Standard Guide for Accelerated Corrosion Testing for Mechanical Fasteners

1 Scope

1.1 This guide covers test procedures for performing accelerated tests to evaluate relative corrosion resistance of various coatings applied to mechanical fasteners. Corrosion mechanisms such as general and crevice corrosion may be evaluated with this method. Test duration may be selected to achieve any desired level of corrosion exposure and provides a frame of reference to determine relative coating resistance to corrosion. Fasteners tightened to a desired tension and subjected to this test procedure may be evaluated to simulate a variety of service conditions. Without large amounts of accumulated field results, it is difficult to relate test duration or the number of test cycles to actual service life for a given application.

1.2 This standard is not intended to cover tests of driven fasteners such as nails, staples, screws and lag bolts.

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

2. Referenced Documents

2.1 ASTM Standards:
   A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
   B117 Practice for Operating Salt Spray (Fog) Apparatus
   B605 Specification for Electrodeposited Coatings of Tin-Nickel Alloy
   D1193 Specification for Reagent Water
   FI470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
   F1789 Terminology for F16 Mechanical Fasteners
   G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

2.2 ASME Standard:
   ASME B18.12 – Glossary of Terms for Mechanical Fasteners

2.3 IFI Standards
   IFI-170 – Accelerated Corrosion Test for Mechanical Fasteners

3. Terminology

3.1 Definitions for many of the terms used in this standard are included in Terminology F1789 and ASME B18.12.

3.2 Definitions of Terms Specific to This Standard:
   3.2.1 cycle—a series of events scheduled over a 24-hour period
   3.2.2 phase—a test period which has elapsed for 8 cycles.
   3.2.3 test duration—a series of cycles as defined in Section 4.

4. Test Duration

4.1 Test duration is specified as A, B, C, D or E in accordance with Table 1.

4.2 A typical cycle is shown in Table 2.

5. Apparatus and Materials

5.1 Coupons 25.4 mm wide and 50.8 mm long having a thickness selected from Table 3 shall be used. Dimensional tolerances of Specification A480/A480M shall apply. Coupons shall have a plain finish and be manufactured from AISI–1008 steel grade. Coupons shall be included with fasteners to be tested to verify that uniform amounts of corrosion have been produced by tests. Refer to Fig. 1, Fig. 1 (a) and Fig. 1(b) and Table 3. Inclusion of a metal loss coupon assists in making comparisons from one test to another and allows one to quantify a repeatable test.

5.2 A fog humidity cabinet shall be used in which salt mist applications are coupled with high humidity and moderately high temperature. Water fog or visible water droplets on parts

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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.


being tested shall be continuous after equilibrium is reached. Dry-off may be sequenced manually or automatically.

5.3 Racks suitable for supporting bolt or screw assemblies shall be agreed upon between supplier and purchaser. Test results shall always state materials used for racks during testing. Nylon or other suitable nonmetallic washers shall be installed to prevent bolt or screw heads or test coupons from contact with test racks. See Fig. 1 and 7.8.

6. Salt Mist Application and Dry-off

6.1 Salt solution shall conform to requirements of Table 4. Solutions shall be sprayed by nozzles to provide a mist such that test fasteners and coupons are thoroughly wet and dripping when examined visually. Solution collection rates shall conform to Practice B117. Salt accumulations shall have been rinsed away during the salt solution spray application.

6.2 For the drying part of a cycle, a dry-off environment area shall be maintained with sufficient air circulation to assure uniform temperature and shall allow thorough drying of tested fasteners and coupons. Temperature and humidity conditions are defined in Table 4.

7. Test Procedure

7.1 Fasteners to be tested with salt spray, shall be sampled in accordance with Practice F1470, Sample Level B.

7.2 Each fastener to be tested shall be installed through its corresponding rack using nonmetallic washers as to maintain a minimum of 5 mm spacing between underside of the head and surface of the rack. The washers for any testing protocol shall be identical. Fig. 1(a) and Fig. 1(b) provide an illustrative representation. Holes in test racks shall be offset to avoid dripping from one test fastener onto another. Fastener load shall be achieved through finger tightening (Fig. 1 illustrates the assembly). If higher loads or proof load tightening is required then the load level and method of tightening shall be by agreement between supplier and purchaser.

7.3 Coupons to be tested shall be permanently identified by numbers stamped onto the surface.

7.4 Coupons to be used shall be cleaned with a methanol or acetone solution and weighed prior to use. A coupon’s weight in ± 0.5-mg shall be recorded for comparison with its weight after testing in accordance with Table 2.

7.5 Coupons as shown in Fig. 1(a) shall be installed by drilling a hole to accept a nonmetallic hex fastener. Coupons shall be raised above coupon racks by two nonmetallic washers to expose both sides of coupons to the test environment. A minimum of 5 mm shall be provided for spacing between coupons and test rack surfaces. Fixtures shall be modified as necessary to maintain isolation from rack materials while creating and maintaining the required fastener tensions.

