



Standard Practice for Conducting Atmospheric Corrosion Tests on Metals¹

This standard is issued under the fixed designation G50; 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 practice covers and defines conditions for exposure of metals and alloys to the weather. It sets forth the general procedures that should be followed in any atmospheric test. It is presented as an aid in conducting atmospheric corrosion tests so that some of the pitfalls of such testing may be avoided. As such, it is concerned mainly with panel exposures to obtain data for comparison purposes.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- D2010/D2010M Test Methods for Evaluation of Total Sulfation Activity in the Atmosphere by the Lead Dioxide Technique
- G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
- G33 Practice for Recording Data from Atmospheric Corrosion Tests of Metallic-Coated Steel Specimens
- G46 Guide for Examination and Evaluation of Pitting Corrosion
- G84 Practice for Measurement of Time-of-Wetness on Surfaces Exposed to Wetting Conditions as in Atmospheric Corrosion Testing

¹ This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.04 on Atmospheric Corrosion.

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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.

- G91 Practice for Monitoring Atmospheric SO₂ Deposition Rate for Atmospheric Corrosivity Evaluation
- G92 Practice for Characterization of Atmospheric Test Sites
- G140 Test Method for Determining Atmospheric Chloride Deposition Rate by Wet Candle Method

3. Significance and Use

3.1 The procedures described herein can be used to evaluate the corrosion resistance of metals when exposed to the weather, as well as to evaluate the relative corrosivity of the atmosphere at specific locations. Because of the variability and complexity of weather effects and the industrial and natural factors influencing the atmospheric corrosivity of a test site, a multi-year exposure period should be considered to minimize their influence. Also, as corrosivity may vary at a site from season to season, exposures should be made either at the same time of the year to minimize variability or these differences should be established by multiple exposures.

3.2 Control specimens should always be employed in weathering tests. The control specimens should be from a material having established weathering characteristics. A substantial amount of corrosion data shall have been accumulated for the control specimens. It is also good practice to retain samples of all materials exposed so that possible effects of long-term aging can be measured.

4. Test Sites

4.1 Test sites should be chosen at a number of locations representative of the atmospheric environments where the metals or alloys are likely to be used. If such information is not available, the selection should include sites typical of industrial, rural, and marine atmospheres. Test site characterization, if needed, shall be conducted in accordance with Practice G92.

4.2 Exposure racks should be located in cleared, well-drained areas such that the exposed specimens will be subjected to the full effects of the atmosphere at the location of the test site. Shadows of trees, buildings, or structures should not fall on the specimens, and local contamination of the atmosphere should be avoided, unless the specific influences of such conditions are intended to be assessed.

4.3 In special cases, the exposure racks may be partially sheltered to allow accumulation of corrosive materials from the

air but at the same time prevent washing by rain. If sheltering is used, its purpose and configuration should be described in detail.

4.4 If local pollution effects are to be investigated, the samples should be exposed at different distances from the source and at different elevations. Where it is particularly important to obtain corrosion rates involving a micro-environment, samples should be mounted directly on the structure involved. Suitable attachment must be devised for each case.

5. Exposure Racks and Frames

5.1 Test racks and frames should be constructed of a material that will remain intact for the entire proposed period of exposure. Galvanized pipe has been found adequate for rack construction in most environments (Note 1). Type 304 stainless steel is adequate as a frame material for all environments. For marine exposures, alloy 400 UNS No. N04400 or Type 316 stainless steel has also been successfully used. Aluminum (5052 and 6061-T6) and copper frames also have given satisfactory service in a wide range of environments. Care should be observed in the use of copper frames, as corrosion products splashed during rainfall might affect the corrosion of other metals such as aluminum or magnesium.

NOTE 1—If galvanized pipe is field-threaded, thread areas must be protected to ensure joint integrity for long exposure periods. In severe environments, additional coatings may be required to provide corrosion-free service.

