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Detection, Testing, and Evaluation of Microbiologically Influenced Corrosion (MIC) on External Surfaces of Buried Pipelines

ABSTRACT

This standard describes types of microorganisms, mechanisms by which MIC occurs, methods of testing for the presence of bacteria, research results, and interpretation of testing results for external surfaces of buried, ferrous-based metal pipelines and related components. Appendixes are included for media specifications (nonmandatory Appendix A), dilution procedures (nonmandatory Appendix B), and site inspection and testing (nonmandatory Appendix C). This standard is maintained Task Group 237.

KEYWORDS

MIC, microorganisms, sampling, MMM, biofilm, bacteria, Archaea

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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, 4th ed., Paragraph 7.4.1.9. Shall and must are used to state mandatory requirements. The term should is used to state something considered good and is recommended but is not mandatory. The term may is used to state something considered optional.

Microbiologically influenced corrosion (MIC) is corrosion caused by the presence or activity (or both) of microorganisms in biofilms on the surface of the corroding material. Many materials, including most metals and some nonmetals, can be degraded in this manner. Microbiologically mediated reactions can alter both rates and types of electrochemical reactions in a corrosion cell. These reactions influence pitting, crevice corrosion, differential aeration cells, concentration cells, dealloying, and galvanic corrosion. Therefore, MIC investigations require microbiological, chemical, and metallurgical testing for proper diagnosis. The conclusion that MIC has taken place should be based on the preponderance of circumstantial evidence. Microorganisms are often resistant to many control methods and can be a serious external corrosion threat to pipelines.

This NACE standard test method applies to the external surfaces of ferrous-based metal pipeline facilities and describes types of microorganisms, mechanisms by which MIC occurs, methods for sampling, and testing for the presence of microorganisms, research results, and interpretation of testing results. Sections 1 through 4 of this standard discuss the technical aspects of MIC. Sections 5 through 7 discuss field equipment and testing procedures.

This standard is intended for use by pipeline operators, pipeline service providers, government agencies, and any other persons or companies involved in planning or managing pipeline integrity. Portions of Sections 3 and 4 of this standard are excerpted from Peabody's Control of Pipeline Corrosion, Chapter 14—"Microbiologically Influenced Corrosion,"1 and enclosed in quotation marks.

This standard was prepared by Task Group (TG) 237, "Microbiologically Influenced Corrosion on External Surfaces of Buried Pipelines: Detection, Testing, and Evaluation—Standard." It was revised in 2015 by TG 237. TG 237 is administered by Specific Technology Group (STG) 35, "Pipelines, Tanks, and Well Casings," and is sponsored by STG 60, "Corrosion Mechanisms." This standard is issued by NACE International under the auspices of STG 35.

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Figures

Section 1: General

1.1 While the evaluation, monitoring, and mitigation of MIC cannot be prescribed in one particular manner for any given pipeline, this standard describes methodologies by which the appropriate tools and techniques may be selected and practically applied to external surfaces of buried, ferrous-based metal pipelines and related components. The methods presented in this standard represent the general consensus of industry experts in pipeline corrosion and microbiology at the time this standard was published.

1.2 Appendix A (Nonmandatory) provides a site inspection and testing checklist.

1.3 All applicable safety and environmental codes, rules, and regulations must be followed when using this standard.

1.4 The term “pipeline” as used in this standard generally refers to any pipe or component of a pipeline system for which the mechanism of external MIC is of interest to the user of this standard.

Section 2: Definitions

Abiotic: The absence of living organisms, their biological components, or the metabolic activities of living organisms.

Acid-producing bacteria (APB): Aerobic or anaerobic bacteria that produce organic acids as an end product of their metabolism. A few organisms (e.g., Thiobacillus) are also capable of producing mineral acids (typically under aerobic conditions).

Aeration: (1) Exposing to the action of air. (2) Causing air to bubble through. (3) Introducing air into a solution by spraying, stirring, or similar method. (4) Supplying or infusing with air, as in sand or soil. (5) The introduction of air into the pulp in a flotation cell to form air bubbles.

Aerobic: Containing air or free molecular oxygen.

Aerobic microorganism (aerobe): A microorganism that uses oxygen as the final electron acceptor in metabolism.

Anaerobic microorganism (anaerobe) bacteria: A microorganism that does not require oxygen for metabolism.

Archaea: Unicellular microorganisms that are genetically distinct from bacteria and eukaryotes, which often inhabit extreme environmental conditions. *Archaea* include halophiles (microorganisms that may inhabit extremely salty environments), methanogens (microorganisms that produce methane), and thermophiles (microorganisms that can thrive in extremely hot environments). *Archaeoglobus* is a common *Archaea*.

Archaeoglobus: Microorganisms that grow at high temperatures between 60 and 95 °C (140 and 203 °F), with optimal growth at 83 °C (181°F) (ssp. *A. fulgidus* VC-16).2 They are sulfate-reducing *archaea*, coupling the reduction of sulfate to sulfide with the oxidation of many different organic carbon sources, including complex polymers. *Archaeoglobus* species have been isolated from oil reservoirs and production systems; however, this group of microorganisms is normally not measured with current culturing techniques.

Autoclave: A pressurized, steam-heated vessel used for sterilization.