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Standard Test Method

Test Method for Measurement of Gouge Resistance of Coating Systems

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Foreword

Organic coatings are the most frequently used materials to protect buried ferrous metal pipelines from corrosion and mechanical damage. During storage, transport, and installation, pipes are exposed to severe mechanical stress that can lead to damage of the protective coating layer.

Therefore, it is important to use coatings with high-mechanical strength and toughness. Impact resistance, wear resistance, hardness, and resistance to shear scratch/indentation are good indicators of the coating's mechanical strength and toughness.
This NACE standard test method describes a reliable measuring methodology for determining the gouge resistance to shear scratch/indentation of coating systems.

The purpose of this standard is to provide a test method for determining the gouge resistance of coating systems used on buried ferrous metal pipelines.

There have been several efforts in the past to develop a reliable test method for determining the gouge resistance of coating systems, but they failed because different kinds of test equipment and test conditions have led to scattered data. This tighter test method should lead to more consistent test data.

This latest effort to develop a test method was driven by the joint efforts of representatives of coating manufacturers, coating applicators, equipment suppliers, corrosion specialists, and other personnel concerned with the construction of underground pipeline facilities.

It is intended to be used by pipeline operating companies, pipeline owners, pipeline contractors, pipeline inspection services, and pipeline coating mills.

This test method was prepared in 2015 by Task Group (TG) 034, "Pipeline Coatings, External—Gouge Test." It is administered by Specific Technology Group (STG) 03, "Coatings and Linings, Protective—Immersion and Buried Service." It is sponsored by STG 35, "Pipelines, Tanks, and Well Casings." This standard is issued by NACE under the auspices of STG 03.

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.

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Test Method for Measurement of Gouge Resistance of Coating Systems

Contents

Section 1: General

1.1 This standard describes the design and operation of an apparatus to determine the gouge resistance of pipe coatings.

1.2 This test method is used for organic coatings that are used on buried ferrous metal pipelines. The primary application is for testing thermosetting coatings (e.g., fusion-bonded epoxy [FBE], liquid epoxy). Polyolefins (polyethylene [PE] and polypropylene [PP] may also use this test method.

Section 2: Equipment

2.1 Gouge Test Apparatus

2.1.1 A shear gouge test apparatus consisting of a gouge tool (see Paragraph 2.1.2), an adjustable load system (see Paragraph 2.1.3), and other accessories necessary for repeatable test results shall be used (see Figures 1 and 2).

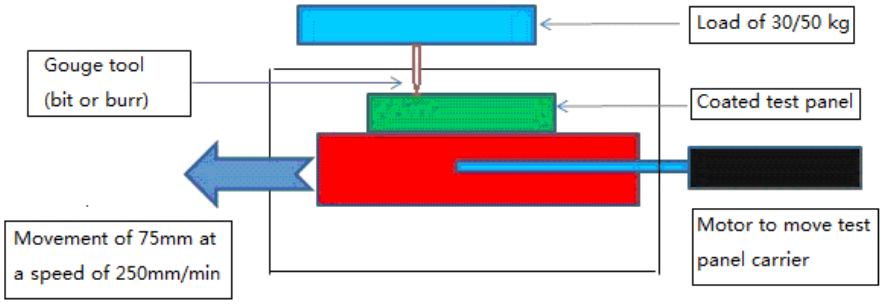

Figure 1: Schematic of a Gouge Test Apparatus

Figure 2: Example of a Gouge Tester

2.1.2 A gouge tool, the SL-1[1,2] smooth carbide bit (i.e., not SL-1M), and single cut burr are shown in Figure 3a and Figure 3b, respectively. The size of the bit and burr are referenced in ISO[(1)] 7755.10 as shown in Figure 3c.[2] They are specified as d = 6 mm (0.24 in), l = 16 mm (0.625 in) and R ≈ 1.2 mm (0.05 in).

