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Standard Test Method for Corrosion of Aircraft Metals by Total Immersion in Maintenance Chemicals[1]

This standard is issued under the fixed designation F 482; 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.

~~ϵ^1 NOTE—Paragraphs 2.1, 4.1.1, and 7.1 were changed editorially and Section 12, Keywords, was added editorially in September 1999.~~

1. Scope

1.1 This test method covers the determination of the corrosiveness of tank-type aircraft maintenance chemicals on aircraft metals and the corrodibility of metals in these maintenance chemicals with time. The determination is made under conditions of total immersion by a combination of weight change measurements and visual qualitative determinations of change.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.* For specific precautions, see Section 5.

2. Referenced Documents

2.1 *ASTM Standards:*

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[1] This test method is under the jurisdiction of ASTM Committee F07 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.07 on Qualification Testing of Aircraft Cleaning Materials.

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D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)[2]
D 329 Specification for Acetone[2]
D 740 Specification for Methyl Ethyl Ketone[2]
D 1193 Specification for Reagent Water[3]
E 1 Specification for ASTM Thermometers[4]

3. Significance and Use

3.1 This test method not only provides information on the accumulated effects of corrosion at specific time periods under a given set of conditions, but also provides information on the initial rate of corrosion of virgin metal, the corrosion rate of metal per unit time after long exposure, and the initial corrosion rate of virgin metal after long exposure of the corroding fluid to metal. The test also provides a means of determining the direction corrosion will take with time, although causes for increase or decrease in the corrosiveness and corrodibility of media and metal (such as passive film formation or destruction, depletion of corrosive contaminate, and so forth) as a function of time are not given.

4. Apparatus

4.1 *Wide-Mouth Glass Jar or Flask* of suitable sizes (3000 to 4000 mL), capable of accommodating a reflux condenser, a thermometer, and a specimen support system. Fig. 1 shows a typical arrangement, but any array meeting the provisions of 4.2-4.5 ~~will be~~ is acceptable.

4.1.1 If agitation is required, ~~the~~ use an apparatus ~~should be~~ capable of accepting a stirring mechanism, such as a magnetic stirrer or impeller. ~~The~~ Choose the glass jar or flask ~~should be chosen so~~ such that the specimens will remain fully immersed in a vertical position during the test, and the ratio of area of immersed metal to volume of solution will be in accordance with 8.1.

4.2 *Specimen-Supporting Device* —a glass or fluorocarbon plastic supporting system designed to keep the specimen fully immersed while assuring free contact with the corroding solution, and designed to physically isolate the specimens from each other.

4.3 *Condenser*—a glass reflux condenser of the water-cooled type, having a condenser jacket 200 to 300 mm in length.

4.4 *Constant-Temperature Device* —Use any suitable regulated heating device (mantle, hot plate, or bath) ~~may be used for maintaining~~ to maintain the solution at the required temperature.

4.5 *Thermometer*— an ASTM ~~3-in. (75-mm)~~ 75-mm (3-in.) immersion thermometer having a range from ~~0~~ −18 to ~~302°F (150°C)~~ 150°C (0 to 302°F) and conforming to requirements for Thermometer 1F in accordance with Specification E 1.

5. Safety Precautions

5.1 The solvents used in the cleaning of test specimens are flammable and harmful if inhaled. Keep away from sparks and open flames. Avoid breathing vapors and prolonged or repeated contact with the skin. Use with adequate ventilation.

~~5.2 The material used for aircraft maintenance may contain flammable~~

5.2 Flammable solvents, acids, or alkalis, or other toxic compounds are occasionally found in the material used for aircraft maintenance. Take suitable precautions to prevent personnel injury.

6. Test Specimens

6.1 The test specimens of a given alloy shall be taken from the same sheet stock and shall measure ~~2~~ 50.8 by ~~1 by 0.06 in. (50.8 by~~ 25.4 by 1.6 mm (2 by 1 by 0.06 in.) with a ~~0.125-in. (3.2-mm)~~ 3.2-mm (0.125-in.) diameter mounting hole ~~and~~ suitably located at one end of the specimen. ~~At~~ Test at least two and preferably three replicates ~~should be tested~~ in each concentration of maintenance chemical solution in accordance with 8.2. The total area of the specimen shall be taken as ~~4.4 in.~~ 28.2 cm^2 ~~(28.2 cm~~ (4.4 in.^{2}).

7. Test Specimen

7.1 Preheat the test specimens to ~~150 ± 5°F (60 ± 2°C)~~ 60 ± 2°C (150 ± 5°F) and immerse in a beaker containing Mineral Spirits, Type II, conforming to Specification D 235. Swab the surface of the individual specimen thoroughly using clean forceps to hold the specimen and the cotton swab.

