

Changing the Landscape of Thermal Insulation Coatings

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ABSTRACT

Thermal insulation of piping, valves, tanks, and vessels is achieved by an INTEGRAL SYSTEM of corrosion mitigating coating, thermal insulation media, and external cladding. For many years the use of thermal insulation coatings TIC 's has been used for personal protection against burns, solar radiant heat gain protection and limited energy process preservation as an alternative to conventional insulation such as mineral wool or calcium silicate. However, the downside of these conventional systems is that they leave an air gap to the primed surface and when damage to the jacketing occurs then corrosion under insulation (CUI) can become a real issue for the plant as it can often go unseen for years. The thermal insulation coatings attempt to alleviate this issue as they are applied direct to the primed surface forming a monolithic barrier and can be inspected visually without removal of the insulation system. Hence CUI is no longer an issue.

There are many examples of these TIC on the market, but all have similar issues related to application and thermal performance. These materials were also uncompetitive compared to conventional insulation utilizing multiple inches for use in projects which required energy preservation.

This paper will detail the development, application and performance verification testing of a next generation thermal insulation system, Basecoat and Top-Coat, which now can compete with conventional thermal insulation but will be applied in less coats and give better thermal performance than 1st generation materials.

Key words: TIC, Insulation , Thermal Conductivity, PPE.

INTRODUCTION

Thermal insulation is a material that restricts the flow of heat. Heat spontaneously flows from a high temperature region to a low temperature region, and the greatest heat flow occurs through the path of least resistance. For this reason, thermal insulation is used as a barrier between two bodies at different temperatures either to reduce heat loss from the hotter body or to reduce heat entry into the cooler body.

There are four component aspects to CUI:

- Steel: a substrate at constant or cyclical temperatures
- Priming system: product to resist the environment
- Insulation: for thermal efficiency
- Cladding: for shielding the insulation system against atmospheric elements.

In practice, the cladding system is never truly sealed throughout its lifetime from the atmospheric elements, and therefore rain, water from deluge water systems, steam or cooling tower water is often able to penetrate the system through an ingress point in the cladding material. Additionally, as the permeable insulation (open cell) types used are sensitive to moisture, condensation build-up is a frequent CUI contributor. Once water has penetrated the system via an ingress point such as cracks, seams, gaps, or unsealed valve sections, it is absorbed into the open-cell insulation, where it causes saturation or accumulates in high concentrations and is able to corrode the steel. In some cases, it has been able to sustain plant life! as can be seen Figure 1 below.



Figure 1; Patch Repairs and plant growth

Potential contaminants are acid or high salt content, rain, and chemicals (chlorides/sulfides) leaching from insulation systems that can form acidic compounds which accelerate the rate of corrosion. The predominant steel materials used in industrial processing are carbon (CS) and stainless (SS, austenitic

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or duplex) types. Both are susceptible to CUI via multiple corrosion mechanisms. The temperatures at which extensive CUI (either in cyclical or constant operation) occurs in CS range from -4°C - 175 °C (25°F - 347°F). The corresponding temperatures for SS are 50 - 175 °C (122°F - 347°F). The rate of corrosion is directly related to the CUI system, the suitability of the CUI coating, the type of insulation and the quality of the cladding installation. Specifiers and asset owners can choose from a wide selection of materials obtainable from a variety of suppliers when designing, building, and maintaining plants. To help them with this process, they mainly refer to NACE SP0198 – 2017¹. This generally accepted guidance document facilitates selection by listing suitable materials for cladding, insulation, and coatings based on operating temperature and chemistry to mitigate CUI. However, this does not include thermal insulation coatings with the potential to eliminate CUI.

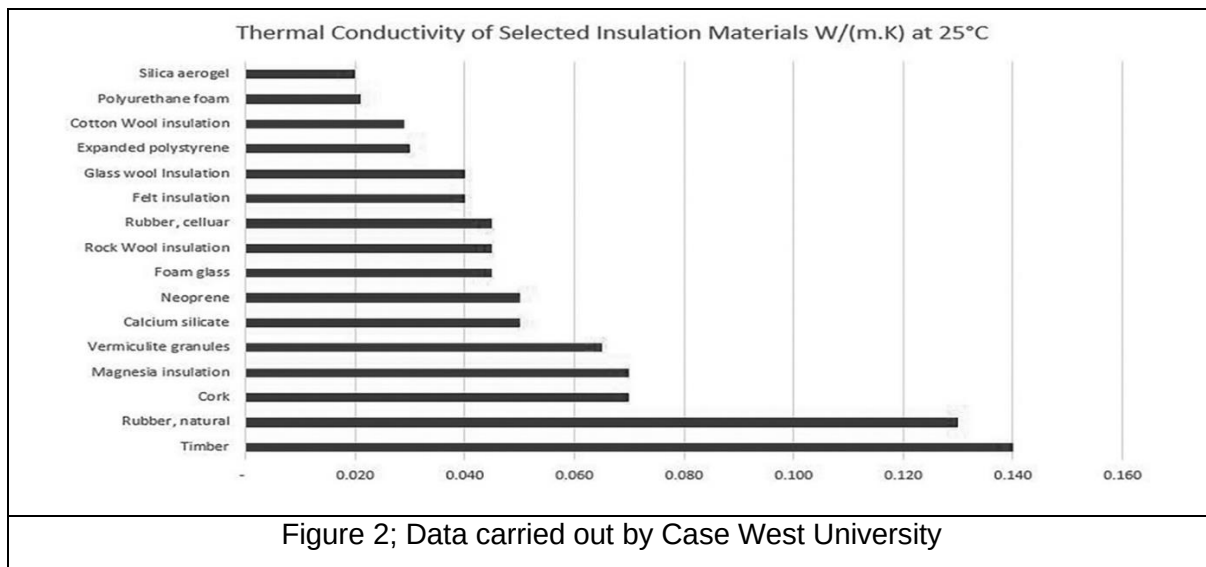
Current technologies for atmospheric liquid insulation are hampered by their chemistries. Generally, technology available today is based upon either waterborne acrylic technology which has temperature limitations to 177°C (350°F) or epoxy syntactic materials with temperature limitations of 200°C (392°F). In the cases of the waterborne acrylic and the epoxy the temperature resistances come from the binder resin. The waterborne acrylic also has issues with the need for multiple coats at 300µm - 500µm (12 – 20 mils) as they are waterborne, the epoxy can be applied at >5000µm (200 mils) per coat. Significant advances in insulation technology have been observed in the materials added to binder systems to impart thermal insulation performance. Traditional glass or polymer beads in insulation formulations have been replaced with materials such as aerogels, nanogels and hollow oxides. However even with significant progress no material has yet solved both high temperature resistance and high build requirements.

