

As part of VMI's ongoing qualification as provider of CR Systems for the US Navy's NAVAIR Group, the VMI 5100MS CR System has been Independently Tested and Certified for Environmental Durability and Ruggedness as Prescribed in MIL-PRF 28800F and MIL-STD 810F.

In August of 2009, the VMI 5100MS CR System was tested by an independent testing facility. The complete system remained operational through ALL tests and no reportable conditions or anomalies were recorded. The following document describes the Testing Standards that were followed for each test and the test procedures utilized.

TEST METHOD

- Random Vibration Section 1
- 30G Shock Section 2
- Transit Drop Section 3
- Bench Handling..... Section 4
- Blowing and Settling Dust..... Section 5
- Blowing Sand..... Section 6
- Operating & Storage Temperature Section 7
- Humidity..... Section 8
- Salt Fog..... Section 9
- Fungus..... Section 10

APPLICABLE DOCUMENTS

Unless otherwise specified, the following specifications and/or standards shall form a part of this procedure to the extent specified herein. In the event of conflict between the document referenced herein and this procedure, this procedure governs.

GOVERNMENT DOCUMENTS:

MIL-PRF-28800F-810F	Performance Specification, Test Equipment for Use With Electrical and Electronic Equipment, General Specification, dated June 24, 1996.
MIL-STD-810F	Department of Defense Test Method Standard for Environmental Engineering Consideration and Laboratory Tests, Notice 2, dated August 30, 2002.

INTERNATIONAL STANDARDS:

ANSI/NCSL Z540-1-1994	Calibration Laboratories and Measuring and Test Equipment General Requirements
-----------------------	--

TEST CONDITIONS AND TOLERANCES

STANDARD AMBIENT:

Unless otherwise specified, all tests specified in this procedure shall be accomplished within the conditions shown below:

- a) Temperature: +15°C to +35°
- b) Relative Humidity: Not greater than 85%
- c) Barometric Pressure: Station (site) pressure (84kPa to 107 kPa)

TEST TOLERANCES:

Unless otherwise indicated, the maximum tolerances allowable for the test conditions during tests shall be as specified below:

Temperature:	± 3.0°C
Vibration Amplitude	
Sine:	± 10%

Vibration Frequency: $\pm 2\%$
below 25-Hz: $\pm \frac{1}{2}$ -Hz
Random
<500 Hz: +3.0/-1.5 dB
500 Hz to 2,000 Hz: ± 3.0 dB
Time: $\pm 1\%$

INSPECTION/TEST EQUIPMENT

The following inspection/test equipment, or equivalent, utilized in the performance of the Environmental Tests are calibrated IAW ISO 10012-1, and ANSI/NC SL Z540-1-1994, traceable to National Institute Of Standards And Technology (NIST).

List of Required Equipment

Description	Cal Freq.
Amplifier	UWCE*
Accelerometer	1 year
Chamber Controller	6 months
Chart Recorder	6 months
Controller	6 months
Data Logger	1 year
DC Power Supply	UWCE*
Digital Multimeter	1 year
Hydrometer	UWCE*
Limit Controler	1 year
n-Hexanes	N/A
pH Hydrion Buffer Capsules	4 years
Ph Tester	UWCE*
Stopwatch	1 year
Temperature Chamber	UWCE*
Temperature Indicator	6 months
Tape Measure	Lifetime
Torque Wrench	1 year
Vibration Control System	6 months
Vibration Shaker	UWCE*
Humidity Sensor	1 year

*UWCE = Use With Calibrated Equipment.

