



## Standard Practice for Characterization of Atmospheric Test Sites<sup>1</sup>

This standard is issued under the fixed designation G 92; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice gives suggested procedures for the characterization of atmospheric test sites. Continuous characterization can provide corrosion data, environmental data, or both which will signal changes in corrosivity of the atmospheric environment. This practice can also provide guidance for classification of future test sites.

1.2 Two methods are defined in this practice for the characterization of atmospheric test sites. The methods are identified as characterization Methods A and B. The preferred characterization technique would require using both Method A and B for concurrent data collection.

1.2.1 Method A is to be used when atmospheric corrosion is monitored on a continuing basis at a test site using specified materials and exposure configurations.

1.2.2 Method B is specified when atmospheric factors are monitored on a continuing basis.

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:

A 36/A 36M Specification for Carbon Structural Steel<sup>2</sup>

B 6 Specification for Zinc<sup>3</sup>

G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens<sup>4</sup>

G 50 Practice for Conducting Atmospheric Corrosion Tests on Metals<sup>4</sup>

G 84 Practice for Measurement of Time-of-Wetness on Surfaces Exposed to Wetting Conditions as in Atmospheric Corrosion Testing<sup>4</sup>

G 91 Practice for Monitoring Atmospheric SO<sub>2</sub> Using the Sulfation Plate Technique<sup>4</sup>

### 3. Summary of Methods

3.1 Characterization Method A is to be used when atmospheric corrosion data are to be obtained.

3.1.1 Corrosion tests to measure the corrosivity of the test site should follow the procedure established by Practice G 50. Additional special instructions are identified in this procedure relating to types of materials for corrosion characterization tests, time of test exposure, positioning of test specimens, removal of test specimens and proper identification, cleaning practices, and reporting of data.

3.2 Characterization Method B is to be used when atmospheric climatological factors influencing the corrosion of metals are to be monitored.

3.2.1 Several atmospheric factors which have been identified as having significant bearing on the corrosion of metals include, but are not limited to, sulfur dioxide, chlorides, temperature, humidity, precipitation, time of wetness, and atmospheric particulate matter.

3.3 The preferred technique utilizes both Methods A and B for concurrent data to be collected.

3.3.1 Should either Method A or B be singled out as the primary technique to be used on a continuing basis, both should be used at some point in time to establish a data base. The availability of computerized weather stations greatly facilitates the collection of reliable atmospheric data.

### 4. Significance and Use

4.1 This practice gives suggested procedures for characterization of atmospheric test sites. It can be useful to researchers, manufacturers, engineering firms, architects, and construction contractors to provide corrosion and environmental data, materials selection information, and a materials storage practice.

4.2 This practice does not give specific parameters for classifying the type of test site.

## PROCEDURES

### 5. Method A

#### 5.1 Materials:

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

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.04.

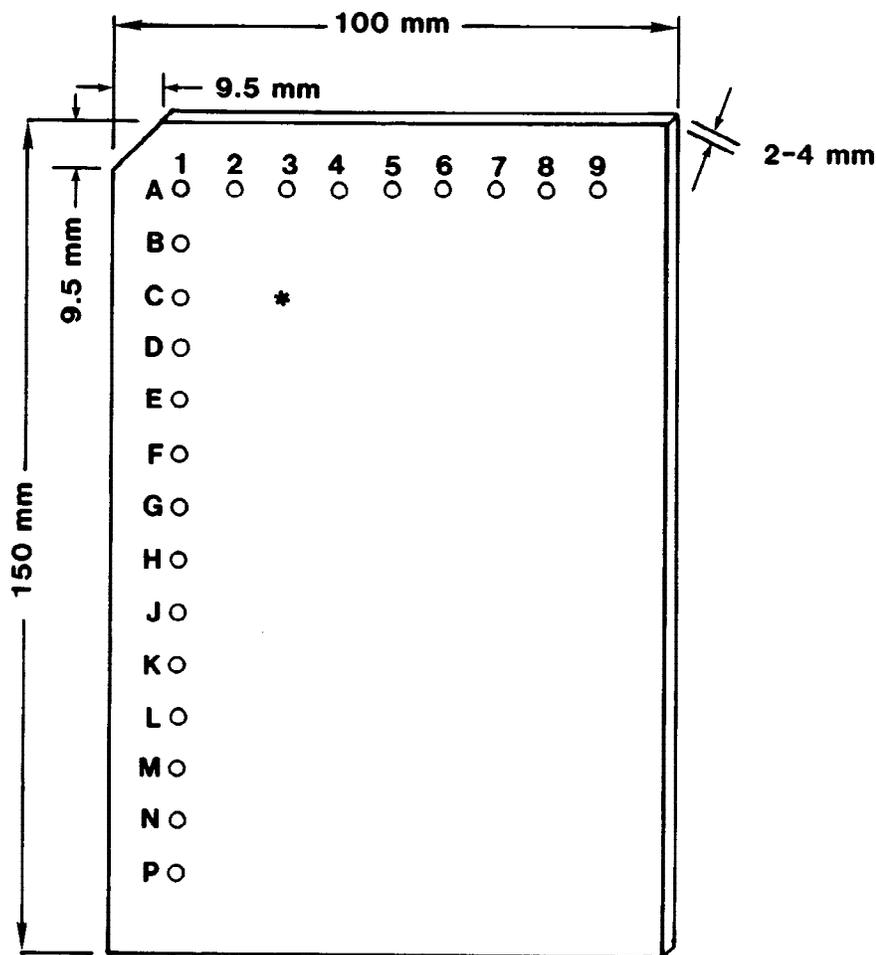
<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.04.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.02.

