CorrCompilations

CORROSION UNDER INSULATION

Editor: Jon R. Cavallo, PE

NACE INTERNATIONAL

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Introduction

Corrosion under insulation (CUI) is most often defined as a type of corrosion that results from moisture buildup on the external surfaces of piping and other equipment covered by insulation. CUI is most commonly classified as galvanic, chloridic, acidic, and/or alkaline in nature.

Carbon and low-alloy steels operating between –4°C (25°F) and +148°C (300°F) are most susceptible to CUI. CUI can be exacerbated in environments in which wet or damp insulation is in contact with carbon and low-alloy steel substrates at over 100°C (212°F).

Most reports of CUI come from the chemical, refining, offshore, and marine industries. However, CUI is not exclusive to these industries, although it is often not recognized as being prevalent elsewhere.

This NACE International CorrCompliation provides the reader with a selection of papers on the subject of CUI; some are general in nature, and some discuss industry-specific issues. The papers have been divided into the following sections:

Section 1. General

The papers in Section 1 introduce the reader to the general characteristics, causes, and results of CUI.

Section 2. Inspection

The Section 2 papers identify and discuss innovative inspection protocols and techniques that have been developed to identify and evaluate CUI.

Section 3. Chemical Processing and Petrochemical Refining

Section 3 contains papers that focus on CUI in the refining and chemical-processing industries.

Section 4. Tanks and Vessels

Section 4 focuses on CUI in aging petrochemical refinery pressure vessels.

Section 5. Offshore Oil and Gas Installations

The Section 5 papers discuss CUI identification and remediation at offshore oil and gas installations worldwide.

Section 6. Miscellaneous

The final section contains miscellaneous papers related to CUI.

Paper No.
03036

CORROSION2003

CORROSION UNDER INSULATON NEW APPROACHES TO COATING & INSULATION MATERIALS

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ABSTRACT

Corrosion of steel under damaged or incorrectly installed thermal insulation is a common problem in many process plants. Over the past years a large range of solutions have been investigated, including protective coatings for the pipes from zinc silicates to special coal tar epoxies, to various types of sophisticated protective cladding for the insulation.

Work and results will be given from tackling this problem from two directions, firstly to develop new coatings which will give performance under wet insulation and will resist temperatures up to 230ºC, with novel experimental inorganic products looking suitable for 300ºC-400ºC. The alternative approach has been to develop an epoxy syntactic foam capable for use at operating temperatures up to 150ºC, and also giving protection to corrosion atmospheres and mechanical abuse.

Standard test methods have not been available for this work and has necessitated the development of test methods which can reproduce observed failures.

Key Words: Inorganic, Insulation, Epoxy Phenolic

INTRODUCTION

Corrosion under insulation (CUI) has been shown to be one of the biggest corrosion problems in the operation of process plant, especially ageing petrochemical plant. For example, a 2 year survey of plant failures at Shell (UK) Stanlow's manufacturing complex showed that around 35% of corrosion incidents, i.e. failures or near failures, were caused by CUI[1]. Although this plant, situated in the north west of England, is in a heavy industrial area, it is not in a particularly aggressive marine environment.

CUI is a form of localised corrosion that affects insulated steel, typically in the temperature range –5ºC to 150ºC, but most severe corrosion is observed between 60ºC and 120º with corrosion rates of 1mm per year (7-10mm of scale build up corresponds to 1mm of corrosion)[(1)]. Other sources[(2)] state narrower operating ranges of 5ºC to 105ºC, and especially the range 60ºC to 80ºC. API 570 quotes that "external CUI is likely to occur in carbon steel piping systems operating between –4ºC and 120ºC and in austenitic stainless steel piping between 65ºC and 204ºC". The UK Health & Safety Executive states that "the risk is low below –4ºC and above 260ºC (but this is negated if any cycling or temperature transient is present)". Most critical area is 30ºC to 120ºC, with US data showing typical corrosion rates of 0.5mm/year at 80ºC under lagging[(2)].

