



Designation: G208 – 12 (Reapproved 2020)

Standard Practice for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors Using Jet Impingement Apparatus¹

This standard is issued under the fixed designation G208; 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 practice covers a generally accepted procedure to use the jet impingement (JI) apparatus for evaluating corrosion inhibitors for oilfield and refinery applications in defined flow conditions.

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

1.3 *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.*

1.4 *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

[D1141 Practice for the Preparation of Substitute Ocean Water](#)

[D1193 Specification for Reagent Water](#)

[D4410 Terminology for Fluvial Sediment](#)

[G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens](#)

[G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements](#)

[G16 Guide for Applying Statistics to Analysis of Corrosion Data](#)

[G31 Guide for Laboratory Immersion Corrosion Testing of Metals](#)

[G46 Guide for Examination and Evaluation of Pitting Corrosion](#)

[G59 Test Method for Conducting Potentiodynamic Polarization Resistance Measurements](#)

[G96 Guide for Online Monitoring of Corrosion in Plant Equipment \(Electrical and Electrochemical Methods\)](#)

[G102 Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements](#)

[G106 Practice for Verification of Algorithm and Equipment for Electrochemical Impedance Measurements](#)

[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](#)

3. Terminology

3.1 The terminology used herein shall be in accordance with Terminology [D4410](#), Guide [G170](#), and Terminology [G193](#).

4. Summary of Practice

4.1 This practice provides a method for evaluating corrosion inhibitor efficiency in jet impingement (JI) apparatus. The method uses a well-defined impinging jet set up and mass loss or electrochemical techniques to measure corrosion rates. Measurements are made using three different experimental designs and at several flow rates to evaluate the inhibitor performance under increasingly severe hydrodynamic conditions.

5. Significance and Use

5.1 Selection of corrosion inhibitor for oilfield and refinery applications involves qualification of corrosion inhibitors in the laboratory (see Guide [G170](#)). Field conditions should be simulated in the laboratory in a fast and cost-effective manner.

¹ This practice 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.

TABLE 1 Parameters to be Reported Along with Test Results

Parameter	Units	Remarks
Solution chemistry		
Material chemistry		
Solution density		
Solution viscosity		
Temperature	C or F or K	
Pressure	psi or kPa	For elevated pressure experiments
Jet velocity	m/s or cm/s or inch/s	
Specimen type	ring or disc	
Disc diameter	mm or cm or m	For disc electrodes only
ring diameter (inner)	mm or cm or m	For ring electrodes only
ring diameter (outer)	mm or cm or m	For ring electrodes only
radial distance	mm or cm or m	
Distance between jet and the nozzle	mm or cm or m	
Rotation speed	RPM	
Electrode diameter or radius	mm or cm or m	
Volume of container	cm ³	
Volume of solution	cm ³	
Tafel constants, anodic, cathodic	For electrochemical measurements	
Description of counter electrode (size, shape, and distance from the working electrode)	For electrochemical measurements	
Initial mass	mg or g	For mass loss measurements
Final mass	mg or g	For mass loss measurements
Corrosion rate in absence of inhibitor	mpy or mm/yr	
Inhibitor efficiency, at each inhibitor concentration	%	
Number of specimens		
Volume of solution/surface area of the electrode	cm	
Inhibitor type	continuous or batch	
Inhibitor concentration	ppm or vol/vol or mass/volume or mass/mass	
Description of EIS model	Provide the model and elements (for electrochemical measurements)	
Solution conductivity	Siemens	For electrochemical measurements
Presence of oil	yes or no	
If oil is present, volume of oil	cm ³	
Duration of experiments	Minutes, hour, day	
Type of reference electrode		For electrochemical measurements
Number of specimens		

5.2 Oilfield and refinery corrosion inhibitors should provide protection over a range of flow conditions from stagnant to that found during typical production conditions. The inhibitors are not equally effective over all flow conditions, so it is important to determine the flow conditions in which they are effective.

5.3 Severity of hydrodynamic conditions depends on the type of laboratory methodology. Typically, rotating cylinder electrode is effective up to 20 Pa of wall shear stress, rotating cage (RC) is effective between 20 and 200 Pa of wall shear stress, and jet impingement (JI) is effective at wall shear stress above 200 Pa **(1)**³ of wall shear stress.

5.4 The JI test system is relatively inexpensive and uses simple flat specimens.

5.5 In this practice, a general procedure is presented to obtain reproducible results using JI simulating the effects of different types of coupon materials; inhibitor concentrations; oil, gas, and brine compositions; temperature; pressure; and flow. Erosive effects predominate when the flow rate is very high (typically above 500 Pa) or when sand or solid particles are present; however, this practice does not cover the erosive effects.

6. Apparatus

6.1 The actual hydrodynamic conditions in the tests must be known to enable comparison of results with those obtained in other tests or predictions of inhibitor performance in practical operating systems. Hydrodynamic parameters in jet impingement are described in [Annex A1](#). These hydrodynamic relationships are valid only for a specific range and are influenced by the geometry and orientation of specimen and apparatus. A minor change in any one parameter drastically alters the hydrodynamic parameters.

