



# Standard Practice for Conducting Moist SO<sub>2</sub> Tests<sup>1</sup>

This standard is issued under the fixed designation G 87; 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 describes the apparatus and procedure to be used in conducting qualitative assessment tests in accordance with the requirements of material or product specifications by means of specimen exposure to condensed moisture containing sulfur dioxide.

1.2 The exposure conditions may be varied to suit particular requirements and this practice includes provisions for use of different concentrations of sulfur dioxide and for tests either running continuously or in cycles of alternate exposure to the sulfur dioxide containing atmosphere and to the ambient atmosphere.

1.3 The variant of the test to be used, the exposure period required, the type of test specimen, and the criteria of failure are not prescribed by this practice. Such details are provided in appropriate material and product purchase specifications.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound values in parentheses may be approximate.

1.5 *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 hazard statements see 4.3.

## 2. Referenced Documents

### 2.1 ASTM Standards:

D 714 Test Method for Evaluating Degree of Blistering of Paints<sup>2</sup>

D 1193 Specification for Reagent Water<sup>3</sup>

D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments<sup>2</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 06.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 11.01.

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

G 46 Guide for Examination and Evaluation of Pitting Corrosion<sup>4</sup>

## 3. Significance and Use

3.1 Moist air containing sulfur dioxide quickly produces easily visible corrosion on many metals in a form resembling that occurring in industrial environments. It is therefore a test medium well suited to detect pores or other sources of weakness in protective coatings and deficiencies in corrosion resistance associated with unsuitable alloy composition or treatments.

3.2 The results obtained in the test should not be regarded as a general guide to the corrosion resistance of the tested materials in all environments where these materials may be used. Performance of different materials in the test should only be taken as a general guide to the relative corrosion resistance of these materials in moist SO<sub>2</sub> service.

## 4. Apparatus

4.1 The apparatus required for moist SO<sub>2</sub> testing consists of a test chamber having an internal capacity of 300 L (10.6 ft<sup>3</sup>), a supply of sulfur dioxide with metering device, specimen supports, provisions for heating the chamber, and necessary means of control. The size and detailed construction of the apparatus are optional, provided the conditions obtained meet the requirements of this method. Suitable apparatus which may be used to obtain these conditions is described in Appendix X1.

4.2 Drops of condensing moisture which accumulate on the ceiling of the chamber shall not be permitted to fall on the specimens being tested.

4.3 **Warning**—Suck-back into cylinder may cause explosion. Always use a check valve, vacuum break, or other protective apparatus in any line or piping from cylinder to test chamber to prevent suck-back. Installation of the chamber under a fume hood is recommended.

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

## 5. Reagents

5.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.<sup>5</sup> Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type IV of Specification D 1193.

5.3 A commercially available source of bottled SO<sub>2</sub> gas having a minimum purity of 99.9 % (liquid phase) with proper regulator, and means of measuring the volumes of gas required for delivery into test chamber shall be provided.

5.4 The volume of gas delivered into test chamber shall be measured by means of either a properly calibrated flowmeter (rotameter type) with metering valve, or in a gas buret using viscous paraffin oil as the pressure controlling fluid.

5.4.1 The volume to be measured may be as small as 0.2 L. Measures should be taken to avoid errors from air contained in delivery tubes between flowmeter or gas burette and test chamber.

## 6. Sampling

6.1 The specific location of samples in a mill product, the number of samples that should be tested, and other factors concerning sampling, are not within the scope of this practice. These factors should be mutually agreed upon between purchaser and supplier (see 7.1).

## 7. Test Specimens

7.1 Select the number and type of test specimens, and their shape and dimensions according to the specification covering the product or material being tested or agreed upon between purchaser and supplier.

7.2 The total combined exposed surface area of the material tested at any one time should be substantially the same and unless otherwise agreed upon, it shall be  $0.5 \pm 0.1 \text{ m}^2$  ( $5.4 \text{ ft}^2 \pm 1 \text{ ft}^2$ ).

7.2.1 More specimens of the same material may be added, if needed.

7.3 To obtain quantitative corrosion-rate data, only materials with similar reactivities should be included in a test run.