5.2 Racks and frames also may be constructed of wood. Insulators may be attached to wooden frames with aluminum bronze, alloy 400, or stainless steel screws. In such a case, no wood sections should be used with dimensions less than 2 by 4 in. (50 by 100 mm), and at least two coats of an exterior grade paint or enamel over a suitable primer must be applied. Periodic maintenance will be required on all wood construction.

5.3 Solid, glazed, electrical insulator knobs should be used to hold the specimens on the frames, using stainless steel, alloy 400, aluminum, nylon, or bronze bolts and nuts. Specimens shall be mounted in the grooves of these insulators. In selecting fasteners for use on specific frame materials, care should be taken to avoid unfavorable galvanic relationships.

5.4 A suitable frame for mounting the insulators is shown in Fig. 1. This frame will accommodate 70 standard 4 by 6-in. (100 by 150-mm) specimens; other sizes can be mounted by rearranging the insulators in the holes provided. It is acceptable to slot the holes in the frames in such a manner that the mounting frames are adjustable for specimens of other sizes. This is a convenience when it is not possible to prepare specimens of a preplanned size, and it is often helpful in fitting the specimens snugly into the frames.

5.5 The racks should be designed to give exposure to as large an area of the underside of the specimens as possible. Structural members of the rack should not be located directly under the specimens where they would shelter the underside of the specimens.

5.6 As most published data on atmospheric corrosion of metals are based on an exposure angle of 30° from the horizontal, facing south, it is recommended that this angle be used. Racks should be designed so that the lowest specimens are at least 30 in. (760 mm) above the ground. See Notes 2 and 3.

NOTE 2—Maximum exposure to the sun may be obtained by exposing specimens facing south (for the northern hemisphere) at an angle equal to the latitude of the test site. Exposure at this angle will yield the lowest corrosion rates for most materials. Although these corrosion rates will change at other angles of exposure, the order of merit established for each material will be the same.

NOTE 3—In special instances, it may be desirable to orient racks and frames in the direction of a specific corrodent source, for example, the ocean, for marine environments. Also, this practice should not be construed as prohibiting special orientation of test frames for specific test purposes, but it is strongly suggested that in such cases testing also be done in accordance with this practice so that a basis point for comparison with available data is determined. Any special orientation or preferential source of corrosion should be specifically identified in the exposure site description.

5.7 A rack of the design and dimensions shown in Fig. 2 will give the correct exposure angle and can support the specimen frame described in 5.4.

5.8 The ground under the racks should be kept free of weeds, bushes, and debris. Organic herbicides, defoliants, or pesticides should not be used for this purpose.

6. Test Specimens

6.1 When the material to be tested is in sheet form, a specimen size of 4 by 6 in. (100 by 150 mm) is appropriate. Specimens may be larger, for example, 4 by 8 in. (100 by 200 mm), to suit a particular test; however, the specimens preferably should not be smaller than 4 by 6 in.

6.2 To assure adequate rigidity of the specimens on the rack, a minimum thickness of 0.030 in. (0.75 mm) is suggested. It may be difficult to accommodate thicknesses greater than 0.250 in. (6.25 mm) in the insulator grooves. (Special deep-throated insulators can be obtained to accommodate thicker specimens, or the edges of thicker specimens can be machined to fit standard insulators.)

6.3 When it is desired to test samples of odd shapes, such as bolts, nuts, pipes, angles, assemblies, and structures, etc., a means of supporting them in the test racks must be devised. It is important that the specimens be electrically insulated from their respective supports and from each other to prevent unintentional galvanic corrosion. However, if desired, galvanic couples of dissimilar metals can be exposed on these frames. Efforts should be made to minimize crevices between specimens and support materials.

