



Designation: D1384 – 24

Standard Test Method for Corrosion Test for Engine Coolants in Glassware¹

This standard is issued under the fixed designation D1384; 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 test method covers a simple beaker-type procedure for evaluating the effects of engine coolants on metal specimens under controlled laboratory conditions (see [Appendix X1](#)).

NOTE 1—For more information on engine coolants, see (Refs [1-8](#)).²

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered 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.* Specific hazard statements are given in [11.1.7.2](#), [11.1.7.3](#), and [11.1.7.4](#).

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:*³

[B32 Specification for Solder Metal](#)

[B36/B36M Specification for Brass Plate, Sheet, Strip, And Rolled Bar](#)

[D1176 Practice for Sampling and Preparing Aqueous Solutions of Engine Coolants or Antirusts for Testing Purposes](#)

[D4725 Terminology for Engine Coolants and Related Fluids](#)

[E1 Specification for ASTM Liquid-in-Glass Thermometers](#)

¹ This test method is under the jurisdiction of ASTM Committee D15 on Engine Coolants and Related Fluids and is the direct responsibility of Subcommittee D15.06 on Glassware Performance Tests.

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² The boldface numbers in parentheses refer to the list of references at the end of this standard.

³ 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.

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[E178 Practice for Dealing With Outlying Observations](#)

[E230 Specification for Temperature-Electromotive Force \(emf\) Tables for Standardized Thermocouples](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

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

2.2 *ASTM Adjuncts:*

All-glass apparatus for corrosion test (2 drawings)⁴

3. Terminology

3.1 *Definitions*—For definitions of general terms used in D15 standards, refer to Terminology [D4725](#).

3.2 *Abbreviations:*

3.2.1 *PTFE, n*—Polytetrafluoroethylene

4. Summary of Test Method

4.1 In this test method, specimens of metals typical of those present in engine cooling systems are totally immersed in aerated engine coolant solutions for 336 h at 88 °C (190 °F). The corrosion-inhibitive properties of the test solution are evaluated on the basis of the weight changes incurred by the specimens. Each test is run in triplicate, and the average weight change is determined for each metal. A single test may occasionally be completely out of line (see [12.2](#)).

5. Significance and Use

5.1 This test method will generally distinguish between coolants that are definitely deleterious from the corrosion standpoint and those that are suitable for further evaluation. However, the results of this test method cannot stand alone as evidence of satisfactory corrosion inhibition. The actual service value of an engine coolant formulation can be determined only by more comprehensive bench, dynamometer, and field tests.

6. Apparatus

6.1 *Container*—A 1000 mL, tall-form, spoutless beaker, made of heat-resistant glass, for containing the engine coolant

⁴ Details available from: ASTM International Headquarters. Order Adjunct No. [ADJD1384](#). Original adjunct produced in (1980).

solution and test specimens. The beaker shall be tightly closed with a No. 15 rubber stopper, having drill holes to accommodate a water condenser, an aerator tube, and a thermometer as shown in Fig. 1. Optionally, an all-glass apparatus may be used (Fig. 2).

6.2 *Condenser*—A water condenser of the reflux, glass-tube type, having a 400 mm (16 in.) condenser jacket.

6.3 *Aerator Tube*—A gas-dispersion tube, porosity size 40 μm to 60 μm to ensure continuous aeration without plugging. Optionally, a capillary tip bleed tube with a 7 mm (0.28 in.) bore and 280 mm (11.2 in.) length may be used when consistent early plugging of gas dispersion tubes occurs.

6.4 *Temperature Measuring Instrument (Environmentally Safe Thermometer or Thermocouple)*—An ASTM Partial Immersion Temperature Measuring Instrument having a range from -20 °C to 150 °C (0 °F to 302 °F) and conforming to the requirements for Thermometer 1C (1F), as prescribed in Specification E1 or Thermocouple as summarized in Specification E230.

6.5 *Heater*—A constant-temperature bath containing a high-boiling liquid or another suitable heating device that is capable of giving continuous service with the specified temperature control.

