

**METHOD 518.2**  
**ACIDIC ATMOSPHERE**

**NOTE:** Tailoring is essential. Select methods, procedures and parameter levels based on the tailoring process described in Part One, paragraph 4.2.2, and Annex C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this Standard.

**1. SCOPE.**

**1.1 Purpose.**

Use the acidic atmosphere test to determine the resistance of materials and protective coatings to corrosive atmospheres, and when necessary, to determine its affect on operational capabilities.

**1.2 Application.**

Use this test Method when the requirements documents state that the materiel is likely to be stored or operated in areas where acidic atmospheres exist, such as industrial areas or near the exhausts of any fuel-burning device.

**1.3 Limitations.**

This Method is not a replacement for the salt fog method, nor is it suitable for evaluating the effects of hydrogen sulfide that readily oxidizes in the test environment to form sulfur dioxide. Consult ASTM G85, (paragraph 6.1, reference a) for information on introducing a sulfur dioxide environment. Caution: Although salt fog chambers are usually used for this test, introducing an acidic or sulfur dioxide atmosphere in a salt fog chamber may contaminate the chamber for future salt fog tests.

**2. TAILORING GUIDANCE.**

**2.1 Effects of the Environment.**

Acidic atmospheres are of increasing concern, especially for materiel in the vicinity of industrial areas or near the exhausts of fuel burning devices. Examples of problems that could occur as a result of acidic atmosphere exposure are as follows. The list is not intended to be all-inclusive, and some of the examples may overlap the categories. Paragraph 6.1, reference a provides further information.

- a. Chemical attack of surface finishes and non-metallic materials.
- b. Corrosion of metals.
- c. Pitting of cement and optics.

**2.2 Test Procedure.**

When an acidic atmosphere test is deemed necessary, the procedure included in this method is considered suitable for most applications. The tailoring options are limited.

**2.3 Sequence.**

- a. General. Use the anticipated life cycle sequence of events as a general sequence guide (see Part One, paragraph 5.5).
- b. Unique to this Method. There are at least two philosophies related to test sequence. One approach is to conserve test item life by applying what are perceived to be the least damaging environments first. For this approach, generally apply the acidic atmosphere test late in the test sequence. Another approach is to apply environments to maximize the likelihood of disclosing synergetic effects. For this approach, consider acidic atmosphere testing following dynamic tests, such as vibration and shock. Perform acidic atmosphere testing after any humidity or fungus testing, and before any sand and dust testing or other tests that damage protective coatings. Because this test is similar in severity to the salt fog test, recommend separate test items be used for each.

- (1) Sand and dust testing deposits may inhibit acid effects as well as abrade protective coatings.
- (2) Acid deposits may inhibit mold/fungal growth.
- (3) Residual deposits may accelerate chemical reactions during humidity testing.

#### **2.4 Determine Test Levels and Conditions.**

Having selected this method and relevant procedures (based on the test item's requirements documents and the tailoring process), complete the tailoring process by identifying appropriate parameter levels and applicable test conditions and techniques for these procedures. Base these selections on the requirements documents, the Life Cycle Environmental Profile (LCEP), and information provided with this procedure. Consider the essential parameters for defining the acidic atmosphere test that include exposure temperature, exposure time (duration), test item configuration, chemical composition of the test atmosphere, and concentration of the test solution.

##### **2.4.1 Temperature Severities.**

The test method and the exposure temperature used in this procedure are similar to that used in the salt fog test.

##### **2.4.2 Test Duration.**

Two severity levels are defined (paragraph 6.1, reference b). In view of the complexity of naturally occurring corrosion processes, no strict equivalencies with real exposure can be quoted. Use severity "a" below for simulating infrequent periods of exposure, or for exposure in areas of much lower acidity. Use severity "b" below to represent approximately 10 years natural exposure in a moist, highly industrial area, or a shorter period in close proximity to vehicle exhaust systems, particularly ship funnel exhausts where the potential acidity is significantly higher.

- a. Three 2-hour spraying periods with 22 hours storage after each.
- b. Four 2-hour spraying periods with 7 days storage after each.

##### **2.4.3 Test Item Configuration.**

The configuration of the materiel is an important factor in how an acidic atmosphere affects it. Therefore, during the test use the anticipated configuration of the materiel during storage or use. As a minimum, consider the following configurations:

- a. In a shipping/storage container or transit case.
- b. Protected or unprotected.
- c. Deployed (realistically or with restraints, such as with openings that are normally covered).
- d. Modified with kits for special applications.

