Designation: D2688 – 15

StandardTest Method for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Method)[1]

This standard is issued under the fixed designation D2688; 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 the determination of the corrosivity of water by evaluating pitting and by measuring the weight loss of metal specimens. Pitting is a form of localized corrosion: weight loss is a measure of the average corrosion rate. The rate of corrosion of a metal immersed in water is a function of the tendency for the metal to corrode and is also a function of the tendency for water and the materials it contains to promote (or inhibit) corrosion.

1.2 The test method employs flat, rectangular-shaped metal coupons which are mounted on pipe plugs and exposed to the water flowing in metal piping in municipal, building, and industrial water systems using a side stream corrosion specimen rack.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *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:*[2]

D1129 Terminology Relating to Water
D2331 Practices for Preparation and Preliminary Testing of Water-Formed Deposits
D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
G16 Guide for Applying Statistics to Analysis of Corrosion Data

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology D1129.

4. Significance and Use

4.1 Since the two tendencies are inseparable for a metal to corrode and for water and the materials it contains to promote or inhibit corrosion, the corrosiveness of a material or the corrosivity of water must be determined in relative, rather than absolute, terms. The tendency for a material to corrode is normally determined by measuring its rate of corrosion and comparing it with the corrosion rates of other materials in the same water environment. Conversely, the relative corrosivity of water may be determined by comparing the corrosion rate of a material in the water with the corrosion rates of the same material in other waters. Such tests are useful, for example, for evaluating the effects of corrosion inhibitors on the corrosivity of water. Although this test methods is intended to determine the corrosivity of water, it is equally useful for determining corrosiveness and corrosion rate of materials. Examples of systems in which this method may be used include but are not limited to open recirculating cooling water and closed chilled and hydronic heating systems.

5. Composition of Specimens

5.1 The specimens shall be similar in composition to the piping in the system in which the corrosion test is being made.

6. Effect of Cold Working on Corrosion

6.1 Cold working can be important in causing localized corrosion; however, plastic deformation can be minimized in specimen preparation by following proper machining practices (**1**)[3] (for example, drilling, reaming, and cutting specimens).

[1] This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.03 on Sampling Water and Water-Formed Deposits, Analysis of Water for Power Generation and Process Use, On-Line Water Analysis, and Surveillance of Water.

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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.

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

7. Types of Corrosion

7.1 *General Corrosion*—Characterized by uniform attack of the metal over the entire surface.

7.2 *Pitting*—A form of localized corrosion, the depth, number, size, shape, and distribution of pits being pertinent characteristics. It may be evaluated by counting the number, by noting the size, shape, and distribution, and by measuring the depth of pits in representative areas. Both sides of the coupons must be examined.

7.2.1 A system may be devised for grading pitting (**2**).

7.3 *Crevice Corrosion*—A pertinent factor to consider in corrosion testing, since active corrosion sites may develop in such locations. Crevices may exist at threads and joints and under deposits, as well as in corrosion specimens. In this method, crevice corrosion may be in evidence where the specimen is fastened to the holder and at coupon markings. Providing a large specimen surface area relative to the crevice area reduces this influence on the overall corrosion results. Light sanding is necessary to remove edges of coupon marking.

7.4 *Edge Corrosion*—The increased corrosion that occurs at edges of corrosion specimens, where the metal may be of different composition or structure, must be given attention. In this method, specimens of a high ratio of surface area to edge area reduce this effect. If an abnormally high degree of edge corrosion is observed, the effect may be evaluated by measurement of the specimen dimensions previous to and following exposure. Use of a specimen of less thickness may also reduce the edge effect in weight loss.

7.5 *Impingement Attack (Erosion-Corrosion)*—associated with turbulent and high-velocity flow, particularly when soft metals and copper are involved, is characterized by continuous broader-type pits and bright metal from which protective films have been scoured away. Some under-cutting also may be present.

8. Water-Formed Deposits

8.1 Water-formed deposits observed on the specimens may be analyzed by the methods listed in Practices D2331. The most common constituents will be calcium, magnesium, aluminum, zinc, copper, iron, carbonate, phosphate, sulfate, chloride, and silica.

9. Summary of Test Method

9.1 Carefully prepared, weighed metal coupons are installed in contact with flowing water for a measured length of time. After removal from the system, these coupons are examined, cleaned, and reweighed. The corrosivity and fouling characteristics of the water are determined from the difference in weight, the depth and distribution of pits, and the weight and characteristics of the foreign matter on the coupons.

