dioxide fire extinguisher cylinders made by Luxfer in Australia have parallel threads. Additionally, all medical oxygen cylinders made by Luxfer USA have parallel threads.
Can o-rings be purchased separately?	Yes, ask Luxfer.
Are the torque recommendations made the same for differing valve materials, e.g. brass and stainless steel.	Yes. However, experience shows that stainless steel valves can have ragged edges that cause galling and thread damage in aluminium cylinders.
If the thread is damaged, can it be re-machined?	No, unless a larger thread is used. Luxfer must be consulted before re-cutting threads.
What could be causing damage while de-valving?	Whatever damage is happening on de-valving will have begun during valving. What starts as very minor "pick up" can snowball rapidly and become a destructive lump of aluminium.

Have there been occasions when valves have been ejected from cylinders during pressure?	Never due to damaged threads. The only cases known to Luxfer involve the mismatch of M25 and $\frac{3}{4}$ NPSM parallel threads. An M25 valve in a $\frac{3}{4}$ NPSM cylinder thread can easily eject.
Do valves also come from Luxfer?	Luxfer does not manufacture valves. They can be purchased from reputable suppliers by Luxfer and fitted to cylinders.
What is the usual burst disc pressure setting in relation to the cylinder pressure?	The burst disc rating is normally in the range of 85-100% of test pressure.
Is the burst disc calibrated by Luxfer?	No. the valve supplier does the calibration.
When should the burst disc be replaced?	Ideally, when the valve is removed for the cylinder's periodic hydrotest.
What is the function of the siphon tube?	The siphon tube ensures liquid withdrawal. Normally used when other chemicals or gases are mixed together (usually in CO <sub>2</sub> ), because the gaseous phase above the liquid mixture will not have all of the components that are in the mixture.
What is the MPR valve, and how does it work?	The MPR valve closes off automatically when the cylinder pressure falls below approximately 3 bar. The device is spring operated.
What should be the minimum pressure retained in the cylinder when returned?	2-3 bar.
How is an MPR valve purged?	The Cigweld MPR valve is purged with a tool called a "lifter" that de-activates the MPR device. The Neriki MPR valve is purged with the use of a special filling adaptor that de-activates the MPR device.
What torque is standard for valving aluminium cylinders?	It depends on the thread. ISO 13341-1997 nominates torques, but for those without access to this standard, a general recommendation is 75-95 Nm for small tapers, 95-110 Nm for large tapers, 85-100 Nm for small parallels and 95-130 Nm for large parallels.
Why use parallel threads for CO <sub>2</sub> ?	They have become the industry standard for aluminium CO <sub>2</sub> cylinders. The main reason is that they are more forgiving when removed and re-inserted for cylinder testing.

## **10. About sustained load cracking in 6351 alloy:**

What is sustained load cracking?	SLC is a metallurgical phenomenon that occasionally develops in cylinders made from 6351 alloy, as well as other types of pressure vessels and structural components under stress for sustained periods of time. SLC is not a manufacturing defect – it is a phenomenon inherent in the metal itself.
How quickly do the SLC cracks grow?	Very slowly. Cracks typically take six or more years to grow large enough to cause a cylinder to leak. Because SLC growth is so slow, properly trained inspectors have adequate opportunity to detect cracks during the normal re-test process.
Does cracking occur in 6351 with parallel threads?	Yes, in the internal shoulder at the bottom of the threads. Almost always found in SCUBA diving cylinders and SCBA life support cylinders that typically are filled to 200+ bar.



How can 6351 cylinders be identified in the fleet?	The quickest, and most easily remembered, identifier is the manufacturing date. The changeover dates from 6351 to 6061 alloy by Luxfer occurred progressively between 1990 and 1993 in Australia, in 1988 in the USA and in 1995 in the UK. The serial numbers are a more precise identifier. Luxfer can provide information for any particular customer on request.
If serial numbers are provided for pre-1991 cylinders, can Luxfer identify if the cylinders are made from 6351 alloy?	Yes.
Can cracks be detected by eddy current testing?	Yes. Eddy current testing detects surface cracks to a depth of about 3 mm. Neck cracks in taper threads can usually be detected by an eddy current probe on the top of the cylinder. Shoulder cracks in parallel threads can usually be detected by a probe that is run down the thread.
What is Visual Plus?	Visual Plus is an eddy current crack detection device that is especially configured to find cracks in parallel cylinder threads.
How effective is Visual Plus?	It is very effective in 6351 alloy cylinders. It is not necessary to use Visual Plus in 6061 alloy cylinders, as sustained load cracking does not occur. It is not a substitute for visual inspection, but an aid to locate the crack for subsequent visual confirmation.
How often should eddy current testing be conducted?	6351 alloy cylinders with parallel threads should be initially tested as soon as possible, and thereafter every 2.5 years.
Is there another method of finding cracks other than eddy current testing?	Yes. Very careful visual inspection with a light source and mirror is adequate if an eddy current tester is unavailable. Ultrasonic testing will also find cracks, but a skilled UT technician is required.

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