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Item No. 21305

Standard Material Requirements

Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments

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Foreword

This NACE standard establishes material requirements for resistance to sulfide stress cracking (SSC) in sour refinery process environments, i.e., environments that contain wet hydrogen sulfide (H_2S). It is intended to be used by refineries, equipment manufacturers, engineering contractors, and construction contractors.

The term "wet H_2S cracking" as used in the refining industry covers a range of damage mechanisms that can occur because of the effects of hydrogen charging in wet H_2S refinery or gas plant process environments. One of the types of material damage that can occur as a result of hydrogen charging is SSC of hard weldments and microstructures, which is addressed by this standard. Other types of material damage include hydrogen blistering, hydrogen-induced cracking (HIC), and stress-oriented hydrogen-induced cracking (SOHIC), which are not addressed by this standard.

Historically many end users, industry organizations (e.g., API[(1)]), and manufacturers that have specified and supplied equipment and products such as rotating equipment and valves to the refining industry have used NACE MR0175/ISO[(2)]15156[1] to establish materials requirements to prevent SSC. However, it has always been recognized that refining environments are outside the scope of NACE MR0175/ISO 15156, which was developed specifically for the oil and gas production industry. In 2000, NACE Task Group (TG) 231 was formed to develop a refinery-specific sour service materials standard. This standard is based on the good experience gained with NACE MR0175/ISO 15156, but tailored to refinery environments and applications. Other references for this standard are NACE SP0296,[2] NACE Publication 8X194,[3] NACE Publication 8X294,[4] and the refining experience of the task group members.

The materials, heat treatments, and materials property requirements set forth in this standard represent the best judgment and experience of TG 231 and its two sponsors, Specific Technology Group (STG) 34, "Petroleum Refining and Gas Processing Industry Corrosion," and STG 60, "Corrosion Mechanisms." In many cases this judgment is based on extensive experience in the oil and gas production industry, as documented in NACE MR0175/ISO 15156, and has been deemed relevant to the refining industry by the task group.

(1) American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005-4070.
(2) International Organization for Standardization (ISO), 1 ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

Whenever possible, the recommended materials are identified by accepted generic descriptors (such as UNS[3] numbers) and/or accepted standards, such as AISI,[4] API, ASTM,[5] ASME,[6] ANSI,[7] or BSI[8] standards. This NACE standard updates and supersedes all previous editions of NACE Standard MR0103. It was originally prepared in 2003 and was revised in 2005, 2007, 2010, and 2012 by NACE TG 231, "Petroleum Refining Sulfide Stress Cracking (SSC): Review of NACE Standard MR0103." TG 231 is administered by STG 34, "Petroleum Refining and Gas Processing." It is also sponsored by STG 60, "Corrosion Mechanisms." This standard is issued by NACE International under the auspices of STG 34.

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.

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[3] Unified Numbering System for Metals and Alloys (UNS). UNS numbers are listed in *Metals & Alloys in the Unified Numbering System*, latest revision (Warrendale, PA: SAE International and West Conshohocken, PA: ASTM International).
[4] American Iron and Steel Institute (AISI), 1140 Connecticut Ave. NW, Washington, DC 20036.
[5] ASTM International (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.
[6] ASME International (ASME), Three Park Avenue, New York, NY 10016-5990.
[7] American National Standards Institute (ANSI), 25 West 43rd St., 4th Floor, New York, NY 10036.
[8] BSI British Standards (BSI) (formerly British Standards Institution), 389 Chiswick High Road., London W4 4AL, U.K.

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Section 1: General

1.1 Scope

1.1.1 This standard establishes material requirements for resistance to SSC in sour petroleum refining and related processing environments containing H_2S either as a gas or dissolved in an aqueous (liquid water) phase with or without the presence of hydrocarbon. This standard does not include and is not intended to include design specifications. Other forms of wet H_2S cracking, environmental cracking, corrosion, and other modes of failure, although outside the scope of this standard, should be considered in the design and operation of equipment. Severely corrosive and/or hydrogen charging conditions may lead to failures by mechanisms other than SSC and should be mitigated by methods that are outside the scope of this standard.

1.1.2 Specifically, this standard is directed at the prevention of SSC of equipment (including pressure vessels, heat exchangers, piping, valve bodies, and pump and compressor cases) and components used in the refining industry. Prevention of SSC in carbon steel materials categorized under P-No. 1 in Section IX of the ASME Boiler and Pressure Vessel Code (BPVC)[5] is addressed by requiring compliance with NACE SP0472.[6]

Note: There are a number of instances in which this standard specifically references the ASME BPVC. This reference is based on historical development of the standard, but is not intended to preclude the use of other pertinent codes and standards where they are appropriate.

1.2 Applicability

1.2.1 This standard applies to all components of equipment exposed to sour refinery environments (see Paragraph 1.3) where failure by SSC would (1) compromise the integrity of the pressure-containment system, (2) prevent the basic function of the equipment, and/or (3) prevent the equipment from being restored to an operating condition while continuing to contain pressure.

1.2.2 It is the responsibility of the user to determine the operating conditions and to specify when this standard applies.

1.2.3 It is the user's responsibility to ensure that a material will be satisfactory in the intended environment. The user may select specific materials for use on the basis of operating conditions that include pressure, temperature, corrosiveness, and fluid properties. A variety of candidate materials may be selected from this standard for any given component. Unlisted materials may also be used based on either of the following processes:

(a) If a metallurgical review based on scientific and empirical knowledge indicates that the SSC resistance will be adequate. These materials may then be proposed for inclusion into the standard using methods in Paragraph 1.6.

(b) If a risk-based analysis indicates that the occurrence of SSC is acceptable in the subject application.

1.2.4 The manufacturer is responsible for meeting metallurgical requirements.

1.3 Factors Contributing to SSC

1.3.1 SSC is defined as cracking of a metal under the combined action of tensile stress and corrosion in the presence of water and H_2S. SSC is a form of hydrogen stress cracking resulting from absorption of atomic hydrogen that is produced by the sulfide corrosion reaction on the metal surface.

1.3.2 SSC in refining equipment is affected by complex interactions of parameters including:

(a) chemical composition, strength (as indicated by hardness), heat treatment, and microstructure of the material exposed to the sour environment;

(b) total tensile stress present in the material (applied plus residual);

(c) the hydrogen flux generated in the material, which is a function of the environment (i.e., presence of an aqueous phase, H_2S concentration, pH, and other environmental parameters such as bisulfide ion concentration and presence of free cyanides);