Dry Air Injection to Control Corrosion Under Thermal Insulation

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Dry air injection combats corrosion under insulation by removing the electrolyte through evaporation. This low-cost system can be installed without removing existing insulation, and its progress may be monitored by sampling at vents. Invasion of insulation and vapor barrier violation are minimized, and water-soaked insulation can be recovered and returned to near-new R-value (the measurement of thermal resistance).

Corrosion under insulation (CUI) (Figure 1) attacks and often damages heating, ventilating, air conditioning, and refrigeration systems. As a result, prevention and repair efforts become higher priority in the design, installation, and maintenance phases. Sometimes this is due to an understanding of corrosion, but often at least one past failure has persuaded the engineers to include corrosion control in the design.

This article discusses corrosion mitigation and monitoring the process of that mitigation, with a primary emphasis on minimizing the invasiveness of the method.

Invasive Procedures

Current methods of solving the corrosion problem of CUI are invasive on three levels. Design invasions occur when the planning process of refining the thermodynamics of the proposed system and its fabrication is interrupted or modified. Should the system be up and running, an operational invasion takes the form of a product retrofit. Finally, the ongoing need to monitor the success of the prevention method requires repeated integrity invasions.

FIGURE 1
Corrosion under thermal insulation.

DESIGN

Making a material choice based upon corrosion resistance, rather than system performance, is a typical design invasion. A system that could be constructed of A106B Seamless S40 or S80 steel pipe, with arc welding as the joining method of choice, might instead use galvanized pipe. The first observed effect would be a material cost increase. Following that would be the increased safety concerns about the arc welding of galvanized steel and the inhalation hazard. Finally, the additional fabrication step of treating the weld sites would be required. Every decision brings with it a train of effects that must be taken into account during the design and fabrication of the system.

OPERATION

Operational invasion occurs when, after designing, fabricating, installing, and starting the system, a decision is made to add a corrosion-mitigation system. This often requires at least partial insulation removal, the treatment application, and then insulation repair or replacement. Unfortunately, it is rarely possible to preserve the serviceable portions of the insulation, so system-wide replacement is frequently required.

MONITORING

After making the investment in some corrosion-mitigation method, monitoring its progress is of vital importance. Most methods contain elements that wear out, lose effectiveness over time (including paints and wraps), or are consumed (such as a sacrificial anode). The integrity invasion frequently takes the form of mounting sight glasses or taking samples (spot insulation removal) for inspection and subsequent replacement. Disturbing the vapor retarder, in particular, is injurious to insulation life because it invariably introduces a more direct vapor pathway than permeation through its various layers. The better the site is for observation, the more difficult it is to prevent local degradation.

Dry Air Injection

THEORY OF OPERATIONS

Dry air injection (DAI) is an effective method of preventing CUI. The air is dried to a –21°C (–70°F) dew point, or <50% relative humidity at the coldest temperature expected on the pipe surface. The dry air is distributed throughout the insulation and rapidly removes liquid water. Without an electrolyte, there will be no corrosion. The DAI is also minimally invasive.

FIGURE 2

DAI equipment—compressor, filters, and dryer.

DESIGN FOR NEW SYSTEMS

The use of DAI has little impact on design. The equipment consists of a compressor, filters, dryer (Figure 2), 3/8-in. (9.5-mm) perforated nylon tube throughout the total insulated pipe length, a vent every 30 ft (9 m) (Figure 3), and sufficient push-to-connect fittings to connect the tube sections. The space requirement is minimal, and the energy consumption averages ~$0.40 per foot per year.

OPERATING SYSTEMS

For systems already in operation, retrofitting DAI can be done without any system shutdown. The air distribution tube is inserted into a trail that is cut into the outer layer of insulation. The trail is then covered and the compressor/dryer is installed. If the insulation is water-compromised, air injection will dry it, returning it nearly to like-new effectiveness. If not, the air supplied can remove several times the amount of water that is infiltrating the insulation through the vapor retarder and any cracks or gaps in it. It is also important that the weather seal over the insulation is reasonably good.

MONITORING

The vents, which allow the moist air to escape, provide sample points throughout the insulation envelope. An air moisture probe (Figure 4) may be temporarily inserted into the vent and the dew point measured. Where the insulation is water-free, the escaping air will be nearly as dry as that which is in the distribution tube. The progress of drying may be documented by recording the declining dew point of the air escaping from particular

FIGURE 3

Typical thermally insulated pipe.

FIGURE 4

Air moisture probe.

vents. In addition, known or anticipated trouble spots may be given a vent simply to monitor their particular condition. An additional option involves remote sensing of progress. Small, microchip-based humidity meters may be installed in vents or buried in the insulation itself. These meters are then sampled remotely and the results tabulated.

Under the insulation, corrosion will be halted when the dew point of escaping air declines to 32°F (0°C) or below. Because a liquid electrolyte is required and water freezes at 32°F, that dew point reading will indicate that the only moisture remaining is ice. Water removal will continue at that point by sublimation.

Summary

DAI has been introduced to prevent water intrusion and reclaim insulation to preserve or return to its original R-value, which measures thermal resistance or how well the insulation holds back heat. After this, it has been demonstrated that with the water removed, corrosion was also halted. DAI protects both the insulation and the pipe underneath it.

Conclusion

DAI permits optimum thermodynamic functionality, maximum insulation pipe life, and real-time progress monitoring. It can be installed, monitored, and maintained without system downtime. Insulation integrity is preserved, while allowing for both system-wide and specific position monitoring.

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