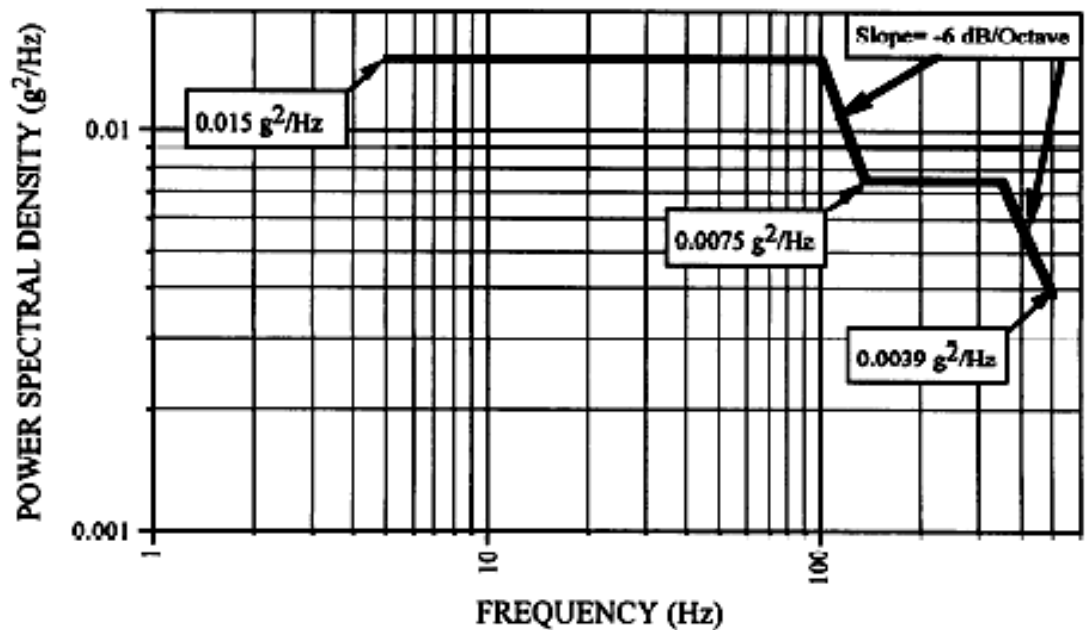
ENVIRONMENTAL TEST REQUIREMENTS AND METHODS

1 RANDOM VIBRATION:

1.1 REQUIREMENTS

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.3.1, Class 3).
- b) The test unit shall be subjected to Vibration in accordance with Table 9-1 (Ref: Fig. 13 of MIL-PRF-28800F-810F), and shall be capable of operating during and after the test is performed (see Section 4.3).

Figure 9-1: Vibration profile for Classes 3 and 4



1.2 METHODS:

- a) Perform a pre-test functional examination of the VMI 5100MS.
- b) Vibration levels of Figure 9-1 shall be applied to equipment of classes 3 and 4, with durations of 10 minutes per axis.
- c) Testing shall be performed in three mutually perpendicular axes.
- d) The VMI 5100MS shall be powered off during the vibration test.

- e) The VMI 5100MS shall be hard mounted to the table by gripping the equipment's structure. Unless the equipment's feet are integral parts of the structure, they should be removed during the test; if they are integral, the equipment should be fixed so that the vibration is applied to the structural frame of the equipment.
- f) An accelerometer will be attached firmly to the test fixture plate to control the input acceleration.
- g) Unless otherwise stated, no response accelerator will be attached to the Unit Under Test (UUT).
- h) Testing for vibration will be in-axis, minimizing UUT rotation and handling.
- i) At the conclusion of the vibration test, conduct a physical evaluation and a performance test of the equipment.