### 7.4 Preparation of Test Specimens:

7.4.1 Suitably clean the specimens before testing (see Practice G 1). Unless otherwise agreed upon the cleaning method shall be optional depending on the nature of the surface and of the likelihood of contamination. The cleaning method shall not include the use of abrasives (other than a paste of pure magnesium oxide), corrosive solvents, corrosion-promoting

materials or protective film formers. Care in handling is necessary so as not to recontaminate the test specimens.

7.4.2 If test specimens are cut from a larger coated article, carry out the cutting in such a way that coating damage is minimized in the area adjacent to the cut. Unless otherwise specified, adequately protect the cut edges by coating them with a suitable medium, stable under the conditions of the test, such as wax or tape. High-quality platers tape or microcrystalline wax are generally suitable.

### 7.5 Position of Specimens During Test:

7.5.1 Place the test specimens in the cabinet so that no part of any specimen is within 20 mm (0.78 in.) of another or within 100 mm (3.93) of the walls or the ceiling or within 200 mm (7.87 in.) of the surface of the water in the base of the chamber.

7.5.2 Arrange the specimens so that moisture which may condense on any of them or their supports will not fall on other specimens placed at lower levels. If possible place all test specimens on the same horizontal plane so they are exposed to equal concentrations of SO<sub>2</sub> gas.

7.5.3 Unless otherwise agreed upon, the angle of inclination of test surfaces to the vertical is optional. A near vertical orientation (0 to 10° from vertical) is suggested unless otherwise agreed upon or specified.

## 8. Conditioning

8.1 Operate a new chamber for at least ten 24-h cycles without introduction of any test material by the procedure applicable to an atmosphere containing an addition of 2 L (122 in.<sup>3</sup>) of sulfur dioxide before it is brought into use for testing. This should reduce any risks of contamination of the atmosphere by vapors from construction materials of chamber.

## 9. Procedure

9.1 Introduce  $2 \pm 0.2 \text{ L}$  ( $122 \text{ in.}^3 \pm 12 \text{ in.}^3$ ) of distilled water into the base of chamber.

9.2 Place the test specimens in the chamber and close the door/lid.

9.3 Introduce the volume of sulfur dioxide, required by the governing materials specification, into the chamber through the inlet pipe. Usually this volume will be 0.2, 1, or 2 L (12 in.<sup>3</sup>, 61 in.<sup>3</sup>, or 122 in.<sup>3</sup>  $\pm 12 \text{ in.}^3$ ).

9.4 Switch on the heater and raise the temperature inside the chamber to  $40 \pm 3^\circ\text{C}$  ( $104 \pm 5.4^\circ\text{F}$ ) in about 1.5 h. Make sure the heating is under control to keep the temperature inside the chamber at  $40 \pm 3^\circ\text{C}$  ( $104 \pm 5.4^\circ\text{F}$ ) for the specified period. Each set point and its tolerance represents an operational control point for equilibrium conditions at a single location in the cabinet which may not necessarily represent the uniformity of conditions throughout the cabinet.

9.5 One test cycle is 24 h. Either Method A or B, and the number of cycles shall be designated by the specification for the material or product being tested or mutually agreed upon by the purchaser and seller. For either method, replace the water in the chamber and the sulfur dioxide in the air of the chamber before each 24 h cycle begins.

9.5.1 *Method A Continuous Exposure*—The specimens shall remain continuously exposed to the atmosphere in the chamber for 24 h. Replacement of the water and sulfur dioxide for a

<sup>5</sup> *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory U. K. Chemicals*, BDH Ltd., Poole, Dorset, and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC) Rockville, MD.”

second period of test shall be made with a minimum of disturbance of the test specimens.

9.5.2 *Method B Alternating Exposure*—Expose the specimens for 8 h, followed by drying in the ambient conditions inside the chamber for 16 h. Ambient conditions shall be an indoor atmosphere with no unusual pollution other than that arising from the test chamber. Such conditions shall be controlled to a temperature in the range of 20 to 30°C (68 to 86°F), and a relative humidity below 75 %.

9.6 *Duration of Test*—The number of cycles shall be designated by the specification for the material or product being tested or mutually agreed upon by purchaser and seller.

9.7 *Cleaning of Tested Specimens*—At the end of the test period, remove the specimens from the chamber. Before they are examined, allow them to hang freely in a normal indoor atmosphere until any fluid corrosion product dries. Examine with all corrosion product in position and any cleaning carried out depends on the criteria laid down for evaluation of the test result (see Practice G 1).

