NACE Standard MR0103-2007
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 defines 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 utilized 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 due to 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 sulfide stress cracking (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 15156[1] to define materials requirements to prevent SSC. However, it has always been recognized that refining environments are outside the scope of 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 the MR0175/ISO 15156 standard, but tailored to refinery environments and applications. Other references for this standard are NACE Standard RP0296,[2] NACE Publications 8X194[3] and 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 MR0175/ISO 15156, and has been deemed relevant to the refining industry by the task group.

Whenever possible, the recommended materials are defined by reference to accepted generic descriptors (such as UNS(2) numbers) and/or accepted standards, such as AISI,(3) API, ASTM,(4) ASME,(5) ANSI,(6) or BSI(7) standards. This NACE standard updates and supersedes all previous editions of MR0103. It was originally prepared in 2003 and was revised in 2005 and 2007 by NACE Task Group (TG) 231 on Petroleum Refining Sulfide Stress Cracking (SSC): Review of NACE Standard MR0103. TG 231 is administered by STG 34 on Petroleum Refining and Gas Processing. It is also sponsored by STG 60 on 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*, 4th ed., Paragraph 7.4.1.9. *Shall* and *must* are used to state mandatory requirements. The term *should* is used to state something good and is recommended but is not mandatory. The term *may* is used to state something considered optional.

(1) American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005.
(2) Metals and Alloys in the Unified Numbering System (latest revision), a joint publication of ASTM International (ASTM) and the Society of Automotive Engineers Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096.
(3) American Iron and Steel Institute (AISI), 1133 15th St. NW, Washington, DC 20005-2701.
(4) ASTM International (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.
(5) ASME International (ASME), Three Park Avenue, New York, NY 10016-5990.
(6) American National Standards Institute (ANSI), 1819 L Street, NW, Washington, DC 20036.
(7) British Standards Institution (BSI), 2 Park St., London W1A 2BS, U.K.

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Contents

Section 1: General

1.1 Scope

1.1.1 This standard defines 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 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[5] is addressed by requiring compliance with NACE Standard RP0472.[6]

1.2 Applicability

1.2.1 This standard applies to all components of equipment exposed to sour refinery environments (as defined in 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, fluid properties, etc. A variety of candidate materials may be selected from this standard for any given component. Nonlisted 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 utilizing 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);

(d) temperature; and

(e) time.

1.3.3 Material susceptibility to SSC is primarily related to material strength (as indicated by hardness), which is affected by chemical composition, heat treatment, and microstructure. Materials with high hardness generally have an increased susceptibility to SSC.

1.3.3.1 SSC has not generally been a concern for carbon steels typically used for refinery pressure vessels and piping in wet H_2S service because these steels have sufficiently low hardness levels. However, improperly heat-treated materials, weld deposits, and heat-affected zones (HAZs) may contain regions of high hardness.

1.3.4 SSC susceptibility for a given material increases with increased tensile stress.

1.3.4.1 Residual stresses contribute to the overall tensile stress level. High residual stresses associated with welds increase susceptibility to SSC.