7.2 Shake off the excess solvent. Transfer and immerse the test specimens separately several times in a beaker of methyl ethyl ketone conforming to Specification D 740.

7.3 Shake off excess methyl ethyl ketone and dry in a vacuum desiccator or in a low temperature oven at ~~100 ± 5°F (37.7 ± 3°C)~~ 37.7 ± 3°C (100 ± 5°F) for 15 min.

8. Conditioning

8.1 *Volume of Solution*—The volume of solution shall be 500 mL per specimen. Use fresh solution for each set of replicates.

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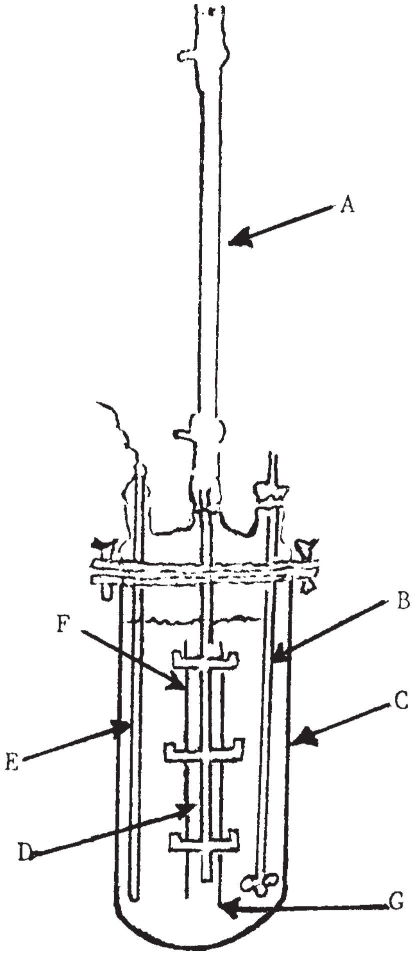
[2] *Annual Book of ASTM Standards*, Vol ~~11.01.~~ 06.04.
[3] *Annual Book of ASTM Standards*, Vol ~~14.03.~~ 11.01.
[4] *Annual Book of ASTM Standards*, Vol 14.03.



A = Condenser
B = Stirring mechanism
C = Containing vessel
D = Specimen holder
E = Thermometer
F = Metal specimen
G = Maintenance chemical solution

NOTE—This is one form that the equipment can take, and is not mandatory. Any array meeting the requirements of 4.2-4.5~~ w ill be~~s acceptable.

FIG. 1 Test Apparatus

8.2 *Solution Concentration*:

8.2.1 Unless otherwise specified, test the specimens in solutions of the maintenance chemical in the concentrated as-received condition and at the recommended dilution using distilled or deionized water conforming to Specification D 1193, Type IV. (For solid materials, concentrated condition shall mean in a saturated solution of the solid material.) In case the material is not soluble to the extent noted, record this fact and continue with the test.

8.2.2 Test diphase materials with an appropriate amount of each phase loaded into the test vessel to simulate use conditions. Totally immerse the corrosion specimens in the working phase of the maintenance chemical.

8.2.3 If water is not used as the diluent, record the type and specification of diluent used in the test.

8.3 *Temperature*— Unless otherwise specified, the temperature shall be~~ 100 ± 2°F (37.7 ± 3°C).~~ 37.7 ± 3°C (100 ± 2°F).

8.4 *Test Duration*— Total test duration shall be 168 h, with specimens being added or removed at intermediate intervals.

8.5 If the maintenance chemical is to be used with agitation, also test the specimens with appropriate agitation to simulate use conditions.

9. Procedure

9.1 Weigh four of five specimens (S_1, S_2, S_3, and S_4) of the same alloy to the nearest 0.1 mg. Record the weights S_1W_1, S_2W_1, S_3W_1, S_4W_1. Retain the fifth specimen of each alloy for comparison purposes.

9.2 Immerse three of the specimens (S_1, S_2, and S_3) in the test solution using only specimens of the same alloy in the containing vessel. Retain S_4 for use in accordance with 9.5.

9.3 At the end of 48-h exposure time, remove S_1 and proceed as follows:

9.3.1 Rinse thoroughly under hot tap water, ~~120~~ 49 to ~~140°F (49~~ 60°C (120 to ~~60°C),~~ 140°F), while scrubbing with a stiff bristle brush. Follow with distilled or deionized water conforming to Specification D 1193, Type IV at room temperature.

9.3.2 Rinse with a stream of acetone conforming to Specification D 329 from a wash bottle and dry.

9.3.3 If corrosion deposits are still adhered, remove corrosion products in accordance with Annex A1 and Annex A2 and rinse dry in accordance with 9.3.1 and 9.3.2.

