Designation: G205 – 26

Standard Guide for Determining Emulsion Properties, Wetting Behavior, and Corrosion-Inhibitory Properties of Crude Oils[1]

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 covers some generally accepted laboratory methodologies that are used for determining emulsion forming tendency, wetting behavior, and corrosion mitigation properties of crude oil.

1.2 This guide does not cover detailed calculations and methods, but rather covers a range of approaches that have found application in evaluating emulsions, wettability, and the corrosion rate of steel in crude oil/water mixtures.

1.3 Only those methodologies that have found wide acceptance in the industry are considered in this guide.

1.4 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.

1.5 This guide is not applicable at higher temperatures (typically above 300 °C) that occur during refining crude oil in refineries.

1.6 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.

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

1.8 *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 appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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 Preparation of Substitute Ocean Water

D4006 Test Method for Water in Crude Oil by Distillation

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

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

G185 Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cylinder Electrode

G193 Terminology and Acronyms Relating to Corrosion

G202 Test Method for Using Atmospheric Pressure 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 www.astm.org/contact. 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.

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 terminologies in Guide G170, Terminology G193, and Terminology D1129. Definitions provided herein and not given in terminologies in Guide G170, Terminology G193, and Terminology D1129 are limited only to this standard.

3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *emulsion, n*—a two-phase immiscible liquid system in which one phase is dispersed as droplets in the other phase.

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

3.2.3 *exterior angle and interior angle, n*—"exterior angle" is measured in the aqueous phase, while "interior angle" is measured in the oil phase.

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

3.3 *Acronyms:*
3.3.1 CO_2—Carbon dioxide
3.3.2 EIP—Emulsion inversion point
3.3.3 H_2S—Hydrogen sulfide
3.3.4 NaCl—Sodium chloride
3.3.5 O/W—Oil-in-water
3.3.6 W/O—Water-in-oil

4. Summary of Guide

4.1 This guide describes methodologies for determining three properties of crude oils that are relevant to corrosion processes caused by the presence of water in hydrocarbon transport and handling: (*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 O/W emulsion (in which water is the continuous phase) is high. The conductivity of W/O emulsion (in which oil is the continuous phase) is low.

4.3 The wettability of a steel surface is determined by either contact angle methodology or spreading methodology.

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

5. Significance and Use

5.1 In the absence of water, the crude oil is noncorrosive. However, trace amounts of water and sediment have the potential to create corrosive situations during crude oil handling or transport if such materials accumulate and persist on steel surfaces. Test Methods D473 and D4006 provide methods for determination of the water and sediment content of crude oil.

5.2 The potential for a corrosive situation to develop during the handling and transport of crude oil that contains 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: oil-in-water (O/W) and water-in-oil (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 (**2**) (see ISO 6614). 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) (**1, 3-5**). 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 by evaluating the tendency of water to displace oil from a multi-electrode array by measuring the resistance (or conductors) between the electrodes (spreading methodology).
5.4.1 In the contact angle methodology, the tendency of water to displace hydrocarbon from steel is determined by direct observation of the contact angle that results when both oil and water are in contact with the steel. Although this contact angle is determined by the interfacial free energies of the phases involved, there is no standard method to determine the steel-oil or steel-water interfacial free energies.
5.4.2 In the spreading methodology of determining wettability, the resistance between isolated steel pins is measured. If a conducting phase (for example, water) covers (wets) the distance between the pins, conductivity between them will be high. If a non-conducting 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. A crude oil can be classified as corrosive or inhibitive based on how the corrosivity of the aqueous phase is altered by the presence of the oil.

[4] Available from American National Standards Institute (ANSI), 1180 Avenue of the Americas, 10th Floor, New York, NY 10036, http://www.ansi.org.
[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.