2.1.3 The SL-1 gouge tool shall be replaced after a maximum of 60 gougings and the smooth gouge tool can be used for up to 100 gouges. Gouge tools shall not be used after direct contact with the metal of the test samples (see Paragraph 5.3.7).

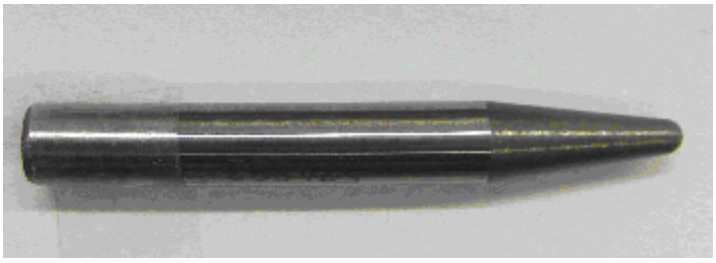

Figure 3a: SL-1 Smooth Carbide Bit

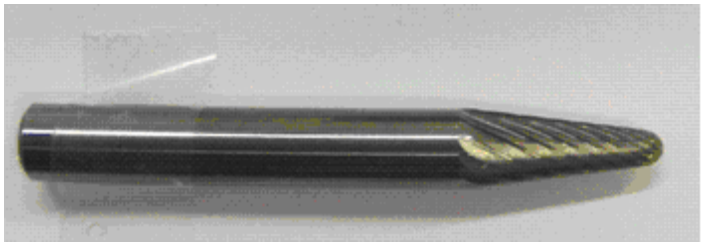

Figure 3b: SL-1 Single Cut Burr

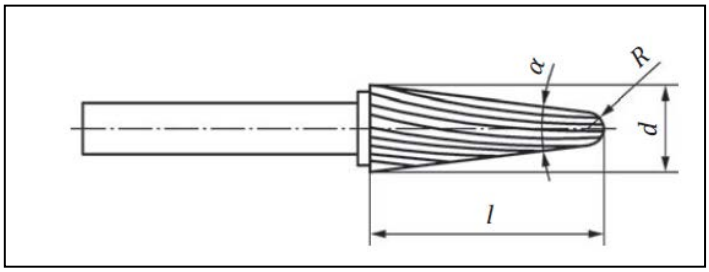

Figure 3c: SL-1 Hard metal burr

2.1.4 An adjustable load system shall apply a total load, including the gouge tool assembly, of 30 kg (66 lb) or 50 kg (110 lb) and other loads as required, to the gouge tool at a 90° angle against the coating. The load at the tip of the gouge tool shall be calibrated a minimum of once per year.

2.1.5 The speed of the sample movement shall be 250 mm/min ± 50 mm/min (10 in/min ± 2 in/min) (see Paragraph 5.3.4).

2.2 The nominal thickness of the coating on the test samples shall be determined using a coating thickness gauge with an accuracy of ± 3% of the reading.

(1) International Organization for Standardization (ISO), 1 ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

2.3 A gouge depth gauge (example shown in Figure 4) shall have an accuracy of 0.01 mm (0.4 mil). The tip of the probe shall have an end radius less than 1.2 mm (0.05 in), but shall not be a sharp needle-type tip.

Figure 4: Example of a Gouge Depth Gauge

2.4 A rigid, straight-edge ruler with a minimum length of 100 mm (4 in) and an accuracy of 1 mm (0.04 in) shall be used for evaluation.

2.5 The accuracy of the load shall be ±1% of the load.

2.6 Holiday testing shall use the appropriate method based on coating thickness in accordance with NACE SP0188.[3]

Section 3: Test Samples

3.1 The test samples shall be laboratory coated panels or cut coupons from a pipe. The laboratory coated panels shall be prepared in accordance with the coating manufacturers' or customer's recommended processes and coating thickness shall be the same as that used in service on the pipeline.