5.1.1 The materials recommended for conducting atmospheric corrosion characterization studies are copper-bearing structural carbon steel (such as Specification A 36/A 36M with 0.2 % copper min) and high-purity zinc (Specification B 6 high grade).

a permanent drilled code (a series of 2.5 mm holes) should perforate the test specimen.

5.2.3 All test specimens of the same alloy should be cleaned by the same procedure to ensure a comparative surface finish following the guidance of Practice G 1. The recommended



\* Template contains 126 drilled holes

FIG. 1 Sample Atmospheric Specimen Drill Code Identification Template

5.1.2 Materials recommended are the absolute minimum required to serve as a characterization base for test sites. Additional materials should be added to meet individual needs. Sufficient material should be obtained at the start to insure that an ample supply of the same heat is available to complete the characterization test. If tests are on-going and additional materials must be obtained, care should be taken in attempting to match material compositions.

5.1.3 Sufficient specimens should be prepared to comply with the specific criteria for the planned characterization test.

5.2 Material Preparation:

5.2.1 Test specimens should be sheared to size, for example, 100 × 150 mm.

5.2.2 An identifying code should be assigned to each specimen. Locating a permanent code on each test specimen can be accomplished easily by using a code template (Fig. 1).

5.2.2.1 Pre-assignment of codes for a definite test period is suggested. After a temporary mark is placed on the specimen,

practice suggested for cleaning is (a) degrease and pickle, if necessary, to remove grease, mill scale, or other impurities; (b) scrub with pumice and brittle brush until free of water-break; (c) dry with towels; and (d) place in a desiccator for 2 h before weighing.

5.2.4 Specimens should be weighed ( $\pm 1.0$  mg) and original mass recorded on a data sheet (Table 1). Specific information, such as nominal composition, density, and exposed area should also be recorded.

5.2.5 Specimens should be stored in a desiccator or sealed in airtight storage bags until the time of exposure.

5.3 Exposure of Test Specimens:

5.3.1 The frequency at which test specimens should be exposed at a test site is dictated by the specific needs for data.

5.3.2 Triplicate specimens of each material should be exposed for each test period.

5.3.3 An exposure period of one year is suggested as a minimum, multiple periods should be considered, for example,

**TABLE 1 Sample Data Sheet for Atmospheric Corrosion Data**

|          |       | Test Site: Kure Beach (250m lot)   |          | Latitude: 34° 00' N |       | Longitude: 77° 55' W                         |                       |
|----------|-------|------------------------------------|----------|---------------------|-------|--|-----------------------|
|          |       | Exposure Dates: 10/7/61 to 10/6/62 |          |                     |       |  |                       |
| Material | Code  | Exposure Period (days)             | Mass (g) |                     |       | Mass Loss Per Unit Area (mg/m <sup>2</sup> ) | Corrosion Rate (mm/y) |
|          |       |                                    | Original | Final               | Loss  |  |                       |
| Cu-steel | A1-B2 | 365                                | 196.583  | 187.332             | 9.251 | 2.86 × 10 <sup>5</sup>                       | 0.0365                |
| Zinc     | A2-B2 | 365                                | 67.521   | 66.938              | 0.583 | 1.84 × 10 <sup>4</sup>                       | 0.0026                |