7. Metal Test Specimens

7.1 *Type*—Either one or both of the following metal test specimen bundles, representative of cooling system metals, may be used as agreed between customer and supplier (see Note 2):

NOTE 2—The specimens prescribed in this test method have been accepted by automobile manufacturers, but their composition may not be the same as that of alloys currently used for engine cooling system components. Therefore, specimens other than those designated in this test method may be used by mutual agreement of the parties involved.

NOTE 3—When assembling the test bundle, sizes are stated in SI units, adjustment to these units may be made to accommodate US customary units, that is, 51 mm or 2 in.

7.1.1 Test Specimen bundle with copper and copper alloy (“conventional bundle”).

7.1.1.1 *Steel*, UNS G10200 (SAE 1020),⁵ cut from 1.59 mm (1/16 in.) cold-rolled sheet stock to size 50.8 mm by 25.4 mm (2 in. by 1 in.). Chemical composition of the carbon steel is as follows: carbon, 0.17 % to 0.23 %; manganese, 0.30 % to 0.60 %; phosphorus, 0.040 % maximum; sulfur, 0.050 % maximum.

7.1.1.2 *Copper*, conforming to UNS C11000 (SAE CA110)⁵ or UNS C11300 (SAE CA113).⁵ Cold-rolled, cut from 1.59 mm (1/16 in.) sheet stock to size 50.8 mm by 25.4 mm (2 in. by 1 in.).

7.1.1.3 *Brass*, conforming to Alloy UNS C26000 (SAE CA 260).⁶ Half-hard, cut from 1.59 mm (1/16 in.) sheet stock to size 50.8 mm by 25.4 mm (2 in. by 1 in.).

7.1.1.4 *Solder*—A brass specimen as described in 7.1.1.3, coated with solder conforming to Alloy Grade 30A (SAE 3A) of Specification B32.⁶ Solder-coated specimens may be prepared by the procedure given in Annex A1. A solid solder specimen cut from 1.59 mm (1/16 in.) sheet stock of Alloy Grade 30A (SAE 3A) to size 50.8 mm by 25.4 mm (2 by 1 in.) may be used subject to mutual agreement of the parties involved. The use of a solid solder specimen must be reported along with the metal specimen weight loss results.

(1) When agreed upon between the supplier and the purchaser of engine coolants, the standard solder specimen may be replaced with one having a different alloy composition than standard Alloy Grade 30A or 30B. Use of specimens other than standard Alloy Grade 30A or 30B shall be noted in the test report.

NOTE 4—Where non-standard alloy is used, the standard flux shown in A1.1.5 may not be satisfactory. A low corrosive flux may be required.

7.1.1.5 *Cast Aluminum*, conforming to Alloy UNS A23190 (SAE 329).⁵ Specimen size, 50.8 mm by 25.4 mm by 3.18 mm (2 in. by 1 in. by 1/8 in.).

7.1.1.6 *Cast Iron*, conforming to Alloy UNS F10007 (SAE G3500).⁵ Specimen size, 50.8 mm by 25.4 mm by 3.18 mm (2 in. by 1 in. by 1/8 in.).

7.1.2 Test Specimen bundle with no copper, copper alloy, or steel test specimen (“aluminum bundle”).

⁵ UNIFIED numbering system for metals and alloys, SAE-ASTM, July 1995.
⁶ Round-robin evaluation of coated solder report is available from ASTM Headquarters. Request RR:D15-0132.