3.2 The size of laboratory coated panels shall be approximately 100 mm x100 mm x min 6 mm (4 in x 4 in x 0.24 in) thickness. The coupons cut from a pipe shall measure approximately 100 mm (pipe longitudinal direction) x 50 mm x pipe wall thickness (4 in [pipe longitudinal direction] x 2 in x pipe wall thickness).

3.3 The test samples shall have a surface representative of the final product without visible scratches or other defects.

3.4 The test samples shall be holiday-free in accordance with NACE SP0188.

3.5 One laboratory coated panel shall be provided. The panel shall be gouged three times, resulting in three parallel gouges. The distance between individual gouges shall be at least 10 mm (0.4 in) (see Paragraph 5.3.2). For coupons cut from a pipe, three samples are required. Each test sample shall be gouged only once at the apex of the pipe segment curvature (see Paragraph 5.3.2). The cut coupon should be strong enough to withstand a deformation caused by the applied load.

Section 4: Conditioning of Test Samples

4.1 The test samples shall be conditioned (i.e., aged) in a standard laboratory atmosphere of 23 ±2 °C (74 ±2 °F), or at other specified temperature for a minimum of 24 hours before the test, or in accordance with the coating system manufacturer's specifications. Aging time of each test sample shall be recorded.

Section 5: Test Procedures

5.1 Cleaning of Test Samples

5.1.1 The test samples shall be washed using warm tap water to remove any machining or cutting oils or loose soils from the sample. If needed, a mild detergent and a nonabrasive pad may be used to lightly scrub the coating surface.

5.1.2 The test samples shall be lightly towel dried, avoiding any excessive scrubbing of the coating surface because gouges may result.

5.2 Coating Thickness

5.2.1 The thicknesses of the individual coating layers should be reported based on measurement with a Tooke gauge in accordance with ASTM[(2)] D4138[4] or other measurements.

5.2.2 If an overall coating thickness is required, the nominal thickness should be determined in accordance with ASTM G12.[5] A minimum of nine measurements shall be performed on the surface of the test sample (ideally in the regions of the panel to be gouge tested). The average thickness and variation on the samples shall be reported and be in accordance with the specified thickness for the mother pipe.

5.3 Procedure

5.3.1 The test sample shall be fixed on the sliding platform of the gouge test apparatus, and the coating side shall be facing up and in a horizontal position. For pipe coupon samples, the longitudinal direction shall be parallel to the direction of movement and perpendicular to the gouge tool.

5.3.2 The gouge test shall be performed with a minimum distance of 12 mm (0.5 in) from the sample edges. The distance between individual gouges should be a minimum of 10 mm (0.4 in) for laboratory coated panels. Coupons cut from a pipe shall be tested only once per sample in the middle of the sample at the apex of the pipe curvature. The test area shall be perpendicular to the gouge tool.

5.3.3 A load of 30 kg for single-layer FBE coatings, and 50 kg for dual- and triple-layer FBE coatings, multilayer liquid abrasion resistant overcoatings (ARO), and extruded polyolefin coatings, shall be applied onto the gouge tool and the test shall be started immediately to avoid the gouge tool penetrating the coating over time and causing a deeper gouge than would normally be observed.

5.3.3.1 Other test loads may be specified by the customer.

5.3.4 The sample shall be moved at a speed of 250 mm/min ±50 mm/min (10 in/min ± 2 in/min) over a distance of 75 mm (3 in). The movement shall be at a constant speed without wavering. Any observation of chattering or skipping of the tool during scribing invalidates that test.

5.3.5 When samples are tested at a temperature other than ambient, the gouge test shall be finished within 2 minutes of removal of the samples from the oven or refrigerator.

5.3.6 The test samples shall be removed from the apparatus.

5.3.7 The SL-1 gouge tool shall be replaced after a maximum of 60 gouges and the smooth gouge tool can be used for up to 100 gouges. Gouge tools shall not be used after contact with the metal of the test samples (see Paragraph 2.1.3).