9.3.4 Weigh to the nearest 0.1 mg and record as S_1W_2. If the specimen has been treated in accordance with Annex A1 and Annex A2, subtract any weight losses of the control specimen of Annex A1 and Annex A2 from the weight loss of the specimen.

9.3.5 Calculate the weight loss of the panel as WL. $S_1 = S_1W_1 - S_1W_2$.

9.4 At the end of 120-h exposure time, remove S_2 and proceed in accordance with 9.3. Record the weight loss as $S_2 W_2$.

9.5 Also at the end of 120-h exposure time, add S_4 to the reaction vessel.

9.6 At the end of 168-h exposure time, remove S_3 and S_4 from the solution and proceed as follows:

9.6.1 Proceed in accordance with 9.3 for S_4 and record the weight loss as S_4W_2.

9.6.2 For S_3, rinse in accordance with 9.3.1 and 9.3.2, then examine for and record the following visible changes in comparison with the fifth virgin specimen:

9.6.2.1 Discoloration and dulling,

9.6.2.2 Etching,

9.6.2.3 Presence of accretions and relative amounts,

9.6.2.4 Pitting, and

9.6.2.5 Presence of selective or localized attack.

9.6.3 If any corrosion deposits remain, remove these products from S_3 in accordance with Annex A1 and Annex A2. Rinse with distilled water conforming to Specification D 1193, Type IV followed by acetone conforming to Specification D 329 and dry.

9.6.4 Weigh to the nearest 0.1 mg and calculate the weight loss as W_3. If the specimen has been treated in accordance with Annex A1 and Annex A2, subtract any weight losses of the control specimen of Annex A1 and Annex A2, from the weight loss of the test specimen.

10. Report

10.1 Report the following data for each test performed:

10.1.1 Name and type of maintenance chemical tested.

10.1.2 Concentrations, diluent used, and other conditions of test peculiar to maintenance chemical type.

10.1.3 Alloy type, surface treatment and condition, and number of specimens tested.

10.1.4 Temperature, duration of test, and agitation if any.

10.1.5 Average corrosion rate, R_1, R_2, R_3, R_4, or weight loss in milligrams per square centimetre per day for each specimen where:

$$R = \frac{W/\text{surface area of panel in cm}^2}{\text{total exposure time of panel }/24}$$

10.1.6 Range in weight losses.

10.1.7 Effect of time on liquid corrosiveness and metal corrodibility calculated in accordance with Annex A3.

10.1.8 Appearance before and after removal of corrosion products with regard to the following:

10.1.8.1 Discoloration and dulling,

10.1.8.2 Etching,

10.1.8.3 Presence of accretions and relative amounts,

10.1.8.4 Pitting, and

10.1.8.5 Presence of selective or localized attack.

11. Precision and Bias

11.1 Committee F07 has no plans to establish a precision and bias statement for this test method.

12. Keywords

12.1 aircraft metals; corrosion rates as weight loss per surface unit divided by exposure time per day; in concentrate; in use dilution; liquid corrosiveness; metal corrodibility; tank-type chemicals; temperature control; time control; total immersion corrosion; visual corrosive deterioration

ANNEXES

(Mandatory Information)

A1. CHEMICAL METHODS FOR CLEANING CORRODED SPECIMENS

A1.1 After scrubbing to remove loosely attached corrosion products, treat the specimens as follows. A blank metal specimen shall be run at the same time to ensure weight losses incurred by cleaning the corroded specimens are not included in the weight loss determination.

A1.1.1 *Aluminum and Its Alloys*—Immerse the specimen for 5 min in a water solution containing 2 weight % of chromic acid and orthophosphoric acid (85 %) maintained at ~~175 ± 5°F (79 ± 3°C).~~ 79 ± 3°C (175 ± 5°F). Rinse in water to remove acid and brush with stiff bristle brush to remove loosened materials.

A1.1.2 *Copper and Nickel Alloys*—Immerse the specimen for 2 to 3 min in hydrochloric acid (1 + 1) or sulfuric acid (1 + 10) at room temperature. Scrub with a bristle brush under running water and dry.

A1.1.3 *Magnesium Alloys*—Immerse the specimen for 1 min in chromic acid (20 weight %) to which has been added, with agitation, 1 weight % of silver nitrate in solution form. Operate the bath at ~~200~~ 93 to ~~212°F (93~~ 100°C (200 to ~~100°C).~~ 212°F).

A1.1.4 *Iron and Steel*—Immerse the specimen for 2 to 3 min in a boiling solution of ammonium citrate (10 weight %).

A1.1.5 *Stainless Steel*—Immerse the specimen for 5 min in a solution of nitric acid (30 volume %) at a temperature of ~~120~~ 49 to ~~130°F (49~~ 54°C (120 to ~~54°C).~~ 130°F).

