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CO Stress Corrosion Cracking of Carbon Steel Cylinders

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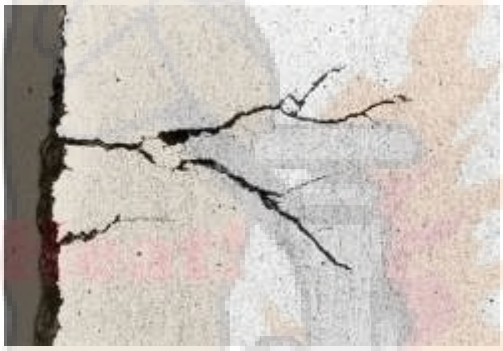
Under certain conditions carbon monoxide can cause carbon steel cylinders to rupture due to Stress Corrosion Cracking (SCC). This reaction however also requires the presence of both carbon dioxide and liquid water plus stress. A corrosive agent or stress alone will not cause SCC, both must be present for SCC to occur. The SCC reaction can occur at room temperature with the rate increasing with increasing temperatures and/or pressure. Presence of oxygen or sulfur compounds will also increase the rate of SCC.

SCC is transgranular cracking of a metal by the combined action of corrosion and tensile stress (applied or residual). These cracks will form throughout the cylinder interior.



SCC can over time lead to the sudden catastrophic failure of the gas cylinder. The rupture will form jagged tearing rather than a smooth straight tear typical of an overpressure failure.

The compressed gas industry had a number of high pressure cylinders in carbon monoxide service fail in the 1960's. This led to a number of studies on the problem. These studies concluded that all of the following had to be present for it to occur

1. Carbon Monoxide
2. Carbon Dioxide
3. Liquid water
4. Carbon Steel under stress (pressure)

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As a result DOT in 49CFR173.302a(c) limits fill pressures of carbon monoxide mixtures >1% to 2000 psig or 5/6 of the working pressure of the cylinder, whichever is less. A number of cylinder failures also occurred in the 1980s with automotive exhaust gas calibration mixture in steel cylinders. These are mixtures of

1. Carbon Monoxide
2. Carbon Dioxide
3. Methane
4. Air

Improper conditioning of the cylinders allowed liquid water to form in the cylinders. CO SCC is not a problem with aluminum or stainless steel cylinders.

The compressed gas industry has published safety alerts on this problem, the European Industrial Gas Association (EIGA) Doc 95/12/E “Avoidance of Failure of Carbon Monoxide and of Carbon Monoxide/Carbon Dioxide Mixtures Cylinders” was adopted by the Compressed Gas Association (CGA) as CGA standard P-57.

There is also a discussion on this issue in ISO 11114 Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials Gas, 2010 edition

Eugene Ngai