Corrosion Under Insulation: CUI

Corrosion is a major cause of economic loss in industrial process plants and power generation facilities. Piping, pipelines and vessels are at particular risk and contribute significantly to this problem. It is estimated that the problem costs approximately 4% of the gross national product of an economy. The consequences and damage can be far worse as human life can easily be endangered.

Corrosion processes can take place under high and low temperature pipe or vessel insulation. They occur both in ferrous metals and stainless steel.

Why Corrosion Occurs

In principle, corrosion is an electrochemical process and with ferrous materials the corrosion continually develops. With continuous increase in volume, iron oxide is formed, which lacks the strength of the original metal and can lead to loss of structural integrity and total destruction of the material. Water and oxygen are always involved when corrosion occurs and temperature can further accelerate the process.

Regarding stainless steel, various processes can occur, including stress corrosion cracking due to the presence of chlorides caused by water penetration through the insulation. In some cases the insulation material will contribute by releasing acids from foamed phenolic systems. Moisture is always the trigger for corrosion under insulation.

Moisture and Temperature

With low temperature insulation (equipment cold / ambient air warm), differences in vapor pressure cause the humidity in the air to make its way toward the cold substrate. Effective insulation must prevent moisture vapor penetration and therefore must NOT be permeable. Where moisture penetrates, oxygen can penetrate as well, and under these conditions the two factors will trigger and promote corrosion.

Under cryogenic conditions, the temperature that promotes corrosion is down to approximately -40^{0}C, with hot piping temperature greater than 150^{0}C. Cycling temperatures are particularly dangerous when they waver between cold and hot and wet and dry. In this case, water penetrates into the cell structure of the insulation due to the pump effect and remains inside because the dry-out conditions are insufficient for complete desorption.

At high temperatures, the causes of moisture absorption by permeable insulation are quite different. The most frequent causes and failures are due to permeability of surface coverings protecting the insulation, such as metal jackets, mastics and elastomeric coverings that can be penetrated by rain and snow.

With operating temperatures above 100^0C, the water begins to evaporate on the pipe surface and turn into a gaseous state, and at temperatures greater than 120^0C, the risk of corrosion decreases. However, in the real world, process equipment and piping generally do not operate at a steady state (constant temperature).

Stress corrosion cracking has been observed at much higher temperatures, due to the deposition of chlorides contributed by thermal cycling and transported by rain and seawater entering the insulation, then evaporating and leaving behind contaminants. The risk of corrosion increase is proportional to the square of the rise in temperature and the amount of moisture.

Avoiding Corrosion

There is no singular or absolute solution for controlling corrosion under insulation. There are various strategies for preventing corrosion under insulation. First, the insulation must be chemically inert and have a neutral pH. Values less than 7.0 present a risk, because in conjunction with moisture they may cause acid attack.

Specifying an effective anti-corrosion coating prior to insulation is the first and most critical step in avoiding corrosion. Understanding the operating temperature and cyclic requirements of the piping or vessel is essential to success.

The long-term goal for avoiding corrosion is to sustain structural integrity of the material and avoid unsafe conditions and reduce maintenance downtime. Corrosion must be detected and repaired by using the right anti-corrosion coating in conjunction with a closed cell insulating material. Following these two steps will arrest CUI and increase the life cycle of the equipment. The final step: develop and support a sustainable inspection schedule to avoid future problems.

Dampney has a 30-year track record for providing protective coatings and sealants for use under insulation to major corporations worldwide. Dampney promotes performance and quality with a comprehensive testing program using industry, NACE and ASTM test protocols. We offer a variety of coatings depending on the environment, material and specific application conditions. Please contact a Dampney technical repesentatative for assistance in selecting the best coating system for your project.

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