KEEPING COOL

Johan Sentjens, Temati BV, the Netherlands, discusses the pitfalls of insulation applications on LNG projects.

During the last 10 years, Temati BV has seen some interesting trends within the cryogenic insulation market. Whereas 10 – 15 years ago the technical aspects of insulation materials were important, today topics like HSE and the level of craftsmanship have a big influence on insulation design. The increasing influence of time and money has led to new insulation concepts, but concerns remain over whether or not there is a good balance between technical and commercial aspects.

This year, Temati celebrates it's 50th anniversary. Within this period the company has experienced a lot of changes including the introduction of its EBD (European Business Development) platform to pro-actively share its expertise and experience. Today, Temati has five branches and nine distributors with headquarters in the Netherlands.

A case study

Last year, Temati was contacted about a galvanic corrosion issue at a new LNG project. The project includes an onshore LNG processing train and storage and loading facilities, including two LNG tanks, three smaller condensate tanks and an LNG and condensate export jetty.

The onshore plant modules and jetty sections, including jetty piping, were fabricated in modules at a location offsite. All of these modules were prefabricated with insulation. After completion, these modules were shipped to the site and assembled.

Towards the end of the construction period, reports came in about the quality of the insulation. The plant operator formed an investigation team and requested the assistance of an independent expert insulation consultant (Popma Consultancy). This team discovered that the insulation systems were in a poor condition, especially around the fittings and elbows, where the insulation sections had many voids and open joints.

Other shortcomings were also found during the site inspection. One of the findings was that the primary vapour barrier (PVB) was damaged due to galvanic corrosion and puncturing by self-tapping screws in the cladding. After further investigation at some 50 spots throughout the jetty area and the plant, it became clear that an unsuitable primary vapour foil was applied. This, in combination with the stainless steel cladding, had led to galvanic corrosion.

During the sea transport and also onsite, seawater became trapped between the stainless steel cladding and the vapour barrier foil. All the joints in the stainless steel cladding were also sealed and no drain holes were installed in the cladding sections. Even in the places where drain holes had been installed, these were sealed prior to sea transport. These drain holes ensure that in an insulation system moisture and seawater does not accumulate between the cladding and the primary vapour barrier. However, in this case seawater did get trapped.

Figure 1. Primary vapour barrier aluminium foil with localised corrosion at the lower half.

Figure 2. Primary vapour barrier aluminium foil with extensive localised corrosion and perforations.

The applied PVB consisted of a butyl rubber adhesion layer covered with a single layer of aluminium foil. In this case, the aluminium layer and the seawater was in direct contact with the stainless steel cladding, causing galvanic corrosion.

The time span between shipping from the prefabrication location to inspection covered several years. In many places it was found that the aluminium layer was completely corroded away.

Technical insulation systems in general

A wide range of materials are used in modern industrial plants. Piping is often made of carbon or stainless steel and pipe supporting is made of carbon steel. Insulation materials can be cellular glass, mineral wool, rigid or flexible foams, calcium silicate or perlite. Protective cladding can be made of aluminium, galvanised steel, stainless steel or GRE. In cold cryogenic insulation systems, vapour barrier materials can be mastics or aluminium laminated type foils. To design a fit-for-purpose insulation system it is important to select suitable products and meet individual client demands, e.g. fire resistance. However, in some cases an old specification is copied during FEED stages and little attention is given as to whether it is in line with the latest standards and techniques. Nevertheless, good standards are available, such as CINI, which is a set of guidelines produced by a committee of asset-owners, contractors and manufacturers.

Figure 3 shows a typical cryogenic insulation system. In contrast to hot insulation, every single detail matters in cold insulation as the tiniest flaw can lead to unwanted icing after commissioning. That is why these systems are often designed with back-ups, such as a secondary vapour barrier and vapour stops.

Galvanic corrosion

Galvanic corrosion, or 'contact corrosion', occurs when two different metals or alloys in a construction are in electrical contact by an electrolyte. In this case it concerned two materials: stainless steel from the outside protective cladding

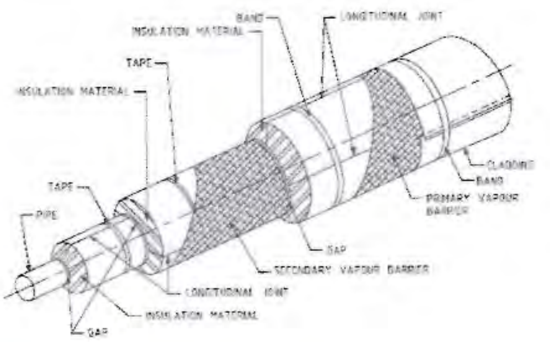

Figure 3. A typical cryogenic insulation system[1].

and aluminium from the PVB foil. These dissimilar metals with different electrode potentials (Figure 4) came into contact in seawater (an electrolyte), resulting in a galvanic couple. Aluminium acted as an anode and stainless steel as a cathode. The potential difference between the two metals is the reason for the accelerated degradation on the anode metal. In other words, the anode metal dissolved into the electrolyte. This degradation process can happen rather quickly, which can be shown in a simple lab test where two plates of the same surface are put in beakers with saltwater (Figure 5). The potential difference can be measured and the degradation is also visually detectable.

However, in this case unwanted degradation can also be used as a protection. In the same manner ships are being protected with sacrificial anodes, aluminium foils can be wrapped around stainless steel pipes and equipment prior to installing thermal insulation. This standardised method is being implemented in many cases where thermal insulated stainless steel systems operate under service conditions with a high risk of moisture ingress or surface condensation. In general, galvanic corrosion within the insulation market is an underestimated issue, e.g. using stainless steel screws in aluminium cladding or end caps that can be in contact with the pipe. On one side, contractors are not always aware of the situation since they merely need to follow the specification. On the other hand, declining knowledge among design engineers and maintenance departments contributes to the problem.

