



Designation: B117 – 19

## Standard Practice for Operating Salt Spray (Fog) Apparatus<sup>1</sup>

This standard is issued under the fixed designation B117; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

### 1. Scope

1.1 This practice covers the apparatus, procedure, and conditions required to create and maintain the salt spray (fog) test environment. Suitable apparatus which may be used is described in [Appendix X1](#).

1.2 This practice does not prescribe the type of test specimen or exposure periods to be used for a specific product, nor the interpretation to be given to the results.

1.3 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.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:<sup>2</sup>

[B368 Test Method for Copper-Accelerated Acetic Acid-Salt Spray \(Fog\) Testing \(CASS Test\)](#)

[D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products](#)

[D1193 Specification for Reagent Water](#)

[D1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments](#)

[E70 Test Method for pH of Aqueous Solutions With the Glass Electrode](#)

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

[G85 Practice for Modified Salt Spray \(Fog\) Testing](#)

### 3. Significance and Use

3.1 This practice provides a controlled corrosive environment which has been utilized to produce relative corrosion resistance information for specimens of metals and coated metals exposed in a given test chamber.

3.2 Prediction of performance in natural environments has seldom been correlated with salt spray results when used as stand alone data.

3.2.1 Correlation and extrapolation of corrosion performance based on exposure to the test environment provided by this practice are not always predictable.

3.2.2 Correlation and extrapolation should be considered only in cases where appropriate corroborating long-term atmospheric exposures have been conducted.

3.3 The reproducibility of results in the salt spray exposure is highly dependent on the type of specimens tested and the evaluation criteria selected, as well as the control of the operating variables. In any testing program, sufficient replicates should be included to establish the variability of the results. Variability has been observed when similar specimens are tested in different fog chambers even though the testing conditions are nominally similar and within the ranges specified in this practice.

### 4. Apparatus

4.1 The apparatus required for salt spray (fog) exposure consists of a fog chamber, a salt solution reservoir, a supply of suitably conditioned compressed air, one or more atomizing nozzles, specimen supports, provision 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 practice.

<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> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.2 Drops of solution which accumulate on the ceiling or cover of the chamber shall not be permitted to fall on the specimens being exposed.

4.3 Drops of solution which fall from the specimens shall not be returned to the solution reservoir for respraying.

4.4 Material of construction shall be such that it will not affect the corrosiveness of the fog.

4.5 All water used for this practice shall conform to Type IV water in Specification **D1193** (except that for this practice limits for chlorides and sodium may be ignored). This does not apply to running tap water. All other water will be referred to as reagent grade.

NOTE 1—Water used with a conductivity  $\leq 1.0 \mu\text{S}/\text{cm}$  (or resistivity  $\geq 1.0 \text{ M}\Omega\text{-cm}$ ) may cause damage to some equipment due to the reactive nature of the water. In addition, it may cause issues with stabilizing pH measurements.

## 5. Test Specimens

5.1 The type and number of test specimens to be used, as well as the criteria for the evaluation of the test results, shall be defined in the specifications covering the material or product being exposed or shall be mutually agreed upon between the purchaser and the seller.

## 6. Preparation of Test Specimens

6.1 Specimens shall be suitably cleaned. The cleaning method shall be optional depending on the nature of the surface and the contaminants. Care shall be taken that specimens are not recontaminated after cleaning by excessive or careless handling.

6.2 Specimens for the evaluation of paints and other organic coatings shall be prepared in accordance with applicable specification(s) for the material(s) being exposed, or as agreed upon between the purchaser and the supplier. Otherwise, the test specimens shall consist of steel meeting the requirements of Practice **D609** and shall be cleaned and prepared for coating in accordance with the applicable procedure of Practice **D609**.

6.3 Specimens coated with paints or nonmetallic coatings shall not be cleaned or handled excessively prior to test.

6.4 Whenever it is desired to determine the development of corrosion from an abraded area in the paint or organic coating, a scratch or scribed line shall be made through the coating with a sharp instrument so as to expose the underlying metal before testing. The conditions of making the scratch shall be as defined in Test Method **D1654**, unless otherwise agreed upon between the purchaser and the seller.

