TAP WATER CORROSION OF COMPOSITES WITH AA 6061 LINERS

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Table of Contents

Amendments to 72/06

Section	Change
	Editorial to align style with IHC associations
5	Amendments to the recommendations
6	References updated

Note: Technical changes from the previous edition are underlined

1 Introduction

Aluminium alloy liner of composite cylinders have been in widespread use for about 25 years. A variety of alloys have been used for the liner including AA 6010, AA6351, AA5283, AA7060 and more recently AA6061.

The AA6061 became a substitute alloy for AA6351, once certain metallurgical deficiencies, notably sustained load cracking (SLC - see IGC Document 57) were observed in cylinders made from AA6351. See EIGA Doc 57, Recommendations for avoidance of sustained load cracking of aluminium alloy cylinders [1].

The publication is part of the programme to develop Globally Harmonised publications amongst Regional Gas Associations.

2 Scope and purpose

This document contains advance information known to EIGA companies of findings concerning cold-drawn hoop-wrapped (H-W) and fully wrapped (F-W) composite cylinders using liners from aluminium alloy 6061 (H-W AA6061).

3 Current Findings

Before production batches of a new cylinder design can commence, a series of mandatory prototype tests have to be performed. One such test is a cyclic fatigue test, in which selected cylinders are cycled over their test pressure range (up to the test pressure) for many thousands of cycles. The medium used to transmit the pressure cycle to the cylinder is often mineral oil or water containing a corrosion inhibitor.

However, some H-W AA6061 cylinders which had been accidentally filled and left with ordinary tap water, and subsequently cycle tested as described above (with mineral oil or water with a corrosion inhibitor), showed a substantial loss of fatigue life. The usual life of between about 18,000 - 20,000 cycles for a certain cylinder design was drastically reduced and for some cylinders, the usual life was reduced to less than 5,000 cycles.

The reduction in fatigue life was observed in cylinders which had been left with tap water for only 3 days prior to the test. After about 10 days the minimum in the fatigue life has been observed. Longer periods of exposure to tap water are being assessed. Also the reduction noted was independent of the cylinder manufacturer though a cold-formed manufacturing route was used.

Note: The reduction in fatigue life at test pressure was not observed for similarly treated non-composite cylinders of a seamless AA6061 construction.

THE CONCERNS FOR EIGA MEMBERS ARE THE EFFECTS OF ACCIDENTAL INTRODUCTION OF TAP/RAIN WATER (OR POTENTIALLY OTHER FLUIDS AS YET NOT DEFINED) ON THE OVERALL LIFE AND SAFETY OF H-W AA6061 CYLINDERS.

4 Preliminary Discussion

It is clear that a mechanism related to corrosion is in progress. Clear signs of intergranular corrosion were visible at the crack initiation sites for failed cylinders which have been metallographically examined, see Fig 1.

At this point it is well to note another feature of aluminium alloy 6061 (regardless of whether it is used for a seamless cylinder or a hoop-wrapped one). One of the mandatory requirements in National Standards, the EC Directive 84/526, - Aluminium gas cylinders of 17 September 1984 on the approximation of the laws of the Member States relating to seamless, unalloyed aluminium and aluminium alloy gas cylinders [3] and EN 1975, Transportable gas cylinders. Specification for the design and construction of refillable transportable seamless aluminium and aluminium alloy gas

cylinders of capacity from 0,5 litre up to 150 litre [4] and ISO 7866 Gas cylinders -- Refillable seamless aluminium alloy gas cylinders -- Design, construction and testing [5] standards dealing with seamless aluminium alloy cylinders, is a series of tests to check for an alloy's susceptibility to intercrystalline corrosion.

This would indicate that the intergranular corrosion created by the contaminants contained in the tap water introduced local stress raisers which led to premature cyclic loading failures. This intergranular corrosion promotes very high stresses during test pressure cyclic testing which effectively reduced the fatigue initiation process that usually provides the majority of the cycle life for aluminium alloys. The above can be explained by the following:-

a) Residual chemicals, notably the chloride content, in the tap water, have created some pre-existing corrosion related defects due to the alloy's susceptibility, albeit small, to intergranular corrosion.

b) The very much thinner wall thickness in a H-W composite AA6061 cylinder, compared to its seamless counterpart, means that the stress takes a lot less time to propagate the cracks to failure which have been initiated in a).

5 Recommendations

The following recommendations include those requirements, standards, and practices which avoid water contamination during use and storage, and offer suggestions to reduce the risk of adverse affects of water used for the hydrostatic test.

Some cylinder manufacturers may use or apply a coating to the internal surface of the liner to reduce the risk of corrosion and possible reduction in their service life. Care needs to be taken when removing a protective coating that may already be on the inner surface. The inner surface present from the manufacturing process could be better than a coating added after manufacturing or at requalification. Before treating the surface, verify with the manufacturer if a coating is already present and if the modification or application of a coating does not compromise the integrity or safe performance of the cylinder.

NOTE—Media blasting and other processes to remove surface coatings and the application of coatings shall only be performed by experts, preferably with the recommendation of the cylinder manufacturer.

In-service F-W and H-W AA 6061 aluminium alloy cylinders that are hydrostatically tested at the time of requalification should use treated water, e.g., use of aluminium-compatible corrosion inhibitors, removal of chlorides, etc., or the time of exposure to the water used in the hydrotest should be minimized, if required e.g., to allow time for the temperature of the water and cylinder to equalize and for the water to de-aerate prior to a volumetric expansion test.