2 MECHANICAL SHOCK:

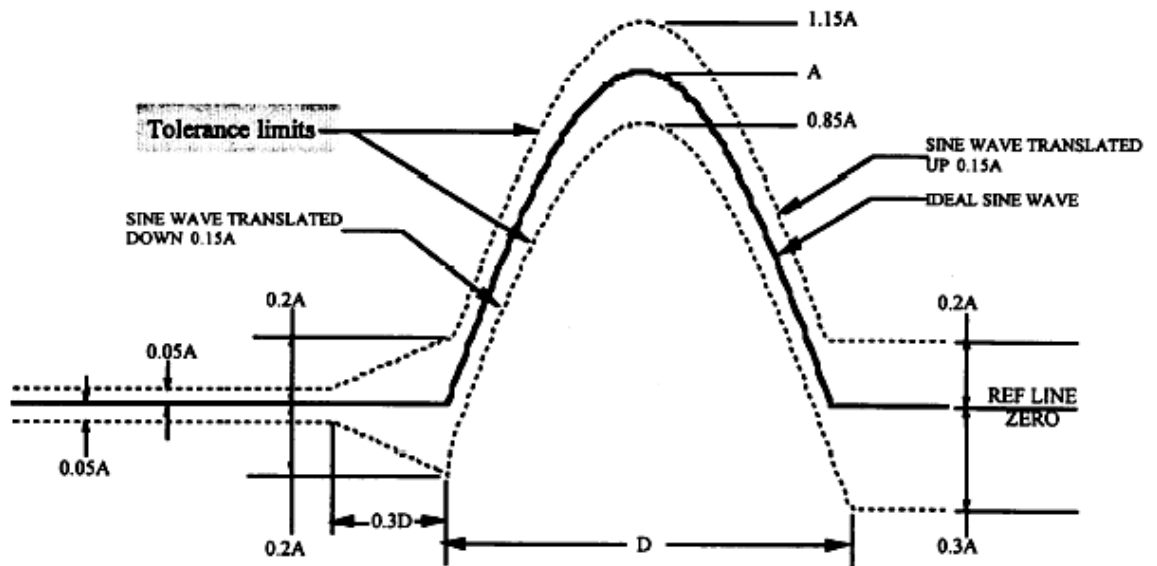
2.1 REQUIREMENTS

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.4).
- b) The VMI 5100MS shall be capable of operating during and after the test is performed (see Section 4.3).

2.2 TEST METHOD

- a) Perform a pre-test functional examination of the VMI 5100MS.
- b) The VMI 5100MS shall be mounted to the vibration table using normal mounting means to secure it.. A control accelerometer will be attached to the table, and testing will be performed with no deviations from the specified levels. Whenever possible, the test load is uniformly distributed in order to minimize the effects of unbalanced loads.
- c) A half-sine shock pulse with the configuration and tolerance limits shown in Figure 9-2 (Ref: Fig. 14 of MIL-PRF-28800F-810F) shall be used.

Figure 9-2: Half-Sine Shock Pulse Configuration and Limits



- d) The duration (D) of the pulse shall be 11 ms, and the peak shock value (A) shall be 30g.
- e) The equipment shall be operating during the test.
- f) The equipment shall be given three shocks in each direction and on each axis for a total of 18 shocks.
- g) Unless otherwise stated, no response accelerator will be attached to the Unit Under Test (UUT).
- h) Testing for shock will be in-axis, minimizing UUT rotation and handling.
- i) After test, a visual inspection and functional test shall be performed on the EUT. The test unit shall show no visual or operational anomalies. The obtained results shall be recorded and included in the test report.

3 **TRANSIT DROP:**

3.1 **REQUIREMENTS**

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.4.2, Class 3).
- b) Equipment that has the enclosure act as the transit case, equipment that is specified to include a transit case, and all Class 1 equipment shall conform to the specified performance and accuracy requirements after being tested in accordance with 9.3.2. The equipment shall remain inside the transit case throughout this test.

3.2 **TEST METHOD**

- a) A pre-test functional examination shall be performed on the VMI 5100MS.
- b) The drop height shall be 2ft, and the unit shall be subjected to ten impacts as specified in Table 9-1 of MIL-PRF-28800F-810F. For equipment 454 kg or less, the floor or barrier receiving the impact shall be of 5.08 cm plywood backed by concrete.
- c) After test, a visual inspection and functionally test shall be performed on the EUT. The test unit shall show no visual or operational anomalies. The obtained results shall be recorded and included in the test report.

4 **BENCH HANDLING:**

4.1 **REQUIREMENTS**

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.4.3, Class 3).
- b) The equipment shall conform to the specified performance and accuracy requirements and there shall be no damage to any controls, indicators, or fuseholders, after being tested in accordance with 9.4.2.

4.2 **TEST METHOD**

- a) A pre-test functional examination shall be performed on the VMI 5100MS.
- b) With the equipment operating as in the satisfactory operating check, place the instrument in a suitable position for its servicing on a horizontal, solid wooden bench top at least 4.1 cm thick.

