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Control of Corrosion under Thermal Insulation and Fireproofing Materials—A Systems Approach

ABSTRACT

Provides current technology and industry practices for mitigating corrosion under thermal insulation and fireproofing materials. Adopts a systems approach. Contains sections on corrosion mechanisms, mechanical design, protective coatings, insulation materials, and inspection and maintenance.

KEYWORDS

carbon steels, coatings, corrosion control, fireproofing materials, insulation, protective coatings, steels, thermal insulation, TG 325.

Foreword

In NACE standards, the terms shall, must, should, and may are used in accordance with the definitions of these terms in the* NACE Publications Style Manual. *The terms shall and must are used to state a requirement, and are considered mandatory. The term should is used to state something good and is recommended, but is not considered mandatory. The term may is used to state something considered optional.

This NACE standard practice provides the current technology and industry practices for mitigating corrosion under thermal insulation and fireproofing materials, a problem termed corrosion under insulation (CUI) in this standard. Because this corrosion problem has many facets and impacts several technologies, a systems approach has been adopted. This standard is intended for use by corrosion-control personnel and others concerned with corrosion under insulation and/or fireproofing of equipment.

This standard is organized into sections by function. Each section was written by specialists in that subject. These specialists are industry representatives from firms producing, specifying, designing, and/or using thermal insulation and fireproofing products on refinery and petrochemical equipment.

This standard was originally prepared in 1998 by NACE Work Group T-5A-30a, "Corrosion Protection Under Insulation," with the assistance of Task Group (TG) T-6H-31, "Coatings for Carbon and Austenitic Stainless Steel Under Insulation," and ASTM[1] Committee C16.40.3, "Corrosion Under Insulation." Work Group T-5A-30a supported NACE TG T-5A-30, "Corrosion Under Thermal Insulation," a component of NACE Unit Committee T-5A, "Corrosion in Chemical Processes." The standard was reaffirmed in 2004 by Specific Technology Group (STG) 36, "Process Industry: Materials Performance in Chemicals." It was revised in 2010 by TG 325, "CUI: Revision of NACE Standard RP0198, The Control of Corrosion under Thermal Insulation and Fireproofing Materials—A Systems Approach," with the assistance of Technology Exchange Group (TEG) 255X, "Coatings, Thermal-Spray for Corrosion Protection." It was reaffirmed in 2016 and revised in 2017 by TG 325, "CUI: Revision of NACE SP0198 (formerly RP0198), "The Control of Corrosion under Thermal Insulation and Fireproofing Materials—A Systems Approach." TG 325 is administered by STG 36 and sponsored by STG 03, "Coatings and Linings, Protective—Immersion and Buried Service," and STG 04, "Coatings and Linings, Protective—Surface Preparation." This standard is issued by NACE International under the auspices of STG 36.

[1] ASTM International (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

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Figures and Tables

Section 1: General

1.1 Corrosion under insulation (CUI) has been occurring for as long as hot or cold equipment has been insulated for thermal protection, energy conservation, or process stabilization. The destructive results and nature of the corrosion mechanism were not mentioned in the literature until the 1950s. As more problems have been experienced, concern and interest have built around this subject. Many articles and symposium papers have been published since 1983 as interest and activity in CUI have increased. The increased activity was driven largely by many occurrences of severe CUI resulting in major equipment outages, production losses, and unexpected maintenance costs in refineries, gas plants, and chemical plants.

1.2 To correct these problems, companies have developed their own criteria and approaches to the prevention of CUI. When comparing the various approaches, it is evident that there are many similarities, some differences, some new ideas, and some old ideas that have stood the test of performance. This standard incorporates the experience of many companies throughout the oil, gas, and chemical industries.

1.3 The first ASTM standard relevant to CUI was ASTM C692,[1] adopted in 1971 and originally titled "Evaluating the Influence of Wicking Type Thermal Insulations on the Stress Corrosion Cracking Tendency of Austenitic Stainless Steels."