##### **2.4.4 Chemical Composition and Concentration.**

Unless otherwise specified, for atomization, use a test solution containing 11.9mg (6 µl) sulfuric acid (95-98 percent)/4 liters (4.23 qt) of solution, and 8.8mg (6 µl) nitric acid (68-71 percent)/4 liters (4.23 qt) solution in distilled or deionized water. This will produce a solution with a pH of 4.17 that is representative of some of the worst rain pHs recorded for rainfall in the eastern United States and other heavily industrialized areas with acidic emissions. Paragraph 6.1, reference c, provides information regarding the more common chemical environmental contaminants together with some consequent likely forms of corrosion that material could encounter.

***WARNING: Strong acids are hazardous. The solution to be sprayed is harmful to people and clothing. Operators carrying out the test must take suitable precautions.***

***WARNING: Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data.***

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- a. Do not enter the chamber during atomization and, before entry after exposure, purge the chamber with clean air to a level that will satisfy local safety requirements. Continue purging at intervals if necessary to ensure the concentration of noxious fumes remains at a suitably low level.
- b. Wear a suitable respirator and/or eye protection. Use rubber gloves to handle materiel.
- c. See paragraph 4.1b for hazardous waste disposal information.

#### 2.4.5 Operational Considerations.

The test item will not normally be required to function during the test, but may be required to do so upon completion of the test, or on completion of a representative sequence of environmental tests.

### 3. INFORMATION REQUIRED.

#### 3.1 Pretest.

The following information is required to conduct acidic atmosphere tests adequately:

- a. General. Information listed in Part One, paragraphs 5.7 and 5.9; and Annex A, Task 405 of this Standard.
- b. Specific to this Method.
  - (1) Areas of the test item visually and functionally examined, and an explanation of their inclusion or exclusion.
  - (2) Whether the test is a demonstration of performance or survival.
  - (3) Whether the requirement is to demonstrate safety, safety and performance, or resistance to chemical attack after the test.
  - (4) If functional performance is to be assessed, the phases of the test when the test item is to function and be assessed, and the levels of performance required.
- c. Tailoring. Necessary variations in the basic test procedures to accommodate environments identified in the LCEP.

#### 3.2 During Test.

Collect the following information during conduct of the test:

- a. General. Information listed in Part One, paragraph 5.10; and in Annex A, Tasks 405 and 406 of this Standard.
- b. Specific to this Method.
  - (1) Record of chamber temperature versus time conditions.
  - (2) Fallout quantities per unit of time (see paragraph 4.1g).
  - (3) Fallout pH.

#### 3.3 Post-Test.

The following post test data shall be included in the test report.

- a. General. Information listed in Part One, paragraph 5.13; and in Annex A, Task 406 of this Standard.
- b. Specific to this Method.
  - (1) Areas of the test item visually and functionally examined and an explanation of their inclusion or exclusion.
  - (2) Test variables:
    - (a) Test solution pH.
    - (b) Test solution fallout rate (ml/cm<sup>2</sup>/hr).
  - (3) Results of examination for corrosion, electrical, and physical effects.
  - (4) Observations to aid in failure analysis.

- (5) Any deviation from the original test plan.

#### 4. TEST PROCESS.

##### 4.1 Test Facility.

- a. For construction of the chamber, supporting racks, and atomization equipment use materials inert to the acid solution being sprayed, and that will not cause electrolytic corrosion with material with which it comes in contact.
- b. Ensure the test chamber has a waste collection system so that all waste material can be tested prior to disposal. Dispose of any material determined to be hazardous waste in accordance with local, state, and federal regulations.
- c. Do not reuse acidic test solution drippings from the walls and ceilings of the chamber and from the test item. Vent the exposure chamber to prevent pressure buildup.
- d. Use a chamber capable of maintaining temperatures in the exposure zone at  $35 \pm 2 \text{ }^\circ\text{C}$  ( $95 \pm 4 \text{ }^\circ\text{F}$ ). Continuously control this temperature during the test. Do not use immersion heaters within the chamber exposure area for the purpose of maintaining the temperature within the exposure zone.
- e. Use an acid solution reservoir and dispenser made of material that is non-reactive with the acid solution, e.g., glass, hard rubber, or plastic. The reservoir provides a continuous supply to a tank normally (but not necessarily) situated inside the test section in which the acid solution level is held reasonably constant. The atomizers are connected to this tank.
- f. Use a chamber with a means for injecting the acid solution into the test chamber and with an input air humidifier to minimize clogging of the nozzles. Use atomizers of such design and construction as to produce a finely divided, wet, dense fog. Use atomizing nozzles and a piping system made of material that is non-reactive to the acid solution. Use a facility designed to provide the required atomization distribution and fallout.
- g. Use a test setup that includes a minimum of 2 fallout collection receptacles. One is to be at the perimeter of the test item nearest to the nozzle, and the other also at the perimeter of the test item but at the farthest point from the nozzle. If multiple nozzles are used, the same principles apply. Place the receptacles so that they are not shielded by the test item and will not collect drops of solution from the test item or other sources.
- h. Constant air pressure for the continuous, uniform atomization of the acid solution using a compressed air supply, and produce a fallout such that each receptacle collects from 1 to 3 ml (0.03 to 0.10 oz) of solution per hour for each  $80 \text{ cm}^2$  ( $12.4 \text{ in.}^2$ ) of horizontal collecting area ( $10 \text{ cm}$  ( $3.9 \text{ in.}$ ) diameter).

