



Standard Guide for Determining Corrosivity of Crude Oils¹

This standard is issued under the fixed designation G205; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide presents some generally accepted laboratory methodologies that are used for determining the corrosivity of crude oil.

1.2 This guide does not cover detailed calculations and methods, but rather a range of approaches that have found application in evaluating the corrosivity of crude oil.

1.3 Only those methodologies that have found wide acceptance in crude oil corrosivity evaluation are considered in this guide.

1.4 This guide does not address the change in oil/water ratio caused by accumulation of water at low points in a pipeline system.

1.5 This guide is intended to assist in the selection of methodologies that can be used for determining the corrosivity of crude oil under conditions in which water is present in the liquid state (typically up to 100°C). These conditions normally occur during oil and gas production, storage, and transportation in the pipelines.

1.6 This guide does not cover the evaluation of corrosivity of crude oil at higher temperatures (typically above 300°C) that occur during refining crude oil in refineries.

1.7 This guide involves the use of electrical currents in the presence of flammable liquids. Awareness of fire safety is critical for the safe use of this guide.

1.8 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appro-*

priate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:²

D96 Test Method for Water and Sediment in Crude Oil by Centrifuge Method (Field Procedure) (Withdrawn 2000)³

D473 Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method

D665 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

D724 Test Method for Surface Wettability of Paper (Angle-of-Contact Method) (Withdrawn 2009)³

D1125 Test Methods for Electrical Conductivity and Resistivity of Water

D1129 Terminology Relating to Water

D1141 Practice for the Preparation of Substitute Ocean Water

D1193 Specification for Reagent Water

D4006 Test Method for Water in Crude Oil by Distillation

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4377 Test Method for Water in Crude Oils by Potentiometric Karl Fischer Titration

G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

G31 Guide for Laboratory Immersion Corrosion Testing of Metals

G111 Guide for Corrosion Tests in High Temperature or High Pressure Environment, or Both

G170 Guide for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors in the Laboratory

G184 Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using Rotating Cage

¹ This guide is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

G193 Terminology and Acronyms Relating to Corrosion
G202 Test Method for Using Atmospheric Pressure Rotating Cage

2.2 *ISO Standard*.⁴

ISO 6614 Petroleum products—Determination of Water Separability of Petroleum Oils and Synthetic Fluids

2.3 *NACE Standard*.⁵

TM0172 Standard Test Method Determining Corrosive Properties of Cargoes in Petroleum Product Pipelines

3. Terminology

3.1 *Definitions*—The terminology used herein, if not specifically defined otherwise, shall be in accordance with Guide **G170**, Terminology and Acronyms **G193**, and Terminology **D1129**. Definitions provided herein and not given in Guide **G170**, Terminology and Acronyms **G193**, and Terminology **D1129** are limited only to this guide.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *emulsion, n*—two-phase immiscible liquid system in which one phase is dispersed as droplets in the other phase.

3.2.2 *emulsion-inversion point, n*—percentage of water at which a water-in-oil (W/O) emulsion converts into an oil-in-water (O/W) emulsion.

3.2.3 *wettability, n*—tendency of a liquid to wet or adhere on to a solid surface.

3.3 *Acronyms*:

CO ₂	= Carbon dioxide
EIP	= Emulsion inversion point
H ₂ S	= Hydrogen sulfide
KOH	= Potassium hydroxide
NaCl	= Sodium chloride
Na ₂ CO ₃	= Sodium carbonate
NaHCO ₃	= Sodium bicarbonate
NaOH	= Sodium hydroxide
Na ₂ S	= Sodium sulfide
O/W	= Oil-in-water
W/O	= Water-in-oil

4. Summary of Guide

4.1 This guide describes methods for determining the corrosivity of crude oils by a combination of three properties: (1) the emulsion of the oil and water, (2) the wettability of the steel surface, and (3) the corrosivity of water phase in the presence of oil.