Generally plants located in areas of high annual rainfall or warm marine locations are more susceptible to CUI than plants in cooler, drier, inland regions, thus there are problems for the majority of refineries and petrochemical plants around the world because of their situations. Regardless of the macroclimate, the microclimate can also have a major effect, and cooling towers, deluge systems and steam vents can all increase the potential for CUI, as is the case for plants where the process operating cycle regularly crosses through the atmospheric dew point.

At first sight it would be expected that the insulation would contribute to the overall corrosion protection of the area concerned, with the insulation itself being generally clad with various jacketing, such as aluzinc, galvanised or stainless steel, or wrapped with some type of PVC tape. When correctly installed and sealed this is the case but, all too often, lack of maintenance, poor installation or design, or mechanical damage by plant operators, allows water ingress and consequent corrosion. In practice, CUI tends to occur where water is likely to collect (i.e. at low points and around discontinuities) and where there are penetrations through the insulation. On vessels this includes nozzles, manholes, support rings, bottoms of vertical storage tanks, brackets etc., on pipework; pipe hangers, low points, valves, flanges etc.

There has long been an acceptance that it is not feasible to be certain of 100% water exclusion on insulation by use of cladding etc., hence the need for a secondary line of defence is recognised, i.e. a suitable coating applied to the insulated steel surface. The standard recommendation for coatings use is NACE RP 0198-98[(3)]. Inorganic zinc silicate would appear to be the ideal coating in this situation in terms of all round anti-corrosive properties, resistance to handling and mechanical damage, and temperature resistance. However, the zinc silicate has a documented history of not performing well in practice with wet insulation (Figure 1), probably due to the fact that the zinc can be dissolved away by its poor alkali resistance, and the inability to complete the zinc salting reaction to insolubility to give an effective barrier when used in a low oxygen/low carbon dioxide environment. This is covered fully in NACE Publication 6 H189[(4)].