7.6 Dry-off shall consist of exposure to high temperature, low humidity air in accordance with Table 4 for three hours.

7.7 Test coupon(s) shall be removed and analyzed after dry-off in each phase. Each coupon shall be cleaned in accordance with the procedures described in Practice G1.

7.8 For corrosion products that are tightly adhered to the fastener specimen, cleaning by mechanically abrading the surface before chemical cleaning will help remove the adherent corrosion products. Vigorous mechanical cleaning may result in the removal of some coating or base metal; therefore, care should be exercised when using mechanical cleaning techniques. Mechanical cleaning should be used only when other methods have failed to provide adequate removal of corrosion products on the coupons. After a final phase, coupon mass loss shall be evaluated based on Table 3. Prior to completion of a final testing phase, mass loss may be linearly extrapolated based on percent of the overall test completed.

8. Report

8.1 Reported test results shall include:
8.1.1 Name of testing agency,
8.1.2 Date(s) and place of testing,
8.1.3 Testing schedule as to number of cycles,
8.1.4 Identification, all materials for coupons,
8.1.5 Materials of construction for racks,
8.1.6 Identification, materials and coatings of fasteners,
8.1.7 Installation torques or tensions involved,
8.1.8 Condition of coupons,
8.1.9 Mass loss of coupons, net and percent, and
8.1.10 Condition of the fasteners, including section loss, estimated percent surface corrosion, timing of on-set, or photographs as agreed with purchaser.

9. Keywords

9.1 corrosion; crevice; testing
TABLE 2 Typical Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 a.m.</td>
<td>8</td>
<td>Salt mist application (in ambient environment.)</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>8</td>
<td>8 hour humidity cabinet exposure including 1 hour progression to wet conditions.</td>
</tr>
<tr>
<td>10:00 p.m.</td>
<td>8</td>
<td>8 hour environmental exposure including 3 hours progression to dry conditions.</td>
</tr>
<tr>
<td>Weekends</td>
<td></td>
<td>Ambient environment</td>
</tr>
</tbody>
</table>

*Times shown are illustrative. A test cycle may be started at any time and follow the order shown in the table. The events for a 24 h period complete one cycle. Ambient is specified in Table 4. Duration times are ± 5 minutes.

TABLE 3 Coupon Mass Loss Target Range

<table>
<thead>
<tr>
<th>Initial Coupon Thickness (mm)</th>
<th>Test Duration (mg of Mass Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>0.79</td>
<td>828–1228</td>
</tr>
</tbody>
</table>

*The corrosion rate (mass loss) is in linear relation with the number of test cycles. This linear relation can be used to calculate the mass loss for the number of cycles different than the test cycles corresponding to test durations shown in Table 3. Values in Table 3 are only applicable to Standard Test Procedure. Mass loss for test duration E(# of Cycles) is a function of the number of the cycles agreed upon.
TABLE 4 Test Environment and Solutions

<table>
<thead>
<tr>
<th>Material</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Mist</td>
<td>25°C—35°C</td>
</tr>
<tr>
<td>Salt Solution</td>
<td>0.90% A</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>0.10% A</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>0.25% A</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>6.5–7.5</td>
</tr>
<tr>
<td>Salt Solution pH</td>
<td></td>
</tr>
<tr>
<td>Dry off</td>
<td>58°C–64°C</td>
</tr>
<tr>
<td>Temperature</td>
<td>&lt;30% RH</td>
</tr>
<tr>
<td>Humidity</td>
<td></td>
</tr>
<tr>
<td>Ambient</td>
<td>23°C–27°C</td>
</tr>
<tr>
<td>Temperature</td>
<td>40–50% RH</td>
</tr>
<tr>
<td>Humidity</td>
<td></td>
</tr>
</tbody>
</table>

*Material must be dissolved separately in water (Specification D1193 type IV) and added to the solution of other materials to avoid insoluble precipitates.*
X1.1 Testing results from this specification cannot guarantee actual material performance. The relationship between test duration and service condition should be agreed upon by the test requestor and testing agency. Five test durations: A, B, C, D, and E(# of Cycles) are intended to estimate approximate years of service: Five service conditions are simulated in testing. They are:
A) mild service—year,
B) moderate service—2 years,
C) severe service—5 years,
D) very severe service—10 years,
E) extended life service > 10 years (See Note X1.1).
Very severe, severe, moderate, and mild service are defined in ASTM B605. Test duration selection A, B, C, D or E(# of Cycles) should be based on the expected service condition. A weight loss exceeding 2% is considered very severe service.

Note X1.1—Extended life service reflects special service applications where design life exceeds a 10-year period and testing exceeds 80 cycles.