4.2 Conductivity of emulsion can be used to determine the type of emulsion: oil in water (O/W) or water in oil (W/O). The conductivity of the O/W emulsion (in which water is the continuous phase) is high. The conductivity of the W/O emulsion (in which oil is the continuous phase) is low.

4.3 The wettability of a steel surface is determined using two methods: (1) contact angle method and (2) spreading method.

4.4 The corrosiveness of water phase in the presence of crude oil can be determined using several methods.

5. Significance and Use

5.1 In the absence of water, the crude oil is noncorrosive. The presence of sediment and water makes crude oil corrosive. Test Methods **D96**, **D473**, **D4006**, and **D4377** provide methods for the determination of the water and sediment content of crude oil.

5.2 The corrosivity of crude oil containing water can be determined by a combination of three properties (**Fig. 1**) **(1)**⁶: the type of emulsion formed between oil and water, the wettability of the steel surface, and the corrosivity of water phase in the presence of oil.

5.3 Water and oil are immiscible but, under certain conditions, they can form emulsion. There are two kinds of emulsion: O/W and W/O. W/O emulsion (in which oil is the continuous phase) has low conductivity and is thus less corrosive; whereas O/W (in which water is the continuous phase) has high conductivity and, hence, is corrosive (see ISO 6614) **(2)**. The conductivities of various liquids are provided in **Table 1** **(3)**. The percentage of water at which W/O converts to O/W is known as the emulsion inversion point (EIP). EIP can be determined by measuring the conductivity of the emulsion. At and above the EIP, a continuous phase of water or free water is present. Therefore, there is a potential for corrosion.

5.4 Whether water phase can cause corrosion in the presence of oil depends on whether the surface is oil wet (hydrophobic) or water wet (hydrophilic) **(4-8)**. Because of higher resistance, an oil-wet surface is not susceptible to corrosion, but a water-wet surface is. Wettability can be characterized by measuring the contact angle or the conductivity (spreading method).

5.4.1 In the contact angle method, the tendency of water to displace hydrocarbon from steel is measured directly by observing the behavior of the three phase system. The contact angle is determined by the surface tensions (surface free energies) of the three phases. A hydrocarbon-steel interface will be replaced by a water-steel interface if this action will result in an energy decrease of the system. To determine whether the surface is oil wet, mixed wet, or water wet, the angle at the oil-water-solid intersection is observed and measured.

5.4.2 In the spreading method of determining wettability, the resistance between steel pins is measured. If a conducting phase (for example, water) covers (wets) the distance between the pins, conductivity between them will be high. On the other hand, if a nonconducting phase (for example, oil) covers (wets) the distance between the pins, the conductivity between them will be low.

5.5 Dissolution of ingredients from crude oils may alter the corrosiveness of the aqueous phase. Based on how the corrosivity of the aqueous phase changes in its presence, a crude oil can be classified as corrosive, neutral, inhibitory, or preventive

⁴ Available from the American National Standards Institute, 25 W. 43rd St., New York, NY 10036.

⁵ Available from the National Association of Corrosion Engineers, 1440 S. Creek Dr., Houston, TX 77084-4906.

⁶ The boldface numbers in parentheses refer to a list of references at the end of this standard.

