

Wet Gas Internal Corrosion Direct Assessment Methodology for Pipelines

This NACE International standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this NACE standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by letters patent, or as indemnifying or protecting anyone against liability for infringement of letters patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. NACE assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official NACE interpretations issued by NACE in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

Users of this NACE standard are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this standard prior to its use. This NACE standard may not necessarily address all potential health and safety problems or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this standard. Users of this NACE standard are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this standard.

CAUTIONARY NOTICE: NACE standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with NACE technical committee procedures. NACE requires that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of NACE standards may receive current information on all standards and other NACE publications by contacting the NACE *FirstService* Department, 15835 Park Ten Place, Houston, Texas 77084-5145 (telephone +1 281-228-6200).

ABSTRACT

This standard practice formalizes a methodology to assess internal corrosion for on-shore and offshore pipelines and other piping systems that normally carry natural gas with condensed water, or with water and liquid hydrocarbons, termed wet gas internal corrosion direct assessment (WG-ICDA). This standard is maintained by Task Group 305.

KEYWORDS

Pipelines, wet gas, internal corrosion, direct assessment

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 standard practice formalizes a methodology to assess internal corrosion for on-shore and offshore pipelines and other piping systems that normally carry natural gas with condensed water, or with water and liquid hydrocarbons, termed *wet gas internal corrosion direct assessment* (WG-ICDA). This standard is intended for use by gas pipeline operators/gas producers and others who manage gas pipeline integrity (both on-shore and offshore) in which pipelines are normally under wet loading conditions and are beyond the application of NACE SP0206¹ and NACE SP0208.²

The WG-ICDA methodology has been developed to meet the needs of gas pipeline operator/gas producers to assess the integrity of pipelines with respect to internal corrosion. WG-ICDA is a structured process that combines pre-assessment, indirect inspection, detailed examination, and post-assessment steps to evaluate the effect of predictable pipeline integrity threats such as internal corrosion. Specifically, the goal of WG-ICDA is to identify locations with the greatest likelihood of internal corrosion. These locations are exposed and examined in accordance with criteria established in Section 4. The results of these detailed examinations are used as a basis for assessing the condition and integrity of the remainder of the pipeline segment (with less likelihood of corrosion). WG-ICDA does not depend on the ability of a pipeline to undergo in-line inspection (ILI) or pressure testing, making it most valuable to those pipeline segments unable to accept pigs or that cannot be hydrostatically tested. This standard is intended to be a stand-alone assessment methodology for internal corrosion in lieu of ILI analyses; however, the WG-ICDA methodology may also serve or assist those cases in which ILI may have been performed or is contemplated to demonstrate the reliability of the WG-ICDA process. It may also be used for optimizing the selection/justification or prioritization of pipelines that are subjected to ILI.

In wet gas systems, subregions of a pipeline that are identified within a region that are more susceptible to internal corrosion depend on the flow pattern that are defined by flow velocities, sudden changes of pipeline geometries, changes in elevation that may be caused by the topography of the terrain, sharp elbows, expansions, changes in internal diameter and other changes that influence the hydrodynamics of the flow. Multiphase flow and flow regimes can be determined by the use of flow models. The flow model must have the thermodynamic calculations to determine the multiphase envelope (gas, water and liquid hydrocarbon), and the interaction between the gas and liquid phase, and allow the prediction under flowing conditions that shows local temperature, pressure, and fluid composition for a pipeline. Depending on the flow (i.e., velocity, gas/liquid quality, temperature, pressure, wall surface conditions, etc.), and specific operating conditions, the effects of flow regimes must be considered. Flow regimes and flow hydrodynamic characteristics influence the threat of internal corrosion, and thus affect pipeline integrity.

WG-ICDA process identifies confirmatory or most probable locations (MPLs) along a WG-ICDA region to determine the position of assessment sites. These assessment sites are selected where internal corrosion damage has the highest likelihood that has been identified by means of integrating available historical information in combination with the use of flow models to determine: liquid holdups, flow regimes (e.g., stratified, slug, annular, or annular/mist but other flow regimes may also exist and must be considered) and predict or calculate internal corrosion rates by means of internal corrosion prediction models (ICPMs) that a pipeline operator/gas producer deems appropriate for its specific application to predict or calculate internal corrosion rates or selecting models using NACE Committee Report 21410. The essential focus is the discrimination of conditions along the length of a WG-ICDA region so that possible local WG-ICDA pipeline subregion integrity threats are identified for prioritized damage assessment, and mitigation.