10. Interferences

10.1 Deviation in metal composition or surface preparation of the coupons may influence the precision of the results.

10.2 The presence of different metals in close proximity to the coupon, (within 76 mm (3 in.)), even if they are insulated from the coupon, constitutes a source of error in the results.

10.3 Deviations in the velocity and direction of flow past the coupons may influence the precision of the results.

10.4 Results are directly comparable only for the water temperature to which the coupon is exposed.

10.5 Crevices, deposits, or biological growths may affect local corrosivity; results should therefore be interpreted with caution.

11. Apparatus

11.1 *Coupon Specimens*—Prepare coupons in accordance with Section 13.

11.2 *Insulating Washer, Screw, and Nut*—Use for attaching the coupon to the mounting rod. The insulating washer has a sleeve that fits into the coupon hole and around the screw.

NOTE 1—The insulating washer may be eliminated if a non-metal screw and nut are used. Screws and nuts of nylon or TFE fluorocarbon have been found satisfactory for this purpose.

11.3 *Specimen Mounting Plug*—Use a 152-mm (6-in.) length of 9.5-mm (0.375-in.) outside diameter PVC, CPVC, or TFE fluorocarbon rod, or equivalent, attached at one end to a drilled PVC, CPVC, or malleable iron pipe plug, and having a flat surface and a hole at the other end suitable for attachment of the test specimen. The pipe plug shall have a saw slot or other suitable witness mark to indicate the orientation of the test specimen when it is mounted in the bypass rack.

11.4 *Bypass Specimen Rack,* as illustrated in Fig. 1, for installation of coupon specimens. The piping, valves, and fittings of the corrosion rack shall be constructed of 2.5 cm (1 in.) Schedule 40 carbon steel, stainless steel, or Schedule 80 PVC or CPVC pipe. If necessary, the rack can be constructed of 16.8-mm (¾-in.) Schedule 40 carbon steel, stainless steel, or Schedule 80 PVC or CPVC pipe. This allows for a lower flow rate to achieve adequate velocity but leaves less clearance around the coupon and may trap more debris. If a 16.8-mm (¾-in.) rack is used, a strainer should be installed ahead of the rack to prevent debris from entering the rack.

11.5 *Dial Depth Gage*—A gage with a knife-edge base, pointed probe, and dial indicator for measurement of pit depth.

11.6 *Emery Paper,* Number 0.

12. Materials

12.1 *Vapor Phase Inhibitor Paper*—Envelopes constructed of vapor phase inhibitor paper are commercially available. Vapor phase inhibitor paper for wrapping coupons is also commercially available.