##### 4.2 Controls.

- a. Compressed air. Preheat the oil and dirt-free compressed air used to produce the atomized solution (to offset the cooling effects of expansion to atmospheric pressure), and pre-humidify it such that the temperature is  $35 \pm 2 \text{ }^\circ\text{C}$  ( $95 \pm 4 \text{ }^\circ\text{F}$ ), and the relative humidity is in excess of 85 percent at the nozzle (see Table 518.2-I)
- b. Preheating. Heat the acid solution to within  $\pm 6 \text{ }^\circ\text{C}$  ( $\pm 11 \text{ }^\circ\text{F}$ ) of the test section temperature before injection into the test section.
- c. Test section air circulation. Use an air velocity in the test chambers that is minimal (essentially zero).

**Table 518.2-I. Temperature and pressure requirements for operation at  $35 \text{ }^\circ\text{C}$  ( $95 \text{ }^\circ\text{F}$ ).**

Air Pressure (kPa(psi))	83 (12)	96 (14)	110 (16)	124 (18)
Preheat temperature ( $^\circ\text{C}$ ( $^\circ\text{F}$ )) (BEFORE ATOMIZING)	46 (115)	47(117)	48(118)	49(120)

### 4.3 Test Interruptions.

Test interruptions can result from two or more situations, one being from failure or malfunction of test chambers or associated test laboratory equipment. The second type of test interruption results from failure or malfunction of the test item itself during operational checks.

#### 4.3.1 Interruption Due To Chamber Malfunction.

- a. General. See Part One, paragraph 5.11 of this Standard.
- b. Specific to this Method.
  - (1) Undertest Interruption. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances toward standard ambient conditions, give the test item a complete visual examination and develop a technical evaluation of the impact of the interruption on the test results. Restart the test at the point of interruption and restabilize the test item at the test conditions.
  - (2) Overtest Interruption. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances away from standard ambient conditions, stabilize the test conditions to within tolerances and hold them at that level until a complete visual examination and technical evaluation can be made to determine the impact of the interruption on test results. If the visual examination or technical evaluation results in a conclusion that the test interruption did not adversely affect the final test results, or if the effects of the interruption can be nullified with confidence, restabilize the pre-interruption conditions and continue the test from the point where the test tolerances were exceeded.

#### 4.3.2 Interruption Due To Test Item Operation Failure.

Failure of the test item(s) to function as required during operational checks presents a situation with several possible options.

- a. The preferable option is to replace the test item with a “new” one and restart from Step 1.
- b. A second option is to replace / repair the failed or non-functioning component or assembly with one that functions as intended, and restart the entire test from Step 1.

<p><b>NOTE:</b> When evaluating failure interruptions, consider prior testing on the same test item and consequences of such.</p>
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### 4.4 Test Setup.

- a. General. See Part One, paragraph 5.8.
- b. Unique to this Method. Ensure the fallout collection containers are situated in the chamber such that they will not collect fluids dripping from the test item.

### 4.5 Test Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item in an acidic atmosphere environment.

#### 4.5.1 Preparation for Test.

##### 4.5.1.1 Preliminary Steps.

- a. Prepare a test solution as specified in paragraph 2.4.4.

**NOTE: MAKE THE SOLUTION BY ADDING ACID TO WATER, NOT VICE VERSA.**

***WARNING: Refer to the supplier's Material Safety Data Sheet (MSDS) or equivalent for health hazard data.***

***Strong acids are hazardous, and the solution to be used is harmful to people and clothing. Operators carrying out the test must take suitable precautions, and use personal protective equipment (PPE).***

- (1) Do not enter the chamber during atomization. Before entry after atomization, purge the chamber with clean air to a level that will satisfy local safety requirements. Continue purging at intervals if necessary to ensure the concentration of noxious fumes remains at a suitably low level.
  - (2) Wear a suitable respirator and/or eye protection. Use rubber gloves to handle material.
- b. Chamber operation verification: Immediately before the test and with the exposure chamber empty, adjust all test parameters to those levels required for the test. Maintain these conditions for at least one 24-hour period (or until proper operation and fallout collection can be verified). With the exception of fallout rate, continuously monitor all test parameters to verify that the test chamber is operating properly.
- c. Conduct an operational checkout in accordance with the test plan and record the results for compliance with Part One, paragraph 5.9. Handle the test item as little as possible, particularly on the significant surfaces, and prepare it for test immediately before exposure. Unless otherwise specified, use test items free of surface contamination such as oil, grease, or dirt that could cause dewetting. Do not include the use of corrosive solvents, solvents that deposit either corrosive or protective films, or abrasives other than pure magnesium oxide in the cleaning methods.

