

Introductory Handbook for

NACE

MR0175/ISO 15156

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Introductory Handbook for NACE MR0175/ISO 15156

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NACE International
The Worldwide Corrosion Authority

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Introductory Handbook for NACE MR0175/ISO 15156

The ANSI/NACE MR0175/ISO 15156 standard¹ provides guidance for the selection of cracking resistant metallic materials for service in aqueous oil and gas production environments containing H₂S.

This introductory handbook places the standard in the context of the corrosion science and the forms of cracking that led to its development. It also describes the make-up of the standard, how to use it, the user support mechanisms, and documents that are available. An introduction to the laboratory tests that, if required, can be used to confirm cracking resistance of metallic materials in oil and gas environments is also included.

1 Corrosion of Metals in Aqueous Environments

1.1 Common Corrosion Mechanisms in Oil and Gas Production

Corrosion of metals in oil and gas production environments is electrochemical in nature.

The four components of this type of corrosion are shown Fig. 1 below.

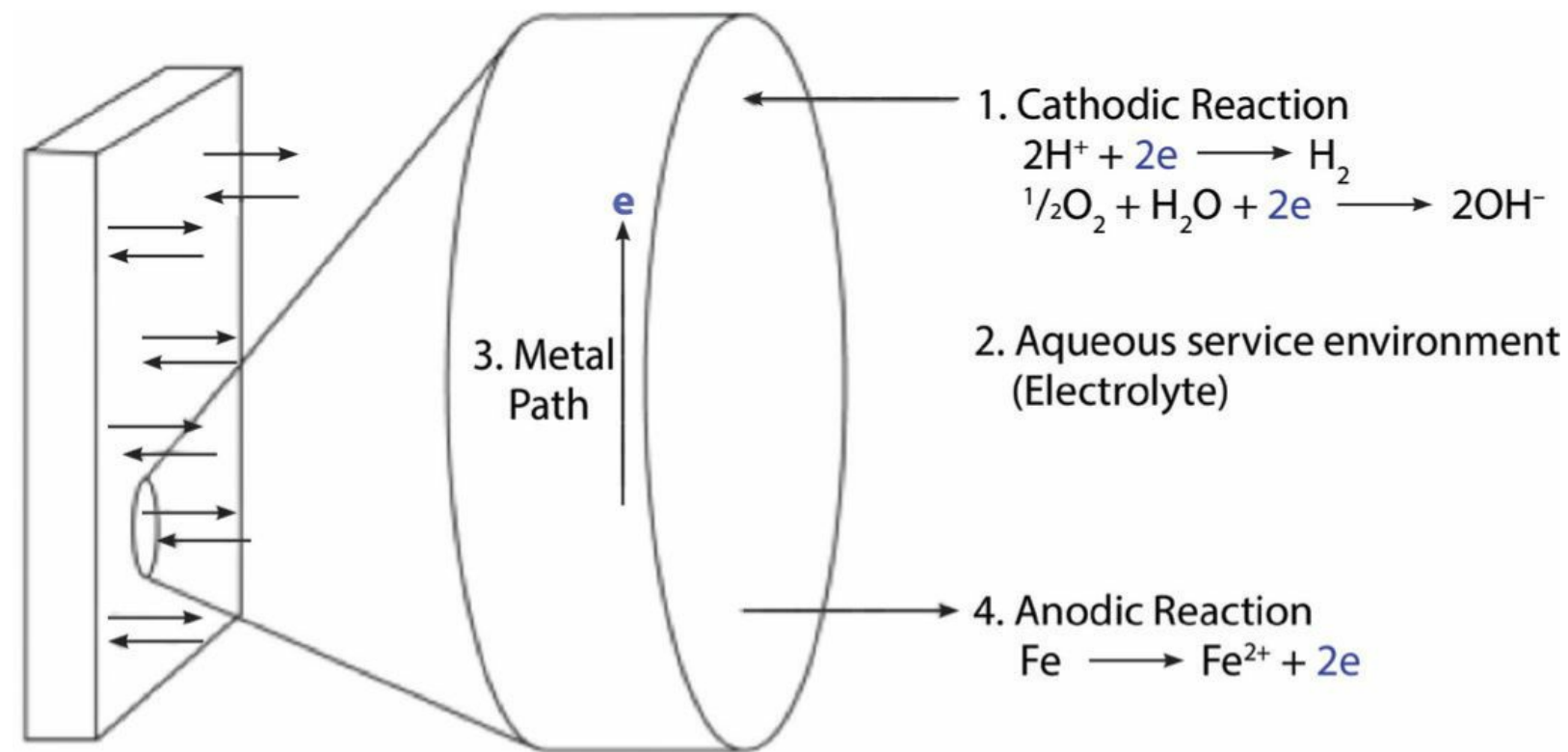


Fig. 1 Components of the electrochemical corrosion process in aqueous service environments.

The corrosion process involves an anodic reaction giving metal loss to the electrolyte in the form of metal ions and releasing electrons to the corroding surface, for example:



This reaction is electrically in balance with a cathodic reaction that takes up these electrons from the corroding surface; the most common cathodic corrosion reactions in oil and gas production are:



...where the H^+ comes from “acid” gases commonly dissolved in the aqueous service environments found in oil and gas production:



...or

An oxygen type reaction: $\frac{1}{2}\text{O}_2 + \text{H}_2\text{O} + 2e = 2\text{OH}^-$

...where oxygen comes from the atmosphere and is a common cause of external rather than internal attack in oil and gas installations.

1.2 H₂S Corrosion

The gases associated with oil and gas production often contain CO₂ and H₂S at significant partial pressures; these gases together, when dissolved in an aqueous service environment, can lead to a relatively low pH that promotes the “acid” type cathodic reactions described above.

Such reactions lead to the formation of hydrogen atoms at the metal surface. In the presence of H₂S there is a greater tendency for these hydrogen atoms to be absorbed by the metal rather than to combine into hydrogen molecules and be lost from the metal surface as gas.

