CGA C-22—2012

WATER CORROSION OF COMPOSITES WITH AA6061 LINERS

FIRST EDITION

PREFACE

As a part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has adopted the European Industrial Gases Association (EIGA) document 72/12, *Water Corrosion of Composites With AA 6061 Liners*.

This standard is intended as an international harmonized standard for the worldwide use and application by all members of Asia Industrial Gases Association (AIGA), CGA, EIGA, and Japan Industrial and Medical Gases Association (JIMGA). The CGA edition has the same technical content as the EIGA edition, however, there are editorial changes primarily in formatting, units used, and spelling. Also, references to European regulatory requirements have been replaced with the relevant North American requirements.

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1 Introduction

Aluminum alloy (AA) liners of composite cylinders have been in widespread use for approximately 25 years. A variety of alloys have been used for the liners including AA6010, AA6351, AA5283, AA7060, and more recently AA6061.

The AA6061 alloy became a substitute for AA6351 once certain metallurgical deficiencies, notably sustained load cracking (SLC), were observed in cylinders made from AA6351. See EIGA Doc 57, *Recommendations for Avoidance of Sustained Load Cracking of Aluminum Alloy Cylinders* [1].

Current practices and compliance with U.S. Department of Transportation (DOT) and Transport Canada (TC) regulations for the hydrostatic testing of fully-wrapped (F-W) and hoop-wrapped (H-W) AA6061 aluminum alloy lined cylinders have shown these cylinders to fulfill their safe service life when water is used for the hydrostatic test, throughout the U.S. and Canada.

2 Scope and purpose

This publication contains advanced information known to CGA companies of findings concerning cold-drawn hoop-wrapped (H-W) and fully-wrapped (F-W) composite cylinders using liners from AA6061 (H-W AA6061).

3 Current findings

Some national bodies require that, before production batches of a new cylinder design can commence, a series of mandatory prototype tests be performed. One test is a hydraulic, cyclic fatigue test, in which selected cylinders are subjected to many thousands of cycles. The fluid used to transmit the pressure cycle to the cylinder is often water containing a corrosion inhibitor.

However, some H-W AA6061 aluminum alloy cylinders that had been filled and left with prolonged exposure to 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 approximately 18 000 cycles to 20 000 cycles for a certain cylinder design was drastically reduced and for some cylinders, the usual life was reduced to less than 5000 cycles.

The reduction in cycle life was observed in cylinders that had been left with tap water from 3 to 10 days prior to the test. Also the reduction noted may be independent of the cylinder manufacturer though a cold-formed manufacturing route was used.

NOTE—The reduction in cycle life at test pressure was not observed for similarly treated noncomposite cylinders of a seamless AA6061 construction.

The concerns of 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.

CGA C-17, *Methods to Avoid and Detect Internal Gas Cylinder Corrosion*, lists potential sources of water that can cause corrosion [2].

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 that have been metallographically examined. See Figure 1.

At this point it is well to note another feature of AA6061 (regardless of whether it is used for a seamless cylinder or a hoop-wrapped one). One of the mandatory requirements in National Standards, European Directive 84/526, BS EN 1975, and ISO 7866 standards dealing with seamless aluminum alloy cylinders, is a series of tests to check for an alloy's susceptibility to intercrystalline corrosion [3, 4, 5].