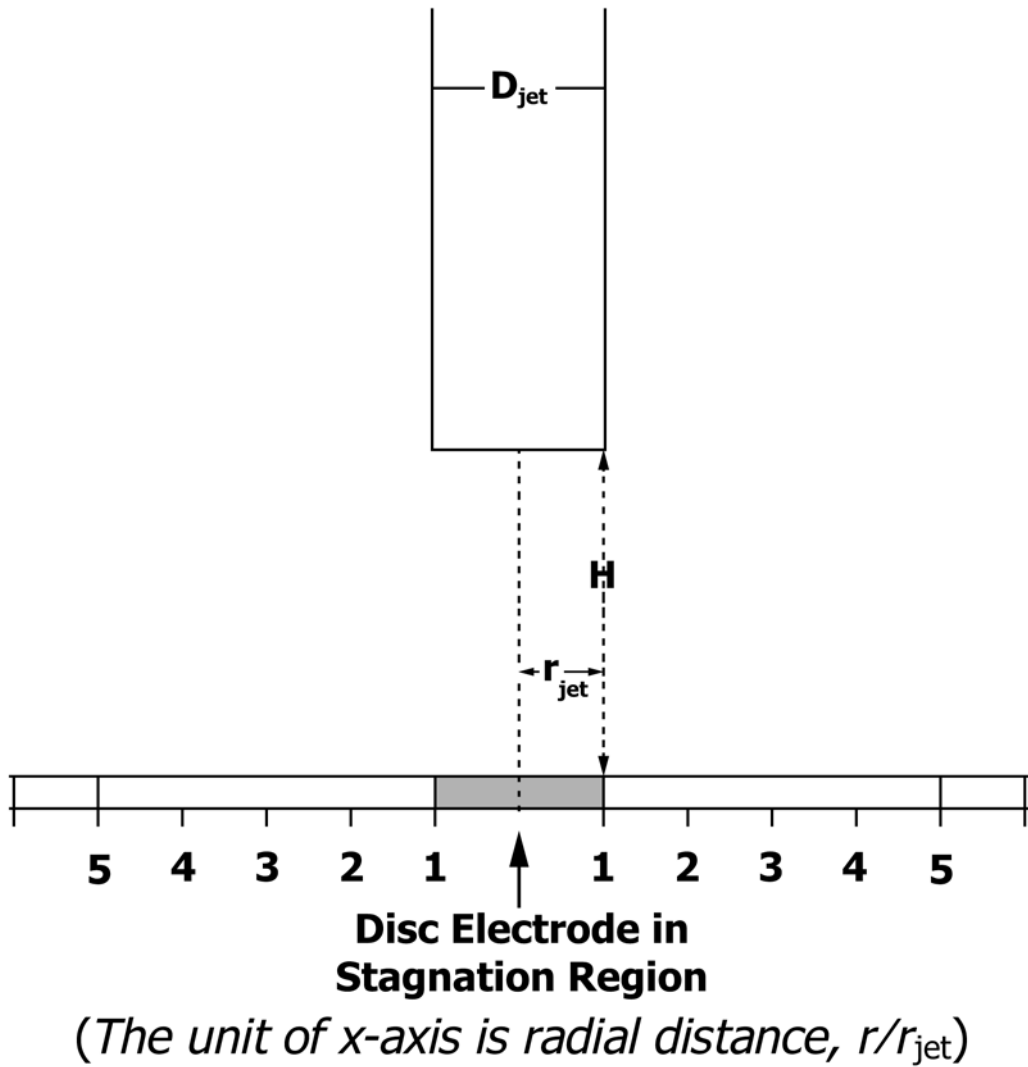
6.2 A proper experimental design must consider the jet velocity, radial distance, radius of the electrode (ring or disc), distance between jet nozzle and the electrode, and jet nozzle diameter. Some typical parameters for describing jet impingement apparatus are listed in [Table 1](#). A good laboratory practice would be to control, record, and report all the system specifications.

6.3 Depending on the geometry of apparatus and size and shape of the specimens there are three jet impingement apparatus designs.

6.3.1 Design 1:

6.3.1.1 In this design, the working electrode is a disc and is exposed only to the stagnation region ([Fig. 1](#)) **(2-4)**. Typical diameter of the jet nozzle is 0.6 cm and is placed axis-symmetric to the specimen (working electrode). The diameter

³ The boldface numbers in parentheses refer to a list of references at the end of this standard.



NOTE 1— r/r_{jet} is less than 2 (D_{jet} is the diameter of the jet, r_{jet} is the radius of the jet, r is the radius of the specimen, and H is the distance between the jet tip and the specimen surface). Shaded area indicates the location of the specimen.

FIG. 1 Schematic Diagram (Side View) of Impinging Jet on a Specimen in Stagnation Region

of the specimen is equal to or less than the diameter of the jet nozzle. The typical distance between the jet nozzle tip and specimen is 3 cm (that is, five times the diameter of the jet nozzle).

6.3.1.2 The jet system is a submerged type and it impinges at 90° onto the specimen. Both the counter electrode and the reference electrode are placed adjacent to the nozzle, so that they are not in the path of the jet impinging on the working electrode (Fig. 2).

6.3.2 Design 2:

6.3.2.1 In this design, the specimen is a ring and is exposed only to the jet region (Fig. 3 and Fig. 4) (5, 6). The diameter of the jet nozzle is 0.2 cm. The diameter of the specimen is three times the diameter of the jet nozzle (measured to the centerline of the ring). The inner and outer diameters of the ring specimen

are within the jet region. Typical distance between the jet nozzle tip and the specimen is 0.4 cm (that is, two times the diameter of the jet).

6.3.2.2 The jet nozzle is manufactured using a nonmetallic cylinder (typically of 1.25 cm of outer diameter with a 0.2 cm inlet hole in the center). The length of the cylinder (typically 20 cm) is long enough so that the fluid flow stabilizes before exiting through the nozzle. The counter electrode is placed at the end of the jet nozzle (Fig. 5). The reference electrode is placed adjacent to the counter electrode.

6.3.3 Design 3:

6.3.3.1 In this design, the specimen is a disc and is exposed to all three regions of jet (stagnant, jet, and hydrodynamic regions) (see Fig. 6). This design facilitates occurrence of