The real issue with CUI is the fact that the only 100% certain way of knowing there is no problem on pipes and vessels is to completely remove the insulation system. This is not the approach that corrosion engineers/end users wish to adopt as it is also the most expensive way of inspection. This created a challenge for researchers to provide techniques which eliminate the need to completely dismantle insulation systems for inspection. The techniques are required to be non-destructive (NDE) technologies and portable to be used on site. These techniques can be used along with conventional techniques to provide economical, comprehensive CUI inspection of piping networks. Some of the proven NDE techniques are.

- Neutron backscatter
- Infrared (IR) thermography
- Guided wave ultrasonic technology (UT)
- Profile radiography
- Computed radiography (CR)
- Pulse eddy current (PEC) testing

Out of these methods, profile radiography and guided wave UT are accepted in API 581 as alternatives to insulation removal for inspection.

The specification of TIC has always been compared to that of conventional insulations and their thermal conductivity values can be seen below in Figure 2.²

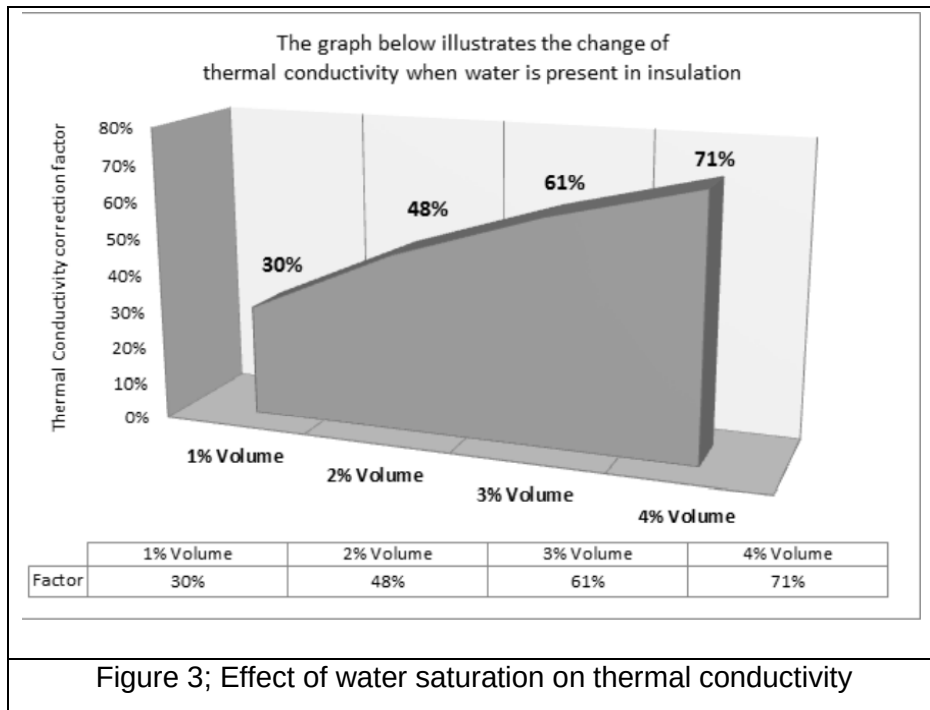


However, there is a fundamental flaw in using this data as the installation of these types of insulation involves exposure to atmospheric elements where it is quite feasible that water can be absorbed and then is part of the insulation system thus lowering thermal conductivity. Also, during its lifetime, the insulation system will get damaged and water from various sources

- Rainfall
- Humidity
- Ground water
- Condensation falling from cold service equipment
- Spray from fire sprinklers, deluge systems, wash-downs, etc.

will enter the system further reducing thermal efficiency. This has been demonstrated in the field in the example below.

Quote from Ludwig Adams ASHRAE Journal "The thermal performance of an insulation material is based in part upon the existence of small air pockets within the structure. When these air pockets are replaced with water, the thermal conductivity of the material increases since water transfers heat more readily than air." This is represented in figure 3 below taken from a presentation by Dr Stephen Badger³



In 2021 when the insulation system on a tank roof in the USA, figure 4, was being removed was permitted by the owner to take samples from various parts of the roof. These samples were taken from various position on the roof as seen in figure 5 and 6 so that we could see the distribution of moisture entrapment across the whole surface

