METHOD 524.1

FREEZE / THAW

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FREEZE / THAW

> **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.

This method was adapted from NATO STANAG 4370, AECTP 300, Method 315.

1.1 Purpose.

The purpose of this Method is to determine the ability of materiel to withstand**:**

a. The effects of moisture phase changes between liquid and solid, in or on materiel, as the ambient temperature cycles through the freeze point.

b. The effects of moisture induced by transfer from a cold-to-warm or warm-to-cold environment.

1.2 Application.

This Method is applicable to materiel that will experience one or more excursions through the freeze point while wet or in the presence of moisture (free water or vapor). See paragraph 2.1 for specific examples. For additional information, see Part Three, paragraph 5.9.

1.3 Limitations.

This Method is not intended to evaluate the effects of low temperature, thermal shock, rain, or icing. These may be determined using Methods 502.7, 503.7, 506.6, and 521.4, respectively.

2. TAILORING GUIDANCE.

2.1 Effects of the Environment.

This Method induces physical changes in or on non-stationary materiel. Examples of problems that could occur during these tests are as follow:

a. Distortion or binding of moving parts.

b. Failure of bonding materials.

c. Failure of seals.

d. Failure of materials due to freezing/re-freezing of absorbed, adjacent, or free water.

e. Changes in characteristics of electrical components.

f. Electrical flashover/reduced insulation resistance.

g. Fogging of optical systems during freeze-thaw transitions.

h. Inability to function correctly due to ice adhesion and interference or blockage of moving parts.

2.2 Test Procedures.

When a freeze/thaw test is thought necessary, the three procedures included in this Method are suitable for most materiel**:**

2.2.1 Procedure I – Diurnal Cycling Effects.

To simulate the effects of diurnal cycling on materiel exposed to temperatures varying slightly above and below the freeze point that is typical of daytime warming and freezing at night when deposits of ice or condensation, or high relative humidity exist. For Procedure I to be effective, frost must form on the test item surfaces during the temperature increase through the freeze point, and then melt just prior to re-freezing.

2.2.2 Procedure II – Fogging.

For materiel transported directly from a cold to a warm environment such as from an unheated aircraft, missile or rocket, to a warm ground area, or from a cold environment to a warm enclosure, and resulting in free water or fogging.

> **NOTE:** Tests for fogging are only appropriate for materiel designed to not fog or that has built-in de-fogging capabilities.

2.2.3 Procedure III – Rapid Temperature Change.

For materiel that is to be moved from a warm environment to a cold environment (freeze) and then back to the warm environment, inducing condensation (free water).

2.3 Determine Test Levels and Conditions.

Specify the most significant parameters for this Method such as temperature, moisture level/form, test item configuration (operational or storage), and the number of freeze/thaw cycles.

2.3.1 Test Item Configuration.

Perform the test using all the configurations in which the materiel may be placed during its life cycle. As a minimum, consider the following configurations**:**

a. In a shipping/storage container or transit case.

b. Protected or not protected.

c. In its operational configuration.

d. Modified with kits for special applications.

2.3.2 Temperature Range.

Use temperatures within the storage or operational range of the test item. Normally, the temperature cycle ranges between +5 °C and -10 °C (41 °F and 14 °F) for diurnal cycling effects, and -10 °C (14 °F) to standard ambient (Part One, paragraph 5.1), but these vary as required to achieve the desired effects.

2.3.3 Moisture.

Use water needed to create the test moisture from local (clean) water sources. Apply the moisture as a water vapor or as free water (spray).

2.3.4 Number of Cycles.

A cycle is a change from one thermal-moisture condition to another and back to the original condition. Unless otherwise specified in the test procedure(s), hold the test item at each condition for a minimum of one hour following test item temperature stabilization. Unless otherwise justified by the materiel's life cycle profile, apply the following minimum number of cycles:

a. Diurnal cycling effects (daily freeze-thaw): Minimum of twenty (see Part Three, paragraph 5.9a, and paragraph 6.1, reference c).

b. Cold-to-warm transfer (for free water or possible fogging): Three.

c. Warm-cold-warm (for freezing and melting, rapid temperature change): Three.

3. INFORMATION REQUIRED.

In addition to the information derived from Part One, apply a brief scenario of service conditions to explain the intended simulation. Also state**:**

a. The type of moisture required (vapor or spray).

b. The initial test conditions and the temperatures to be used.

c. Whether the test is a demonstration of survival or of functional performance.

d. The number of cycles to be used.