## 10. Evaluation of Results

10.1 Different criteria for evaluation of the results of the test may be applied to meet particular requirements, for example, mass change, change in appearance, alteration revealed by micrographic examination, or change in mechanical properties. Usually the appropriate criteria will be indicated in the specification for the material or product tested. For most routine applications of the test, only the following need to be considered:

10.1.1 Appearance after drying in air,

10.1.2 Appearance after removing superficial corrosion products by washing with water and a soft bristle brush,

10.1.3 The number and distribution of corrosion defects, for example, pits, cracks, blisters, and other defects may conveniently be assessed by methods such as that described in Test Method D 1654, Test Method D 714, and Guide G 46.

10.1.4 The number of cycles elapsing before the appearance of the first sign of corrosion.

## 11. Report

11.1 The report shall indicate the outcome of the test according to the criteria for evaluation of results prescribed for the test. The result obtained for each specimen tested and, when appropriate, the average result for a group of replicate test specimens shall be reported. The report, may, if required, be accompanied by photographic records of the tested specimens.

11.2 The report shall contain information about all test details. This information may vary according to the purposes of the test and to the directions prescribed for it but a general list of the details likely to be required is as follows:

11.2.1 Chemical composition of the material tested,

11.2.2 Dimensions and shape of the test specimen and the nature and area of the surface tested,

11.2.3 Preparation of the test specimen including any cleaning treatment applied and any protection given to edges or other special areas. Known characteristics of any coating with an indication of the surface finish,

11.2.4 Amount of sulfur dioxide introduced per cycle,

11.2.5 Number of test specimens subjected to test representing each material or product,

11.2.6 Method used to clean test specimens after the test and an indication of the loss of mass resulting from the cleaning operation, when appropriate,

11.2.7 Temperature of test,

11.2.8 Duration of test (number of cycles), and

11.2.9 Character of any control test panels placed in the cabinet expressly to check the correctness of the operating conditions and the results obtained with them.

11.2.10 Method A or B.

## APPENDIXES

### (Nonmandatory Information)

#### X1. MOIST-SO<sub>2</sub> TEST APPARATUS

##### X1.1 Location

X1.1.1 The chamber shall be located in an area free of unusual pollution, direct sunlight, and drafts. Temperature should be controlled between 20 to 30°C (68 to 86°F) at a relative humidity below 75 %.

##### X1.2 Chamber

X1.2.1 Standard SO<sub>2</sub> chambers are available from several suppliers, but certain pertinent details are required before they

will function according to this practice and provide consistent control for duplication of results.

X1.2.2 The chamber consists of the basic chamber, inert, non-conducting specimen supports, provisions for heating the chamber, and suitable controls for maintaining and indicating the desired temperature and relative humidity.

X1.2.3 The chamber shall have an inlet tube through which gas can be introduced into the chamber located at a point no less than 50 mm (1.95 in.) above the internal floor, a means by

which excess pressure can be relieved located in or near the ceiling and a suitable drain in the floor of the chamber.

X1.2.4 The floor and lower parts of the walls of chamber shall be capable of being heated from an external source and must be able to retain without leakage at least 2.5 L of water containing dissolved sulfur dioxide.

X1.2.5 External means of heating the water placed in the base of chamber, sufficient to maintain the temperature inside the chamber at  $40 \pm 3^\circ\text{C}$  ( $104 \pm 5.4^\circ\text{F}$ ) shall be provided.

X1.2.6 A full-opening door/lid made of transparent material such as glass, acrylic, polycarbonate or suitable plastic material shall be provided. The door/lid should occupy at least 75 % of the area of the front wall/ton of the chamber.