- c) The test shall be performed as specified in Steps 1 through 5, in a manner simulating shocks liable to occur during its servicing.

Step 1 Using one edge as a pivot, lift the opposite edge of the chassis until one of the conditions specified in a through c occurs (whichever occurs first):

- a. The chassis forms an angle of 45 degrees with the horizontal bench top.
- b. The lifted edge of the chassis has been raised 10.16 cm above the horizontal bench top.
- c. The lifted edge of the chassis is just below the point of perfect balance.

Let the chassis drop back freely to the horizontal bench top. Repeat, using other practical edges of the same horizontal face as pivot points, for a total of four drops.

Step 2 Repeat Step 1, with the test item resting on other faces until the test item has been dropped for a total of four times on each face on which the test item could reasonably be placed during its servicing.

Step 3 Repeat Steps 1 and 2 with instrument not operating and cabinet or case removed, except for equipment where the case serves as the only chassis or support structure.

Step 4 Examine the instrument for mechanical damage. Damage to the instrument, other than cosmetic, will constitute a failure.

Step 5 Perform the satisfactory operation test.

5 **BLOWING DUST:**

5.1 **REQUIREMENTS**

- a) Testing will be performed per MIL-STD-810F, (Section 4.4.2 of Method 510.4).
- b) The test unit shall show no evidence of undue surface abrasion, exposure of base metal, chipping or peeling due to testing.

5.2 **TEST METHOD**

- a) With the test item in the chamber, adjust the test section temperature to standard ambient conditions and the air velocity to the required value, determined from the test plan. Adjust the test section relative humidity to less than 30% and maintain it throughout the test.
- b) Adjust the dust feed control for a dust concentration of $10 \pm 7 \text{ g/m}^3$.
- c) Unless otherwise specified, maintain the conditions of Steps a and b for at least 6 hours. If required, periodically reorient the test item to expose other vulnerable faces to the dust stream.
- d) Stop the dust feed. Reduce the test section air velocity to approximately 1.5 m/s and adjust the temperature to standard ambient conditions or as otherwise determined from the test plan.
- e) Maintain the step d conditions for 1 hour following test temperature stabilization.
- f) Adjust the air velocity to that used in Step a and restart the dust feed to maintain the dust concentration as in Step b.
- g) Continue the exposure for at least 6 hours or as otherwise specified. If required, operate the test item in accordance with the test plan.
- h) Allow the test item to return to standard ambient conditions, and the dust to settle.
- i) Remove accumulated dust from the test item by brushing, wiping or shaking, taking care to avoid introduction of additional dust or disturbing any which may have already entered the test item. Do not remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.
- j) Perform an operational check in accordance with the approved test plan, and document the results for comparison with pretest data.

- k) Inspect the test item for dust penetration, giving special attention to bearings, grease seals, lubricants, filters, ventilation points, etc. Document the results.

6 BLOWING SAND:

6.1 REQUIREMENTS

- a) Testing will be performed per MIL-STD-810F, (Section 4.4.3 of Method 510.4).
- b) The test unit shall show no evidence of undue surface abrasion, exposure of base metal, chipping or peeling due to testing.

6.2 TEST METHOD

- a) Position the test item at the required distance from the sand injection point and adjust air velocity according to test plan.
- b) Stabilize the test item at its high operating temperature.
- c) Adjust the sand feeder to obtain the sand mass flow rate determined from the pretest calibration.
- d) Maintain the conditions of Steps a through c for the duration specified in the test plan. If required, re-orient the test item at 90-minute intervals to expose all vulnerable faces to the blowing sand and repeat Steps a-c.
- e) If operation of the test item during the test is required, perform an operational test of the item during the last hour of the test and document the results. If not, proceed to Step f.
- f) Allow the test item to return to standard ambient conditions. Remove accumulated sand from the test item by using the methods anticipated to be used in service such as brushing, wiping, shaking, etc., taking care to avoid introduction of additional sand into the test item.
- g) Conduct an operational check of the test item in accordance with the approved test plan and record results for comparison with pretest data.
- h) Visually inspect the test item looking for abrasion and clogging effects, and any evidence of sand penetration. Document the results.