3.1 Pretest.

The following information is required to adequately conduct freeze/thaw tests.

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) Low temperature extreme and time at that temperature.

  (2) Rate of temperature rise.

  (3) Means of introducing moisture using water vapor.

  (4) Number of cycles.

c. Tailoring. Necessary variations in the basic test procedures to accommodate LCEP requirements.

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. For test validation purposes, record deviations from planned or pre-test procedures or parameter levels, including any procedural anomalies that may occur. Include**:**

  (1) The transfer times between chambers (door open to door close).

  (2) Conditions at which frost forms.

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) Length of time for visual examination and performance checks.

  (2) Results of visual and operational checks (during and after testing).

  (3) Location of any free water on or in the test item.

4. TEST PROCESS.

See Part One for test facility, test conditions, and test control information.

4.1 Test Facility.

In addition to the requirements specified in Part One, recommend using two chambers for Procedures II and III in order to simulate the sudden temperature changes often associated with movement between outside ambient and indoor conditions. Either a single chamber or combination of chambers is acceptable, as long as the test procedure requirements are satisfied.

4.2 Controls.

a. Temperature. Unless otherwise specified in the test plan, if any action other than test item operation (such as opening the chamber door) results in a significant change of the test item temperature (more than 2 °C (3.6 °F)), re-stabilize the test item at the required temperature before continuing. If the operational check is not completed within 15 minutes, reestablish the test item temperature conditions before continuing.

b. Rate of temperature change. Unless otherwise specified, control the rate of temperature change to not exceed 3 °C (5.4 °F) per minute to prevent thermal shock.

c. Temperature measurement. Install temperature sensor instrumentation on or in the test item to measure temperature stabilization data (see Part One, paragraph 5.4).

d. Temperature recording. Continuously record the chamber and test item temperature, if required.

4.3 Test Interruptions.

4.3.1 Interruption Due To Chamber Malfunction.

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.

a. General. See Part One, paragraph 5.11 of this Standard.

b. Specific to this Method. Interruption of a freeze-thaw test is unlikely to generate any adverse effects. Normally, continue the test from the point of interruption once the test conditions have been re-established.

4.3.2 Interruption Due To Test Item Operation Failure.

Failure of the test item(s) to function as required during mandatory or optional performance checks during testing 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.

4.4 Test Execution.

4.4.1 Preparation for Test.

4.4.1.1 Preliminary Steps.

Before starting the test, review pretest information in the test plan to determine test details (e.g., procedures, test item configuration/orientation, cycles, durations, parameter levels for storage/operation, etc.). (See Part One, paragraph 5.9, and paragraph 3.1, above.)

4.4.1.2 Pretest Standard Ambient Checkout.

Step 1 Remove unrepresentative coatings/deposits and contaminants such as oils, grease and dirt that could affect the adhesion of ice to the specimen surface.

Step 2 Ensure any fluids contained in the test item are compatible with the temperatures used in the test.

Step 3 Install temperature sensors in, on, or around the test item (as described in the test plan) to measure temperature stabilization and surface temperatures.

Step 4 Place the test item in the test chamber at standard ambient conditions and in the required configuration.

Step 5 Conduct a visual examination of the test item with special attention to stress areas, such as corners of molded cases, and document the results.

Step 6 Conduct an operational checkout (Part One, paragraph 5.8.2) as described in the plan and record the results.

Step 7 If the test item operates satisfactorily; proceed to paragraph 4.4.2, 4.4.3, or 4.4.4 as appropriate. If not, resolve the problems and repeat Step 6 above.

4.4.2 Procedure I – Diurnal Cycling Effects.

Step 1 Spray the test item sufficient to fill any horizontal pockets to simulate water collected during a rain storm.

Step 2 Reduce the temperature inside the chamber to -10 °C (14 °F) or as otherwise specified for the initial conditions at a rate not exceeding 3 °C (5 °F) per minute. Maintain the condition for a minimum of one hour after the test item temperature has stabilized.

Step 3 Increase the chamber temperature to 4 °C (39 °F) over a period of three hours. When the chamber air temperature reaches 0 °C (32 °F), introduce moisture using water vapor, steam, vapor generator or other means to raise and maintain the humidity at or close to saturation.