## Test Method Documentation

|                                    | Steel   | Zinc  |
|------------------------------------|---|---|
| 1. Composition (weight %)          | 0.15 C, 1.0 Mn, 0.01 P, 0.027 S, 0.24 Si, 0.21 Cu, 0.05 Ni, 0.03 Cr, Balance Fe | 0.01 Cu, 0.012 Cd, 0.03 Pb, 0.02 Fe, Balance Zn |
| 2. Density (g/cm <sup>3</sup> )    | 7.85 g/cm <sup>3</sup>  | 7.13 g/cm <sup>3</sup>                          |
| 3. Dimensions (mm)                 | 100 × 150 × 2.00 mm   | 100 × 150 × 2.00 mm                             |
| 4. Exposed area (cm <sup>2</sup> ) | 322.9 cm <sup>2</sup>   | 317.7 cm <sup>2</sup>                           |

**TABLE 2 Sample Data Sheet for Atmospheric Climatological Data**

|        |                  | Test Site: Kure Beach (250m lot) |      | Latitude: 34° 00' N   |     | Longitude: 77° 55' W |                    |                         |            |
|--------|------------------|----------------------------------|------|-----------------------|-----|----------------------|--------------------|-------------------------|------------|
|        |                  | Dates: 5/1/83 to 5/3/83          |      |                       |     |                      |                    |                         |            |
| Date   | Temperature (°C) |                                  |      | Relative Humidity (%) |     |                      | Precipitation (mm) | Time of Wetness (h/day) |            |
|        | High             | Low                              | Mean | High                  | Low | Mean                 |                    | Skyward                 | Groundward |
| 5/1/83 | 25.6             | 12.8                             | 19.2 | 100                   | 56  | 82                   | 0                  | 12                      | 13         |
| 5/2/83 | 26.1             | 16.7                             | 21.4 | 97                    | 56  | 82                   | 0                  | 10                      | 13         |
| 5/3/83 | 26.7             | 17.8                             | 22.2 | 100                   | 60  | 85                   | 1.3                | 12                      | 14         |

3, 6, and 12 months; 1 and 2 years or 1, 2, and 4 years. Shorter test periods may be necessary where corrosion is severe and longer test periods where corrosion is less severe.

5.3.3.1 Consideration should also be given to use of test periods which could allow definition of changes in environment corrosivity occurring during an overall longer term evaluation period. For example, exposure of specimens on the schedule, 0–3, 3–6, 6–9, 9–12, 0–6, 6–12, and 0–12 months, would allow some assessment of relative changes in corrosivity at a test site during a one year period. While this is a relatively extensive exposure frequency, it may prove useful in some instances.

5.3.4 A standard atmospheric exposure test rack (see Practice G 50), or other appropriate devices, should be positioned at 30° to the horizontal facing south in accordance with Practice G 50. The test specimens should be mounted with porcelain insulators or other appropriate insulating materials.

5.3.5 All test specimens should be positioned at approximately the same elevation on the test rack.

5.3.6 It is suggested that the general weather conditions be documented at the time the specimens are exposed, for example, clear, cloudy, or rain.<sup>5</sup>

5.3.6.1 Initial weather conditions at time of exposure of test specimens may have an effect on long term corrosion behavior (1).

#### 5.4 Removals and Reporting:

5.4.1 After the predetermined exposure period is completed (for example, one year), the specimens should be removed and placed in pre-labeled envelopes. Observations or photographs needed to document appearance can be made at this time or after the specimens reach the laboratory or other process area.

Wet specimens should be carefully dried if extended storage (more than 24 h) is anticipated before cleaning.

5.4.2 The test specimens being removed should be identified as to exposure location, exposure period, specimen code, original mass, composition, original dimensions, and exposed area and information documented as shown in Table 1.

5.4.3 As each specimen is clearly identified and observations documented, it can be cleaned, in accordance with Practice G 1. Specimens should then be dried and placed in a desiccator for 2 h or more before final weighing.

5.4.4 Each specimen should then be weighed to the nearest milligram and the mass recorded. Also a description of the type of corrosion attack should be recorded, for example, pitting (depth).