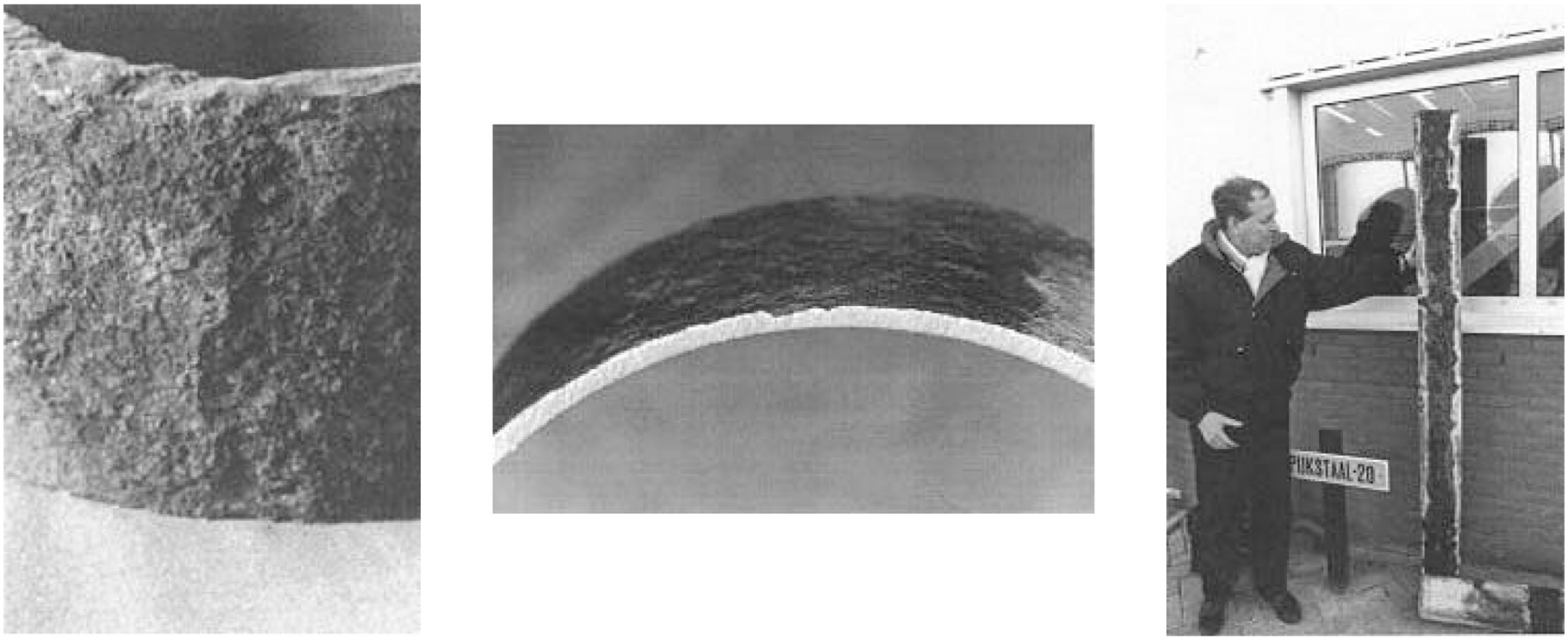

FIGURE 1

Corrosion of zinc silicate coated piping under insulation in less than 5 years in Northern Europe

NACE gives a fairly comprehensive list of possible generic coating types for use under insulation, based largely on practical experience, rather than controlled testing. In fact, one of the major problems in this area is that no standard test regime exists and the formal development of such would be an extremely worthwhile task for a NACE Work Group. A method was suggested by Collins, Delahunt and Maatsch which is the basis of that currently in use and could easily be worked up into a standard test method.[(5)] The coatings recommended vary from more or less conventional systems to epoxy phenolics and special coal tar epoxies (unlikely to be an ongoing practical proposition because of increasing concern and legislation on coal tar because of benzopyrenes). Most thermally stable thin film systems do not give good corrosion resistance and the most effective system, sealed aluminum metal spray, is expensive, slow to apply and extremely difficult to apply in a maintenance situation.

The introduction of thicker film polysiloxane systems some years ago appeared to give a potential route to corrosion protection at higher temperatures but in practice was not robust enough for thermal cycling conditions which could lead to cracking.

This has led to a review of how to achieve better corrosion resistance and, at the same time, operate at higher temperatures. Initially a simple test method was developed whereby an insulated pipe was wetted once a day and heated and cooled over a 24 hour cycle (Figure 2). Application of a high temperature at the base of the pipe produces a temperature gradient along the pipe, giving an induction of failure temperatures of the coating.

Although this needs further development, it does reproduce some of the problems seen in practice, especially the IOZ/silicone aluminum type flaking (Figure 3), and also allowed reproduction of the cracking observed in the thick film polysiloxanes.