7 **OPERATING AND STORAGE TEMPERATURE:**

7.1 **REQUIREMENTS**

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.1.1.1, Class 3).
- b) Degradation of the equipment performance shall be noted if it exceeds any bound established in the purchase description and when compared with pretest qualification. The item shall have failed the test when any of the conditions specified in 1 through 7 occur:
 - 1. Monitored functional parameters deviate beyond acceptable limits established in 9.7.2.
 - 2. Catastrophic or structural failure.
 - 3 Mechanical binding or loose parts, including screws, clamps, bolts, and nuts, that results in component failure or a hazard to personnel safety.
 - 4 Malfunction.
 - 5 Degradation of performance beyond limits established in the purchase description.
 - 6 Any additional deviations from acceptable criteria established before the test.
 - 7 Deterioration, corrosion, or change in tolerance limits of any internal or external parts that could in any manner prevent the test item from conforming to operational service or maintenance requirements.
- c) Additional or different failure criteria shall be as specified in the purchase description.

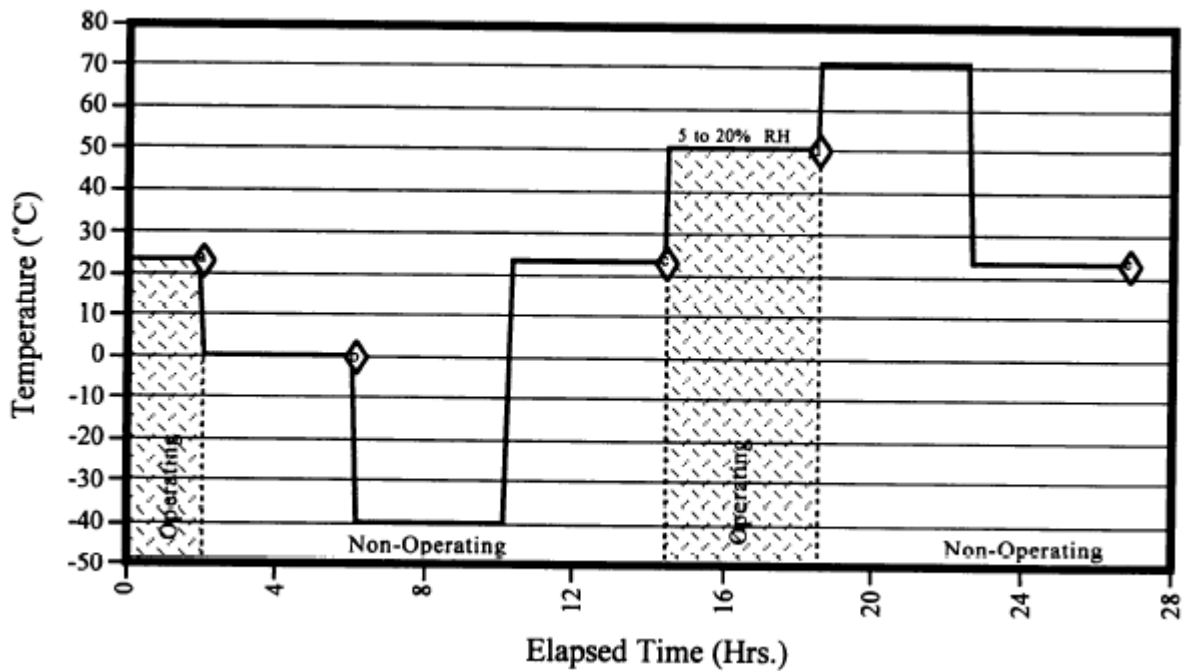
7.2 **PRETEST QUALIFICATION**

- a) Prior to proceeding with the environmental tests, the test item shall be operated under standard ambient conditions to evaluate the performance characteristics of the equipment, defined in the purchase description. This test is used to establish the level of performance of the equipment at the outset of testing, prior to any environmental tests.
- b) This test is performed before, during, and after the environmental tests, whenever a satisfactory operational test is required. Degradation of the equipment performance shall be noted if it exceeds any bound established in the purchase description.