6.4 The total number of test specimens required should be determined from a knowledge of the duration of the test and the planned removals of the specimens for intermediate evaluations. Usually it should not be necessary to remove specimens prior to completing one year's exposure, unless specific data are required for corrosion occurring during earlier stages of exposure. For reliable results, sufficient specimens should be used for multiple removals at each exposure period. Triplicate specimens for each examination period will usually satisfy this

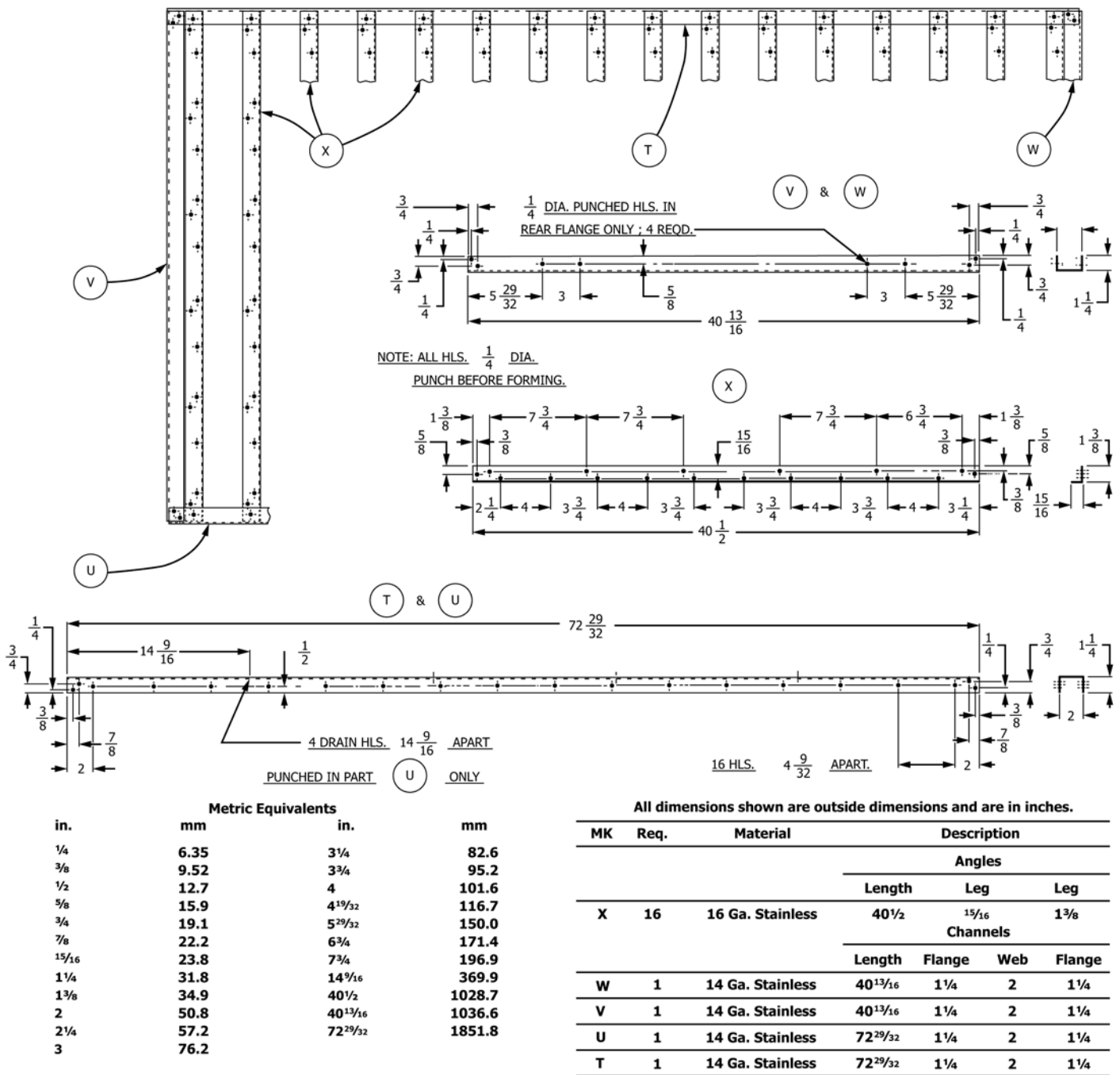


FIG. 1 Suitable Test Frame

requirement. A suggested suitable removal schedule is 1, 2, 4, 8, and 16 years. Removal schedules for tests of different periods of total exposure should be adjusted accordingly.