5.4 Gouge Depth Measurement

5.4.1 Any loose coating chips above the normal coating surface should be removed using a sharp knife or razor blade before taking a gouge depth measurement. Care should be taken to avoid creating a holiday in the coating.

[(2)] ASTM International (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

5.4.2 The measurement reference points shall be marked for each gouge. A rigid, straight-edge ruler shall be used to draw a line across the middle point of all gouges as shown in Figure 5. Using this first line as a reference point, two more parallel lines shall be drawn across the width of the test sample, each at a distance of 25 mm (1 in) from the first line. The three lines that cross the width of the gouge shall be the measurement reference points.

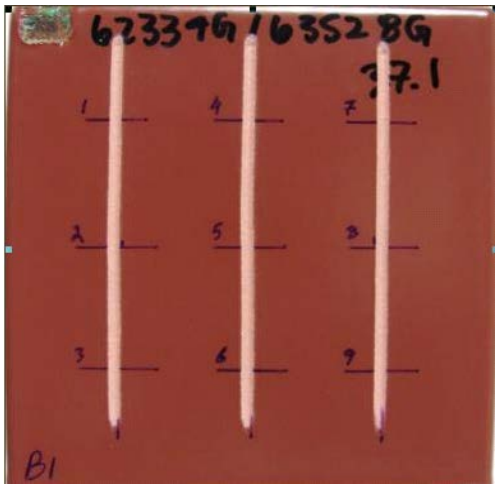

Figure 5: Test Sample with Gouges and Straight Lines Drawn Through Middle Points

5.4.3 The probe tip of the gouge depth gauge (see Figure 4) shall be positioned on a non-damaged area of the coating surface just in front of the gouge. The gauge shall be set at zero.

5.4.4 Single-point measurements shall be taken at the three reference points where the lines intersect the gouge. The foot of the gauge shall not come in contact with the gouge or the adjacent deformed coating, but slide on either side of this area.

5.4.5 The depth of all gouges shall be recorded at the area where each gouge is intersected by the marked lines. The depth of the (nine) gouges shall be averaged.

5.5 Holiday Testing of the Test Samples

5.5.1 The holiday test shall be performed at an ambient temperature of 23 ±2 °C (74 ±2 °F).

5.5.2 Testing voltages for holiday detection shall be related to the residual coating thickness of the gouge for the gouged test samples and the average coating thickness for the test samples before the gouge test in accordance with NACE SP0188, or in accordance with the coating manufacturer's recommendations.

5.5.3 If any holiday is detected, the test shall be considered a failure.

Section 6 Report

The report shall include the following:

6.1 The simple procedure used for the test;

6.2 Test apparatus type;

6.3 Gouge tool used;

6. 4 Sample movement speed;

6.5 Coating name, agreed specifications, and specifying body;

6.6 Type of test sample, its dimensions and number, and thickness of the coating system including thickness of individual coating layers if required; the bottom of the gouging in which layer shall be reported by the visual check.

6.7 Test temperature, applied load (kg), and holiday detection voltage (kV) used;

6.8 Test results, including individually measured and average depth of gouges (µm) and number of determined holidays; and

6.9 Test date, operator, and employer.

References

1. ISO 7755.1 (latest revision), “Hard metal burrs—Part 1: General specifications” (Geneva, Switzerland: ISO).

2. ISO 7755.10 (latest revision), “Hard metal burrs—Part 10: Conical round- (ball-) nose burrs (style L)” (Geneva, Switzerland: ISO).

3. NACE SP0188 (latest revision), “Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates” (Houston, TX: NACE).

4. ASTM D4138 (latest revision), “Standard Practices for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive, Cross-Sectioning Means” (West Conshohocken, PA: ASTM).

5. ASTM G12 (latest revision), “Standard Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel” (West Conshohocken, PA: ASTM).

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