The solution

The non-conformities discovered by the inspection team could be subdivided into two groups. One related to galvanic corrosion and the other related to earlier mentioned fittings and elbows. The scope of these non-conformities, combined with

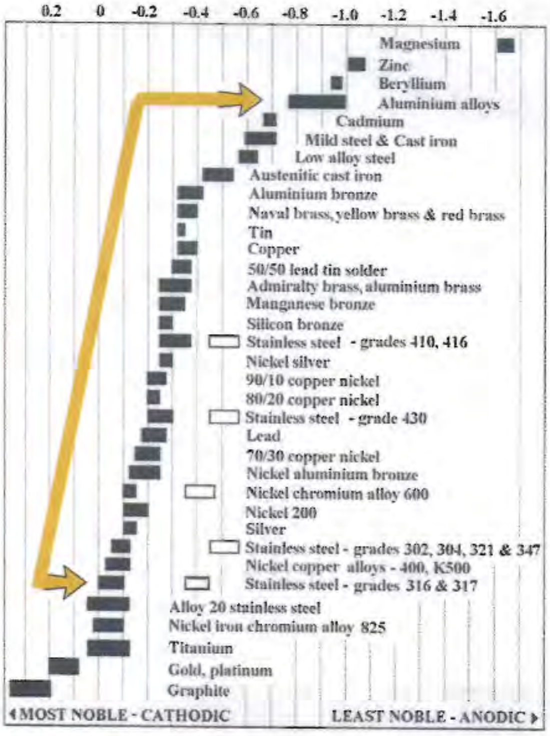

Figure 4. Galvanic series.

the remaining insulation still to be executed plus the rapidly approaching start-up date, meant a difficult task lay ahead.

With regards to elbow joints in the loading lines, the project management team decided to completely re-insulate all elbow joints, as well as the outer layers of the adjacent straight sections. After considering various options, the quickest method was to replace all elbows by prefabricated sections.

While dealing with the galvanic corrosion issues, the project management team decided to remove all the stainless steel cladding and install a new PVB on top of the existing damaged PVB. The client selected Tembutil-IF, as this product already had a standard polyethylene layer on top.

The philosophy in these 'bush fires' is always a two-way action. Short-term 'fire fighting' and long-term action to ensure it does not happen again. The 'fire fighting' involved teaming up with the PIR manufacturer. Temati and the PIR manufacturer organised to factory-apply Tembutil-IF to pre-cut PIR pipe-sections and elbows. An overlap of Tembutil-IF on all pipe sections on the longitudinal side makes on-site application easier. The company supplied Tembutil-IF tape for circumferential joints and Tembutil-IF in pre-cut fish-tail shapes adapted to the 3D elbow model for the bends. Wrapping vapour barrier foil around elbows onsite always brings a risk of not maintaining enough overlap, which is the vital and critical detail of the total vapour barrier. Applying this in a conditioned factory

Figure 5. Lab test set-up.

Figure 6. Prefabricated elbows with Tembutil-IF.

environment in QA/QC becomes the PIR manufacturer and Temati's responsibility.

This project became the start of a new system to supply pre-formed PIR sections, which can be produced for all common shapes (T-joints, elbow joints and valves etc.), and finished with a Tembutil-IF vapour barrier. The system has several significant advantages, including reducing the risk of errors. Traditionally, when applying Tembutil-IF on-site, at least two workers are needed, one on each side of the pipe, to position the foil over the insulation in such a way that it can be applied and pressed onto the insulation in one single pass. Once the Tembutil is fixed to the insulation material it is not possible to correct it. When working in small areas (which seems to be more a rule than an exception) this procedure increases the risk of errors. Finally, by reducing labour on-site, the new system contributes to HSE goals.

During the project, Temati and the client met to discuss this situation and a long-term solution to prevent it from happening in the future. A simple root cause analysis presented several lessons to be learned. First of all, the client's specification needed to be reviewed. The initial specification was more than 10 years old and only mastic PVB was mentioned. However, the specification left too many options for choosing vapour barrier materials. Temati recommended that the specification should make some references to applicable CINI chapters. Closer study of the CINI chapter 3.3.06 regarding vapour-barrier-foil showed that some changes within this chapter were also necessary and that it was still possible to make choices that could lead to galvanic corrosion issues (see the 'Note' at the end of the article).

The client's project organisation was also discussed, for instance how QA/QC was organised regarding insulation. In general with clients and EPC organisations, cryogenic insulation QA/QC is seldom organised well enough and too much responsibility is left on the contractors shoulders for a large part of the procurement/subcontracting and contract-management strategies. Procedures dictate that a contractor is responsible for guaranteeing the end quality meets the clients specifications. This works on paper but these projects are not always executed properly.

Subcontracting to various prefabrication production locations showed the need for more on-the-job expediting. Regardless of the insulation system or the contractor, it is becoming increasingly important to have an autonomous independent QA/QC involved from the pre-EPC, or preferably during FEED, all the way up to commissioning and start-up. LNG

Reference

1. Image courtesy of the CINI Manual 2010.

Note

These corrections and recommendations will be included in the CINI update 2013. In specification CINI 3.3.06 'Butyl rubber tape with aluminium foil backing' preference is given to the polyester/aluminium/polyester laminate. When applying a type without a polyester protective foil a warning is included that the aluminium foil shall not come in direct contact with the metal jacketing to avoid galvanic corrosion.