Case History: CO\textsubscript{2} Gas Cylinder - Internal Stress Corrosion Cracking (SCC)

CO\textsubscript{2} SCC of carbon steel is a well-documented failure mechanism but with most case histories describing failures of buried pipe work, although there have been incidences also of pressurised (CO\textsubscript{2}) beverage cylinder failures. This article describes the failure by internal SCC of a CO\textsubscript{2} gas cylinder deployed, for fire prevention purposes, in an electrical substation (Fig 1).

The cylinder was a high strength (~1,000 MPa) carbon steel, 1970s vintage, and had undergone internal inspection and hydraulically pressure tests several times during its life. Failure manifested itself as an isolated perforation approximately 350 mm from the base (circled on foreground cylinder).

The bore harboured a uniform layer of strongly adherent crystalline magnetite iron oxide (Fig 2) and there was an accumulation of ‘loose’ amorphous haematite oxide in the base. Magnetic particle flaw detection of the bore (Fig 3) revealed numerous linear defect indications, inhabiting the region opposite the perforation, and it was evident at the cut line that many of the defects were almost wall penetrating. Sectional microscopy revealed the cracking was multi-branched, predominantly intergranular and inhabiting prior austenite boundaries (Fig 4). It was concluded that CO\textsubscript{2} SCC was initiated due to inadequate drying after its last hydraulic test.

Figure 1. Bank of 45kg x 150 barg CO\textsubscript{2} cylinders
Figure 2. Internal magnetite layer
Figure 3. Internal MPFD
Figure 4. Miscellaneous sectional photomicrographs