This standard was prepared by Task Group (TG) 305, "Internal Corrosion Direct Assessment for Wet Gas Pipelines." TG 305 is administered by Specific Technology Group (STG) 35, "Pipelines, Tanks, and Well Casings." This standard is issued by NACE International under the auspices of STG 35.

Wet Gas Internal Corrosion Direct Assessment Methodology for Pipelines

1.	General	6
2.	Definitions	13
3.	Step 1—Pre-Assessment.....	16
4.	Step 2—Indirect Inspection	19
5.	Step 3—Detailed Examination	26
6.	Step 4—Post-Assessment	29
7.	Records.....	30
	References.....	32
	Appendix A Factors Influencing Corrosion Severity (Nonmandatory)	36
	Appendix B Internal Corrosion Prediction Models (Nonmandatory)	40
	Appendix C Examples of WG-ICDA Region and Subregion Identification, and Assessment Site Selection (Nonmandatory)	42

Figures

1:	Figure 1: Pre-Assessment Step	9
2:	Figure 2: Indirect Examination Step.....	10
3:	Figure 3: Direct Examination Step	11
4:	Figure 4: Post-Assessment Step.....	12
5:	Figure 5: Indirect Inspection Approaches for Predicting Corrosion Rates.....	20
C1:	Figure C1: WG-ICDA Region Identification for an Idealized Example	42
C2:	Figure C2: Example of a Flow Pattern Map	43
C3:	Figure C3: WG-ICDA Subregion Identification Example	44
C4:	Figure C4: Graphical Representation of the Example Pipeline Segment Showing Elevation Profile, Liquid Holdup, and WG-ICDA Regions Identified (1 ft = 0.3 m)	44
C5:	Figure C5: Graphical Representation of WG-ICDA Subregions Identified within WG-ICDA Region	45

Tables

1:	Typical Data for Use of WG-ICDA Methodology	17
2:	Minimum Number of Final Assessment Sites.....	24
3:	Final Assessment Site Selection	26
C1:	Summary Table for WG-ICDA Region 1 and Its Subregions.....	47
C2:	Final Assessment Site Selection	53

Section 1: General

1.1 Introduction

1.1.1 This standard covers the NACE internal corrosion direct assessment (ICDA) process for wet natural gas pipeline systems (i.e., WG-ICDA). It is intended to serve as a guide for applying the WG-ICDA process to onshore and offshore natural gas pipeline system that:

- (a) Contains saturated wet gas as demonstrated on a water dew point curve for that specific gas composition after verifying both the gas moisture content and its associated water holding capacity; or,
- (b) Contains free water; or,
- (c) Operates below the water dew point or a gas pipeline which transitions through its water dew point; or,
- (d) Is not covered by dry gas internal corrosion direct assessment (DG-ICDA); and,
- (e) Meets the feasibility requirements described in Paragraph 3.4 of this standard.

1.1.2 The three primary purposes of the WG-ICDA process are to (1) to identify the susceptible locations in onshore and offshore pipelines where internal corrosion is likely to occur (2) assess the integrity of a pipeline because of internal corrosion and (3) determine the frequency of pipeline integrity assessment.

1.1.3 The WG-ICDA process assesses how the internal corrosion severity is distributed along the subregion. The methodology includes methods of examination available to a pipeline operator/gas producer to determine the occurrence, extent, and severity of internal corrosion.

1.1.4 WG-ICDA also provides a framework for the use of multiphase (bulk, wet gas, water and condensate) flow modeling results (e.g., flow velocities, temperature and pressure profiles, liquid hold-up, and flow patterns) in understanding the hydrodynamics of the flow along this pipeline segment and aids in understanding how these variables can affect internal corrosion.

1.1.5 One benefit of the WG-ICDA process is that, for gas pipelines, an assessment can be performed on a pipeline segment for which alternative methods (e.g. ILI, hydrostatic testing) may be impractical.

1.1.6 The WG-ICDA process has limitations, and not all pipelines can be successfully assessed with WG-ICDA. These limitations are dependent on the specifics of the feasibility assessment of each pipeline segment and shall be identified in the pre-assessment step.

1.1.7 Drips, compressor stations, vessels, separators and other equipment unrelated to gas pipeline systems are not included in this standard.