6.5 Unless otherwise specified, the cut edges of plated, coated, or duplex materials and areas containing identification marks or in contact with the racks or supports shall be protected with a suitable coating stable under the conditions of the practice.

NOTE 2—Should it be desirable to cut test specimens from parts or from preplated, painted, or otherwise coated steel sheet, the cut edges shall be protected by coating them with paint, wax, tape, or other effective media so that the development of a galvanic effect between such edges and the adjacent plated or otherwise coated metal surfaces, is prevented.

## 7. Position of Specimens During Exposure

7.1 The position of the specimens in the salt spray chamber during the test shall be such that the following conditions are met:

7.1.1 Unless otherwise specified, the specimens shall be supported or suspended with the surface of interest at an angle between  $15^\circ$  and  $30^\circ$  from the vertical. It is recommended that the orientation of specimens in the cabinet be consistent to minimize variability.

7.1.2 The specimens shall not contact each other or any metallic material or any material capable of acting as a wick.

7.1.3 Each specimen shall be placed to permit unencumbered exposure to the fog.

7.1.4 Salt solution from one specimen shall not drip on any other specimen.

NOTE 3—Suitable materials for the construction or coating of racks and supports are glass, rubber, plastic, or suitably coated wood. Bare metal shall not be used. Specimens shall preferably be supported from the bottom or the side. Slotted wooden strips are suitable for the support of flat panels. Suspension from glass hooks or waxed string may be used as long as the specified position of the specimens is obtained, if necessary by means of secondary support at the bottom of the specimens.

## 8. Salt Solution

8.1 The salt solution shall be prepared by dissolving  $5 \pm 1$  parts by mass of sodium chloride in 95 parts of water conforming to Type IV water in Specification **D1193** (except that for this practice limits for chlorides and sodium may be ignored). Careful attention should be given to the chemical content of the salt. The salt used shall be sodium chloride with not more than 0.3 % by mass of total impurities. Halides (Bromide, Fluoride, and Iodide) other than Chloride shall constitute less than 0.1 % by mass of the salt content. Copper content shall be less than 0.3 ppm by mass. Sodium chloride that has had anti-caking agents added shall not be used because such agents may act as corrosion inhibitors. See **Table 1** for a listing of these impurity restrictions. Upon agreement between the purchaser and the seller, analysis may be required and limits established for elements or compounds not specified in the chemical composition given above.

8.2 The pH of the salt solution shall be such that when atomized at  $35^\circ\text{C}$  ( $95^\circ\text{F}$ ) the collected solution will be in the pH range from 6.5 to 7.2 (**Note 4**). Before the solution is atomized it shall be free of suspended solids (**Note 5**). The pH measurement shall be made at  $23^\circ\text{C} \pm 3^\circ\text{C}$  ( $73^\circ\text{F} \pm 5^\circ\text{F}$ ) using a suitable glass pH-sensing electrode, reference electrode, and pH meter system in accordance with Test Method **E70**. pH measurement shall be recorded once daily (except on weekends, or holidays when the salt spray test is not interrupted for exposing, rearranging, or removing test specimens or to check and replenish the solution in the reservoir. The maximum interval between pH measurements shall not exceed 96 h). Only diluted, reagent grade hydrochloric acid (HCl) or reagent grade sodium hydroxide (NaOH) shall be used to adjust the pH.

NOTE 4—Temperature affects the pH of a salt solution prepared from water saturated with carbon dioxide at room temperature and pH adjustment may be made by the following three methods:

**TABLE 1 Maximum Allowable Limits for Impurity Levels in Sodium Chloride<sup>A,B,C</sup>**

NOTE 1—A measurable limit for anti-caking agents is *not* being defined as a result of how salt is manufactured. During salt manufacturing, it is common practice to create salt slurry from the raw salt mined. A crystallization process then captures the pure salt from this slurry. Some naturally occurring anti-caking agents can be formed in this process and are not removed from the resultant product. Avoid salt products where extra anti-caking agents are added. Additionally, when doing an elemental analysis of salt, there can be trace elements present that are either a stand-alone element or part of an anti-caking agent. It is not economically feasible to know where such elements came from due to the long list of possible anti-caking agents for which there would have to be testing. Therefore, a salt product that meets the impurity, halide, and copper limits with no anti-caking agents added will be acceptable. The salt supplier can provide an analysis of the salt with a statement indicating that anti-caking agents were not added to the product.

