

The integrity management rules for both large (65 FR 75378; December 1, 2000) and small (66 FR 2136; January 16, 2002) hazardous liquid pipelines in high consequence areas did not specifically address the SCC threat. By this Advisory Bulletin, we are reminding owners and operators of both gas and hazardous liquid pipeline systems to consider the stress corrosion cracking threat as a possible risk factor when developing and implementing Integrity Management Plans. All owners and operators of pipeline systems, whether or not their pipeline systems are subject to the Integrity Management Plan rules, should determine whether their pipeline system is susceptible to SCC and assess the impact of SCC on pipeline integrity. Based on this evaluation an operator should prioritize application of internal inspection, hydrostatic testing, or other forms of integrity verification.

#### SUPPLEMENTARY INFORMATION:

## II. Background

Recent incidents throughout North America and the world, including Australia, Russia, Saudi Arabia, and South America, have highlighted the threats to pipelines from SCC failures. In the United States, SCC failures on hazardous liquid pipelines have been very rare when compared with SCC occurrences on natural gas pipelines. However, three SCC-caused failures of hazardous liquid pipelines have occurred in 2003. Another hazardous liquid pipeline operator has reported finding significant SCC defects.

SCC is the cracking induced from the combined influence of tensile stress and a corrosive medium. The impact of SCC on a material usually falls between dry cracking and the fatigue threshold of that material. The required tensile stresses may result from directly applied stresses (pressure and overburden) or in the form of residual stresses (fabrication and construction). The most effective means of preventing SCC are to: (1) properly design the pipeline using appropriate materials; (2) reduce pipeline stresses; and (3) remove critical environmental electrolytes, such as hydroxides, chlorides, and oxygen.

Most pipelines are buried. No matter how well these pipelines are designed, constructed, and protected, once in place they are subjected to environmental abuse, external damage, coating disbondment, inherent mill defects, soil movements/instability, and third party damage. SCC develops in pipelines due to a combination of environmental, stress (absolute hoop and/or tensile, fluctuating stress) and material (steel type, amount of

inclusions, surface roughness) factors. Although the age of a pipeline is not indicative of the presence of SCC, it is a factor to consider when assessing pipelines that are subject to conditions that may cause crack growth.

Two types of SCC are found on pipelines: high pH (9 to 11) SCC and near-neutral pH (6 to 8) SCC. Characteristics of both forms of SCC as summarized by experts are as follows:

- Cracks usually oriented in longitudinal direction (cracks may exist at other orientations, depending on the direction of tensile stress).

- Occurrence in clusters consisting of several cracks to hundreds of cracks.

- Cracks tend to interlink to form long shallow flaws (cracks may grow to cause ruptures).

- Fracture faces are covered with magnetite and carbonate films.

High pH SCC was originally noted in gas transmission pipelines. It is typically found within 20 miles downstream of the compressor station. High pH SCC usually occurs in a relatively narrow cathodic potential range (–600 to –750 mV Cu/CuSO<sub>4</sub>) in the presence of a carbonate/bicarbonate environment in a pH window from 9 to 11. Temperatures greater than 100° F are necessary for high pH SCC susceptibility. Other characteristics of high pH SCC according to experts are as follows:

- Cracks are narrow and inter-granular and, have extensive crack branching.

- Cracks are generally not associated with long seams or other metallurgical features.

- Cracks are commonly found on the bottom half of a pipe.

- Cracks are commonly associated with coal tar and asphalt coatings.

For other details on high pH SCC please refer to Appendix A3 of standard ASME B31.8S.

A Near-neutral pH SCC was initially noted in Canada and has been observed by operators in the United States. The environment primarily responsible for near-neutral pH SCC is groundwater containing dissolved CO<sub>2</sub>. The CO<sub>2</sub> originates from the decay of organic matter. Cracking is exacerbated by the presence of sulfate reducing bacteria. This primarily occurs due to disbonded coatings, which normally prevent the cathodic current from reaching the pipe surface. There is a corrosion condition below the disbonded coating that results in an environment with a pH of between 6 and 8. Other characteristics of near-neutral pH SCC according to experts are as follows:

- Cracks are wide (compared with high pH SCC) and trans-granular and have limited crack branching.

- Cracks are frequently associated with long seams and other metallurgical features (dents, mechanical damage).

- Cracks are commonly associated with tape coatings.

Pipeline operators know the pipeline metallurgy, coating type, and operating pressure of each pipeline. The only remaining variable in determining the likelihood of SCC is soil type. RSPA/OPS has previously directed certain pipeline operators to evaluate and establish the extent of SCC susceptibility, utilize over the ditch coating surveys to identify locations of holidays (uncoated spots) and match them with high stress levels (60% or greater of specified minimum yield strength), and match the areas with high temperature locations. The areas where all factors are present are then excavated and evaluated.

If a pipeline is susceptible to SCC, pipeline operators are required to quantify the life cycle of the pipeline by conducting fracture mechanic calculations to estimate where in the system an SCC rupture might occur. Appropriate in-line inspection technologies can help to identify SCC in a pipeline. If the pipeline cannot accommodate internal inspection tools, an appropriately designed hydrostatic test program can be effective in exposing SCC. If excavations of suspected SCC locations do not reveal SCC, RSPA/OPS recommends continuous monitoring for SCC as part of an operator's integrity management program for corrosion.

Because of the randomness of SCC failures, RSPA/OPS has, in the past, often ordered operators to reduce operating pressure by 20% of the prefailure pressure to add a factor of safety and allow the operator to continue service. This protects the public and environment from other SCC failures, even if there is another crack on the pipeline of the same size. Based on technical studies, RSPA/OPS has often required the pipeline operator to perform a spike hydrostatic pressure test to expose other cracks and ensure a safe return to full operating pressure. The pipeline operator can then commence a rigorous SCC management program that may include in-line inspection, recoating the pipeline, or even replacing sections of pipe where SCC is present.

By the end of 2003, RSPA/OPS will invite scholars and consultants to a public meeting to discuss research and technologies that can effectively identify, assess, and manage SCC.