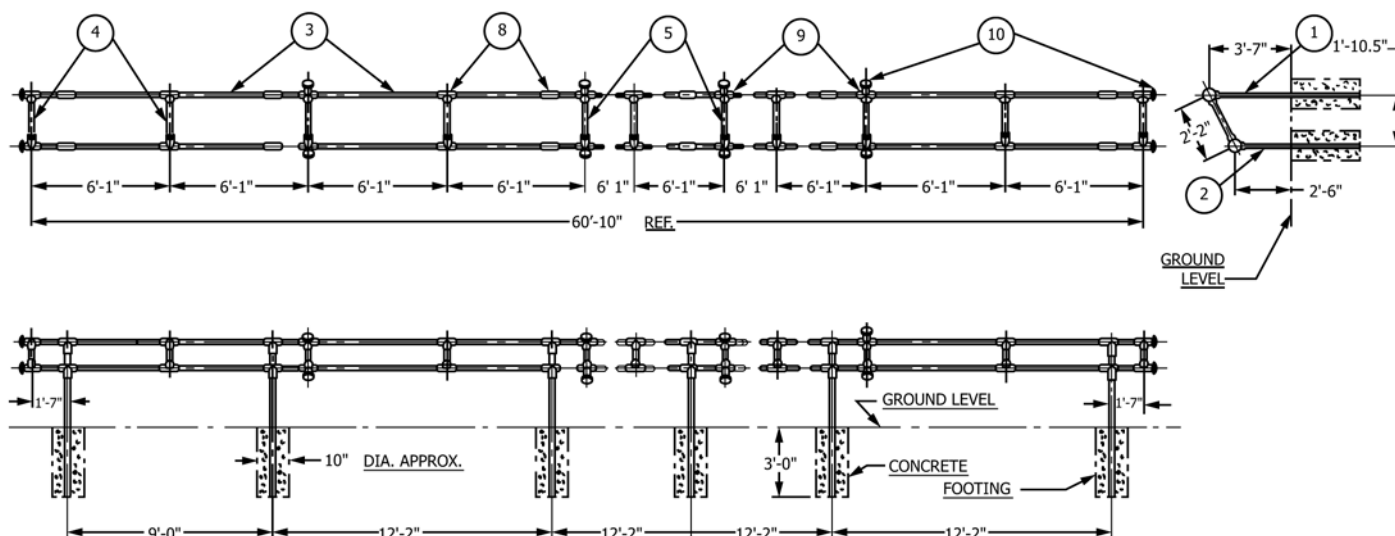
6.5 Included with each series of test specimens should be an appropriate number of control specimens, as defined in 3.2.

7. Preparation of Test Specimens

7.1 Specimens should be identified in a manner that will endure for the life of the test. A good method is the use of a series of edge notches or drilled holes in the body of the specimen arranged according to some desired code. Another

method is to attach a stainless steel tag by means of an insulated cord and a suitably located hole. Numbers stamped on the back of the specimen and further protected by covering with a good grade of electrical tape is a suitable technique for short-term exposure tests. For materials that do not exhibit significant atmospheric corrosion (copper, aluminum, stainless steels, etc.), it is sufficient to stamp the identification on the face of the panel.

7.2 Oil, grease, and dirt should be removed by degreasing with a solvent cleaner or scrubbing, or both, to remove insoluble soils (see Practice G1). Any mill scale or rust should



NOTE 1—Items 1, 2, 3, 4, 5, and 8 are 1¼-in. (31.8-mm) hot-dip galvanized pipe.