Step 4 When the test item surface temperature reaches 0 °C (32 °F), ensure frost has formed on the test item surfaces.

Step 5 Continue raising the test chamber towards a test item surface temperature of 4 °C (39 °F) (water at maximum density) until the frost just melts, then reduce the temperature to -10 °C (14 °F) over a period of three hours. Maintain the conditions for a minimum of one hour following test item temperature stabilization.

Step 6 Repeat Steps 3 through 5 for a total of twenty cycles unless otherwise specified.

Step 7 Maintain the chamber and test item at the low temperature conditions until a visual examination and/or operational checks have been completed. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2. Otherwise go to Step 8.

Step 8 Return the test item to standard ambient conditions. Perform a complete visual and operational check, and document the results. See paragraph 5 for analysis of results.

4.4.3 Procedure II – Fogging.

Step 1 Adjust the chamber temperature to 10 °C (18 °F) below the freezing point or as otherwise specified for the initial conditions at a rate not exceeding 3 °C (5 °F) per minute. Maintain the condition until the test item temperature has stabilized plus one hour.

Step 2 Transfer the test item to another chamber (previously adjusted to the upper specified temperature) as quickly as possible such that condensation or fogging occurs. The use of insulated transport containers is recommended. Maintain this second chamber at the specified upper temperature (usually room ambient) with a relative humidity of 95 ± 5 percent.

Step 3 Start operation and any performance tests of the test item 60 ± 15 seconds after completion of the transfer, and document results. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2 for test item failure.

Step 4 Return the test item to the low temperature chamber and repeat Steps 1-3 as required to complete the number of cycles identified in paragraph 2.3.4.

Step 5 Return the test item to standard ambient conditions. Perform a complete visual and operational check, and document the results. See paragraph 5 for analysis of results.

4.4.4 Procedure III – Rapid Temperature Change.

Step 1 Adjust the chamber temperature to the specified upper temperature (usually standard ambient) at a rate of approximately 3 °C (5 °F) per minute, and a relative humidity of 95 ± 5 percent. Maintain these conditions until the test item temperature has stabilized plus one hour.

Step 2 Transfer the test item as quickly as possible and in not more than 5 minutes to another chamber stabilized at -10 °C (14 °F). Stabilize the test item temperature and hold for one additional hour.

Step 3 Unless otherwise specified, perform an operational check. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2 for test item failure.

Step 4 Transfer the test item as quickly as possible and in not more than 5 minutes to another chamber stabilized at the specified upper temperature (usually standard ambient) and a relative humidity of 95 ± 5 percent. Note the presence of any free water, and repeat Step 2 through 4 for a total of three cycles unless otherwise specified.

Step 5 Return the test item to standard ambient conditions. Perform an operational check and physical inspection, and document results. If the test item fails to operate as intended, see paragraph 5 for analysis of results, and follow the guidance in paragraph 4.3.2 for test item failure.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraph 5.14, the following information is provided to assist in the evaluation of the test results. Apply any data relative to failure of a test item to meet the requirements of the materiel specifications to the test analysis, and consider related information such as:

a. Results of nondestructive examinations (if any) of materiel following the freeze-thaw test(s) may be conducted at the extreme temperatures.

b. Degradation or changes in operating characteristics allowed at the temperature extremes.

c. Evidence of improper lubrication and assurance that the lubricants specified for the environmental condition were used.

6. REFERENCE/RELATED DOCUMENTS.

6.1 Referenced Documents.

a. Allied Environmental Conditions and Test Publication (AECTP) 300, "Climatic Environmental Tests" (under STANAG 4370), Method 315.

b. NATO STANAG 4370, Environmental Testing.

c. Environmental Standards for Materiel Design Group of the AirLand Battlefield Environment Executive (ALBE) Committee (1987), "Environmental Factors and Standards for Atmospheric Obscurants, Climate, and Terrain", Washington, D.C.

6.2 Related Documents.

a. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.

b. MIL-HDBK-310, Global Climatic Data for Developing Military Products.

c. Synopsis of Background Material for MIL-STD-210B, Climatic Extremes for Military Equipment. Bedford, MA: Air Force Cambridge Research Laboratories, 24 January 1974. DTIC number AD-780-508.

d. NATO Allied Environmental Conditions and Test Publication (AECTP) 230, "Climatic Conditions".

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