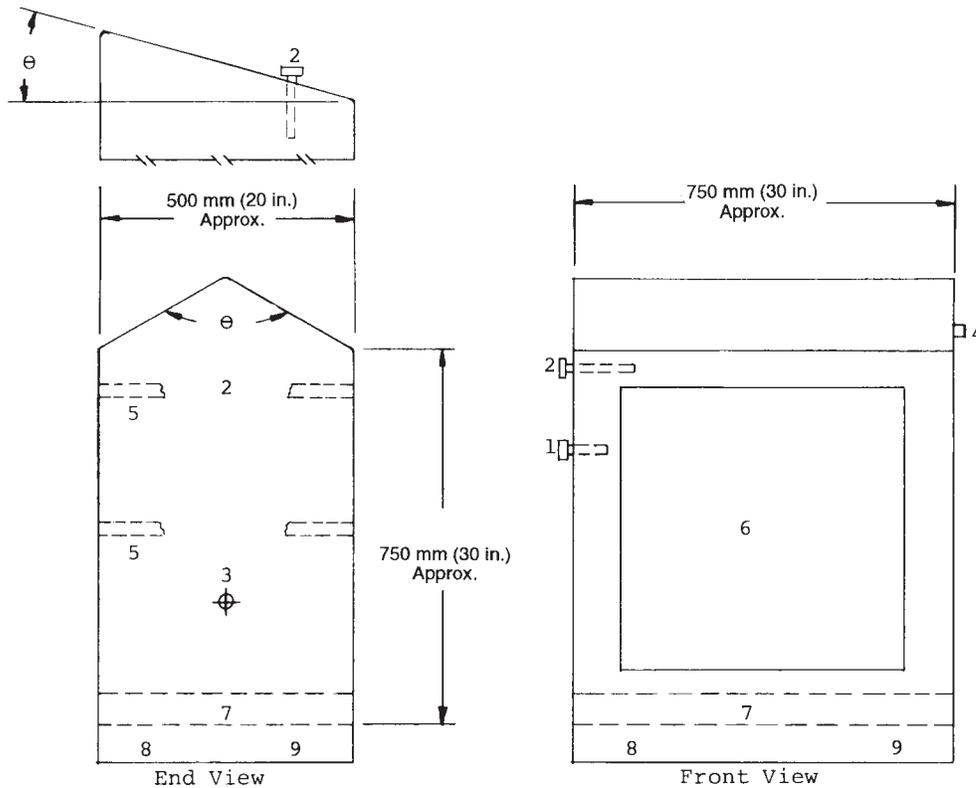
X1.2.7 All materials used in the construction of the chamber must be resistant to the action of moist sulfur dioxide and shall themselves not emit any gases or vapors likely to influence corrosion of test materials. A suitable plastic material, lead or plastic clad steel, or austenitic stainless steel may be used for the basic construction of the chamber and internal fittings.

X1.2.8 Specimen supports shall be of nonconducting material such as glass, plastic, or suitably coated wood or steel. Any material used to suspend the test specimens in the chamber shall be of synthetic fibre or other inert insulating material; metallic materials shall not be used.

X1.2.9 Some variation in the dimensions and shape of the chamber can be tolerated but the total internal area of chamber (including ceiling) should be 300 L ( $10.6 \text{ ft}^3$ ). The ceiling must be so shaped that moisture condensing on it shall not fall on specimens being tested. An inclination or slope of the ceiling of at least  $12^\circ$  to the horizontal or installation of an internal baffle suspended from the ceiling at that angle provides a suitable safeguard. Suitable dimensions and shape for the chamber are outlined in Fig. X1.1

**X1.3 Temperature Controls**

X1.3.1 A temperature controlling device with its actuating element shall be placed in the upper part of the chamber. A thermometer capable of being read from outside the cabinet



NOTE 1— $\theta$  Angle of ceiling/lid  
 $12^\circ$  min (from horizontal)  
 $120^\circ$  max (included angle)

NOTE 2—Legend:

- 1 Automatic thermostat for controlling heater
- 2 Thermometer
- 3 Gas inlet
- 4 Excessive pressure vent
- 5 Specimen support
- 6 Door/lid
- 7 Internal reservoir
- 8 Heater
- 9 Air space or water jacket

**FIG. X1.1 Typical Moist SO<sub>2</sub> Test Chamber**

shall also be installed in the upper part of the chamber with its bulb located approximately 250 mm (10 in.) from any side wall.

## **X2. Standard Practice for Conducting Moist SO<sub>2</sub> Tests**

### **24-h Constant Atmosphere Cycle (Method A) or 8-h Moist SO<sub>2</sub> and 16-h Purge/Soak (Method B)**

X2.1 Introduce  $2 \pm 0.2$  L ( $122 \pm 12$  in<sup>3</sup>) of distilled water into the base of a 300 L (10.6 ft<sup>3</sup>) chamber (wet bottom).

X2.2 Place specimens in chamber and close the door/lid.