NOTE 2—Fill all legs with concrete to about 6 in. (152 mm) above ground line.

Metric Equivalents

ft-in.	m	ft-in.	m	Req.	Item	Name
0-0	0.254	3-7	1.092	12	10	Plugs
1-7	0.483	5-5½	1.654	8	9	4-way fittings
1-10¼	0.565	6-1	1.854	26	8	Tees
1-10.5	0.572	6-6⅝	1.984	4	5	Joining braces 28¾ in. L
2-2	0.660	9-0	2.743	7	4	Cross braces 22¼ in. L
2-4¾	0.730	11-9½	3.594	10	3	Stringers 11 ft – 9½ in. L
2-6	0.762	12-2	3.708	6	2	Front legs 5 ft – 5⅝ in. L
3-0	0.914	60-10	18.542	6	1	Back legs 6 ft – 6⅝ in. L

FIG. 2 Suitable Test Rack Support

be removed from all ferrous specimens unless it is specifically desired to perform the test with the mill scale intact. Pickling with inhibited acid as well as blasting with sand or grit are acceptable descaling methods. If acid pickling is used, care must be taken to stop the pickling action as soon as the mill scale and rust have been removed. Stainless steels should be pickled in accordance with Practice A380 to ensure surfaces free of iron contamination.

7.3 Specimens should be weighed to at least the nearest 0.01 g before exposure. More corrosion-resistant materials are frequently weighed to the nearest 0.1 mg. When deemed appropriate, the specimens should be photographed to take into account pre-exposure surface defects. Records should be kept of the weight, dimensions, and appearance of each specimen at the beginning of the test. Data to be recorded prior to exposure are explicitly outlined in Practice G33. Changes in the physical appearance and any corrosion losses of the specimens due to weathering can then be determined. If information on changes in mechanical properties is desired, initial measurements should be determined on materials in test (see also 3.2). For materials that change their mechanical properties on aging at the temperature of the test site, mechanical properties shall be determined on separate specimens stored at that temperature but protected from corrosion.

8. Procedure

8.1 Mount the specimens on the racks so that they are supported by the insulators and do not make electrical contact with each other or with the supporting racks.

8.2 Atmospheric factors such as time of wetness of the specimens, temperature of the specimens, and the concentration of atmospheric contaminants such as sulfur dioxide and chlorides in the local environment have a great influence on the corrosion rate of many metals, particularly in the early stages of exposure. Therefore, if possible, expose the test materials in an environment similar to that to which they will be subjected in actual use. Measurement of sulfate levels shall be made in accordance with Practice G91. Measurement of chloride levels shall be made in accordance with Practice G140. Measure of time-of-wetness shall be measured in accordance with Practice G84.

8.3 Periodic observations of weather factors and a means for determining atmospheric variables may be incorporated in the test.³ Also see Test Method D2010/D2010M.

³ Guttman, H., and Sereda, P. J., "Measurement of Atmospheric Factors Affecting the Corrosion of Metals," *Metal Corrosion in the Atmosphere*, ASTM STP 435, ASTM, 1968, pp. 326–359.

8.4 Make periodic evaluations as to the conditions of both the top (skyward) and the bottom (groundward) surfaces, noting whether or not any oxide coating is tightly adhering or if it continues to flake off as it oxidizes. Also record the color of the oxide coating, uniformity, and texture. Make such evaluations annually, whether specimens are removed or not. Data to be recorded during exposure are also outlined in Practice **G33**.

8.5 Establish a removal schedule (see **6.4**).

9. Evaluation of Test Specimens

9.1 Remove specimens from exposure at the scheduled intervals.

9.2 Following recording of data in accordance with Practice **G33**, clean all surfaces of specimens in accordance with Practice **G1** and reweigh specimens to the nearest 0.01 g (or to the same precision as originally weighed). For certain tests, it may be of interest to preserve corrosion products for laboratory analysis.