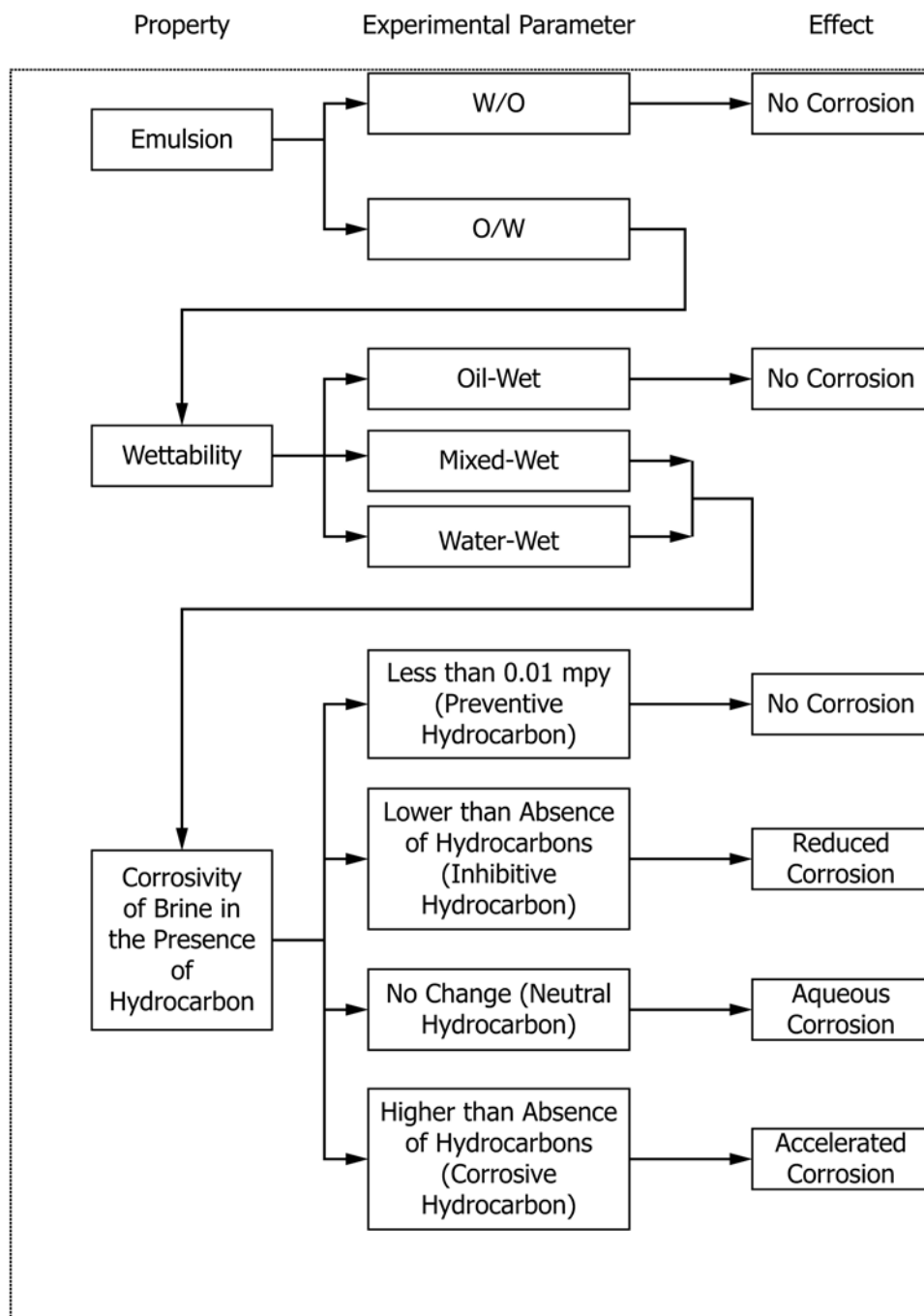


FIG. 1 Predicting Influence of Crude Oil on the Corrosivity of Aqueous Phase

crude. Corrosiveness of the aqueous phase in the presence of oil can be determined by methods described in Test Method D665, Guide G170, Practice G184, Test Method G202, and NACE TM0172.

6. Materials

6.1 Methods for preparing coupons and probes for tests and for removing coupons after the test are described in Practice

G1. Standard laboratory glassware should be used for weighing and measuring reagent volumes.

6.2 The coupons/probes should be made of the field material (such as carbon steel) and have the same metallographic structure as that used in the service components. The probes for wettability and EIP measurements should be ground to a