1.4 A symposium was held jointly by NACE, ASTM, and Materials Technology Institute (MTI)[(2)] on this subject with speakers from industries worldwide in October 1983. The papers were published in 1985 as ASTM Publication STP 880.[2]

1.5 The first NACE state-of-the-art report on CUI was written in 1989 by Task Group T-6H-31 and issued as NACE Publication 6H189.[3] NACE Task Group T-5A-30 was organized shortly thereafter to serve as a forum for further discussion regarding CUI. In addition to reviews of the corrosion mechanisms, perspectives on such CUI topics as methods for mitigation, insulation materials, and inspection were often exchanged. While corrosion engineers were becoming knowledgeable about CUI, ASTM Committee C16 on Thermal Insulation was preparing standards for testing insulation with a propensity to cause chloride stress corrosion cracking (SCC) of austenitic stainless steel. These two groups interacted but proceeded to develop their standards and information separately.

1.6 In this standard, the term equipment includes all objects in a facility with external metal surfaces that are insulated or fireproofed and subject to corrosion.

1.7 In previous editions of this standard, carbon steel and austenitic stainless steels were the primary metals addressed. Because of their increased usage in applications where CUI is a concern, duplex stainless steels have been more explicitly addressed in this revision.

1.8 Although most of the attention has been focused on corrosion under thermal insulation, fireproofing materials also function, at least in part, as insulation applied to protect equipment during a potential fire. Other fire protection mechanisms initiated as endothermic reactions within the fireproofing material during a fire are not covered in this standard. Corrosion mechanisms, the root cause of failure, and corrosion prevention may be the same for corrosion under fireproofing as for corrosion under insulation.

[(2)] Materials Technology Institute (MTI), 1215 Fern Ridge Parkway, Suite 206, St. Louis, MO 63141-4405.

1.9 Whenever CUI is a consideration, a protective coating or coating system should be applied to the equipment before it is insulated. Protective coatings or coating systems may have service lives that are shorter than the anticipated operational life of the equipment, and thus may require inspection and maintenance to effectively maintain integrity and to minimize the threat of CUI.

1.10 This standard practice may not be applicable to insulation with coating or another insulation layer that is directly bonded to the steel substrate. In such applications, CUI conditions are eliminated.

Section 2: Corrosion Mechanisms

2.1 Carbon Steel

Carbon steel corrodes, not because it is insulated, but because it is contacted by aerated water. The role of insulation in the CUI problem is threefold. Insulation provides:

(a) An annular space or crevice for the retention of water and other corrosive media;
(b) A material that may wick or absorb water; and
(c) A material that may contribute contaminants that increase the corrosion rate.

The corrosion rate of carbon steel may vary because the rate is controlled largely by the metal temperature of the steel surface and contaminants present in the water. These factors and others are reviewed below.

2.1.1 Effects of Water, Contaminants, and Temperature

2.1.1.1 Sources of Water Under Insulation

The two primary water sources involved in CUI of carbon steel are:

(a) Infiltration from external sources; and
(b) Condensation.

Water infiltrates from such external sources as the following:

(a) Rainfall;
(b) Drift from cooling towers;
(c) Condensate falling from cold service equipment;
(d) Steam discharge;
(e) Process liquids spillage;
(f) Spray from fire sprinklers, deluge systems, and washdowns;
(g) Groundwater; and
(h) Condensation on cold surfaces after vapor barrier damage.

External water enters an insulated system primarily through breaks in the weatherproofing. The weatherproofing breaks may be the result of inadequate design, incorrect installation, mechanical abuse, or poor maintenance practices.

Condensation results when the temperature of the metal surface is lower than the atmospheric dew point. Although infiltration of external water can be reduced and sometimes prevented, insulation systems cannot be made vapor tight, so condensation as a water source must be recognized in the design of the insulation system.