5.4.5 After the mass loss has been calculated, a mass loss per unit area (mg/m<sup>2</sup>) and corrosion rate (mm/y) can be calculated using the following equations (see Practice G 1 for further guidance).

$$M_a = \frac{M}{A} \quad (1)$$

where:

- $M_a$  = mass loss per unit area, milligrams per square metre
- $M$  = mass loss, milligrams, and
- $A$  = exposed surface area, metres squared

$$C = \frac{(8.76 \times 10^4) M_l}{a \times t \times d} \quad (2)$$

where:

- $C$  = corrosion rate, millimetres per year
- $M_l$  = mass loss, grams
- $a$  = area, centimetres squared
- $t$  = time, hours
- $d$  = density, grams per cubic centimetre

<sup>5</sup> Also available are data from the National Climate Data Center, NOAA, Asheville, NC.

## 6. Method B

6.1 Several atmospheric factors have been identified as having a significant influence on the corrosion of metals and deterioration of materials. Several of these factors are identified in Table 2 with a suggested format to report these data.

6.2 The atmospheric factors to be monitored are dependent on individual needs, and at what frequency the monitoring devices can be attended. Daily attention is often preferred. Available also are computer monitored systems. Suggestions for monitoring systems requiring minimal attention are listed in Table 3.

6.2.1 Sulfur dioxide can be monitored easily by the use of sulfation plates. (See Practice G 91.) (2). Monthly attention is needed to change the plates.

6.2.2 The hygrothermograph can be used to record temperature and relative humidity. Instruments can be run by either batteries or a hand-wound spring, and will operate for one month unattended.

6.2.3 The standard 200 mm rain gage needs to be visually checked and precipitation (rain, snow) measured after each

occurrence. Also samples of precipitation can be collected for laboratory analysis (acidity, pH, contaminants).

6.2.4 Chloride ion concentration can be monitored by the wet candle method (3). This system may require weekly attention to replace evaporated distilled water in the 500-mL flask. Also monthly laboratory analysis is required to obtain chloride analyses.

6.2.5 Time of wetness (see Practice G 84) can be monitored by the Sereda miniature moisture sensor (4). This device, with suitable recorder or computer interface, should operate unattended on a monthly basis.

6.2.6 Other monitoring devices can provide useful climatological data to suit special needs (for example, wind speed and direction, solar radiation, barometric pressure, and dust particles).

6.3 Hourly, daily, weekly, and monthly variations in the atmospheric factors are intimately linked with the corrosion process. Quantizing these changes can provide insight into observed corrosion performance. Time averages or other measures of the atmospheric factors over a time span coincident with the corrosion experiment can be used.

6.4 Atmospheric monitoring should be performed at a site as near to the placement of the corrosion specimens exposed in Method A as possible. Microclimatological variations at a given test area could reasonably be expected to exist and thus close proximity of the two methods is important.

6.5 Additional information on atmospheric monitoring is available in selected references (4-10).

## 7. Keywords

7.1 atmospheric characterization; atmospheric factors; atmospheric testing; identification; mass loss; monitoring; reporting; standard test materials

**TABLE 3 Recommended Methods for Monitoring Atmospheric Factors**

| Atmospheric Factors  | Monitoring Device  |
|----------------------|--|
| Sulfur dioxide       | sulfation plate  |
| Chloride ion         | wet candle   |
| Temperature/humidity | hygrothermograph (combination of hygrograph and thermograph used for recording temperature and humidity) |
| Precipitation        | standard 200 mm rain/snow gage (periodic sampling for pH range)  |
| Time of wetness      | Cu/Au sensor (procedure defined in Practice G 84)  |
| Climatological data  | National Weather Service <sup>A</sup>  |

<sup>A</sup> National Weather Service monitors climatological data in many areas and data are available from the National Climate Data Center, NOAA, Ashville, NC.

## REFERENCES

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- (7) *Code of Federal Regulations*, Title 40-Protection of Environment, Part 50. Office of the Federal Register, National Archives and Records Service, General Services Administration, July 1, 1982, pp. 563-614.
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- (9) *Surface Observation*, Federal Meteorological Handbook No. 1, 3rd Edition, U.S. Department of Commerce, January 1, 1982, p. 251.
- (10) *Joint Automated Weather Observing System*, Proposed Functional Requirement, National Weather Service, U.S. Department of Commerce, February 1981, p. 88.

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