Impurity Description	Allowable Amount
Total Impurities	≤ 0.3 %
Halides (Bromide, Fluoride and Iodide) excluding Chloride	< 0.1 %
Copper	< 0.3 ppm
Anti-caking Agents	None Added

<sup>A</sup> A common formula used to calculate the amount of salt required by mass to achieve a 5 % salt solution of a known mass of water is:

$$0.053 \times \text{Mass of Water} = \text{Mass of NaCl required}$$

The mass of water is 1 g per 1 mL. To calculate the mass of salt required in grams to mix 1 L of a 5 % salt solution, multiply 0.053 g by 1000 g (35.27 oz, the mass of 1 L of water). This formula yields a result of 53 g (1.87 oz) of NaCl required for each litre of water to achieve a 5 % salt solution by mass.

The 0.053 multiplier for the sodium chloride used above is derived by the following:

1000 g (mass of a full litre of water) divided by 0.95

(water is only 95 % of the total mixture by mass) yields 1053 g

This 1053 g is the total mass of the mixture of 1 L of water with a 5 % sodium chloride concentration. 1053 g minus the original weight of the litre of water, 1000 g, yields 53 g for the weight of the sodium chloride. 53 g of total sodium chloride divided by the original 1000 g of water yields a 0.053 multiplier for the sodium chloride.

As an example: to mix the equivalent of 200 L (52.83 gal) of 5 % sodium chloride solution, mix 10.6 kg (23.37 lb) of sodium chloride into 200 L (52.83 gal) of water. 200 L of water weighs 200 000 g. 200 000 g of water  $\times$  0.053 (sodium chloride multiplier) = 10 600 g of sodium chloride, or 10.6 kg.

<sup>B</sup> In order to ensure that the proper salt concentration was achieved when mixing the solution, it is recommended that the solution be checked with either a salimeter hydrometer or specific gravity hydrometer. When using a salimeter hydrometer, the measurement should be between 4 % and 6 % at 25 °C (77 °F).

<sup>C</sup> If the purity of the salt used is >99.9 %, then the limits for halides can be ignored. This is due to the fact that the halides cannot be  $\geq 0.1\%$  with a salt purity of >99.9 %. If the salt used is of lower purity, then test for halides.

(1) When the pH of a salt solution is adjusted at room temperature, and atomized at 35 °C (95 °F), the pH of the collected solution will be higher than the original solution due to the loss of carbon dioxide at the higher temperature. When the pH of the salt solution is adjusted at room temperature, it is therefore necessary to adjust it below 6.5 so the collected solution after atomizing at 35 °C (95 °F) will meet the pH limits of 6.5 to 7.2. Take about a 50 mL sample of the salt solution as prepared at room temperature, boil gently for 30 s, cool, and determine the pH. When the pH of the salt solution is adjusted to 6.5 to 7.2 by this procedure, the pH of the atomized and collected solution at 35 °C (95 °F) will come within this range.

(2) Heating the salt solution to boiling and cooling to 35 °C (95 °F) and maintaining it at 35 °C (95 °F) for approximately 48 h before adjusting the pH produces a solution the pH of which does not materially change when atomized at 35 °C (95 °F).

(3) Heating the water from which the salt solution is prepared to 35 °C (95 °F) or above, to expel carbon dioxide, and adjusting the pH of the salt solution within the limits of 6.5 to 7.2 produces a solution the pH of which does not materially change when atomized at 35 °C (95 °F).

NOTE 5—The freshly prepared salt solution may be filtered or decanted

before it is placed in the reservoir, or the end of the tube leading from the solution to the atomizer may be covered with a double layer of cheesecloth to prevent plugging of the nozzle.

NOTE 6—The pH can be adjusted by additions of dilute ACS reagent grade hydrochloric acid or sodium hydroxide solutions.

## 9. Air Supply

9.1 The compressed air supply to the Air Saturator Tower shall be free of grease, oil, and dirt before use by passing through well-maintained filters (Note 7). This air should be maintained at a sufficient pressure at the base of the Air Saturator Tower to meet the suggested pressures of Table 2 at the top of the Air Saturator Tower.