Anodic and cathodic reactions take place on different surfaces, such as in galvanic cells between carbon and stainless steels. While corrosion takes place on the carbon steel, the hydrogen discharge/absorption processes occur on the stainless steel.

The presence of absorbed hydrogen is often a factor in the cracking of metals associated with sour service.

2 What is Sour Service?

“Sour service” in this context is a level of H₂S in oil and gas production environments that could cause cracking of metallic materials.

The definition of sour service used in the standard is: **“Exposure to oilfield environments that contain sufficient H₂S to cause cracking of materials by the mechanisms addressed by NACE MR0175/ISO 15156.”**

This definition addresses both the sensitivity of all metallic materials, including carbon and low-alloy steels, and corrosion-resistant alloys and other alloys to all forms of stress-related cracking. It also encompasses other H₂S-related cracking mechanisms.

The definition in bold above is applied in all parts of the standard.

The original definition of sour service (as used in earlier editions of NACE MR0175²) was a level of H₂S equivalent to a partial pressure ($p_{\text{H}_2\text{S}}$) in the gas phase of $p_{\text{H}_2\text{S}} \geq 0.3$ kPa (0.05 psi). This level of H₂S can, in many cases, still be appropriate for carbon and low-alloy steels with respect to sulfide stress cracking (SSC, see below).

3 Forms of H₂S-Related Cracking

3.1 Historical Perspective

Cracking of metals associated with their exposure to H₂S was first reported in 1952. This ultimately led to the publication of the first edition of NACE MR0175 in 1975, which addressed the specification of carbon and low-alloy steels to avoid the occurrence of sulfide stress cracking in sour service. Since that time, the standard has developed to include corrosion-resistant alloys, other alloys, and other forms of cracking associated with H₂S.

The forms of H₂S-related cracking addressed by the standard are described and illustrated below:

Note: The definitions of the individual forms of cracking, shown in the bold text immediately below the sub-section titles, are those applied in ANSI/NACE MR0175/ISO 15156.

3.2 Hydrogen Stress Cracking (HSC)

Cracking that results from the presence of hydrogen in a metal and tensile stress (residual and/or applied).

This form of cracking plays a role in several of the mechanisms described below.

3.3 Sulfide Stress Cracking (SSC)

Cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H₂S.