X2.3 Introduce SO<sub>2</sub> gas [usually 0.2, 1, or 2 L (12 in<sup>3</sup>, 61 in<sup>3</sup>, or  $122 \pm 12$  in<sup>3</sup>)] into the chamber. The SO<sub>2</sub> gas is injected by means of a gas dispersion ring or other means to aid dispersion of gas throughout the chamber.

X2.4 Switch on heat and raise chamber temperature to

40°C ( $\pm 3^\circ\text{C}$ ) [104°F ( $\pm 5.4^\circ\text{F}$ )] in about 1 1/2 h.

Method A: Maintain 40°C temperature for 24 h.

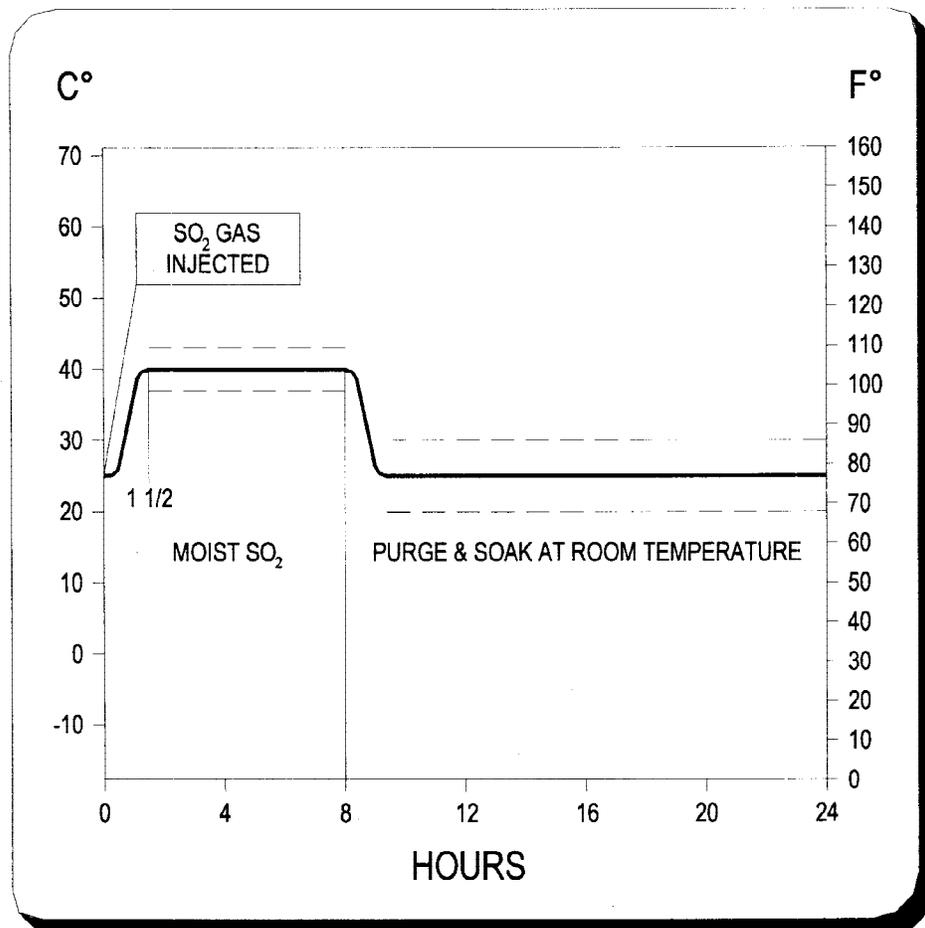
Method B: Maintain 40°C temperature for 8 h and 20 to 30°C (68 to 86°F) for 16 h with relative humidity below 75 %.

Each set point and its tolerance represents an operational control point for equilibrium conditions at a single location in the cabinet which may not necessarily represent the uniformity of conditions throughout the cabinet. (See Fig. X2.1.)

X2.5 Switch off heat, completely purge the chamber of residual vapors, and open door/lid.

“Synopsis chart” for ASTM G87

(Method B Illustrated)



NOTE 1—Dashed chart lines indicate temperature tolerance limits.

NOTE 2—Temperature changes illustrated are pictorial representations only and are not based on actual tests.

NOTE 3—Reprinted with permission.

FIG. X2.1 Practice for Operating Moist SO<sub>2</sub> Apparatus (Method B)

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