NOTE 7—The air supply may be freed from oil and dirt by passing it through a suitable oil/water extractor (that is commercially available) to stop any oil from reaching the Air Saturator Tower. Many oil/water extractors have an expiration indicator, proper preventive maintenance intervals should take these into account.

9.2 The compressed air supply to the atomizer nozzle or nozzles shall be conditioned by introducing it into the bottom of a tower filled with water. A common method of introducing the air is through an air dispersion device (X1.4.1). The level of the water must be maintained automatically to ensure adequate humidification. It is common practice to maintain the temperature in this tower between 46 °C and 49 °C (114 °F and 121 °F) to offset the cooling effect of expansion to atmospheric pressure during the atomization process. Table 2 shows the temperature, at different pressures, that are commonly used to offset the cooling effect of expansion to atmospheric pressure.

9.3 Careful attention should be given to the relationship of tower temperature to pressure since this relationship can have a direct impact to maintaining proper collection rates (Note 8). It is preferable to saturate the air at temperatures well above the chamber temperature as insurance of a wet fog as listed in Table 2.

NOTE 8—If the tower is run outside of these suggested temperature and pressure ranges to achieve proper collection rates as described in 10.2 of this practice, other means of verifying the proper corrosion rate in the chamber should be investigated, such as the use of control specimens (panels of known performance in the test conducted). It is preferred that control panels be provided that bracket the expected test specimen performance. The controls allow for the normalization of test conditions during repeated running of the test and will also allow comparisons of test results from different repeats of the same test. (Refer to Appendix X3, Evaluation of Corrosive Conditions, for mass loss procedures).

## 10. Conditions in the Salt Spray Chamber

10.1 *Temperature*—The exposure zone of the salt spray chamber shall be maintained at 35 °C  $\pm$  2 °C (95 °F  $\pm$  3 °F). Each set point and its tolerance represents an operational control point for equilibrium conditions at a single location in

**TABLE 2 Suggested Temperature and Pressure Guideline for the Top of the Air Saturator Tower for the Operation of a Test at 35 °C (95 °F)**

Air Pressure, kPa	Temperature, °C	Air Pressure, psi	Temperature, °F
83	46	12	114
96	47	14	117
110	48	16	119
124	49	18	121

the cabinet which may not necessarily represent the uniformity of conditions throughout the cabinet. The temperature within the exposure zone of the closed cabinet shall be recorded (Note 9) at least once daily (except on Saturdays, Sundays, and holidays when the salt spray test is not interrupted for exposing, rearranging, or removing test specimens or to check and replenish the solution in the reservoir)

NOTE 9—A suitable method to record the temperature is by a continuous recording device or by a thermometer which can be read from outside the closed cabinet. The recorded temperature must be obtained with the salt spray chamber closed to avoid a false low reading because of wet-bulb effect when the chamber is open.

10.2 *Atomization and Quantity of Fog*—Place at least two clean fog collectors per atomizer tower within the exposure zone so that no drops of solution will be collected from the test specimens or any other source. Position the collectors in the proximity of the test specimens, one nearest to any nozzle and the other farthest from all nozzles. A typical arrangement is shown in Fig. 1. The fog shall be such that for each 80 cm<sup>2</sup> (12.4 in.<sup>2</sup>) of horizontal collecting area, there will be collected from 1.0 mL to 2.0 mL of solution per hour based on an average run of at least 16 h (Note 11). The sodium chloride concentration of the collected solution shall be 5 %  $\pm$  1 mass % (Notes 11-13). The pH of the collected solution shall be 6.5 to 7.2. The pH measurement shall be made as described in 8.2 (Note 4). Both sodium chloride concentration and volume of condensate collected (measured in mL) shall be recorded once daily (except on weekends, or holidays when the salt spray test is not interrupted for exposing, rearranging, or removing test specimens or to check and replenish the solution in the reservoir. The maximum interval between these data collection measurements shall not exceed 96 h).

NOTE 10—Common methods of measuring sodium chloride concentration are specific gravity hydrometer, salimeter hydrometer, refractometer, and titration. This list is not all inclusive of every method, and an

appropriate method can be chosen by the user.