7.3 TEST METHOD

- a) The temperature test procedure consists of a five independent tests (1 through 5) that can be performed in any sequence, except as indicated for test 1. The profiles are provided in Fig. 9-3. The humidity during the test is uncontrolled for all tests except test 4, where the humidity shall be controlled within the range of 5 to 20 percent relative humidity (with the applicable tolerance), to simulate an arid environment. The testing may be interrupted after any test, 1 through 5.

Figure 9-3: Sample temperature testing profile for Class 3 (including the arid climate test)



- b) Performance of the satisfactory operation test shall occur at the end of each temperature test period, adding whatever time is required to perform the satisfactory operation test. (This means that the total time required to perform the temperature testing will be the cumulative total consisting of: the time required for each temperature test, the time required to perform a satisfactory operation test at each temperature test, and any interruption period).

c) **Temperature Tests:**

- 1 Place the test item in the test chamber in accordance with the bullet below. With the temperature at the room ambient the equipment is operating for 2 hours, after which the satisfactory operational test is performed. *Test 1 shall always be performed first in the test sequence.*
 - The test item shall be installed in the test facility in a manner that will simulate service usage, making connections and attaching instrumentation as necessary. Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be covered. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed. The test item shall be operated to determine that no malfunction or damage was caused due to faulty installation or handling.
- 2 The temperature is maintained at 0 °C. The equipment is not operating for 4 hours. Operate the test item for the warm up period recommended by the manufacturer. Perform a functional test and compare the results with test 1. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.
- 3 The temperature is maintained at or -40 °C. The equipment is not operating for 4 hours. Following the 4 hour cold storage soak, the temperature is raised to 23 °C. For an additional 4 hours the equipment is maintained at these conditions. Operate the test item for the warm up period recommended by the manufacturer. Perform the a functional test and compare the results with test 1. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.
- 4 The humidity during this test is controlled at within the range of 5 to 20% (with the applicable tolerance). The temperature is maintained at 50 °C. The equipment is operating for 4 hours. Following the 4 hour arid heat operating soak, perform a functional test and compare the results with test 1. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

- 5 The temperature is maintained at 71 °C. The equipment is not operating for 4 hours. Following the 4 hour hot storage soak, the temperature is lowered to 23 °C. For an additional 4 hours the equipment is maintained at these conditions. Operate the test item for the warm up period recommended by the manufacturer. Perform a functional test and compare the results with test 1. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