A2. METHOD FOR ELECTROLYTIC CLEANING OF CORROSION TEST SPECIMENS AFTER EXPOSURE

A2.1 This method is known to be suitable for the metals and alloys listed in Table A2.1; other metals or alloys must be evaluated before use.

A2.2 After scrubbing, remove loosely attached corrosion products. Treat the specimen as a cathode in hot, diluted sulfuric acid under the following condition:

Test solution	sulfuric acid (5 weight %)
Inhibitor	2 mL organic inhibitor/litre of solution
Anode	carbon
Cathode	test specimen
~~Cathode current density~~	~~20 A/dm^2 (6.5 A/0.325 dm^2)~~
Cathode current density	20 A/dm^3 (6.5 A/0.325 dm^3)
~~Temperature~~	~~165°F (74°C)~~
Temperature	74°C (165°F)
Exposure period	3 min

A2.3 After the electrolytic treatment, scrub the specimens, while wet, with a stiff bristle brush. ~~A~~ Run a blank metal specimen ~~should be run~~ at the same time to ensure weight losses incurred by cleaning the corroded specimens are not included in the weight loss determination.

TABLE A2.1 Weight Losses of 0.5-dm^2 Specimens Subjected to Electrolytic Cleaning Treatment

Material	Total Weight Loss, g
Copper-nickel-zinc (75-20-5)	0.0000
Brass (admiralty)	0.0001
Brass (red)	0.0000
Brass (yellow)	0.0002
Bronze (phosphor, 5 % tin)	0.0000
Bronze (silicon)	0.0002
Bronze (case) (85-5-5-5)	0.0010
Copper	0.0001
Copper-nickel (70-30)	0.0000
Iron and steel	0.0003
Nickel-molybdenum-iron (60-20-20)	0.0004
Nickel-chromium-iron (80-13-7)	0.0000
Lead (chemical)	0.0030
Nickel-copper (70-30)	0.0000
Nickel	0.0011
Stainless steel	0.0000
Tin	0.0003
Magnesium and zinc	too high to be useful

A2.4 Note~~ that this electrolytic treatment may result in~~ the possible redeposition of adherent metal from reducible corrosion products~~,~~ (and thus lowering the apparent weight loss) resulting from this electrolytic treatment. However, general experience has indicated that in most cases of corrosion in liquids, the possible errors from this source are not likely to be serious.~~ Instead of using~~ Use either 2 mL of any proprietary inhibitor~~,~~ or about 0.5 g/L of such inhibitors as diorthotolyl thiourea, quinoline ethiodide, or beta-naphthol~~ quinoline may be used.~~ quinoline.

A3. CRITERIA FOR CORROSIVENESS OF ENVIRONMENT AND METAL CORRODIBILITY

A3.1 The corrosion results obtained by this method provides information on the corrosiveness of the environment and the corrodibility of the material under test in the environment. Therefore, R_1 is the initial corrosion rate of virgin metal per unit time, R_5 is the corrosion rate of metal per unit time after long exposure, and R_4 is the corrosion rate of virgin metal after long exposure of the corroding fluid to corroding metal. The significance of these values can be appreciated by comparing the corrosion rate R_1 for a unit time interval of 0 to 48 h with the corrosion rate for the unit time interval of 120 to 168 h, which shows the magnitude and direction of change in corrosiveness of the environment that~~ may have~~ possibly has occurred during the total time of the test. Comparisons of R_5, the corrosion rate of metal after long exposure, with R_4, where R_5 is the corrosion rate calculated by substracting R_2 from R_3, correspondingly shows the magnitude and direction of change in the corrodibility of the metal specimen during the test.~~ C~~ Therefore, take comparisons of corrosion rates R_1, R_4, and R_5~~ may, therefore, be taken~~ for possible changes in corrosiveness of the environment and corrodibility of the metal.

A3.2 Table A3.1 is the criteria for all possible combinations of changes and their significance.

TABLE A3.1 Criteria for Corrodibility Changes with Time

Effect of Time on Liquid Corrosiveness	Effect of Time on Metal Corrodibility	Criteria
Unchanged	unchanged	$R_1 = R_5 = R_4$
Unchanged	decreased	$R_5 < R_1 = R_4$
Unchanged	increased	$R_1 = R_4 < R_5$
Decreased	unchanged	$R_5 = R_4 < R_1$
Decreased	decreased	$R_5 < R_4 < R_1$
Decreased	increased	$R_1 > R_4 < R_5$
Increased	unchanged	$R_1 < R_5 = R_4$
Increased	decreased	$R_1 < R_4 > R_5$
Increased	increased	$R_1 < R_4 < R_2$

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