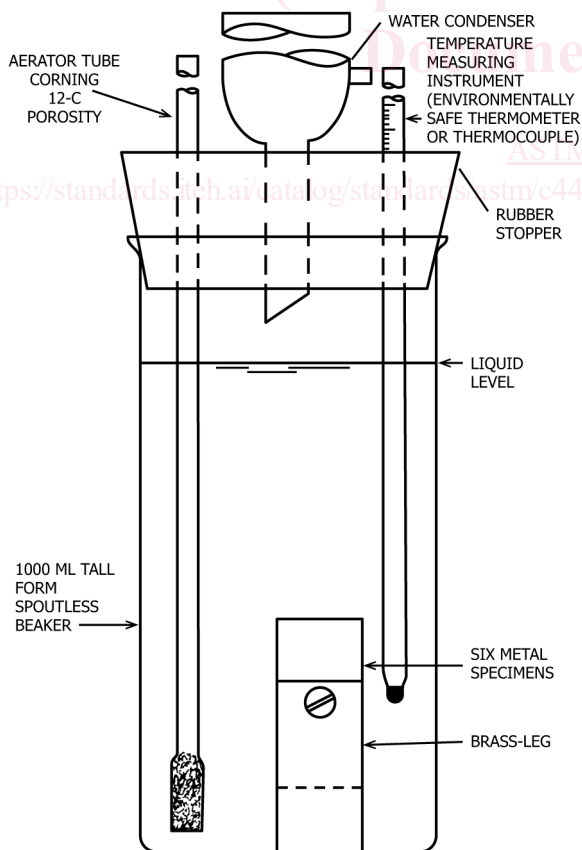


FIG. 1 Metal Specimens and Equipment for the 336 h Corrosion Test

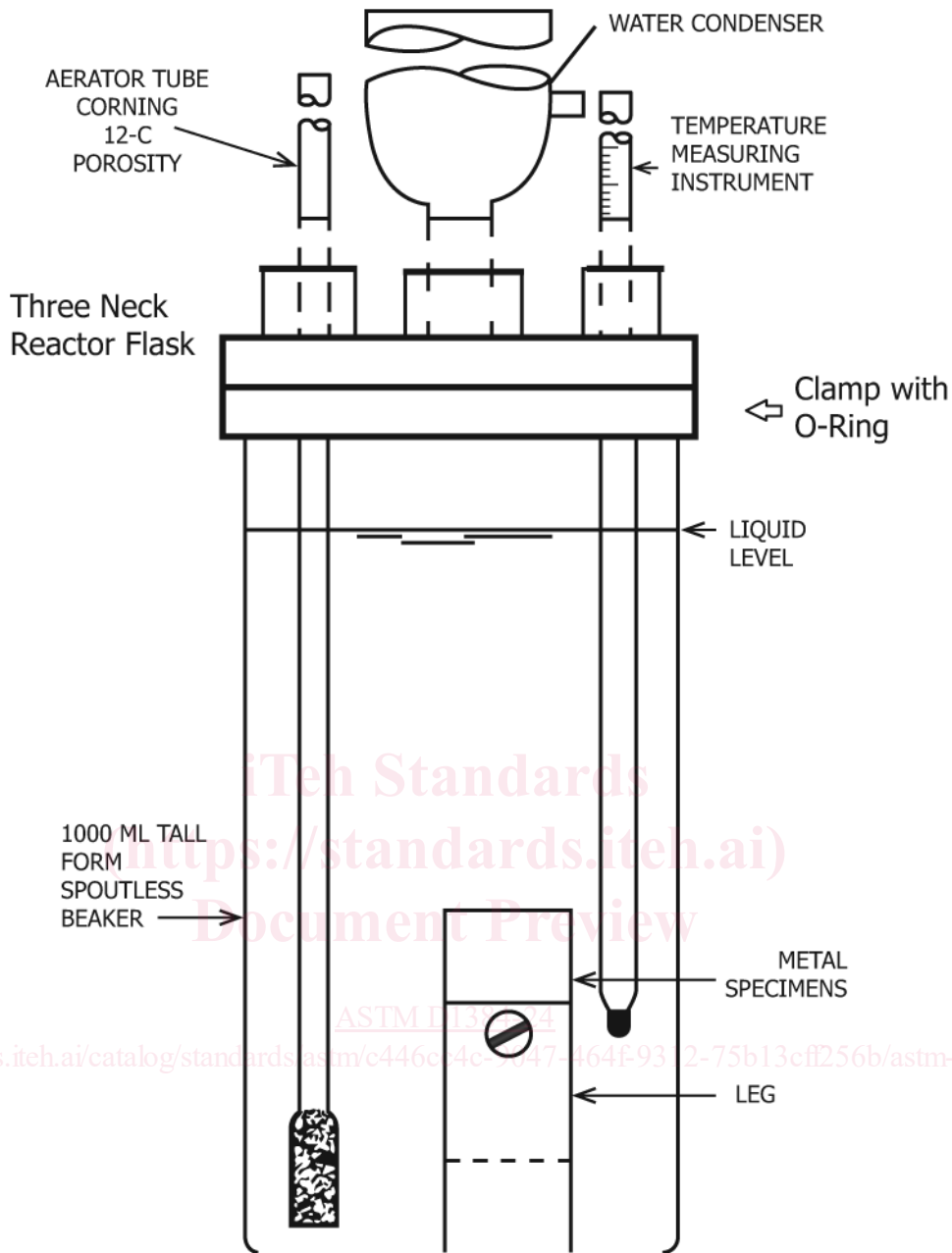


FIG. 2 Metal Specimens and All Glass Equipment for the 336 h Corrosion Test

7.1.2.1 *Aluminum 3003*, conforming to Alloy UNS A93003 (SAE 3003).⁵ Specimen size, 50.8 mm by 25.4 mm by 1.59 mm (2 in. by 1 in. by $\frac{1}{16}$ in.).

7.1.2.2 *Aluminum 319*, conforming to Alloy UNS A23190 (SAE 329).⁵ Specimen size, 50.8 mm by 25.4 mm by 3.18 mm (2 in. by 1 in. by $\frac{1}{8}$ in.).

7.1.2.3 *Aluminum 380.1*, conforming to Alloy UNS A13801 (SAE 306).⁵ Specimen size, 50.8 mm by 25.4 mm by 3.18 mm (2 in. by 1 in. by $\frac{1}{8}$ in.).

7.1.2.4 *Aluminum 7075*, conforming to Alloy UNS A97075 (SAE 7075).⁵ Specimen size, 50.8 mm by 25.4 mm by 1.59 mm (2 in. by 1 in. by $\frac{1}{16}$ in.).

7.1.2.5 *Aluminum 7075 Clad*, conforming to Alloy UNS A87075.⁵ Specimen size, 50.8 mm by 25.4 mm by 1.59 mm (2 in. by 1 in. by $\frac{1}{16}$ in.).

7.1.2.6 *Cast Iron*, conforming to Alloy UNS F10007 (SAE G3500).⁵ Specimen size, 50.8 mm by 25.4 mm by 3.18 mm (2 in. by 1 in. by $\frac{1}{8}$ in.).

7.2 Arrangement:

7.2.1 *Conventional Bundle (See Fig. 3): Metal Specimen Arrangement*—None of the hardware used in metal specimen arrangement (metal specimen, screws, washers, metal spacers, insulating sleeves, insulating spacers and nuts) can be reused for a test. The metal test specimens shall be drilled through the center with a 6.75 mm ($\frac{17}{64}$ in.) drill to accommodate a 50.8 mm (2 in.) 10–24 brass machine screw covered with a thin-walled insulating sleeve. Polytetrafluoroethylene (PTFE) tubing with a 6.35 mm ($\frac{1}{4}$ in.) outside diameter 1.59 mm ($\frac{1}{16}$ in.) wide and a wall thickness of 0.4 mm ($\frac{1}{64}$ in.) is