8 HUMIDITY CYCLE:

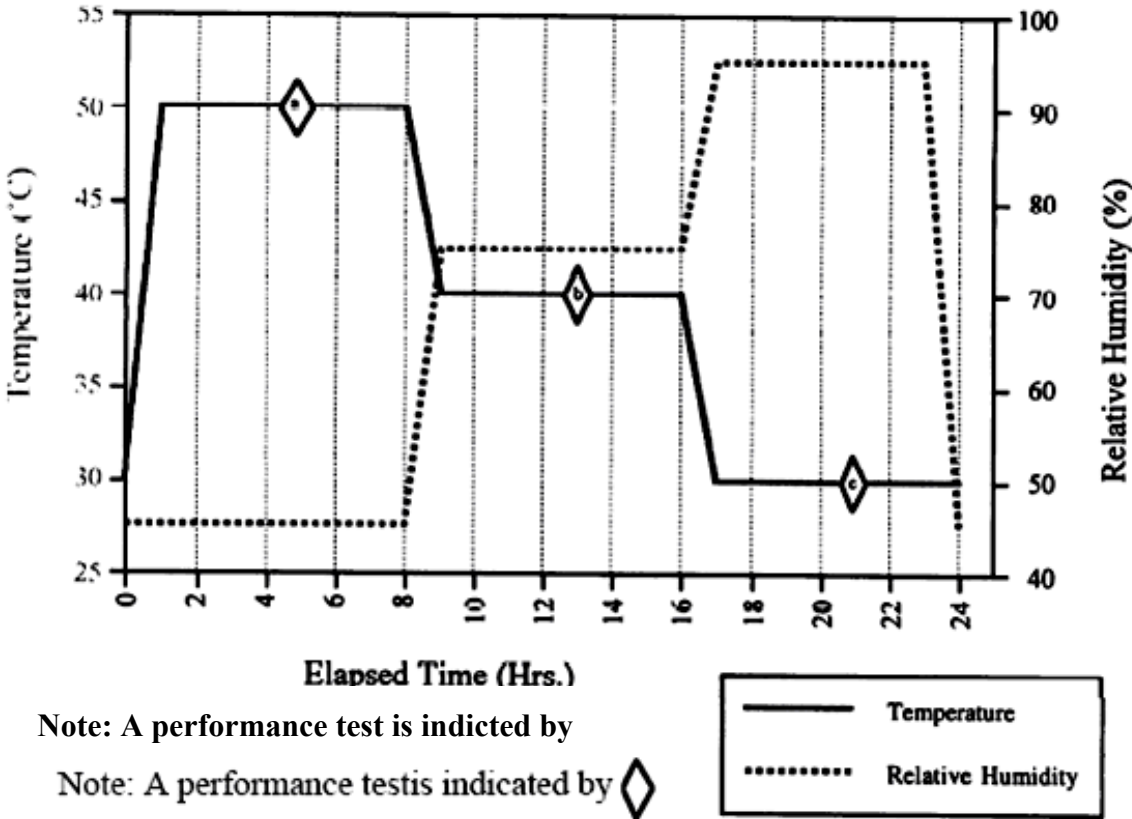
8.1 REQUIREMENTS

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.5.1.1.2, Class 3).
- b) The EUT shall not be damaged during the humidity test. Performance of the EUT shall not degrade during operational testing (see Section 4.3).

8.2 TEST METHOD

- a) The humidity cycle testing follows immediately after the testing of Section 9.7.
- b) This procedure consists of 5 days of temperature humidity cycling, with each days cycle consisting of the profile displayed in Figure 8.

Figure 9-4: Five day humidity cycle profile for Class 3 that follows initial temperature test



- c) Functional tests shall be performed at the times indicated on the figures with a diamond symbol of Figure 9-4, noted as (a), (b), and (c) (as applicable).
- d) A functional test (at normal room ambient conditions) shall be conducted prior to and at-the-conclusion of the five-day humidity test.
- e) During the humidity cycle, the equipment is only operating during the warm-up period and the satisfactory operational test.
- f) The functional test, as annotated by (a), (b), and (c) shall each be performed at least once each during the 5 days of humidity cycling, at the indicated times. Functional test (a) and (b), as appropriate, shall be performed at any of cycles 2, 3, 4, or 5. Functional test (c) shall be performed at least at Cycle 5. Functional test's may also be performed at any, or all cycles at the indicated times.

- g) To accommodate varying times for completing satisfactory operational tests, the cycle timing after a test maybe adjusted to allow a return back to the regular profile timing. However, a minimum 4 hour dwell time prior to period of operation should be observed.

9 **SALT FOG:**

9.1 **REQUIREMENTS**

- a) Testing will be performed per MIL-PRF-28800F-810F, (Method 4.5.6.2, Class 3).
- b) The test duration shall be 48 hours with the samples being constantly wetted with a 5 ± 1 percent salt solution. A 48 hour drying period in a standard ambient atmosphere shall follow. Degradation of material beyond the requirements of the intended use shall constitute a failure of this test.

9.2 **PREOPERATIONAL INSPECTION**

- a) Prior to the beginning of testing, the preoperational inspection specified in steps b and c shall be performed on all equipment.
- b) The equipment shall be given a thorough mechanical and visual examination and test to determine that all materials, workmanship, and safety characteristics comply with the specified requirements.
- c) Electrical circuit configuration. The equipment shall be examined or tested to confirm that the wiring is correct. Where applicable, the tests shall include the requirements specified in 1 and 2:
 - 1 All intra-module wiring shall be tested to assure correctness.
 - 2 The module grounding system shall be examined or tested to ensure proper separation of shield, signal, and framework grounds, and metal-to-metal contact for panels and components that serve as electromagnetic shields.