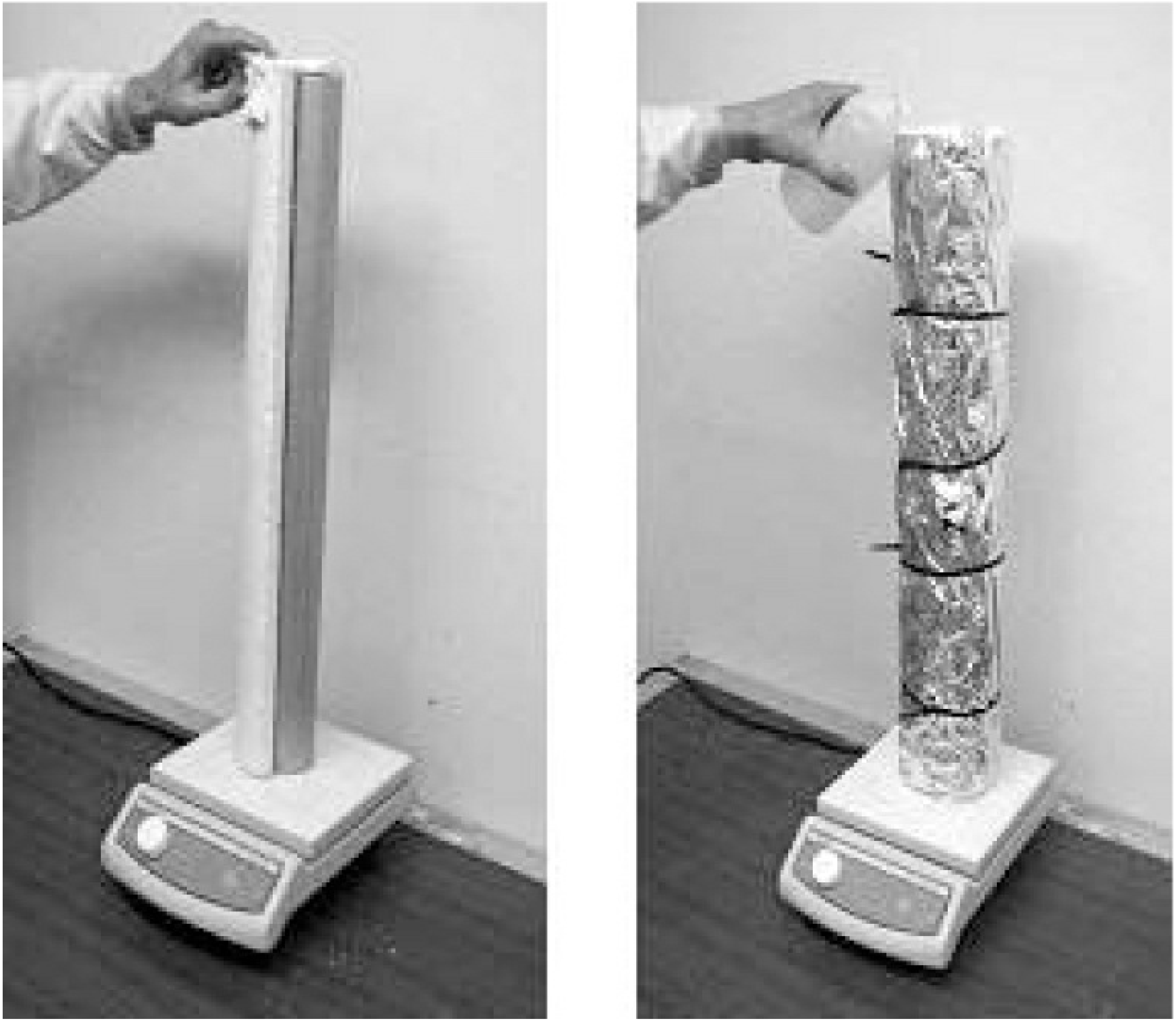

FIGURE 2
Wet Insulation Cyclic Testing Apparatus (180ºC – 450ºC)