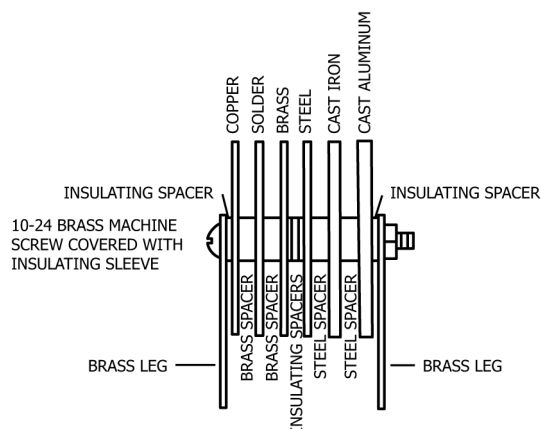


FIG. 3 Metal Specimen Arrangement

satisfactory. Two half-hard brass legs shall be cut from 1.59 mm ($\frac{1}{16}$ in.) sheet stock to size 50.8 mm by 25.4 mm (2 in. by 1 in.). A 6.35 mm ($\frac{1}{4}$ in.) diameter hole shall be drilled in each leg with the center 6.35 mm ($\frac{1}{4}$ in.) from the top and 12.7 mm ($\frac{1}{2}$ in.) from each side. The test “bundle” shall be made up on the insulated screw with the specimens in the following order: brass leg, copper, solder, brass, steel, cast iron, cast aluminum, and brass leg. The specimens shall be separated by 4.76 mm ($\frac{3}{16}$ in.) thick solid metal spacers having a 6.75 mm ($\frac{1}{4}$ in.) inside diameter and a 11.11 mm ($\frac{7}{16}$ in.) outside diameter. Insulating spacers made from polytetrafluoroethylene shall be used between the brass legs and the specimen “bundle,” and between the brass and steel specimens. Brass spacers shall be used between the brass, solder, and copper specimens, and steel spacers between the cast iron, steel, and cast aluminum specimens. The nut shall be tightened firmly to ensure good electrical contact between the test specimens in each section of the “bundle.”

7.2.2 *Alternate Metal Specimen Arrangement*—When agreed upon between the supplier and the purchaser, an alternate metal specimen arrangement may be used to evaluate multiple solder alloys, such as high lead Alloy Grade L50113⁶ consisting of 97 % lead, 2.5 % tin, 0.3 % silver, concurrently with Standard Alloy Grade 30A or 30B. It is recommended that the metal specimen arrangement be modified by replacing the copper specimen with the high lead solder specimen and arranging specimens in the bundle as follows:

High Lead Solder	Brass	Alloy Grade 30A or 30B	Steel	Cast Iron	Cast Aluminum
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Use of alternate specimens and metal specimens arrangements shall be noted in the test report.

7.2.3 *Aluminum Bundle Metal Specimen Arrangement* (See Fig. 4)—When agreed upon between the supplier and the purchaser, an aluminum metal specimen arrangement may be used to evaluate multiple aluminum alloys as specified in 7.1.2. The metal specimen arrangement shall be arranged as follows:

7.2.3.1 All the hardware used in metal specimen arrangement (metal specimen, screws, washers, metal spacers, insulating sleeves, insulating spacers, and nuts) shall be new and unused. The metal test specimens shall be drilled through the center with a 6.75 mm ($\frac{1}{4}$ in.) drill to accommodate a 50.8 mm (2 in.) 10–24 brass machine screw covered with a

thin-walled insulating sleeve. PTFE tubing with a 6.35 mm ($\frac{1}{4}$ in.) outside diameter 1.59 mm ($\frac{1}{16}$ in.) wide and a wall thickness of 0.4 mm ($\frac{1}{64}$ in.) is satisfactory. Two PTFE legs shall be cut from 1.59 mm ($\frac{1}{16}$ in.) sheet stock to size 50.8 mm by 25.4 mm (2 in. by 1 in.). A 6.35 mm ($\frac{1}{4}$ in.) diameter hole shall be drilled in each leg with the center 6.35 mm ($\frac{1}{4}$ in.) from the top and 12.7 mm ($\frac{1}{2}$ in.) from each side. The test “bundle” shall be made up on the insulated screw with the specimens in the following order: PTFE leg, AL3003, AL319, AL380.1, AL7075, AL7075 Clad, cast iron, and PTFE leg. The specimens shall be separated by 4.76 mm ($\frac{3}{16}$ in.) thick solid PTFE spacers having a 6.75 mm ($\frac{1}{4}$ in.) inside diameter and a 11.11 mm ($\frac{7}{16}$ in.) outside diameter. Insulating spacers made from PTFE shall be used between the PTFE legs and the specimen “bundle,” and between the specimens. The nut shall be tightened firmly.”

7.2.3.2 The use of alternate specimens and their arrangements shall be noted in the test report.

8. Preparation of Test Specimens

8.1 Sand the cast iron and cast aluminum specimens on the 25.4 mm by 50.8 mm (1 in. by 2 in.) cut surfaces with “coarse” grade (No. 1) emery cloth. Remove any burrs from coupon edges and hole. Scrub all specimens vigorously, using a moistened bristle brush and ground pumice powder or fine silicon carbide grit until the entire metal area is bright, shiny, and free from any visible oxide film or tarnish.