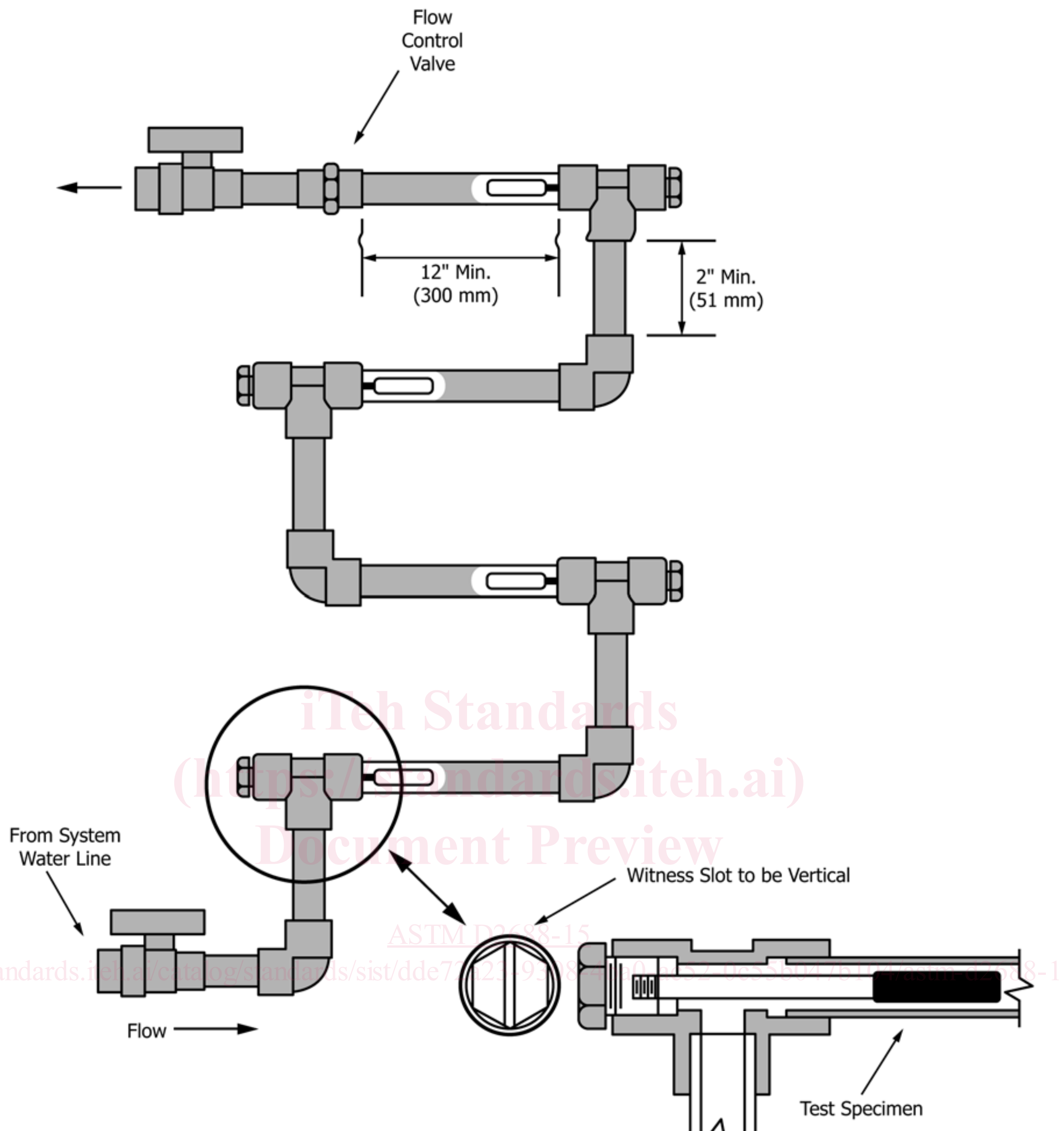

FIG. 1 Installation of Corrosion Coupons

13. Coupon Preparation

13.1 In this procedure, coupons are to be made principally from sheet metal; however, in a few cases, as with cast iron or cast bronze, it may be necessary to prepare coupons from castings.

13.2 Use a coupon size of 13 by 76 by 1.6 mm (0.5 by 3.0 by 0.0625 in.) for all sheet metals; and a 13 by 76 by 3 mm (0.5 by 3.0 by 0.125 in.) for cast metals. Other sizes are suitable, providing the total area is about 259 mm^2 (4 in.^{2}), the principal requirement being to keep the flat area large compared to the edge area.

13.3 *Sheet Metal Coupon Preparation*—Obtain sheet metal of the type desired except for stainless steel; use cold-rolled steel free of rust spots for ferrous metal. Obtain stainless steel with a No. 4 finish.[4]

13.3.1 Shear 14-gage sheet metal material to the dimensions of 13 by 75 mm (0.5 by 3.0 in.).

13.3.2 Drill or punch a 5 mm (0.019 in.) hole with its center about 3 mm (⅛ in.) from one end of the coupon.

[4] *Metals Handbook*, Vol 1, American Society for Metals, Metals Park, OH 44073, 1961, p. 430.

TABLE 1 Flow versus Velocity

Flow Rate	Schedule 40 Rack Steel or Stainless Steel Rack		Schedule 80 Rack PVC Rack	
	19 mm (¾ in.) Nominal Pipe Size; m/sec (ft/sec)	25 mm (1 in.) Nominal Pipe Size; m/sec (ft/sec)	19 mm (¾ in.) Nominal Pipe Size; m/sec (ft/sec)	25 mm (1 in.) Nominal Pipe Size; m/sec (ft/sec)
8 lpm (2 gpm)	0.37 (1.20)	0.23 (0.74)	0.45 (1.48)	0.27 (0.89)
11 lpm (3 gpm)	0.55 (1.80)	0.34 (1.11)	0.68 (2.22)	0.41 (1.34)
15 lpm (4 gpm)	0.73 (2.40)	0.45 (1.48)	0.90 (2.96)	0.54 (1.78)
19 lpm (5 gpm)	0.91 (3.00)	0.56 (1.85)	1.13 (3.71)	0.68 (2.23)
26 lpm (7 gpm)	1.28 (4.21)	0.79 (2.60)	1.58 (5.19)	0.95 (3.12)
38 lpm (10 gpm)	1.83 (6.01)	1.13 (3.71)	2.26 (7.41)	1.36 (4.45)
45 lpm (12 gpm)	2.20 (7.21)	1.36 (4.45)	2.71 (8.89)	1.63 (5.35)
53 lpm (14 gpm)	2.56 (8.41)	1.58 (5.19)	3.16 (10.37)	1.90 (6.24)
61 lpm (16 gpm)	2.93 (9.61)	1.81 (5.93)	3.61 (11.86)	2.17 (7.13)
64 lpm (17 gpm)	3.12 (10.22)	1.92 (6.30)	3.84 (12.60)	2.31 (7.57)

13.3.3 Deburr all sharp edges on the coupon specimen using a file or emery belt, and deburr the hole with an oversize drill.