9.3 **TEST METHOD**

- a) The equipment (unless a transit case is specified then before the transit case is closed the cables and connectors shall be removed from the

equipment in the transit case) shall be not operating but with cables and connectors attached as for the satisfactory operation test. Unused connectors may have caps or covers installed.

- b) Perform the functional test required in the purchase description before any cleaning is performed. Inspect the equipment to detect evidence of physical degradation. Visible corrosion is permissible if it is removed by suitable cleaning and the equipment is returned to a condition that conforms to its normal ambient condition. Perform a functional test required in the purchase description.
- c) The equipment shall have one or more samples of each material used for the fabrication of panels and structural parts (chassis, rails, braces, and so forth) with finishes as in the completed equipment, subjected to the salt fog test. After exposure, the material shall be inspected to detect any evidence of physical degradation. Visible corrosion is permissible if it is removed by suitable cleaning and the material is, as a result of the cleaning, returned to a condition that conforms to its normal ambient condition.
- d) The equipment shall be in its normal operating mode (except for equipment in transit cases), without power applied. The salt concentration shall be 5% sodium chloride. The test chamber temperature shall be 35 °C. Store the equipment (or equipment in its transit case) in a standard ambient atmosphere for 48 hours following the 48 hour salt exposure.
- e) At the end of the drying period, a functional test shall be performed to verify that equipment performance has not deteriorated.

10 FUNGUS:

10.1 REQUIREMENTS

- a) Testing will be performed per MIL-STD-810F, (Section 4.5 of Method 508.5).
- b) The Unit Under Test shall be capable of operating during and after the test is performed (see Section 4.3).

10.2 PREPARATION FOR INCUBATION

- a) Assure the condition of the items subjected to testing is similar to their condition as delivered by the manufacturer or customer for use, or as

otherwise specified. Accomplish any cleaning of the test item at least 72 hours before the beginning of the fungus test to allow for evaporation of volatile materials.

- b) Install the test item in the chamber or cabinet on suitable fixtures, or suspend them from hangers.
- c) Hold the test item in the operating chamber (at $30 \pm 1^\circ\text{C}$ and a RH of greater than 90% but less than 100%) for at least four hours immediately before inoculation.
- d) Inoculate the test item and the cotton fabric chamber control items with the mixed fungus spore suspension by spraying the suspension on the control items, and on and into the test item (if not permanently or hermetically sealed) in the form of a fine mist from an atomizer or nebulizer. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inoculation.

NOTE: In spraying the test and control items with composite spore suspension, cover all external and internal surfaces that are exposed during use or maintenance. If the surfaces are non-wetting, spray until drops begin to form on them.

- e) In order for air to penetrate, replace the covers of the test items without tightening the fasteners.
- f) Start incubation immediately following the inoculation.

10.3 INCUBATION OF THE TEST ITEM

- a) Except as noted in Step b, incubate the test items at constant temperature and humidity conditions of $30 \pm 1^\circ\text{C}$ and a relative humidity above 90% but below 100% for the test duration (28 days, minimum).
- b) After 7 days, inspect the growth on the control cotton strips to verify the environmental conditions in the chamber are suitable for growth. At this time at least 90 percent of the part of the surface area of each test strip located at the level of the test item should be covered by fungus. If it is not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test.
- c) If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period from the time of inoculation as specified in the test plan. If there is no increase in fungus growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

10.4 INSPECTION

- a) At the end of the incubation period, inspect the test item immediately. If possible, inspect the item within the chamber. If the inspection is conducted outside of the chamber and is not completed in 8 hours, return the test item to the test chamber or to a similar humid environment for a minimum of 12 hours. Except for hermetically sealed material, open the test item enclosure and examine both the interior and exterior of the test item.
- b) Record the results of the inspection.

10.4 OPERATION/USE

- a) If operation of the test item is required (e.g., electrical material), conduct the operation in the period as specified in paragraph 9.10.4.
- b) Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inspection and in making operation and use decisions.
- c) Disturbance of any fungus growth must be kept to a minimum during the operational checkout.