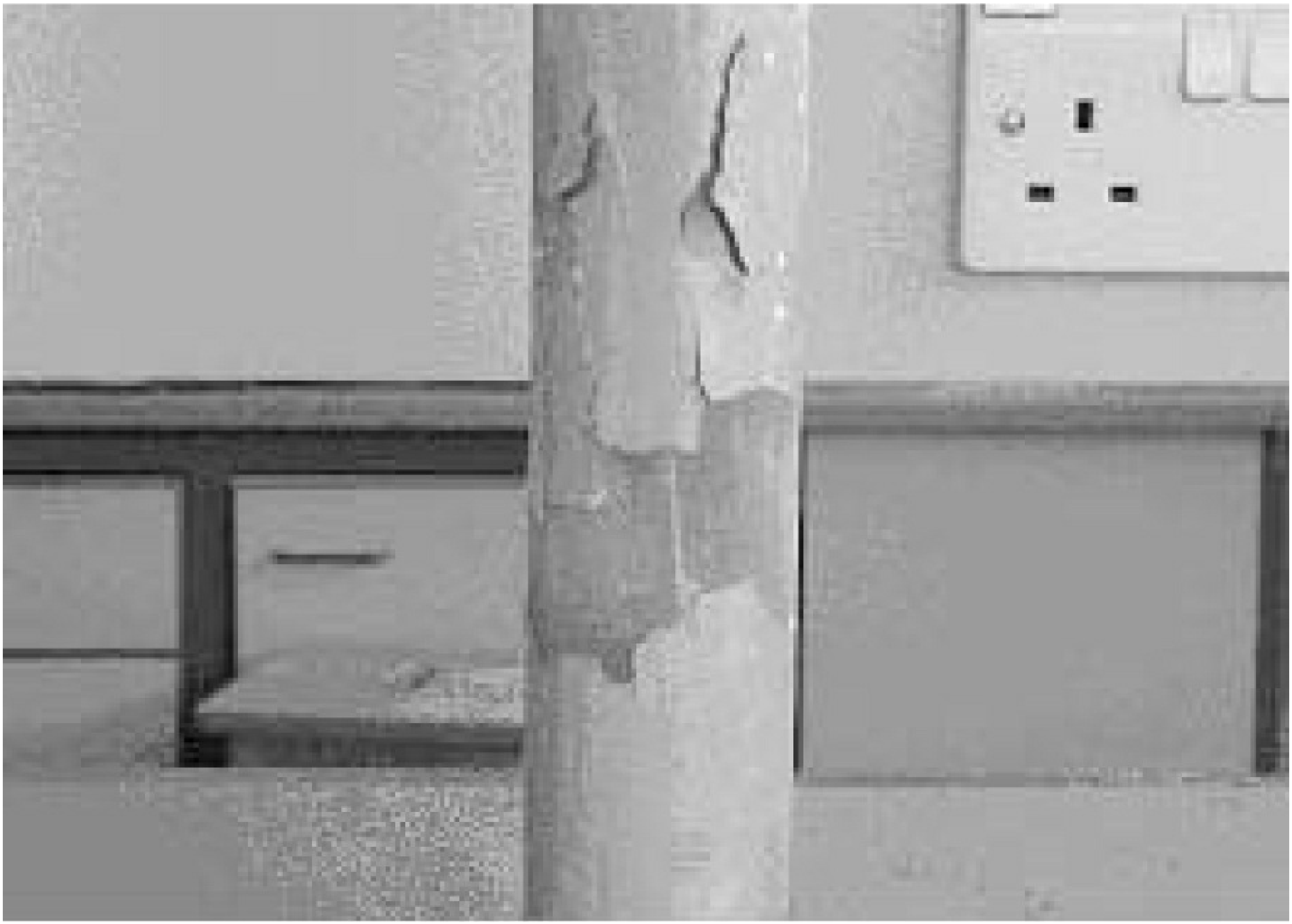

FIGURE 3
Example of detachment of silicone aluminium coating from zinc silicate in under insulation situation

The NACE Standard recommends epoxy phenolics up to 150ºC, however, extensive testing, as described above, and simply heating/cooling or heating/quenching has shown that correctly formulated materials can go to much higher temperatures, i.e. 230ºC, without showing any film defects, and continuing to have satisfactory corrosion resistance (Figures 4, 5 and 6). Taking this approach allows many of the practical requirements of coatings to be achieved, i.e. ambient application and corrosion resistance prior to thermal cure, ability to temperature cycle and maintain corrosion resistance. It has been interesting to observe that considerable difference in performance can be observed between red iron oxide pigmentation and titanium dioxide, with the former showing better general performance.