Preventing Corrosion Under Insulation

Corrosion under insulation (CUI) is a serious concern both in terms of monetary loss and danger to personnel safety. It is a top culprit for piping leaks and near misses and results in significant maintenance costs. It can mean the difference between a safely operating refinery or the depressurization of an entire hydrocarbon system at a gas plant.[1]

CUI is caused by water trapped between insulation and a metal surface. It may be due to leakage, condensation, rain, or other causes. CUI occurs mainly on carbon steel (CS), but it also affects stainless steel (such as 18-8 grades and 300 series). CUI tends to be the most severe on equipment operating at temperatures of 120 to 200 °F (49 to 93 °C), but it can affect both carbon and stainless equipment operating at temperatures anywhere from 25 to 302 °F (–4 to 150 °C).[1-2]

Based on Exxon data,[1] 84% of CUI leaks happen on piping, 81% of which is less than 4 in (100 mm) in Nominal Pipe Size (NPS). Pipe wall thickness appears to be a key factor in CUI failure, with failures of piping in the 16 to 20-year range occurring mainly on <4-in NPS low Wall Thickness (WT) >Sch 40 wall piping, and failure in the over 25-year range occurring mainly on piping with >6-in (150-mm) heavy WT >Sch 40 wall thickness.[1]

Temperature and containment sources influence the CUI rate, with wet insulation being the root cause of the problem. Maintenance costs are significant both in terms of materials and resources. Approximately $0.35 of every general maintenance dollar goes to costs for fixed equipment, such as vessels and piping. Of fixed equipment costs, about 54% is spent on piping (about $0.20 of every maintenance dollar), with CUI making up 40 to 60% of piping cost (or $0.10 of every maintenance dollar).[1]

One example of the cost impact of CUI occurred in 2006 when a leak in a 4-in hydrocarbon line caused a massive fire at an aging Gulf Coast petrochemical facility. Half the unit was destroyed, and resulting costs reached $50 million.[2] This demonstrates how dangerous and expensive a leak from CUI can be. Another example occurred in 2008 at a Dow Chemical Plant. Despite excellent maintenance, inspection, and safety records, aging materials suffered from CUI in a high condensation area. An 8-in (200-mm) CS hydrocarbon line sprang a pinhole leak that caused the piping to fail drastically as the operators worked on isolating and de-pressurizing the area. The force of the explosion buckled the pipe, fortunately causing it to seal itself and offset what could have been a terrible disaster.[3]

Use of Volatile Corrosion Inhibitors to Prevent CUI

Testing performed at California State University, Northridge,[4] demonstrated that Cortec® VpCI®-619†, a volatile corrosion inhibitor (VCI), is an effective means of controlling CUI in the temperature range of 170 to 350 °F (77 to 177 °C).

In this investigation, four API 5L X65 steel pipes were insulated with a thermal insulator (fiberglass system) to determine the effective protection of a VCI corrosion inhibitor against CUI. The specimens underwent isothermal and cyclic wet/dry test conditions at 170 °F and 350 °F. Results demonstrated that this VCI could successfully reduce corrosion attack under insulation even in a chronic wet environment. After corrosion testing, chemical analysis of insulated samples exhibited the presence of a protective Mo-rich inhibition compound on pipe surfaces. In a companion test, the corrosion rate dropped by a factor of 15 when the VCI was added to a 200-ppm salt solution during the testing of bare pipe segments at boiling temperature. The report states, "These results showed that an effective protective coating system under the insulation is critical and requires the inclusion of VCI to prolong the pipe integrity and lower inspection and maintenance cost."[4]

The test was performed in two parts. In the portion of the test that involved boiling a steel pipe segment in a 200-ppm chloride solution, one sample included VCI and one did not. The corrosion rate of the control pipe was ~5.3 mpy, while the corrosion rate of the pipe boiled in the VCI/chloride solution was 0.36 mpy, 15 times less than the control.

The other part of the test involved insulated piping that was subjected to cyclic corrosion testing for 240 h. The purpose was to see if VCI impregnated into the thermal insulation would protect the pipe. The insulation of the control pipe remained untreated. Both the control and treated sample were injected with a 200-ppm sodium chloride (NaCl) solution every 48 h, and the samples were inspected every five days. After 240 h, the untreated pipe showed localized corrosion, but the surface of the VCI-treated pipe remained well-protected. Consistent with inhibitor chemistry, a molybdenum-rich protective film was detected on the surface of the VCI-protected pipe.

†Trade name.

References

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