#### 4.5.1.2 Pretest Standard Ambient Checkout.

All items require a pretest checkout at room ambient conditions to provide baseline data. Conduct the checkout as follows:

Step 1 Prepare the test item in its required configuration in accordance with Part One, paragraph 5.8.1.

Step 2 Conduct a complete visual examination of the test item with attention to:

- (a) High-stress areas.
- (b) Areas where dissimilar metals are in contact.
- (c) Electrical and electronic components - especially those having closely spaced, unpainted or exposed circuitry.
- (d) Metallic surfaces.
- (e) Enclosed volumes where condensation has occurred or may occur.
- (f) Components or surfaces provided with coatings or surface treatments for corrosion protection.
- (g) Cathodic protection systems; mechanical systems subject to malfunction if clogged or coated with salt deposits.
- (h) Electrical and thermal insulators.

**NOTE:** Consider partial or complete disassembly of the test item if a complete visual examination is required. Be careful not to damage any protective coatings, etc.

- Step 3 Document the results. (Use photographs, if necessary.)
- Step 4 Conduct an operational checkout in accordance with the test plan and record the results for compliance with Part One, paragraph 5.9.
- Step 5 If the test item meets the requirements of the test plan or other applicable documents, proceed to Step 1 of the test procedure below. If not, resolve any problems and restart the pretest standard ambient checkout at the most reasonable step above.

#### 4.5.1.3 Procedure.

- Step 1 With the test item installed in the test chamber in its storage configuration (or as otherwise specified in the requirements documents), adjust the test chamber temperature to 35 °C (95 °F), and temperature condition the test item for at least 2 hours before introducing the acid solution.
- Step 2 Expose the test item to one of the two following severities as specified in the test plan. (See paragraph 2.4.2.) During either the (a) or (b) options shown below, continuously atomize the acidic solution (of a composition as given in paragraph 2.4.4). During the entire exposure period, measure the acidic solution fallout rate and pH at least at 24-hour intervals (Recommend more frequent intervals. Repeat the interval if fallout quantity requirements are not met). Ensure the fallout is between 1 and 3 ml/80cm<sup>2</sup>/hr.
  - (a) Four 2-hour exposure periods with 7 days storage after each.
  - (b) Three 2-hour exposure periods with 22 hours storage after each.
- Step 3 At the completion of Step 2, stabilize the test item at standard ambient conditions.
- Step 4 Using appropriate protective clothing, visually examine the test item to the extent practical.
- Step 5 If required, place the test item in an operational configuration and conduct an operational check of the test item. See paragraph 5 for analysis of results.
- Step 6 If required, test items may be cleaned by rinsing with a dilute sodium bicarbonate solution (to neutralize any acidic residue), followed by distilled/deionized water, and dried by the application of heat (up to 55 °C (131 °F)), where this is acceptable, or by other means. Collect the rinse water and check it for hazardous substances prior to disposal (see paragraph 4.1b also).
- Step 7 At the end of this test, and in conformity with the requirements documents, examine the test item for corrosion and deterioration of parts, finishes, materials, and components. Document the results.

## 5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results. Analyze any corrosion for its immediate effect on the satisfactory operation of the test item. Satisfactory operation following this test is not the sole criterion for pass/fail.

## 6. REFERENCE/RELATED DOCUMENTS.

### 6.1 Referenced Documents.

- a. ASTM G85, "Standard Practice for Modified Salt Spray (Fog) Testing", ASTM International. Visit the ASTM Website or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org).
- b. International Electrotechnical Commission (IEC) 68-2-52, 1966, Test Kb, Salt Mist, Cyclic, NaCl solution.
- c. Acid Deposition in the United Kingdom, Warren Spring Laboratory, ISBN 085624 323X (UK).

### 6.2 Related Documents.

- a. DEF STAN 00-50, Guide to Chemical Environmental Contaminants and Corrosion Affecting the Design of Military Materiel (UK).
- b. NATO STANAG 4370, Environmental Testing.
- c. NATO Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests, Method 319, "Acidic Atmosphere".

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- d. Egbert, Herbert W. "The History and Rationale of MIL-STD-810 (Edition 2)", January 2010; Institute of Environmental Sciences and Technology, Arlington Place One, 2340 S. Arlington Heights Road, Suite 100, Arlington Heights, IL 60005-4516.

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