If for operational reasons, the residence time of the water in the cylinder is extended beyond the minimum, the cylinder manufacturer shall be consulted for their recommendations.

As found in industry requirements, standards, and practices for hydrostatically testing cylinders (e.g., ISO 11623:2002 Transportable gas cylinders -- Periodic inspection and testing of composite gas cylinders), the cylinder shall be clean and dry after the test [6]. The tested cylinder shall be free from residues and any inhibitors or chemicals used in the testing process.

Companies that use F-W and H-W AA 6061 aluminium alloy cylinders should ensure that there is no ingress of water into the cylinders from sources such as backflow or other contamination. One possible method of reducing the risk of exposure to the ingress of moisture into cylinders is the use of positive pressure, non-return (check) cylinder valves.

6 References

Unless otherwise specified, the latest edition shall apply

[1] EIGA Doc 57 Recommendations for avoidance of sustained load cracking of aluminium alloy cylinders

[2] AIGA 62 Methods to Avoid and Detect Internal Gas Cylinder Corrosion, lists potential sources of water that can cause corrosion

[3] Directive 84/526/EEC - aluminium gas cylinders of 17 September 1984 on the approximation of the laws of the Member States relating to seamless, unalloyed aluminium and aluminium alloy gas cylinders

[4] EN 1975:2000: Transportable gas cylinders. Specification for the design and construction of refillable transportable seamless aluminium and aluminium alloy gas cylinders of capacity from 0,5 litre up to 150 litre

[5] ISO 7866 Gas cylinders -- Refillable seamless aluminium alloy gas cylinders -- Design, construction and testing

[6] ISO 11623 Transportable gas cylinders -- Periodic inspection and testing of composite gas cylinders

Figure 1 – HW Cylinders (AA 6061)
Fatigue crack initiated from a corrosion pit.
Magnification X 125

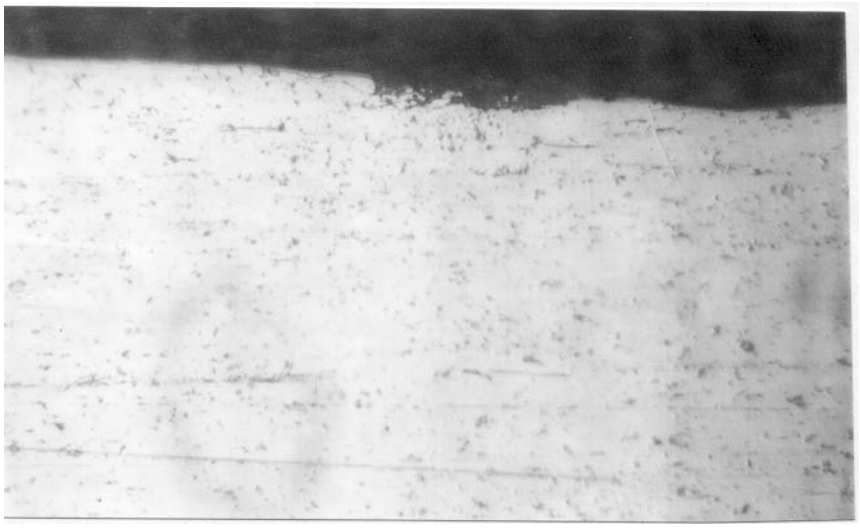

Figure 2 - AA 7060 Cylinder
Metallographic examination according to the intercrystalline test as per EN 1975.
Magnification X 300

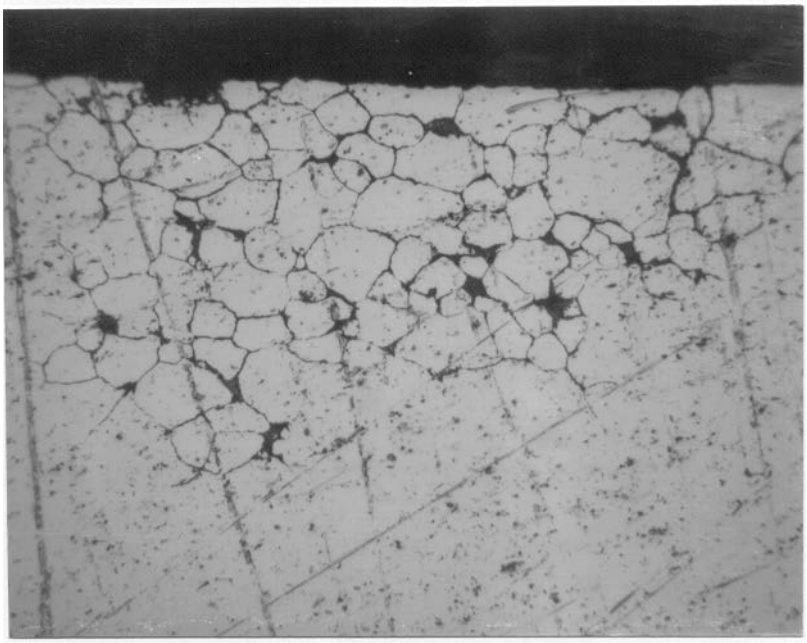

Figure 3 - HW AA 6061 Cylinder
Metallographic examination according to the intercrystalline test as per EN 1975.
Magnification X 300