September 2021

MAINTENANCE AND RELIABILITY

Corrosion under insulation on stainless steel

Corrosion under insulation (CUI) is a severe form of localized external corrosion that occurs on stainless steel (SS) that has been insulated.

Rupesh, S., Independent Consultant

Corrosion under insulation (CUI) is a severe form of localized external corrosion that occurs on stainless steel (SS) that has been insulated. It is a costly problem in the process, chemical and pharmaceutical industries, with millions of dollars spent on inspection and repair of equipment over the past several years.

Although CUI is common in carbon steel, it also affects SS, which is otherwise considered corrosion resistant. This corrosion manifests in the form of severe pitting. The main reasons for CUI occurrence in SS are the presence of chlorides and fluoride ions in insulation, the presence of an electrolyte (mainly water) and the presence of oxygen. Sometimes, the presence of acids gives rise to accelerated acid corrosion, which is not discussed in this article.

Furthermore, metal temperatures in the range of 50°C–175°C are prone to external stress corrosion cracking (ESCC) failures under these circumstances.

Relevant standards and test methodologies

A number of standards define the requirements for thermal insulation that is to be used in contact with SS. However, only ASTM C795, the standard specification for thermal insulation for use in contact with austenitic SS, is considered for this article.

ASTM C795 references two other test methods, ASTM C692 and ASTM C871. Fig. 1 from ASTM C795 shows the reference standard for determining the chemical acceptability of the insulation material. It indicates the acceptability of insulation material on the basis of the plot points of Cl + F and Na +SiO_3 analyses. Tests must be conducted in accordance with ASTM C692 and ASTM C871.

ASTM C692, the standard test method for evaluating the influence of thermal insulations on ESCC tendency of austenitic SS (otherwise known as the “28-d coupon test”) is a test method that evaluates the corrosion possibility of insulation in contact with stressed SS coupons. In this test, water is wicked through insulation or dripped onto non-wicking insulation that is in contact with the SS coupons. After a period of 28 d, the SS coupons are examined for any signs of ESCC. Four coupons must be tested to comply with the requirements of the standard, and none of them can show ESCC. If any of the coupons show cracking, then the insulation has failed the test.

ASTM C871, the standard test method for chemical analysis of thermal insulation materials for leachable chloride, fluoride, silicate and sodium ions, is the test method for determining leachable chloride, fluoride, silicates and sodium ions in an insulation. The results from this test are checked with the empirical graph in **FIG. 1** in ASTM C795 for “chemical acceptability” for use on SS, which is determined if the plot points of these analyses fall within the acceptable area of **FIG. 1**.

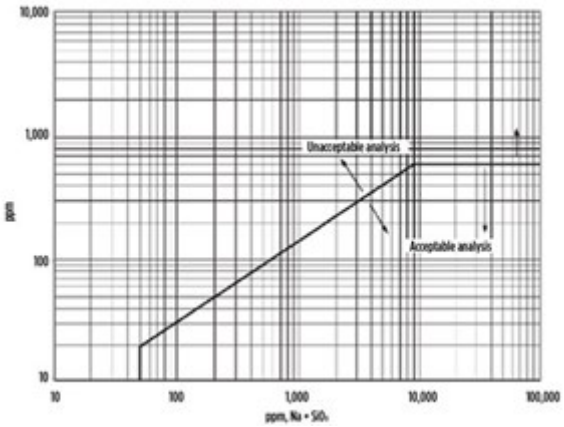

FIG. 1. Acceptability of insulation material on the basis of the plot points of Cl + F and Na + SiO_3 analyses. Figure: ASTM C795: Standard specification for thermal insulation for use in contact with austenitic SS (2018).

For an insulation material to be acceptable for use in contact with SS, the material must meet the chemical acceptability criteria and pass the 28-d coupon test. Passing only one of the two tests is not sufficient.

Pre- and post-insulation considerations

Once the insulation material selection is finalized, there are several important considerations for pre-insulation laying activities and regular monitoring post-insulation to minimize CUI on SS. Pre-insulation laying activities include:

1. Hiring an insulation contractor of good repute is an important step to avoid CUI problems. Before laying the insulation, ensuring a selection of good-quality vapor barrier mastic, glass cloth fabric, foam sealer and SS jacketing is vital for achieving a leakproof arrangement and eliminating the ingress of rainwater or moisture into the insulation material.
2. Insulation material lots received at the site are often dumped into a corner without adequate storage to prevent moisture ingress. Such practices must be strictly avoided. ASTM C390, the standard practice for sampling and acceptance of thermal insulation lots, provides helpful insight in this regard.
3. Insulation of equipment and piping should be carried out at the site after installation. If the insulation is carried out at a vendor shop for some reason, it must be ensured that there is no possibility of water/moisture ingress during transportation. A detailed procedure must be prepared and approved by a competent authority prior to shipping. This is specifically important when the insulated equipment/piping is transported through a sea route, as the sea atmosphere is high in moisture and salt laden, which can have detrimental effects on insulation material during transportation.
4. Some standards suggest the use of aluminum over the metal surface prior to laying insulation to shed water; however, it should be noted that aluminum is a potential fire hazard due to its low melting point. The use of aluminum should be avoided in fire hazard zones.
5. Some specifications recommend the application of paints prior to laying insulation; however, the effectiveness of this procedure must be checked with the insulation material specialist for the intended use.

Regular monitoring post-insulation activities include:

1. An insulated surface always looks acceptable from the outside. This may give a false impression, as the surface below the insulation could be encountering CUI, which can go unnoticed for a considerable period of time.
2. All the low points under insulation in vertical equipment, such as dish heads, bottoms of horizontal vessels, individual nozzle low points, nozzle interfaces, piping low points, areas near supports, etc., must be regularly monitored for corrosion. These low points typically show signs of CUI, as the moisture/water generally drips down to these areas due to gravity. A portion of the insulation can be opened up for inspection. In case of doubt, the previously mentioned tests can be repeated to ascertain any signs of CUI.

3. Upon opening the affected area, if any pitting is observed on the surface, then loss of thickness must be assessed for fitness-for-service (FFS) of pressure equipment using standards such as API 579-1/ASME FFS-1.Based on the results of the assessment, it should be decided whether or not the equipment should be put back in service.
4. A periodic inspection schedule should be in place to check the insulated surfaces for any sign of CUI or leakage.

CUI on SS may not be eliminated completely; however, it can be reduced to a great extent using the approaches outlined in this article. **HP**

The Author

Rupesh, S. - Independent Consultant, Kerala, India

Suthan Rupesh is a Consulting Mechanical Engineer based in Kerala, India. He has more than 17 yr of experience in the field of static equipment. He has also worked as a Lead/Senior Engineer for EPC companies such as Worley/Jacobs (Singapore), JGC Corp. (Saudi Arabia), Engineers India Ltd., Larsen & Toubro and Atkins (India). His research interests include shell-and-tube heat exchangers and corrosion studies. Mr. Rupesh is also a Member of The Institution of Engineers (India), and he holds a BEng degree in mechanical engineering from Lukhdhirji Engineering College in Morbi, India.