13.3.4 Stamp identifying numbers or letters on the coupon area below the mounting hole.

13.4 *Cast Metal Coupon Preparation* —Obtain rough castings of the desired metal, measuring about 19 by 114 by 6 mm (¾ by 4½ by ¼ in.) from a commercial foundry or elsewhere.

13.4.1 Surface grind to the dimensions of 13 by 102 by 3 mm (0.5 by 4.0 by 0.125 in.) and a surface roughness of about 124 µin.

13.4.2 Drill a 7-mm (9⁄32-in.) hole with its center about 8 mm (5⁄16 in.) from one end of the coupon.

13.4.3 Deburr all sharp edges on the coupon specimen using a file or emery belt, and deburr the hole with an oversize drill.

13.4.4 Stamp identifying numbers or letters on the small coupon area between the edge and the mounting hole.

13.4.5 The approximate weight of metal coupons, g, is as follows:

Steel	10.35
Cast Iron	11.65
Copper	13.33
Zinc	8.7
Lead	16.60

13.5 *Cleaning Metal Coupons*—Degrease and clean corrosion in specimens in accordance with Practice .

14. Procedure

14.1 Weigh the clean, dry specimens on an analytical balance to the nearest 0.0001 g.

14.2 After weighing, store the specimens in a desiccator until ready for use. If storing in a desiccator is inconvenient or impractical, use an alternative method for providing a corrosion-free atmosphere.

14.3 Store coupons in separate envelopes made from vapor phase inhibitor-impregnated paper or in envelopes and wrapped in vapor-phase inhibitor-impregnated paper.

14.4 Attach the coupon to the mounting rod, using a plastic screw and nut or using an insulating washer to preclude any contact of coupon with the metal screw and nut assembly. For added protection, attach the specimen to the holder using a non-metal screw and nut.

14.5 The coupons should be placed into the corrosion coupon rack following the galvanic series in seawater. This means that the most active (least noble) metal be first in the flow path. Other coupons follow the galvanic series. This prevents the more noble metal from cathodically depositing on the more active metal or alloy.

14.6 Install the holder and coupon assembly in a suitable line or in a bypass piping arrangement as shown in Fig. 1.

14.7 Adjust the rate of flow of water in the test piping to a rate that gives a flow velocity that corresponds to the normal flow in those parts of the system under prime consideration. Normally, the flow velocity will be in the range from 0.4 to 1.8 m (1.5 to 6 ft)/s. Check and readjust the flow as necessary to maintain the desired rate. See Table 1.

14.8 Remove specimens from the system at chosen intervals. Since the corrosion will be high initially and then fall to a lower, nearly constant rate, two time series should be chosen.

14.8.1 Use short time intervals for the first time series in order to establish the rate at which passivity occurs. Removal of three or four sets of coupons at 4 to 7-day intervals is recommended.

14.8.2 Use long time intervals for the second time series in order to establish the mean steady-state corrosion rate. Removal of the first coupons after 1 month and the remaining coupons at 1 to 3-month intervals is recommended.

14.9 Protect the specimen if it cannot be examined, cleaned, and reweighed immediately after removal from the system. Dry between paper towels. Store the ferrous metal coupons in separate envelopes made from vapor phase inhibitor-impregnated paper or wrap carefully in plastic film. For nonferrous metal coupons, wrap carefully in plastic film. The interim period between removal of specimens and reweighing should be kept to a minimum and in no case should it exceed 1 week.

14.10 Examine the specimen and record either by photograph or by description the appearance of the specimen, paying particular attention to the amount and nature of any adherent deposit. Chemical analysis of the deposit may be performed in accordance with Practices D2331, but this step is optional.

14.11 For ferrous coupons, use one of the following alternative procedures for cleaning the coupon prior to reweighing.

14.11.1 Clean the coupons as well as possible with a plastic knife. Remove oily and greasy deposits in accordance with Practice . Remove remaining loose corrosion products by brushing with a bristle brush. Remove corrosion products in accordance with Practice .