8.2 Rinse the specimens thoroughly with tap water; then rinse with acetone, dry, and weigh to the nearest 1 mg. Cast aluminum specimens should be dried in a 100 °C oven for 1 h, to a constant weight, prior to recording the weight.

NOTE 5—Test specimens that have been prepared by the specimen supplier in the manner described in this section may be used as supplied without further preparation.

NOTE 6—If the test specimens are not to be used immediately, keep them in a desiccator until required.

9. Test Solutions

9.1 The concentration of the engine coolant to be tested shall be as follows:

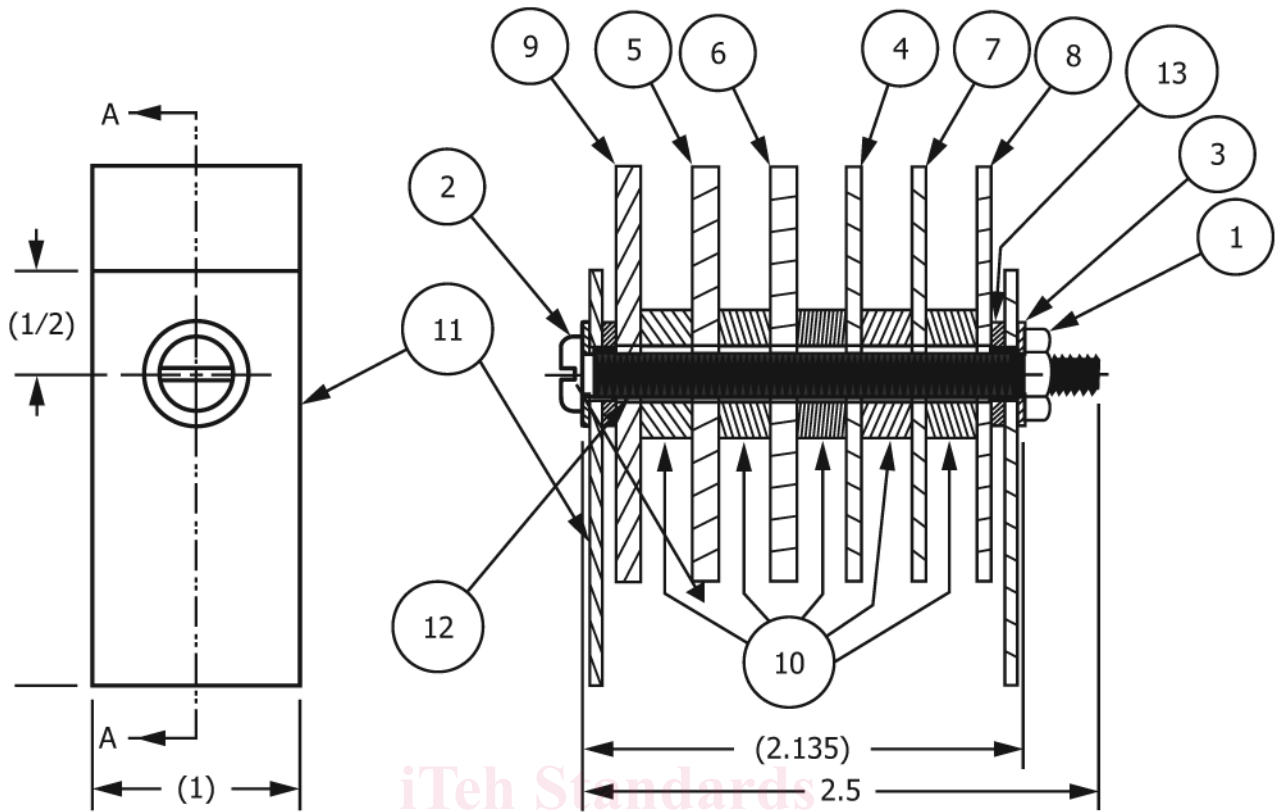
9.1.1 *Engine Coolant*—The engine coolant, EG or PG based, shall be mixed with the proper quantity of corrosive water to give a 33 $\frac{1}{3}$ volume % coolant test solution.