9.3 When appropriate, determine the mass loss of each specimen and convert the results to a corrosion rate (Practice **G1**).

9.4 Where the corrosion that occurs is highly localized (as in pitting) and the loss in mass is low, mass loss results can be misleading. In such cases, other means of evaluation are necessary; for example, the tensile strengths of the exposed specimens can be determined after cleaning and compared with the tensile strengths of unexposed specimens cut from the same material (see **3.2**, **7.3**, and Practice **G46**).

NOTE 4—When using tensile strength determinations to evaluate corrosion effects further, the investigator should be aware of the possible effects of sensitivity to pitting, stress corrosion cracking, intergranular corrosion, or influences of specimen geometry on tensile properties of a material to avoid misinterpretation of the data obtained.

9.5 Measure the depth of any pits on the skyward and groundward surfaces. Where many pits occur, measure the deepest pits. For this purpose, a depth gage, calibrated-focus microscope, or micrometer calipers with pointed anvils are suitable. It may also be of interest to determine the pit density (pits per unit area). Microscopical examination of metallographic sections also is a useful method of determining depth and type of localized corrosion (see Practice **G46**).

9.6 Report the nature, depth, and frequency of any localized corrosion attributable to contact with the supports, or any other form of crevice corrosion that may have occurred; for example, when riveted or complex specimens are exposed.

10. Report

10.1 The report should include detailed descriptions of the exposed specimens, pertinent data on exposure conditions, the method of rating surface conditions, and the results of the corrosion evaluation (see Practice **G33**).

10.2 Data for the exposed specimens should include dimensions, chemical composition, metallurgical history, surface preparation, and post-corrosion cleaning methods.

10.3 Details of exposure conditions should include its location, dates and periods of exposure, and a description of the atmospheric conditions prevailing during the exposure period. A general description of these conditions on a yearly basis is normally sufficient. A more detailed compilation might be justified for certain tests. Site characterization in accordance with Practice **G92** shall be reported if such a characterization was performed.

10.4 The results of the tests may be expressed as corrosion rates in either penetration per unit time (for example, mils or millimetres per year) or loss in thickness over the exposure period (see Practice **G1**). The latter is more meaningful to the ultimate user of the metal or alloy tested. When pitting occurs, the procedure outlined in **10.5** should be followed.

10.5 Any changes in the physical appearance of the specimens during the exposure period should be noted. If the corrosive attack is nonuniform (that is, if pitting is predominant), the corrosion rate data can be misleading. In cases where corrosion is in the form of pitting, a pitting factor should be reported in accordance with Practices **G1** or **G33**. Depths of pitting may also be recorded for the skyward and groundward surfaces. Changes in mechanical properties and metallographic sectioning can further define damage not identified by mass loss or corrosion rate calculations.

10.6 The corrosion rates as determined by **9.3** will be the average of the top and bottom surfaces. It has been observed in weathering tests that the bottom surface often corrodes at a different rate from the top surface for more information on measurement of this difference, see the report by Townsend.⁴

10.7 If the tensile strength is measured on the exposed specimens when the corrosion is highly localized and the mass loss is low, any loss in tensile strength should be reported as a percentage of the original tensile strength.

10.8 A comparison of the corrosion data from the test specimen with corrosion data from the control specimen obtained in one environment will allow an evaluation of the material being tested. The degree of corrosion in other environments may differ, but the relationship established in the test environment will usually be maintained, depending upon the relative corrosivity of the test site.

11. Keywords

11.1 atmospheric corrosion; exposure angle; evaluation—atmospheric test; exposure site design; frames; marine exposures; racks; specimens; specimen preparation

⁴ Townsend, H. E., “Atmospheric Corrosion of Skyward- and Groundward-Exposed Surfaces of Zinc and 55% Al-Zn Alloy-Coated Steel Sheet,” *Corrosion*, Vol 54, No. 7, 1998, 561-565.

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