NOTE 11—Suitable collecting devices are glass or plastic funnels with the stems inserted through stoppers into graduated cylinders, or crystallizing dishes. Funnels and dishes with a diameter of 10 cm (3.94 in.) have an area of about 80 cm<sup>2</sup> (12.4 in.<sup>2</sup>).

NOTE 12—The specific gravity of salt solution will change with temperature. Table 3 shows salt concentration and density versus temperature<sup>3</sup> and can be used to determine if the sample measured is within specification. The sample to be measured may be a composite sample from multiple fog-collecting devices within a single cabinet, if necessary, to obtain sufficient solution volume for measurement.

Table 3 shows the salt concentration and salt density of 4 %, 5 %, and 6 % salt solution between 20 °C and 40 °C. A measurement that falls within the range between 4 % and 6 % is acceptable.

It is important to understand the equipment being used to measure specific gravity. One common practice for specific gravity measurement is the use of a hydrometer. If used, careful attention to the hydrometer type is important as most are manufactured and calibrated for measurements at 15.6 °C (60 °F). Since salt density is temperature dependent, an offset will be necessary to make an accurate measurement at other temperatures. Contact the hydrometer manufacturer to find the proper offset for the hydrometer being used.

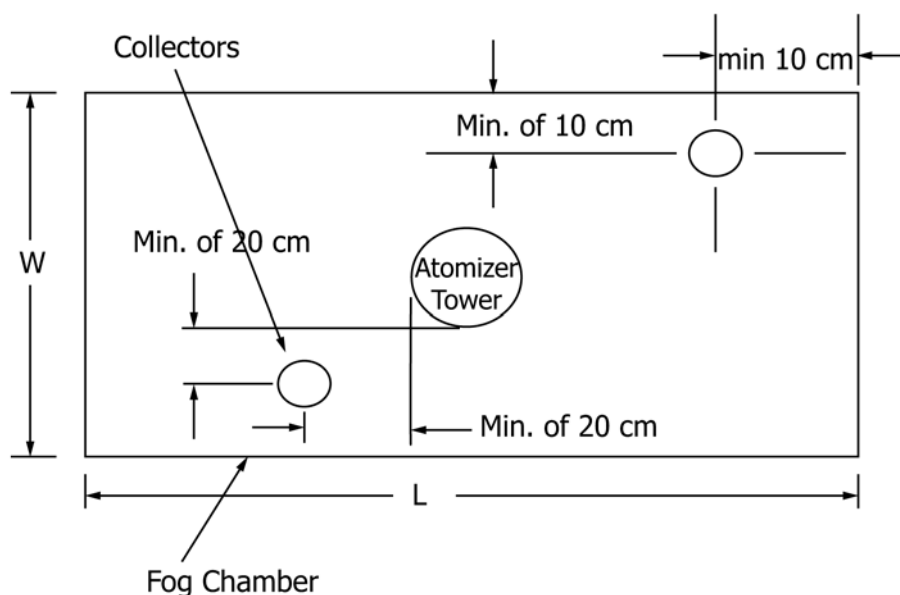
NOTE 13—Salt solutions from 2 % to 6 % will give the same results, though for uniformity the limits are set at 4 % to 6 %.

10.3 The nozzle or nozzles shall be so directed or baffled that none of the spray can impinge directly on the test specimens.

## 11. Continuity of Exposure

11.1 Unless otherwise specified in the specifications covering the material or product being tested, the test shall be continuous for the duration of the entire test period. Continuous operation implies that the chamber be closed and the spray operating continuously except for the short daily interruptions

<sup>3</sup> "Thermodynamic Properties of the NaCl + H<sub>2</sub>O system II. Thermodynamic Properties of NaCl(aq), NaCl·2H<sub>2</sub>O(cr), and Phase Equilibria," *Journal of Physics and Chemistry Reference Data*, Vol. 21, No. 4, 1992.



NOTE 1—This figure shows a typical fog collector arrangement for a single atomizer tower cabinet. The same fog collector arrangement is also applicable for multiple atomizer tower and horizontal ("T" type) atomizer tower cabinet constructions as well.

FIG. 1 Arrangement of Fog Collectors