9.1.2 *Corrosive Water* (Note 7)—The corrosive water shall contain 100 ppm each of sulfate, chloride, and bicarbonate ions introduced as sodium salts.

9.2 *Preparation of Sample*—The preparation of the sample shall be done in accordance with the section on Preparation of Solutions Requiring Inclusion of Separated Solids and Liquids in Test Method D1176, except that the corrosive water shall be used for dilution instead of distilled water. Thus, any insoluble materials will be included in the representative sample.

NOTE 7—The specified corrosive water can be prepared by dissolving the following amounts of anhydrous sodium salts in a quantity of distilled or deionized water.

sodium sulfate	148 mg
sodium chloride	165 mg
sodium bicarbonate	138 mg



Item	Quantity	Description
1	1	10-24 Hex Nut
2	1	10-24 x 2 1/2" Pan Head Screw
3	2	#10 Flat Washer -Brass
4	1	AL3003 Corrosion Coupon
5	1	AL 319.0 Corrosion Coupon
6	1	AL380.1 Corrosion Coupon
7	1	AL7075 Corrosion Coupon
8	1	AL 7075 Clad (7-72 Cladding) Corrosion Coupon (edges bare)
9	1	Gray Cast Iron Corrosion Coupon
10	5	PTFE spacers
11	2	PTFE Leg
12	1	PTFE sleeve
13	2	PTFE spacers

FIG. 4 Aluminum Bundle Metal Specimen Arrangement

The resulting solution should be made up to a volume of 1 L with distilled or deionized water at 20 °C.

If relatively large amounts of corrosive water are needed for testing, a concentrate may be prepared by dissolving ten times the above amounts of the three chemicals, in distilled or deionized water, and adjusting the total volume to 1 L by further additions of distilled or deionized water. When needed, the water concentrate is diluted to the ratio of one part by volume of concentrate to nine parts of distilled or deionized water.

10. Test Conditions

10.1 *Beaker Assembly*—The arrangement of the assembled metal specimens with relation to the aerator tube and other components is shown in Fig. 1. Note that the tip of the condenser just emerges from the bottom of the rubber stopper.

10.2 *Test Temperature*—The test solution shall be maintained at a temperature of 88 °C ± 2 °C (190 °F ± 5 °F).

10.3 *Aeration Rate*—The aeration rate shall be 100 mL/min ± 10 mL/min. The aerator tube should be located at least

12.7 mm (1/2 in.) away from the test “bundle” to avoid direct contact with the metal specimens.

10.4 *Test Duration*—The test shall be run continuously for 2 weeks (336 h).

11. Procedure

11.1 Make triplicate tests concurrently on each engine coolant solution in accordance with the following procedure:

11.1.1 Carefully clean the test beaker, condenser, rubber stopper, and aerator tube, and thoroughly rinse with water.

11.1.2 Bolt the specimens together in the order given in 7.2 and place the “bundle” in the test beaker as shown in Fig. 1.

11.1.3 Pour 750 mL of the prepared test solution into the 1000 mL beaker.

11.1.4 Fit the condenser and aeration tube to the beaker, and set the aeration rate at 100 mL/min, using a flow meter or other suitable device.

11.1.5 Raise the temperature of the test solution to 88 °C (190 °F). Pass water through the condenser at a rate sufficient to maintain adequate cooling.

11.1.6 Check the tests once each working day to ensure proper solution temperature, aeration rate, and solution level. The tests may operate unattended on weekends and holidays. Make up evaporation losses during the corrosion tests by addition of distilled or deionized water.

11.1.7 At the end of the test, *immediately* disassemble specimens and brush very lightly with a soft bristle brush and water to remove loosely held corrosion products. To remove the more tenacious corrosion products and films, the individual specimens shall then be subjected to additional cleaning treatments as follows:

11.1.7.1 *Iron and Steel*—Remove adherent deposits by means of a brass scraper or brass bristle brush, followed by scrubbing with a wet bristle brush and fine pumice to clean the specimen completely.

11.1.7.2 *Copper and Brass*—Dip in a 1 + 1 mixture of concentrated HCl (sp gr 1.19) and water for 15 s to remove tarnish films, rinse with tap water to remove acid, and scrub with a wet bristle brush and fine pumice powder. (**Warning**—HCl is a strong acid. Avoid contact with skin and eyes. Handle in a fume hood.)

11.1.7.3 *Aluminum*—In a fume hood, dip for 10 min in an aqueous solution containing 4 parts concentrated nitric acid (HNO₃, 70 mass %) plus one part distilled water at 25 °C (76 °F). Rinse thoroughly with water, then brush very lightly with a soft bristle brush to remove any loose films, and again rinse with water.⁷ Dry the specimen in a 100 °C oven for 1 h, to a constant weight prior to recording the weight. (**Warning**—HNO₃ is a strong toxic oxidant and acid. Avoid contact with skin, eyes, and clothing. Do not breathe vapor. Handle in a fume hood.)

11.1.7.4 *Solder*—Immerse for 5 min in boiling 1 % glacial acetic acid. Rinse in water to remove the acid, and brush very gently with a soft bristle brush to remove any loosened material. (**Warning**—Avoid contact with skin and eyes with glacial acetic acid. Handle in a fume hood.)

11.1.8 The acid dip times given in 11.1.7 for the cleaning of nonferrous specimens are average values found to be adequate in most cases. Other times, suggested by experience, may be used if necessary, if gross weight losses are adjusted by the appropriate tare.

11.1.9 Follow each of the four operations noted above by thorough rinsing, first in tap water and then in acetone. Then dry and weigh the specimens to the nearest 1 mg. Store in a desiccator specimens that cannot be weighed immediately.

11.1.10 Because cleaning methods and materials may vary among laboratories, occasionally determine cleaning losses obtained by a particular operator on an untested set of triplicate metal specimens. Deduct the average cleaning losses from gross weight differences to determine actual corrosion losses.

12. Report

12.1 Report corrosion weight loss as a positive value and weight gain as a negative value. If no sign is given to the value it will be interpreted as a weight loss. *Example*: Initial weight of a brass specimen after cleaning was 405 mg. At the end of test after cleaning it was 398 mg. The cleaning blank was determined by taking the weight of a brass specimen after the initial cleaning, 406 mg, and then cleaning it alongside of the brass specimen removed at the end of the test, 404 mg. Using the equation below, calculate the weight change of the specimen.

$$\begin{aligned} &(\text{Initial weight} - \text{end of test weight}) - (\text{Cleaning} \\ &\text{blank} - \text{cleaning blank recleaned alongside of end of test} \\ &\text{specimen}) = \text{Final reported weight change} \\ &(405 \text{ mg} - 398 \text{ mg}) - (406 \text{ mg} - 404 \text{ mg}) = 5 \text{ mg} \\ &\text{(positive value means that it is a weight loss)} \end{aligned}$$

12.1.1 Report the corrected corrosion weight changes of individual specimens to the nearest 1 mg for each test.

12.2 Report the average corrected metal weight change for triplicate tests on each engine coolant solution. A single weight change that appears completely out of line should be dealt with as described in Practice E178.

13. Precision and Bias

13.1 The precision of this test method is based on an interlaboratory study of ASTM D1384 – Corrosion Test for Engine Coolants, completed in 2021. Eight laboratories participated, testing up to five different coolants against a standard bundle of coupons and an alternate bundle (described below). Two of the laboratories submitted repeatability data. Every “test result” represents an individual determination. Except for the lack of consistent replicates, Practice E691 was followed for the design of the study and analysis of the data; the details are given in ASTM Research Report No D15-2000.⁸

13.1.1 *Repeatability limit (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty.

13.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.1.2 Repeatability standard deviations are listed in Tables 9 and 10.

13.1.2 *Reproducibility limit (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty.

⁷ A round-robin evaluation of nitric acid cleaning of aluminum specimens is available from ASTM Headquarters. Request RR:D15-1018.

⁸ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D15-2000. Contact ASTM Customer Service at service@astm.org.